# FEASIBILITY STUDY OF GAS BASED POWER PLANT UNDER PRIVATE SECTOR

By

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# Declaration

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

Abul Fajal Mohammad Sakib Aman

**This work is dedicated**
**to my loving**

**Father**

**&**

**Mother**

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## List of Symbols

| | | |
|---|---|---|
| oe | : | Oil Equivalent |
| kwh | : | Kilowatt Hour |
| MW | : | Mega Watt |
| kw | : | Kilo Watt |
| FY | : | Fiscal Year |
| mmscftd | : | Million million square feet per day |
| CCPP | : | Combined Cycle Power Plant |
| HFO | : | Heavy Fuel Oil |
| HSD | : | High Speed Diesel |
| sq. | : | Square |
| km | : | Kilometre |
| GT | : | Gas Turbine |
| ST | : | Steam Turbine |
| HRSR | : | Heat Recovery Steam Generator |
| KJ | : | Kilo Joule |
| Rpm | : | Revolution per minute |
| HV | : | High Voltage |
| LV | : | Low Voltage |
| DOE | : | Department of Environment |
| EIA | : | Environmental Impact Assessment |
| M | : | Metre |
| V | : | Volt |
| °C | : | Degree Celsius |
| AC | : | Alternative Current |
| DC | : | Direct Current |
| TEWAC | : | Totally enclosed water-to-air Cooled |
| CACW | : | Closed Air Circuit Water |

# Acknowledgement

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Lastly the author thanks his parents, brother, wife and friends for their encouraging and providing moral support to complete this thesis smoothly.

# Abstract

This project was designed to analyze the feasibility for installation of Power Plant. This report deals basically with the feasibility study and evaluation of the project: 'Feasibility Study of Gas Based Power Plant Under Private Sector'. The main objective of the study focuses on feasibility analysis using both financial and economic appraisal including BCR (F), BCR (E), IRR (F), IRR (E) and discounted payback period to check the viability of the project.

Feasibility of proposed plant location is evaluated on the basis of site selection criteria. Plant capacity is determined on the basis of raw materials supply and profitability. Fixed Capital Investment cost is determined by „Ratio of plant capacities Power factor" method on the basis of the cost of 150 MW combined cycle plant at Chandpur in 2012. Plant operating costs, overheads and other expenses are also taken from the similar costs of Ashuganj Power station and Shikalbaha Power Station.

Economic and Financial Evacuation are performed on plant capacities of 150 MW, 225 MW, 300 MW and 450 MW with duel fuel option (Gas and HFO). Conclusions are made on the findings of above mentioned evaluations.

# Chapter-1

# Introduction

## 1.1 Back Ground

The per capita energy consumption in Bangladesh is one of the lowest in the region. On average per capita energy conumption in Bangladesh is 160 kg oe (Kilogram oil equivalent) compared to 530 kg oe in India, 510 kg oe in Pakistan, 470 kg oe in Srilanka and 340 kg oe in Nepal. The average energy consumption in Asia is 640 Kg oe. It is therefore evident that per capita energy consumption is far lower than the average of Asia [1]. On top of this low level of consumption, there is already a serious energy crisis. The frequent power outages threatening the citizen's welfare and project development. Due to the severe crisis of power, the Gov. has been forced to enter into cotractual agreements for high cost, temporary solution of purchasing power on an emergency basis [2].

Presently only 47% of the total population have access to electricity. Per capita generation is only 220 kwh, which are very low comparing with other developing countries in the world. The Government‟s vision is – "To provide access to affordable and reliable electricity to all by the year 2021" [3]. Realization of this vision would call for large addition to generation capacity over time, expansion of grid and distribution networks.

The installed capacity of the power plants in Bangladesh in public and private sectors are 5440 MW and 4701 MW respectively. But de-rated capacity of public and private sector are 5141 MW and 4536 MW respectively [4]. Hence, considering the de-rated installed capacity of 9677 MW, Public sector and Private sector participation in power generation is 54% and 46% respectively. At present, electricity demand is about 7500-8000 MW whereas electricity generation is 6000 to 7000 MW (so far maximum generation 6675 MW at 12/07/2013) [5]. Public sector generation is not increasing as per

the demand due to various reasons. Now a day in Bangladesh, different entities like Private Sector, IPP, SIPP & Rental are involved in the field of power generation. There are Twenty Five numbers of power plants under public sector and Forty Nine numbers of power plants under private sector having ownership of IPP, SIPP & Rental [4].

To generate electricity, Gas based power plant are ideal as it can be started and stopped quickly enabling it to be brought into service as required to meet energy demand peaks. However, due to availability of natural gas at relatively cheap prices compared to distillate fuels, many countries around the world use gas turbines as base load units [6, 7]. The use of gas based power stations has increased in recent years due to mainly to the development of nominal output gas turbines [7].

Natural gas, Coal, Diesel and Furnace oil are used as a primary fuel for power generation. Now a day in Bangladesh, the gas base generation is around 64-65% of total generation, whereas the Coal base generation is only 2-3%, Oil (Diesel) base generation is 6-7% and Furnace Oil base generation is 19-20%, Hydro base generation is 2%, and imported 5% [8].

Though the least cost option is the pre-requisite condition of setting up new power plants, but the present crisis of electricity in the country, enforce to follow the fuel diversification policy to mitigate the crisis of electricity. Hence to escape from dependentness on single fuel i.e. gas, liquid fuel especially HFO base power plant is one of the shortest possible solution to mitigate the present power crisis in the country, though it is costlier than gas or coal [9].

## 1.2 Business Opportunity

Bangladesh is now facing severe power crisis which is not possible to solve immediately. Hence a coordinated program is required to be followed to solve the total power crisis. The present shortage of power generation is mainly due to dependence on single fuel [9]. i.e. gas is primary fuel for power generation. Suddenly the situation has risen of unavailability of gas for power generation. Due to non-availability of sufficient gas supply, the gas based power plant failed to run with its maximum generation capability which altogether being 600-800 MW. Moreover the power projects, dependent on gas, failed to commission in time due to shortage of gas for the plants [10].

But the demand of power at consumer end is increasing 7-8% annually which makes the supply demand gap wider to wider. This is the cause of severe load shedding throughout the country [11]. In fact, the power crisis has created a negative impact on industrial development along with other development program dependent on electricity.

This critical situation of gas shortage has compelled us to select alternative fuel for power generation. i.e. diversification of fuel. Hence the Government of Bangladesh is planning to use Gas and side by side Coal, Liquid fuel (HFO, HSD), Renewable energy and even to set up nuclear power plant to increase power generation in the country and to up hold the development programs of the nation [9].

On the circumstances above, there are no alternative to set up the proposed plant at Shikalbaha premises at a shortest possible time with duel fuel facilities to mitigate the present power crisis to some extent.

## 1.3 Similar Types of Plant under Operation

Presently, Bangladesh Power Development Board (BPDB) is operating 150MW combined cycle power plant at Chandpur and kumargaon (Sylhet), 225 MW combined cycle power plant at Ashuganj, 360 MW combined cycle power plant at Horipur, 100 MW combined cycle power plant at Bhola, 90 MW combined cycle power plant at Fechuganj, 300 MW combined cycle power plant at Bibiana and 300 MW combined cycle power plant at Meghnaghat [4].

## 1.4 Scope of the Study

To fulfill the main objective the scope of the study includes:

**Chapter 1** presents introduction and background of the study. **Chapter 2** presents specific objectives of this work and also outline of the methodology which have been followed to draw effective results of the work.

**Chapter 3** presents the technical feasibility analysis that includes the feasibility of the proposed plant location at Shikalbaha, availability of raw materials, selection of plant capacity and selection of optimum generation for the proposed plant depending upon

marketing opportunity are also determined in this chapter. Process description are also presented in brief.

**Chapter 4** presents market feasibility that means the generation and demand situation of the products of the plant in Bangladesh has been studied. **Chapter 5** presents the determination of profitability by NPV, BCR, IRR, Payback Period etc. calculations. i.e. economic and financial analysis of the proposed project to find out feasibility of the proposed project by following appropriate methodology.

**Chapter 6** provides the SWOT analysis that means the strength, weakness, opportunity and the threats of the project. Finally, a summary of major contributions is given in **conclusion** and references are provided at the end.

# Chapter-2

# Objectives & Methodology

## 2.1 Objectives of the Present Work

The objectives of the present work are as follows:

(i) To find out annual production and consumption of natural gas.

(ii) To identify key barriers and issues for project development.

(iii) To forecast demand and supply electrical energy.

(iv) To calculate product cost.

(v) To find the financial feasibility of the gas based power plant by calculating Net Present Value (NPV), Payback Period, Benefit Cost Ratio (BCR), Internal Rate of Return (IRR) and Profitability Index.

The possible outcome of the thesis is a feasibility report including economic, financial and marketing analysis and recommendation about the power plant.

## 2.2 Methodology

(i) Collection of Data from BPDB to get proper demand supply scenario of power.

(ii) Assessment of proposed project costs for project scenarios of interest, including cost estimates for capital and operating costs. These are based on best available estimates from technology vendors and technical experts.

(iii) Unit cost of power will be calculated from plant installation cost and operating costs.

(iv) Analysis of financial feasibility of gas based power plant by calculating NPV, Payback Period, and IRR.

(v) Assessment of available Gas resources based on information gathered from Petrobangla.

(vi) SWOT (Strength, Weakness, Opportunities and Threats) analysis may be presented in brief.

# Chapter-3

# Technical Feasibility

## 3.1 Site Selection

Chittagong district (Chittagong Division) with an area of 5282.98 sq. km, is bounded by Feni district and Tripura (Indian State) on the north. Cox‟s Bazar district on the south, Badarban, Rangamati and Khagrachhari district on the east and Noakhali district and the Bay of Bengal on the west. Chittagong district is quite different from other districts for its unique natural beauty characterized by hills, rivers, sea, forests and valleys. Annual average temperature maximum 32.5° C, minimum 13.5° C, total annual rainfall 2687mm, Main rivers are Kanaphuli, Halda & Sangu.

Chittagong town consists of six thanas, 68 wards and 236 mahallas. It has an area of 209.66 sq. km. The town has a population 3,202,710; male 54.36% and female 45.64%; Population density per sq. km 15,276. The main sea port of Bangladesh is located at the estuary of the Karnaphuli River. Chittagong is also called the commercial capital of Bangladesh. Interesting places of the city include Batali hill (87.5m in height), War Cemetery, Patenga Sea Beach, Foy‟s Lake etc. The first export processing Zone (1983) of Bangladesh is situated here. Chittagong Municipal Committee was established in 1860. At present it has been turned into Chittagong City Corporation.

Main occupations Agriculture 18.71%, fishing 1.16%, agriculture laborer 12.13%, wage laborer 3.54%, industry 1.72%, commerce 16.58%, transport 4.52%, construction 1.43%, service 24.09% and others 16.12%.

**Fig: 3.1** Bangladesh Map (Chittagong Region – Red Color)

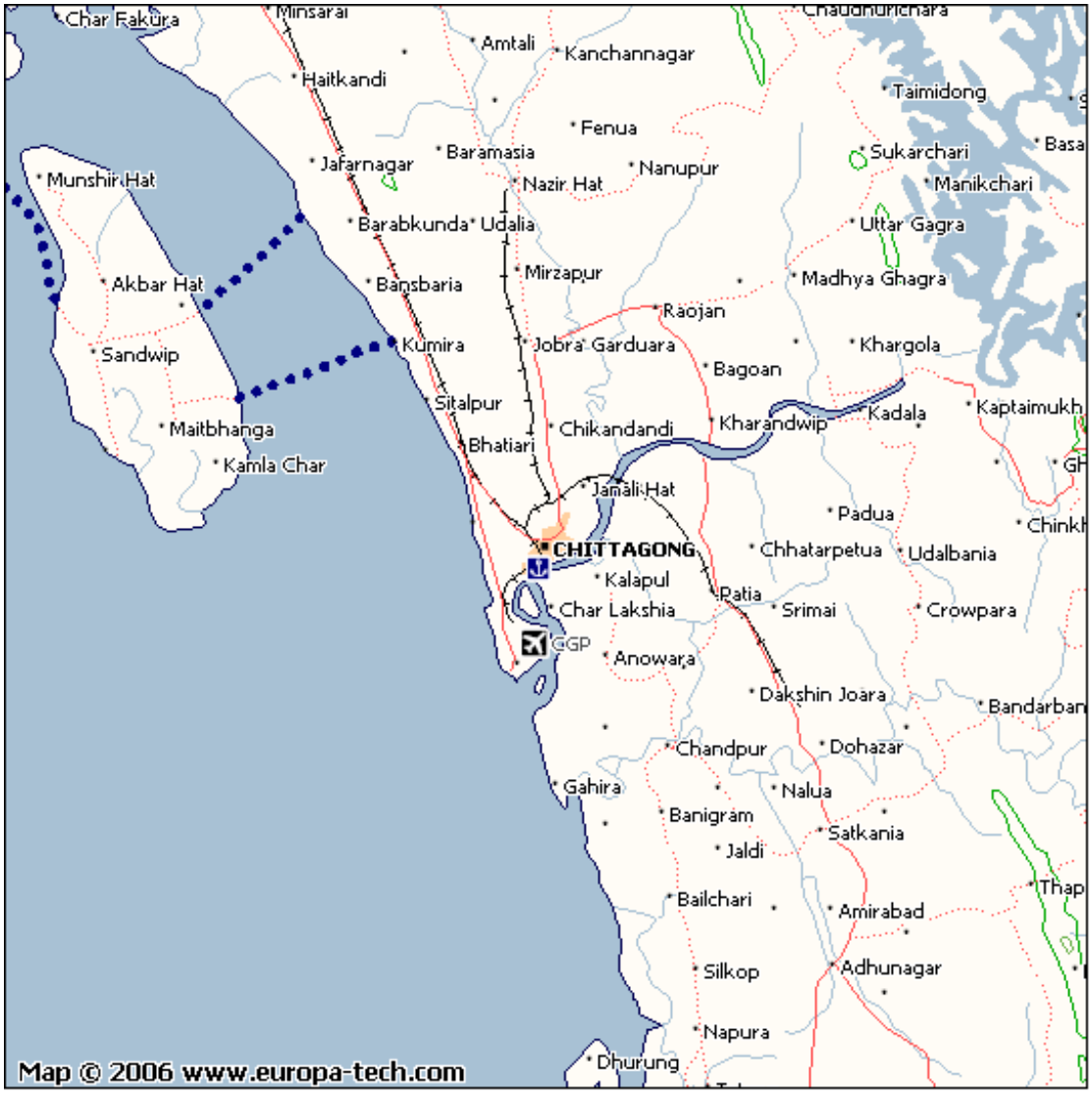


**Fig: 3.2** Chittagong Map

At Shikalbaha t here are 60 MW steam power plant and 150 MW gas turbine power plants on BPDB and 55 MW rental power plants on private sector. The site is situated near the Karnaphuli River. Around 10 acres of unused land is available on the river side under the ownership of BPDB which is suitable for setting up the proposed power plant. In addition to that, another piece of land having area of about 10 acres is also available adjacent to the 132/33 KV Grid Sub-Station which may be used for the 230/132 KV Sub-Station.

There are also strips of land having area of around 16 acres which can also be acquired if necessary. But the available land is sufficient for the proposed power plant. As

the land is near by the Karnaphuli River, the transportation of fuel for the proposed plant will be convenient through this river.

The water required for the proposed plant may get from Karnaphuli river but desalination plant need to be installed to have salinity free water for the proposed plant.

## ➢ Transportation

Raw materials, products and manpower transportation are very important issues in selection of power location. Water, railroads and highways are common means of transportation used by major industrial concerns. The kind and quantity of products and raw materials determine the most suitable type of transportation facilities. Careful attention should be given to local freight rates. The proximity to railroad centers and the possibility of canal, river, lake or ocean transport must be considered. Motor tucking facilities are widely used and can serve as a useful supplement to rail and water facilities. If possible, the plant site should have access to all three types of transportation and certainly at least two types should be available. There is usually a need for convenient and effective transportation facilities for the plant personnel are necessary.

The site of the proposed power plant is located very close to Karnaphuli River. That‟s why the equipment like turbine, generator, transformer etc. can easily be transported through the river. Moreover the existing road communication with the Shikalbaha power station complex can also be used for the same purpose.

Office duty and shift personnel may be taken lift and drop from residential area to plant area by microbus. The officers or workers living at other locations can reach to the proposed plant area very easily by public bus, transport or boat as the plant will be located by the side of Karnaphuli River.

## ➢ Availability of Water

As the proposed plant is the combined cycle, the requirement of water for steam unit is more than the GT unit. Hence the supply source of water for plant to be dedicated to run the plant smoothly. Here the Karnaphuli River is contaminated with salinity. The water quality for steam unit should be free from all minerals which cannot be achieved with simply chemical treatment plant. Hence, desalination plant might be required in this case.

The reverse osmosis and Multi Stage Flashing (MSF) both are use in desalination process. Here we suggest reverse osmosis system for desalination plant. The water requirement for the ST unit is around 400-500 tons which is remained in closed circuit. Moreover, as a makeup water another 10-12% demy water is required.

## ➢ Load Centre

The proposed plant is very close to 132 KV Grid sub-station and 5-6 kilometer away from Chittagong town. The electricity demand in chittagong district cannot be fulfilled with the present generation capacity. Hence demand is existing and to fulfill the demand, the proposed plant is being near the load centre would be effectively influence in system voltage improvement. It also helps in improving the load shedding situation in Chittagong area.

## ➢ Social Impact

With the commissioning of the proposed plant, the supply situation in Chittagong area will be improved. On the basis of availability of electricity, the industrial infrastructure development will be enhanced. The scope of employment situation will be opened and this will help in poverty reduction. Moreover the availability of electricity will create different facilities in the sector of education, health etc.

## ➢ Environmental Impact

Considering environmental pollution, the proposed plant is to be selected in such a way that it does not have any affect like noise, NOx, Sox etc. in the environment. The

residual of HFO to be discarded in a proper way to avoid the environmental pollution. To avoid the sound pollution special equipment like silencer etc. to be installed in the appropriate places of the plant to maintain sound level in an acceptable level.

An environmental action plan (EAP) has been developed setting out the project mitigation, Management, monitoring, and ongoing consultation activities for the project.

## ➢ Availability of Natural Gas

Karnaphuli Gas Distribution Company Limited (KGDCL) is the sole Authority to supply gas at Shikalbaha. As there are already two power stations (Shikalbaha & Energis Power), Western Marine and Ocean Builders Shipyard established there, so required gas line is available at Shikalbaha. It‟ll be need to set up gas booster station here to maintain required gas pressure (18-20 bar).

## ➢ Availability of HFO

Bangladesh Petroleum Corporation (BPC) is the sole authority to import and distribute liquid fuel all over the country. Big vessel cannot reach Shikalbaha Power Station due to obstacle of Karnaphuli 3rd bridge because of low height. The bridge is around 800 meter away from the complex.

Considering 80% plant factor the daily fuel (HFO) consumption of the proposed plant (GT only) will be around 1000 MT. In that case, if lower capacity barge is used, than a number of trips will be required to ensure fuel supply in each day. Moreover, the proposed plant will be required storing HFO for 15 days for reliable operation of the plant.

To avail the facility of mother vessel for fuel supply a pumping station may be constructed at distance of 500-600 meters in south side from the 3rd Karnaphuli Bridge. On the basis of necessity, a booster pump may be installed at the Shikalbaha complex. For the storage of HFO one or two HFO Tanks to be constructed considering 15 days reserve.

## ➢ River Dredging and Site Filling

The Karnaphuli River is highly turbid and carries high levels of sediments. Based upon EIA studies carried out for and by the dredging contractor, the turbidity created by

the dredge was not expected to significantly affect long-term sediment loadings in the river and would only have a short-term effect on benthos (i.e., bottom dwelling organisms) within and immediately adjacent to the borrow areas.

Organisms were expected to quickly re-colonize the affected areas once dredging is completed. The river is sufficiently large to allow fish and other active swimmers that may be affected by the turbidity to avoid highly turbid areas. Overall, no long-term deleterious effects were expected on aquatic life due to dredging activities.

The thermal plume modeling undertaken as part of the EIA, based upon the open channel discharge design during the dry season, indicates that the power station‟s discharge temperature will typically combine with the ambient river temperature to produce an average temperature compliant with both DOE and World Bank standards. Modeling was also undertaken to determine the potential for cooling water re- circulation at the cooling water intake during tidal conditions.

- **Noise**

The power station is being designed to meet the applicable guidelines for environmental noise. Where appropriate, exhausts and air intakes will be equipped with silencers to reduce noise levels at the source. Noise modeling, based upon conservative assumptions shows that the predicted noise level at the nearest Village of Shikalbaha would exceed the night-time noise limits of the DOE and World Bank. Construction phase noise will be generated by equipment on the project site and by traffic on the road and river networks. The most sensitive receptors for construction-generated noise are the residential area of Shikalbaha, which are adjacent to the project site. Through the implementation of the noise management measures, as set out in the EIA report, along with good site practices, noise effects should be limited to a short-term intermittent increase in ambient noise levels. Operation Phase as required in the contract between the Project Sponsor and the Construction Contractor, mitigation measures at noise sources (e.g., moving the power block and installing acoustical shielding) and at the project site boundary (e.g., vegetative planting) will be implemented to ensure the power station is compliant with both Bangladeshi and World Bank noise limits at the nearest residence.

## 3.2 Plant Selection

Combined Cycle Power Plant is selected for this project due to following reason:

- The higher thermal efficiency makes combined-cycle plants ideal for intermediate load applications.

| Types of Plant | Efficiency (%) |
|---|---|
| Diesel power plant | 35-42 |
| Steam power plant | 33-48 |
| Gas Turbine power plant | 32-38 |
| Combined Cycle power plant | 45-55 |
| Nuclear power plant | 38 |
| Wind power plant | 30-45 |

- With combined-cycle units often taking as long as 120 to 180 minutes to reach this temperature (cold start), the increase in emissions may require further evaluation [7].

- Combined-cycle gas turbines have elevated start up/shutdown emissions, just as in the case of simple-cycle gas turbines. For example, intermediate load combined-cycle plants may operate 16 hours per day, five days per week, 52 weeks per year, resulting in 260 start ups/shutdowns per unit annually.

- In many cases, supplemental duct firing in the HRSG provides additional heat that can be recovered, thereby allowing more power to be produced in the steam cycle.

- The turbines used in combined cycle plants are fuelled with natural gas, which is more versatile than a coal or oil and can be used in 90% of energy publications. To meet the energy demand now a day"s plants are not only using natural gas but also using other alternatives like bio gas derived from agriculture.

- The capital cost for building a combined cycle unit is two thirds the capital cost of a comparable coal plant.

- Combining two or more thermodynamic cycle‟s results in improved overall efficiency, reducing fuel costs. In stationary power plants [6].

- Combined cycle systems typically operate at higher efficiencies than conventional boiler-steam power systems. This allows a greater amount of electricity to be generated per unit of fuel utilized and thus, minimizes the volume of greenhouse gases released per unit of electricity produced. Natural gas has a low carbon content compared to the other hydrocarbons fuels, which results in lower emissions of CO2 per unit of heat released. Therefore, the efficiency of the combine cycle gas turbine, coupled with the use of indigenous natural gas fuel, will reduce emissions of CO2 per unit of power produced.

## 3.3 Fuel Selection

There are following types of fuel can be used for such type of plants:

Natural Gas.
Coal.
HFO.
Diesel.

Considering price and some types of losses Natural Gas is more feasible than other fuels. (Losses pipelines: 0.2-0.4% per 100 km) But, as of 2011, 79 natural gas wells are present in the 23 operational gas fields which produce over 2000 millions of cubic feet of gas per day (MMCFD). It is well short of over 2500 MMCFD that is demanded [12]. To overcome gas shortage Gov. has already taken some planning such as short term, medium term and long term basis.

According to Petrobangla, it‟ll be possible to supply 880 cubic feet more gas supply per day to the national gas grid at the end of December 2015 under long term plan. After implementation of long term and medium term plan, it‟ll be possible to supply additional 2800 million cubic feet gas per day to the additional gas grid with presently supplied 2000 million cubic feet gas per day [10].

According to the projection report of „The Institute of Energy Economics – Japan (IEEJ)", in 2019 and 2020, the production will be greater than the demand and demand supply gap will be the dissolved. Currently the country has a shortage of 500 MMCFD against a demand of 2500 MMCFD as the available production of is about 2000 MMCFD (as on 8-9/2/2011 production was 1987.5 MMCFD). It can also be mentioned that the expected growth rate of demand of gas is 6-7% annually [11].

**Table 3.1** Gas Production Projection

| **Year** | **Gas Demand Projection (mmcftd)** | **Gas Production Projection (mmcftd)** |
|---|---|---|
| 2010-2011 | 2335 | 1896 |
| 2011-2012 | 2500 | 2022 |
| 2012-2013 | 2650 | 2218 |
| 2013-2014 | 2805 | 2440 |
| 2014-2015 | 2975 | 2668 |
| 2015-2016 | 3150 | 2900 |
| 2016-2017 | 3340 | 3132 |
| 2017-2018 | 3540 | 3402 |
| 2018-2019 | 3750 | 3675 |
| 2019-2020 | 3975 | 3970 |
| 2020-2021 | 4210 | 4280 |
| 2021-2022 | 4465 | 4550 |
| 2022-2023 | 4735 | 4845 |
| 2023-2024 | 5020 | 5150 |

Though Global demand of gas is increasing day by day, Global proven gas reserves have more than doubled since 1980, reaching 190 trillion cubic metres at the beginning of 2010.

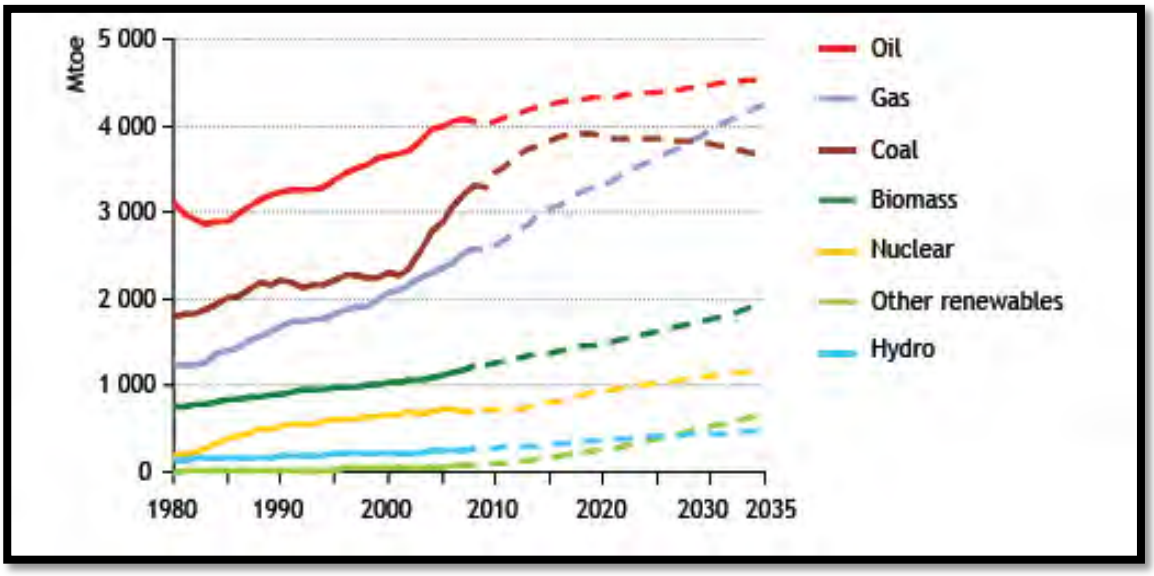


**Fig: 3.3** Global Demand of Gas

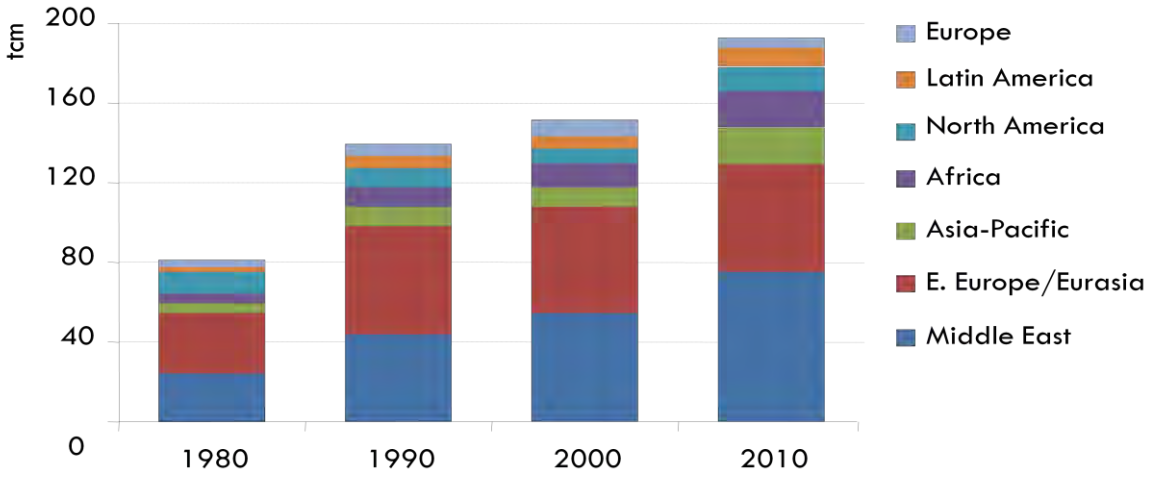


**Fig: 3.4** Global proven gas reserves

As described earlier that gas, the primary fuel is shortage to supply for power generation which compel to select alternative fuel for the same. But to arrange coal either domestic or import base is time dependent issue. The power demand is increasing at the rate 7-8% which needs to cope with new power generation plants based on alternative fuel other than gas [9].

Selection of liquid fuel in power generation is one of the major ethics. The unit cost of electricity based on diesel fuel is varying expensive in compare to HFO based power plant. But in both cases the unit price is more than gas or coal. Right now the availability of gas or coal is not sufficient enough for desired power generation.

Considering Diesel as the primary fuel, the configuration of the plants needs to select. To maintain the plant availability and economically viable, the proposed plant may be selected as combined cycle duel fuel gas turbine with 1+1+1 configuration. In these configuration the each GT having capacity 100 MW and the ST unit is also 100 MW.

Alternatively if HFO is used as the primary fuel is the proposed plant, the configuration 1+1+1 may be used. Here the GT unit having capacity of 100 MW and ST unit is of 100 MW. In both cases, the diverter flaps should be one enough i.e. without bypass facility to ensure economic operation of the plant. But in case of HSD based plant, the cost per unit electricity will be too high compare to other fuel base plant.

As the oil based plant is costlier and other program of setting up new power plants is going on, the proposed plant may be selected with the capacity of 300 MW instead of 450 MW.

Considering the gas availability through importing LNG, exploring new gas field and rearranging the present allocation of gas in the power plants in Chittagong district, the proposed plant is planned to operate with Gas and HFO. On the basis of this criterion, financial and economical analysis of the proposed plant with 100% HFO and 100% Gas.

## 3.4 Combined Cycle Gas Turbine

In electric power generation a combined cycle is an assembly of heat engines that work in tandem from the same source of heat, converting it into mechanical energy, which in turn usually drives electrical generators.

The principle is that the exhaust of one heat engine is used as the heat source for another, thus extracting more useful energy from the heat, increasing the system's overall efficiency.

This works because heat engines are only able to use a portion of the energy their fuel generates (usually less than 50%). In an ordinary (non combined cycle) heat engine the remaining heat (e.g., hot exhaust fumes) from combustion is generally wasted.

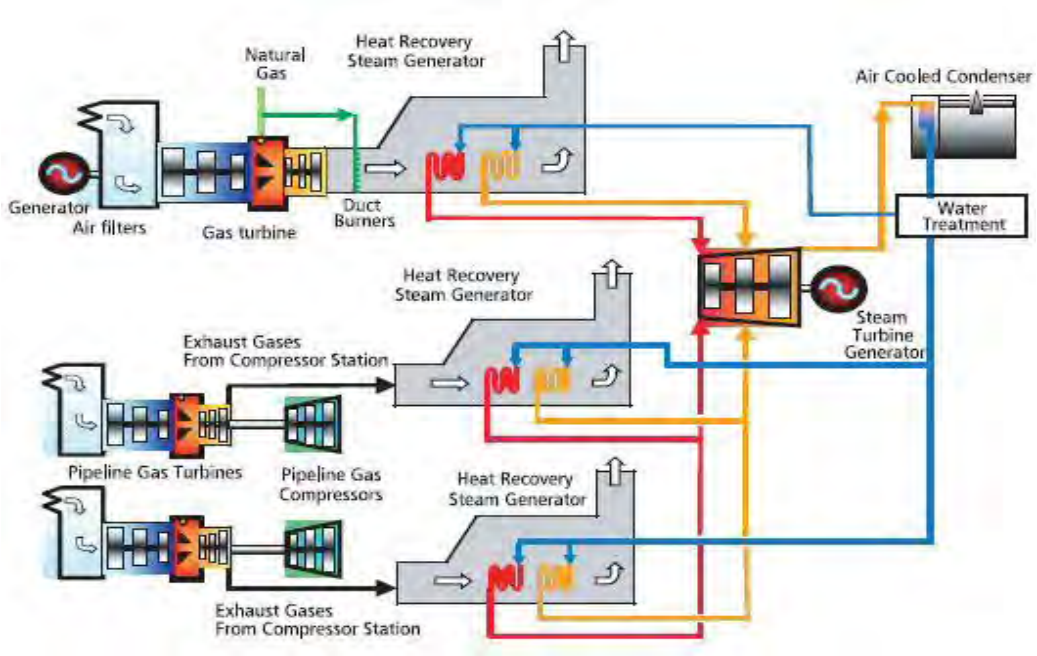


**Fig: 3.5** Combined Cycle

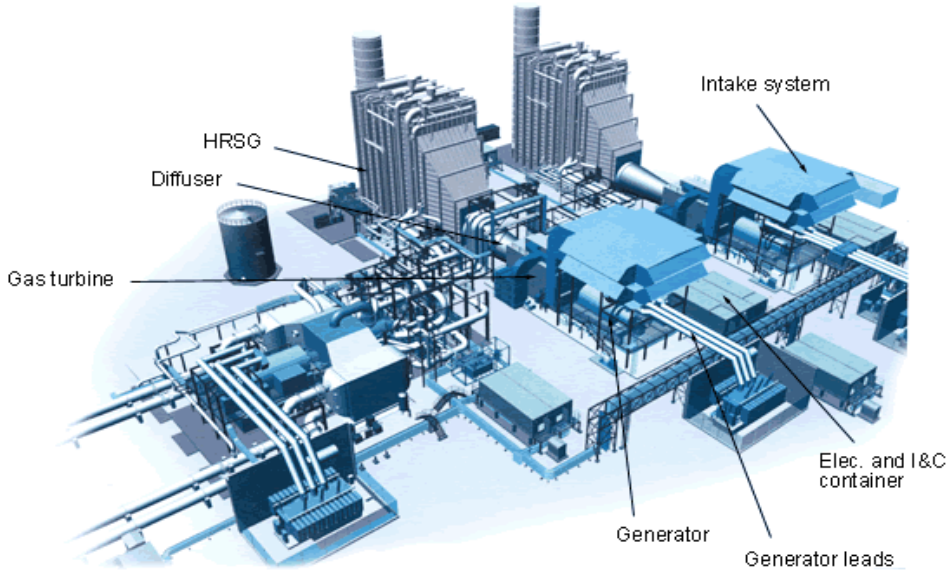


**Fig: 3.6** Combined Cycle Plant with structure

## ➢ Cycle Operation

The thermodynamic cycle of the basic combined cycle consists of two power plant cycles. One is the Joule or Brayton cycle which is a gas turbine cycle and the other is Rankine cycle which is a steam turbine cycle.

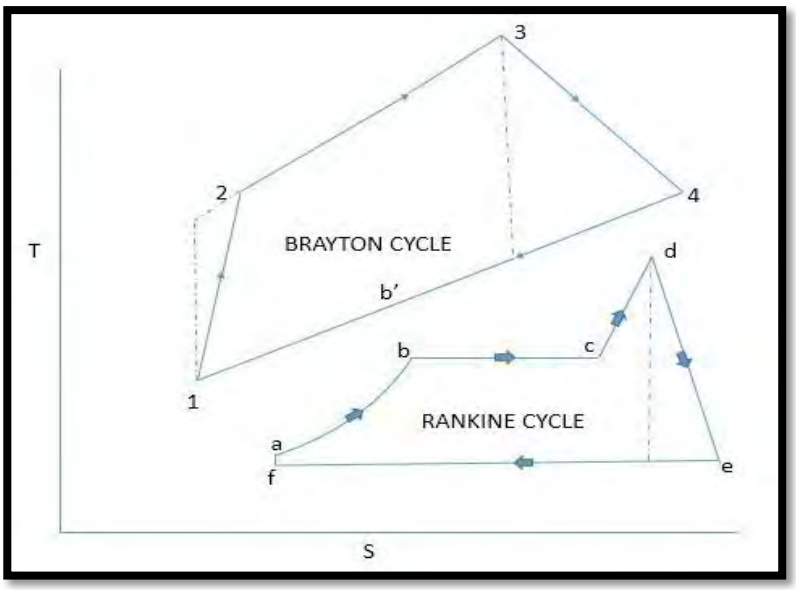


**Fig: 3.7** T-S Diagram

- The cycle 1-2-3-4-1 which is the gas turbine power plant cycle is the **topping cycle**. It depicts the **heat and work transfer** process taking place in **high temperature region**.

- The cycle a-b-c-d-e-f-a which is the **Rankine steam cycle** takes place at a **low temperature** and is known as the **bottoming cycle**.

- Transfer of heat energy from high temperature exhaust gas to water and steam takes place by a **waste heat recovery boiler in the bottoming cycle**.

- During the constant pressure process 4-1 the exhaust gases in the gas turbine reject heat. The feed water, wet and super heated steam absorb some of this heat in the process a-b, b-c and c-d.

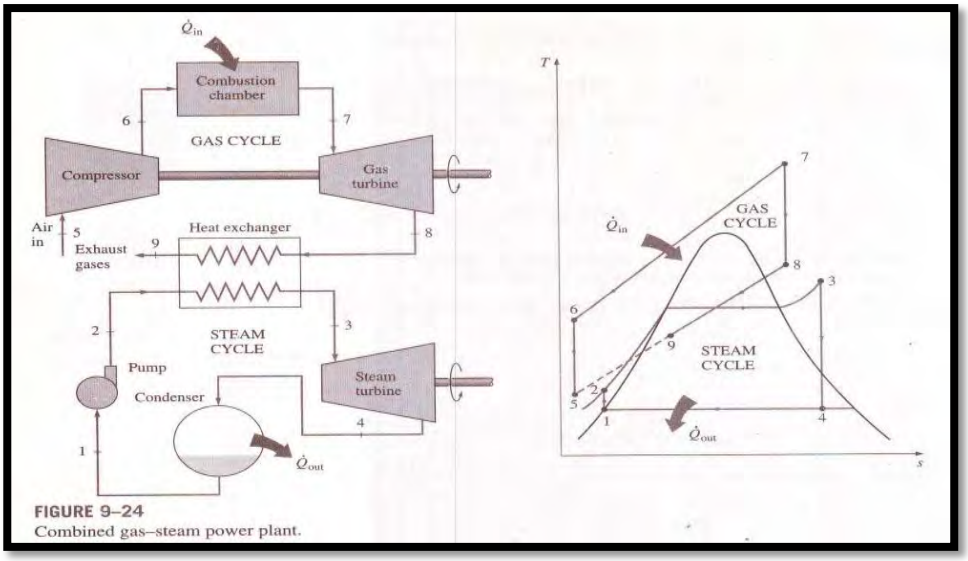

FIGURE 9–24
Combined gas–steam power plant.

**Fig: 3.8** Combined Gas & Steam Cycle

## 3.5 Major Machinery Parts of this Project

Brief descriptions of major parts of this plant are given below:

### ➢ Natural Gas Booster Compressors

The plant shall require centrifugal type gas booster compressors (GBC manufacturer will be Man Turbo / Atlas copco, Country of origin will be Germany/ USA) as the supply pressure of natural gas is in the range of 18-20 bar. The capacity of the compressors have to be 3 x 60% for maximum gas requirement of the plant including auto changeover system without interrupting operation of the plant with rated pressure & flow and at all modes of operation & at any temperature prevailing in the site of the GT unit.

The gas booster compressors have to be centrifugal type, 6.6 KV motor driven. Appropriate control, sealing, cooling & anti-surge system with all necessary ancillaries and auxiliaries shall have to be provided including compressor house station [underground cable with RCC slab on three sides]. Cable should be single point bonding at source end but provision should be made for both ends with Link Box & Protective Device (Surge Voltage Limiter) for open end.

## ➢ Gas Turbine

Assumed Gas Turbine performance at conditions of 30°C and 101.3 KPa are as follows:

| | | |
|---|---|---|
| Capacity | : | 228 MW. |
| Heat Rate | : | 10950 KJ/Kwh. |
| Exhaust Temp. | : | 553°C |
| Exhaust Flow | : | 2800 t/h. |

## ➢ Gas Turbine Generator

Assumed Gas Turbine Generator performances are as follows:

| | | |
|---|---|---|
| Rate Output | : | 240 MW |
| Rated Speed | : | 3000 rpm |
| Rated Voltage | : | 15000 V. |
| Frequency | : | 50 Hz. |
| Power Factor | : | 0.8 |
| Protection | : | IP54 |
| Cooling Mode | : | TEWAC |
| Excitation | : | Brushless. |

## ➢ Heat Recovery Steam Generator (HRSG)

In Heat Recovery Steam Generator highly purified water flows in tubes and the hot gases passes a around that and thus producing steam .The steam then rotates the steam turbine and coupled generator to produce Electricity. The hot gases leave the HRSG at around 140 degrees centigrade and are discharged into the atmosphere.

The steam condensing and water system is the same as in the steam power plant.The HRSGs also utilize a reheat section to further increase steam cycle efficiency.

Assumed HRSG performances are as follows:

HP Steam:

| | | |
|---|---|---|
| Rated Output | : | 360 t/h. |
| Outlet Pressure | : | 5.72 Mpa. |
| Outlet Temp. | : | 532°C. |

IP Steam:

| | | |
|---|---|---|
| Rated Output | : | 60 t/h. |
| Outlet Pressure | : | 0.59 Mpa. |
| Outlet Temp. | : | 255°C. |

LP Steam:

| | | |
|---|---|---|
| Rated Output | : | 28 t/h. |
| Outlet Pressure | : | 0.065 Mpa. |
| Outlet Temp. | : | 108°C. |

| | | |
|---|---|---|
| Feed Water Temperature | : | 108°C. |
| Outlet Gas Temperature | : | 106°C. |
| Blowdown | : | ≤ 1.5 % |
| Gas Pressure Drop | : | 2.74 Kpa. |

The heat recovery steam generator unit shall be of outdoor, forced circulation and water tube type arranged for using exhaust gas from the gas turbine unit. The steam generator shall be of welded construction throughout. The entire steam generator (exclusive of minor boiler component parts) shall be either suspended from a steel framework located above the unit proper or bottom supported. Supports at intermediate levels shall not be used.

- **Steam Turbine**

The total steam is expanded in a steam turbine to generate power. The steam turbine generally consists of three turbine sections (HP, IP, LP), utilizing a dual down flow

LP turbine exhaust. The steam from the low pressure turbine exhaust is condensed by the heat rejection system. Steam turbine shall be of proven design and of the single line impulse, impulse reaction or reaction type, throttle or nozzle controlled, designed for high efficiency operation and suitable for coupling to and running in conjunction with the condenser supplied. The steam turbine shall be of sliding pressure type with hot and cold start provisions. Steam will be supplied to the turbine stop valve at steam conditions specified in the heat recovery steam generator section of this Specification. Condenser vacuum will be maintained by the use of mechanical vacuum pumps or steam jet air ejectors. The unit shall be designed to operate safely at 47.5 to 52.5 Hz. The

Assumed Steam Turbine performances are as follows:

| | | |
|---|---|---|
| Inlet Steam Pressure (HP) | : | 5.62 Mpa. |
| Inlet Steam Temperature | : | 530°C. |
| Steam Flow Rate | : | 360 t/h. |
| Inlet Steam Pressure (LP) | : | 0.58 Mpa. |
| Inlet Steam Temperature | : | 255°C. |
| Steam Flow Rate | : | 60.0 t/h. |
| Power Output | : | 115 MW |
| Exhaust Pressure | : | 10 Kpa. |
| Governing System | : | Electronic-Hydraulic Control. |
| Rated Speed | : | 3000 rpm. |
| Cooling Water Temp. | : | 32°C. |

## ➢ Condenser

A surface type condenser set shall be provided for operation with steam turbo generator. The condenser shall consist of single shell having water box and hot well. The condenser shall be equipped with backwashing facility. The source of condenser circulating water shall be from cooling tower basin only.

### ➢ Steam Turbine Generator

Assumed Steam Turbine Generator performances are as follows:

| | | |
|---|---|---|
| Rate Output | : | 120 MW |
| Rated Speed | : | 3000 rpm |
| Rated Voltage | : | 10500 V. |
| Frequency | : | 50 Hz. |
| Power Factor | : | 0.8 |
| Protection | : | IP44 |
| Cooling Mode | : | CACW |
| Excitation | : | Brushless. |

## 3.6 Process Description

Combined cycle power plant as in name suggests, it combines existing gas and steam technologies into one unit, yielding significant improvements in thermal efficiency over conventional steam plant. In a CCGT plant the thermal efficiency is extended to approximately 50-60 per cent, by piping the exhaust gas from the gas turbine into a heat recovery steam generator.

However the heat recovered in this process is sufficient to drive a steam turbine with an electrical output of approximately 50 per cent of the gas turbine generator.

First step is the same as the simple cycle gas turbine plant. An open circuit gas turbine has a compressor, a combustor and a turbine. For this type of cycle the input temperature to turbine is very high. The output temperature of flue gases is also very high.

This is therefore high enough to provide heat for a second cycle which uses steam as the working medium i.e. thermal power station.

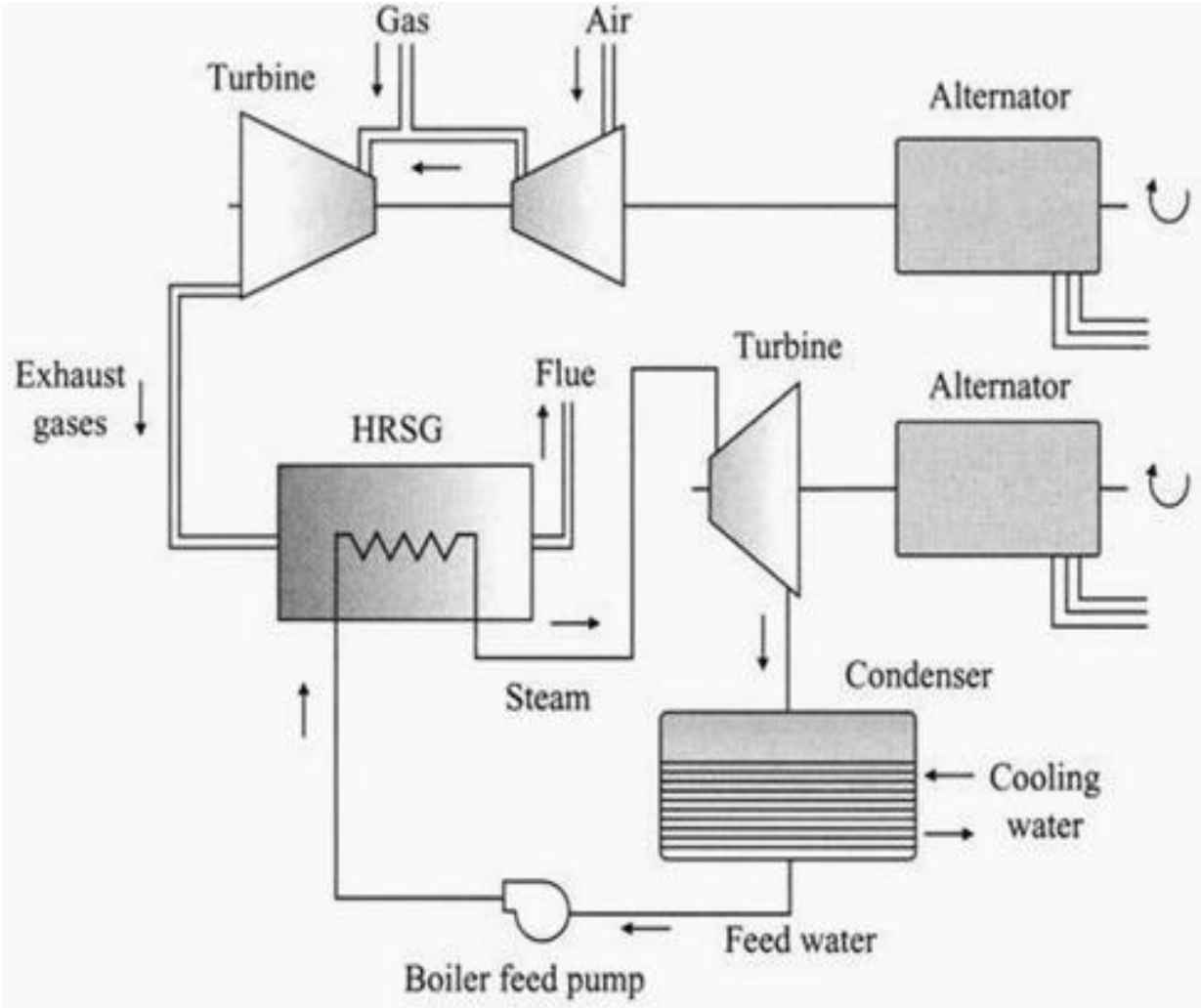


**Fig: 3.9** Working Principle of CCPP

## ➢ Air Intake System

This air is drawn though the large air inlet section where it is cleaned cooled and controlled. Heavy-duty gas turbines are able to operate successfully in a wide variety of climates and environments due to inlet air filtration systems that are specifically designed to suit the plant location. Under normal conditions the inlet system has the capability to process the air by removing contaminants to levels below those that are harmful to the compressor and turbine.

Three stage air filters will be used at this project, which are as follows:

Pre-Filter.

Coalescer - Filter.

Fine- Filter.

Inlet air chilling could be used to further reduce the air temperature. Inlet air chilling has a higher capital cost than evaporative cooling and may not be economically justified since this equipment will not be fully utilized for a significant portion of the year. It is recommended that further studies regarding inlet air cooling methods and tradeoffs be pursued.

The air which is purified then compressed and mixed with natural gas and ignited, which causes it to expand. The pressure created from the expansion spins the turbine blades, which are attached to a shaft and a generator, creating electricity.

In second step the heat of the gas turbine‟s exhaust is used to generate steam by passing it through a heat recovery steam generator (HRSG) with a live steam temperature between 420 and 580 °C**.**

## ➢ Feed water System

Steam generator feed water shall be supplied with condensate from a surface condenser, deaerated in the Deaerator. Suitable chemicals will be added in the feed water cycle for oxygen scavenging and Ph control. Deminarelized water will be used as make up to the plant. The boiler feed water pump of steam turbine generating plant shall be composed of Three (3) x 60% duty motor driven pumps.

Each pump shall be horizontal, multi-stage, centrifugal type capable of supplying two times of heat recovery steam generator MCR flow plus a margin to cover boiler swing and eventual reduction in effective capacity from water. Provision shall be made for standby pump to run automatically on failure of the running pump. The rated pressure of the feed pump should be derived from the system resistance of the feed system at rated feed flow. This system resistance shall include a static portion, incorporating the drum design pressure, the pressure drop through the feed regulating valve and the height of the economizer.

Each boiler feed pump shall be equipped with a minimum flow re-circulation system, consisting of a flow orifice, differential pressure transmitters and control valves. Recirculation water shall be returned to the condenser. Each feed water supply line to the respective heat recovery steam generator shall be fitted with a flow nozzle and its differential pressure transmitter which alone with the feed water regulator form a part of the heat recovery steam generator drum level controls. A motorized shut-off valve shall be provided ahead of the feed water regulator as well as motorized bypass valve. In the main header, a pressure transmitter shall indicate header pressure while a pressure switch shall be used to automatically initiate operation of a standby pump. The feed water shall be circulated in each heat recovery steam generator drum by the circulating pump. The circulating pump shall take suction from the drum and shall discharge through the evaporator back to the drum. Each drum shall be provided with two local level gauges and two level transmitters. A level transmitter shall send a signal to the level controller and to a recorder.

## ➢ Condensate

The condenser shell be located underside or alongside the turbine, with an integral hot well located under condenser shell. Three (3) x 60% capacity condensate pumps shall take their suction from the hot well. Condensate may also be used for the following secondary use: - Spray water for the condensate receiver and flash chamber. - Vacuum pump seals. - Turbine exhausts hood spray. - Chemical injection units. - Gland seal emergency spray. - Auxiliary cooling water make-up - Bypass steam de-superheater spray - Condenser sparging de-superheater spray. - Condenser ball cleaning (tube cleaning) system. Pressure transmitters shall be used to provide condensate pump discharge pressure indication. A pressure switch shall be used to switch to the standby condensate pump when the operation pump or its motor has failed.

In order to ensure a minimum flow through the gland seal condenser, the condensate flow shall be measured by a flow nozzle and differential pressure transmitter, which in turn controls the re-circulation flow to the condenser through a control valve.

The condenser hot well level shall be controlled by split range level transmitters located on the hot well. The control signals from these controllers shall be programmed so that condensate shall be dumped to the make-up water tank to prevent high level in the hot well.

## ➢ Main Steam

The main steam system for the combined cycle unit coming from main header fed from heat recovery steam generator(s). Super heater outlet on heat recovery steam generator(s) shall be fitted with a safety valve, non-return valve, by-pass valve and header shut-off valve. The feeder shall also be fitted with motor-operated vents and drains which shall be operated from central control room. The main steam header shall be pitched for draining of condensate. As the heat recovery steam generators are brought into service, the main steam line must be drained form drain legs which are fitted with motor-operated valves, and through the turbine above seat drain, which is fitted with a mo- tor-operated valve and a steam trap assembly. The heat recovery steam generator feeder temperatures shall be monitored by thermocouples and pressure by pressure transmitters and pressure switches. Flow from each heat recovery steam generator shall be measured by a flow nozzle and flow proportional signals shall be transmitted to the control panel.

In addition, super heater outlet shall be fitted with a steam sampling connection as well as an acid cleaning connection, each feeder also shall have manual free blow for maintenance purposes. A motor operated relief valve shall be provided in the common main steam header. A control switch for remote operation of this relief valve shall be provided in the control room.

The main steam header shall deliver steam to the steam turbine stop valve; bypass system, steam seal/gland regulator, and condenser ejector system. As a part of the main steam system, a turbine bypass shall be provided. The bypass system shall be placed in operation at start-up when the motor operated shut of valve is opened. Bypass line shall be fitted with relief valves for overpressure protection.

## ➢ Cooling System

A closed loop fresh water-cooling system shall be provided for equipment components requiring cooling water. The system shall consist of two full capacity (100%) cooling water pumps. Cooling water head tank, two auxiliary cooling water heat exchangers, and required piping system including its valves, etc.

Cooling water may be used for the following components. :

Steam turbine lubes oil coolers. - Steam turbine hydraulic unit. - Instrument air compressors. - Boiler feed pump coolers. - Heat recovery steam generator circulation pump coolers. - Sample coolers. - Gas Compressor lube oil system.

Thermo control valves shall be provided on the outlet of each component requiring cooling so that system flows and pressures can be balanced. Make-up water shall be supplied from the condensate system to the cooling water head tank.

## ➢ Lubricating Oil System

The lubrication system of the unit shall be equipped with the main oil pump, auxiliary motor driven oil pumps, delivery pipes, return pipes, reservoir, strainer, oil cooler, pressure gauges and thermometers, and all necessary oil piping for the system.

The unit shall be equipped with a gear driven main oil pump, a full capacity motor driven auxiliary oil pump and an emergency DC motor driven oil pump. The emergency DC motor driven oil pump shall have sufficient capacity to prevent damage the turbine generator during an emergency shutdown. Each oil pump shall be equipped with a section strainer. Pressure switches shall be provided as required to permit automatic sequential starting of the auxiliary oil pump, and emergency DC oil pump in case of oil pressure drop. Auxiliary contacts required for indication shall also be furnished on pumps and pressure switches.

Each oil reservoir shall be furnished complete with, vapour extractor, level indicator, high and low level alarm switches, strainer, drain valves, overflow pipe, manhole, valves, and piping. The system shall include oil pressure and temperature alarm,

and trip mechanism, each bearing shall be provided with thermocouple cell and a thermometer in pocket of oil drain.

Complete oil coolers each for 100% capacity shall be provided. One of two oil coolers shall normally be in service; change over from one oil cooler to the other during operation shall be possible. It shall also be possible to use both oil coolers at same time. The oil coolers shall be of either air cooling type or water cooling type. The oil coolers shall be provided with blowers or water pumps, depending upon the type of cooling.

## ➢ Electrical System

The electrical system shall consist of apparatus required to operate the gas turbine generating units, the heat recovery steam generators, steam turbine generating set, associated equipment, and step-up transformer and 230 kv switchgear equipment necessary to delivery power to the 230 kv national grid system.

The gas turbine generators and steam turbine generator shall be of open circuit air cooling type. Each generator shall have a complete rotating rectifier type excitation system or static excitation system mounted in a suitable enclosure including rectifiers, static voltage regulator and required control functions. If rotating rectifier type excitation system is not used and external static excitation is used, separate excitation transformer shall have to be provided for each generator. The generators shall be connected to the low voltage windings of their step - up transformers by 15.75 KV IPB (copper).

The transformer shall be of three phase, oil immersed, self cooled / forced air cooled (ONAN/ONAF) by cooling fans, outdoor use type. Ratio of delta star connection shall be 15.75 KV to 230 KV on full load condition. The connection of the single phase transformer shall be arranged in vector symbol Ynd 1 (HV/LV) according to IEC 76-4 and neutral of star connected high tension winding shall be solidly grounded.

Three phase, oil immersed type, self air-cooled (ONAN) for stepping down the voltage from 15.75 kV to 6.6 KV with off circuit tap changer. The capacity of each auxiliary transformer shall 110% of total auxiliary load for both GT & ST and common station service.

Three phase, oil immersed type, self air cooled (ONAN) for stepping down the voltage from 6.6 kV to 415 V with on load tap changer. The capacity of each station transformer shall enable to supply 55% of total 415 V auxiliary load for both GT & ST and common station service.

## ➢ Power Evacuation of the Proposed Plant

The existing Shikalbaha 132/33 grid sub-station are connected with 9 nos. 132 circuits like Zulda-1, Dohazari-1 & 2, Shamirpur 1& 2, Bakulia 1 & 2 and Modunaghat 1 & 2. Moreover the existing 60 MW, 150 MW and 55 MW rental power plants are connected with the same grid sub-station. Due to low capacity of existing bus bar, it has been planned to replace the same with higher capacity. Moreover there is no scope for the expansion of the sub-station due to different obstacle at site. In addition to that, load flow study considering Kaptai 1-5 units, Raozan 420 MW, Hathazari 100 MW, Dohazari 100 MW, Zulda 100 MW, Shikalbaha 60 MW, 150 MW, 55 MW along with the proposed 300 MW Power Plant being connected in the 132 KV shows that 132 KV Shikalbaha- Bakulia circuits get over loaded . Based on all the constraints as mentioned above it would not be wise to connect the proposed plant with the existing 132 KV system.

On overall observation on reality basis, it has been suggested to connect the proposed power plant with 230 KV network instead of existing 132 KV systems. To evacuate power from the proposed power plant it will be required to construct a 230/132 KV sub-station at Shikalbaha power station premises. The land is available to set up such type of substation here.

## ➢ KV Switchgear

The 6.6 kV common switchgear will consist of metal clad circuit breakers and fed through auxiliary transformers as shown on the drawing from gas turbine generator circuit and as well as Steam turbine generator. The 6.6 kV switchgear shall supply auxiliaries and common auxiliary power. In addition of present requirement, two(2) nos. of spare 6.6 kV circuit breakers to be installed for future requirement.

## ➢ Balance of Plant

The auxiliary for the gas turbine generating set and the steam turbine generating set shall be fed through either the unit auxiliary transformer or the station transformers. The unit auxiliary transformer shall step generator voltage down to 6.6 kV to feed the auxiliary equipment. The station trans- formers shall step the medium voltage of 6.6 kV down to 400/230 to feed gas turbine generator unit MCC and the heat recovery steam generator MCC and steam turbine generating unit MCC and common station load. The motor control centers shall contain all the motor starters and circuit breakers to supply the low voltage auxiliaries of the gas turbine generating units, the steam turbine generating unit and the heat recovery steam generators.

Electrical installation materials shall be chosen for power plant service including lighting, lighting transformers, panel boards, switch's, outlets, receptacles, power and control cable, conduit, conduit elbows, bushings, couplings, lockouts, cable trays, wire ways, pull boxes, floor ducts, junction boxes, cable accessories, copper bar and ground rods connections, and various devices for the safe operation of the system. A main ground grid made up of copper conductor and an adequate number of driven ground rods to give a low grounding resistance shall be provided.

Combined cycle shall be designed for operation as a base load generating unit. The gas turbine unit shall also be suitable for peak load operation as well as base load plant.

## ➢ Emergency Diesel Generating Set

One (1) set of emergency diesel generating set (capacity 1000 KVA at 0.8 p.f., 1500 rpm) complete with ancillary equipment having diesel storage capacity for 24 hours of continuous operation for supplying power to essential auxiliaries. EDG shall be of automatic starting system [compressed air/ Battery] including quick start & loading capability. The starting system shall be capable of carrying out at least five (5) consecutive starts without auxiliary power supply. In case of power failure in 0.4 kV bus, EDG will start and supply power to 0.4 kV emergency buses in auto mode. EDG synchronizing facility with 0.4 kV live bus is also required.

EDG is required for the safe shutdown of the plant/ equipment under emergency condition and in case of power failure for certain essential applications like battery chargers, emergency lighting and all auxiliaries necessary for safe coasting down of equipment and turning gear/ barring operation of the turbines.

## ➢ Fire Protection System

A $CO_2$ fire protection system shall be provided for the gas turbine generating units complete with $CO_2$ cylinder kept in a container/shed/room. Proper water hydrant system shall also be provided for other area, equipment and facilities. Fire protection wall and Deluge system is required for all outdoor transformers. Required nos. of portable DCP / $CO_2$ / Foam cylinders to be provided in different areas of the power plant.

## ➢ Control and Protection Equipment

All Control & Protection System must be Micro-Processor based and Protective Relays shall be as follows:

a) Generator Unit Protection: ABB, Switzerland/ ABB Sweden/ Siemens, Germany
b) Step- Up Transformer Protection: ABB, Switzerland / ABB, Sweden/Siemens, Germany.
c) 15.75/6.6/0.415 AUX. transformer, 15.75kV & 6.6kV Protection: Siemens, Germany/ Areva, UK-France/ABB, Finland/ ABB, Switzerland / ABB, Sweden.

The unit shall be furnished with a state of the art automatic control system suitable for unattended operation in base load or peak load operation. The automatic control system shall have a sequence the unit for normal start-up, emergency start-up, synchronization, operation, spinning reserve, voltage control, load control, station performance monitoring, normal shutdown, emergency shutdown, and return to standby status. Upon actuating the normal start command, the unit shall be started, come up to the rated speed, synchronized, closed the main circuit breaker and when parallel operation, picked up a pre-set base load which can be adjusted from approximately zero to the full

capability of the unit. A" Base-Peak" selection shall be provided in the control system which shall permit the operator to select the loading of the unit at base or peak rating. During either parallel or isolated operation, loading shall be manually controllable in addition to the automatic controls provided during either parallel or isolated operation; voltage shall be manually controlled in addition to the automatic controls provided. Upon actuating the stop command the unit's load shall be reduced gradually by pre-set programming, the generator circuit breaker shall be opened, speed shall be reduced to turning gear rotational speed, the turning gear shall be engaged automatically and the unit shall be returned to standby status. An emergency stop control shall be provided. The units shall be automatically prevented from starting, or if operating, shall be automatically shut down upon the occurrence of abnormal conditions or malfunctions, which would be injurious to the unit. All auxiliary sequence, timing voltage, synchronizing, load sensing and protective relays required for complete automatic control and protection of the unit shall be provided.

## 3.7 Organizational Structure

The Power Plant Project will be implemented by Private Sector. To implement this project company may follow the following structure:

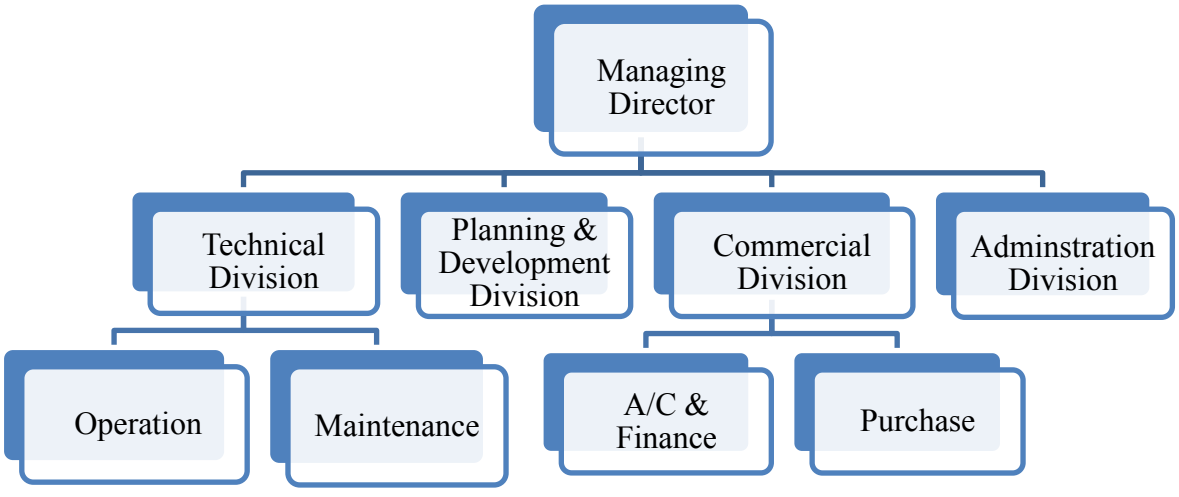


**Fig: 3.10** Organizational Structures

All the above mentioned divisions do their respective jobs. Here, the possible contribution of those to the implementation of Shikalabaha Combined Cycle Power Plant will be discussed in brief:

- **Planning & Development Division**

Among its 4 departments, planning department will start the main work of project planning, preliminary feasibility etc. Then Planning Department will prepare DPP (Development Plant Proposal) as per specified format and will perform the necessary activities to Government‟s approval to implement the project. Moreover several tender committees and procurement department will be under P&D division.

- **Administration Division**

It will provide right people to the right place to implement the project efficiently. At beginning of the project their main objective to hire qualified & experienced personnel to implement the project properly.

- **Commercial Division**

Accounts & Finance and Purchase department will be under this division. Manpower Salary, pay & bill, cash & bank investment of funds, annual accounting, budgeting etc. activities are the main concern of this division.

- **Technical Division**

This division consists of two department, operation and mechanical. Operation department has the highest inventory of manpower of all disciplines and this department is the heart of any project. To maintain logistic & technical support to make operation smoothly will be the main concern of maintenance department.

# Chapter-4

# Market Feasibility: Generation & Demand Situation in Bangladesh

Before starting any business venture it is one of the most important considerations to find out the demand of the products to be generated. In fact it‟s the inception factor of any primitive business proposal. In the proposed power plant project, the product to be proposed is power. The demand of power should be found out inside Bangladesh. Power exporting will not be encouraged here.

## 4.1 Generation Situation of Power in Bangladesh

Electricity is the major source of power for most of the country's economic activities. Installed electricity generation capacity of Bangladesh is 10,241 MW in 2013 and de-rated capacity is 9677 MW. Only three-fourth of which is considered to be „available‟. Only 40% of the population has access to electricity with a per capita availability of 136 kWh per annum [13]. The maximum generation was 6675.00 MW in 2013. But the maximum demand is 8,349MW.

**Table 4.1** Installed Capacity of BPDB Power Plants according fuel basis as on January 2014

| **Unit Type** | **Capacity(MW)** | **Total (%)** |
|---|---|---|
| Coal | 250.00 | 2.44 % |
| Gas | 6615.00 | 64.49 % |
| HFO | 1963.00 | 19.17 % |
| HSD | 683.00 | 6.67 % |
| Hydro | 230.00 | 2.25 % |
| Imported | 500.00 | 4.88 % |
| Total | 10241.00 | 100 % |

**Table 4.2** De-rated Capacity of BPDB Power Plants (Fuel Basis) as on January 2014

| **Unit Type** | **Capacity(MW)** | **Total (%)** |
|---|---|---|
| Coal | 200.00 | 2.05 % |
| Gas | 6220.00 | 64.28 % |
| HFO | 1876.00 | 19.39 % |
| HSD | 661.00 | 6.83 % |
| Hydro | 220.00 | 2.27 % |
| Imported | 500.00 | 5.18 % |
| Total | 9677.00 | 100 % |

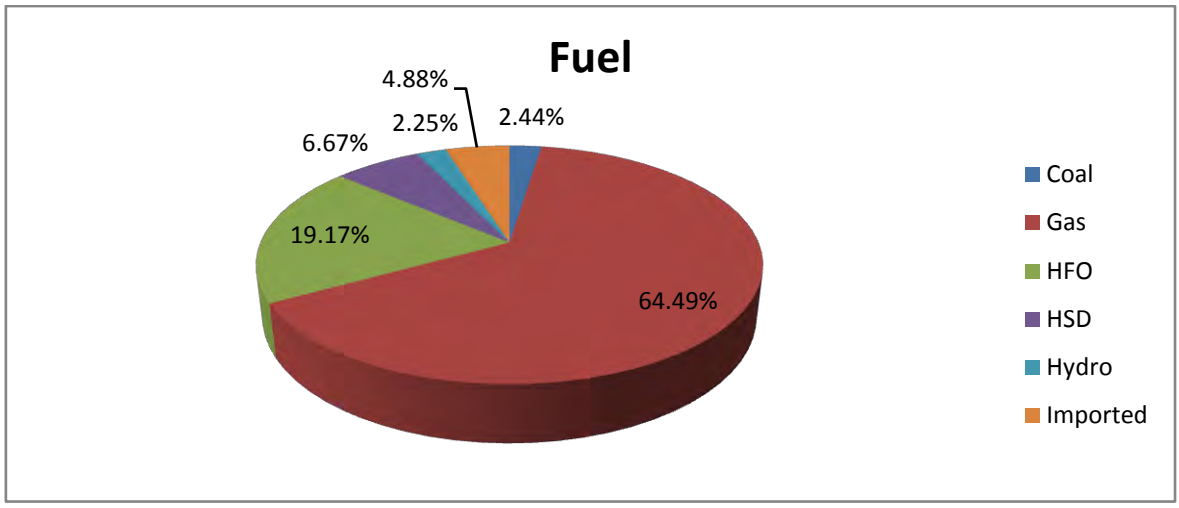


**Fig: 4.1** Installed Generation Capacity (Fuel Basis)

## ➢ Maximum Generation

**Table 4.3** Maximum Generation

| Year | Maximum generation | Date |
|---|---|---|
| 2014 | 7356.00 MW | 30/03/14 |
| 2013 | 6675.00 MW | 12/07/2013 |
| 2012 | 6350.00 MW | 04/08/2012 |
| 2011 | 5174.00 MW | 23/11/2011 |
| 2010 | 4698.50 MW | 20/08/2010 |
| 2009 | 4296.00 MW | 18/09/2009 |
| 2008 | 4036.70 MW | 19/09/2008 |

**Maximum generation in history: 7356.00 MW as on 30/03/2014**

## 4.2 Demand Situation of Power in Bangladesh

According to latest figures, the installed power generation capacity stood at 10,241 MW, near about 40 percent of which remains out of production due to force outage, maintenance and mechanical fault, reducing real production capacity to 6,400MW.

Even this capacity is not being utilized for disruptions in energy supply, reducing production further by 1300-1800 MW (of which 1004 MW for short supply of fuel oil, 290 MW for non availability of gas and 104 MW for shortage of water). The sorry state of the power supply is evident as per the load shedding being maintained day to day. For instance, the authorities had to go for load shedding 8-10 times across the country, including capital Dhaka. [14] According to Bangladesh Power Development Board (BPDB), we found region wise load shedding data which is given below:

**Table 4.4** Regionwise Demand and Load shed of 03-04-2013

| Region | Demand (MW) | Load Shed (MW) |
|---|---|---|
| Dhaka | 2350 | 201 |
| Chittagong | 605 | 51 |
| Khulna | 635 | 58 |
| Rajshahi | 620 | 50 |
| Comilla | 410 | 37 |
| Mymensingh | 310 | 29 |
| Sylhet | 280 | 25 |
| Barisal | 120 | 8 |
| Rangpur | 285 | 28 |
| Total | 5615 | 487 |

## 4.3 Demand Forecast of Power

In the Power System Master Plan (PSMP) -2010 study is now underway. The preliminary demand forecast was made based on 7 % GDP growth rate. The electricity development is required to be accelerated to increase access and attain economic development. The desirable economic growth rate would be about 7% p.a. Based upon this preliminary study the anticipated peak demand would be about 10,283 MW in FY2015, 17,304 MW in FY2020 and 25,199 MW in 2025 [13]. According to PSMP- 2010 Study year-wise peak demand forecast is given below:

**Table 4.5** Power Demand Forecast

| Fiscal Year | Peak Demand (MW) |
|---|---|
| 2011 | 6765 |
| 2012 | 7518 |
| 2013 | 8349 |
| 2014 | 9268 |
| 2015 | 10283 |
| 2016 | 11405 |
| 2017 | 12644 |
| 2018 | 14014 |
| 2019 | 15527 |
| 2020 | 17304 |
| 2021 | 18838 |
| 2022 | 20443 |
| 2023 | 21993 |
| 2024 | 23581 |
| 2025 | 25199 |
| 2026 | 26838 |
| 2027 | 28487 |
| 2028 | 30134 |
| 2029 | 31873 |
| 2030 | 33708 |

**Table 4.6** Calendar Year Wise Projection (From 2012 to 2016)

| YEAR | 2012 | 2013 | 2014 | 2015 | 2016 | TOTAL |
|---|---|---|---|---|---|---|
| | In MW | | | | | |
| Public | 632 | 1467 | 1660 | 1410 | 750 | 5919 |
| Private | 1354 | 1372 | 1637 | 770 | 1600 | 6735 |
| Power Import | | 500 | | | | 500 |
| Total | 1986 | 3339 | 3297 | 2182 | 2350 | 13000 |

## 4.4 Observation & Comment

From the above analysis we can easily realize the deficit or need for power in Bangladesh. The Power System Master Plan 2010 forecasts the demand for electricity on the basis of GDP growth and the elasticity of electricity demand. The projection also considers the possible impact of demand-side management (DSM) programs. DSM programs involve using energy-saving equipment and machinery, holiday staggering programs in the industrial segment, and avoiding wastage of electricity.

The power demand forecast shows that the demand for electricity will be growing at around 10 percent over the next decade. As per PDB‟s information, Bangladesh has now an installed Electric Power Production capacity of 10241 MW and the demand of electricity during the pick hours stand at 7500MW at summer and against that demand the supply by PDB is only 6500MW. However, people do not rely on the information published by PDB because, load shedding occurs in some places for even 7-8 hrs every day which is hampering the education, entertainment and overall normal life style of people. Most power generating plants were set up nearly 30-40 years ago and suffering acute problems. At present, most of these plants urgently needed to overhaul to sustain at least the present production capacity. There shall always remain a gap of 1000-1200MW between demand and supply. The area of electrification by PDB and its subsidiary companies is not more than 50-60% and the remaining area of Bangladesh is without electricity. So, the power shortage as per PDB‟s data is based on the connected area only. If the total power demand is taken into consideration, then it shall take appreciable time and the demand shall be almost triple of installed production capacity. As a part of master plan in power sector, PDB estimated 10%growth in power demand. Accordingly, the

demand in July-Aug 2016 should have been 11000MW [13]. As the demand is gradually increasing, here is sufficient room to generate power.

At present BPDB buys power from private sector such as IPP, SIPP, Rental, Quick rental etc. to ensure government‟s commitment to their stated vision of providing electricity to all by 2021 [8]. Most of the cases they buy electricity with high rate (17 to 26 Tk.) where they buy power to consumer with an average 5 to 7 Tk. Based on the information gathered on various new gas exploration projects, it is very likely that sufficient gas is going to available in the country in the future which can be sufficient enough to generate more than the existing capacity of gas based power plants in the country. From these analyses it‟s clear, if it‟s possible to generate and sell power at convenient rate, it‟ll be good business opportunity for private sector.

# Chapter-5

## Economic Feasibility

In this chapter capital investment requirement for plant installation, operation, product sales and all other costs will be estimated by proper following appropriate methodologies. Then expected outcomes will be determined to calculate profitability of the project. The financial and economic parameters will include Discounted Pay Back Period, Net Present Value, Benefit Cost Ratio, Internal Rate of Return etc. for various plant capacities.

Cost estimation and financial analysis done in this chapter by following the methodology described in „Valle-Riestra, J.F." [19], „Peters, Timmerhaus" [20] and „Sulivan" [31].

### 5.1 Calculation of Total Fixed Capital Investment

- Materials, Engineering & Construction Cost

We can re-write the Power law or Power factor equation as, $PC = C (Q/Q_o)^a$ [20],

Where, PC is the purchase Cost of the proposed plant equipment,

C is the purchase Cost of the previous plant equipment,

Q is the Capacity of the Proposed Plant

$Q_o$ is the capacity of the previous plant.

According to „Plant Design and Economics for Chemical Engineers" $4^{th}$ edition by Max S. Peters and Klaus D. Timmerhouse, Chapter-6; Cost Estimation, Method E:

Power Factor Applied to Plant Capacity Ratio for Estimating Fixes Capital Investment. The power factor or exponent „a" in the above mentioned equation has been found to average between 0.6 and 0.7 for many processes facilities. Here, in this thesis, the relevant values of Power Factor „a" is taken in table 5.1 and corresponding plant direct and indirect costs are determined in table 5.2 to 5.4

**Table 5.1** Determination of „Multiplying Factor" using assumed Power Factor „a" value

| Capacity of Reference Plant,$Q_o$ 150 MW | Capacity of Proposed new Plant,Q (MW) | Ratio ($Q/Q_o$) | For Plant Direct Cost (Supply of Equipments, materials, etc.) | | For Plant Indirect Cost (Supply of Equipments, materials, etc.) | | For Plant Indirect Cost (Supply of Equipments, materials, etc.) | |
|---|---|---|---|---|---|---|---|---|
| | | | Power Factor „a" | Multiplying Factor $(Q/Q_o)^a$ | Power Factor „a" | Multiplying Factor $(Q/Q_o)a$ | Power Factor „a" | Multiplying Factor $(Q/Q_o)^a$ |
| 150 | 150 | 1.00 | .65 | 1.00 | .30 | 1.00 | .50 | 1.00 |
| | 225 | 1.50 | | 1.30 | | 1.13 | | 1.22 |
| | 300 | 2.00 | | 1.57 | | 1.23 | | 1.41 |
| | 450 | 3.00 | | 2.04 | | 1.39 | | 1.73 |

**Table 5.2** Determination of „Plant Direct Cost" i.e. cost of „Supply of Equipment and Materials" using „Multiplying Factor": (cost in Lakh Taka)

| Cost for the Reference Plant of Capacity, $Q_o$=150 MW (In year 2012) | Capacity of proposed plant, Q | Multiplying Factor $(Q/Q_o)^a$ From Table 5.1 | Plant direct Cost in 2012 PC= $C(Q/Q_o)^a$ Tk. In Lakh | Yearly Cost Escalation | Year 2012 to 2014 is 3 Years. So, total escalation is | Plant direct cost in 2014 = cost in 2012 + Escalation (Tk in Lakh) |
|---|---|---|---|---|---|---|
| Tk. 80799.84 Lakh | 150 | 1.00 | 80799.84 | 10% | 30% | 105039.7927 |
| | 225 | 1.30 | 105164.66 | | | 136714.058 |
| | 300 | 1.57 | 126788.54 | | | 164825.102 |
| | 450 | 2.04 | 165021.0398 | | | 214527.3517 |

**Table 5.3** Determination of cost of „Engineering Design" i.e. „For Plant Indirect Cost (Custom duty, taxes & VAT, landing charges, C&F cost etc.)" using „Multiplying Factor": (cost in Lakh Taka)

| Cost for the Reference Plant of Capacity, $Q_o$=150MW (In year 2012) | Capacity of proposed plant, Q | Multiplying Factor $(Q/Q_o)^a$ From Table 5.1 | Plant Indirect Cost in 2012 PC= $C(Q/Q_o)^a$ Tk. In Lakh | Yearly Cost Escalation | Year 2012 to 2014 is 3 Years. So, total escalation is | Plant direct cost in 2014 = cost in 2012 + Escalation (Tk in Lakh) |
|---|---|---|---|---|---|---|
| Tk. 20261.709 Lakh | 150 | 1.00 | 20261.7 | 10% | 30% | 26340.22 |
| | 225 | 1.13 | 22882.5 | | | 29747.25 |
| | 300 | 1.23 | 24945.09 | | | 32428.61 |
| | 450 | 1.39 | 28171.66 | | | 36623.16 |

**Table 5.4** Determination of cost of „Erection & Construction" i.e. „For Plant Indirect Cost (Erection & Commissioning)" using „Multiplying Factor"(cost in Lakh Taka)

| Cost for the Reference Plant of Capacity, $Q_o$=225MW (In year 2012) | Capacity of proposed plant, Q | Multiplying Factor $(Q/Q_o)^a$ From Table 5.1 | Plant Indirect Cost in 2012 PC= $C(Q/Q_o)^a$ Tk. In Lakh | Yearly Cost Escalation | Year 2012 to 2014 is 3 Years. So, total escalation is | Plant direct cost in 2014 = cost in 2012 + Escalation (Tk in Lakh) |
|---|---|---|---|---|---|---|
| Tk. 8150.1 Lakh | 150 | 1.00 | 8150.1 | 10% | 30% | 10595.13 |
| | 225 | 1.22 | 9981.8 | | | 12976.34 |
| | 300 | 1.41 | 11525.9 | | | 14983.78 |
| | 450 | 1.73 | 14116.39 | | | 18351.31 |

## ➢ Other Costs in Fixed Capital Investment

Despite Plant direct and indirect costs there are some other costs in Total Fixed Capital Investment. Those costs are for land acquisition, land development, site preparation and miscellaneous construction works, project implementation office expenditure, Pre-shipment inspection cost, duties and taxes on imported machineries, contingency etc. Calculation of these cost items using Microsoft Excel Spreadsheet are presented in Annexure. Calculations are performed for plant capacities of 150 MW, 225 MW, 300 MW and 450 MW are attached in Annexure-1, Annexure-2, Annexure-3 and Annexure-4 respectively.

Estimated other costs for 300 MW capacities are shown in Table 5.5.

**Table 5.5** Estimated Costs other than Plant Direct and Indirect Cost (Taka in Lakh)

| Sl. | Item | L.C. | F.C. | Total |
|---|---|---|---|---|
| I) | Pre-Construction Expenditure | | | |
| | Land acquisition & Land Development | 865 | | 865 |
| | **Sub-Total of (I)** | **865** | | **865** |
| II) | Construction Works including cost of Civil Works for Residential, Non Residential and fuel unloading system. Administrative office building 17,000/- per m² (all calculation based on PWD rate of 2011) | 410.3 | | 410.3 |
| | Doors, Windows & Finishing | 350 | | 350 |
| | Drainage System | 21 | | 21 |
| | Internal Road (RCC), @ Tk. 2,509/m² | 30 | | 30 |
| | Deep Tube-well & pump house | 40 | | 40 |
| | **Sub-Total of (II)** | **851.3** | | **851.3** |
| III) | Transport Vehicle | | | |
| | Rental @ Tk. 3000/day for 700 days during project implementation | 21 | | 21 |
| | **Sub-Total of (III)** | **21** | | **21** |
| IV) | Other Cost during Project Implementation | | | |
| | Utility Charge (Power, Water, Gas etc.) during construction | 08 | | 08 |
| | Interest during construction @ 3% p.a. | 3955.8 | | 3955.8 |
| | Bank Charges @ 1.25% on F.C. of EPC Contract | 1648.25 | | 1648.25 |
| | Insurance @ 3% on imported materials | 3955.8 | | 3955.8 |
| | Project office expenditure<br>(Office furniture, A/C for office, computer, laser printer, color printer with scanner, photocopier, tender notice publishing, fax/telephone/courier/postal bill, office stationeries and consumables, entertainment, transport maintenance, repair of office equipment & accessories, labor bill etc). | 17.65 | | 17.65 |
| | Physical Contingency (2% of the total items) | 1037.598 | 3460.491 | 4498.089 |
| | Price Contingency (2% of the total cost) | 1037.598 | 3460.491 | 4498.089 |
| | **Sub-Total of IV)** | **11660.7** | **6920.98** | **18581.7** |

Cost of onsite training may be included in initial fixed capital investment cost. This cost may be considered as same although the plant capacities are smaller.

So, cost of onsite training

= cost (in 2012) for 225 MW + cost escalation
= 400 Lakh + 10%*3 of (TK. 410 Lakh)
= 520 Lakh

Pre-Shipment inspection cost (for 300 MW capacity plant)

= Cost of supply of Equipment and Materials*0.50%
= 164825.102*0.5%
= 824.126 Lakh

So, Total Fixed Capital Investment = Sum of (Sub-Totals I. II, III, IV) and (Materials, Engineering and Construction (EPC) cost) plus cost of onsite training plus PSI cost.

Here, Total Fixed Capital Investment,

= (865+851.3+21+18581.7)+(164825.1+32428.63+14983.8)+520+ 824.126
= **233900.656 Lakh TK.**

## 5.2 Calculation of Total Operating Capital Investment

### ➢ Variable Operating Costs calculations

Basis: Operating cost of Ashuganj Plant of present capacity 150MW is as follows:

Salary & Wages: As total paid for 155 Lakh Tk in FY ;2012-2013
Maintenance and other miscellaneous costs are considered the yearly cost in 2012-2013.

Assumption:

- For each cost item, a certain portion will be fixed and the rest portion will vary on plant capacity.
- For each cost item, it may be assumed that 30% of the cost will remain, if the plant operating capacity is minimum or zero.
- The rest 70% of each cost item will be factor of plant capacity.

In the table 5.6 below, the cost calculation is presented for the plant capacities of 300 MW.

Plant operating days = 300 days/year.

**Table 5.6** Yearly Operating Expenses for 300 MW Capacity (cost in lakh taka)

| Sl. No | Name of the cost item | Cost for 150 MW Plant | Fixed Part | Variable part of cost item for | | | Yearly itemized total operating cost | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 30% | 225 MW | 300 MW | 450 MW | 225 MW | 300 MW | 450 MW |
| 1. | Manpower Salary, wages & Allowances | 155 | 46.5 | 162.75 | 217 | 325.5 | 209.25 | 263.5 | 372 |
| 2. | Utility Expense | 10 | 3 | 10.5 | 14 | 21 | 13.5 | 17 | 24 |
| 3. | Maintenance & other miscellaneous expenses | 80 | 24 | 84 | 112 | 168 | 108 | 136 | 192 |
| | | 245 | 73.5 | 257.25 | 343 | 514.5 | 330.75 | 416.5 | 588 |

## ➢ Other Costs

According to "Plant Design and Economics for Chemical Engineers"-4th edition by Max S. Peters and Klaus D. Timmerhaus, McGraw-Hill, Class life asset depreciation range, The depreciation life of assets used in Power Plant is 20 years [20] So, the annual depreciation rate is 5%.

In the above mentioned book, estimated life of Equipment: Life of Buildings is 40-60 years [20]. For depreciation calculation, it is estimated as 33.33 years and annual depreciation rate is 3% in this project. The values are given in Table-5.7:

**Table 5.7** Yearly Depreciation Cost for Various Plant Capacities (Tk. In Lakh)

| Sl. | Depreciable items | Investment cost for | | | | Rate / year | Depreciation per year for | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 150 MW | 225 MW | 300 MW | 450 MW | | 150 MW | 225 MW | 300 MW | 450 MW |
| 1 | Machinery & Equipment | 143020 | 180641.2 | 213581.6 | 270547 | 5% | 7151.01 | 9032.06 | 10679.08 | 13527.34 |
| 2 | Office buildings, store etc. | 851.3 | 851.3 | 851.3 | 851.3 | 3% | 25.53 | 25.53 | 25.53 | 25.53 |

## 5.3 Cost of Raw Materials

As it‟s a duel fuel plant, so raw material for generation will be Gas or HFO. The cost will depend upon consumption which is directly proportional to plant operating capacity.

For the plant of 300 MW capacity

If fuel will be gas then,

Daily gas consumption (at 300MW load) = 50 mmscft = 1415829 $m^3$
Yearly gas consumption (300 days) = 15000 mmscft = 424748690.4 $m^3$
Yearly cost for gas (5.82Tk/$m^3$) = 24720.373 Lakh TK

If fuel will be HFO,

Daily HFO consumption = 993208 litre
Yearly gas consumption (300 days) = 297962400 litre
Yearly cost for HFO (60 Tk/litre) = 178777.44 Lakh TK.

## 5.4 Costs for VAT

VAT means the tax applicable for value addition. In the case of generation of electricity; the VAT rate is 15% on the incremental value. To calculate the amount of incremental value (value addition), we need to determine the annual output from the plant.

## 5.5 Calculation of total Output

The output or main product from this plant is power.

Daily Gross generation for 300 MW will be = 6800000 kwh
Daily loss & Auxiliary Consumption for Plant (3% of Gross Generation) = 204000 kwh
Daily Net Generation of 300 MW Plant = 6596000 kwh.
Yearly Net Generation for 300 MW will be (300 days) = 1978800000 kwh

The price for our power will be 4.5 tk/kwh. (If we use natural gas as fuel)

So, the annual value of power = 89046 Lakh tk.

Now, the total value of annual output before VAT is = 89046 Lakh Tk / Year

The price for our power will be 13.5 tk/kwh. (If we use HFO as fuel)

So, the annual value of power = 267138 Lakh tk.

Now, the total value of annual output before VAT is = 267138 Lakh Tk / Year

## 5.6 VAT Calculation for 300 MW capacity plant

Amount of VAT = 15% (Summation of values of outputs – Summation of values of inputs) [Here, values will be obtained from section 5.3 and 5.5]

When Natural Gas use as fuel,

Amount of VAT = 15% (TK 89046 Lakh – 24720.373 Lakh ) / Year
= 15% * 64325.62 Lakh / Year.
= 9648.844 Lakh / Year.

When HFO use as fuel,

Amount of VAT = 15% (TK 267138 Lakh – 178777.44 Lakh ) / Year

= 15% * 88360.56 Lakh / Year.

= 13254.08 Lakh / Year.

## 5.7 Income Calculation

INCOME = REVENUE – EXPENDATURE

If we use Natural Gas as Fuel, then, yearly total revenue is from sales of electricity. It is calculated as Tk 89046 Lakh / Year in the section -5.5

Yearly total expenditure = Cost of raw material + VAT + Total other operating expenses.

Cost of raw materials = 24720.37 Lakh TK [Section 5.3]

VAT = 9648.84 Lakh TK [Section-5.6]

Total other operating expenses = 416.5 [Table 5.6]

So, yearly income = Tk [89046 – (24720.37 + 9648.84 + 416.5)] Lakh / Year

= TK 54260.28 Lakh / Year

If we use HFO as Fuel, then, yearly total revenue is from sales of electricity. It is calculated as Tk 267138 Lakh / Year in the section -5.5

Yearly total expenditure = Cost of raw material + VAT + Total other operating expenses.

Cost of raw materials = 178777.44 Lakh TK [section 5.3]

VAT = 13254.08 Lakh TK [section-5.6]

Total other operating expenses = 416.5[Table 5.2.1]

So, yearly income = Tk [267138 – (178777.44 + 13254.08 + 416.5)] Lakh / Year

= TK 74689.98 Lakh / Year

## 5.8 Financial and Economic Evaluation of the Project

The methods/criteria more often used for evaluating a project are (1) Simple Rate of Return (SRR) (2) Pay Back Period (PBP) (3) Benefit Cost Ratio (BCR) (4) Net Present Value (NPV) or Net Present worth (NPW) and (5) Internal Rate of Return (IRR). The SRR and the PBP are the undiscounted measures while BCR, NPV and IRR are the discounted measures of project worth of investment. Discussions and calculations on these methods are given below:

## 5.9 Calculation of Payback Period

### ➢ Simple Payback Period

Payback period or payout period is defined as the minimum length of time theoretically necessary to recover the original capital investment in the form of „cash flow to the project" based on total income minus all costs except depreciation [20]. Generally, for this method, original capital investment means only the original, depreciable, fixed-capital investment, and interest effects are neglected.

Thus, Payout period in years = $\frac{depciable \quad fixed \ capital \ investment}{avg\frac{profit}{year} + avg\frac{depriciation}{year}}$ [20]

### ➢ Discounted Payback Period

Here, Time value of money is considered. In this method, an appropriate interest rate is chosen representing the minimum acceptable rate of return (MARR). The annual cash flows to the project during the estimated life are discounted at the designated interest rate to permit computation of an average annual figure for profit plus depreciation which reflects the time value of money. The time to recover the fixed-capital investment plus compounded interest on the total capital investment during the estimated life by means of the average annual cash flow is the „payout period including interest" or „discounted payback period" [20].

## ➢ Discounted Payback Period for 300 MW Project

In the case of 300 MW capacity project, annual cash flows are found as the following table-5.8 (Data are taken from the Table-5.7 and section-5.7).

Annual Cash Flows for 300 MW duel fuel Combined Cycle Power Plant

**Table 5.8** Annual cash flows for 300 MW Duel Fuel Combined Cycle Power Plant

**FUEL - Natural Gas**

| Years → | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Yearly profit (Tk. In Lakh) | | | | 54260.282 | 54260.282 | 54260.282 | 54260.282 |
| Total Yearly Depreciation | | | | 10704.621 | 10704.621 | 10704.621 | 10704.621 |
| Yearly Cash inflow (Profit+Depriciation) | -1408.84 | -172991.68 | -59500.091 | 64964.903 | 64964.903 | 64964.903 | 64964.903 |
| Comment → | Investment Period | | | Period of Return on Investment | | | |

**FUEL – HFO**

| Years → | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Yearly profit (Tk. In Lakh) | | | | 74689.976 | 74689.976 | 74689.976 | 74689.976 |
| Total Yearly Depreciation | | | | 10704.621 | 10704.621 | 10704.621 | 10704.621 |
| Yearly Cash inflow (Profit+Depriciation) | -1408.84 | -172991.68 | -59500.091 | 85394.597 | 85394.597 | 85394.597 | 85394.597 |
| Comment → | Investment Period | | | Period of Return on Investment | | | |

According to Chapter-10 of Peters & Timmerhaus [20], for payback period calculation, zero time (end of zero years) will be moment when Cash Inflow or Return starts. In the table above, the starting of year-4 (or end of year-3) should be considered as zero time. The present value of all capital investment should be calculated to that point of time at the specified discount rate.

The present worth of investment cost at the starting of return (at the end of year-3), will be,

PW = (-1408.84)*(1+15%) ^0 + (-172991.68)*(1+15%) ^1 + (-59500.091)*(1+15%) ^2

= - 279038.15

Here, Discount rate (i.e. MARR) is 15%

So, the modified Payback period in the following table 5.9 (TK. in Lakh)

**Table 5.9** Discounted payback period for 300 MW plant (Fuel – Gas)

| **FUEL – GAS** | | | |
|---|---|---|---|
| **End of Year** | **Net Cash Flow (TK. Lakh)** | **Present Worth of Cash Flow (at i = 15% / yr) PW** | **Cumulative PW at MARR = 15%** |
| 0 | -279038.1481 | -279038.1481 | -279038.1481 |
| 1 | 64964.90292 | 57491.06453 | -221547.0836 |
| 2 | 64964.90292 | 50877.04825 | -170670.0353 |
| 3 | 64964.90292 | 45023.93651 | -125646.0988 |
| 4 | 64964.90292 | 39844.1916 | -85801.90723 |
| 5 | 64964.90292 | 35260.34655 | -50541.56068 |
| 6 | 64964.90292 | 31203.8465 | -19337.71418 |
| 7 | 64964.90292 | 27614.02345 | 8276.309279 |
| 8 | 64964.90292 | 24437.1889 | 32713.49818 |

**Table 5.10** Discounted Payback Period for 300MW Plant (Fuel – HFO)

| **FUEL – HFO** | | | |
|---|---|---|---|
| **End of Year** | **Net Cash Flow (TK. Lakh)** | **Present Worth of Cash Flow (at i = 15% / yr) PW** | **Cumulative PW at MARR = 15%** |
| 0 | -279038.1481 | -279038.1481 | -279038.1481 |
| 1 | 85394.59663 | 75570.43949 | -203467.7086 |
| 2 | 85394.59663 | 66876.49513 | -136591.2135 |
| 3 | 85394.59663 | 59182.73905 | -77408.47445 |
| 4 | 85394.59663 | 52374.10535 | -25034.36909 |
| 5 | 85394.59663 | 46348.7658 | 21314.39671 |
| 6 | 85394.59663 | 41016.6069 | 62331.00361 |
| 7 | 85394.59663 | 36297.88222 | 98628.88583 |
| 8 | 85394.59663 | 32122.01966 | 130750.9055 |

„Payback period" mainly indicates a project"s liquidity rather than its profitability [30]. Historically, the payback period has been used as a measure of project"s riskiness, since liquidity deals with how fast an investment can be recovered. A low-valued payback period is considered desirable.

As, the payback period for the 300 MW capacity plant is estimated at less than 7 years (when fuel will be gas) & 5 years (when fuel will be HFO), the project"s liquidity is good and riskiness on return is low.

## ➢ Discounted Payback Period for 150 MW Capacity Project

The discounted cash flow for 150 MW calculated for the same discount rate 15%/year and presented in table 5.12 and 5.13 By following the same methodology of section 5.9.2.1, discounted payback period for 150 MW Plant is determined in Table-5.12 and 5.13 and found as less than 11 years (Fuel – Gas) and less than 7 years (Fuel – HFO)

**Table 5.11** Discounted Payback Period for 150 MW Plant (Fuel – Gas)

| **FUEL – GAS** |
|---|

| **End of Year** | **Net Cash Flow (TK. Lakh)** | **Present Worth of Cash Flow (at i = 15% / yr) PW** | **Cumulative PW at MARR = 15%** |
|---|---|---|---|
| 0 | -187112.0457 | -187112.0457 | -187112.0457 |
| 1 | 33009.20867 | 29211.68909 | -157900.3566 |
| 2 | 33009.20867 | 25851.05229 | -132049.3043 |
| 3 | 33009.20867 | 22877.03743 | -109172.2669 |
| 4 | 33009.20867 | 20245.16586 | -88927.10106 |
| 5 | 33009.20867 | 17916.07599 | -71011.02507 |
| 6 | 33009.20867 | 15854.9345 | -55156.09057 |
| 7 | 33009.20867 | 14030.91549 | -41125.17509 |
| 8 | 33009.20867 | 12416.73937 | -28708.43572 |
| 9 | 33009.20867 | 10988.26493 | -17720.17079 |
| 10 | 33009.20867 | 9724.128255 | -7996.042532 |
| 11 | 33009.20867 | 8605.423235 | 609.3807031 |
| 12 | 33009.20867 | 7615.418792 | 8224.799495 |
| 13 | 33009.20867 | 6739.308665 | 14964.10816 |

**Table 5.12** Discounted Payback Period for 150 MW Plant (Fuel – HFO)

| FUEL – HFO | | | |
|---|---|---|---|
| **End of Year** | **Net Cash Flow (TK. Lakh)** | **Present Worth of Cash Flow (at i = 15% / yr) PW** | **Cumulative PW at MARR = 15%** |
| 0 | -187112.0457 | -187112.0457 | -187112.0457 |
| 1 | 44484.79459 | 39367.07486 | -147744.9709 |
| 2 | 44484.79459 | 34838.11934 | -112906.8515 |
| 3 | 44484.79459 | 30830.19411 | -82076.65742 |
| 4 | 44484.79459 | 27283.35762 | -54793.2998 |
| 5 | 44484.79459 | 24144.56426 | -30648.73554 |
| 6 | 44484.79459 | 21366.87103 | -9281.864505 |
| 7 | 44484.79459 | 18908.73543 | 9626.870921 |
| 8 | 44484.79459 | 16733.39418 | 26360.2651 |

## ➢ Discounted Payback Period for 225 MW Project

The discounted cash flow for 225 MW calculated for the same discount rate 15%/year and presented in table 5.14 and 5.15 By following the same methodology of section 5.9.2.1, discounted payback period for 225 MW Plant is determined in Table-5.14 and 5.15 and found as less than 8 years (Fuel – Gas) and less than 6 years (Fuel – HFO).

**Table 5.13** Discounted Payback Period for 225 MW Plant (Fuel – Gas)

| FUEL – GAS | | | |
|---|---|---|---|
| **End of Year** | **Net Cash Flow (TK. Lakh)** | **Present Worth of Cash Flow (at i = 15% / yr) PW** | **Cumulative PW at MARR 15%** |
| 0 | -236109.9346 | -236109.9346 | -236109.9346 |
| 1 | 49524.31345 | 43826.82606 | -192283.1085 |
| 2 | 49524.31345 | 38784.80183 | -153498.3067 |
| 3 | 49524.31345 | 34322.83348 | -119175.4732 |
| 4 | 49524.31345 | 30374.18892 | -88801.28432 |
| 5 | 49524.31345 | 26879.8132 | -61921.47112 |
| 6 | 49524.31345 | 23787.44531 | -38134.02581 |
| 7 | 49524.31345 | 21050.83656 | -17083.18925 |
| 8 | 49524.31345 | 18629.0589 | 1545.869649 |
| 9 | 49524.31345 | 16485.89283 | 18031.76248 |

**Table 5.14** Discounted Payback Period for 225 MW Plant (Fuel – HFO)

| FUEL – HFO | | | |
|---|---|---|---|
| **End of Year** | **Net Cash Flow (TK. Lakh)** | **Present Worth of Cash Flow (at i = 15% / yr) PW** | **Cumulative PW at MARR = 15%** |
| 0 | -236109.9346 | -236109.9346 | -236109.9346 |
| 1 | 65056.70691 | 57572.307 | -178537.6276 |
| 2 | 65056.70691 | 50948.94425 | -127588.6833 |
| 3 | 65056.70691 | 45087.56128 | -82501.12206 |
| 4 | 65056.70691 | 39900.49671 | -42600.62535 |
| 5 | 65056.70691 | 35310.17408 | -7290.451272 |
| 6 | 65056.70691 | 31247.94166 | 23957.49039 |
| 7 | 65056.70691 | 27653.04572 | 51610.53611 |
| 8 | 65056.70691 | 24471.72188 | 76082.25799 |

## ➢ Discounted Payback Period for 450 MW Project

The discounted cash flow for 450 MW calculated for the same discount rate 15%/year and presented in table 5.16 and 5.17 By following the same methodology of section 5.9.2.1, discounted payback period for 450 MW Plant is determined in Table-5.16 and 5.17 and found as less than 6 years (Fuel – Gas) and less than 4 years (Fuel – HFO)

**Table 5.15** Discounted Payback Period for 450 MW Plant (Fuel – Gas)

| FUEL – GAS | | | |
|---|---|---|---|
| **End of Year** | **Net Cash Flow (TK. Lakh)** | **Present Worth of Cash Flow (at i = 15% / yr) PW** | **Cumulative PW at MARR = 15%** |
| 0 | -354032.476 | -354032.476 | -354032.476 |
| 1 | 94980.0638 | 84053.15381 | -269979.3222 |
| 2 | 94980.0638 | 74383.32195 | -195596.0002 |
| 3 | 94980.0638 | 65825.94863 | -129770.0516 |
| 4 | 94980.0638 | 58253.05188 | -71516.99972 |
| 5 | 94980.0638 | 51551.37335 | -19965.62638 |
| 6 | 94980.0638 | 45620.68438 | 25655.058 |
| 7 | 94980.0638 | 40372.28706 | 66027.34507 |
| 8 | 94980.0638 | 35727.68767 | 101755.0327 |

**Table 5.16** Discounted Payback Period for 450 MW Plant (Fuel – HFO)

| FUEL – HFO | | | |
|---|---|---|---|
| **End of Year** | **Net Cash Flow (TK. Lakh)** | **Present Worth of Cash Flow (at i = 15% / yr) PW** | **Cumulative PW at MARR = 15%** |
| 0 | -354032.476 | -354032.476 | -354032.476 |
| 1 | 125624.6044 | 111172.2163 | -242860.2597 |
| 2 | 125624.6044 | 98382.49226 | -144477.7675 |
| 3 | 125624.6044 | 87064.15244 | -57413.61504 |
| 4 | 125624.6044 | 77047.92252 | 19634.30748 |
| 5 | 125624.6044 | 68184.00223 | 87818.30971 |
| 6 | 125624.6044 | 60339.82498 | 148158.1347 |
| 7 | 125624.6044 | 53398.0752 | 201556.2099 |
| 8 | 125624.6044 | 47254.93381 | 248811.1437 |

## 5.10 Net Present Value (NPV)

Net present value is computed by finding the difference between the present worth of benefit stream less the present worth of cost stream. Or, it is simply the present worth of cash flow stream since it is a discounted cash flow measure of project worth along with internal rate of return.

NPV = Present worth of benefit stream – Present worth of cost stream.

Mathematically, it can be shown as [20],

$$NPV = \sum_{t=1}^{t=n} \frac{Bn}{(1+i)^n} - \sum_{t=1}^{t=n} \frac{Cn}{(1+i)^n}$$

Or, NPV = Present worth of cash flow stream.

Mathematically, $NPV = \sum_{t=1}^{t=n} \frac{Bn - Cn}{(1+i)^n}$

Where,

Bn = Benefits in each year of the project.

Cn = Costs in each year of the project.

n= number of years in a project.

i= interest (discount) rate.

Bn - Cn = Cash flow in nth year of the project.

The project is profitable or feasible if the calculated NPV is positive when discounted at the opportunity cost of capital. Two types of NPV are calculated in the following section 5.12 those are Financial Net Present Value, NPV (F) and Economic Net Present Value, NPV (E).

## 5.11 Benefit Cost Ratio (BCR)

It is the ratio of present worth of benefit stream to present worth of cost stream

BCR = $\frac{Sum\ of\ the\ present\ \ worths\ of\ benefits}{Sum\ of\ the\ present\ \ worths\ of\ Costs}$ [20]

Mathematically it can be presented as, BCR=$\frac{\sum_{t=1}^{t=n}\frac{Bn}{(1+i)^n}}{\sum_{t=1}^{t=n}\frac{Cn}{(1+i)^n}}$

Where,

Bn = Benefit in each year.

Cn = Cost in each year.

n= number of year.

i= interest (discount) rates.

The investment is said to be profitable when the BCR is one or greater than 1. This method is widely used in govt. sector economic analysis and not in private investment analysis.

## 5.12 Calculation of NPV and BCR

Net Present Value and Benefit Cost Ratio are calculated at a certain discount factor. It is generally defined as the Minimum Acceptable Rate of Return (MARR) or opportunity cost. In the govt. sector projects the usual value of MARR is 15% or 0.15 and it will be the discount factor.

**Table 5.17** Calculation of NPV (F) and BCR (F) for 300 MW Capacity Plant (Fuel – Gas)

| Year No. | Year | Capital Cost (Tk in Lakh) | Operating Cost (Tk in Lakh) | Total Cost (Tk in Lakh) | Benefit (Tk in Lakh) | 0.15 n=year $(1+i)^n$ | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | 15% | |
| | | | | | | | Discount Factor | |
| 0 | 1 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1.00 | 1408.84 | 0.00 |
| 1 | 2 | 172991.68 | 0.00 | 172991.68 | 0.00 | 1.15 | 150427.55 | 0.00 |
| 2 | 3 | 59500.09 | 0.00 | 59500.09 | 0.00 | 1.32 | 44990.62 | 0.00 |
| 3 | 4 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 1.52 | 32348.74 | 67331.57 |
| 4 | 5 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 1.75 | 28129.34 | 58549.19 |
| 5 | 6 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 2.01 | 24460.30 | 50912.34 |
| 6 | 7 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 2.31 | 21269.82 | 44271.60 |
| 7 | 8 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 2.66 | 18495.50 | 38497.04 |
| 8 | 9 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 3.06 | 16083.04 | 33475.69 |
| 9 | 10 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 3.52 | 13985.25 | 29109.30 |
| 10 | 11 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 4.05 | 12161.09 | 25312.43 |
| 11 | 12 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 4.65 | 10574.86 | 22010.81 |
| 12 | 13 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 5.35 | 9195.53 | 19139.83 |
| 13 | 14 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 6.15 | 7996.11 | 16643.33 |
| 14 | 15 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 7.08 | 6953.14 | 14472.46 |
| 15 | 16 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 8.14 | 6046.21 | 12584.75 |
| 16 | 17 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 9.36 | 5257.58 | 10943.26 |
| 17 | 18 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 10.76 | 4571.80 | 9515.88 |
| 18 | 19 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 12.38 | 3975.48 | 8274.68 |
| 19 | 20 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 14.23 | 3456.94 | 7195.37 |
| 20 | 21 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 16.37 | 3006.04 | 6256.85 |
| 21 | 22 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 18.82 | 2613.94 | 5440.74 |
| 22 | 23 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 21.64 | 2272.99 | 4731.07 |
| 23 | 24 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 24.89 | 1976.52 | 4113.98 |
| | | | | | | | **431657.26** | **488782.18** |

From the Table 5.17

Discounted Total Benefit is = TK. 488782.178 Lakh.

Discounted Total Cost is = TK. 431657.26 Lakh.

Net Present Value = TK. (488782.178 – 431657.26) Lakh.

**NPV (F) = Tk. 57124.92 Lakh.**

Now, Benefit Cost Ratio is = TK. (488782.178 / 431657.26) Lakh.

**BCR (F) = 1.13**

Calculation of NPV (F) and BCR (F) for 300 MW capacity plant (Fuel – HFO)

**Table 5.18** Calculation of NPV (F) and BCR (F) for 300 MW Capacity Plant (Fuel – HFO)

| Year No. | Year | Capital Cost (Tk. In Lakh) | Operating Cost (Tk. In Lakh) | Total Cost (Tk. In Lakh) | Benefit (Tk. In Lakh) | 0.15 n=year $(1+i)^n$ | Discounted Value of Total Cost at 15% Discount Factor | Discounted Value of Total Benefit at 15% Discount Factor |
|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 1408.84 | 0 | 1408.84 | 0 | 1 | 1408.84 | 0 |
| 1 | 2 | 172991.68 | 0 | 172991.685 | 0 | 1.15 | 150427.5522 | 0 |
| 2 | 3 | 59500.091 | 0 | 59500.09104 | 0 | 1.3225 | 44990.61704 | 0 |
| 3 | 4 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 1.520875 | 151208.5218 | 201994.707 |
| 4 | 5 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 1.7490063 | 131485.6712 | 175647.5713 |
| 5 | 6 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 2.0113572 | 114335.3662 | 152737.0185 |
| 6 | 7 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 2.3130608 | 99422.05758 | 132814.7987 |
| 7 | 8 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 2.6600199 | 86453.96311 | 115491.1293 |
| 8 | 9 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 3.0590229 | 75177.35923 | 100427.069 |
| 9 | 10 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 3.5178763 | 65371.61672 | 87327.88606 |
| 10 | 11 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 4.0455577 | 56844.88411 | 75937.29223 |
| 11 | 12 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 4.6523914 | 49430.334 | 66032.42802 |
| 12 | 13 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 5.3502501 | 42982.89913 | 57419.50263 |
| 13 | 14 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 6.1527876 | 37376.43403 | 49930.00229 |
| 14 | 15 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 7.0757058 | 32501.24698 | 43417.39329 |
| 15 | 16 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 8.1370616 | 28261.9539 | 37754.25504 |
| 16 | 17 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 9.3576209 | 24575.61209 | 32829.78699 |
| 17 | 18 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 10.761264 | 21370.09747 | 28547.64086 |
| 18 | 19 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 12.375454 | 18582.69345 | 24824.03553 |
| 19 | 20 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 14.231772 | 16158.86387 | 21586.11785 |
| 20 | 21 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 16.366537 | 14051.18597 | 18770.53726 |
| 21 | 22 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 18.821518 | 12218.42258 | 16322.20632 |
| 22 | 23 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 21.644746 | 10624.71529 | 14193.22288 |
| 23 | 24 | 0 | 229969.2606 | 229969.2606 | 307208.7 | 24.891458 | 9238.882862 | 12341.93294 |
| | | | | | | | **1294499.791** | **1466346.534** |

From Table 5.18,

Discounted Total Benefit is = TK. 1466346.534 Lakh.

Discounted Total Cost is = TK. 1294499.791 Lakh.

Net Present Value = TK. (1466346.534 – 1294499.791) Lakh.

**NPV (F) = Tk. 171846.74 Lakh.**

Benefit Cost Ratio is = TK. (1466346.534 / 1294499.791) Lakh.

**BCR (F) = 1.13**

## 5.13 Internal Rate of Return (IRR)

Internal Rate of Return (IRR) is that discount rate which just makes the net present value (NPV) of the cash flow equal zero. It is considered to be the most useful measure of project worth and used by almost all institutions including World Bank in economic and financial analysis of the project. It represents the average earning power of the money used in the project over the project life. It is also sometimes called yield of the investment.

Mathematically [20],

IRR is that discount rate „i" such that

NPV = 0 = $\sum_{t=1}^{t=n} \frac{Bn-Cn}{(1+i)^n}$

Where,

Bn = Benefit in each year of the project.

Cn = Cost in each year of the project.

n = number of year in the project.

i = interest (discount) rates.

A project is profitable or feasible for investment when the internal rate of return is higher than the opportunity cost of capital. The computation of IRR for projects involves a trial and error method. Here alternative discount rates are used to the cash flow streams of the project under consideration till the NPV of the project reaches zero. However, it is not always possible to get a discount rate which makes the NPV exactly equal to zero through this trial and error method. It would be possible to get discount rate, which makes the NPV nearer to zero i.e. either positive or negative. Under such situation, can be use interpolation

to estimate the true value. Interpolation is simply finding the intermediate values between two discount rate have chosen.

## ➢ Determination of IRR(F) for 300 MW Plant project

This calculation is done by the following formula, [27]

IRR = A + (C/C-D) * (B-A)

Where,

A = Lower Discount Rate.

B = Higher Discount Rate.

C = Lower Discount NPV.

D = Higher Discount NPV.

**Table 5.19** IRR (F) for 300 MW Plant (Fuel – Gas)

| Year | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|
| | 13% | | 15% | | 20% | |
| | Discount Factor | | Discount Factor | | Discount Factor | |
| 0 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1408.84 | 0.00 |
| 1 | 153089.99 | 0.00 | 150427.55 | 0.00 | 144159.74 | 0.00 |
| 2 | 46597.30 | 0.00 | 44990.62 | 0.00 | 41319.51 | 0.00 |
| 3 | 34096.96 | 70970.35 | 32348.74 | 67331.57 | 28471.29 | 59260.94 |
| 4 | 30174.30 | 62805.62 | 28129.34 | 58549.19 | 23726.08 | 49384.11 |
| 5 | 26702.92 | 55580.19 | 24460.30 | 50912.34 | 19771.73 | 41153.43 |
| 6 | 23630.90 | 49186.01 | 21269.82 | 44271.60 | 16476.44 | 34294.52 |
| 7 | 20912.30 | 43527.44 | 18495.50 | 38497.04 | 13730.37 | 28578.77 |
| 8 | 18506.46 | 38519.86 | 16083.04 | 33475.69 | 11441.97 | 23815.64 |
| 9 | 16377.40 | 34088.37 | 13985.25 | 29109.30 | 9534.98 | 19846.37 |
| 10 | 14493.27 | 30166.70 | 12161.09 | 25312.43 | 7945.82 | 16538.64 |
| 11 | 12825.91 | 26696.20 | 10574.86 | 22010.81 | 6621.51 | 13782.20 |
| 12 | 11350.36 | 23624.95 | 9195.53 | 19139.83 | 5517.93 | 11485.17 |
| 13 | 10044.57 | 20907.04 | 7996.11 | 16643.33 | 4598.27 | 9570.97 |
| 14 | 8889.00 | 18501.80 | 6953.14 | 14472.46 | 3831.89 | 7975.81 |
| 15 | 7866.37 | 16373.28 | 6046.21 | 12584.75 | 3193.24 | 6646.51 |
| 16 | 6961.39 | 14489.63 | 5257.58 | 10943.26 | 2661.04 | 5538.76 |
| 17 | 6160.52 | 12822.68 | 4571.80 | 9515.88 | 2217.53 | 4615.63 |
| 18 | 5451.79 | 11347.50 | 3975.48 | 8274.68 | 1847.94 | 3846.36 |
| 19 | 4824.59 | 10042.04 | 3456.94 | 7195.37 | 1539.95 | 3205.30 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 20 | 4269.55 | 8886.76 | 3006.04 | 6256.85 | 1283.29 | 2671.08 |
| 21 | 3778.36 | 7864.39 | 2613.94 | 5440.74 | 1069.41 | 2225.90 |
| 22 | 3343.68 | 6959.64 | 2272.99 | 4731.07 | 891.18 | 1854.92 |
| 23 | 2959.01 | 6158.97 | 1976.52 | 4113.98 | 742.65 | 1545.77 |
| | **474715.72** | **569519.40** | **431657.26** | **488782.18** | **354002.61** | **347836.80** |

| | | | |
|---|---|---|---|
| Discounted Rate | 13% | 15% | 20% |
| NPV | 94803.676 | 57124.921 | -6165.812 |
| BCR | 1.17253962 | 1.132 | 0.983 |
| **IRR** | | | **19.57%** |

In the table above we can see that for the discount rate of i = 19.57%, the difference between discounted total benefit and total cost will be nearer to zero.

**Table 5.20** IRR (F) for 300 MW Plant (Fuel – HFO)

| Year | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|
| | **22%** | | **28%** | | **15%** | |
| | **Discount Factor** | | **Discount Factor** | | **Discount Factor** | |
| 0 | 1408.84 | 0 | 1408.84 | 0 | 1408.84 | 0 |
| 1 | 141796.4631 | 0 | 135149.7539 | 0 | 150427.5522 | 0 |
| 2 | 39975.87412 | 0 | 36315.97353 | 0 | 44990.61704 | 0 |
| 3 | 126645.6557 | 169181.9469 | 109657.8887 | 146488.5235 | 151208.5218 | 201994.707 |
| 4 | 103807.9145 | 138673.727 | 85670.22556 | 114444.159 | 131485.6712 | 175647.5713 |
| 5 | 85088.45452 | 113666.9893 | 66929.86372 | 89409.4992 | 114335.3662 | 152737.0185 |
| 6 | 69744.63485 | 93169.6634 | 52288.95603 | 69851.17125 | 99422.05758 | 132814.7987 |
| 7 | 57167.73349 | 76368.57656 | 40850.7469 | 54571.22754 | 86453.96311 | 115491.1293 |
| 8 | 46858.79794 | 62597.1939 | 31914.64601 | 42633.77151 | 75177.35923 | 100427.069 |
| 9 | 38408.85077 | 51309.17533 | 24933.3172 | 33307.63399 | 65371.61672 | 87327.88606 |
| 10 | 31482.66457 | 42056.70109 | 19479.15406 | 26021.58906 | 56844.88411 | 75937.29223 |
| 11 | 25805.46276 | 34472.70581 | 15218.08911 | 20329.36645 | 49430.334 | 66032.42802 |
| 12 | 21152.01865 | 28256.31624 | 11889.13212 | 15882.31754 | 42982.89913 | 57419.50263 |
| 13 | 17337.72021 | 23160.91495 | 9288.384467 | 12408.06058 | 37376.43403 | 49930.00229 |
| 14 | 14211.24607 | 18984.35652 | 7256.550364 | 9693.797327 | 32501.24698 | 43417.39329 |
| 15 | 11648.56235 | 15560.94796 | 5669.179972 | 7573.279162 | 28261.9539 | 37754.25504 |
| 16 | 9548.00193 | 12754.87538 | 4429.046853 | 5916.624345 | 24575.61209 | 32829.78699 |
| 17 | 7826.23109 | 10454.81589 | 3460.192854 | 4622.36277 | 21370.09747 | 28547.64086 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 18 | 6414.943517 | 8569.521217 | 2703.275667 | 3611.220914 | 18582.69345 | 24824.03553 |
| 19 | 5258.150423 | 7024.197719 | 2111.934115 | 2821.266339 | 16158.86387 | 21586.11785 |
| 20 | 4309.959363 | 5757.539114 | 1649.948527 | 2204.114327 | 14051.18597 | 18770.53726 |
| 21 | 3532.753577 | 4719.294356 | 1289.022287 | 1721.964318 | 12218.42258 | 16322.20632 |
| 22 | 2895.699653 | 3868.274062 | 1007.048662 | 1345.284624 | 10624.71529 | 14193.22288 |
| 23 | 2373.524306 | 3170.716444 | 786.756767 | 1051.003612 | 9238.882862 | 12341.93294 |
| | 874700.1575 | 923778.4492 | 671357.9274 | 665908.2373 | 1294499.791 | 1466346.534 |

| Discount Rate: | 22% | 28% | 15% |
|---|---|---|---|
| NPV | 49078.29175 | -5449.690054 | 171846.7433 |
| BCR | 1.056108703 | 0.991882586 | 1.132751465 |
| **IRR:** | | | **27.60%** |

In the table above we can see that for the discount rate of i = 27.6%, the difference between discounted total benefit and total cost will be nearer to zero.

## 5.14 Cost Estimation and Economic Evaluation Summary

Beyond the PBP(F), NPV(F), BCR(F), IRR(F) etc., the calculations for Economic Net Present Value NPV (E), Economic Benefit Cost Ratio BCR(E) and Economic Internal Rate of Return IRR(E) are performed using the economic values of Costs and Benefits by multiplying those with corresponding SCF (Standard Conversion Factor prefixed by IMED under Planning Commission of Bangladesh These parameters are evaluated for all 4 proposed plant capacities in the Microsoft Excel sheets and are attached in the Annexure. The results are presented in the following table-:

**Table 5.21** Summary Table of Cost Estimation & Economic & Financial Evaluation

| **Capacity (MW)** | **150** | **225** | **300** | **450** |
|---|---|---|---|---|
| Investment ( Lakh TK.) | 156911 | 197947 | 233901 | 296712 |
| Generation Cost/Unit (Fuel – Gas) TK. | 1.88 | 1.77 | 1.75 | 1.75 |
| Generation Cost/Unit (Fuel – HFO) TK. | 9.72 | 9.72 | 9.72 | 9.72 |
| Sell Price / Unit (Fuel - Gas) | 4.5 | 4.5 | 4.5 | 4.5 |
| Sell Price / Unit (Fuel - HFO) | 13.5 | 13.5 | 13.5 | 13.5 |
| Gas Consumption (mmscftd) | 28 | 38 | 50 | 75 |
| HFO Consumption (Litre/Day) | 496604 | 744906 | 993208 | 1489812 |
| Discounted Payback Period (Fuel – Gas) | 11 | 8 | 7 | 6 |
| Discounted Payback Period (Fuel – HFO) | 7 | 6 | 5 | 4 |
| IRR (F) [Fuel - Gas] | 12.48% | 16.72% | 19.57% | 27.26% |
| IRR (F) [Fuel - HFO] | 19.94% | 24.43% | 27.60% | 32.61% |
| BCR (F) (15%) [Fuel - Gas] | 0.92055 | 1.05068 | 1.132 | 1.2432 |
| BCR (F) (15%) [Fuel - HFO] | 1.06284 | 1.10544 | 1.13275 | 1.16747 |
| NPV (F) (15%) [Fuel - Gas] | -21093 | 17681.3 | 57124.9 | 143425 |
| NPV (F) (15%) [Fuel - HFO] | 43347.5 | 104903 | 171847 | 315508 |
| IRR (E) [Fuel - Gas] | 16.98% | 20.96% | 23.74% | 27.65% |
| IRR (E) [Fuel - HFO] | 24.42% | 28.52% | 31.62% | 35.95% |
| BCR (E) (15%) [Fuel - Gas] | 1.08431 | 1.2568 | 1.363 | 1.50669 |
| BCR (E) (15%) [Fuel - HFO] | 1.14547 | 1.18951 | 1.21765 | 1.25324 |
| NPV (E) (15%) [Fuel - Gas] | 16524.2 | 65133.2 | 113195 | 214402 |
| NPV (E) (15%) [Fuel - HFO] | 80964.8 | 152355 | 227916 | 386484 |

# Chapter-6

## SWOT Analysis

SWOT Analysis is a strategic planning technique used to assess the internal and external environment in which a company operates and competes. Internal environmental factors are classified into strength and weaknesses, while external environmental factors are classified into Opportunities and Threats.

The SWOT analysis is an extremely useful tool for understanding and decision making for all sorts of situation in business and organizations. SWOT analysis provides information that is helpful in matching the firm‟s resources and capabilities to the competitive environment in which it operates. As such, it is instrumental in strategy formulation and selection. Fig. 6.1 shows how a SWOT analysis fits into an environmental scan [30].

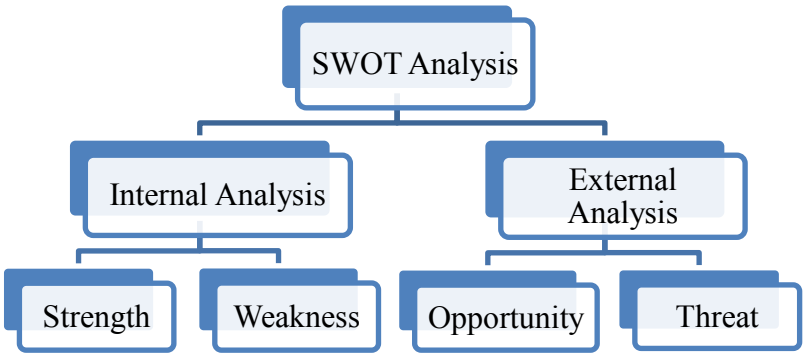


**Fig 6.1** SWOT Analysis frame work

Internal analysis examines the capabilities of the organization and its business. This can be done by determining and analyzing organization strengths and weakness. External analysis looks at the main points in the environmental analysis, and identifies those points

that pose opportunities for the organization, and those that pose threats or obstacles to performance.

**Strength & Weakness: A** firm‟s strengths are its resources and capabilities that can be used as a basis for developing a competitive advantage. To know about the strength of a company, it is important to analyze about what the company does well and what makes the company stand out from competitors. What advantages does the company have over other competitors? The absence of certain strengths may be viewed as a weakness. To determine the weakness, we can list the areas that are a struggle for the company.

**Opportunities & Threats:** The external environmental analysis may reveal certain new opportunities for profit and growth. Therefore it is important to analyze the external environment and try to uncover areas where the strengths are not being fully utilized. Changes in the external environment may present threats to the company. Analysis of threats is important for understanding and estimation of damage that could happen due to the influence of external environment. To find out the threats to the company, analyzer should study the strength and weakness of competitors and their emerging business trends that may amplify the weaknesses. Apart from that any other external threats that may hinder in the success of the company should also be examined carefully.

By analyzing all the data and various reports it has been made the following SWOT Analysis. This analysis contains the most featured parameters of the 300 MW capacity power project.

## ➢ STRENGTHS

### • Low Labor Cost

Labor cost plays a significant role in any project. The labor cost can be shown as strength in our proposed plant since we get it at lower price in Bangladesh than any other country.

### • Existing Transmission Line

The existing Shikalbaha 132/33 grid sub-station are connected with 9 nos. 132 circuits like Zulda-1, Dohazari-1 & 2, Shamirpur 1& 2, Bakulia 1 & 2 and Modunaghat 1 & 2. Moreover the exixting 60 MW, 150 MW and 55 MW rental power plants are connected with the same grid sub-station. To evacuate power from the proposed power plant it will be required to construct a 230/132 KV sub-station at Shikalbaha power station premises. As 132 KV substations and required transmission line are already established here, we‟ve to set up only 230 KV substations.

### • Selling Assurance

The ultimate goal of any production oriented project is to earn revenue by selling its products. There is high demand of power already existing in market and Gov. is ready to purchase power to meet this demand. So it‟s not need to bother about the selling assurance of product.

## ➢ WEAKNESS

- **Decreasing supply of Natural Gas**

The only natural resource that Bangladesh has got enough is natural gas. But the supply of natural gas is decreasing day by day. Although government is trying to lease the gas blocs to the foreign investors, still the total supply of Natural Gas, Coal and any other fossil fuels to the national grid is quite low and it is not sufficient to ensure enough supply to the upcoming gas based power projects.

- **Capital Intensive Industry**

Power industry is a capital intensive industry as a small power plant needs a huge investment to establish and operate. SME based entrepreneurs cannot invest in this industry due to its initial huge investment. Only investors with large capital or joint ventures projects or foreign investors are coming to invest in power plants**.**

- **Huge Operating Cost**

HFO also be used as well as Gas as raw material in this proposed plant by considering the present scenario. Hence the cost of oil is high which leads the total operating cost little higher.

- **No Substitute Products**

Power is the only product in this proposed plant since there is no byproduct. It‟ll be difficult to earn additional revenue from selling power other than byproduct.

- **Lack of Skill Manpower**

Power industry is new sector for private investors. Most of the time investors have to depend on foreign experts. So lack of skill manpower is the weakness of this project.

## ➢ OPPORTUNITIES

### • Government Incentives

Bangladesh government has announced Fiscal incentives and incentives for foreign investors to facilitate the investment in the power plants. Exemption from corporate income tax for a period of 15 years has been announced for the investors. They are also allowed to import plant and equipment and spare parts up to a maximum of ten percent (10%) of the original value of total plant and equipment within a period of twelve 12 years of commercial operation without payment of customs duties. For foreign investors government announced, tax exemption on royalties, technical know-how and technical assistance fees. The foreign investors are also exempted from paying tax on interest on foreign loans. They are also enjoying tax exemption on capital gains from transfer of shares by the investing company**.**

### • Power Demand

The biggest opportunity of the power industry of Bangladesh is the high demand of power within the country. As automation in businesses and industrialization is taking place all over the country, the demand for power is also increasing at the same time. Demand is also increasing with the improvement of living standard, increase of agricultural production, development of existing industries as well as overall development of the country. On the other hand, only 47% of people have access to power in the country. So, government is also trying to increase the production of power to ensure enough supply to the people. Government has a plan to ensure power for all by 2021.

### • LNG Import

Govt. has taken short, medium and long term planning such as mining and import of LNG to overcome the gas crisis. Bangladesh signed an initial agreement to import 4 million tons of liquefied natural gas a year from Qatar. The government has already invited bids to construct the terminal at a cost of over 10 billion taka. [31] Hope the problem of unavailability of gas will be solved in near future.

- **Support from developed & donor countries**

Recently ADB has declared to provide 185 Million US Dollar as loan aimed at boosting the country‟s power supply system[28] Other donor organization and several countries like Kuwait, Qatar etc. has shown interest to support on Bangladesh Power Sector.

## ➢ THREATS

- Increasing price of raw material

The price of oil in the international market is increasing since the depression of 2009. Recently the economic crisis in Europe and political instability of Middle East leads the international market of oil towards an unpredictable situation. As oil is one of the main raw materials for power plants and Bangladesh government imports most of their oil from international market, the increasing price of oil in the international market will be a treat for power industry.

- Energy Infrastructure

Bangladesh's energy infrastructure is quite small, insufficient and poorly managed. And no initiative is taken to improve the infrastructure. With this type of poor infrastructure it is quite difficult to reach the goal of the government to produce the additional power in the coming years.

- Political influence in the industry

The political influence is a threat for the power industry. In Bangladesh, there are political influences in the bidding process of tender and even in the selection process of Concern Company. Donor agencies withdraw their donation on the specific projects due to the political influence. Sometimes the donors withdraw their donation even in the last stage of selection process because of this political influence.

- Possibility of rapid market captures by competitors

Since power occupies a lucrative sector in market demand, many competitors tend to enter in the market. So, it can be difficult to sustain in the market with increasing graph of profit for a long time by facing this competition.

# Chapter-7

## Conclusion

Govt. has taken several steps for developing Power Sector. They emphasizes on power for increasing economic development. Recently ADB has declared to provide 185 Million US Dollar as loan aimed at boosting the country‟s power supply system. The Government and ADB on April 3, 2013 signed a loan agreement in this regard. [28] Other donor organization and several countries like Kuwait, Qatar etc. has shown interest to support on Bangladesh Power Sector. From the above analysis of the feasibility study it has been seen that this type of plant is financially feasible.

If this plant could be established through private sector, the plant can be on operation in a minimum time which will help to gain maximum profit. Moreover, Govt. encourages the private sector to initiate this type of plants and commits to provide all necessary supports when needed.

Financial analysis shows that, the profitability increases as the plant capacity increased as presented in table 5.21. When fuel will be Gas then, Financial Net Present Value for 150 MW, 225 MW, 300 MW and 450 MW are TK. -21093.04 Lakh, TK. 17681.34 Lakh, TK. 57124.9 Lakh and TK. 143425.4 Lakh respectively (Discounted @15% per year). The corresponding Financial Benefit Cost Ratio, BCR(F) are 0.92, 1.05, 1.132 and 1.24 at the same discount rate. The Financial Internal Rate of Return, IRR (F) are 12.48%, 16.72%, 19.57% and 27.26% respectively. The discounted Financial Pay Back Periods are 11 years, 8years, 7 years and 6 years respectively. Economic Net Present Values, NPV (E) for 150 MW, 225 MW, 300 MW and 450 MW plants are TK. 16524.23 Lakh, TK. 65133.24 Lakh, TK. 113195 Lakh and TK. 214401.5 Lakh respectively. Corresponding BCR (E) are 1.08, 1.25, 1.363 and 1.50, and corresponding IRR (E) are 16.98%, 20.96%, 23.74% and 27.65% respectively.

When fuel will be HFO then, Financial Net Present Value for 150 MW, 225 MW, 300 MW and 450 MW are TK. 43347.49 Lakh, TK. 104902.6 Lakh, TK. 171846.7 Lakh and TK. 315508.01 Lakh respectively (Discounted @15% per year). The corresponding Financial Benefit Cost Ratio, BCR (F) are 1.06, 1.10, 1.13 and 1.16 at the same discount rate. The Financial Internal Rate of Return, IRR (F) are 19.94%, 24.43%, 27.60% and 32.61% respectively. The discounted Financial Pay Back Periods are 7 years, 6 years, 5 years and 4 years respectively. Economic Net Present Values, NPV (E) for 150 MW, 225 MW, 300 MW and 450 MW plants are TK. 80964.75 Lakh, TK. 152354.5 Lakh, TK. 227916.4 Lakh and TK. 386484.2 Lakh respectively. Corresponding BCR (E) are 1.14, 1.18, 1.21 and 1.25, and corresponding IRR (E) are 24.42%, 28.52%, 31.62% and 35.95% respectively.

The values of Financial and Economic parameters determined in the project thesis shows that, for all plant capacities except 150 MW, NPV (F) and NPV (E) are highly „+ve" for Gas and all 4 plant capacities NPV (F) and NPV (E) are „+ve" for HFO, actually excellent. BCR (F) and BCR (E) for all of the capacities except 150 MW are greater than 1 for Gas and for HFO fuel BCR (F) and BCR (E) for all 4 plant capacities are greater than 1. Except 150 MW, IRR (F) and IRR (E) are also much higher than 15% for Gas, and for HFO for all 4 plants IRR (F) and IRR (E) are also much higher than 15%. SO, it is certain that, the power plant project economically and financially feasible for 225 MW, 300 MW and 450 MW capacity plant.

From the above analysis, the following conclusion can be done,

- Profitability increases with the increase in plant capacity.
- Being conservative on raw material supply from Petrobangla and BPC and consideration of profitability and operating cost, it may be recommended installing 300 MW plant instead of 225 MW and 450 MW.

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# ANNEXURE – 1

## Cost Estimation and Economic Analysis of 150 MW Combined Cycle Power Plant at Shikalbaha

# 150 MW Total Investment Cost

| Direct Cost | | | | | |
|---|---|---|---|---|---|
| 150 MW Plant Cost, C | New Plant (MW) | Factor $(Q/Q_o)^a$ | Direct Cost $C*(Q/Q_o)^a$ | Cost Escalation | Total Direct Cost at 2014 |
| | | 0.65 | | | |
| 80799.84 | **150** | **1** | **80799.84** | 30% | **105039.792** |
| | 225 | 1.30 | 105164.6593 | | 136714.0571 |
| | 300 | 1.57 | 126788.54 | | 164825.102 |
| | 450 | 2.04 | 165021.0387 | | 214527.3503 |

| Indirect Cost (Custom Duty, Taxes & VAT, C & F Cost, Landing Charges etc.) | | | | | |
|---|---|---|---|---|---|
| 150 MW Plant Cost, C | New Plant (MW) | Factor $(Q/Q_o)^a$ | Direct Cost $C*(Q/Q_o)^a$ | Cost Escalation | Total Direct Cost at 2014 |
| | | 0.3 | | | |
| 20261.709 | **150** | **1** | **20261.709** | 30% | **26340.2217** |
| | 225 | 1.13 | 22882.49897 | | 29747.24866 |
| | 300 | 1.23 | 24945.09 | | 32428.618 |
| | 450 | 1.39 | 28171.66077 | | 36623.159 |

| Indirect Cost (Erection & Commissioning) | | | | | |
|---|---|---|---|---|---|
| 150 MW Plant Cost, C | New Plant (MW) | Factor $(Q/Q_o)^a$ | Direct Cost $C*(Q/Q_o)^a$ | Cost Escalation | Total Direct Cost at 2014 |
| | | 0.5 | | | |
| 8150.1 | **150** | **1** | **8150.1** | 30% | **10595.13** |
| | 225 | 1.225 | 9981.793176 | | 12976.33113 |
| | 300 | 1.41 | 11525.98 | | 14983.78 |
| | 450 | 1.732 | 14116.38729 | | 18351.30347 |

# Detailed Breakdown of Investment Cost

Installation of a 150 MW Combined Cycle
Power Plant at Shikalbaha

| Sl. No. | Item | L.C. | F.C. | Total | % of Cost |
|---|---|---|---|---|---|
| I) | **Pre-Construction Expendeture** | | | | |
| | Land acquisition & Land Development | 865 | 0 | 865 | 0.551 |
| | **Sub-Total – I** | **865** | **0** | **865** | **0.551** |
| II) | **Construction Works (based on PWD** | | | | |
| | **rate 2011)** | | | | |
| | Residential, Non Residential and fuel | 811.3 | 0 | 811.3 | 0.517 |
| | unloading system | | | | |
| | (Administrative building 17,000/- per m² | | | | |
| | Internal Road (RCC) @ Tk. 2509/m² ) | | | | |
| | Deep Tube-well & pump house | 40 | 0 | 40 | 0.025 |
| | **Sub-Total – II** | **851.3** | **0** | **851.3** | **0.543** |
| III) | **Machinery, Equipment & Spares** | | | | |
| | Supply of material & Equipment | 21007.95854 | 84031.8 | 105039.8 | 66.942 |
| | Engineering Design | 0 | 26340 | 26340 | 16.787 |
| | Erection & Commissioning | 5191.617249 | 5404 | 10595 | 6.752 |
| | Training | 250 | 270 | 520 | 0.331 |
| | Pre-Shipment inspection @0.5% | 0 | 525.199 | 525.199 | 0.335 |
| | **Sub-Total – III** | **26449.57579** | **116571** | **143020** | **91.148** |
| IV) | **Transport Vehicle** | | | | |
| | Rental @ Tk. 3000/day for 700 days | 21 | 0 | 21 | 0.013 |
| | during project implementation | | | | |
| | **Sub-Total – IV** | **21** | 0 | **21** | **0.013** |
| V) | **Other Cost** | | | | |
| | Charge of electrical energy during construction | 8 | 0 | 8 | 0.005 |
| | Interest during construction @ 3% p.a. | 2520.955025 | 0 | 2520.96 | 1.607 |
| | Bank Charges @ 1.25% | 1050.397927 | 0 | 1050.4 | 0.669 |
| | Insurance @ 3% on imported materials | 2520.955025 | 0 | 2520.96 | 1.607 |
| | Project office expenditure | 17.65 | 0 | 17.65 | 0.011 |
| | Physical Contingency (2% of the total items) | 686.0966753 | 2331.42 | 3017.51 | 1.923 |
| | Price Contingency (2% of the total cost) | 686.0966753 | 2331.42 | 3017.51 | 1.923 |
| | **Sub-Total – V** | **7490.151328** | **4662.83** | **12153** | **7.745** |
| **Total Investment Cost** | | **35677.02712** | **121234** | **156911** | **100.000** |

# 150 MW Annual Phasing Cost

| Sl. | Dsecription | Year 01 | | | | |
|---|---|---|---|---|---|---|
| | | GOB | Project Aid | | | Total |
| | | | RPA | | DPA | |
| | | | Through GOB | Special AC | | |
| **A)** | **Supplies & Services** | | | | | |
| | Travel Expenses | 0.8 | | | | 0.8 |
| | Postal | 0.32 | | | | 0.32 |
| | Telephone / Fax | 0.6 | | | | 0.6 |
| | Bank Charges @ 1.25% | 0 | | | | 0 |
| | Insurance @ 3% on imported materials | 0 | | | | 0 |
| | Duties & Taxes on Imported Materials & Equipments @ 3% | 0 | | | | 0 |
| | Stationaries, Seal & Stumps | 0.4 | | | | 0.4 |
| | Entertainment | 0.4 | | | | 0.4 |
| | Casual Labour | 0.3 | | | | 0.3 |
| | Copy / Photo Copy | 0.2 | | | | 0.2 |
| | Computer Accessories | 0.12 | | | | 0.12 |
| | Computer and office equipment | 0.3 | | | | 0.3 |
| | Utility Charge | 3 | | | | 3 |
| | **Sub-Total** | **6.44** | | | | **6.44** |
| | **Acquisition of Asset** | | | | | |
| | Vehicle (Rental) | 6.3 | | | | 6.3 |
| | Machinery Equipment & Spares | 0 | | | | 0 |
| | Pre-Shipment Inspection Cost @0.50% | 0 | | | | 0 |
| | A/C, Computer, Laser Printer, Color Printer, Scanner & Photocopier | 5 | | | | 5 |
| | Office Equipment | 0.8 | | | | 0.8 |
| | Furniture | 3 | | | | 3 |
| | Deep Tube Well & Pump House | 8 | | | | 8 |
| **B)** | **Land Properties** | | | | | |
| | Land Acquisition | 765 | | | | 765 |
| | **Construction Works** | | | | | |
| | Land Development | 60 | | | | 60 |
| | Building Works | 280.3 | | | | 280.3 |
| | Doors, Windows & Finishing | 240 | | | | 240 |
| | Internal Road (RCC) | 20 | | | | 20 |
| | Drainage System | 14 | | | | 14 |
| | **Sub-Total** | **1402** | | | | **1402** |
| **C)** | **Physical Contengency** | 0 | | | | 0 |
| **D)** | **Price Contengency** | 0 | | | | 0 |
| | **Total (A+B+C+D)** | **1409** | | | | **1409** |

| Sl | Dsecription | Year 02 | | | | |
|---|---|---|---|---|---|---|
| | | GOB | Project Aid | | DPA | Total |
| | | | RPA | | | |
| | | | Through GOB | Special AC | | |
| **A)** | **Supplies & Services** | | | | | |
| | Travel Expenses | 0.60 | | | | 0.60 |
| | Postal | 0.08 | | | | 0.08 |
| | Telephone / Fax | 0.60 | | | | 0.60 |
| | Bank Charges @ 1.25% | 1050.40 | | | | 1050.40 |
| | Insurance @ 3% on imported materials | 2520.96 | | | | 2520.96 |
| | Duties & Taxes on Imported Materials & Equipments @ 3% | 2520.96 | | | | 2520.96 |
| | Stationaries, Seal & Stumps | 0.30 | | | | 0.30 |
| | Entertainment | 0.30 | | | | 0.30 |
| | Casual Labour | 0.30 | | | | 0.30 |
| | Copy / Photo Copy | 0.15 | | | | 0.15 |
| | Computer Accessories | 0.09 | | | | 0.09 |
| | Computer and office equipment | 0.30 | | | | 0.30 |
| | Utility Charge | 2.50 | | | | 2.50 |
| | **Sub-Total** | **6097.53** | | | | **6097.53** |
| | **Acquisition of Asset** | | | | | |
| | Vehicle (Rental) | 6.30 | | | | 6.30 |
| | Machinery Equipment & Spares | 106871.36 | | | | 106871.36 |
| | Pre-Shipment Inspection Cost @0.50% | 525.20 | | | | 525.20 |
| | A/C, Computer, Laser Printer, Color Printer, Scanner & Photocopier | 0.00 | | | | 0.00 |
| | Office Equipment | 0.20 | | | | 0.20 |
| | Furniture | 0.00 | | | | 0.00 |
| | Deep Tube Well & Pump House | 32.00 | | | | 32.00 |
| **B)** | **Land Properties** | | | | | |
| | Land Acquisition | 0.00 | | | | 0.00 |
| | **Construction Works** | | | | | |
| | Land Development | 40.00 | | | | 40.00 |
| | Building Works | 130.00 | | | | 130.00 |
| | Doors , Windows & Finishing | 110.00 | | | | 110.00 |
| | Internal Road (RCC) | 10.00 | | | | 10.00 |
| | Drainage System | 7.00 | | | | 7.00 |
| | **Sub-Total** | **107732.06** | | | | **107732.06** |
| **C)** | **Physical Contengency** | **905.25** | | | | **905.25** |
| **D)** | **Price Contengency** | **905.25** | | | | **905.25** |
| | **Total (A+B+C+D)** | **115640.1** | | | | **115640.1** |

| Sl | Dsecription | Year 03 | | | | |
|---|---|---|---|---|---|---|
| | | GOB | Project Aid | | DPA | Total |
| | | | RPA | | | |
| | | | Through GOB | Special AC | | |
| **A)** | **Supplies & Services** | | | | | |
| | Travel Expenses | 0.60 | | | | 0.60 |
| | Postal | 0.00 | | | | 0.00 |
| | Telephone / Fax | 0.60 | | | | 0.60 |
| | Bank Charges @ 1.25% | 0.00 | | | | 0.00 |
| | Insurance @ 3% on imported materials | 0.00 | | | | 0.00 |
| | Duties & Taxes on Imported Materials & Equipments @ 3% | 0.00 | | | | 0.00 |
| | Stationaries, Seal & Stumps | 0.30 | | | | 0.30 |
| | Entertainment | 0.30 | | | | 0.30 |
| | Casual Labour | 0.30 | | | | 0.30 |
| | Copy / Photo Copy | 0.15 | | | | 0.15 |
| | Computer Accessories | 0.09 | | | | 0.09 |
| | Computer and office equipment | 0.15 | | | | 0.15 |
| | Utility Charge | 2.50 | | | | 2.50 |
| | **Sub-Total** | **4.99** | | | | **4.99** |
| | **Acquisition of Asset** | | | | | |
| | Vehicle (Rental) | 8.40 | | | | 8.40 |
| | Machinery Equipment & Spares | 35623.79 | | | | 35623.79 |
| | Pre-Shipment Inspection Cost @0.50% | 0.00 | | | | 0.00 |
| | A/C , Computer, Laser Printer, Color Printer, Scanner & Photocopier | 0.00 | | | | 0.00 |
| | Office Equipment | 0.00 | | | | 0.00 |
| | Furniture | 0.00 | | | | 0.00 |
| | Deep Tube Well & Pump House | 0.00 | | | | 0.00 |
| **B)** | **Land Properties** | 0.00 | | | | 0.00 |
| | Land Acquisition | 0.00 | | | | 0.00 |
| | **Construction Works** | | | | | |
| | Land Development | 0.00 | | | | 0.00 |
| | Building Works | 0.00 | | | | 0.00 |
| | Doors, Windows & Finishing | 0.00 | | | | 0.00 |
| | Internal Road (RCC) | 0.00 | | | | 0.00 |
| | Drainage System | 0.00 | | | | 0.00 |
| | Sub-Total | **35632.19** | | | | **35632.19** |
| **C)** | **Physical Contengency** | **2112.26** | | | | **2112.26** |
| **D)** | **Price Contengency** | **2112.26** | | | | **2112.26** |
| | **Total (A+B+C+D)** | **39861.70** | | | | **39861.70** |

# 150 MW Economic Value of Investment Cost

| Sl. | Item of Cost | Year – 1 | | | Year – 2 | | | Year – 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| No. | | PV | SCF | AV | PV | SCF | AV | PV | SCF | AV |
| | | | | | | | | | | |
| I) | Revenue Component | | | | | | | | | |
| | a) Foreign Currency | 0.00 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 |
| | b) Local Currency | 6.44 | 0.82 | 5.28 | 6097.53 | 0.82 | 4999.97 | 4.99 | 0.82 | 4.09 |
| | | | | | | | | | | |
| II) | Capital Component | | | | | | | | | |
| | a) Foreign Currency | 0.00 | 1.00 | 0.00 | 96709.43 | 1.00 | 96709.43 | 35623.8 | 1.00 | 35623.79 |
| | b) Local Currency | 1402.40 | 0.82 | 1149.97 | 11022.64 | 0.82 | 9038.56 | 8.40 | 0.82 | 6.89 |
| | | | | | | | | | | |
| III) | Physical Contingency | | | | | | | | | |
| | a) Foreign Currency | 0.00 | 1.00 | 0.00 | 656.31 | 1.00 | 656.31 | 1531.39 | 1.00 | 1531.39 |
| | b) Local Currency | 0.00 | 0.82 | 0.00 | 248.94 | 0.82 | 204.13 | 580.87 | 0.82 | 476.31 |
| | | | | | | | | | | |
| IV) | Price Contingency | | | | | | | | | |
| | a) Foreign Currency | 0.00 | 1.00 | 0.00 | 656.31 | 1.00 | 656.31 | 1531.39 | 1.00 | 1531.39 |
| | b) Local Currency | 0.00 | 0.82 | 0.00 | 248.94 | 0.82 | 204.13 | 580.87 | 0.82 | 476.31 |
| | **Total** | **1408.84** | | **1155.25** | **115640.10** | | **112468.85** | **39861.7** | | **39650.17** |

# 150 MW Financial Operating / Recurring Cost Table (Fuel –Gas)

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 1 -7 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 13843.409 | 0 | 13843.409 |
| ii) | Utilities (Power, Water, Gas) | 10 | 0 | 10 |
| iii) | Manpower Salary, Wages & Allowances | 155 | 0 | 155 |
| iv) | Machine & Equipment Depriciation | 7151.0176 | 0 | 7151.0176 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 80 | 0 | 80 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 6678.45 | 0 | 6678.45 |
| **Total Operating Cost** | | **27943.42** | **0** | **27943.42** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 8-14 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 13843.409 | 0 | 13843.409 |
| ii) | Utilities (Power, Water, Gas) | 10 | 0 | 10 |
| iii) | Manpower Salary, Wages & Allowances | 155 | 0 | 155 |
| iv) | Machine & Equipment Depriciation | 7151.0176 | 0 | 7151.0176 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 80 | 0 | 80 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 6678.45 | 0 | 6678.45 |
| **Total Operating Cost** | | **27943.42** | **0** | **27943.42** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 15-21 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 13843.409 | 0 | 13843.409 |
| ii) | Utilities (Power, Water, Gas) | 10 | 0 | 10 |
| iii) | Manpower Salary, Wages & Allowances | 155 | 0 | 155 |
| iv) | Machine & Equipment Depriciation | 7151.0176 | 0 | 7151.0176 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 80 | 0 | 80 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 6678.45 | 0 | 6678.45 |
| **Total Operating Cost** | | **27943.42** | **0** | **27943.42** |

# 150 MW Financial Operating / Recurring Cost Table (Fuel –HFO)

| Operating / Recurring Cost For HFO | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 1-7 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 89388.72 | 0 | 89388.72 |
| ii) | Utilities (Power, Water, Gas) | 10 | 0 | 10 |
| iii) | Manpower Salary, Wages & Allowances | 155 | 0 | 155 |
| iv) | Machine & Equipment Depriciation | 7151.01759 | 0 | 7151.0176 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 80 | 0 | 80 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 20035.35 | 0 | 20035.35 |
| **Total Operating Cost** | | **116845.6266** | **0** | **116845.6** |

| Operating / Recurring Cost For HFO | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 8-14 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 89388.72 | 0 | 89388.72 |
| ii) | Utilities (Power, Water, Gas) | 10 | 0 | 10 |
| iii) | Manpower Salary, Wages & Allowances | 155 | 0 | 155 |
| iv) | Machine & Equipment Depriciation | 7151.01759 | 0 | 7151.0176 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 80 | 0 | 80 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 20035.35 | 0 | 20035.35 |
| **Total Operating Cost** | | **116845.6266** | **0** | **116845.6** |

| Operating / Recurring Cost For HFO | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 15-21 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 89388.72 | 0 | 89388.72 |
| ii) | Utilities (Power, Water, Gas) | 10 | 0 | 10 |
| iii) | Manpower Salary, Wages & Allowances | 155 | 0 | 155 |
| iv) | Machine & Equipment Depriciation | 7151.01759 | 0 | 7151.0176 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 80 | 0 | 80 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 20035.35 | 0 | 20035.35 |
| **Total Operating Cost** | | **116845.6266** | **0** | **116845.6** |

# 150 MW Economical Operating / Recurring Cost Table (Fuel –Gas)

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. | Item of Cost | Year 1-7 | | |
| | | PV | SCF | AV |
| i) | Raw Materials | 13843.41 | 1 | 13843.41 |
| ii) | Utilities (Power, Water, Gas) | 10 | 1.11 | 11.1 |
| iii) | Manpower Salary, Wages & Allowances | 155 | 0.82 | 127.1 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 74 | 0.82 | 60.68 |
| | Foreign Currency | 6 | 1 | 6 |
| **Total Operating Cost** | | **14088.41** | | **14048.29** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. | Item of Cost | Year 8-14 | | |
| | | PV | SCF | AV |
| i) | Raw Materials | 13843.41 | 1 | 13843.41 |
| ii) | Utilities (Power, Water, Gas) | 10 | 1.11 | 11.1 |
| iii) | Manpower Salary, Wages & Allowances | 155 | 0.82 | 127.1 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 74 | 0.82 | 60.68 |
| | Foreign Currency | 6 | 1 | 6 |
| **Total Operating Cost** | | **14088.41** | | **14048.29** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. | Item of Cost | Year 15-21 | | |
| | | PV | SCF | AV |
| i) | Raw Materials | 13843.41 | 1 | 13843.41 |
| ii) | Utilities (Power, Water, Gas) | 10 | 1.11 | 11.1 |
| iii) | Manpower Salary, Wages & Allowances | 155 | 0.82 | 127.1 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 74 | 0.82 | 60.68 |
| | Foreign Currency | 6 | 1 | 6 |
| **Total Operating Cost** | | **14088.41** | | **14048.29** |

# 150 MW Economical Operating / Recurring Cost Table (Fuel –HFO)

| SL. | Item of Cost | Year 1-7 | | |
|---|---|---|---|---|
| | | L.C | F.C. | Total |
| i) | Raw Materials | 89388.72 | 1 | 89388.72 |
| ii) | Utilities (Power, Water, Gas) | 10 | 1.11 | 11.1 |
| iii) | Manpower Salary, Wages & Allowances | 155 | 0.82 | 127.1 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 74 | 0.82 | 60.68 |
| | Foreign Currency | 6 | 1 | 6 |
| **Total Operating Cost** | | **89633.72** | | **89593.6** |

| SL. | Item of Cost | Year 8-14 | | |
|---|---|---|---|---|
| | | L.C | F.C. | Total |
| i) | Raw Materials | 89388.72 | 1 | 89388.72 |
| ii) | Utilities (Power, Water, Gas) | 10 | 1.11 | 11.1 |
| iii) | Manpower Salary, Wages & Allowances | 155 | 0.82 | 127.1 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 74 | 0.82 | 60.68 |
| | Foreign Currency | 6 | 1 | 6 |
| **Total Operating Cost** | | **89633.72** | | **89593.6** |

| SL. | Item of Cost | Year 15-21 | | |
|---|---|---|---|---|
| | | L.C | F.C. | Total |
| i) | Raw Materials | 89388.72 | 1 | 89388.72 |
| ii) | Utilities (Power, Water, Gas) | 10 | 1.11 | 11.1 |
| iii) | Manpower Salary, Wages & Allowances | 155 | 0.82 | 127.1 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 74 | 0.82 | 60.68 |
| | Foreign Currency | 6 | 1 | 6 |
| **Total Operating Cost** | | **89633.72** | | **89593.6** |

# Generation Cost / Unit

**Fuel – Gas**

| Capacity | Opearating Cost | VAT Cost | Gas Cost | Total Cost | Total Generation | Unit Cost |
|---|---|---|---|---|---|---|
| (MW) | Lakh TK. | Lakh TK. | Lakh TK. | Lakh TK. | KWH | |
| | | | | | | |
| 150 | 245 | 4601.938603 | 13843.40932 | 18690.348 | 989400000 | **1.88906** |

**Fuel – HFO**

| Capacity | Opearating Cost | VAT Cost | HFO Cost | Total Cost | Total Generation | Unit Cost |
|---|---|---|---|---|---|---|
| (MW) | Lakh TK. | Lakh TK. | Lakh TK. | Lakh TK. | KWH | |
| | | | | | | |
| 150 | 245 | 6627.042 | 89388.72 | 96260.762 | 989400000 | **9.72921** |

# Benefit Cost Ratio (Financial)
# Fuel-Gas

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|
| | | | | | | 15% | |
| | | | | | | Discount Factor | |
| 0 | 1408.8 | 0.0 | 1408.8 | 0.0 | 1.0 | 1408.8 | 0.0 |
| 1 | 115640.1 | 0.0 | 115640.1 | 0.0 | 1.2 | 100556.6 | 0.0 |
| 2 | 39861.7 | 0.0 | 39861.7 | 0.0 | 1.3 | 30141.2 | 0.0 |
| 3 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 1.5 | 18373.2 | 33665.8 |
| 4 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 1.7 | 15976.7 | 29274.6 |
| 5 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 2.0 | 13892.8 | 25456.2 |
| 6 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 2.3 | 12080.7 | 22135.8 |
| 7 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 2.7 | 10505.0 | 19248.5 |
| 8 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 3.1 | 9134.8 | 16737.8 |
| 9 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 3.5 | 7943.3 | 14554.6 |
| 10 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 4.0 | 6907.2 | 12656.2 |
| 11 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 4.7 | 6006.2 | 11005.4 |
| 12 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 5.4 | 5222.8 | 9569.9 |
| 13 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 6.2 | 4541.6 | 8321.7 |
| 14 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 7.1 | 3949.2 | 7236.2 |
| 15 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 8.1 | 3434.1 | 6292.4 |
| 16 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 9.4 | 2986.2 | 5471.6 |
| 17 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 10.8 | 2596.7 | 4757.9 |
| 18 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 12.4 | 2258.0 | 4137.3 |
| 19 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 14.2 | 1963.5 | 3597.7 |
| 20 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 16.4 | 1707.4 | 3128.4 |
| 21 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 18.8 | 1484.7 | 2720.4 |
| 22 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 21.6 | 1291.0 | 2365.5 |
| 23 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 24.9 | 1122.6 | 2057.0 |
| | | | | | | **265484.1** | **244391.1** |

| | |
|---|---|
| **Discount Rate** | 15% |
| **NPV** | -21093.0 |
| **BCR** | 0.9 |

# Benefit Cost Ratio (Financial)
# Fuel-HFO

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at 15% Discount Factor | Discounted Value of Total Benefit at 15% Discount Factor |
|---|---|---|---|---|---|---|---|
| 0 | 1408.84000 | 0.00 | 1408.84 | 0.00 | 1.0000 | 1408.84 | 0.00 |
| 1 | 115640.09889 | 0.00 | 115640.10 | 0.00 | 1.1500 | 100556.61 | 0.00 |
| 2 | 39861.69528 | 0.00 | 39861.70 | 0.00 | 1.3225 | 30141.17 | 0.00 |
| 3 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 1.5208 | 76827.90 | 100997.35 |
| 4 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 1.7490 | 66806.87 | 87823.79 |
| 5 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 2.0113 | 58092.93 | 76368.51 |
| 6 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 2.3130 | 50515.59 | 66407.40 |
| 7 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 2.6600 | 43926.60 | 57745.56 |
| 8 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 3.0590 | 38197.04 | 50213.53 |
| 9 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 3.5178 | 33214.82 | 43663.94 |
| 10 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 4.0455 | 28882.45 | 37968.65 |
| 11 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 4.6523 | 25115.18 | 33016.21 |
| 12 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 5.3502 | 21839.28 | 28709.75 |
| 13 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 6.1527 | 18990.68 | 24965.00 |
| 14 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 7.0757 | 16513.64 | 21708.70 |
| 15 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 8.1370 | 14359.68 | 18877.13 |
| 16 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 9.3576 | 12486.68 | 16414.89 |
| 17 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 10.761 | 10857.98 | 14273.82 |
| 18 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 12.375 | 9441.72 | 12412.02 |
| 19 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 14.2317 | 8210.20 | 10793.06 |
| 20 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 16.3665 | 7139.30 | 9385.27 |
| 21 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 18.8215 | 6208.09 | 8161.10 |
| 22 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 21.6447 | 5398.34 | 7096.61 |
| 23 | 0.00000 | 116845.63 | 116845.63 | 153604.35 | 24.8914 | 4694.21 | 6170.97 |
| | | | | | | **689825.780** | **733173.267** |

| | |
|---|---|
| **Discount Rate** | 15% |
| **NPV** | 43347.4860 |
| **BCR** | 1.06283831 |

# Benefit Cost Ratio (Economical)
# Fuel-Gas

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at 15% Discount Factor | Discounted Value of Total Benefit at 15% Discount Factor |
|---|---|---|---|---|---|---|---|
| 0 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1.00 | 1155.25 | 0.00 |
| 1 | 112468.85 | 0.00 | 112468.85 | 0.00 | 1.15 | 97799.00 | 0.00 |
| 2 | 39650.17 | 0.00 | 39650.17 | 0.00 | 1.32 | 29981.23 | 0.00 |
| 3 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 1.52 | 9236.98 | 29274.60 |
| 4 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 1.75 | 8032.16 | 25456.17 |
| 5 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 2.01 | 6984.48 | 22135.80 |
| 6 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 2.31 | 6073.46 | 19248.52 |
| 7 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 2.66 | 5281.27 | 16737.84 |
| 8 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 3.06 | 4592.41 | 14554.65 |
| 9 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 3.52 | 3993.40 | 12656.22 |
| 10 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 4.05 | 3472.52 | 11005.40 |
| 11 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 4.65 | 3019.58 | 9569.92 |
| 12 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 5.35 | 2625.73 | 8321.67 |
| 13 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 6.15 | 2283.24 | 7236.23 |
| 14 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 7.08 | 1985.43 | 6292.38 |
| 15 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 8.14 | 1726.46 | 5471.63 |
| 16 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 9.36 | 1501.27 | 4757.94 |
| 17 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 10.76 | 1305.45 | 4137.34 |
| 18 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 12.38 | 1135.17 | 3597.69 |
| 19 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 14.23 | 987.11 | 3128.42 |
| 20 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 16.37 | 858.35 | 2720.37 |
| 21 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 18.82 | 746.40 | 2365.54 |
| 22 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 21.64 | 649.04 | 2056.99 |
| 23 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 24.89 | 564.38 | 1788.69 |
| | | | | | | 195989.76 | 212513.99 |

| Discount Rate | 15% |
|---|---|
| NPV | 16524.229 |
| BCR | 1.0843116 |

# Benefit Cost Ratio (Economical )
# Fuel-HFO

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at 15% Discount Factor | Discounted Value of Total Benefit at 15% Discount Factor |
|---|---|---|---|---|---|---|---|
| 0 | 1155.25 | 0 | 1155.25 | 0.00 | 1.00 | 1155.25 | 0.00 |
| 1 | 112468.85 | 0 | 112468.85 | 0.00 | 1.15 | 97799.00 | 0.00 |
| 2 | 39650.17 | 0 | 39650.17 | 0.00 | 1.32 | 29981.23 | 0.00 |
| 3 | 0 | 89593.6 | 89593.60 | 133569.00 | 1.52 | 58909.25 | 87823.79 |
| 4 | 0 | 89593.6 | 89593.60 | 133569.00 | 1.75 | 51225.43 | 76368.51 |
| 5 | 0 | 89593.6 | 89593.60 | 133569.00 | 2.01 | 44543.85 | 66407.40 |
| 6 | 0 | 89593.6 | 89593.60 | 133569.00 | 2.31 | 38733.79 | 57745.56 |
| 7 | 0 | 89593.6 | 89593.60 | 133569.00 | 2.66 | 33681.55 | 50213.53 |
| 8 | 0 | 89593.6 | 89593.60 | 133569.00 | 3.06 | 29288.31 | 43663.94 |
| 9 | 0 | 89593.6 | 89593.60 | 133569.00 | 3.52 | 25468.09 | 37968.65 |
| 10 | 0 | 89593.6 | 89593.60 | 133569.00 | 4.05 | 22146.17 | 33016.21 |
| 11 | 0 | 89593.6 | 89593.60 | 133569.00 | 4.65 | 19257.54 | 28709.75 |
| 12 | 0 | 89593.6 | 89593.60 | 133569.00 | 5.35 | 16745.68 | 24965.00 |
| 13 | 0 | 89593.6 | 89593.60 | 133569.00 | 6.15 | 14561.46 | 21708.70 |
| 14 | 0 | 89593.6 | 89593.60 | 133569.00 | 7.08 | 12662.14 | 18877.13 |
| 15 | 0 | 89593.6 | 89593.60 | 133569.00 | 8.14 | 11010.56 | 16414.89 |
| 16 | 0 | 89593.6 | 89593.60 | 133569.00 | 9.36 | 9574.40 | 14273.82 |
| 17 | 0 | 89593.6 | 89593.60 | 133569.00 | 10.76 | 8325.56 | 12412.02 |
| 18 | 0 | 89593.6 | 89593.60 | 133569.00 | 12.38 | 7239.62 | 10793.06 |
| 19 | 0 | 89593.6 | 89593.60 | 133569.00 | 14.23 | 6295.32 | 9385.27 |
| 20 | 0 | 89593.6 | 89593.60 | 133569.00 | 16.37 | 5474.19 | 8161.10 |
| 21 | 0 | 89593.6 | 89593.60 | 133569.00 | 18.82 | 4760.17 | 7096.61 |
| 22 | 0 | 89593.6 | 89593.60 | 133569.00 | 21.64 | 4139.28 | 6170.97 |
| 23 | 0 | 89593.6 | 89593.60 | 133569.00 | 24.89 | 3599.37 | 5366.06 |
| | | | | | | 556577.22 | 637541.97 |

| Discount Rate | 15% |
|---|---|
| NPV | 80964.7512 |
| BCR | 1.14546903 |

# 150 MW Internal Rate of Return (Financial)

## Fuel – Gas

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 12% | | 15% | | 16% | |
| 0 | 1408.8 | 0.0 | 1408.8 | 0.0 | 1408.8 | 0.0 | 1408.8 | 0.0 | 1408.8 | 0.0 |
| 1 | 115640.1 | 0.0 | 115640.1 | 0.0 | 103250.1 | 0.0 | 100556.6 | 0.0 | 99689.7 | 0.0 |
| 2 | 39861.7 | 0.0 | 39861.7 | 0.0 | 31777.5 | 0.0 | 30141.2 | 0.0 | 29623.7 | 0.0 |
| 3 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 19889.6 | 36444.2 | 18373.2 | 33665.8 | 17902.2 | 32802.6 |
| 4 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 17758.5 | 32539.4 | 15976.7 | 29274.6 | 15432.9 | 28278.1 |
| 5 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 15855.8 | 29053.1 | 13892.8 | 25456.2 | 13304.2 | 24377.7 |
| 6 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 14157.0 | 25940.2 | 12080.7 | 22135.8 | 11469.2 | 21015.2 |
| 7 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 12640.2 | 23160.9 | 10505.0 | 19248.5 | 9887.2 | 18116.6 |
| 8 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 11285.9 | 20679.4 | 9134.8 | 16737.8 | 8523.5 | 15617.7 |
| 9 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 10076.7 | 18463.8 | 7943.3 | 14554.6 | 7347.8 | 13463.6 |
| 10 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 8997.0 | 16485.5 | 6907.2 | 12656.2 | 6334.3 | 11606.5 |
| 11 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 8033.1 | 14719.2 | 6006.2 | 11005.4 | 5460.6 | 10005.6 |
| 12 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 7172.4 | 13142.1 | 5222.8 | 9569.9 | 4707.4 | 8625.5 |
| 13 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 6403.9 | 11734.1 | 4541.6 | 8321.7 | 4058.1 | 7435.8 |
| 14 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 5717.8 | 10476.8 | 3949.2 | 7236.2 | 3498.4 | 6410.2 |
| 15 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 5105.2 | 9354.3 | 3434.1 | 6292.4 | 3015.8 | 5526.0 |
| 16 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 4558.2 | 8352.1 | 2986.2 | 5471.6 | 2599.9 | 4763.8 |
| 17 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 4069.8 | 7457.2 | 2596.7 | 4757.9 | 2241.3 | 4106.7 |
| 18 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 3633.8 | 6658.2 | 2258.0 | 4137.3 | 1932.1 | 3540.3 |
| 19 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 3244.4 | 5944.8 | 1963.5 | 3597.7 | 1665.6 | 3052.0 |
| 20 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 2896.8 | 5307.9 | 1707.4 | 3128.4 | 1435.9 | 2631.0 |
| 21 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 2586.4 | 4739.2 | 1484.7 | 2720.4 | 1237.8 | 2268.1 |
| 22 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 2309.3 | 4231.4 | 1291.0 | 2365.5 | 1067.1 | 1955.3 |
| 23 | 0.0 | 27943.4 | 27943.4 | 51201.5 | 2061.9 | 3778.1 | 1122.6 | 2057.0 | 919.9 | 1685.6 |
| | | | | | 304890.0 | 308661.9 | 265484.1 | 244391.1 | 254763.6 | 227284.0 |

| Discount Rate: | 12% | 15% | 16% |
|---|---|---|---|
| NPV | 3771.90222 | -21093.03 | -27479.55 |
| BCR | 1.01237135 | 0.920548 | 0.8921370 |
| IRR: | | | 12.48% |

# 150 MW Internal Rate of Return (Financial )

## Fuel – HFO

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 13% | | 15% | | 20% | |
| 0 | 1408.8 | 0 | 1408.84 | 0 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1408.84 | 0.00 |
| 1 | 115640.1 | 0 | 115640.10 | 0 | 102336.37 | 0.00 | 100556.61 | 0.00 | 96366.75 | 0.00 |
| 2 | 39861.7 | 0 | 39861.70 | 0 | 31217.55 | 0.00 | 30141.17 | 0.00 | 27681.73 | 0.00 |
| 3 | 0 | 116845.63 | 116845.63 | 153604.4 | 80979.88 | 106455.52 | 76827.90 | 100997.35 | 67619.00 | 88891.41 |
| 4 | 0 | 116845.63 | 116845.63 | 153604.4 | 71663.61 | 94208.42 | 66806.87 | 87823.79 | 56349.16 | 74076.17 |
| 5 | 0 | 116845.63 | 116845.63 | 153604.4 | 63419.12 | 83370.29 | 58092.93 | 76368.51 | 46957.64 | 61730.14 |
| 6 | 0 | 116845.63 | 116845.63 | 153604.4 | 56123.12 | 73779.02 | 50515.59 | 66407.40 | 39131.36 | 51441.79 |
| 7 | 0 | 116845.63 | 116845.63 | 153604.4 | 49666.48 | 65291.16 | 43926.60 | 57745.56 | 32609.47 | 42868.16 |
| 8 | 0 | 116845.63 | 116845.63 | 153604.4 | 43952.63 | 57779.79 | 38197.04 | 50213.53 | 27174.56 | 35723.46 |
| 9 | 0 | 116845.63 | 116845.63 | 153604.4 | 38896.14 | 51132.56 | 33214.82 | 43663.94 | 22645.47 | 29769.55 |
| 10 | 0 | 116845.63 | 116845.63 | 153604.4 | 34421.36 | 45250.05 | 28882.45 | 37968.65 | 18871.22 | 24807.96 |
| 11 | 0 | 116845.63 | 116845.63 | 153604.4 | 30461.38 | 40044.29 | 25115.18 | 33016.21 | 15726.02 | 20673.30 |
| 12 | 0 | 116845.63 | 116845.63 | 153604.4 | 26956.97 | 35437.43 | 21839.28 | 28709.75 | 13105.01 | 17227.75 |
| 13 | 0 | 116845.63 | 116845.63 | 153604.4 | 23855.73 | 31360.56 | 18990.68 | 24965.00 | 10920.85 | 14356.46 |
| 14 | 0 | 116845.63 | 116845.63 | 153604.4 | 21111.26 | 27752.70 | 16513.64 | 21708.70 | 9100.70 | 11963.72 |
| 15 | 0 | 116845.63 | 116845.63 | 153604.4 | 18682.54 | 24559.92 | 14359.68 | 18877.13 | 7583.92 | 9969.76 |
| 16 | 0 | 116845.63 | 116845.63 | 153604.4 | 16533.22 | 21734.44 | 12486.68 | 16414.89 | 6319.93 | 8308.14 |
| 17 | 0 | 116845.63 | 116845.63 | 153604.4 | 14631.17 | 19234.02 | 10857.98 | 14273.82 | 5266.61 | 6923.45 |
| 18 | 0 | 116845.63 | 116845.63 | 153604.4 | 12947.93 | 17021.25 | 9441.72 | 12412.02 | 4388.84 | 5769.54 |
| 19 | 0 | 116845.63 | 116845.63 | 153604.4 | 11458.35 | 15063.06 | 8210.20 | 10793.06 | 3657.37 | 4807.95 |
| 20 | 0 | 116845.63 | 116845.63 | 153604.4 | 10140.13 | 13330.14 | 7139.30 | 9385.27 | 3047.81 | 4006.62 |
| 21 | 0 | 116845.63 | 116845.63 | 153604.4 | 8973.57 | 11796.58 | 6208.09 | 8161.10 | 2539.84 | 3338.85 |
| 22 | 0 | 116845.63 | 116845.63 | 153604.4 | 7941.21 | 10439.45 | 5398.34 | 7096.61 | 2116.53 | 2782.38 |
| 23 | 0 | 116845.63 | 116845.63 | 153604.4 | 7027.62 | 9238.45 | 4694.21 | 6170.97 | 1763.78 | 2318.65 |
| | | | | | 784806.19 | 854279.10 | 689825.78 | 733173.27 | 522352.42 | 521755.20 |

| Discount Rate: | 13% | 15% | 20% |
|---|---|---|---|
| NPV | 69472.9109 | 43347.4861 | -597.21892 |
| BCR | 1.08852238 | 1.06283831 | 0.99885667 |
| IRR: | | | 19.94% |

# 150 MW Internal Rate of Return (Economic)

## Fuel – Gas

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 13% | | 15% | | 17% | |
| 0 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 |
| 1 | 112468.85 | 0.00 | 112468.85 | 0.00 | 99529.96 | 0.00 | 97799.00 | 0.00 | 96127.22 | 0.00 |
| 2 | 39650.17 | 0.00 | 39650.17 | 0.00 | 31051.90 | 0.00 | 29981.23 | 0.00 | 28964.99 | 0.00 |
| 3 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 9736.17 | 30856.67 | 9236.98 | 29274.60 | 8771.34 | 27798.85 |
| 4 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 8616.08 | 27306.79 | 8032.16 | 25456.17 | 7496.87 | 23759.70 |
| 5 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 7624.85 | 24165.30 | 6984.48 | 22135.80 | 6407.58 | 20307.44 |
| 6 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 6747.65 | 21385.22 | 6073.46 | 19248.52 | 5476.57 | 17356.78 |
| 7 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 5971.37 | 18924.98 | 5281.27 | 16737.84 | 4680.83 | 14834.86 |
| 8 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 5284.40 | 16747.77 | 4592.41 | 14554.65 | 4000.71 | 12679.37 |
| 9 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 4676.46 | 14821.03 | 3993.40 | 12656.22 | 3419.41 | 10837.06 |
| 10 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 4138.46 | 13115.96 | 3472.52 | 11005.40 | 2922.57 | 9262.45 |
| 11 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 3662.36 | 11607.04 | 3019.58 | 9569.92 | 2497.92 | 7916.62 |
| 12 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 3241.02 | 10271.72 | 2625.73 | 8321.67 | 2134.98 | 6766.34 |
| 13 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 2868.16 | 9090.02 | 2283.24 | 7236.23 | 1824.77 | 5783.20 |
| 14 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 2538.20 | 8044.26 | 1985.43 | 6292.38 | 1559.63 | 4942.91 |
| 15 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 2246.19 | 7118.82 | 1726.46 | 5471.63 | 1333.02 | 4224.71 |
| 16 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 1987.78 | 6299.84 | 1501.27 | 4757.94 | 1139.33 | 3610.86 |
| 17 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 1759.10 | 5575.08 | 1305.45 | 4137.34 | 973.79 | 3086.20 |
| 18 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 1556.72 | 4933.70 | 1135.17 | 3597.69 | 832.30 | 2637.78 |
| 19 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 1377.63 | 4366.10 | 987.11 | 3128.42 | 711.36 | 2254.51 |
| 20 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 1219.14 | 3863.81 | 858.35 | 2720.37 | 608.00 | 1926.94 |
| 21 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 1078.89 | 3419.30 | 746.40 | 2365.54 | 519.66 | 1646.95 |
| 22 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 954.77 | 3025.93 | 649.04 | 2056.99 | 444.15 | 1407.65 |
| 23 | 0.00 | 14048.29 | 14048.29 | 44523.00 | 844.93 | 2677.81 | 564.38 | 1788.69 | 379.62 | 1203.12 |
| | | | | | 209867.44 | 247617.13 | 195989.76 | 212513.99 | 184381.85 | 184244.31 |

| Discount Rate: | 13% | 15% | 17% |
|---|---|---|---|
| NPV | 37749.687 | 16524.229 | -137.5349 |
| BCR | 1.1798739 | 1.0843116 | 0.9992540 |
| IRR: | | | 16.99% |

# 150 MW Internal Rate of Return (Economic)

## Fuel – HFO

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 15% | | 20% | | 25% | |
| 0 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 |
| 1 | 112468.85 | 0.00 | 112468.8 | 0.00 | 97799.00 | 0.00 | 93724.04 | 0.00 | 89975.08 | 0.00 |
| 2 | 39650.17 | 0.00 | 39650.17 | 0.00 | 29981.23 | 0.00 | 27534.84 | 0.00 | 25376.11 | 0.00 |
| 3 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 58909.25 | 87823.79 | 51848.15 | 77296.88 | 45871.92 | 68387.33 |
| 4 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 51225.43 | 76368.51 | 43206.79 | 64414.06 | 36697.54 | 54709.86 |
| 5 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 44543.85 | 66407.40 | 36005.66 | 53678.39 | 29358.03 | 43767.89 |
| 6 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 38733.79 | 57745.56 | 30004.72 | 44731.99 | 23486.42 | 35014.31 |
| 7 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 33681.55 | 50213.53 | 25003.93 | 37276.66 | 18789.14 | 28011.45 |
| 8 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 29288.31 | 43663.94 | 20836.61 | 31063.88 | 15031.31 | 22409.16 |
| 9 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 25468.09 | 37968.65 | 17363.84 | 25886.57 | 12025.05 | 17927.33 |
| 10 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 22146.17 | 33016.21 | 14469.87 | 21572.14 | 9620.04 | 14341.86 |
| 11 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 19257.54 | 28709.75 | 12058.22 | 17976.78 | 7696.03 | 11473.49 |
| 12 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 16745.68 | 24965.00 | 10048.52 | 14980.65 | 6156.83 | 9178.79 |
| 13 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 14561.46 | 21708.70 | 8373.77 | 12483.88 | 4925.46 | 7343.03 |
| 14 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 12662.14 | 18877.13 | 6978.14 | 10403.23 | 3940.37 | 5874.43 |
| 15 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 11010.56 | 16414.89 | 5815.11 | 8669.36 | 3152.29 | 4699.54 |
| 16 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 9574.40 | 14273.82 | 4845.93 | 7224.47 | 2521.84 | 3759.63 |
| 17 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 8325.56 | 12412.02 | 4038.27 | 6020.39 | 2017.47 | 3007.71 |
| 18 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 7239.62 | 10793.06 | 3365.23 | 5016.99 | 1613.97 | 2406.17 |
| 19 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 6295.32 | 9385.27 | 2804.36 | 4180.83 | 1291.18 | 1924.93 |
| 20 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 5474.19 | 8161.10 | 2336.96 | 3484.02 | 1032.94 | 1539.95 |
| 21 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 4760.17 | 7096.61 | 1947.47 | 2903.35 | 826.36 | 1231.96 |
| 22 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 4139.28 | 6170.97 | 1622.89 | 2419.46 | 661.08 | 985.57 |
| 23 | 0.00 | 89593.60 | 89593.60 | 133569.00 | 3599.37 | 5366.06 | 1352.41 | 2016.22 | 528.87 | 788.45 |
| | | | | | 556577.22 | 637541.97 | 426740.97 | 453700.17 | 343750.58 | 338782.83 |

| Discount Rate: | 15% | 20% | 25% |
|---|---|---|---|
| NPV | 80964.75 | 26959.20 | -4967.75 |
| BCR | 1.15 | 1.06 | 0.99 |
| IRR: | | | 24.42 % |

# SCHEDULE

# ANNEXURE – 2

**Cost Estimation and Economic Analysis of 225 MW Combined Cycle Power Plant at Shikalbaha**

# 225 MW Total Investment Cost

| Direct Cost | | | | | |
|---|---|---|---|---|---|
| 150 MW Plant Cost, C | New Plant (MW) | Factor $(Q/Q_o)^a$ | Direct Cost $C*(Q/Q_o)^a$ | Cost Escalation | Total Direct Cost at 2014 |
| | | 0.65 | | | |
| 80799.84 | **225** | **1.30** | **105164.6593** | 30% | **136714.0571** |
| | 150 | 1.0 | 80799.84 | | 105039.79 |
| | 300 | 1.57 | 126788.54 | | 164825.102 |
| | 450 | 2.042343632 | 165021.0387 | | 214527.3503 |

| Indirect Cost (Custom Duty, Taxes & VAT, C & F Cost, Landing Charges etc.) | | | | | |
|---|---|---|---|---|---|
| 150 MW Plant Cost, C | New Plant (MW) | Factor $(Q/Q_o)^a$ | Direct Cost $C*(Q/Q_o)^a$ | Cost Escalation | Total Direct Cost at 2014 |
| | | 0.3 | | | |
| 20261.709 | **225** | **1.13** | **22882.49897** | 30% | **29747.24866** |
| | 150 | 1.0 | 20261.709 | | 26340.22 |
| | 300 | 1.23 | 24945.09 | | 32428.618 |
| | 450 | 1.39038917 | 28171.66077 | | 36623.159 |

| Indirect Cost (Erection & Commissioning) | | | | | |
|---|---|---|---|---|---|
| 150 MW Plant Cost, C | New Plant (MW) | Factor $(Q/Q_o)^a$ | Direct Cost $C*(Q/Q_o)^a$ | Cost Escalation | Total Direct Cost at 2014 |
| | | 0.5 | | | |
| 8150.1 | **225** | **1.22** | **9981.793176** | 30% | **12976.33113** |
| | 150 | 1.0 | 8150.1 | | 10595.13 |
| | 300 | 1.41 | 11525.98 | | 14983.78 |
| | 450 | 1.732 | 14116.38729 | | 18351.30347 |

# Detailed Breakdown of Investment Cost

Installation of a 225 MW Combined Cycle
Power Plant at Shikalbaha

| Sl. No. | Item | L.C. | F.C. | Total | % of Cost |
|---|---|---|---|---|---|
| I) | **Pre-Construction Expendeture** | | | | |
| | Land acquisition & Land Development | 865 | 0 | 865 | 0.437 |
| | **Sub-Total – I** | **865** | **0** | **865** | **0.437** |
| II) | **Construction Works (based on PWD** | | | | |
| | **rate 2011)** | | | | |
| | Residential, Non Residential and fuel | 811.3 | 0 | 811.3 | 0.410 |
| | unloading system | | | | |
| | (Administrative building 17,000/- per m² | | | | |
| | Internal Road (RCC) @ Tk. 2509/m² ) | | | | |
| | Deep Tube-well & pump house | 40 | 0 | 40 | 0.020 |
| | **Sub-Total – II** | **851.3** | **0** | **851.3** | **0.430** |
| III) | **Machinery, Equipment & Spares** | | | | |
| | Supply of material & Equipment | 27342.8116 | 109371.2 | 136714.1 | 69.066 |
| | Engineering Design | 0 | 29747 | 29747 | 15.028 |
| | Erection & Commissioning | 6358.4066 | 6618 | 12976 | 6.555 |
| | Training | 250 | 270 | 520 | 0.263 |
| | Pre-Shipment inspection @0.5% | 0 | 683.5703 | 683.57029 | 0.345 |
| | **Sub-Total – III** | **33951.2182** | **146690** | **180641** | **91.257** |
| IV) | **Transport Vehicle** | | | | |
| | Rental @ Tk. 3000/day for 700 days | 21 | 0 | 21 | 0.011 |
| | during project implementation | | | | |
| | **Sub-Total – IV** | **21** | 0 | **21** | **0.011** |
| V) | **Other Cost** | | | | |
| | Charge of electrical energy during construction | 8 | 0 | 8 | 0.004 |
| | Interest during construction @ 3% p.a. | 3281.137 | 0 | 3281.14 | 1.658 |
| | Bank Charges @ 1.25% | 1367.141 | 0 | 1367.14 | 0.691 |
| | Insurance @ 3% on imported materials | 3281.137 | 0 | 3281.14 | 1.658 |
| | Project office expenditure | 17.650 | 0 | 17.65 | 0.009 |
| | Physical Contingency (2% of the total items) | 872.872 | 2933.8 | 3806.67 | 1.923 |
| | Price Contingency (2% of the total cost) | 872.872 | 2933.8 | 3806.67 | 1.923 |
| | **Sub-Total – V** | **9700.809** | **5867.6** | **15568.41** | **7.865** |
| **Total Investment Cost** | | **45389.32691** | **152558** | **197947** | 100.000 |

# 225 MW Annual Phasing Cost

| Sl. | Dsecription | Year 01 | | | | |
|---|---|---|---|---|---|---|
| | | GOB | Project Aid | | DPA | Total |
| | | | RPA | | | |
| | | | Through GOB | Special AC | | |
| **A)** | **Supplies & Services** | | | | | |
| | Travel Expenses | 0.8 | | | | 0.8 |
| | Postal | 0.32 | | | | 0.32 |
| | Telephone / Fax | 0.6 | | | | 0.6 |
| | Bank Charges @ 1.25% | 0 | | | | 0 |
| | Insurance @ 3% on imported materials | 0 | | | | 0 |
| | Duties & Taxes on Imported Materials & Equipments @ 3% | 0 | | | | 0 |
| | Stationaries, Seal & Stumps | 0.4 | | | | 0.4 |
| | Entertainment | 0.4 | | | | 0.4 |
| | Casual Labour | 0.3 | | | | 0.3 |
| | Copy / Photo Copy | 0.2 | | | | 0.2 |
| | Computer Accessories | 0.12 | | | | 0.12 |
| | Computer and office equipment | 0.3 | | | | 0.3 |
| | Utility Charge | 3 | | | | 3 |
| | **Sub-Total** | **6.44** | | | | **6.44** |
| | **Acquisition of Asset** | | | | | |
| | Vehicle (Rental) | 6.3 | | | | 6.3 |
| | Machinery Equipment & Spares | 0 | | | | 0 |
| | Pre-Shipment Inspection Cost @0.50% | 0 | | | | 0 |
| | A/C, Computer, Laser Printer, Color Printer, Scanner & Photocopier | 5 | | | | 5 |
| | Office Equipment | 0.8 | | | | 0.8 |
| | Furniture | 3 | | | | 3 |
| | Deep Tube Well & Pump House | 8 | | | | 8 |
| **B)** | **Land Properties** | | | | | |
| | Land Acquisition | 765 | | | | 765 |
| | **Construction Works** | | | | | |
| | Land Development | 60 | | | | 60 |
| | Building Works | 280.3 | | | | 280.3 |
| | Doors, Windows & Finishing | 240 | | | | 240 |
| | Internal Road (RCC) | 20 | | | | 20 |
| | Drainage System | 14 | | | | 14 |
| | **Sub-Total** | **1402.4** | | | | **1402.4** |
| **C)** | **Physical Contengency** | 0 | | | | 0 |
| **D)** | **Price Contengency** | 0 | | | | 0 |
| | **Total (A+B+C+D)** | **1408.84** | | | | **1408.84** |

| Sl | Dsecription | Year 02 | | | | |
|---|---|---|---|---|---|---|
| | | GOB | Project Aid | | DPA | Total |
| | | | RPA | | | |
| | | | Through GOB | Special AC | | |
| **A)** | **Supplies & Services** | | | | | |
| | Travel Expenses | 0.6 | | | | 0.6 |
| | Postal | 0.08 | | | | 0.08 |
| | Telephone / Fax | 0.6 | | | | 0.6 |
| | Bank Charges @ 1.25% | 1367.14058 | | | | 1367.14058 |
| | Insurance @ 3% on imported materials | 3281.13739 | | | | 3281.13739 |
| | Duties & Taxes on Imported Materials & Equipments @ 3% | 3281.13739 | | | | 3281.13739 |
| | Stationaries, Seal & Stumps | 0.3 | | | | 0.3 |
| | Entertainment | 0.3 | | | | 0.3 |
| | Casual Labour | 0.3 | | | | 0.3 |
| | Copy / Photo Copy | 0.15 | | | | 0.15 |
| | Computer Accessories | 0.09 | | | | 0.09 |
| | Computer and office equipment | 0.3 | | | | 0.3 |
| | Utility Charge | 2.5 | | | | 2.5 |
| | **Sub-Total** | **7934.63536** | | | | **7934.63536** |
| | **Acquisition of Asset** | | | | | |
| | Vehicle (Rental) | 6.3 | | | | 6.3 |
| | Machinery Equipment & Spares | 134968.236 | | | | 134968.236 |
| | Pre-Shipment Inspection Cost @0.50% | 683.57029 | | | | 683.57029 |
| | A/C, Computer, Laser Printer, Color Printer, Scanner & Photocopier | 0 | | | | 0 |
| | Office Equipment | 0.2 | | | | 0.2 |
| | Furniture | 0 | | | | 0 |
| | Deep Tube Well & Pump House | 32 | | | | 32 |
| **B)** | **Land Properties** | | | | | |
| | Land Acquisition | 0 | | | | 0 |
| | **Construction Works** | | | | | |
| | Land Development | 40 | | | | 40 |
| | Building Works | 130 | | | | 130 |
| | Doors , Windows & Finishing | 110 | | | | 110 |
| | Internal Road (RCC) | 10 | | | | 10 |
| | Drainage System | 7 | | | | 7 |
| | **Sub-Total** | **135987.306** | | | | **135987.306** |
| **C)** | **Physical Contengency** | **1142.0015** | | | | **1142.0015** |
| **D)** | **Price Contengency** | **1142.0015** | | | | **1142.0015** |
| | **Total (A+B+C+D)** | **146205.945** | | | | **146205.945** |

| Sl | Dsecription | Year 03 | | | | |
|---|---|---|---|---|---|---|
| | | GOB | Project Aid | | DPA | Total |
| | | | RPA | | | |
| | | | Through GOB | Special AC | | |
| **A)** | **Supplies & Services** | | | | | |
| | Travel Expenses | 0.6 | | | | 0.6 |
| | Postal | 0 | | | | 0 |
| | Telephone / Fax | 0.6 | | | | 0.6 |
| | Bank Charges @ 1.25% | 0 | | | | 0 |
| | Insurance @ 3% on imported materials | 0 | | | | 0 |
| | Duties & Taxes on Imported Materials & Equipments @ 3% | 0 | | | | 0 |
| | Stationaries, Seal & Stumps | 0.3 | | | | 0.3 |
| | Entertainment | 0.3 | | | | 0.3 |
| | Casual Labour | 0.3 | | | | 0.3 |
| | Copy / Photo Copy | 0.15 | | | | 0.15 |
| | Computer Accessories | 0.09 | | | | 0.09 |
| | Computer and office equipment | 0.15 | | | | 0.15 |
| | Utility Charge | 2.5 | | | | 2.5 |
| | **Sub-Total** | **4.99** | | | | **4.99** |
| | **Acquisition of Asset** | | | | | |
| | Vehicle (Rental) | 8.4 | | | | 8.4 |
| | Machinery Equipment & Spares | 44989.4 | | | | 44989.4 |
| | Pre-Shipment Inspection Cost @0.50% | 0 | | | | 0 |
| | A/C , Computer, Laser Printer, Color Printer, Scanner & Photocopier | 0 | | | | 0 |
| | Office Equipment | 0 | | | | 0 |
| | Furniture | 0 | | | | 0 |
| | Deep Tube Well & Pump House | 0 | | | | 0 |
| **B)** | **Land Properties** | 0 | | | | 0 |
| | Land Acquisition | 0 | | | | 0 |
| | **Construction Works** | | | | | |
| | Land Development | 0 | | | | 0 |
| | Building Works | 0 | | | | 0 |
| | Doors, Windows & Finishing | 0 | | | | 0 |
| | Internal Road (RCC) | 0 | | | | 0 |
| | Drainage System | 0 | | | | 0 |
| | Sub-Total | **44997.8** | | | | **44997.8** |
| **C)** | **Physical Contengency** | **2664.67** | | | | **2664.67** |
| **D)** | **Price Contengency** | **2664.67** | | | | **2664.67** |
| | **Total (A+B+C+D)** | **50332.1** | | | | **50332.1** |

# 225 MW Economic Value of Investment Cost

| Sl. No. | Item of Cost | Year – 1 | | | Year – 2 | | | Year - 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **PV** | **SCF** | **AV** | **PV** | **SCF** | **AV** | **PV** | **SCF** | **AV** |
| | | | | | | | | | | |
| I) | Revenue Component | | | | | | | | | |
| | a) Foreign Currency | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| | b) Local Currency | 6.44 | 0.82 | 5.2808 | 7934.6354 | 0.82 | 6506.401 | 4.99 | 0.82 | 4.0918 |
| | | | | | | | | | | |
| II) | Capital Component | | | | | | | | | |
| | a) Foreign Currency | 0 | 1 | 0 | 122154.98 | 1 | 122154.98 | 44989.41 | 1 | 44989.412 |
| | b) Local Currency | 1402.4 | 0.82 | 1149.97 | 13832.324 | 0.82 | 11342.505 | 8.4 | 0.82 | 6.888 |
| | | | | | | | | | | |
| III) | Physical Contingency | | | | | | | | | |
| | a) Foreign Currency | 0 | 1 | 0 | 827.95109 | 1 | 827.95109 | 1931.886 | 1 | 1931.8859 |
| | b) Local Currency | 0 | 0.82 | 0 | 314.05041 | 0.82 | 257.52134 | 732.7843 | 0.82 | 600.88312 |
| | | | | | | | | | | |
| IV) | Price Contingency | | | | | | | | | |
| | a) Foreign Currency | 0 | 1 | 0 | 827.95109 | 1 | 827.95109 | 1931.886 | 1 | 1931.8859 |
| | b) Local Currency | 0 | 0.82 | 0 | 314.05041 | 0.82 | 257.52134 | 732.7843 | 0.82 | 600.88312 |
| | **Total** | 1408.84 | | **1155.25** | 146205.94 | | **142174.8** | 50332.14 | | **50065.93** |

# 225 MW Financial Operating / Recurring Cost Table (Fuel –Gas)

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 1 -7 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 18787.48 | 0 | 18787.48 |
| ii) | Utilities (Power, Water, Gas) | 13.5 | 0 | 13.5 |
| iii) | Manpower Salary, Wages & Allowances | 209.25 | 0 | 209.25 |
| iv) | Machine & Equipment Depriciation | 9032.0609 | 0 | 9032.0609 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 108 | 0 | 108 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 10017.675 | 0 | 10017.675 |
| **Total Operating Cost** | | **38193.51** | **0** | **38193.51** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 8-14 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 18787.48 | 0 | 18787.48 |
| ii) | Utilities (Power, Water, Gas) | 13.5 | 0 | 13.5 |
| iii) | Manpower Salary, Wages & Allowances | 209.25 | 0 | 209.25 |
| iv) | Machine & Equipment Depriciation | 9032.0609 | 0 | 9032.0609 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 108 | 0 | 108 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 10017.675 | 0 | 10017.675 |
| **Total Operating Cost** | | **38193.51** | **0** | **38193.51** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 15-21 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 18787.48 | 0 | 18787.48 |
| ii) | Utilities (Power, Water, Gas) | 13.5 | 0 | 13.5 |
| iii) | Manpower Salary, Wages & Allowances | 209.25 | 0 | 209.25 |
| iv) | Machine & Equipment Depriciation | 9032.0609 | 0 | 9032.0609 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 108 | 0 | 108 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 10017.675 | 0 | 10017.675 |
| **Total Operating Cost** | | **38193.51** | **0** | **38193.51** |

# 225 MW Financial Operating / Recurring Cost Table (Fuel –HFO)

| Operating / Recurring Cost For HFO | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 1-7 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 134083.08 | 0 | 134083.08 |
| ii) | Utilities (Power, Water, Gas) | 13.5 | 0 | 13.5 |
| iii) | Manpower Salary, Wages & Allowances | 209.25 | 0 | 209.25 |
| iv) | Machine & Equipment Depriciation | 9032.060915 | 0 | 9032.060915 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 108 | 0 | 108 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 30053.025 | 0 | 30053.025 |
| **Total Operating Cost** | | **173524.4549** | **0** | **173524.4549** |

| Operating / Recurring Cost For HFO | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 8-14 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 134083.08 | 0 | 134083.08 |
| ii) | Utilities (Power, Water, Gas) | 13.5 | 0 | 13.5 |
| iii) | Manpower Salary, Wages & Allowances | 209.25 | 0 | 209.25 |
| iv) | Machine & Equipment Depriciation | 9032.060915 | 0 | 9032.060915 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 108 | 0 | 108 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 30053.025 | 0 | 30053.025 |
| **Total Operating Cost** | | **173524.4549** | **0** | **173524.4549** |

| Operating / Recurring Cost For HFO | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 15-21 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 134083.08 | 0 | 134083.08 |
| ii) | Utilities (Power, Water, Gas) | 13.5 | 0 | 13.5 |
| iii) | Manpower Salary, Wages & Allowances | 209.25 | 0 | 209.25 |
| iv) | Machine & Equipment Depriciation | 9032.060915 | 0 | 9032.060915 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 108 | 0 | 108 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 30053.025 | 0 | 30053.025 |
| **Total Operating Cost** | | **173524.4549** | **0** | **173524.4549** |

# 225 MW Economical Operating / Recurring Cost Table (Fuel –Gas)

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. | Item of Cost | Year 1-7 | | |
| | | PV | SCF | AV |
| i) | Raw Materials | 18787.484 | 1 | 18787.484 |
| ii) | Utilities (Power, Water, Gas) | 13.5 | 1.11 | 14.985 |
| iii) | Manpower Salary, Wages & Allowances | 209.25 | 0.82 | 171.585 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 100 | 0.82 | 82 |
| | Foreign Currency | 8 | 1 | 8 |
| **Total Operating Cost** | | **19118.23** | | **19064.05** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. | Item of Cost | Year 8-14 | | |
| | | PV | SCF | AV |
| i) | Raw Materials | 18787.484 | 1 | 18787.484 |
| ii) | Utilities (Power, Water, Gas) | 13.5 | 1.11 | 14.985 |
| iii) | Manpower Salary, Wages & Allowances | 209.25 | 0.82 | 171.585 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 100 | 0.82 | 82 |
| | Foreign Currency | 8 | 1 | 8 |
| **Total Operating Cost** | | **19118.23** | | **19064.05** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. | Item of Cost | Year 15-21 | | |
| | | PV | SCF | AV |
| i) | Raw Materials | 18787.484 | 1 | 18787.484 |
| ii) | Utilities (Power, Water, Gas) | 13.5 | 1.11 | 14.985 |
| iii) | Manpower Salary, Wages & Allowances | 209.25 | 0.82 | 171.585 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 100 | 0.82 | 82 |
| | Foreign Currency | 8 | 1 | 8 |
| **Total Operating Cost** | | **19118.23** | | **19064.05** |

# 225 MW Economical Operating / Recurring Cost Table (Fuel –HFO)

| SL. | Item of Cost | Year 1-7 | | |
|---|---|---|---|---|
| | | L.C | F.C. | Total |
| i) | Raw Materials | 134083.1 | 1 | 134083.1 |
| ii) | Utilities (Power, Water, Gas) | 13.5 | 1.11 | 14.985 |
| iii) | Manpower Salary, Wages & Allowances | 209.25 | 0.82 | 171.585 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 100 | 0.82 | 82 |
| | Foreign Currency | 8 | 1 | 8 |
| **Total Operating Cost** | | **134413.8** | **0** | **134359.7** |

| SL. | Item of Cost | Year 8-14 | | |
|---|---|---|---|---|
| | | L.C | F.C. | Total |
| i) | Raw Materials | 134083.1 | 1 | 134083.1 |
| ii) | Utilities (Power, Water, Gas) | 13.5 | 1.11 | 14.985 |
| iii) | Manpower Salary, Wages & Allowances | 209.25 | 0.82 | 171.585 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 100 | 0.82 | 82 |
| | Foreign Currency | 8 | 1 | 8 |
| **Total Operating Cost** | | **134413.8** | **0** | **134359.7** |

| SL. | Item of Cost | Year 15-21 | | |
|---|---|---|---|---|
| | | L.C | F.C. | Total |
| i) | Raw Materials | 134083.1 | 1 | 134083.1 |
| ii) | Utilities (Power, Water, Gas) | 13.5 | 1.11 | 14.985 |
| iii) | Manpower Salary, Wages & Allowances | 209.25 | 0.82 | 171.585 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 100 | 0.82 | 82 |
| | Foreign Currency | 8 | 1 | 8 |
| **Total Operating Cost** | | **134413.8** | **0** | **134359.7** |

# Generation Cost / Unit

## Fuel – Gas

| Capacity | Opearating Cost | VAT Cost | Gas Cost | Total Cost | Total Generation | Unit Cost |
|---|---|---|---|---|---|---|
| (MW) | Lakh TK. | Lakh TK. | Lakh TK. | Lakh TK. | KWH | |
| | | | | | | |
| 225 | 330.75 | 7199.552 | 18787.5 | 26317.79 | 1484100000 | **1.77332** |

## Fuel - HFO

| Capacity | Opearating Cost | VAT Cost | HFO Cost | Total Cost | Total Generation | Unit Cost |
|---|---|---|---|---|---|---|
| (MW) | Lakh TK. | Lakh TK. | Lakh TK. | Lakh TK. | KWH | |
| | | | | | | |
| 225 | 330.75 | 9940.563 | 134083 | 144354.4 | 1484100000 | **9.72673** |

# Benefit Cost Ratio (Financial)
# Fuel-Gas

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|
| | | | | | | 15% | |
| | | | | | | Discount Factor | |
| 0 | 1408.8 | 0.0 | 1408.8 | 0.0 | 1.0 | 1408.8 | 0.0 |
| 1 | 146205.9 | 0.0 | 146205.9 | 0.0 | 1.2 | 127135.6 | 0.0 |
| 2 | 50332.1 | 0.0 | 50332.1 | 0.0 | 1.3 | 38058.3 | 0.0 |
| 3 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 1.5 | 25112.9 | 50498.7 |
| 4 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 1.7 | 21837.3 | 43911.9 |
| 5 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 2.0 | 18988.9 | 38184.3 |
| 6 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 2.3 | 16512.1 | 33203.7 |
| 7 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 2.7 | 14358.4 | 28872.8 |
| 8 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 3.1 | 12485.5 | 25106.8 |
| 9 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 3.5 | 10857.0 | 21832.0 |
| 10 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 4.0 | 9440.9 | 18984.3 |
| 11 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 4.7 | 8209.4 | 16508.1 |
| 12 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 5.4 | 7138.6 | 14354.9 |
| 13 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 6.2 | 6207.5 | 12482.5 |
| 14 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 7.1 | 5397.8 | 10854.3 |
| 15 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 8.1 | 4693.8 | 9438.6 |
| 16 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 9.4 | 4081.5 | 8207.4 |
| 17 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 10.8 | 3549.2 | 7136.9 |
| 18 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 12.4 | 3086.2 | 6206.0 |
| 19 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 14.2 | 2683.7 | 5396.5 |
| 20 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 16.4 | 2333.6 | 4692.6 |
| 21 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 18.8 | 2029.2 | 4080.6 |
| 22 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 21.6 | 1764.6 | 3548.3 |
| 23 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 24.9 | 1534.4 | 3085.5 |
| | | | | | | 348905.292 | 366586.6335 |

| | |
|---|---|
| **Discount Rate** | 15% |
| **NPV** | 17681.3409 |
| **BCR** | 1.05067662 |

# Benefit Cost Ratio (Financial)
# Fuel-HFO

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|
| | | | | | | 15% | |
| | | | | | | Discount Factor | |
| 0 | 1408.8 | 0.0 | 1408.8 | 0.0 | 1.0 | 1408.8 | 0.0 |
| 1 | 146205.9 | 0.0 | 146205.9 | 0.0 | 1.2 | 127135.6 | 0.0 |
| 2 | 50332.1 | 0.0 | 50332.1 | 0.0 | 1.3 | 38058.3 | 0.0 |
| 3 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 1.5 | 114095.1 | 151496.0 |
| 4 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 1.7 | 99213.2 | 131735.7 |
| 5 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 2.0 | 86272.3 | 114552.8 |
| 6 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 2.3 | 75019.4 | 99611.1 |
| 7 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 2.7 | 65234.3 | 86618.3 |
| 8 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 3.1 | 56725.5 | 75320.3 |
| 9 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 3.5 | 49326.5 | 65495.9 |
| 10 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 4.0 | 42892.6 | 56953.0 |
| 11 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 4.7 | 37297.9 | 49524.3 |
| 12 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 5.4 | 32433.0 | 43064.6 |
| 13 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 6.2 | 28202.6 | 37447.5 |
| 14 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 7.1 | 24524.0 | 32563.0 |
| 15 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 8.1 | 21325.2 | 28315.7 |
| 16 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 9.4 | 18543.7 | 24622.3 |
| 17 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 10.8 | 16124.9 | 21410.7 |
| 18 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 12.4 | 14021.7 | 18618.0 |
| 19 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 14.2 | 12192.8 | 16189.6 |
| 20 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 16.4 | 10602.4 | 14077.9 |
| 21 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 18.8 | 9219.5 | 12241.7 |
| 22 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 21.6 | 8016.9 | 10644.9 |
| 23 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 24.9 | 6971.2 | 9256.4 |
| | | | | | | **994857.3** | **1099759.9** |

| | |
|---|---|
| **Discount Rate** | 15% |
| **NPV** | 104902.643 |
| **BCR** | 1.105 |

# Benefit Cost Ratio (Economical)
# Fuel-Gas

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at 15% Discount Factor | Discounted Value of Total Benefit at 15% Discount Factor |
|---|---|---|---|---|---|---|---|
| 0 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1.00 | 1155.25 | 0.00 |
| 1 | 142174.83 | 0.00 | 142174.83 | 0.00 | 1.15 | 123630.29 | 0.00 |
| 2 | 50065.93 | 0.00 | 50065.93 | 0.00 | 1.32 | 37857.04 | 0.00 |
| 3 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 1.52 | 12534.93 | 43911.89 |
| 4 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 1.75 | 10899.93 | 38184.25 |
| 5 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 2.01 | 9478.20 | 33203.70 |
| 6 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 2.31 | 8241.92 | 28872.78 |
| 7 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 2.66 | 7166.88 | 25106.77 |
| 8 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 3.06 | 6232.07 | 21831.97 |
| 9 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 3.52 | 5419.19 | 18984.32 |
| 10 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 4.05 | 4712.34 | 16508.11 |
| 11 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 4.65 | 4097.69 | 14354.88 |
| 12 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 5.35 | 3563.21 | 12482.50 |
| 13 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 6.15 | 3098.44 | 10854.35 |
| 14 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 7.08 | 2694.30 | 9438.56 |
| 15 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 8.14 | 2342.87 | 8207.45 |
| 16 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 9.36 | 2037.28 | 7136.91 |
| 17 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 10.76 | 1771.54 | 6206.01 |
| 18 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 12.38 | 1540.47 | 5396.53 |
| 19 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 14.23 | 1339.54 | 4692.63 |
| 20 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 16.37 | 1164.82 | 4080.55 |
| 21 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 18.82 | 1012.89 | 3548.31 |
| 22 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 21.64 | 880.77 | 3085.48 |
| 23 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 24.89 | 765.89 | 2683.03 |
| | | | | | | 253637.75 | 318770.99 |

| | |
|---|---|
| **Discount Rate** | 15% |
| **NPV** | 65133.235 |
| **BCR** | 1.2567963 |

# Benefit Cost Ratio (Economical )
# Fuel-HFO

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at 15% Discount Factor | Discounted Value of Total Benefit at 15% Discount Factor |
|---|---|---|---|---|---|---|---|
| 0 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1.00 | 1155.25 | 0.00 |
| 1 | 142174.83 | 0.00 | 142174.83 | 0.00 | 1.15 | 123630.29 | 0.00 |
| 2 | 50065.93 | 0.00 | 50065.93 | 0.00 | 1.32 | 37857.04 | 0.00 |
| 3 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 1.52 | 88343.65 | 131735.68 |
| 4 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 1.75 | 76820.57 | 114552.76 |
| 5 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 2.01 | 66800.49 | 99611.10 |
| 6 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 2.31 | 58087.38 | 86618.35 |
| 7 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 2.66 | 50510.77 | 75320.30 |
| 8 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 3.06 | 43922.41 | 65495.91 |
| 9 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 3.52 | 38193.40 | 56952.97 |
| 10 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 4.05 | 33211.65 | 49524.32 |
| 11 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 4.65 | 28879.70 | 43064.63 |
| 12 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 5.35 | 25112.78 | 37447.50 |
| 13 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 6.15 | 21837.20 | 32563.04 |
| 14 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 7.08 | 18988.87 | 28315.69 |
| 15 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 8.14 | 16512.06 | 24622.34 |
| 16 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 9.36 | 14358.31 | 21410.73 |
| 17 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 10.76 | 12485.49 | 18618.03 |
| 18 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 12.38 | 10856.95 | 16189.59 |
| 19 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 14.23 | 9440.82 | 14077.90 |
| 20 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 16.37 | 8209.41 | 12241.65 |
| 21 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 18.82 | 7138.62 | 10644.92 |
| 22 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 21.64 | 6207.49 | 9256.45 |
| 23 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 24.89 | 5397.82 | 8049.09 |
| | | | | | | 803958.42 | 956312.96 |

| | |
|---|---|
| **Discount Rate** | 15% |
| **NPV** | 152354.5 |
| **BCR** | 1.189505 |

# 225 MW Internal Rate of Return (Financial)

## Fuel – Gas

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 13% | | 15% | | 17% | |
| 0 | 1408.8 | 0.0 | 1408.8 | 0.0 | 1408.8 | 0.0 | 1408.8 | 0.0 | 1408.8 | 0.0 |
| 1 | 146205.9 | 0.0 | 146205.9 | 0.0 | 129385.8 | 0.0 | 127135.6 | 0.0 | 124962.3 | 0.0 |
| 2 | 50332.1 | 0.0 | 50332.1 | 0.0 | 39417.5 | 0.0 | 38058.3 | 0.0 | 36768.3 | 0.0 |
| 3 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 26470.0 | 53227.8 | 25112.9 | 50498.7 | 23846.9 | 47953.0 |
| 4 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 23424.8 | 47104.2 | 21837.3 | 43911.9 | 20382.0 | 40985.5 |
| 5 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 20729.9 | 41685.1 | 18988.9 | 38184.3 | 17420.5 | 35030.3 |
| 6 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 18345.0 | 36889.5 | 16512.1 | 33203.7 | 14889.3 | 29940.5 |
| 7 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 16234.6 | 32645.6 | 14358.4 | 28872.8 | 12725.9 | 25590.1 |
| 8 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 14366.9 | 28889.9 | 12485.5 | 25106.8 | 10876.8 | 21871.9 |
| 9 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 12714.0 | 25566.3 | 10857.0 | 21832.0 | 9296.4 | 18693.9 |
| 10 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 11251.4 | 22625.0 | 9440.9 | 18984.3 | 7945.7 | 15977.7 |
| 11 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 9957.0 | 20022.1 | 8209.4 | 16508.1 | 6791.2 | 13656.2 |
| 12 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 8811.5 | 17718.7 | 7138.6 | 14354.9 | 5804.4 | 11671.9 |
| 13 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 7797.8 | 15680.3 | 6207.5 | 12482.5 | 4961.0 | 9976.0 |
| 14 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 6900.7 | 13876.4 | 5397.8 | 10854.3 | 4240.2 | 8526.5 |
| 15 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 6106.8 | 12280.0 | 4693.8 | 9438.6 | 3624.1 | 7287.6 |
| 16 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 5404.2 | 10867.2 | 4081.5 | 8207.4 | 3097.5 | 6228.7 |
| 17 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 4782.5 | 9617.0 | 3549.2 | 7136.9 | 2647.5 | 5323.7 |
| 18 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 4232.3 | 8510.6 | 3086.2 | 6206.0 | 2262.8 | 4550.2 |
| 19 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 3745.4 | 7531.5 | 2683.7 | 5396.5 | 1934.0 | 3889.0 |
| 20 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 3314.5 | 6665.1 | 2333.6 | 4692.6 | 1653.0 | 3324.0 |
| 21 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 2933.2 | 5898.3 | 2029.2 | 4080.6 | 1412.8 | 2841.0 |
| 22 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 2595.8 | 5219.7 | 1764.6 | 3548.3 | 1207.5 | 2428.2 |
| 23 | 0.0 | 38193.5 | 38193.5 | 76802.2 | 2297.1 | 4619.2 | 1534.4 | 3085.5 | 1032.1 | 2075.4 |
| | | | | | 382627.4 | 427139.5 | 348905.3 | 366586.6 | 321191.2 | 317821.4 |

| Discount Rate: | 13% | 15% | 17% |
|---|---|---|---|
| NPV | 44512.152 | 17681.340 | -3369.7810 |
| BCR | 1.1163328 | 1.050676 | 0.9895084 |
| IRR: | | | 16.72% |

# 225 MW Internal Rate of Return (Financial )

## Fuel – HFO

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 15% | | 20% | | 25% | |
| 0 | 1408.8 | 0.0 | 1408.8 | 0.0 | 1408.8 | 0.0 | 1408.8 | 0.0 | 1408.8 | 0.0 |
| 1 | 146205.9 | 0.0 | 146205.9 | 0.0 | 127135.6 | 0.0 | 121838.3 | 0.0 | 116964.8 | 0.0 |
| 2 | 50332.1 | 0.0 | 50332.1 | 0.0 | 38058.3 | 0.0 | 34952.9 | 0.0 | 32212.6 | 0.0 |
| 3 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 114095.1 | 151496.0 | 100419.2 | 133337.1 | 88844.5 | 117968.1 |
| 4 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 99213.2 | 131735.7 | 83682.7 | 111114.3 | 71075.6 | 94374.5 |
| 5 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 86272.3 | 114552.8 | 69735.6 | 92595.2 | 56860.5 | 75499.6 |
| 6 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 75019.4 | 99611.1 | 58113.0 | 77162.7 | 45488.4 | 60399.7 |
| 7 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 65234.3 | 86618.3 | 48427.5 | 64302.2 | 36390.7 | 48319.8 |
| 8 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 56725.5 | 75320.3 | 40356.2 | 53585.2 | 29112.6 | 38655.8 |
| 9 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 49326.5 | 65495.9 | 33630.2 | 44654.3 | 23290.1 | 30924.6 |
| 10 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 42892.6 | 56953.0 | 28025.2 | 37211.9 | 18632.0 | 24739.7 |
| 11 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 37297.9 | 49524.3 | 23354.3 | 31010.0 | 14905.6 | 19791.8 |
| 12 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 32433.0 | 43064.6 | 19461.9 | 25841.6 | 11924.5 | 15833.4 |
| 13 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 28202.6 | 37447.5 | 16218.3 | 21534.7 | 9539.6 | 12666.7 |
| 14 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 24524.0 | 32563.0 | 13515.2 | 17945.6 | 7631.7 | 10133.4 |
| 15 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 21325.2 | 28315.7 | 11262.7 | 14954.6 | 6105.3 | 8106.7 |
| 16 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 18543.7 | 24622.3 | 9385.6 | 12462.2 | 4884.3 | 6485.4 |
| 17 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 16124.9 | 21410.7 | 7821.3 | 10385.2 | 3907.4 | 5188.3 |
| 18 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 14021.7 | 18618.0 | 6517.8 | 8654.3 | 3125.9 | 4150.6 |
| 19 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 12192.8 | 16189.6 | 5431.5 | 7211.9 | 2500.8 | 3320.5 |
| 20 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 10602.4 | 14077.9 | 4526.2 | 6009.9 | 2000.6 | 2656.4 |
| 21 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 9219.5 | 12241.7 | 3771.9 | 5008.3 | 1600.5 | 2125.1 |
| 22 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 8016.9 | 10644.9 | 3143.2 | 4173.6 | 1280.4 | 1700.1 |
| 23 | 0.0 | 173524.5 | 173524.5 | 230406.5 | 6971.2 | 9256.4 | 2619.3 | 3478.0 | 1024.3 | 1360.1 |
| | | | | | 994857.3 | 1099759.9 | 747618.8 | 782632.8 | 590711.5 | 584400.4 |

| Discount Rate: | 15% | 20% | 25% |
|---|---|---|---|
| NPV | 104902.643 | 35014.027 | -6311.157 |
| BCR | 1.105 | 1.047 | 0.989 |
| IRR: | | | 24.43% |

# 225 MW Internal Rate of Return (Economic)

## Fuel – Gas

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 13% | | 15% | | 21% | |
| 0 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 |
| 1 | 142174.83 | 0.00 | 142174.83 | 0.00 | 125818.44 | 0.00 | 123630.29 | 0.00 | 117499.86 | 0.00 |
| 2 | 50065.93 | 0.00 | 50065.93 | 0.00 | 39208.97 | 0.00 | 37857.04 | 0.00 | 34195.70 | 0.00 |
| 3 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 13212.35 | 46285.01 | 12534.93 | 43911.89 | 10761.16 | 37698.11 |
| 4 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 11692.34 | 40960.18 | 10899.93 | 38184.25 | 8893.52 | 31155.46 |
| 5 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 10347.20 | 36247.95 | 9478.20 | 33203.70 | 7350.02 | 25748.32 |
| 6 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 9156.82 | 32077.83 | 8241.92 | 28872.78 | 6074.40 | 21279.60 |
| 7 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 8103.38 | 28387.46 | 7166.88 | 25106.77 | 5020.16 | 17586.45 |
| 8 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 7171.13 | 25121.65 | 6232.07 | 21831.97 | 4148.89 | 14534.25 |
| 9 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 6346.13 | 22231.55 | 5419.19 | 18984.32 | 3428.84 | 12011.78 |
| 10 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 5616.05 | 19673.94 | 4712.34 | 16508.11 | 2833.75 | 9927.09 |
| 11 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 4969.95 | 17410.56 | 4097.69 | 14354.88 | 2341.94 | 8204.21 |
| 12 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 4398.19 | 15407.58 | 3563.21 | 12482.50 | 1935.49 | 6780.34 |
| 13 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 3892.20 | 13635.02 | 3098.44 | 10854.35 | 1599.58 | 5603.58 |
| 14 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 3444.43 | 12066.39 | 2694.30 | 9438.56 | 1321.97 | 4631.06 |
| 15 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 3048.17 | 10678.22 | 2342.87 | 8207.45 | 1092.53 | 3827.32 |
| 16 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 2697.49 | 9449.76 | 2037.28 | 7136.91 | 902.92 | 3163.08 |
| 17 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 2387.16 | 8362.62 | 1771.54 | 6206.01 | 746.21 | 2614.11 |
| 18 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 2112.53 | 7400.54 | 1540.47 | 5396.53 | 616.71 | 2160.42 |
| 19 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 1869.50 | 6549.15 | 1339.54 | 4692.63 | 509.67 | 1785.47 |
| 20 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 1654.42 | 5795.71 | 1164.82 | 4080.55 | 421.22 | 1475.60 |
| 21 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 1464.09 | 5128.95 | 1012.89 | 3548.31 | 348.11 | 1219.50 |
| 22 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 1295.66 | 4538.89 | 880.77 | 3085.48 | 287.70 | 1007.85 |
| 23 | 0.00 | 19064.05 | 19064.05 | 66784.50 | 1146.60 | 4016.72 | 765.89 | 2683.03 | 237.77 | 832.94 |
| | | | | | 272208.45 | 371425.70 | 253637.75 | 318770.99 | 213723.38 | 213246.55 |

| Discount Rate: | 13% | 15% | 21% |
|---|---|---|---|
| NPV | 99217.250 | 65133.235 | -476.8307 |
| BCR | 1.3644899 | 1.2567963 | 0.9977689 |
| IRR: | | | 20.96% |

# 225 MW Internal Rate of Return (Economic)

## Fuel – HFO

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 15% | | 20% | | 29% | |
| 0 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 |
| 1 | 142174.83 | 0.00 | 142174.83 | 0.00 | 123630.29 | 0.00 | 118479.03 | 0.00 | 110213.05 | 0.00 |
| 2 | 50065.93 | 0.00 | 50065.93 | 0.00 | 37857.04 | 0.00 | 34768.01 | 0.00 | 30085.89 | 0.00 |
| 3 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 88343.65 | 131735.68 | 77754.43 | 115945.31 | 62589.25 | 93331.40 |
| 4 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 76820.57 | 114552.76 | 64795.36 | 96621.09 | 48518.80 | 72349.93 |
| 5 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 66800.49 | 99611.10 | 53996.13 | 80517.58 | 37611.47 | 56085.21 |
| 6 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 58087.38 | 86618.35 | 44996.77 | 67097.98 | 29156.18 | 43476.91 |
| 7 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 50510.77 | 75320.30 | 37497.31 | 55914.98 | 22601.69 | 33703.03 |
| 8 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 43922.41 | 65495.91 | 31247.76 | 46595.82 | 17520.69 | 26126.38 |
| 9 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 38193.40 | 56952.97 | 26039.80 | 38829.85 | 13581.93 | 20253.01 |
| 10 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 33211.65 | 49524.32 | 21699.83 | 32358.21 | 10528.63 | 15700.01 |
| 11 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 28879.70 | 43064.63 | 18083.19 | 26965.17 | 8161.73 | 12170.55 |
| 12 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 25112.78 | 37447.50 | 15069.33 | 22470.98 | 6326.92 | 9434.53 |
| 13 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 21837.20 | 32563.04 | 12557.77 | 18725.82 | 4904.59 | 7313.59 |
| 14 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 18988.87 | 28315.69 | 10464.81 | 15604.85 | 3802.01 | 5669.45 |
| 15 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 16512.06 | 24622.34 | 8720.68 | 13004.04 | 2947.29 | 4394.92 |
| 16 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 14358.31 | 21410.73 | 7267.23 | 10836.70 | 2284.72 | 3406.92 |
| 17 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 12485.49 | 18618.03 | 6056.03 | 9030.58 | 1771.10 | 2641.02 |
| 18 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 10856.95 | 16189.59 | 5046.69 | 7525.49 | 1372.95 | 2047.30 |
| 19 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 9440.82 | 14077.90 | 4205.57 | 6271.24 | 1064.30 | 1587.06 |
| 20 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 8209.41 | 12241.65 | 3504.64 | 5226.03 | 825.04 | 1230.28 |
| 21 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 7138.62 | 10644.92 | 2920.54 | 4355.03 | 639.57 | 953.70 |
| 22 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 6207.49 | 9256.45 | 2433.78 | 3629.19 | 495.79 | 739.30 |
| 23 | 0.00 | 134359.65 | 134359.65 | 200353.50 | 5397.82 | 8049.09 | 2028.15 | 3024.32 | 384.33 | 573.10 |
| | | | | | 803958.42 | 956312.96 | 610788.09 | 680550.26 | 418543.15 | 413187.61 |

| Discount Rate: | 15% | 20% | 29% |
|---|---|---|---|
| NPV | 152354.53 | 69762.16 | -5355.53 |
| BCR | 1.1895054 | 1.1142166 | 0.987204 |
| IRR: | | | 28.52 % |

# SCHEDULE

# ANNEXURE – 3

**Cost Estimation and Economic Analysis of 300 MW Combined Cycle Power Plant at Shikalbaha**

# 300 MW Total Investment Cost

| Direct Cost | | | | | |
|---|---|---|---|---|---|
| 150 MW Plant Cost, C | New Plant (MW) | Factor $(Q/Q_o)^a$ | Direct Cost $C*(Q/Q_o)^a$ | Cost Escalation | Total Direct Cost at 2014 |
| | | 0.65 | | | |
| 80799.84 | **300** | **1.57** | **126788.54** | 30% | **164825.102** |
| | 150 | 1.0 | 80799.84 | | 105039.79 |
| | 225 | 1.30 | 105164.66 | | 136714.058 |
| | 450 | 2.042343632 | 165021.0387 | | 214527.3503 |

| Indirect Cost (Custom Duty, Taxes & VAT, C & F Cost, Landing Charges etc.) | | | | | |
|---|---|---|---|---|---|
| 150 MW Plant Cost, C | New Plant (MW) | Factor $(Q/Q_o)^a$ | Direct Cost $C*(Q/Q_o)^a$ | Cost Escalation | Total Direct Cost at 2014 |
| | | 0.3 | | | |
| 20261.709 | **300** | **1.23** | **24945.09** | 30% | **32428.618** |
| | 150 | 1.0 | 20261.709 | | 26340.22 |
| | 225 | 1.13 | 22882.5 | | 29747.25 |
| | 450 | 1.39038917 | 28171.66077 | | 36623.159 |

| Indirect Cost (Erection & Commissioning) | | | | | |
|---|---|---|---|---|---|
| 150 MW Plant Cost, C | New Plant (MW) | Factor $(Q/Q_o)^a$ | Direct Cost $C*(Q/Q_o)^a$ | Cost Escalation | Total Direct Cost at 2014 |
| | | 0.5 | | | |
| 8150.1 | **300** | **1.41** | **11525.98** | 30% | **14983.78** |
| | 150 | 1.0 | 8150.1 | | 10595.13 |
| | 225 | 1.22 | 9981.8 | | 12976.34 |
| | 450 | 1.732 | 14116.38729 | | 18351.30347 |

# Detailed Breakdown of Investment Cost

Installation of a 300 MW Combined Cycle
Power Plant at Shikalbaha

| Sl. No. | Item | L.C. | F.C. | Total | % of Cost |
|---|---|---|---|---|---|
| I) | **Pre-Construction Expendeture** | | | | |
| | Land acquisition & Land Development | 865 | 0 | 865 | 0.370 |
| | **Sub-Total – I** | **865** | **0** | **865** | **0.370** |
| II) | **Construction Works (based on PWD** | | | | |
| | **rate 2011)** | | | | |
| | Residential, Non Residential and fuel | 811.3 | 0 | 811.3 | 0.347 |
| | unloading system | | | | |
| | (Administrative building 17,000/- per m² | | | | |
| | Internal Road (RCC) @ Tk. 2509/m² ) | | | | |
| | Deep Tube-well & pump house | 40 | 0 | 40 | 0.017 |
| | **Sub-Total – II** | **851.3** | **0** | **851.3** | **0.364** |
| III) | **Machinery, Equipment & Spares** | | | | |
| | Supply of material & Equipment | 32965.0204 | 131860.1 | 164825.1 | 70.468 |
| | Engineering Design | 0 | 32429 | 32429 | 13.864 |
| | Erection & Commissioning | 7342.055524 | 7642 | 14984 | 6.406 |
| | Training | 250 | 270 | 520 | 0.222 |
| | Pre-Shipment inspection @0.5% | 0 | 824.12551 | 824.12551 | 0.352 |
| | **Sub-Total – III** | **40557.07593** | **173025** | **213582** | **91.313** |
| IV) | **Transport Vehicle** | | | | |
| | Rental @ Tk. 3000/day for 700 days | 21 | 0 | 21 | 0.009 |
| | during project implementation | | | | |
| | **Sub-Total – IV** | **21** | 0 | **21** | **0.009** |
| V) | **Other Cost** | | | | |
| | Charge of electrical energy during construction | 8 | 0 | 8 | 0.003 |
| | Interest during construction @ 3% p.a. | 3955.802448 | 0 | 3955.80245 | 1.691 |
| | Bank Charges @ 1.25% | 1648.25102 | 0 | 1648.25102 | 0.705 |
| | Insurance @ 3% on imported materials | 3955.802448 | 0 | 3955.80245 | 1.691 |
| | Project office expenditure | 17.65 | 0 | 17.65 | 0.008 |
| | Physical Contingency (2% of the total items) | 1037.597637 | 3460.49113 | 4498.08877 | 1.923 |
| | Price Contingency (2% of the total cost) | 1037.597637 | 3460.49113 | 4498.08877 | 1.923 |
| | **Sub-Total – V** | **11660.70119** | **6920.982** | **18581.68** | **7.944** |
| **Total Investment Cost** | | **53955.07712** | **179946** | **233901** | 100.000 |

# 300 MW Annual Phasing Cost

| Sl. | Dsecription | Year 01 | | | | |
|---|---|---|---|---|---|---|
| | | GOB | Project Aid | | DPA | Total |
| | | | RPA | | | |
| | | | Through GOB | Special AC | | |
| **A)** | **Supplies & Services** | | | | | |
| | Travel Expenses | 0.8 | | | | 0.8 |
| | Postal | 0.32 | | | | 0.32 |
| | Telephone / Fax | 0.6 | | | | 0.6 |
| | Bank Charges @ 1.25% | 0 | | | | 0 |
| | Insurance @ 3% on imported materials | 0 | | | | 0 |
| | Duties & Taxes on Imported Materials & Equipments @ 3% | 0 | | | | 0 |
| | Stationaries, Seal & Stumps | 0.4 | | | | 0.4 |
| | Entertainment | 0.4 | | | | 0.4 |
| | Casual Labour | 0.3 | | | | 0.3 |
| | Copy / Photo Copy | 0.2 | | | | 0.2 |
| | Computer Accessories | 0.12 | | | | 0.12 |
| | Computer and office equipment | 0.3 | | | | 0.3 |
| | Utility Charge | 3 | | | | 3 |
| | **Sub-Total** | **6.44** | | | | **6.44** |
| | **Acquisition of Asset** | | | | | |
| | Vehicle (Rental) | 6.3 | | | | 6.3 |
| | Machinery Equipment & Spares | 0 | | | | 0 |
| | Pre-Shipment Inspection Cost @0.50% | 0 | | | | 0 |
| | A/C, Computer, Laser Printer, Color Printer, Scanner & Photocopier | 5 | | | | 5 |
| | Office Equipment | 0.8 | | | | 0.8 |
| | Furniture | 3 | | | | 3 |
| | Deep Tube Well & Pump House | 8 | | | | 8 |
| **B)** | **Land Properties** | | | | | |
| | Land Acquisition | 765 | | | | 765 |
| | **Construction Works** | | | | | |
| | Land Development | 60 | | | | 60 |
| | Building Works | 280.3 | | | | 280.3 |
| | Doors, Windows & Finishing | 240 | | | | 240 |
| | Internal Road (RCC) | 20 | | | | 20 |
| | Drainage System | 14 | | | | 14 |
| | **Sub-Total** | **1402** | | | | **1402** |
| **C)** | **Physical Contengency** | 0 | | | | 0 |
| **D)** | **Price Contengency** | 0 | | | | 0 |
| | **Total (A+B+C+D)** | **1409** | | | | **1409** |

| Sl | Dsecription | Year 02 | | | | |
|---|---|---|---|---|---|---|
| | | GOB | Project Aid | | DPA | Total |
| | | | RPA | | | |
| | | | Through GOB | Special AC | | |
| **A)** | **Supplies & Services** | | | | | |
| | Travel Expenses | 0.60 | | | | 0.60 |
| | Postal | 0.08 | | | | 0.08 |
| | Telephone / Fax | 0.60 | | | | 0.60 |
| | Bank Charges @ 1.25% | 1648.25 | | | | 1648.25 |
| | Insurance @ 3% on imported materials | 3955.80 | | | | 3955.80 |
| | Duties & Taxes on Imported Materials & Equipments @ 3% | 3955.80 | | | | 3955.80 |
| | Stationaries, Seal & Stumps | 0.30 | | | | 0.30 |
| | Entertainment | 0.30 | | | | 0.30 |
| | Casual Labour | 0.30 | | | | 0.30 |
| | Copy / Photo Copy | 0.15 | | | | 0.15 |
| | Computer Accessories | 0.09 | | | | 0.09 |
| | Computer and office equipment | 0.30 | | | | 0.30 |
| | Utility Charge | 2.50 | | | | 2.50 |
| | **Sub-Total** | **9565.08** | | | | **9565.08** |
| | **Acquisition of Asset** | | | | | |
| | Vehicle (Rental) | 6.30 | | | | 6.30 |
| | Machinery Equipment & Spares | 159568.13 | | | | 159568.13 |
| | Pre-Shipment Inspection Cost @0.50% | 824.13 | | | | 824.13 |
| | A/C, Computer, Laser Printer, Color Printer, Scanner & Photocopier | 0.00 | | | | 0.00 |
| | Office Equipment | 0.20 | | | | 0.20 |
| | Furniture | 0.00 | | | | 0.00 |
| | Deep Tube Well & Pump House | 32.00 | | | | 32.00 |
| **B)** | **Land Properties** | | | | | |
| | Land Acquisition | 0.00 | | | | 0.00 |
| | **Construction Works** | | | | | |
| | Land Development | 40.00 | | | | 40.00 |
| | Building Works | 130.00 | | | | 130.00 |
| | Doors , Windows & Finishing | 110.00 | | | | 110.00 |
| | Internal Road (RCC) | 10.00 | | | | 10.00 |
| | Drainage System | 7.00 | | | | 7.00 |
| | **Sub-Total** | **160727.76** | | | | **160727.76** |
| **C)** | **Physical Contengency** | **1349.43** | | | | **1349.43** |
| **D)** | **Price Contengency** | **1349.43** | | | | **1349.43** |
| | **Total (A+B+C+D)** | **172991.68** | | | | **172991.68** |

| Sl | Dsecription | Year 03 | | | | |
|---|---|---|---|---|---|---|
| | | GOB | Project Aid | | DPA | Total |
| | | | RPA | | | |
| | | | Through GOB | Special AC | | |
| **A)** | **Supplies & Services** | | | | | |
| | Travel Expenses | 0.60 | | | | 0.60 |
| | Postal | 0.00 | | | | 0.00 |
| | Telephone / Fax | 0.60 | | | | 0.60 |
| | Bank Charges @ 1.25% | 0.00 | | | | 0.00 |
| | Insurance @ 3% on imported materials | 0.00 | | | | 0.00 |
| | Duties & Taxes on Imported Materials & Equipments @ 3% | 0.00 | | | | 0.00 |
| | Stationaries, Seal & Stumps | 0.30 | | | | 0.30 |
| | Entertainment | 0.30 | | | | 0.30 |
| | Casual Labour | 0.30 | | | | 0.30 |
| | Copy / Photo Copy | 0.15 | | | | 0.15 |
| | Computer Accessories | 0.09 | | | | 0.09 |
| | Computer and office equipment | 0.15 | | | | 0.15 |
| | Utility Charge | 2.50 | | | | 2.50 |
| | **Sub-Total** | **4.99** | | | | **4.99** |
| | **Acquisition of Asset** | | | | | |
| | Vehicle (Rental) | 8.40 | | | | 8.40 |
| | Machinery Equipment & Spares | 53189.38 | | | | 53189.38 |
| | Pre-Shipment Inspection Cost @0.50% | 0.00 | | | | 0.00 |
| | A/C , Computer, Laser Printer, Color Printer, Scanner & Photocopier | 0.00 | | | | 0.00 |
| | Office Equipment | 0.00 | | | | 0.00 |
| | Furniture | 0.00 | | | | 0.00 |
| | Deep Tube Well & Pump House | 0.00 | | | | 0.00 |
| **B)** | **Land Properties** | 0.00 | | | | 0.00 |
| | Land Acquisition | 0.00 | | | | 0.00 |
| | **Construction Works** | | | | | |
| | Land Development | 0.00 | | | | 0.00 |
| | Building Works | 0.00 | | | | 0.00 |
| | Doors, Windows & Finishing | 0.00 | | | | 0.00 |
| | Internal Road (RCC) | 0.00 | | | | 0.00 |
| | Drainage System | 0.00 | | | | 0.00 |
| | Sub-Total | **53197.78** | | | | **53197.78** |
| **C)** | **Physical Contengency** | **3148.66** | | | | **3148.66** |
| **D)** | **Price Contengency** | **3148.66** | | | | **3148.66** |
| | **Total (A+B+C+D)** | **59500.09** | | | | **59500.09** |

# 300 MW Economic Value of Investment Cost

| Sl. No. | Item of Cost | Year – 1 | | | Year - 2 | | | Year - 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **PV** | **SCF** | **AV** | **PV** | **SCF** | **AV** | **PV** | **SCF** | **AV** |
| | | | | | | | | | | |
| I) | Revenue Component | | | | | | | | | |
| | a) Foreign Currency | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| | b) Local Currency | 6.44 | 0.82 | 5.2808 | 9565.0759 | 0.82 | 7843.3623 | 4.99 | 0.82 | 4.0918 |
| | | | | | | | | | | |
| II) | Capital Component | | | | | | | | | |
| | a) Foreign Currency | 0 | 1 | 0 | 144435.44 | 1 | 144435.44 | 53189.38 | 1 | 53189.38 |
| | b) Local Currency | 1402.4 | 0.82 | 1149.97 | 16292.31 | 0.82 | 13359.70 | 8.4 | 0.82 | 6.89 |
| | | | | | | | | | | |
| III) | Physical Contingency | | | | | | | | | |
| | a) Foreign Currency | 0 | 1 | 0 | 978.33431 | 1 | 978.33431 | 2282.7801 | 1 | 2282.7801 |
| | b) Local Currency | 0 | 0.82 | 0 | 371.09232 | 0.82 | 304.29571 | 865.88209 | 0.82 | 710.02331 |
| | | | | | | | | | | |
| IV) | Price Contingency | | | | | | | | | |
| | a) Foreign Currency | 0 | 1 | 0 | 978.33431 | 1 | 978.33431 | 2282.7801 | 1 | 2282.7801 |
| | b) Local Currency | 0 | 0.82 | 0 | 371.09232 | 0.82 | 304.29571 | 865.88209 | 0.82 | 710.02331 |
| | **Total** | **1408.84** | | **1155.249** | **172991.7** | | **168203.8** | **59500.09** | | **59185.96** |

# 300 MW Financial Operating / Recurring Cost Table (Fuel –Gas)

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 1 -7 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 24720.374 | 0 | 24720.374 |
| ii) | Utilities (Power, Water, Gas) | 17 | 0 | 17 |
| iii) | Manpower Salary, Wages & Allowances | 263.5 | 0 | 263.5 |
| iv) | Machine & Equipment Depriciation | 10679.082 | 0 | 10679.082 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 136 | 0 | 136 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 13356.9 | 0 | 13356.9 |
| **Total Operating Cost** | | **49198.39** | **0** | **49198.39** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 8-14 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 24720.374 | 0 | 24720.374 |
| ii) | Utilities (Power, Water, Gas) | 17 | 0 | 17 |
| iii) | Manpower Salary, Wages & Allowances | 263.5 | 0 | 263.5 |
| iv) | Machine & Equipment Depriciation | 10679.082 | 0 | 10679.082 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 136 | 0 | 136 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 13356.9 | 0 | 13356.9 |
| **Total Operating Cost** | | **49198.39** | **0** | **49198.39** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 15-21 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 24720.374 | 0 | 24720.374 |
| ii) | Utilities (Power, Water, Gas) | 17 | 0 | 17 |
| iii) | Manpower Salary, Wages & Allowances | 263.5 | 0 | 263.5 |
| iv) | Machine & Equipment Depriciation | 10679.082 | 0 | 10679.082 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 136 | 0 | 136 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 13356.9 | 0 | 13356.9 |
| **Total Operating Cost** | | **49198.39** | **0** | **49198.39** |

# 300 MW Financial Operating / Recurring Cost Table (Fuel –HFO)

| Operating / Recurring Cost For HFO | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 1-7 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 178777.44 | 0 | 178777.44 |
| ii) | Utilities (Power, Water, Gas) | 17 | 0 | 17 |
| iii) | Manpower Salary, Wages & Allowances | 263.5 | 0 | 263.5 |
| iv) | Machine & Equipment Depriciation | 10679.08163 | 0 | 10679.082 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 136 | 0 | 136 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 40070.7 | 0 | 40070.7 |
| **Total Operating Cost** | | **229969.2606** | **0** | **229969.3** |

| Operating / Recurring Cost For HFO | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 8-14 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 178777.44 | 0 | 178777.44 |
| ii) | Utilities (Power, Water, Gas) | 17 | 0 | 17 |
| iii) | Manpower Salary, Wages & Allowances | 263.5 | 0 | 263.5 |
| iv) | Machine & Equipment Depriciation | 10679.08163 | 0 | 10679.082 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 136 | 0 | 136 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 40070.7 | 0 | 40070.7 |
| **Total Operating Cost** | | **229969.2606** | **0** | **229969.3** |

| Operating / Recurring Cost For HFO | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 15-21 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 178777.44 | 0 | 178777.44 |
| ii) | Utilities (Power, Water, Gas) | 17 | 0 | 17 |
| iii) | Manpower Salary, Wages & Allowances | 263.5 | 0 | 263.5 |
| iv) | Machine & Equipment Depriciation | 10679.08163 | 0 | 10679.082 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 136 | 0 | 136 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 40070.7 | 0 | 40070.7 |
| **Total Operating Cost** | | **229969.2606** | **0** | **229969.3** |

# 300 MW Economical Operating / Recurring Cost Table (Fuel –Gas)

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. | Item of Cost | Year 1-7 | | |
| | | PV | SCF | AV |
| i) | Raw Materials | 24720.374 | 1 | 24720.374 |
| ii) | Utilities (Power, Water, Gas) | 17 | 1.11 | 18.87 |
| iii) | Manpower Salary, Wages & Allowances | 263.5 | 0.82 | 216.07 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 120 | 0.82 | 98.4 |
| | Foreign Currency | 16 | 1 | 16 |
| **Total Operating Cost** | | **25136.87** | | **25069.71** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. | Item of Cost | Year 8-14 | | |
| | | PV | SCF | AV |
| i) | Raw Materials | 24720.374 | 1 | 24720.374 |
| ii) | Utilities (Power, Water, Gas) | 17 | 1.11 | 18.87 |
| iii) | Manpower Salary, Wages & Allowances | 263.5 | 0.82 | 216.07 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 120 | 0.82 | 98.4 |
| | Foreign Currency | 16 | 1 | 16 |
| **Total Operating Cost** | | **25136.87** | | **25069.71** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. | Item of Cost | Year 15-21 | | |
| | | PV | SCF | AV |
| i) | Raw Materials | 24720.374 | 1 | 24720.374 |
| ii) | Utilities (Power, Water, Gas) | 17 | 1.11 | 18.87 |
| iii) | Manpower Salary, Wages & Allowances | 263.5 | 0.82 | 216.07 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 120 | 0.82 | 98.4 |
| | Foreign Currency | 16 | 1 | 16 |
| **Total Operating Cost** | | **25136.87** | | **25069.71** |

# 300 MW Economical Operating / Recurring Cost Table (Fuel –HFO)

| SL. | Item of Cost | Year 1-7 | | |
|---|---|---|---|---|
| | | L.C | F.C. | Total |
| i) | Raw Materials | 178777.44 | 1 | 178777.44 |
| ii) | Utilities (Power, Water, Gas) | 17 | 1.11 | 18.87 |
| iii) | Manpower Salary, Wages & Allowances | 263.5 | 0.82 | 216.07 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 120 | 0.82 | 98.4 |
| | Foreign Currency | 16 | 1 | 16 |
| **Total Operating Cost** | | **179193.9** | | **179126.8** |

| SL. | Item of Cost | Year 8-14 | | |
|---|---|---|---|---|
| | | L.C | F.C. | Total |
| i) | Raw Materials | 178777.44 | 1 | 178777.44 |
| ii) | Utilities (Power, Water, Gas) | 17 | 1.11 | 18.87 |
| iii) | Manpower Salary, Wages & Allowances | 263.5 | 0.82 | 216.07 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 120 | 0.82 | 98.4 |
| | Foreign Currency | 16 | 1 | 16 |
| **Total Operating Cost** | | **179193.9** | | **179126.8** |

| SL. | Item of Cost | Year 15-21 | | |
|---|---|---|---|---|
| | | L.C | F.C. | Total |
| i) | Raw Materials | 178777.44 | 1 | 178777.44 |
| ii) | Utilities (Power, Water, Gas) | 17 | 1.11 | 18.87 |
| iii) | Manpower Salary, Wages & Allowances | 263.5 | 0.82 | 216.07 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 120 | 0.82 | 98.4 |
| | Foreign Currency | 16 | 1 | 16 |
| **Total Operating Cost** | | **179193.9** | | **179126.8** |

# Generation Cost / Unit

## Fuel – Gas

| Capacity | Opearating Cost | VAT Cost | Gas Cost | Total Cost | Total Generation | Unit Cost |
|---|---|---|---|---|---|---|
| (MW) | Lakh TK. | Lakh TK. | Lakh TK. | Lakh TK. | KWH | |
| | | | | | | |
| 300 | 416.5 | 9648.844 | 24720.37378 | 34785.72 | 1978800000 | **1.75792** |

## Fuel – HFO

| Capacity | Opearating Cost | VAT Cost | HFO Cost | Total Cost | Total Generation | Unit Cost |
|---|---|---|---|---|---|---|
| (MW) | Lakh TK. | Lakh TK. | Lakh TK. | Lakh TK. | KWH | |
| | | | | | | |
| 300 | 416.5 | 13254.08 | 178777.44 | 192448 | 1978800000 | **9.72549** |

# Benefit Cost Ratio (Financial)
# Fuel-Gas

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at 15% Discount Factor | Discounted Value of Total Benefit at 15% Discount Factor |
|---|---|---|---|---|---|---|---|
| 0 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1.00 | 1408.84 | 0.00 |
| 1 | 172991.7 | 0.00 | 172991.68 | 0.00 | 1.15 | 150427.55 | 0.00 |
| 2 | 59500.09 | 0.00 | 59500.09 | 0.00 | 1.32 | 44990.62 | 0.00 |
| 3 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 1.52 | 32348.74 | 67331.57 |
| 4 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 1.75 | 28129.34 | 58549.19 |
| 5 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 2.01 | 24460.30 | 50912.34 |
| 6 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 2.31 | 21269.82 | 44271.60 |
| 7 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 2.66 | 18495.50 | 38497.04 |
| 8 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 3.06 | 16083.04 | 33475.69 |
| 9 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 3.52 | 13985.25 | 29109.30 |
| 10 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 4.05 | 12161.09 | 25312.43 |
| 11 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 4.65 | 10574.86 | 22010.81 |
| 12 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 5.35 | 9195.53 | 19139.83 |
| 13 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 6.15 | 7996.11 | 16643.33 |
| 14 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 7.08 | 6953.14 | 14472.46 |
| 15 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 8.14 | 6046.21 | 12584.75 |
| 16 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 9.36 | 5257.58 | 10943.26 |
| 17 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 10.76 | 4571.80 | 9515.88 |
| 18 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 12.38 | 3975.48 | 8274.68 |
| 19 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 14.23 | 3456.94 | 7195.37 |
| 20 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 16.37 | 3006.04 | 6256.85 |
| 21 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 18.82 | 2613.94 | 5440.74 |
| 22 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 21.64 | 2272.99 | 4731.07 |
| 23 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 24.89 | 1976.52 | 4113.98 |
| | | | | | | **431657.26** | **488782.18** |

| | |
|---|---|
| **Discount Rate** | 15% |
| **NPV** | 57124.9211 |
| **BCR** | 1.1323 |

# Benefit Cost Ratio (Financial)
# Fuel-HFO

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at 15% Discount Factor | Discounted Value of Total Benefit at 15% Discount Factor |
|---|---|---|---|---|---|---|---|
| 0 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1.00 | 1408.84 | 0.00 |
| 1 | 172991.68 | 0.00 | 172991.68 | 0.00 | 1.15 | 150427.55 | 0.00 |
| 2 | 59500.09 | 0.00 | 59500.09 | 0.00 | 1.32 | 44990.62 | 0.00 |
| 3 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 1.52 | 151208.52 | 201994.71 |
| 4 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 1.75 | 131485.67 | 175647.57 |
| 5 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 2.01 | 114335.37 | 152737.02 |
| 6 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 2.31 | 99422.06 | 132814.80 |
| 7 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 2.66 | 86453.96 | 115491.13 |
| 8 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 3.06 | 75177.36 | 100427.07 |
| 9 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 3.52 | 65371.62 | 87327.89 |
| 10 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 4.05 | 56844.88 | 75937.29 |
| 11 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 4.65 | 49430.33 | 66032.43 |
| 12 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 5.35 | 42982.90 | 57419.50 |
| 13 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 6.15 | 37376.43 | 49930.00 |
| 14 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 7.08 | 32501.25 | 43417.39 |
| 15 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 8.14 | 28261.95 | 37754.26 |
| 16 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 9.36 | 24575.61 | 32829.79 |
| 17 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 10.76 | 21370.10 | 28547.64 |
| 18 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 12.38 | 18582.69 | 24824.04 |
| 19 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 14.23 | 16158.86 | 21586.12 |
| 20 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 16.37 | 14051.19 | 18770.54 |
| 21 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 18.82 | 12218.42 | 16322.21 |
| 22 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 21.64 | 10624.72 | 14193.22 |
| 23 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 24.89 | 9238.88 | 12341.93 |
| | | | | | | **1294499.79** | **1466346.53** |

| | |
|---|---|
| **Discount Rate** | 15% |
| **NPV** | 171846.743 |
| **BCR** | 1.1328 |

# Benefit Cost Ratio (Economical)
# Fuel-Gas

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at 15% Discount Factor | Discounted Value of Total Benefit at 15% Discount Factor |
|---|---|---|---|---|---|---|---|
| 0 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1.00 | 1155.25 | 0.00 |
| 1 | 168203.76 | 0.00 | 168203.76 | 0.00 | 1.15 | 146264.14 | 0.00 |
| 2 | 59185.96 | 0.00 | 59185.96 | 0.00 | 1.32 | 44753.09 | 0.00 |
| 3 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 1.52 | 16483.74 | 58549.19 |
| 4 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 1.75 | 14333.69 | 50912.34 |
| 5 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 2.01 | 12464.08 | 44271.60 |
| 6 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 2.31 | 10838.33 | 38497.04 |
| 7 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 2.66 | 9424.63 | 33475.69 |
| 8 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 3.06 | 8195.33 | 29109.30 |
| 9 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 3.52 | 7126.38 | 25312.43 |
| 10 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 4.05 | 6196.85 | 22010.81 |
| 11 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 4.65 | 5388.57 | 19139.83 |
| 12 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 5.35 | 4685.71 | 16643.33 |
| 13 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 6.15 | 4074.53 | 14472.46 |
| 14 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 7.08 | 3543.07 | 12584.75 |
| 15 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 8.14 | 3080.93 | 10943.26 |
| 16 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 9.36 | 2679.07 | 9515.88 |
| 17 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 10.76 | 2329.63 | 8274.68 |
| 18 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 12.38 | 2025.76 | 7195.37 |
| 19 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 14.23 | 1761.53 | 6256.85 |
| 20 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 16.37 | 1531.77 | 5440.74 |
| 21 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 18.82 | 1331.97 | 4731.07 |
| 22 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 21.64 | 1158.24 | 4113.98 |
| 23 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 24.89 | 1007.16 | 3577.37 |
| | | | | | | **311833.44** | **425027.98** |

| | |
|---|---|
| **Discount Rate** | 15% |
| **NPV** | 113194.54 |
| **BCR** | 1.3629968 |

# Benefit Cost Ratio (Economical )
# Fuel-HFO

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at 15% Discount Factor | Discounted Value of Total Benefit at 15% Discount Factor |
|---|---|---|---|---|---|---|---|
| 0 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1.00 | 1155.25 | 0.00 |
| 1 | 168203.76 | 0.00 | 168203.76 | 0.00 | 1.15 | 146264.14 | 0.00 |
| 2 | 59185.96 | 0.00 | 59185.96 | 0.00 | 1.32 | 44753.09 | 0.00 |
| 3 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 1.52 | 117778.77 | 175647.57 |
| 4 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 1.75 | 102416.32 | 152737.02 |
| 5 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 2.01 | 89057.67 | 132814.80 |
| 6 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 2.31 | 77441.45 | 115491.13 |
| 7 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 2.66 | 67340.39 | 100427.07 |
| 8 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 3.06 | 58556.86 | 87327.89 |
| 9 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 3.52 | 50919.01 | 75937.29 |
| 10 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 4.05 | 44277.40 | 66032.43 |
| 11 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 4.65 | 38502.09 | 57419.50 |
| 12 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 5.35 | 33480.08 | 49930.00 |
| 13 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 6.15 | 29113.11 | 43417.39 |
| 14 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 7.08 | 25315.75 | 37754.26 |
| 15 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 8.14 | 22013.69 | 32829.79 |
| 16 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 9.36 | 19142.34 | 28547.64 |
| 17 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 10.76 | 16645.51 | 24824.04 |
| 18 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 12.38 | 14474.36 | 21586.12 |
| 19 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 14.23 | 12586.40 | 18770.54 |
| 20 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 16.37 | 10944.70 | 16322.21 |
| 21 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 18.82 | 9517.13 | 14193.22 |
| 22 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 21.64 | 8275.76 | 12341.93 |
| 23 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 24.89 | 7196.32 | 10732.12 |
| | | | | | | 1047167.58 | 1275083.94 |

| | |
|---|---|
| **Discount Rate** | 15% |
| **NPV** | 227916.362 |
| **BCR** | 1.218 |

# 300 MW Internal Rate of Return (Financial)

## Fuel – Gas

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 13% | | 15% | | 20% | |
| 0 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1408.84 | 0.00 |
| 1 | 172991.68 | 0.00 | 172991.68 | 0.00 | 153089.99 | 0.00 | 150427.55 | 0.00 | 144159.74 | 0.00 |
| 2 | 59500.09 | 0.00 | 59500.09 | 0.00 | 46597.30 | 0.00 | 44990.62 | 0.00 | 41319.51 | 0.00 |
| 3 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 34096.96 | 70970.35 | 32348.74 | 67331.57 | 28471.29 | 59260.94 |
| 4 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 30174.30 | 62805.62 | 28129.34 | 58549.19 | 23726.08 | 49384.11 |
| 5 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 26702.92 | 55580.19 | 24460.30 | 50912.34 | 19771.73 | 41153.43 |
| 6 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 23630.90 | 49186.01 | 21269.82 | 44271.60 | 16476.44 | 34294.52 |
| 7 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 20912.30 | 43527.44 | 18495.50 | 38497.04 | 13730.37 | 28578.77 |
| 8 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 18506.46 | 38519.86 | 16083.04 | 33475.69 | 11441.97 | 23815.64 |
| 9 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 16377.40 | 34088.37 | 13985.25 | 29109.30 | 9534.98 | 19846.37 |
| 10 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 14493.27 | 30166.70 | 12161.09 | 25312.43 | 7945.82 | 16538.64 |
| 11 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 12825.91 | 26696.20 | 10574.86 | 22010.81 | 6621.51 | 13782.20 |
| 12 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 11350.36 | 23624.95 | 9195.53 | 19139.83 | 5517.93 | 11485.17 |
| 13 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 10044.57 | 20907.04 | 7996.11 | 16643.33 | 4598.27 | 9570.97 |
| 14 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 8889.00 | 18501.80 | 6953.14 | 14472.46 | 3831.89 | 7975.81 |
| 15 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 7866.37 | 16373.28 | 6046.21 | 12584.75 | 3193.24 | 6646.51 |
| 16 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 6961.39 | 14489.63 | 5257.58 | 10943.26 | 2661.04 | 5538.76 |
| 17 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 6160.52 | 12822.68 | 4571.80 | 9515.88 | 2217.53 | 4615.63 |
| 18 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 5451.79 | 11347.50 | 3975.48 | 8274.68 | 1847.94 | 3846.36 |
| 19 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 4824.59 | 10042.04 | 3456.94 | 7195.37 | 1539.95 | 3205.30 |
| 20 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 4269.55 | 8886.76 | 3006.04 | 6256.85 | 1283.29 | 2671.08 |
| 21 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 3778.36 | 7864.39 | 2613.94 | 5440.74 | 1069.41 | 2225.90 |
| 22 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 3343.68 | 6959.64 | 2272.99 | 4731.07 | 891.18 | 1854.92 |
| 23 | 0.00 | 49198.39 | 49198.39 | 102402.90 | 2959.01 | 6158.97 | 1976.52 | 4113.98 | 742.65 | 1545.77 |
| | | | | | 474715.72 | 569519.40 | 431657.26 | 488782.18 | 354002.61 | 347836.80 |

| Discount Rate: | 13% | 15% | 20% |
|---|---|---|---|
| NPV | 94803.679 | 57124.921 | -6165.812 |
| BCR | 1.200 | 1.132 | 0.983 |
| IRR: | | | 19.57% |

# 300 MW Internal Rate of Return (Financial )

## Fuel – HFO

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 22% | | 28% | | 15% | |
| 0 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1408.84 | 0.00 |
| 1 | 172991.68 | 0.00 | 172991.68 | 0.00 | 141796.46 | 0.00 | 135149.75 | 0.00 | 150427.55 | 0.00 |
| 2 | 59500.09 | 0.00 | 59500.09 | 0.00 | 39975.87 | 0.00 | 36315.97 | 0.00 | 44990.62 | 0.00 |
| 3 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 126645.66 | 169181.95 | 109657.89 | 146488.52 | 151208.52 | 201994.71 |
| 4 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 103807.91 | 138673.73 | 85670.23 | 114444.16 | 131485.67 | 175647.57 |
| 5 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 85088.45 | 113666.99 | 66929.86 | 89409.50 | 114335.37 | 152737.02 |
| 6 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 69744.63 | 93169.66 | 52288.96 | 69851.17 | 99422.06 | 132814.80 |
| 7 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 57167.73 | 76368.58 | 40850.75 | 54571.23 | 86453.96 | 115491.13 |
| 8 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 46858.80 | 62597.19 | 31914.65 | 42633.77 | 75177.36 | 100427.07 |
| 9 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 38408.85 | 51309.18 | 24933.32 | 33307.63 | 65371.62 | 87327.89 |
| 10 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 31482.66 | 42056.70 | 19479.15 | 26021.59 | 56844.88 | 75937.29 |
| 11 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 25805.46 | 34472.71 | 15218.09 | 20329.37 | 49430.33 | 66032.43 |
| 12 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 21152.02 | 28256.32 | 11889.13 | 15882.32 | 42982.90 | 57419.50 |
| 13 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 17337.72 | 23160.91 | 9288.38 | 12408.06 | 37376.43 | 49930.00 |
| 14 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 14211.25 | 18984.36 | 7256.55 | 9693.80 | 32501.25 | 43417.39 |
| 15 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 11648.56 | 15560.95 | 5669.18 | 7573.28 | 28261.95 | 37754.26 |
| 16 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 9548.00 | 12754.88 | 4429.05 | 5916.62 | 24575.61 | 32829.79 |
| 17 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 7826.23 | 10454.82 | 3460.19 | 4622.36 | 21370.10 | 28547.64 |
| 18 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 6414.94 | 8569.52 | 2703.28 | 3611.22 | 18582.69 | 24824.04 |
| 19 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 5258.15 | 7024.20 | 2111.93 | 2821.27 | 16158.86 | 21586.12 |
| 20 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 4309.96 | 5757.54 | 1649.95 | 2204.11 | 14051.19 | 18770.54 |
| 21 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 3532.75 | 4719.29 | 1289.02 | 1721.96 | 12218.42 | 16322.21 |
| 22 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 2895.70 | 3868.27 | 1007.05 | 1345.28 | 10624.72 | 14193.22 |
| 23 | 0.00 | 229969.26 | 229969.26 | 307208.70 | 2373.52 | 3170.72 | 786.76 | 1051.00 | 9238.88 | 12341.93 |
| | | | | | 874700.16 | 923778.45 | 671357.93 | 665908.24 | 1294499.79 | 1466346.53 |

| Discount Rate: | 22% | 28% | 15% |
|---|---|---|---|
| NPV | 49078.29 | -5449.69 | 171846.74 |
| BCR | 1.06 | 0.99 | 1.13 |
| IRR: | | | 27.60% |

# 300 MW Internal Rate of Return (Economic)

## Fuel – Gas

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 13% | | 15% | | 24% | |
| 0 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 |
| 1 | 168203.76 | 0.00 | 168203.76 | 0.00 | 148852.89 | 0.00 | 146264.14 | 0.00 | 135648.19 | 0.00 |
| 2 | 59185.96 | 0.00 | 59185.96 | 0.00 | 46351.29 | 0.00 | 44753.09 | 0.00 | 38492.43 | 0.00 |
| 3 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 18745.17 | 61713.34 | 16483.74 | 58549.19 | 13148.75 | 46703.49 |
| 4 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 16588.64 | 54613.58 | 14333.69 | 50912.34 | 10603.83 | 37664.11 |
| 5 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 14680.21 | 48330.60 | 12464.08 | 44271.60 | 8551.47 | 30374.28 |
| 6 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 12991.34 | 42770.44 | 10838.33 | 38497.04 | 6896.35 | 24495.39 |
| 7 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 11496.76 | 37849.95 | 9424.63 | 33475.69 | 5561.57 | 19754.34 |
| 8 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 10174.13 | 33495.53 | 8195.33 | 29109.30 | 4485.14 | 15930.92 |
| 9 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 9003.65 | 29642.06 | 7126.38 | 25312.43 | 3617.05 | 12847.52 |
| 10 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 7967.83 | 26231.91 | 6196.85 | 22010.81 | 2916.97 | 10360.90 |
| 11 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 7051.18 | 23214.08 | 5388.57 | 19139.83 | 2352.40 | 8355.57 |
| 12 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 6239.98 | 20543.44 | 4685.71 | 16643.33 | 1897.10 | 6738.36 |
| 13 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 5522.11 | 18180.03 | 4074.53 | 14472.46 | 1529.92 | 5434.16 |
| 14 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 4886.82 | 16088.52 | 3543.07 | 12584.75 | 1233.80 | 4382.39 |
| 15 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 4324.62 | 14237.63 | 3080.93 | 10943.26 | 995.00 | 3534.18 |
| 16 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 3827.10 | 12599.67 | 2679.07 | 9515.88 | 802.42 | 2850.15 |
| 17 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 3386.81 | 11150.15 | 2329.63 | 8274.68 | 647.11 | 2298.51 |
| 18 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 2997.18 | 9867.39 | 2025.76 | 7195.37 | 521.87 | 1853.63 |
| 19 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 2652.37 | 8732.21 | 1761.53 | 6256.85 | 420.86 | 1494.87 |
| 20 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 2347.23 | 7727.62 | 1531.77 | 5440.74 | 339.40 | 1205.54 |
| 21 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 2077.20 | 6838.60 | 1331.97 | 4731.07 | 273.71 | 972.21 |
| 22 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 1838.23 | 6051.86 | 1158.24 | 4113.98 | 220.74 | 784.04 |
| 23 | 0.00 | 25069.71 | 25069.71 | 89046.00 | 1626.75 | 5355.63 | 1007.16 | 3577.37 | 178.01 | 632.29 |
| | | | | | 346784.73 | 495234.26 | 311833.44 | 425027.98 | 242489.34 | 238666.84 |

| Discount Rate: | 13% | 15% | 24% |
|---|---|---|---|
| NPV | 159448.233 | 113194.54 | -3822.501 |
| BCR | 1.428 | 1.363 | 0.984 |
| IRR: | | | 23.74% |

# 300 MW Internal Rate of Return (Economic)

## Fuel – HFO

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 25% | | 15% | | 32% | |
| 0 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 |
| 1 | 168203.76 | 0.00 | 168203.76 | 0.00 | 134563.01 | 0.00 | 146264.14 | 0.00 | 127427.09 | 0.00 |
| 2 | 59185.96 | 0.00 | 59185.96 | 0.00 | 37879.02 | 0.00 | 44753.09 | 0.00 | 33968.07 | 0.00 |
| 3 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 91712.91 | 136774.66 | 117778.77 | 175647.57 | 77882.29 | 116148.57 |
| 4 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 73370.33 | 109419.72 | 102416.32 | 152737.02 | 59001.74 | 87991.34 |
| 5 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 58696.26 | 87535.78 | 89057.67 | 132814.80 | 44698.29 | 66660.11 |
| 6 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 46957.01 | 70028.62 | 77441.45 | 115491.13 | 33862.34 | 50500.08 |
| 7 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 37565.61 | 56022.90 | 67340.39 | 100427.07 | 25653.29 | 38257.64 |
| 8 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 30052.49 | 44818.32 | 58556.86 | 87327.89 | 19434.31 | 28983.06 |
| 9 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 24041.99 | 35854.66 | 50919.01 | 75937.29 | 14722.96 | 21956.86 |
| 10 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 19233.59 | 28683.72 | 44277.40 | 66032.43 | 11153.76 | 16633.99 |
| 11 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 15386.87 | 22946.98 | 38502.09 | 57419.50 | 8449.82 | 12601.51 |
| 12 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 12309.50 | 18357.58 | 33480.08 | 49930.00 | 6401.38 | 9546.59 |
| 13 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 9847.60 | 14686.07 | 29113.11 | 43417.39 | 4849.53 | 7232.27 |
| 14 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 7878.08 | 11748.85 | 25315.75 | 37754.26 | 3673.88 | 5478.99 |
| 15 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 6302.46 | 9399.08 | 22013.69 | 32829.79 | 2783.25 | 4150.75 |
| 16 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 5041.97 | 7519.27 | 19142.34 | 28547.64 | 2108.52 | 3144.51 |
| 17 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 4033.58 | 6015.41 | 16645.51 | 24824.04 | 1597.36 | 2382.20 |
| 18 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 3226.86 | 4812.33 | 14474.36 | 21586.12 | 1210.12 | 1804.70 |
| 19 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 2581.49 | 3849.86 | 12586.40 | 18770.54 | 916.76 | 1367.20 |
| 20 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 2065.19 | 3079.89 | 10944.70 | 16322.21 | 694.52 | 1035.76 |
| 21 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 1652.15 | 2463.91 | 9517.13 | 14193.22 | 526.15 | 784.66 |
| 22 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 1321.72 | 1971.13 | 8275.76 | 12341.93 | 398.60 | 594.44 |
| 23 | 0.00 | 179126.78 | 179126.78 | 267138.00 | 1057.38 | 1576.90 | 7196.32 | 10732.12 | 301.97 | 450.33 |
| | | | | | 627932.32 | 677565.66 | 1047167.58 | 1275083.94 | 482871.22 | 477705.57 |

| Discount Rate: | 25% | 15% | 32% |
|---|---|---|---|
| NPV | 49633.342 | 227916.362 | -5165.651 |
| BCR | 1.079 | 1.218 | 0.989 |
| IRR: | | | 31.62 % |

# SCHEDULE

# ANNEXURE – 4

**Cost Estimation and Economic Analysis of 450 MW Combined Cycle Power Plant at Shikalbaha**

# 450 MW Total Investment Cost

| Direct Cost | | | | | |
|---|---|---|---|---|---|
| 150 MW Plant Cost, C | New Plant (MW) | Factor $(Q/Q_o)^a$ | Direct Cost $C*(Q/Q_o)^a$ | Cost Escalation | Total Direct Cost at 2014 |
| | | 0.65 | | | |
| 80799.84 | **450** | **2.042343632** | **165021.0387** | 30% | **214527.3503** |
| | 150 | 1.0 | 80799.84 | | 105039.79 |
| | 225 | 1.30 | 105164.66 | | 136714.058 |
| | 300 | 1.57 | 126788.54 | | 164825.102 |

| Indirect Cost (Custom Duty, Taxes & VAT, C & F Cost, Landing Charges etc.) | | | | | |
|---|---|---|---|---|---|
| 150 MW Plant Cost, C | New Plant (MW) | Factor $(Q/Q_o)^a$ | Direct Cost $C*(Q/Q_o)^a$ | Cost Escalation | Total Direct Cost at 2014 |
| | | 0.3 | | | |
| 20261.709 | **450** | **1.39038917** | **28171.66077** | 30% | **36623.159** |
| | 150 | 1.0 | 20261.709 | | 26340.22 |
| | 225 | 1.13 | 22882.5 | | 29747.25 |
| | 300 | 1.23 | 24945.09 | | 32428.618 |

| Indirect Cost (Erection & Commissioning) | | | | | |
|---|---|---|---|---|---|
| 150 MW Plant Cost, C | New Plant (MW) | Factor $(Q/Q_o)^a$ | Direct Cost $C*(Q/Q_o)^a$ | Cost Escalation | Total Direct Cost at 2014 |
| | | 0.5 | | | |
| 8150.1 | **450** | **1.732** | **14116.38729** | 30% | **18351.30347** |
| | 150 | 1.0 | 8150.1 | | 10595.13 |
| | 225 | 1.22 | 9981.8 | | 12976.34 |
| | 300 | 1.41 | 11525.98 | | 14983.78 |

# Detailed Breakdown of Investment Cost

Installation of a 450 MW Combined Cycle
Power Plant at Shikalbaha

| Sl. No. | Item | L.C. | F.C. | Total | % of Cost |
|---|---|---|---|---|---|
| I) | **Pre-Construction Expendeture** | | | | |
| | Land acquisition & Land Development | 865 | 0 | 865 | 0.292 |
| | **Sub-Total – I** | **865** | **0** | **865** | **0.292** |
| II) | **Construction Works (based on PWD** | | | | |
| | **rate 2011)** | | | | |
| | Residential, Non Residential and fuel | 811.3 | 0 | 811.3 | 0.273 |
| | unloading system | | | | |
| | (Administrative building 17,000/- per m² | | | | |
| | Internal Road (RCC) @ Tk. 2509/m² ) | | | | |
| | Deep Tube-well & pump house | 40 | 0 | 40 | 0.013 |
| | **Sub-Total – II** | **851.3** | **0** | **851.3** | **0.287** |
| III) | **Machinery, Equipment & Spares** | | | | |
| | Supply of material & Equipment | 42905.47035 | 171621.9 | 214527.4 | 72.302 |
| | Engineering Design | 0 | 36623 | 36623 | 12.343 |
| | Erection & Commissioning | 8992.144849 | 9359 | 18351 | 6.185 |
| | Training | 250 | 270 | 520 | 0.175 |
| | Pre-Shipment inspection @0.5% | 0 | 1072.63676 | 1072.63676 | 0.362 |
| | **Sub-Total – III** | **52147.6152** | **218947** | **271094** | **91.366** |
| IV) | **Transport Vehicle** | | | | |
| | Rental @ Tk. 3000/day for 700 days | 21 | 0 | 21 | 0.007 |
| | during project implementation | | | | |
| | **Sub-Total – IV** | **21** | 0 | **21** | **0.007** |
| V) | **Other Cost** | | | | |
| | Charge of electrical energy during construction | 8 | 0 | 8 | 0.003 |
| | Interest during construction @ 3% p.a. | 5148.656442 | 0 | 5148.65644 | 1.735 |
| | Bank Charges @ 1.25% | 2145.273517 | 0 | 2145.27352 | 0.723 |
| | Insurance @ 3% on imported materials | 5148.656442 | 0 | 5148.65644 | 1.735 |
| | Project office expenditure | 17.65 | 0 | 17.65 | 0.006 |
| | Physical Contingency (2% of the total items) | 1327.063032 | 4378.937 | 5706.00003 | 1.923 |
| | Price Contingency (2% of the total cost) | 1327.063032 | 4378.937 | 5706.00003 | 1.923 |
| | **Sub-Total – V** | **15122.36246** | **8757.874** | **23880.24** | **8.048** |
| **Total Investment Cost** | | **69007.28** | **227704.72** | **296712.00** | 100.00 |

# 450 MW Annual Phasing Cost

| Sl. | Dsecription | Year 01 | | | | |
|---|---|---|---|---|---|---|
| | | GOB | Project Aid | | DPA | Total |
| | | | RPA | | | |
| | | | Through GOB | Special AC | | |
| A) | **Supplies & Services** | | | | | |
| | Travel Expenses | 0.8 | | | | 0.8 |
| | Postal | 0.32 | | | | 0.32 |
| | Telephone / Fax | 0.6 | | | | 0.6 |
| | Bank Charges @ 1.25% | 0 | | | | 0 |
| | Insurance @ 3% on imported materials | 0 | | | | 0 |
| | Duties & Taxes on Imported Materials & Equipments @ 3% | 0 | | | | 0 |
| | Stationaries, Seal & Stumps | 0.4 | | | | 0.4 |
| | Entertainment | 0.4 | | | | 0.4 |
| | Casual Labour | 0.3 | | | | 0.3 |
| | Copy / Photo Copy | 0.2 | | | | 0.2 |
| | Computer Accessories | 0.12 | | | | 0.12 |
| | Computer and office equipment | 0.3 | | | | 0.3 |
| | Utility Charge | 3 | | | | 3 |
| | **Sub-Total** | **6.44** | | | | **6.44** |
| | **Acquisition of Asset** | | | | | |
| | Vehicle (Rental) | 6.3 | | | | 6.3 |
| | Machinery Equipment & Spares | 0 | | | | 0 |
| | Pre-Shipment Inspection Cost @0.50% | 0 | | | | 0 |
| | A/C, Computer, Laser Printer, Color Printer, Scanner & Photocopier | 5 | | | | 5 |
| | Office Equipment | 0.8 | | | | 0.8 |
| | Furniture | 3 | | | | 3 |
| | Deep Tube Well & Pump House | 8 | | | | 8 |
| B) | **Land Properties** | | | | | |
| | Land Acquisition | 765 | | | | 765 |
| | **Construction Works** | | | | | |
| | Land Development | 60 | | | | 60 |
| | Building Works | 280.3 | | | | 280.3 |
| | Doors, Windows & Finishing | 240 | | | | 240 |
| | Internal Road (RCC) | 20 | | | | 20 |
| | Drainage System | 14 | | | | 14 |
| | **Sub-Total** | **1402** | | | | **1402** |
| C) | **Physical Contengency** | 0 | | | | 0 |
| D) | **Price Contengency** | 0 | | | | 0 |
| | **Total (A+B+C+D)** | **1409** | | | | **1409** |

| Sl | Dsecription | Year 02 | | | | |
|---|---|---|---|---|---|---|
| | | GOB | Project Aid | | DPA | Total |
| | | | RPA | | | |
| | | | Through GOB | Special AC | | |
| **A)** | **Supplies & Services** | | | | | |
| | Travel Expenses | 0.60 | | | | 0.60 |
| | Postal | 0.08 | | | | 0.08 |
| | Telephone / Fax | 0.60 | | | | 0.60 |
| | Bank Charges @ 1.25% | 2145.27 | | | | 2145.27 |
| | Insurance @ 3% on imported materials | 5148.66 | | | | 5148.66 |
| | Duties & Taxes on Imported Materials & Equipments @ 3% | 5148.66 | | | | 5148.66 |
| | Stationaries, Seal & Stumps | 0.30 | | | | 0.30 |
| | Entertainment | 0.30 | | | | 0.30 |
| | Casual Labour | 0.30 | | | | 0.30 |
| | Copy / Photo Copy | 0.15 | | | | 0.15 |
| | Computer Accessories | 0.09 | | | | 0.09 |
| | Computer and office equipment | 0.30 | | | | 0.30 |
| | Utility Charge | 2.50 | | | | 2.50 |
| | **Sub-Total** | **12447.81** | | | | **12447.81** |
| | **Acquisition of Asset** | | | | | |
| | Vehicle (Rental) | 6.30 | | | | 6.30 |
| | Machinery Equipment & Spares | 202516.37 | | | | 202516.37 |
| | Pre-Shipment Inspection Cost @0.50% | 1072.64 | | | | 1072.64 |
| | A/C, Computer, Laser Printer, Color Printer, Scanner & Photocopier | 0.00 | | | | 0.00 |
| | Office Equipment | 0.20 | | | | 0.20 |
| | Furniture | 0.00 | | | | 0.00 |
| | Deep Tube Well & Pump House | 32.00 | | | | 32.00 |
| **B)** | **Land Properties** | | | | | |
| | Land Acquisition | 0.00 | | | | 0.00 |
| | **Construction Works** | | | | | |
| | Land Development | 40.00 | | | | 40.00 |
| | Building Works | 130.00 | | | | 130.00 |
| | Doors , Windows & Finishing | 110.00 | | | | 110.00 |
| | Internal Road (RCC) | 10.00 | | | | 10.00 |
| | Drainage System | 7.00 | | | | 7.00 |
| | **Sub-Total** | **203924.51** | | | | **203924.51** |
| **C)** | **Physical Contengency** | **1711.80** | | | | **1711.80** |
| **D)** | **Price Contengency** | **1711.80** | | | | **1711.80** |
| | **Total (A+B+C+D)** | **219795.91** | | | | **219795.91** |

| Sl | Dsecription | Year 03 | | | | |
|---|---|---|---|---|---|---|
| | | GOB | Project Aid | | DPA | Total |
| | | | RPA | | | |
| | | | Through GOB | Special AC | | |
| **A)** | **Supplies & Services** | | | | | |
| | Travel Expenses | 0.60 | | | | 0.60 |
| | Postal | 0.00 | | | | 0.00 |
| | Telephone / Fax | 0.60 | | | | 0.60 |
| | Bank Charges @ 1.25% | 0.00 | | | | 0.00 |
| | Insurance @ 3% on imported materials | 0.00 | | | | 0.00 |
| | Duties & Taxes on Imported Materials & Equipments @ 3% | 0.00 | | | | 0.00 |
| | Stationaries, Seal & Stumps | 0.30 | | | | 0.30 |
| | Entertainment | 0.30 | | | | 0.30 |
| | Casual Labour | 0.30 | | | | 0.30 |
| | Copy / Photo Copy | 0.15 | | | | 0.15 |
| | Computer Accessories | 0.09 | | | | 0.09 |
| | Computer and office equipment | 0.15 | | | | 0.15 |
| | Utility Charge | 2.50 | | | | 2.50 |
| | **Sub-Total** | **4.99** | | | | **4.99** |
| | **Acquisition of Asset** | | | | | |
| | Vehicle (Rental) | 8.40 | | | | 8.40 |
| | Machinery Equipment & Spares | 67505.46 | | | | 67505.46 |
| | Pre-Shipment Inspection Cost @0.50% | 0.00 | | | | 0.00 |
| | A/C , Computer, Laser Printer, Color Printer, Scanner & Photocopier | 0.00 | | | | 0.00 |
| | Office Equipment | 0.00 | | | | 0.00 |
| | Furniture | 0.00 | | | | 0.00 |
| | Deep Tube Well & Pump House | 0.00 | | | | 0.00 |
| **B)** | **Land Properties** | 0.00 | | | | 0.00 |
| | Land Acquisition | 0.00 | | | | 0.00 |
| | **Construction Works** | | | | | |
| | Land Development | 0.00 | | | | 0.00 |
| | Building Works | 0.00 | | | | 0.00 |
| | Doors, Windows & Finishing | 0.00 | | | | 0.00 |
| | Internal Road (RCC) | 0.00 | | | | 0.00 |
| | Drainage System | 0.00 | | | | 0.00 |
| | Sub-Total | **67513.86** | | | | **67513.86** |
| **C)** | **Physical Contengency** | **3994.20** | | | | **3994.20** |
| **D)** | **Price Contengency** | **3994.20** | | | | **3994.20** |
| | **Total (A+B+C+D)** | **75507.25** | | | | **75507.25** |

# 450 MW Economic Value of Investment Cost

| Sl. | Item of Cost | Year – 1 | | | Year - 2 | | | Year – 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **No.** | | **PV** | **SCF** | **AV** | **PV** | **SCF** | **AV** | **PV** | **SCF** | **AV** |
| | | | | | | | | | | |
| I) | Revenue Component | | | | | | | | | |
| | a) Foreign Currency | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| | b) Local Currency | 6.44 | 0.82 | 5.28 | 12447.81 | 0.82 | 10207.20 | 4.99 | 0.82 | 4.09 |
| | | | | | | | | | | |
| II) | Capital Component | | | | | | | | | |
| | a) Foreign Currency | 0 | 1 | 0 | 183532.06 | 1 | 183532.06 | 67505.46 | 1 | 67505.46 |
| | b) Local Currency | 1402.4 | 0.82 | 1149.97 | 20392.45 | 0.82 | 16721.81 | 8.4 | 0.82 | 6.89 |
| | | | | | | | | | | |
| III) | Physical Contingency | | | | | | | | | |
| | a) Foreign Currency | 0 | 1 | 0 | 1241.06 | 1 | 1241.06 | 2895.80 | 1 | 2895.80 |
| | b) Local Currency | 0 | 0.82 | 0 | 470.75 | 0.82 | 386.011 | 1098.41 | 0.82 | 900.69 |
| | | | | | | | | | | |
| IV) | Price Contingency | | | | | | | | | |
| | a) Foreign Currency | 0 | 1 | 0 | 1241.06 | 1 | 1241.06 | 2895.80 | 1 | 2895.80 |
| | b) Local Currency | 0 | 0.82 | 0 | 470.745 | 0.82 | 386.01 | 1098.41 | 0.82 | 900.69 |
| | **Total** | 1408.84 | | **1155.249** | 219795.91 | | **213715.2** | 75507.25 | | **75109.41** |

# 450 MW Financial Operating / Recurring Cost Table (Fuel –Gas)

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 1 -7 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 37080.561 | 0 | 37080.561 |
| ii) | Utilities (Power, Water, Gas) | 24 | 0 | 24 |
| iii) | Manpower Salary, Wages & Allowances | 372 | 0 | 372 |
| iv) | Machine & Equipment Depriciation | 13527.351 | 0 | 13527.351 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 192 | 0 | 192 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 20035.35 | 0 | 20035.35 |
| **Total Operating Cost** | | **71256.8** | **0** | **71256.8** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 8-14 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 37080.561 | 0 | 37080.561 |
| ii) | Utilities (Power, Water, Gas) | 24 | 0 | 24 |
| iii) | Manpower Salary, Wages & Allowances | 372 | 0 | 372 |
| iv) | Machine & Equipment Depriciation | 13527.351 | 0 | 13527.351 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 192 | 0 | 192 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 20035.35 | 0 | 20035.35 |
| **Total Operating Cost** | | **71256.8** | **0** | **71256.8** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 15-21 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 37080.561 | 0 | 37080.561 |
| ii) | Utilities (Power, Water, Gas) | 24 | 0 | 24 |
| iii) | Manpower Salary, Wages & Allowances | 372 | 0 | 372 |
| iv) | Machine & Equipment Depriciation | 13527.351 | 0 | 13527.351 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 192 | 0 | 192 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 20035.35 | 0 | 20035.35 |
| **Total Operating Cost** | | **71256.8** | **0** | **71256.8** |

# 450 MW Financial Operating / Recurring Cost Table (Fuel –HFO)

| Operating / Recurring Cost For HFO | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cos | Year 1-7 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 268166.16 | 0 | 268166.16 |
| ii) | Utilities (Power, Water, Gas) | 24 | 0 | 24 |
| iii) | Manpower Salary, Wages & Allowances | 372 | 0 | 372 |
| iv) | Machine & Equipment Depriciation | 13527.35137 | 0 | 13527.351 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 192 | 0 | 192 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 60106.05 | 0 | 60106.05 |
| **Total Operating Cost** | | **342413.1** | **0.0** | **342413.1** |

| Operating / Recurring Cost For HFO | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 8-14 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 268166.16 | 0 | 268166.16 |
| ii) | Utilities (Power, Water, Gas) | 24 | 0 | 24 |
| iii) | Manpower Salary, Wages & Allowances | 372 | 0 | 372 |
| iv) | Machine & Equipment Depriciation | 13527.35137 | 0 | 13527.351 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 192 | 0 | 192 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 60106.05 | 0 | 60106.05 |
| **Total Operating Cost** | | **342413.1** | **0.0** | **342413.1** |

| Operating / Recurring Cost For HFO | | | | |
|---|---|---|---|---|
| SL. No. | Item of Cost | Year 15-21 | | |
| | | L.C | F.C. | Total |
| i) | Raw Materials | 268166.16 | 0 | 268166.16 |
| ii) | Utilities (Power, Water, Gas) | 24 | 0 | 24 |
| iii) | Manpower Salary, Wages & Allowances | 372 | 0 | 372 |
| iv) | Machine & Equipment Depriciation | 13527.35137 | 0 | 13527.351 |
| v) | Building & Other Cost Depriciation | 25.539 | 0 | 25.539 |
| vi) | Manintenance & Other Miscellaneous | 192 | 0 | 192 |
| vii) | Taxes, if any ( here 15% VAT on Generation) | 60106.05 | 0 | 60106.05 |
| **Total Operating Cost** | | **342413.1** | **0.0** | **342413.1** |

# 300 MW Economical Operating / Recurring Cost Table (Fuel –Gas)

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. | Item of Cost | Year 1-7 | | |
| | | PV | SCF | AV |
| i) | Raw Materials | 37080.561 | 1 | 37080.561 |
| ii) | Utilities (Power, Water, Gas) | 24 | 1.11 | 26.64 |
| iii) | Manpower Salary, Wages & Allowances | 372 | 0.82 | 305.04 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 160 | 0.82 | 131.2 |
| | Foreign Currency | 32 | 1 | 32 |
| **Total Operating Cost** | | **37668.56** | | **37575.44** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. | Item of Cost | Year 8-14 | | |
| | | PV | SCF | AV |
| i) | Raw Materials | 37080.561 | 1 | 37080.561 |
| ii) | Utilities (Power, Water, Gas) | 24 | 1.11 | 26.64 |
| iii) | Manpower Salary, Wages & Allowances | 372 | 0.82 | 305.04 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 160 | 0.82 | 131.2 |
| | Foreign Currency | 32 | 1 | 32 |
| **Total Operating Cost** | | **37668.56** | | **37575.44** |

| Operating / Recurring Cost For GAS | | | | |
|---|---|---|---|---|
| SL. | Item of Cost | Year 15-21 | | |
| | | PV | SCF | AV |
| i) | Raw Materials | 37080.561 | 1 | 37080.561 |
| ii) | Utilities (Power, Water, Gas) | 24 | 1.11 | 26.64 |
| iii) | Manpower Salary, Wages & Allowances | 372 | 0.82 | 305.04 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 160 | 0.82 | 131.2 |
| | Foreign Currency | 32 | 1 | 32 |
| **Total Operating Cost** | | **37668.56** | | **37575.44** |

# 300 MW Economical Operating / Recurring Cost Table (Fuel –HFO)

| SL. | Item of Cost | Year 1-7 | | |
|---|---|---|---|---|
| | | L.C | F.C. | Total |
| i) | Raw Materials | 268166.16 | 1 | 268166.16 |
| ii) | Utilities (Power, Water, Gas) | 24 | 1.11 | 26.64 |
| iii) | Manpower Salary, Wages & Allowances | 372 | 0.82 | 305.04 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 160 | 0.82 | 131.2 |
| | Foreign Currency | 32 | 1 | 32 |
| **Total Operating Cost** | | **268754.2** | | **268661** |

| SL. | Item of Cost | Year 8-14 | | |
|---|---|---|---|---|
| | | L.C | F.C. | Total |
| i) | Raw Materials | 268166.16 | 1 | 268166.16 |
| ii) | Utilities (Power, Water, Gas) | 24 | 1.11 | 26.64 |
| iii) | Manpower Salary, Wages & Allowances | 372 | 0.82 | 305.04 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 160 | 0.82 | 131.2 |
| | Foreign Currency | 32 | 1 | 32 |
| **Total Operating Cost** | | **268754.2** | | **268661** |

| SL. | Item of Cost | Year 15-21 | | |
|---|---|---|---|---|
| | | L.C | F.C. | Total |
| i) | Raw Materials | 268166.16 | 1 | 268166.16 |
| ii) | Utilities (Power, Water, Gas) | 24 | 1.11 | 26.64 |
| iii) | Manpower Salary, Wages & Allowances | 372 | 0.82 | 305.04 |
| iv) | Manintenance & Other Miscellaneous | | | |
| | Local Currency | 160 | 0.82 | 131.2 |
| | Foreign Currency | 32 | 1 | 32 |
| **Total Operating Cost** | | **268754.2** | | **268661** |

# Generation Cost / Unit

## Fuel – Gas

| Capacity | Opearating Cost | VAT Cost | Gas Cost | Total Cost | Total Generation | Unit Cost |
|---|---|---|---|---|---|---|
| (MW) | Lakh TK. | Lakh TK. | Lakh TK. | Lakh TK. | KWH | |
| | | | | | | |
| 450 | 588 | 14473.2659 | 37080.56067 | 52141.82657 | 2968200000 | **1.75668** |

## Fuel – HFO

| Capacity | Opearating Cost | VAT Cost | HFO Cost | Total Cost | Total Generation | Unit Cost |
|---|---|---|---|---|---|---|
| (MW) | Lakh TK. | Lakh TK. | Lakh TK. | Lakh TK. | KWH | |
| | | | | | | |
| 300 | 588 | 19881.126 | 268166.16 | 288635.286 | 2968200000 | **9.72425** |

# Benefit Cost Ratio (Financial)
# Fuel-Gas

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at 15% Discount Factor | Discounted Value of Total Benefit at 15% Discount Factor |
|---|---|---|---|---|---|---|---|
| 0 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1.00 | 1408.84 | 0.00 |
| 1 | 219795.9 | 0.00 | 219795.9 | 0.00 | 1.15 | 191126.88 | 0.00 |
| 2 | 75507.25 | 0.00 | 75507.25 | 0.00 | 1.32 | 57094.33 | 0.00 |
| 3 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 1.52 | 46852.50 | 100997.35 |
| 4 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 1.75 | 40741.31 | 87823.79 |
| 5 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 2.01 | 35427.22 | 76368.51 |
| 6 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 2.31 | 30806.28 | 66407.40 |
| 7 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 2.66 | 26788.07 | 57745.56 |
| 8 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 3.06 | 23293.97 | 50213.53 |
| 9 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 3.52 | 20255.63 | 43663.94 |
| 10 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 4.05 | 17613.59 | 37968.65 |
| 11 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 4.65 | 15316.17 | 33016.21 |
| 12 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 5.35 | 13318.41 | 28709.75 |
| 13 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 6.15 | 11581.22 | 24965.00 |
| 14 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 7.08 | 10070.63 | 21708.70 |
| 15 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 8.14 | 8757.07 | 18877.13 |
| 16 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 9.36 | 7614.84 | 16414.89 |
| 17 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 10.76 | 6621.60 | 14273.82 |
| 18 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 12.38 | 5757.91 | 12412.02 |
| 19 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 14.23 | 5006.88 | 10793.06 |
| 20 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 16.37 | 4353.81 | 9385.27 |
| 21 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 18.82 | 3785.92 | 8161.10 |
| 22 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 21.64 | 3292.11 | 7096.61 |
| 23 | 0.00 | 71256.80 | 71256.80 | 153604.35 | 24.89 | 2862.70 | 6170.97 |
| | | | | | | **589747.90** | **733173.27** |

| | |
|---|---|
| **Discount Rate** | 15% |
| **NPV** | 143425.366 |
| **BCR** | 1.243 |

# Benefit Cost Ratio (Financial)
# Fuel-HFO

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at 15% Discount Factor | Discounted Value of Total Benefit at 15% Discount Factor |
|---|---|---|---|---|---|---|---|
| 0 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1.00 | 1408.84 | 0.00 |
| 1 | 219795.91 | 0.00 | 219795.91 | 0.00 | 1.15 | 191126.88 | 0.00 |
| 2 | 75507.25 | 0.00 | 75507.25 | 0.00 | 1.32 | 57094.33 | 0.00 |
| 3 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 1.52 | 225142.17 | 302992.06 |
| 4 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 1.75 | 195775.80 | 263471.36 |
| 5 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 2.01 | 170239.83 | 229105.53 |
| 6 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 2.31 | 148034.63 | 199222.20 |
| 7 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 2.66 | 128725.77 | 173236.69 |
| 8 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 3.06 | 111935.45 | 150640.60 |
| 9 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 3.52 | 97335.17 | 130991.83 |
| 10 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 4.05 | 84639.28 | 113905.94 |
| 11 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 4.65 | 73599.38 | 99048.64 |
| 12 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 5.35 | 63999.46 | 86129.25 |
| 13 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 6.15 | 55651.70 | 74895.00 |
| 14 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 7.08 | 48392.78 | 65126.09 |
| 15 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 8.14 | 42080.68 | 56631.38 |
| 16 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 9.36 | 36591.90 | 49244.68 |
| 17 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 10.76 | 31819.04 | 42821.46 |
| 18 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 12.38 | 27668.73 | 37236.05 |
| 19 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 14.23 | 24059.77 | 32379.18 |
| 20 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 16.37 | 20921.54 | 28155.81 |
| 21 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 18.82 | 18192.64 | 24483.31 |
| 22 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 21.64 | 15819.69 | 21289.83 |
| 23 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 24.89 | 13756.25 | 18512.90 |
| | | | | | | **1884011.70** | **2199519.80** |

| | |
|---|---|
| **Discount Rate** | 15% |
| **NPV** | 315508.099 |
| **BCR** | 1.167 |

# Benefit Cost Ratio (Economical)
# Fuel-Gas

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at 15% Discount Factor | Discounted Value of Total Benefit at 15% Discount Factor |
|---|---|---|---|---|---|---|---|
| 0 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1.00 | 1155.25 | 0.00 |
| 1 | 213715.20 | 0.00 | 213715.20 | 0.00 | 1.15 | 185839.30 | 0.00 |
| 2 | 75109.41 | 0.00 | 75109.41 | 0.00 | 1.32 | 56793.51 | 0.00 |
| 3 | 0.00 | 37575.44 | 37575.44 | 133569 | 1.52 | 24706.46 | 87823.79 |
| 4 | 0.00 | 37575.44 | 37575.44 | 133569 | 1.75 | 21483.88 | 76368.51 |
| 5 | 0.00 | 37575.44 | 37575.44 | 133569 | 2.01 | 18681.63 | 66407.40 |
| 6 | 0.00 | 37575.44 | 37575.44 | 133569 | 2.31 | 16244.90 | 57745.56 |
| 7 | 0.00 | 37575.44 | 37575.44 | 133569 | 2.66 | 14126.00 | 50213.53 |
| 8 | 0.00 | 37575.44 | 37575.44 | 133569 | 3.06 | 12283.48 | 43663.94 |
| 9 | 0.00 | 37575.44 | 37575.44 | 133569 | 3.52 | 10681.29 | 37968.65 |
| 10 | 0.00 | 37575.44 | 37575.44 | 133569 | 4.05 | 9288.07 | 33016.21 |
| 11 | 0.00 | 37575.44 | 37575.44 | 133569 | 4.65 | 8076.59 | 28709.75 |
| 12 | 0.00 | 37575.44 | 37575.44 | 133569 | 5.35 | 7023.12 | 24965.00 |
| 13 | 0.00 | 37575.44 | 37575.44 | 133569 | 6.15 | 6107.06 | 21708.70 |
| 14 | 0.00 | 37575.44 | 37575.44 | 133569 | 7.08 | 5310.49 | 18877.13 |
| 15 | 0.00 | 37575.44 | 37575.44 | 133569 | 8.14 | 4617.81 | 16414.89 |
| 16 | 0.00 | 37575.44 | 37575.44 | 133569 | 9.36 | 4015.49 | 14273.82 |
| 17 | 0.00 | 37575.44 | 37575.44 | 133569 | 10.76 | 3491.73 | 12412.02 |
| 18 | 0.00 | 37575.44 | 37575.44 | 133569 | 12.38 | 3036.29 | 10793.06 |
| 19 | 0.00 | 37575.44 | 37575.44 | 133569 | 14.23 | 2640.25 | 9385.27 |
| 20 | 0.00 | 37575.44 | 37575.44 | 133569 | 16.37 | 2295.87 | 8161.10 |
| 21 | 0.00 | 37575.44 | 37575.44 | 133569 | 18.82 | 1996.41 | 7096.61 |
| 22 | 0.00 | 37575.44 | 37575.44 | 133569 | 21.64 | 1736.01 | 6170.97 |
| 23 | 0.00 | 37575.44 | 37575.44 | 133569 | 24.89 | 1509.57 | 5366.06 |
| | | | | | | 423140.46 | 637541.97 |

| | |
|---|---|
| **Discount Rate** | 15% |
| **NPV** | 214401.51 |
| **BCR** | 1.507 |

# Benefit Cost Ratio (Economical )
# Fuel-HFO

Discount Rate – 15%

| Year No. | Capital Cost | Operating Cost | Total Cost | Benefit | 0.15 n = Year No. $(1+i)^n$ | Discounted Value of Total Cost at 15% Discount Factor | Discounted Value of Total Benefit at 15% Discount Factor |
|---|---|---|---|---|---|---|---|
| 0 | 1155.25 | 0.00 | 1155.25 | 0 | 1.00 | 1155.25 | 0.00 |
| 1 | 213715.20 | 0.00 | 213715.20 | 0 | 1.15 | 185839.30 | 0.00 |
| 2 | 75109.41 | 0.00 | 75109.41 | 0 | 1.32 | 56793.51 | 0.00 |
| 3 | 0.00 | 268661.04 | 268661.04 | 400707 | 1.52 | 176648.99 | 263471.36 |
| 4 | 0.00 | 268661.04 | 268661.04 | 400707 | 1.75 | 153607.82 | 229105.53 |
| 5 | 0.00 | 268661.04 | 268661.04 | 400707 | 2.01 | 133572.02 | 199222.20 |
| 6 | 0.00 | 268661.04 | 268661.04 | 400707 | 2.31 | 116149.58 | 173236.69 |
| 7 | 0.00 | 268661.04 | 268661.04 | 400707 | 2.66 | 100999.64 | 150640.60 |
| 8 | 0.00 | 268661.04 | 268661.04 | 400707 | 3.06 | 87825.77 | 130991.83 |
| 9 | 0.00 | 268661.04 | 268661.04 | 400707 | 3.52 | 76370.24 | 113905.94 |
| 10 | 0.00 | 268661.04 | 268661.04 | 400707 | 4.05 | 66408.90 | 99048.64 |
| 11 | 0.00 | 268661.04 | 268661.04 | 400707 | 4.65 | 57746.87 | 86129.25 |
| 12 | 0.00 | 268661.04 | 268661.04 | 400707 | 5.35 | 50214.67 | 74895.00 |
| 13 | 0.00 | 268661.04 | 268661.04 | 400707 | 6.15 | 43664.93 | 65126.09 |
| 14 | 0.00 | 268661.04 | 268661.04 | 400707 | 7.08 | 37969.50 | 56631.38 |
| 15 | 0.00 | 268661.04 | 268661.04 | 400707 | 8.14 | 33016.96 | 49244.68 |
| 16 | 0.00 | 268661.04 | 268661.04 | 400707 | 9.36 | 28710.40 | 42821.46 |
| 17 | 0.00 | 268661.04 | 268661.04 | 400707 | 10.76 | 24965.57 | 37236.05 |
| 18 | 0.00 | 268661.04 | 268661.04 | 400707 | 12.38 | 21709.19 | 32379.18 |
| 19 | 0.00 | 268661.04 | 268661.04 | 400707 | 14.23 | 18877.55 | 28155.81 |
| 20 | 0.00 | 268661.04 | 268661.04 | 400707 | 16.37 | 16415.26 | 24483.31 |
| 21 | 0.00 | 268661.04 | 268661.04 | 400707 | 18.82 | 14274.14 | 21289.83 |
| 22 | 0.00 | 268661.04 | 268661.04 | 400707 | 21.64 | 12412.30 | 18512.90 |
| 23 | 0.00 | 268661.04 | 268661.04 | 400707 | 24.89 | 10793.30 | 16098.17 |
| | | | | | | 1526141.67 | 1912625.91 |

| | |
|---|---|
| **Discount Rate** | 15% |
| **NPV** | 386484.247 |
| **BCR** | 1.253 |

# 450 MW Internal Rate of Return (Financial)

## Fuel – Gas

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 15% | | 20% | | 28% | |
| 0 | 1408.84 | 0 | 1408.84 | 0 | 1408.84 | 0 | 1408.84 | 0 | 1408.84 | 0 |
| 1 | 219795.91 | 0 | 219795.91 | 0 | 191126.88 | 0 | 183163.26 | 0 | 171715.56 | 0 |
| 2 | 75507.25 | 0 | 75507.25 | 0 | 57094.327 | 0 | 52435.588 | 0 | 46085.966 | 0 |
| 3 | 0 | 71256.80 | 71256.80 | 153604.35 | 46852.503 | 100997.35 | 32680.238 | 88891.406 | 26927.686 | 73244.262 |
| 4 | 0 | 71256.80 | 71256.80 | 153604.35 | 40741.307 | 87823.786 | 27233.532 | 74076.172 | 21037.255 | 57222.079 |
| 5 | 0 | 71256.80 | 71256.80 | 153604.35 | 35427.224 | 76368.509 | 22694.61 | 61730.143 | 16435.355 | 44704.75 |
| 6 | 0 | 71256.80 | 71256.80 | 153604.35 | 30806.281 | 66407.399 | 18912.175 | 51441.786 | 12840.121 | 34925.586 |
| 7 | 0 | 71256.80 | 71256.80 | 153604.35 | 26788.071 | 57745.565 | 15760.146 | 42868.155 | 10031.345 | 27285.614 |
| 8 | 0 | 71256.80 | 71256.80 | 153604.35 | 23293.975 | 50213.534 | 13133.455 | 35723.463 | 7836.9881 | 21316.886 |
| 9 | 0 | 71256.80 | 71256.80 | 153604.35 | 20255.63 | 43663.943 | 10944.546 | 29769.552 | 6122.647 | 16653.817 |
| 10 | 0 | 71256.80 | 71256.80 | 153604.35 | 17613.591 | 37968.646 | 9120.4546 | 24807.96 | 4783.318 | 13010.795 |
| 11 | 0 | 71256.80 | 71256.80 | 153604.35 | 15316.166 | 33016.214 | 7600.3788 | 20673.3 | 3736.9672 | 10164.683 |
| 12 | 0 | 71256.80 | 71256.80 | 153604.35 | 13318.406 | 28709.751 | 6333.649 | 17227.75 | 2919.5056 | 7941.1588 |
| 13 | 0 | 71256.80 | 71256.80 | 153604.35 | 11581.222 | 24965.001 | 5278.0409 | 14356.458 | 2280.8637 | 6204.0303 |
| 14 | 0 | 71256.80 | 71256.80 | 153604.35 | 10070.628 | 21708.697 | 4398.3674 | 11963.715 | 1781.9248 | 4846.8987 |
| 15 | 0 | 71256.80 | 71256.80 | 153604.35 | 8757.0679 | 18877.128 | 3665.3062 | 9969.7628 | 1392.1287 | 3786.6396 |
| 16 | 0 | 71256.80 | 71256.80 | 153604.35 | 7614.8416 | 16414.893 | 3054.4218 | 8308.1356 | 1087.6006 | 2958.3122 |
| 17 | 0 | 71256.80 | 71256.80 | 153604.35 | 6621.6014 | 14273.82 | 2545.3515 | 6923.4464 | 849.68796 | 2311.1814 |
| 18 | 0 | 71256.80 | 71256.80 | 153604.35 | 5757.9143 | 12412.018 | 2121.1262 | 5769.5386 | 663.81872 | 1805.6105 |
| 19 | 0 | 71256.80 | 71256.80 | 153604.35 | 5006.882 | 10793.059 | 1767.6052 | 4807.9489 | 518.60837 | 1410.6332 |
| 20 | 0 | 71256.80 | 71256.80 | 153604.35 | 4353.8104 | 9385.2686 | 1473.0043 | 4006.6241 | 405.16279 | 1102.0572 |
| 21 | 0 | 71256.80 | 71256.80 | 153604.35 | 3785.9221 | 8161.1032 | 1227.5036 | 3338.8534 | 316.53343 | 860.98216 |
| 22 | 0 | 71256.80 | 71256.80 | 153604.35 | 3292.1062 | 7096.6114 | 1022.9197 | 2782.3778 | 247.29174 | 672.64231 |
| 23 | 0 | 71256.80 | 71256.80 | 153604.35 | 2862.701 | 6170.9665 | 852.43307 | 2318.6482 | 193.19667 | 525.50181 |
| | | | | | 589747.9 | 733173.27 | 428826.95 | 521755.2 | 341618.37 | 332954.12 |

| Discount Rate: | 15% | 20% | 28% |
|---|---|---|---|
| NPV | 143425.37 | 92928.244 | -8664.2519 |
| BCR | 1.2431978 | 1.2167034 | 0.9746376 |
| IRR: | | | 27.26% |

# 450 MW Internal Rate of Return (Financial )

## Fuel – HFO

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 15% | | 23% | | 33% | |
| 0 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1408.84 | 0.00 | 1408.84 | 0.00 |
| 1 | 219795.91 | 0.00 | 219795.91 | 0.00 | 191126.88 | 0.00 | 178695.87 | 0.00 | 165260.09 | 0.00 |
| 2 | 75507.25 | 0.00 | 75507.25 | 0.00 | 57094.33 | 0.00 | 49908.95 | 0.00 | 42685.99 | 0.00 |
| 3 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 225142.17 | 302992.06 | 184007.29 | 247633.52 | 145544.38 | 195870.87 |
| 4 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 195775.80 | 263471.36 | 149599.43 | 201328.07 | 109431.87 | 147271.33 |
| 5 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 170239.83 | 229105.53 | 121625.55 | 163681.36 | 82279.60 | 110730.32 |
| 6 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 148034.63 | 199222.20 | 98882.56 | 133074.27 | 61864.36 | 83255.88 |
| 7 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 128725.77 | 173236.69 | 80392.33 | 108190.47 | 46514.56 | 62598.41 |
| 8 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 111935.45 | 150640.60 | 65359.61 | 87959.73 | 34973.35 | 47066.47 |
| 9 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 97335.17 | 130991.83 | 53137.90 | 71511.97 | 26295.75 | 35388.32 |
| 10 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 84639.28 | 113905.94 | 43201.54 | 58139.82 | 19771.24 | 26607.76 |
| 11 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 73599.38 | 99048.64 | 35123.21 | 47268.14 | 14865.60 | 20005.84 |
| 12 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 63999.46 | 86129.25 | 28555.45 | 38429.38 | 11177.14 | 15041.98 |
| 13 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 55651.70 | 74895.00 | 23215.81 | 31243.40 | 8403.86 | 11309.76 |
| 14 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 48392.78 | 65126.09 | 18874.65 | 25401.14 | 6318.70 | 8503.58 |
| 15 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 42080.68 | 56631.38 | 15345.24 | 20651.33 | 4750.90 | 6393.67 |
| 16 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 36591.90 | 49244.68 | 12475.81 | 16789.70 | 3572.10 | 4807.27 |
| 17 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 31819.04 | 42821.46 | 10142.93 | 13650.16 | 2685.79 | 3614.49 |
| 18 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 27668.73 | 37236.05 | 8246.29 | 11097.69 | 2019.39 | 2717.66 |
| 19 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 24059.77 | 32379.18 | 6704.30 | 9022.52 | 1518.34 | 2043.35 |
| 20 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 20921.54 | 28155.81 | 5450.65 | 7335.38 | 1141.61 | 1536.36 |
| 21 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 18192.64 | 24483.31 | 4431.42 | 5963.72 | 858.35 | 1155.16 |
| 22 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 15819.69 | 21289.83 | 3602.78 | 4848.55 | 645.38 | 868.54 |
| 23 | 0.00 | 342413.10 | 342413.10 | 460813.05 | 13756.25 | 18512.90 | 2929.09 | 3941.91 | 485.25 | 653.04 |
| | | | | | 1884011.70 | 2199519.80 | 1201317.48 | 1307162.25 | 794472.44 | 787440.05 |

| Discount Rate: | 15% | 23% | 33% |
|---|---|---|---|
| NPV | 315508.099 | 105844.771 | -7032.384 |
| BCR | 1.167 | 1.088 | 0.991 |
| IRR: | | | 32.61% |

# 450 MW Internal Rate of Return (Economic)

## Fuel – Gas

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 15% | | 22% | | 28% | |
| 0 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 |
| 1 | 213715.20 | 0.00 | 213715.20 | 0.00 | 185839.30 | 0.00 | 175176.39 | 0.00 | 166965.00 | 0.00 |
| 2 | 75109.41 | 0.00 | 75109.41 | 0.00 | 56793.51 | 0.00 | 50463.19 | 0.00 | 45843.15 | 0.00 |
| 3 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 24706.46 | 87823.79 | 20693.05 | 73557.37 | 17917.37 | 63690.66 |
| 4 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 21483.88 | 76368.51 | 16961.52 | 60292.92 | 13997.94 | 49758.33 |
| 5 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 18681.63 | 66407.40 | 13902.88 | 49420.43 | 10935.89 | 38873.70 |
| 6 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 16244.90 | 57745.56 | 11395.81 | 40508.55 | 8543.67 | 30370.07 |
| 7 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 14126.00 | 50213.53 | 9340.83 | 33203.73 | 6674.74 | 23726.62 |
| 8 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 12283.48 | 43663.94 | 7656.41 | 27216.17 | 5214.64 | 18536.42 |
| 9 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 10681.29 | 37968.65 | 6275.75 | 22308.34 | 4073.94 | 14481.58 |
| 10 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 9288.07 | 33016.21 | 5144.06 | 18285.52 | 3182.76 | 11313.73 |
| 11 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 8076.59 | 28709.75 | 4216.44 | 14988.13 | 2486.53 | 8838.85 |
| 12 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 7023.12 | 24965.00 | 3456.10 | 12285.35 | 1942.60 | 6905.36 |
| 13 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 6107.06 | 21708.70 | 2832.87 | 10069.96 | 1517.66 | 5394.81 |
| 14 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 5310.49 | 18877.13 | 2322.02 | 8254.07 | 1185.67 | 4214.69 |
| 15 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 4617.81 | 16414.89 | 1903.30 | 6765.63 | 926.31 | 3292.73 |
| 16 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 4015.49 | 14273.82 | 1560.08 | 5545.60 | 723.68 | 2572.45 |
| 17 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 3491.73 | 12412.02 | 1278.75 | 4545.57 | 565.37 | 2009.72 |
| 18 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 3036.29 | 10793.06 | 1048.16 | 3725.88 | 441.70 | 1570.10 |
| 19 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 2640.25 | 9385.27 | 859.15 | 3054.00 | 345.08 | 1226.64 |
| 20 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 2295.87 | 8161.10 | 704.22 | 2503.28 | 269.59 | 958.31 |
| 21 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 1996.41 | 7096.61 | 577.23 | 2051.87 | 210.62 | 748.68 |
| 22 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 1736.01 | 6170.97 | 473.14 | 1681.86 | 164.55 | 584.91 |
| 23 | 0.00 | 37575.44 | 37575.44 | 133569.00 | 1509.57 | 5366.06 | 387.82 | 1378.57 | 128.55 | 456.96 |
| | | | | | 423140.46 | 637541.97 | 339784.41 | 401642.80 | 295412.25 | 289525.32 |

| Discount Rate: | 15% | 22% | 28% |
|---|---|---|---|
| NPV | 214401.51 | 61858.391 | -5886.9251 |
| BCR | 1.5066911 | 1.1820519 | 0.9800722 |
| IRR: | | | 27.65% |

# 450 MW Internal Rate of Return (Economic)

## Fuel – HFO

| Year | Capital Cost | Operating Cost | Total Cost | Benefit | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at | Discounted Value of Total Cost at | Discounted Value of Total Benefit at |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 15% | | 25% | | 36% | |
| 0 | 1155.25 | 0.00 | 1155.25 | 0 | 1155.25 | 0.00 | 1155.25 | 0.00 | 1155.25 | 0.00 |
| 1 | 213715.20 | 0.00 | 213715.20 | 0 | 185839.30 | 0.00 | 170972.16 | 0.00 | 157143.53 | 0.00 |
| 2 | 75109.41 | 0.00 | 75109.41 | 0 | 56793.51 | 0.00 | 48070.02 | 0.00 | 40608.46 | 0.00 |
| 3 | 0.00 | 268661.04 | 268661.04 | 400707 | 176648.99 | 263471.36 | 137554.45 | 205161.98 | 106804.11 | 159297.96 |
| 4 | 0.00 | 268661.04 | 268661.04 | 400707 | 153607.82 | 229105.53 | 110043.56 | 164129.59 | 78532.43 | 117130.85 |
| 5 | 0.00 | 268661.04 | 268661.04 | 400707 | 133572.02 | 199222.20 | 88034.85 | 131303.67 | 57744.44 | 86125.63 |
| 6 | 0.00 | 268661.04 | 268661.04 | 400707 | 116149.58 | 173236.69 | 70427.88 | 105042.94 | 42459.14 | 63327.67 |
| 7 | 0.00 | 268661.04 | 268661.04 | 400707 | 100999.64 | 150640.60 | 56342.30 | 84034.35 | 31219.96 | 46564.46 |
| 8 | 0.00 | 268661.04 | 268661.04 | 400707 | 87825.77 | 130991.83 | 45073.84 | 67227.48 | 22955.85 | 34238.57 |
| 9 | 0.00 | 268661.04 | 268661.04 | 400707 | 76370.24 | 113905.94 | 36059.07 | 53781.98 | 16879.30 | 25175.42 |
| 10 | 0.00 | 268661.04 | 268661.04 | 400707 | 66408.90 | 99048.64 | 28847.26 | 43025.59 | 12411.25 | 18511.34 |
| 11 | 0.00 | 268661.04 | 268661.04 | 400707 | 57746.87 | 86129.25 | 23077.81 | 34420.47 | 9125.92 | 13611.28 |
| 12 | 0.00 | 268661.04 | 268661.04 | 400707 | 50214.67 | 74895.00 | 18462.25 | 27536.38 | 6710.24 | 10008.29 |
| 13 | 0.00 | 268661.04 | 268661.04 | 400707 | 43664.93 | 65126.09 | 14769.80 | 22029.10 | 4934.00 | 7359.04 |
| 14 | 0.00 | 268661.04 | 268661.04 | 400707 | 37969.50 | 56631.38 | 11815.84 | 17623.28 | 3627.94 | 5411.06 |
| 15 | 0.00 | 268661.04 | 268661.04 | 400707 | 33016.96 | 49244.68 | 9452.67 | 14098.62 | 2667.60 | 3978.72 |
| 16 | 0.00 | 268661.04 | 268661.04 | 400707 | 28710.40 | 42821.46 | 7562.14 | 11278.90 | 1961.47 | 2925.53 |
| 17 | 0.00 | 268661.04 | 268661.04 | 400707 | 24965.57 | 37236.05 | 6049.71 | 9023.12 | 1442.26 | 2151.12 |
| 18 | 0.00 | 268661.04 | 268661.04 | 400707 | 21709.19 | 32379.18 | 4839.77 | 7218.50 | 1060.48 | 1581.71 |
| 19 | 0.00 | 268661.04 | 268661.04 | 400707 | 18877.55 | 28155.81 | 3871.81 | 5774.80 | 779.77 | 1163.02 |
| 20 | 0.00 | 268661.04 | 268661.04 | 400707 | 16415.26 | 24483.31 | 3097.45 | 4619.84 | 573.36 | 855.16 |
| 21 | 0.00 | 268661.04 | 268661.04 | 400707 | 14274.14 | 21289.83 | 2477.96 | 3695.87 | 421.59 | 628.80 |
| 22 | 0.00 | 268661.04 | 268661.04 | 400707 | 12412.30 | 18512.90 | 1982.37 | 2956.70 | 309.99 | 462.35 |
| 23 | 0.00 | 268661.04 | 268661.04 | 400707 | 10793.30 | 16098.17 | 1585.89 | 2365.36 | 227.93 | 339.96 |
| | | | | | 1526141.67 | 1912625.91 | 901626.11 | 1016348.49 | 601756.28 | 600847.94 |

| Discount Rate: | 15% | 25% | 36% |
|---|---|---|---|
| NPV | 386484.247 | 114722.379 | -908.347 |
| BCR | 1.253 | 1.127 | 0.998 |
| IRR: | | | 35.95 % |

# SCHEDULE