Penerbit Akademia Baru

Journal of Advanced Review on Scientific Research
ISSN (online): 2289-7887 | Vol. 24, No.1. Pages 1-12, 2016

Feasibility Assessment of a Diesel Power Plant: A Review

M. A. Khattak[*,a], *S. M. Syahir*[b], *A. Aziz Aiza*[c], *S. Mansor S. Al*[d], *S. Othman S. Nurhaizam*[e]

Department of Nuclear Engineering, Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, 81310 Skudai Johor, Malaysia

[*,a]*muhdadil@utm.my*,[b]*syahir1994@gmail.com*,[c]*aizatabdulaziz93@gmail.com*,[d]*shaikhalie@yahoo.com*, [e]*syed.tajuddin93@gmail.com*

Abstract - *A Diesel power plant uses a Diesel engine. Of all types of standard prime movers of equivalent size, the Diesel engine has the highest thermal efficiency. Diesel engines are classified as two-stroke and four-stroke engines. The constant pressure process is observed in the Diesel cycle; the constant volume process is noted in the Otto cycle. The Diesel cycle can operate with a higher compression ratio than the Otto cycle. High-compression heat of air is the source of ignition energy in C.I. engines, while a spark plug provides ignition energy to S.I. engines. M.E.P. is defined as the mean pressure which, if imposed on the pistons uniformly, would produce the network of the cycle. The ideal Diesel cycle follows four distinct processes, i.e., isentropic compression, constant pressure combustion, isentropic expansion, and constant volume cooling. The Otto cycle also comprises four processes, i.e., isentropic compression, constant volume combustion, isentropic expansion, and constant volume cooling. The diesel power plant has various advantages. Among them are small plant area, high efficiency and simple layout of the plant. On the other hand, the disadvantages of diesel power plant cannot be ignored as well. Diesel power plant affects the environmental, high operation, maintenance cost and unit cost of the plant. These factors depends on certain criteria, such as, the fuel price of each country may be differ from each other.*

Keywords: Feasibility assessment, Diesel power plant, advantages and disadvantages, classification

1.0 INTRODUCTION

Combustion of fossil fuels in thermal power plant is a well-known method to generate electricity. The United States Energy Information Administration reports that fossil fuels were responsible for 66.8% of total global generated electricity in 2009 [19]. Diesel power plants comprise of diesel engines and other support systems typical of any power plant [5]. This power plant convert fossil fuel to be electrical energy [1]. The oil and gas engines are called Internal Combustion (IC) engines. The fuel burn inside the engines and the product of the combustion form the working fluid that generates mechanical power [6]. Several countries used diesel power plant to meet their energy demand such as India, Nigeria and Pakistan [2, 7-10]. As example, total generation of electricity produced by diesel power plant in India is 1022.39 MW [7].

Penerbit Akademia Baru

Journal of Advanced Review on Scientific Research
ISSN (online): 2289-7887 | Vol. 24, No.1. Pages 1-12, 2016

2.0 GENERAL LAYOUT OF DIESEL POWER PLANT

General layout of diesel power plant is as shown in Fig. 1 [6].

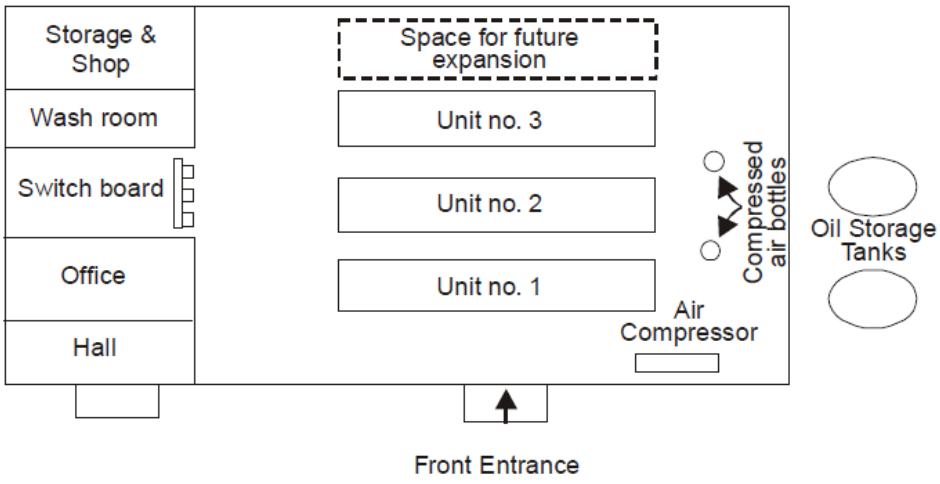

Figure 1: General layout of Diesel Power Plant [6]

Generally the units are placed parallel lines as shown in fig. In any plant some space is always provided for further expansion. Also sufficient space should provide for maintenance of diesel engine. Proper ventilation is also provided in power plant. Storage of fuel for power plant is always provided outside the main building. Also, in Fig. 2 shows the system involve in producing the electricity by the diesel power plant [6].

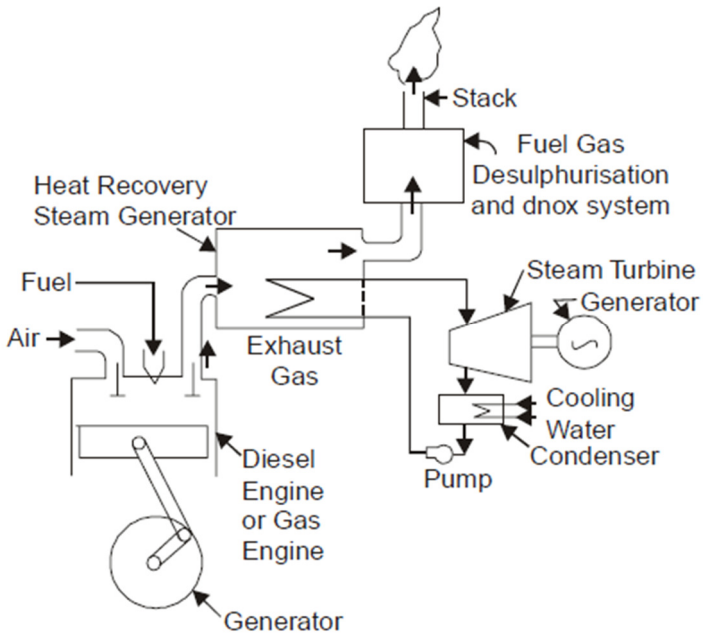

Figure 2: Combined cycle of Diesel Power Plant

Journal of Advanced Review on Scientific Research
ISSN (online): 2289-7887 | Vol. 24, No.1. Pages 1-12, 2016

3.0 COMPONENTS OF DIESEL POWER PLANT

3.1 Diesel Engine

Diesel engine is one of the main components present in the diesel power plant. Mainly the engines are classified in to two types they are two stroke engine and four stroke engine. In the diesel engine the engine is straight away joined to the generator to develop power. In the engine the air entered in the cylinder must be compressed. Fuel must be injected by the end of the compression stroke. After the burning of the fuel the burnt gases expand and apply pressure on the piston. To the generator the shaft of the engine is straight attached to the engine. After the completion of the combustion the burnt gases are ejected in the atmosphere.

3.2 Air Filters

Air filters are used to remove the dust particles present in the air during the entrance in to the engine. Air filters are a dry air filter type which consists of wool, felt or cloth. In case of the oil bath type filters the air is brushed over a bath of oil so the dust must be elements that get coated.

3.3 Super Chargers

The super changers are used to increase the air pressure which is provided to the engine. Then the power of the engine is improved.

3.4 Engine Starting System

In the diesel power plant diesel engine used is not self-starting. Starting of the engine includes the air tanks along with the air compressor. In the cold conditions the engine is started by delivering the air.

3.5 Fuel Supply System

The fuel system contains the fuel transfer pump, fuel pump, storage tank, heaters and strainers. With the help of the Pumps the diesel from the storing tank is drawn and with the help of the filter it is supplied to the small day tank. Day tank delivers the day-to-day fuel essential for the engine. In place of the high placed flows the day tank is used so that the diesel movements the engine takes place under gravity. Again the diesel filtered before it is injected into the engine with the help of fuel injection pump. The figure shows the set up for the fuel system.

With the help of the fuel injection system some functions are performs they are:

- Initially the fuel must be filtered.
- At the time of injection of the fuel correct quantity is to be injected in to the system.
- Injection process must take place at a particular time.
- The fuel supply must be regulated.
- In the combustion chamber atomized fuel must be separated properly.
- According to the loads of the plants the fuel must be supplied.

Penerbit Akademia Baru
Journal of Advanced Review on Scientific Research
ISSN (online): 2289-7887 | Vol. 24, No.1. Pages 1-12, 2016

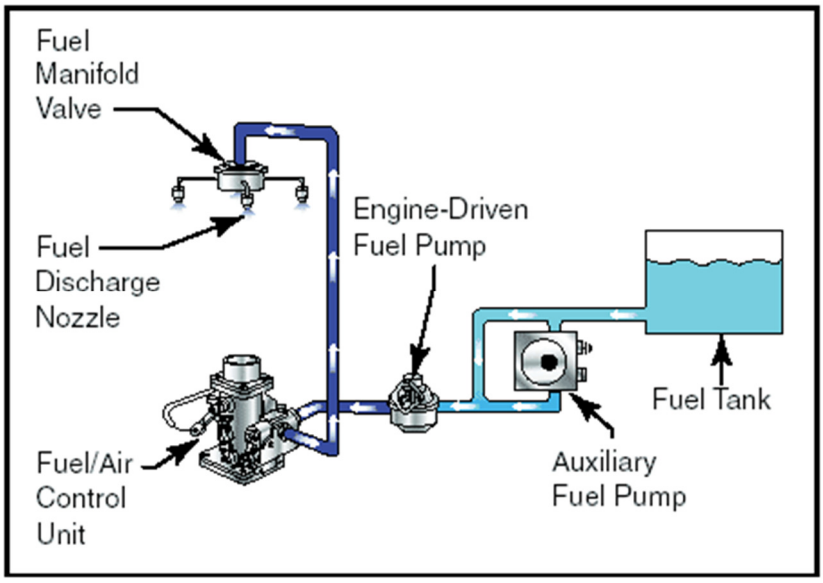

Figure 3: Fuel supply systems

3.6 Lubrication System

The lubrication system must include oil tanks, coolers, pipes and oil pumps. The main aim is in moving parts. It is used to reduce the friction and reduce tear and wear of the engine components. Like cylinder walls and piston. Due to the friction the Lubrication oil must be gets heated of and the moving parts are cooled earlier reflow. In the lubrication system the oil is forced from the oil tank through the oil chiller. The oil is cooled with the cold water which enters the engine. After cooling of the hot oil the moving parts are returned in to the lubricating oil tank.

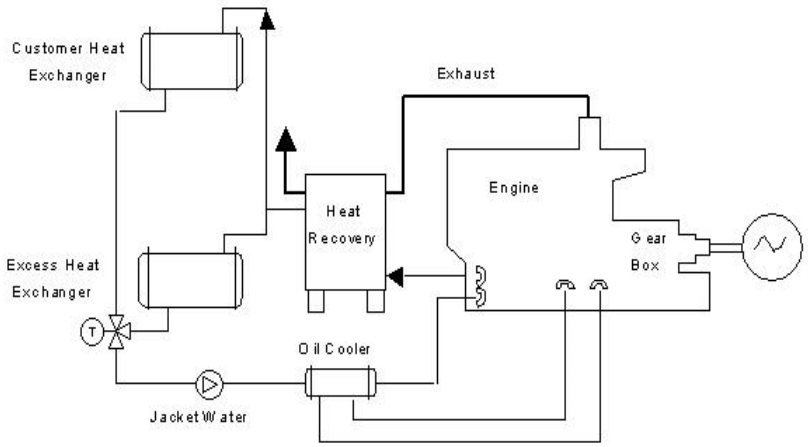

Figure 4: Schematic of cooling system

3.7 Cooling System

Inside the engine cylinder the high temperature of the burning fuel is around 1500°C to 2000°C. In case we lower this temperature the water is dispersed through the engine. The water jacket covers the engine. And the heat from the piston, cylinder, and combustion

Journal of Advanced Review on Scientific Research
ISSN (online): 2289-7887 | Vol. 24, No.1. Pages 1-12, 2016

chamber must be passed by the flowing water. The level of the hot water in the jacket is delivered through the heat exchanger. In the heat exchanger, the heat is carried away by the water which is circulated over the heat exchanger and the water is cooled in the cooling tower. The figure shows the cooling system works.

3.8 Governing System

The governing system is used to control the speediness of the engine. This is completed by changing the fuel stream permitting it to the engine load.

3.9 Exhaust System

The exhaust gases approaching out of the engine are very loud. To reduce the sound a silencer is used.

3.10 Starting System

For starting a diesel engine, initial rotation of the engine shaft is required. Until the firing start and the unit runs with its own power. For small DG set, the initial rotation of the shaft is provided by handles but for large diesel power station. Compressed air is made for starting. The figure below shows how the starting system works.

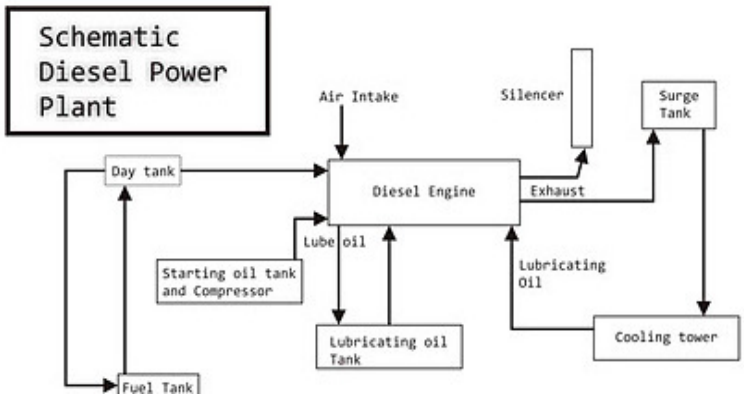

Figure 5: Schematic for starting system

4.0 ADVANTAGE OF DIESEL POWER PLANT

4.1 Adaptability to different types of fuel

Diesel power plant has a lot of advantages compared to other power plant. One of the major advantages of the diesel engine is its adaptability to different types of fuel varying from natural gas to light fuels to heavy residues such as crude and furnace oils [15]. Crude oil fuels from different sources must be purified efficiently. This treatment used to protects the diesel engine from wear of important components such as cylinder liners, pistons, piston rings and the injection system [16]. They are also capable of burning liquid fuels derived from plants and biological wastes. Highly promising trials of community based generating plants based on bio fuels is underway in many countries and they are expected to give suitable alternative to the depleting oil reserves.

Journal of Advanced Review on Scientific Research
ISSN (online): 2289-7887 | Vol. 24, No.1. Pages 1-12, 2016

4.2 Required Small Space

Diesel Power Plant is one of the power plants that come in smaller size compared to others and because of this advantage it occupies less space as the number and size of the auxiliaries is small [17]. Reciprocating engines are well suited to a variety of distributed generation applications. Commercial and institutional facilities commonly use diesel engines for their emergency power generation. The majority of industrial facilities also use the diesel engines for emergency applications, though use of diesel engines for continuous duty is more common in some process plants.

4.3 Simple Design & Installation

Besides that, the design and layout of diesel power plant are quite simple since it is smaller compared to other power plants. Hence it can be quickly installed and commissioned, while the erection and starting of a steam power plant or hydro-plant takes a fairly long time. Smaller in size will require less operating staff to operate the plant.

4.4 High Efficiency for Small Capacity

In many cases, multiple reciprocating engine units are used to increase overall plant capacity and ensure better availability. Reciprocating engines have higher electrical efficiencies than gas turbines of comparable size resulting in lower fuel-related operating costs [15]. This because, reciprocating engines burn less fuel to generate a given amount of horsepower. They are 20-30 % more efficient than a gas engine [18]. In addition, the capital investments needed for installing reciprocating engine generating sets are generally lower than the capital cost for installing gas turbine generating sets up to 3-5 MW in size [15]. Diesel engine is more durable compared to gas engine because a diesel engine must be built heavier to withstand the pressure within the engine, it can be expected to run many hours longer than its gas counterpart.

The economic efficiency of a diesel power plant is improved considerably if the waste heat of the engine which is 55 to 60 percent of total heat release in currently available engines can be used for preheating of fuel and oil or for domestic heating within the power station building or adjacent premises [18]. In diesel power plants with a high power rating above 750 kW the waste heat can be used in a heating system serving a whole block or a whole town area in proximity to the power station [18]. Though the reciprocating engine maintenance costs are generally higher than comparable gas turbines, the maintenance activities are invariably handled by in-house staff or provided by local established service organizations, making them attractive for industrial purposes [15].

4.5 Less Standby losses

Furthermore, in diesel power plant there is an automatic protection against exceeding maximum or minimum limits for the temperature of cooling water and oil, the oil pressure, and the rotational speed (rpm) [18]. Protection is also provided in the event of a short circuit in the line. There are three levels of automation for stationary diesels are used which is automatic regulation of the rotational speed (rpm) and of the temperature of the cooling water and oil, along with automatic emergency signalling and protection in the event of a breakdown; automatic or remotely controlled start-up and shutdown of the diesel engines, an automatic check of conditions required for connecting load to the line, synchronization with other units and with the power system, and a load connection and load distribution with units operating in parallel; and automatic refilling of the feeder tanks for fuel, oil, and water and of the air feed vessels, an automatic (trickle) charging of start-up batteries and of batteries used in auxiliary operations, and automatic control of the auxiliary equipment [18].

Journal of Advanced Review on Scientific Research
ISSN (online): 2289-7887 | Vol. 24, No.1. Pages 1-12, 2016

4.6 Limited Cooling Water Requirement

Diesel power plants are used mainly for servicing areas remote from transmission lines or areas where sources of water supply are limited and where the construction of a steam power plant or of a hydroelectric power plant is not feasible [18].

5.0 DISADVANTAGE OF DIESEL POWER PLANT

5.1 High Maintenance and Operation Cost

In the most diesel power plant the operations and maintenance cost of generator is a major portion of the cost of power generation [3]. Operations and maintenance cost includes cost of labour, logistics, materials and spare parts required for operating and maintaining the system. Operation and maintenance activities for a typical diesel generator can be classify as Routine Preventive Maintenance, Major Overhaul and Breakdown Maintenance [2]. The activities consists of general inspection, lubrication service, cooling system service, fuel system service, servicing and testing starting batteries, and regular engines exercise [10]. The annual cost of plant using diesel is twice as that of plant using natural gas. A comparison between different terms of economic objective function for both fuels is shown in Fig. 6.

The capital cost of equipment and operating and maintenance cost is equal in both cases, however the cost of fuels is different and makes a great difference in the total annual cost of the plant. Also diesel usage leads to more production of contaminants; therefore the environmental tax rises rapidly. As shown in the figure, in the case of natural gas, annualized capital cost and operating and maintenance cost of the plant constitute 46.66% and 2.8% of the total cost, while fuel cost and environmental tax account for 11.46% and 39.08%, respectively [4].

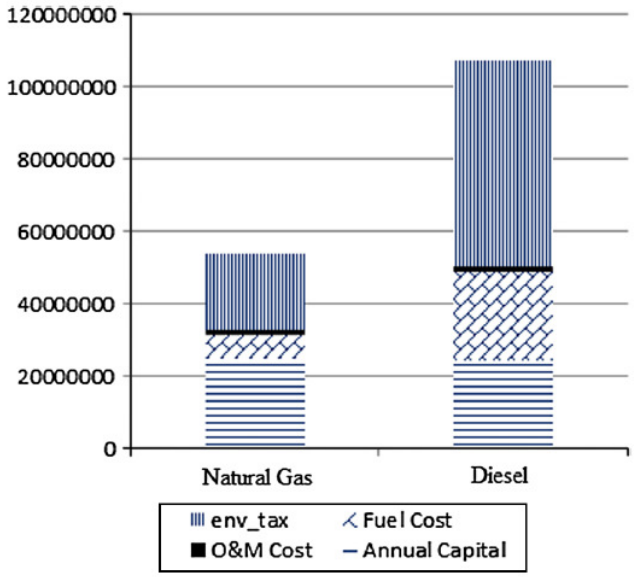

Figure 6: Economic comparison between the annual cost of the plant in the case of using natural gas and diesel [4]

5.2 High Unit Cost

Penerbit Akademia Baru

Journal of Advanced Review on Scientific Research
ISSN (online): 2289-7887 | Vol. 24, No.1. Pages 1-12, 2016

Total annual cost of the plant with natural gas and diesel are approximately 52 million $/year and 108 million $/year, respectively. In general total annual cost of plant with natural gas as fuel is lower than diesel [4]. The unit cost associated with various values of the cost function parameters are shown in Table 1 [2].

Table 1: Unit cost of Diesel generated Electricity (CEU) for some combinations of input [2]

Fuel price P (₦)/ gal	Interest rate i	Gen size S (kW)	Salvage factor λ	Power factor Ψ	O&M factor B	Initial cost CA_T (₦)	Life span N (years)	Unit cost CE_U (N)/ kW h
640	10%	2500	0.05	0.8	0.2	47M	20	46.3
640	20%	2500	0.05	0.8	0.2	47M	20	46.5
640	10%	2000	0.05	0.8	0.2	40M	20	46.4
640	10%	1500	0.05	0.8	0.2	34M	20	46.6
640	10%	1000	0.05	0.8	0.2	21M	15	46.6
640	10%	500	0.05	0.8	0.2	11M	10	47.0
640	10%	250	0.05	0.8	0.2	6.5M	10	47.8
640	10%	200	0.05	0.8	0.4	5.1M	5	48.2
640	10%	100	0.05	0.8	0.2	2M	5	49.0
[a]320	10%	2500	0.05	0.8	0.2	47M	20	[a]23.6
[a]320	10%	100	0.05	0.8	0.2	2M	5	[a]25.3

[a] This is the price of at $2/DGE of compressed natural gas.

Fig. 7 shows the effects of economy of scale with unit cost decreasing with generator size.

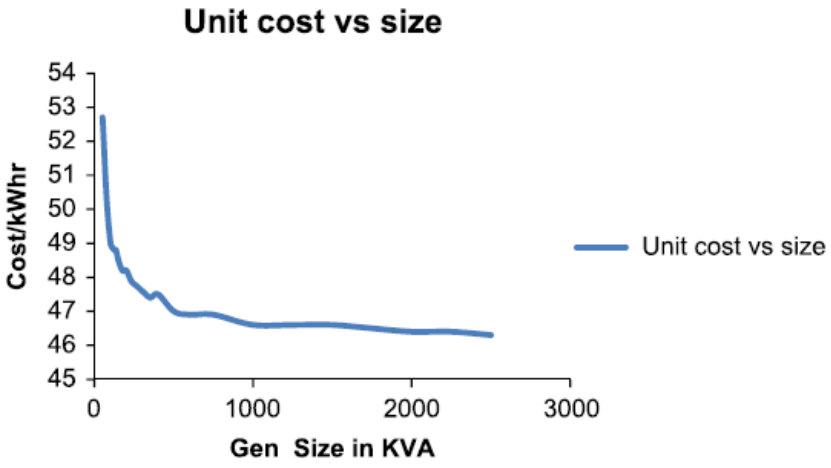

Figure 7: Variation of unit cost with generator size [2]

The fuelling cost is the most significant components of the cost components. At the prevalent price of natural gas the diesel gallon equivalent of compressed natural gas (CNG) is $2/DGE. Fig. 8 shows the substantial reduction in the unit cost of power generation fuelled by CNG [2].

Journal of Advanced Review on Scientific Research
ISSN (online): 2289-7887 | Vol. 24, No.1. Pages 1-12, 2016

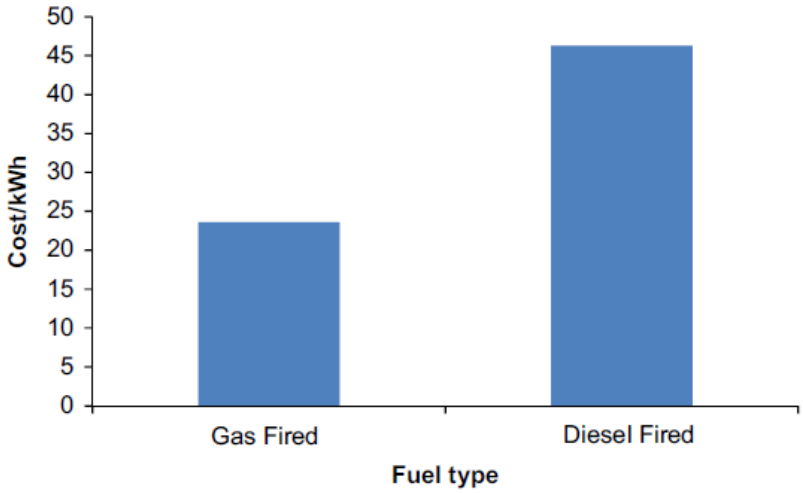

Figure 8: Cost/kWh: natural gas fired vs Diesel Fired system [2]

In the article [4], it has calculated the capital cost of different equipment in Diesel power plant; it is shown on Table 2.

Table 2: Capital cost of different equipment in diesel power plant [4]

Capital cost of different equipment.

Equipment	Value
Combustion chamber ($)	5.50E+05
CPH ($)	1.33E+06
Condenser ($)	1.21E+07
Cooling water pump ($)	7.77E+04
Deaerator ($)	2.23E+06
Gas turbine ($)	7.69E+06
HRSG ($)	2.02E+06
Integral pump ($)	7.66E+04
Pump ($)	2.32E+04
Steam turbine ($)	1.20E+07
Compressor ($)	3.64E+07
Total ($)	1.25E+08
Annualized capital cost ($/year)	2.45E+07

5.3 Environmental Impact

Environmental effects are reflected by the levels of main air pollutants, quantity of generated waste, and quantity of sewage and water use [14]. Fossil fuel combustion is now known to be responsible for substantial emissions of air pollutants (including sulphur, Nitrogen oxides, hydrocarbons, and soot) that play a major role in the formation of fine particulate matter, ground-level ozone, and acid rain [12]. Thermal power plant are considered as the main source of atmospheric pollutants due to their massive emission of sulphur dioxide (SO_2), and nitric oxide (NO) [13]. Table 3 [4] shows the amount of pollutants produce by natural gas and diesel.

Table 3: Amount of produced pollutants for natural gas and diesel [4]

Pollutant	Natural Gas (gr/kg fuel)	Diesel (gr/kg fuel)
CO	31.8021	80.047
NO_x	2.4×10^{-7}	0.0011
UHC	3.2065	10.17
CO_2	2712.6	3158.5
SO_2	–	10.04

It shows clearly that diesel fuel produce more pollutants compare to natural gas. The pollutants can affects three environmental issues, including respiratory effects, climate change and acidification. The effects of each of the fuels on these issues is represented in Table 4 [4].

Table 4: Effect of natural gas and diesel on environmental issues [4]

Environmental issue	Natural Gas	Diesel
Respiratory effect	4.8×10^{-5}	0.2099
Climate change	0.2105	0.2804
Acidification	6.6×10^{-6}	0.012

Total environmental impact of diesel is twice as its value for natural gas. As it can be seen, utilizing diesel considerably increases the respiratory effects due to more CO and SO_2 production.

6.0 CONCLUSION

As a conclusion, diesel power plant has their own advantages. Firstly, diesel power plant was designed to generate only a small capacity of power or electricity. Because of that, it can be commissioned anywhere and required only a small space compared to other type of power plant like steam power plant. Secondly, the simple design and layout of the diesel power plant. Lastly, the efficiency of the diesel power plant. The efficiency of the diesel power plant are higher than steam power plant.

The disadvantages of the diesel power plant are high maintenance and operation cost. To maintain the efficiency of the plant required high cost to optimise the production of electricity. Besides that, high unit cost. The unit cost of the diesel power plant are depending on the power produce. The higher power output should be more costly. Lastly, effect on environmental. The combustion of the diesel will produce greenhouse effect like SO_2. Also, the diesel power plant produce a noise that will disturbing the surrounding.

REFERENCES

[1] Rehiara, Adelhard Beni, Sabar Setiawidayat, and Elias Kondorura Bawan. "Optimal operation scheme for diesel power plant units of PT. PLN-Manokwari Branch using Lagrange Multiplier Method." Procedia Environmental Sciences 17 (2013): 557-565.

[2] Oladokun, V. O., and O. C. Asemota. "Unit cost of electricity in Nigeria: A cost model for captive diesel powered generating system." Renewable and Sustainable Energy Reviews 52 (2015): 35-40.

[3] Jacobus, Headley, Baochuan Lin, David Henry Jimmy, Rashid Ansumana, Anthony P. Malanoski, and David Stenger. "Evaluating the impact of adding energy storage on the performance of a hybrid power system." Energy Conversion and Management 52, no. 7 (2011): 2604-2610.

[4] Vandani, Amin Mohammadi Khoshkar, Fatemeh Joda, and Ramin Bozorgmehry Boozarjomehry. "Exergic, economic and environmental impacts of natural gas and diesel in operation of combined cycle power plants."Energy Conversion and Management 109 (2016): 103-112.

[5] Operation and maintenance of diesel power generating plants. (n.d.). IDC Technologies

[6] Raja, A. K. Power plant engineering. New Age International, 2006.

[7] CEA - Daily Generation. Retrieved May 17, 2016, from http://www.cea.nic.in/dailygeneration.html

[8] Saif Group - Power Generation. Retrieved May 17, 2016, from http://www.saifgroup.com/power.php

[9] Sitara Energy Ltd. | Home. Retrieved May 17, 2016, from http://sitara.pk/

[10] Kovach, D. (2013, October 16). Implementing a standby generator maintenance program for diesel engines. Electrical construction and maintenance

[11] Diesel Service & Supply INC.(2013).Approximate Fuel Consumption Chart.Retrieved May 17; 2016, from Diesel Service and Supply Inc: ⟨http://www.dieselserviceandsupply.com/⟩.

[12] Inter Academy Council. Lighting the way: toward a sustainable energy future. Amsterdam; 2007. See also www.interacademycouncil.net/CMS/Reports/ 11840.aspx.

[13] Liu, Yu, Xiaohong Hu, and Kuishuang Feng. "Economic and environmental implications of raising China's emission standard for thermal power plants: An environmentally extended CGE analysis." Resources, Conservation and Recycling (2016).

[14] Mesjasz-Lech, Agata. "Planning of production resources use and environmental effects on the example of a thermal power plant." Procedia-Social and Behavioral Sciences 213 (2015): 539-545.

[15] IDC Technologies (2013). Operation and Maintenance of Diesel Power Generating Plants Retrieved May 17 2006 from: http://104.197.130.119/power-plant-equipment-operation-and-maintenance-guide.pdf

[16] GEA Mechanical Equipment (2013). High performance equipment fordiesel engine power plants (brochure).Germany:GEA Westfalia Separator Group GmbH

[17] Raja, A.K. Srivastava, A.P. and Dwivedi, M. (2006) Power Plant Engineering. (1st ed.) India,New Age International (P) Ltd., Publishers

[18] Diesel Power Plant. (n.d.) The Great Soviet Encyclopedia, 3rd Edition. (1970-1979). Retrieved May 17 2016 from: http://encyclopedia2.thefreedictionary.com/Diesel+Power+Plant

[19] U.S. Energy Information Administration. Total energy: monthly energy review. Review. U.S. Department of Energy; 2009.

[20] Diesel Power Plant and its Components. (n.d.). Retrieved May 18, 2016, from http://www.mechnol.com/diesel-power-plant-and-its-components.html

Journal of Advanced Review on Scientific Research
ISSN (online): 2289-7887 | Vol. 24, No.1. Pages 1-12, 2016

[21] PRASAD, S. (2013, December 28). Diesel engine power plant. Retrieved May 18, 2016, from http://www.slideshare.net/surajprasad12/diesel-engine-power-plant?next_slideshow=1#