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Economic Viability Of A Proposed Gas To Power Project: A Case Study Of University Of Calabar

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Abstract: ***The increasing demand of environmentally friendly electrical energy sources particularly from natural gas assets is a major challenge to our economic growth. The continuous use of petrol and diesel powered engines poses a lot of environmental, health, safety and financial challenges which may not be easily quantifiable. The purpose of this work is to determine a better alternative for electricity power generation in Nigeria, expand our knowledge of power generation in Nigeria and also get a more environmentally friendly fuel. An economic analysis of the two fuels was conducted using critical economic profit indicators. Diesel generator usage is represented as case A and gas to power project is represented as case B. Results shows that the payout time (PO) for case A of 2.12years was lesser than case B which is 6.02years; the net expenditure for 20 years for case A is $30,000,000 and that of case B is $15,300,000; the Net Present Value (NPV) for case A is $3,389,900 and that of case B is $284,900. Case A had a DCF-ROR of 48% while Case B had DCF-ROR of 16.5% indicating that case B is a better alternative due to a moderate discount rate as compared to an overestimated case A. Due to this an incremental analysis was done with net expenditure of $8,400,000. This gave a Payout time (PO) of 5.26 years; NPV of $605,900 and DCFROR of 20% to further confirm the choice of case B. From these results, it is glaring that Case B which is Gas to Power is the better alternative over quite a period of time. Therefore, it is recommended that the University of Calabar consider switching to Gas to Power on a lighter scale.***

Keywords: Environmental, Safety, Payout, incremental and Lighter

I. INTRODUCTION

Gas to power is a technology which involves the conversion of gas fuel to electrical power. The two major sources or types of gas fuel are: the biogas fuel which is formed when methane-rich gases are produced by the anaerobic decay of non fossil organic matter (biomass); and natural gas. The source of gas relevant to this case study is the natural gas (Daniel, 1996). Natural gas is a fossil fuel formed when layers of buried plants and animals are exposed to intense heat and pressure over thousands of years (GRI, 1996). It is a hydrocarbon mixture consisting primarily of methane, but commonly includes varying amounts of higher alkanes and even a lesser percentage of carbon dioxide, nitrogen and hydrogen sulphide (Ajienka et al., 2011). Natural gas is an energy source commonly used for cooking, heating, and electricity generation. It is also used as fuel for vehicles and as a chemical feedstock in the manufacture of plastics and other commercially important organic chemicals. Natural gas can be "associated" (found in oil fields) or "non-associated" (isolated in natural gas fields) and is also found in coal beds (as coal bed methane). It sometimes contains a significant amount of ethane, propane, butane and pentane- heavier hydrocarbons removed for commercial use prior to the methane being sold as a consumer fuel or chemical plant feedstock. Non hydrocarbons such as carbon dioxide, nitrogen, helium (rarely) and hydrogen sulphide must also be removed before the natural gas can be transported (Armendariz, 2009). In addition to transporting gas via pipelines for use in power generation, other end uses for natural gas include export as liquefied natural gas (LNG), or conversion of natural gas into other liquid products via gas-to-liquids (GTL) technologies, or compression of natural gas under high pressure into compressed natural gas (CNG). In this case, a gas turbine will be used in converting natural gas energy to electrical energy.

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In Nigeria,the increasing demand of environmentally friendly electrical energy sources particularly from natural gas assets is a major challenge to our economic growth. The continuous use of petrol and diesel powered engines poses a lot of environmental, health, safety and financial challenges which may not be easily quantifiable. The use of alternative sources of power generation like coal, diesel and petrol powered sources has a lot of short and long term challenges such as high cost of production, huge maintenance procedures, environmental pollution of its waste effluents and unwanted metallic engine parts. Erratic power supply in Nigeria is a very serious problem various Governments has endlessly battled and this is worsen with huge loss of direct foreign investments and loss of foreign exchange from massive importation of petrol and diesel generators thus the aim of this study is to carry out both critical economic and technical evaluation of gas to power project using gas and diesel plant projects as case studies.

NATURAL GAS TURBINE PLANTS

A gas turbine, also called a combustion turbine is a type of internal combustion engine (Fig. 1). It has an upstream rotating compressor coupled to a downstream turbine, and a combustion chamber in-between (Black and Veatch, 2011). The basic operation of the gas turbine is similar to that of the steam power plant except that natural gas is used instead of water. Gas turbine plants use the dynamic pressure from flowing gases (air and combustion products) to directly operate the turbine. Natural-gas fuelled combustion turbine plants can start rapidly and so are used to supply peak energy during periods of high demand, though a higher cost than base-loaded plants. These may be comparatively small units, and sometimes completely unmanned, being remotely operated. Combined cycle plants have both a gas turbine fired by natural gas, and a steam boiler and steam turbine to produce electricity. This greatly increases the overall efficiency of the plant, and many new base load power plants are combined plants fired by natural gas (Pehnt, 2006).

DIESEL POWERED ELECTRICITY GENERATORS

A diesel generator is the combination of a diesel engine with an electric generator (often an alternator) to generate electrical energy. This is a specific case of engine generator (Doe, 2004). Diesel generating sets are used in places without connection to the power grid, as emergency power-supply if the grid fails, as well as for more complex applications such as peak-lopping, grid support and export to the power grid (Clarey, 2010). Sizing of diesel generators is critical to avoid low-load or a shortage of power and is complicated by modern electronics, specifically non-linear loads. The packaged combination of a diesel engine, a generating set and various ancillary devices (such as base canopy, sound attenuation, control systems, circuit breakers, jacket water heaters and stating system is referred to as a generating set or a 'genset' for short (EIA, 2011 and 2012).

STUDY LOCATION

The study location is the University of Calabar which is the reference point of the research and the Odukpani gas to power plant project site which is of close proximity to the reference point (Figure 1).

Figure 1: 150 megawatts of electricity gas to power plant at Odukpani, Cross Rivers state

II. MATERIALS AND METHODS

MATERIALS

The materials used in this project are mainly information gotten from the study location and they include;

- ✓ Cost of acquiring a gas turbine
- ✓ Cost of the diesel powered generator/ generating set
- ✓ Quantity of diesel used yearly
- ✓ Quantity of natural gas to be used yearly
- ✓ Cost of the diesel used yearly
- ✓ Cost of the natural gas used yearly
- ✓ Cost of maintenance of the diesel generator yearly
- ✓ Cost of maintenance of a gas turbine yearly
- ✓ Cost of installing and maintenance of gas pipelines from source/ flow station to the study location
- ✓ Cost of waste disposal from diesel generator
- ✓ Cost of waste disposal from gas turbine
- ✓ Environmental effects of using diesel generator (greenhouse gases)
- ✓ Environmental effects of using gas turbine (greenhouse gases)
- ✓ Durability of use of diesel generator
- ✓ Durability of use of gas turbine

DIESEL GENERATOR COST CALCULATIONS

There are more than ten diesel generators in use daily at both campuses of the University of Calabar whose total capacity sums up to 2250KVA and a total of 1,284,800 (16 drums of 220liters each used daily) liters used yearly

Cost of equipment and installation= $3,500,000

Total cost of diesel used annually= $1,375,000

Annual Cost of lubricating oil= $20,000

Total annual cost of maintenance and repairs/replacement=$255,000

Total cost of waste management=$100,000

The cash flow for the first year is the Capital Expenditure (CAPEX) which is cost of equipment and installation while the cash flow for the remaining years are the sum of all the operating expenditures (OPEX) i.e. $(1,375,000+

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20,000+155,000+100,000)= $1,650,000 annual operational and maintenance expenses (Table 1).

GAS TO POWER COST CALCULATIONS

A 3mw capacity of Alstom gas turbine which is a close cycle gas turbine i.e (uses both gas and steam or heat) will be sufficient to power the University of Calabar which consumes about 1,200,000scf/day and gas is sold at $1.30 per Mscf.

Total Cost of equipment and installation=$6,500,000

Annual Cost of natural gas used in scf =$569,400

Total Annual Cost of maintenance (including lubricating oil) = $510,600

Annual Cost of waste management= Nil

The cost of waste management is zero because the waste produced is heat and this heat is used further more to produce steam that will drive another steam turbine producing more power in a close cycle i.e. twice the production for close cycle thus making this method more productive and reliable. The gas turbine also has a longer lifespan/durability. The economic analysis of these two power projects is compared over a period of twenty years to determine the positivity in the cash flows.

Net present value is the difference between the present value of cash inflows and the present value of cash flows. NPV is used in capital budgeting to analyze the profitability of an investment or project. NPV analysis is sensitive to the reliability of future cash inflows that an investment or project will yield. In addition to the formula, net present value can often be calculated using tables, and spreadsheets such as Microsoft excel.

INCREMENTAL ANALYSIS

Incremental analysis sometimes called marginal or differential analysis is used to analyze the financial information needed for decision making. It identifies the relevant revenues and/or cost of each alternative and the impact of the alternative on future income.

	Case A Diesel generator ($)	**Case B Gas turbine ($)**
Equipment and installation costs (CAPEX)	3,500,000	6,500,000
Annual cost of fuels (cost of diesel/gas)	1,375,000	569,400
Total annual cost of maintenance (including lubricating oil)	175,000	510,600
Annual cost of waste management (paid to the government)	100,000	Nil
Annual total operating expenditure (OPEX**)**	1,650,000	1,080,000
Total OPEX over a 20 year period assuming all parameters are fixed	33,000,000	21,600,000
Savings made over the years	None	8,400,000

Table 1: A Table Showing The Expenditures And Savings Over A Period Of 20 Year

INTERNAL RATE OF RETURN (DCF-ROR)

Also known as discounted cash flow rate of return (DCF-ROR). IRR measures the effective rate of return earned by an investment as though the money had been loaned at that rate. It describes the discount rate at which the NPV is exactly equivalent to zero, or the present value of the cash inflows is equal to the present value of the cash outflows. The IRR is used in screening projects to identify those that are to be accepted. If the IRR is greater than the hurdle rate, the project is accepted, otherwise the project is rejected.

To generate a DCF-ROR, we make use of two or three discounted rate values which are 15% which has already been generated, 30% and 50%.graphs were used to get the IRR.

The formula $PV= F(1+i)^{-n}$ was used.

PAYOUT

This is the time taken to gain back returns on investment. Lower time is better but for the case of this analysis, longer time is better because it is not an investment that yields profit but requires expenditure.

PROFIT PER DOLLAR

This is also called the net cash returns on investments and this was done for cases A and B while incremental analysis was produced to confirm the choice of selection.

III. RESULTS

Results of cumulative cash flows for case A was produced with a unit cost of $1,000,000 and estimated for a period of 20 years and the final cumulative cash flow gave $30,000,000. The expected actual cash flows is $1,700,000 which means it is a good option (Table 2). However, results of cumulative cash flows for case B was produced with an initial unit cost of $6,500,000. The cash flow results after a period of 20 years gave $1,100,000 while the cumulative cash flow was $15,300,000 (Table 3).

RESULTS OF NET PRESENT VALUE AT 15% DISCOUNT RATE FOR CASE A AND B

Results of the net present value for case A at a discount rate of 15% shows that in the first year, the NPV was $1,434.782 while after 20 years the NPV gave a total sum of $3,389,900. This value is quite high as this involves the future cost of maintenance (Table 4). Results of Net present value for case B at a discount rate of 15% shows that with an initial cash flow of $6,500,000 the net present value after 20 years gave $284,863 only which is quite low and this means the cost of maintenance is also low for a gas turbine pilot scheme as shown in Table 5.

RESULTS OF INTERNAL RATE OF RETURN (DCF-ROR)

Result of DCF-ROR was produced at discount rates of 30% and 50%. The NPV at 30% gave $1,982,300 and $203,200 at 50% as shown in Table 6 for case A. Result of case B showed that the NPV at 30% and 50% are $2,913,400 and $4,340,000 as shown in Table 7.

Years	Cash flow	Cumulative cash flow
0	(3500)	(3500)
1	1650	(1850)
2	1650	(200)
3	1650	1450
4	1650	3100
5	1650	4750
6	1650	6400
7	1650	8050
8	1650	9700
9	1650	11350
10	1650	13000
11	1700	14700
12	1700	16400
13	1700	18100
14	1700	19800
15	1700	21500
16	1700	23200
17	1700	24900
18	1700	26600
19	1700	28300
20	1700	30000

Table 2: Result Of Cumulative Cash Flow For Case A

Years	Cash flow	Cumulative cash flow
0	(6500)	(6500)
1	1080	(5420)
2	1080	(4340)
3	1080	(3260)
4	1080	(2180)
5	1080	(1100)
6	1080	(20)
7	1080	1060
8	1080	2140
9	1080	3220
10	1080	4300
11	1100	5400
12	1100	6500
13	1100	7600
14	1100	8700
15	1100	9800
16	1100	10900
17	1100	12000
18	1100	13100
19	1100	14200
20	1100	15300

Table 3: Results Of Cumulative Cash Flow For Case B

Years	Cash flow ($1000)	PV at 15% ($1000)
0	(3500)	(3500)
1	1650	1434.782
2	1650	1247.637
3	1650	1084.902
4	1650	943.393
5	1650	820.342
6	1650	713.341
7	1650	620.296
8	1650	539.388
9	1650	469.033
10	1650	407.855
11	1700	365.403
12	1700	317.742
13	1700	276.298
14	1700	240.259
15	1700	208.921
16	1700	181.670
17	1700	157.974
18	1700	137.369
19	1700	119.451
20	1700	103.870
NPV		3389.926

Table 4: Results Of Net Present Value At 15% Discount Rate

Years	Cash flow	PV at 15%
0	(6500)	(6500)
1	1080	939.13
2	1080	816.63
3	1080	710.11
4	1080	617.49
5	1080	536.95
6	1080	466.91
7	1080	406.01
8	1080	353.05
9	1080	307.003
10	1080	266.95
11	1100	236.437
12	1100	205.597
13	1100	178.780
14	1100	155.462
15	1100	135.183
16	1100	117.551
17	1100	102.22
18	1100	88.89
19	1100	77.3
20	1100	67.21
NPV		284.863

Table 5: Results Of Net Present Value For Case B

Years	Cash flow ($1000)	PV at 30% ($1000)	PV at 50% ($1000)
0	(3500)	(3500)	(3500)
1	1650	1269.23	1100
2	1650	976.33	733.3
3	1650	751.02	488.89
4	1650	577.7	325.93
5	1650	444.4	217.28
6	1650	341.84	144.46
7	1650	262.95	96.57
8	1650	202.27	64.38
9	1650	155.6	42,92
10	1650	119.7	28.61
11	1700	94.86	19.65
12	1700	72.97	13.10
13	1700	56.12	8.73
14	1700	43.18	5.82
15	1700	33.21	3.88
16	1700	25.55	2.59
17	1700	19.65	1.73

18	1700	15.12	1.15
19	1700	11.63	0.76
20	1700	8.95	0.51
NPV		1982.28	(203.21)

Table 6: Results Of Discounted Rates At 30% And 50% For Case A

Years	Cashflow ($1000)	PV at 30%	PV at 50%
0	(6500)	(6500)	(6500)
1	1080	830.8	720
2	1080	639.05	480
3	1080	491.57	320
4	1080	378.14	213.33
5	1080	290.9	142.22
6	1080	223.75	94.81
7	1080	172.12	63.21
8	1080	132.4	42.13
9	1080	101.84	28.09
10	1080	78.34	18.73
11	1100	61.37	12.72
12	1100	47.21	8.48
13	1100	36.32	5.65
14	1100	27.94	3.17
15	1100	21.5	2.51
16	1100	16.53	1.67
17	1100	12.71	1.11
18	1100	9.8	0.744
19	1100	7.5	0.496
20	1100	5.79	0.33
NPV		(2913.42)	(4340)

Table 7: Results Of Discounted Rates At 30% And 50% For Case B

RESULTS OF ECONOMIC PROFIT INDICATORS FOR CASE A, B AND INCREMENTAL ANALYSIS

Incremental analysis result was produced for the present value at discount rates of 30% and 50%. The net present value (NPV) for PV at 30% discount rate after a period of 20 years cash flow yielded the sum of $1,103,000.28 while it gave the sum of $1,859,000.33 at a discount rate of 50% as shown in tables 8 and 9. Results of economic profit indicators revealed that the net expenditures for a period of 20 years was favourable for case B at $15,300,000 which is much closer to $8,400,000 after incremental analysis as shown if Table 10 and figure 2. The payout time on the other hand was quicker for case A at a period of 2.12 years as against the most favourable period of 6.02 for case B and confirmed by the incremental value of 5.26 years (Table 10 and Figure 3). The present value per dollar of $2,350,000 for case B was the best option as against case A with the sum of $8,570,000 which too high a value when compared to the incremental value of $2,800,000 (Table 10 and Figure 4). The net present value of $284,000 was the best option for case B as against $3,389,000 for case A when compared to $605,000 for the incremental analysis (Table 10 and Figure 5). The highest economic profit indicator which is the discounted cash flow rate of return (DCF-ROR) gave a minimal value of 16.5% for case B as against 48% for case A indicating also the importance of case B as the best option since it is much closer to 20% for the incremental analysis (Table 10 and Figure 6).

Years	CASE A ($1000)	CASE B ($1000)	Incremental (A-B)$1000	Cumulative (A-B)$1000	PV at 15% (A-B)$1000
0	(3500)	(6500)	(3000)	(3000)	(3000)
1	1650	1080	570	(2430)	495.65
2	1650	1080	570	(1860)	431.00
3	1650	1080	570	(1290)	374.78
4	1650	1080	570	(720)	325.90
5	1650	1080	570	(150)	283.39
6	1650	1080	570	420	246.43
7	1650	1080	570	990	214.3
8	1650	1080	570	1560	186.33
9	1650	1080	570	2130	162.03
10	1650	1080	570	2700	140.9
11	1700	1100	600	3270	128.96
12	1700	1100	600	3840	112.14
13	1700	1100	600	4410	97.5
14	1700	1100	600	4980	84.8
15	1700	1100	600	5550	73.74
16	1700	1100	600	6120	64.15
17	1700	1100	600	6690	55.75
18	1700	1100	600	7260	48.48
19	1700	1100	600	7830	42.16
20	1700	1100	600	8400	36.7
NPV					605.09

Table 8: Results Of Incremental Analysis For Case A And B

Years	Incremental cash flow $1000	PV at 30% (A-B) $1000	PV at 50% (A-B) $1000
0	(3000)	(3000)	(3000)
1	570	438.46	380
2	570	337.28	253.33
3	570	259.45	168.89
4	570	199.57	112.59
5	570	153.52	75.06
6	570	118.09	50.04
7	570	90.83	33.36
8	570	69.87	22.24
9	570	53.75	14.83
10	570	41.35	9.88
11	600	33.48	6.94
12	600	25.75	4.62
13	600	19.81	3.08
14	600	15.23	2.06
15	600	11.72	1.37
16	600	9.02	0.91
17	600	6.94	0.61
18	600	5.34	0.41
19	600	4.10	0.27
20	600	3.16	0.18
NPV		(1103.28)	(1859.33)

Table 9: Results Of Present Values At 30% And 50% For Incremental Analysis

PROFIT INDICATORS	CASE A (DIESEL)	CASE B (GAS TURBINE)	INCREMENTAL ANALYSIS
Net expenditure in 20years ($1000)	30000	15300	8400
PO (years)	2.12	6.02	5.26
P/$	8,570	2,350	2,800

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NPV($1000)	3389.9	284.9	605.09
DCF-ROR (%)	48	16.5	20

Table 10: Results Of Economic Profit Indicators For Case A, Case B And Incremental Analysis

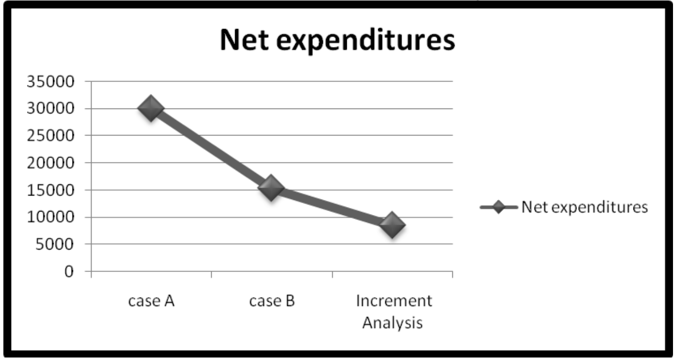

Figure 2: Results of Net expenditures for case A, B and incremental analysis

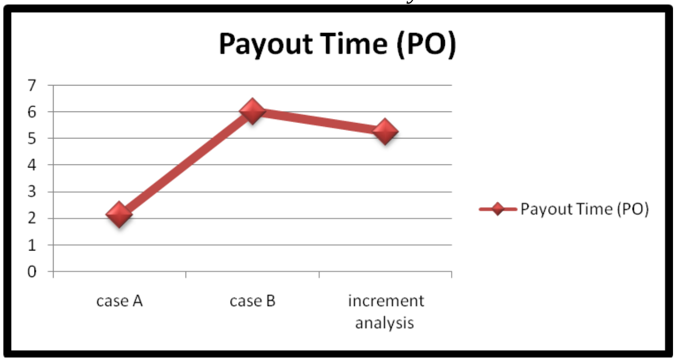

Figure 3: Results of payout (PO) for case A, B and incremental analysis

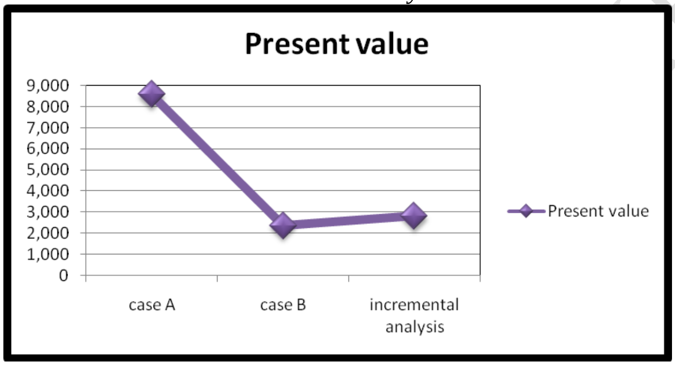

Figure 4: Results of present value for case A, B and incremental analysis

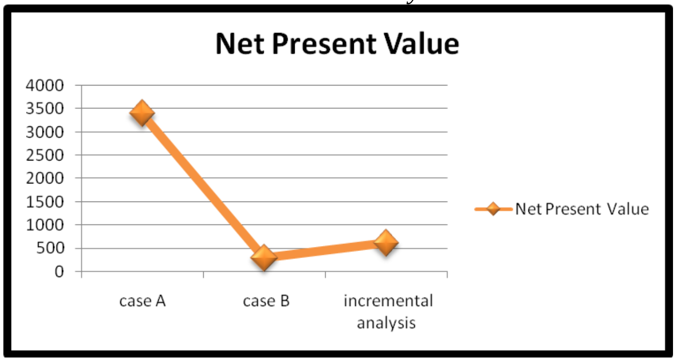

Figure 5: Results of Net present value for case A, B and incremental analysis

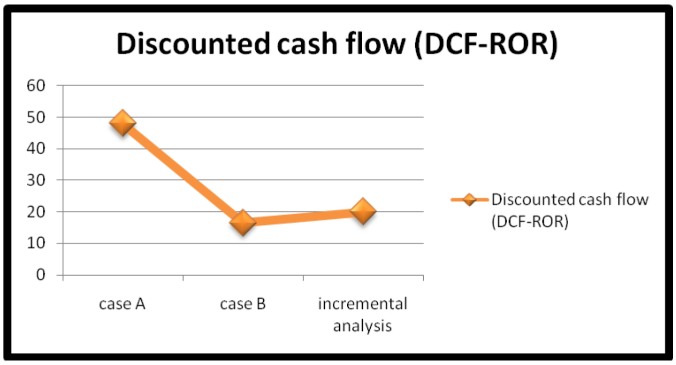

Figure 6: Results of Discounted cash flow (DCF-ROR) for case A, B and incremental analysis

IV. DISCUSSION

The results obtained from case B are closer to the values from the incremental analysis so this indicates that case B is a more feasible venture as it involves less cost and expenditure over the long run. The payout for this analysis represents the time taken before the OPEX=CAPEX i.e., the cost of operation and maintenance sums up to the cost of the equipment. This means that a lower PO is not a good indication in this case.

From the results, case B (GTP) has a higher PO of 6.02 years which means that it takes a longer time before the cost of maintenance and operation of the equipment sums up to the cost of the equipment which is a positive indication while that of case A (diesel generator) is 2.12years which is a negative indication in this case because it means that it takes a short time before the cost of maintenance and operation becomes equal with the cost of acquiring the equipment. The NPV for case B is also very low at $284,900 which is a good indication because it means the total expenditure over a period of 20 years is lower while that of case A at $3,389,900 is very high which means the total expenditure on the long run is higher. The IRR for case B (GTP) being low at 16.5% also represents a better situation because only expense are involved while that of case A (diesel generator) being high at 48% represents a worse case.

V. CONCLUSION

The capital cost of diesel generator is very low compared to gas turbine but the long term operating and maintenance expenditures accumulated becomes extremely high when compared to that of a gas turbine.

In the economic analysis of this work, we want to acquire equipment which does not affect the inflow of cash into the establishment rather we are trying to determine the savings that will be made in the long run if the new equipment is to be purchased. Therefore, the cash flow for this case consists only of outflow of cash i.e. expenditures. The results gotten from the GTP calculations are closer to the results gotten from the incremental analysis. Thus the use of Gas to Power for power generation is a more economical and better alternative.

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VI. RECOMMENDATIONS

As a result of the advantages of use of GTP in power generation, it is recommended that;

- ✓ University of Calabar should conduct an economic and technical feasibility study before deciding which equipment to acquire especially when there is an alternative.
- ✓ Companies and establishments should be less stringent in releasing simple and necessary information about the company especially to students who are conducting a research work.

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