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Economic Analysis of the Gas Distribution Pipeline Network for Estates in Nigeria

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Research Article

Abstract

This work presents the economic analysis of the gas distribution pipeline network for the University of Abuja Staff Quarters. The problem statement was the need to encourage gas distribution to buildings and estates across Nigeria through gas pipeline network supply in an economical manner that encourages investment into this venture. The methodology includes subjecting three (3) design connections (series, parallel, and grid) to economic analysis to determine the viability of the project. The results of the economic study indicated a profitable and investment-worthy project, with the grid connection being the most lucrative of the three (3) connections. The net present value is ₦6, 862,078.46; the internal rate of return is 15.57%. The payback period for the project was 4.29 years; the project will break-even after the distribution of up to 39,535.58 kg of LPG, and the profitability index is 1.30. It can be concluded that the optimized design could be adopted for the gas pipeline network of the University of Abuja staff quarters and other estates in Nigeria, with similar elevation and building layout.

Keywords

Equivalent Annual Cost, Net Present Value, Internal Rate of Return, Break-even, Payback Period, Contribution Margin, Profitability Index.

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1. Introduction

Economic analysis, which is sometimes referred to as cost-benefit analysis (CBA), is an efficient approach that could be employed to determine the strengths and weaknesses of alternatives, which hence provides the best option in achieving the desired benefits, especially in satisfying business requirements. Campbell, *et al.*, (2003) described CBA as a process business used to analyse decisions and as a tool used to compare completed or potential alternatives necessary for the evaluation of the value received from a project and the incurred expenses. Maravas *et al.*, (2018) defined CBA as an important tool in the appraisal of engineering projects so as to determine the long-term financial and social sustainability of such projects. In carrying out a CBA, the following critical financial/economic indices which must be estimated: Net Present Value (NPV), Equivalent Annual Cost (EAC), Internal Rate of Return (IRR), Payback Period (PP), and profitability index (PI).

The Net Present Value (NPV) is the present worth of future revenue for any particular project and is one of the primary indicators in CBA, which is expressed in monetary values; as defined by Maravas *et al.*, (2018). In the calculation of the NPV, it is important to give due consideration to the revenue (positive cash flows) and the incurred expenses (negative cash flows). In order to carry out proper economic analysis, future cash flows are discounted each year and the discount rate reflects the opportunity cost of the capital mobilized, thereby increasing the risks associated with such project. Žižlavský (2014) postulated that riskier projects typically lead to higher return on investment. A positive NPV indicates that the actual value of all incomes exceeds the real value of all costs incurred, which makes the execution of such a project desirable. A typical example is the calculation of an NPV of ₦36,000.00 in which the present value of a particular project was ₦360,000.00 and an initial investment of ₦324,000.00. For an investment decision to be made regarding a project, the NPV must be positive. David, *et al.*, (2013) and Žižlavský (2014) concluded that no investment should be made if the project offers a negative or neutral NPV.

David, *et al.*, (2013) described equivalent annual cost (EAC) as the yearly cost of possessing and maintaining assets for a period covering the lifespan of such assets. In most decision-making processes, EAC is a veritable tool because it has to do with budgeting, and it enables the estimation of the equivalent annual amounts from the prices of assets.

The internal rate of return (IRR) measures the extent of profitability of potential investments and is known to be a useful tool in capital budgeting. According to David, *et al.*, (2013), the discount rate at which the NPV of any particular project is zero is referred to as the IRR. A project is worthwhile and acceptable if the IRR is higher than the cost of capital, but if the IRR is less than the discount rate, the project is considered unprofitable and should be rejected as submitted by David, *et al.*, (2013) and Maravas *et al.*, (2018).

The payback period (PP) is the amount of time (usually measured in years) it takes to recover an initial investment outlay, as measured in after-tax cash flows. According to Boardman *et al.*, (2006), payback period has been a widely used capital budgeting tool in the analysis of capital projects and associated investments. The payback period is the time in which the recovery of the initial outlay of investment is expected through the cash inflows generated by the investment. It is an important technique employed in the appraisal of different investment opportunities. Due to economic and operational inconsistencies, cash flow estimates are considered to be very accurate for investments relating to periods in the near future but somewhat inaccurate for periods in a distant future. Conversely, the payback period is an indicator of risk inherent in a project because it takes initial inflows into account and ignores the cash flows after the point at which the initial investment is recovered. Boardman *et al.,* (2006) concluded that one of the drawbacks of payback period method is its non-consideration of all project's cash flows in present-value.

The profitability index (PI) is the ratio of the present value of future cash flows of the project to the initial investments in the project. Profitability index method indicates the present value of benefits for every Naira invested. Rangel *et al.,* (2016) stated that PI is a ratio of the present value of future project cash flows and the project's initial investment. This index helps in the cost-benefit analysis of investment projects and helps them rank in order of the best return on initial investments. The PI for this project is calculated based on the NPV. The NPV method is a good measure as well to consider whether any investment is profitable or not. If the PI is more than 1, then the investment is worthy because it is possible to earn back more than invested. However, if the PI is less than 1, then it's better to step back and seek other business opportunities. Because when PI is less than 1, it means it is impossible to get back the money invested. Also, if the index is equal to 1, then it's an indifferent or neutral project. David *et al.,* (2013) and Rangel *et al.,* (2016) agreed that there should be no investment in such a project until and unless such project is considered better than other projects available during the period.

As far as the review of the existing literature that was carried out by Adegbola *et al.,* (2021) is concerned, there is no significant economic model for a transmission and distribution gas pipeline network for estates in Nigeria at large. The challenge of a reliable economic model for the distribution of gas for its safe usage in households situated in estates in Nigeria has discouraged many investors from making any considerable investment in this regard. The rising trend in the potential dangers of using gas cylinders has made it imperative to develop a reliable economic model that promotes gas distribution to buildings and estates across Nigeria through gas pipeline network supply. The aforementioned is a challenge that this work intends to address to make cooking gas more accessible and affordable to residents of the University of Abuja staff quarters in Giri, Abuja, Nigeria, which is located at latitude 9.00°N and longitude 7.07°E.

1.1 Aim and Objective of the Study:

This study aims to ascertain the economic viability of the gas pipeline distribution network for the University of Abuja Staff Quarters, Giri, Abuja designed by Adegbola *et al.,* (2021). The objective is to carry out a cost analysis of three (3) connections for the gas pipeline distribution network to determine the most economically viable.

2. Literature Review

It has been widely reported that in Africa, Nigeria has the largest gas reserves and operational gas pipeline industry since the discovery of gas in commercial quantity. However, Nigerians have not been able to enjoy the full benefits from gas due to a lack of sufficient gas development infrastructure despite the efforts of the Nigerian government in building new gas pipelines as part of its plan to maximize gas utilization. It was in this regard that Adamu *et al.,* (2017) carried out a study to analyse the economics of possible gas pipeline options to assess the viability of investing in building new gas pipeline networks in Nigeria.

There are many types of models related to natural gas transmission networks that have been presented in literature. These optimization models and techniques are applicable in the production and transportation of natural gas and also in the natural gas market. In pipeline network optimization, studies were conducted by Chebouba *et al.,* (2009), Hamedi *et al.,* (2009), Kabirian *et al.,* (2007) and Woldeyohannes *et al.,* (2011), in the areas of pipeline network design, minimization of fuel consumption at compressor stations, economically locating compressor stations in the network, and so on. In other studies, heuristic approaches were suggested for the reduction of compressor station costs. The ant colony optimization algorithm was used for the first time for studying gas flow operations in the study carried out by Chebouba *et al.,* (2009). The authors focused on utilizing the ant colony optimization as a decision tool to obtain fast and reliable results, and the objective function of the problem was nonlinear and non-convex. One source, one demand, and six pipelines connected in series by five compressor stations were tested. However, the model has limitations because of its non-application to multiple sources of gas supplies and meeting demands from multiple consumers, which is the case for this research work.

A hierarchical algorithm was proposed by Hamedi *et al.,* (2009), to solve a distribution network problem by using a single-objective, multi-period mixed-integer nonlinear programming (MINLP) model. The model was converted into mixed-integer programming (MIP) by adding a set of constraints. The objective was to minimize direct and indirect costs. The model was tested for seven samples. The smallest test instance includes 190 nodes, and the largest one has 319 nodes. Kabirian *et al.,* (2007) developed an integrated nonlinear optimization model for formulating a strategic plan to find the best long-run development plans for an existing network. A heuristic random search optimization method was used to solve the problem. The objective was to minimize the net present value of operating and investment costs. They used a network with two compressor stations, four demand, three supply, and one trans-shipment node, and ten pipelines to assess the performance of the model. The limitation of this model was that the proposed transmission and distribution network required more than two compressor stations, and the demands and supplies exceed expectations.

Woldeyohannes *et al.,* (2011) developed a simulation model through the integration of compressor station parameters such as speed, suction, and discharge pressure. The model was used to simulate the transmission pipeline network system to determine pressure and flow parameters under different situations. The developed simulation model in this study could be of tremendous help in making operational and design decisions. Unfortunately, this model did not consider the economic viability of the network, which is a key factor for consideration in the proposed design for the University of Abuja staff quarters. The proposed design is aimed at delivering gas to consumers at minimal and affordable cost, while also ensuring good return on investment for investors.

Based on the study by Tabkhi *et al.*, (2009), Gunes (2013) selected the general algebraic modelling system (GAMS) environment to solve the mixed-integer linear programming (MINLP) problem. According to Gunes (2013), the optimization of the model by Tabkhi *et al.*, (2009) led to a decrease in the operational costs of the existing Turkish pipeline network from US$20,485,390/year to US$18,733,680/year. Initially, there were four (4) compressor stations (CS) in the Russia-west network. Through optimization, three (3) CSs were identified for this entrance network, while an extra compressor station was assigned to the Nigeria & Algeria network that has no CS. Gunes (2013) concluded that although there were eight (8) compressor stations available for the entire network, a reduction in the overall cost was achieved after the optimization and that the model is fit for current and future use. In carrying the analysis of the investment cost, gas deliveries, and the cost-benefit of six possible gas pipeline route options, the researchers relied on gas pipeline models available in existing literature. According to Adamu *et al.*, (2017), the Warri-Shagamu pipelines route option was found to be more viable and estimated to have an annual gas delivery of 37.25 billion m^3 investment cost of ₦414 billion, NPV of ₦874.8 billion, IRR of 50.38%, payback period of 2.60 years for forty years of operation.

3. Methodology

3.1 Cost analysis of the gas pipeline network project

Cost-benefit analysis (CBA) was used to assess the pros and cons of embarking on this project either by the Management of the University of Abuja or through Public-Private Partnership arrangement. For the three (3) connections, the CBA estimated all the planned project costs and the projected revenues and determined key financial/economic indices such as equivalent annual cost (EAC), net present value (NPV), internal rate of return (IRR), break-even, payback period and profitability index (PI).

3.2 Basic Assumptions

For this work, some basic assumptions were made, including the discount rate of 10% (cost of cash), project life (15 years), constant bank interest rate (15.4%), unchanged number of households within the staff quarters, and constant volume of gas consumed by the households.

3.3 Financial and economic indices of the gas pipeline network

3.3.1 Equivalent Annual Cost (EAC)

Equivalent annual cost (EAC) helps to compare the cost-effectiveness of two or more assets with different lifespan. David *et al.*, (2013) presented the formula for EAC as:

$$EAC = CA \times \frac{i}{1-(1+i)^{-n}} + M_{ac} \tag{1}$$

Where:
CA is the cost of assets (₦)
i is the discount rate (*%*)
n is the number of years (*years*)
M_{ac} is the annual maintenance cost (₦)

3.3.2 Net Present Value (NPV)

In the calculation of the net present value (NPV) of a series of cash flows based on a specified discount rate, the NPV formula is usually utilized. The NPV formula can be beneficial for financial analysis and financial modelling when determining the value of an investment (a company, a project, a cost-saving initiative)

$$NPV = \frac{F}{\left[(1+i)^n\right]} \tag{2}$$

Where,
NPV is the net present value (₦)
F is the future value of money (₦)
i is the discount or interest rate (*%*)
n is the number of periods in the future the cash flow (*years*).

3.3.3 Internal Rate of Return (IRR)

IRR is the discount rate that sets the NPV of a project to zero.

$$NPV = 0 = CF_o + \frac{CF_1}{(1+IRR)^1} + \frac{CF_2}{(1+IRR)^2} + \ldots + \frac{CF_n}{(1+IRR)^n} = \sum_{i=1}^{n} \frac{CF_i}{(1+IRR)^i} \tag{3}$$

Where,
CF is the cash flow (₦)
IRR is the internal rate of return (*%*)
To calculate the IRR, the NPV value was set to zero, and then the discount rate is found out.

3.3.4 Payback Period

The cash inflows for this work are uneven, the cumulative net cash flow for each period was calculated, and then the Payback period (PP) is calculated using the formula presented by Boardman *et al.*, (2006):

$$PP = A + \frac{B}{C} \tag{4}$$

Where,
A is the period that has the last negative cumulative cash flow (*year*);
B is the absolute value of cumulative net cash flow obtained at the end of period A (*year*)
C is the total cash inflow during the period following period A (*year*)

3.3.5 Break-even (Sales)

In simple terms, the break-even point is the juncture where total cost and total sales (revenue) are equal. This point is vital for every company to know because, from this point, the company starts to become profitable. As stated by David *et al.*, (2013), if total cost and total revenue are equal at this point, that means the units produced would generate zero profit.
That means at this point,

$$R - TC = 0 \tag{5}$$

Where:
R is the Revenue (₦)

TC is the Total Cost (₦)

$$\text{But: } TC = VC \times N + FC \quad (6)$$

Where:
VC is the Variable Cost (₦)
N is the number of units produced to break-even (kg)
FC is the Fixed Cost (₦)

$$\text{Also, } R = P \times N \quad (7)$$

Putting equations 5 and 6 into equation 7 implies:

$$P \times N - (VC \times N + FC) = 0$$

Solving for N (the break-even point):

$$N = \frac{FC}{(P - VC)} \quad (8)$$

Where:
N is the number of units produced to break-even (kg)
FC is the fixed cost (₦)
P is the price per kg (₦)
VC is the variable cost per kg (₦)
The break-even point (*N*), when given in the units required, produces a break-even quantity where the total revenue and the total cost would be equal.

3.2.6 Contribution Margin
According to David, *et al.*, (2013), the contribution margin (CM) shows the aggregate amount of income available after variable costs to cover fixed expenses and provide profit to the company.

$$CM / unit = P / unit - VC / unit \quad (9)$$

$$CM = TR - VC \quad (10)$$

Where:
CM is contribution margin (₦)
P is the price (₦)
VC is the variable cost (₦)
TR is the total revenue (₦)

3.2.7 Profitability Index (PI)
The PI for this project is calculated based on the NPV. The NPV method is a good measure as well to consider whether any investment is profitable or not. In this case, Rangel *et al.*, (2016), stated that the idea is to find a ratio, not the amount.

$$PI = \frac{1}{(NPV / IIR)} \quad (11)$$

Where:
PI is the profitability index
NPV is the net present value (₦)
IIR is the initial investment required (₦)

3.3 Computing Procedure
Equations 1 to 11 were computed using Microsoft Excel Spreadsheet (2007). Three (3) examples were presented as in Equation 1, for the equivalent annual cost (EAC) was computed as follows: Input values of the cost of assets (CA), discount rate (i), number of years (n) and annual maintenance cost (Mac) into cells C5 to F5 respectively. In cell G5, type "(C5*D5/(1-(1+D5)^(-E5)))+F5 and press "Enter" to obtain the EAC (₦). Furthermore, Equation 8 was used to obtain the Break-even (sales) using the excel spreadsheet as follows: Input the values of fixed cost (FC), the sales price of gas per kg (P), and variable cost per kg (VC) into cells C12 to E12. In F5, type "C12/(D12-E12)" and press "Enter" to obtain the break-even (sales) in kg. Also, Equation 10 was used to calculate the Contribution Margin (CM) using the excel spreadsheet as follows: Input values of total revenue (TR) and total variable cost (VC) into cells B25 to C25. In cell D25, type "B25-C25" and press "Enter" to obtain the CM (₦).

4. Results and Discussion

4.1 Capital expenditures, operating expenses, and revenue for the gas pipeline network
The capital expenditures and operating expenses were estimated for the gas pipeline network. Also, the projected revenue for the gas pipeline network is presented.

4.1.1 Capital Expenditures (CAPEX)
The fixed, one-time costs that would be incurred for this project to secure the necessary government's permits, procurement of the storage vessel, pipes, fittings, operation vehicle, generating set, and also in the laying of the pipes are all categorized as capital expenses.
It could be observed from Table 1 that the grid connection has the least total pipe lengths (4,891.32 m) and, by extension, the least capital expenses, as detailed in Table 2. This connection is acceptable as it is in agreement with the model developed by Hamedi, *et al.*, (2009), which has the objective of minimizing the direct and indirect costs.
The pipe lengths for the trunk, reticulation, and service pipes for series, parallel and grid connections are as contained in Table 1, while the Capital expenditures are as detailed in Table 2.

Table 1: Pipe Lengths for Trunk, Reticulation, and Service Pipes for Series, Parallel and Grid Connections.

S/N	Description	Series	Parallel	Grid
1	Trunk pipe length (m)	19.52	19.52	19.52
2	Reticulation pipe length (m)	3,622.91	3,616.06	3,223.34
3	Service pipe length (m)	1,668.58	1,663.49	1,648.46
	Total Length (m)	5,311.01	5,299.07	4,891.32

Table 2: Capital Expenses (CAPEX) for Series, Parallel and Grid Connections

			Series	Parallel	Grid
S/No	Item/Description	Specifications	Amount (₦)	Amount (₦)	Amount (₦)
1	Registration with DPR including inspection of site and issuance of Operating License (Payable once)		300,000.00	300,000.00	300,000.00
2	Registration with the Gwagwalada Area Council and issuance of Operating License (Payable once)		100,000.00	100,000.00	100,000.00
3	Environmental Impact Assessment Permit (Payable once)		50,000.00	50,000.00	50,000.00
4	Gas Vessel (60 years lifespan)	5,000kg Capacity	2,000,000.00	2,000,000.00	2,000,000.00
S/No	Item/Description	Specifications	Amount (₦)	Amount (₦)	Amount (₦)
5	Fare from Lagos to Abuja and Other Logistics (Once in 60 years)		180,000.00	180,000.00	180,000.00
6	Installation and Calibration of Vessel		100,000.00	100,000.00	100,000.00
7	Trunk Pipes	Diameter (50.8mm), Thickness (4mm), Length (5.5m)	34,000.00	34,000.00	34,000.00
8	Reticulation Pipes	Diameter (50.8mm), Thickness (4mm), Length (5.5m)	5,253,000.00	5,057,500.00	4,828,000.00
9	Service Pipes	Diameter (12.7mm), Thickness (3mm), Length (5.5m)	785,000.00	810,000.00	785,000.00
10	Metering gauges (Replaceable every 5 years)	12.7mm.	2,604,000.00	2,604,000.00	2,604,000.00
11	3-way manifold valves	Size: 12.7 mm.	1,860,000.00	1,860,000.00	1,860,000.00
12	Ball Valves	Size: 12.7mm.	1,612,000.00	1,612,000.00	1,612,000.00
13	Pressure regulators	Size: 12.7 mm.	1,612,000.00	1,612,000.00	1,612,000.00
14	Non-Return/Control Valves	Size: 50.8 mm & 12.7 mm.	60,000.00	60,000.00	60,000.00

15	Fire Detectors	Size: 50.8 mm & 12.7 mm.	45,000.00	45,000.00	45,000.00
16	Fire Extinguishers	9 Kg Capacity of ABC Powder Fire Extinguisher suitable for Class B Fire	992,000.00	992,000.00	992,000.00
17	Construction of Base for Gas Vessels (Cement, Granite, Sharp Sand, and Labour)		200,000.00	200,000.00	200,000.00
S/No	Item/Description	Specifications	Amount (₦)	Amount (₦)	Amount (₦)
18	Purchase of Vehicle	Toyota Hilux, 2005 model, manual transmission, 6-cylinder petrol engine	2,000,000.00	2,000,000.00	2,000,000.00
19	Power Generating Set	4.5KVA, Petrol Engine	250,000.00	250,000.00	250,000.00
20	Labour (Digging)	(Depth: 700mm, Width: 300mm)	2,655,505.00	2,649,535.00	2,445,660.00
21	Labour (Laying of Pipes)	50.8mm.	232,500.00	227,100.00	217,500.00
22	Labour (Welding and Laying of Pipes)	12.7mm.	3,400.00	3,400.00	3,400.00
23	Labour (installation of Gauges / Regulators)	12.7mm pressure regulators	124,000.00	124,000.00	124,000.00
	Grand Total		**23,052,405.00**	**22,870,535.00**	**22,402,560.00**

4.1.2 Operating Expenses (OPEX)

All expenses which are related to the operation of this project, including annual renewal of permits and licenses, salaries and wages, maintenance of plants and equipment, communication, and purchase of the LPG, were considered as operating expenses. Some of the operating costs are either fixed or variable costs.

It could be observed from Table 3 that the three (3) connections have the same operating expenses with a total fixed cost of ₦4,240,000.00 and a total variable cost of N3,374,784.00. This trend has become obvious given the fact that the operating cost remains the same even though the capital expenses are different for the three (3) connections. This model has considered the economic viability of this project from the operating cost perspective not considered in the model developed by Woldeyohannes *et. al.*, (2011).

The operating costs for the three (3) connections are the same, with details presented in Table 3.

Table 3: The Operating Expenditure (OPEX) – Fixed Costs and Variable Costs for Series, Parallel and Grid Connections

S/No	**Item/Description**	**Specifications**	**Unit price (₦)**	**Quantity (Pieces)**	**Total price (₦)**
Fixed costs					
1	Annual Renewal of DPR Operating License		150,000.00	1	150,000.00
2	Gwagwalada Area Council's Annual Tax and Operating License Renewal		100,000.00	1	100,000.00
3	Salaries and Wages	Monthly salaries and allowances	50,000.00	24	1,200,000.00
4	Electricity		10,000.00	12	120,000.00

5	Maintenance Tools and Devices		100,000.00	1	100,000.00
6	Maintenance of Pipelines, Gauges, and Valves		100,000.00	4	400,000.00
7	Maintenance and Fuelling of Generating Set	Monthly maintenance cost and purchase of Petrol for Generator in case of power failure	20,000.00	12	240,000.00
8	Marketing of Products		50,000.00	4	200,000.00
9	General maintenance works		100,000.00	12	1,200,000.00
10	Water Supply		5,000.00	12	60,000.00
11	Stationeries	Customized Booklets, Print papers, Pens, and other consumables	50,000.00	4	200,000.00
12	Telephone communication and information technology gadgets		10,000.00	12	120,000.00
13	Insurance (Staff and Equipment)	Against Injuries to staff and damage/theft of equipment	150,000.00	1	150,000.00
					4,240,000.00
Variable costs					
14	Truck of LPG	Cost of LPG and Transportation from Lagos to Abuja	180.00	18,749	3,374,784.00
	Total				3,374,784.00
	Grand Total (fixed and variable costs)				**7,614,784.00**

4.1.3 Revenue

The revenue projection was carried from the projected annual gas sales of 18,749 kg of LPG to all the 124 houses per annum. Also, each household is charged an amount for procurement and installation of metering gauges and regulators and is charged an annual maintenance fee. The bulk of the expected revenue is from the annual gas sales (₦5,062,176.00) and annual maintenance cost (₦6,200,000.00).

Details of the projected revenue for the three (3) connections are contained in Table 4.

Table 4: The Projected Annual Revenue

S/No	Item/Description	Specifications	Unit price (₦)	Quantity (Pieces)	Total price (₦)
1	Annual Gas Sales	124 houses consume 12.6kg per month	270.00	18,749	5,062,176.00
2	Metering Gauges/Regulators (Cost, Installation, and Testing)	12.7mm replaceable every five years	10,000.00	124	1,240,000.00
3	Annual Maintenance Cost	Change of Valves and Repair of leakages.	50,000.00	124	6,200,000.00

Total	12,502,176.00

4.2 Financial and economic indices of the gas pipeline network

Essential financial and economic indices for the gas pipeline network were estimated to determine the profitability or otherwise of the project.

4.2.1 Basic Data and Assumptions

For this work, the discount rate (cost of cash) was taken to be 10% as suggested by David *et al.*, (2013). The cost analysis was based on a 15-year projection, and it is assumed that the initial capital for the project is sourced from a Bank at an interest rate of 15.4% as used by Adamu *et al.*, (2017). It is also assumed that the number of households within the staff quarters remains 124 for 15 years and that the volume of gas consumed by the households remains the same for the period. As of 29th October 2019, the landing cost per kg of LPG was ₦180.00, while the average selling price per kg of LPG in Abuja was ₦270.00. Other basic data and assumptions are contained in Table 5.

Table 5: Basic Data and Assumptions

Item	**Value**
Year	12
Quarter	4
Annual Gas Sales (kg)	18,749
Discount rate (Cost of Capital)	10%
Inflation Rate (OPEX) (Adamu *et al.*, (2017))	3%
TAX (11%) - VAT (5%), WHT (5%) Stamp Duty (1%)	11%
Contingency (Expenditure)	1%
Interest Rate on Loan (Adamu *et al.*, (2017))	15.4%
Number of Years for the Loan	15
Average Life Span of Gas Vessel (Years)	60
Gas Purchase rate (₦/kg)	180
Gas Selling rate (₦/kg)	270

4.2.2 Equivalent Annual Cost (EAC)

For this project, the equivalent annual cost (EAC), which is the yearly cost of possessing and maintaining assets for a period covering the lifespan of the assets was calculated as submitted by David, *et al.*, (2013). The prices of the assets were converted into equivalent annual amounts using this approach. The list of assets, their respective lifespan, and the yearly maintenance costs are contained in Table 6. Using Table 6, the EAC for the Gas storage vessel was calculated. The EAC for the Gas vessel, which cost ₦2,000,000 and with 60 years lifespan and annual maintenance cost of ₦100,000, was computed to be ₦300,659.02.

Equivalent annual cost (EAC) for all the assets was calculated using the Excel software and found to be ₦3,036,695.93, ₦3,011,064.75, and ₦2,972,805.89 for the series, parallel and grid connections respectively as detailed in Table 7. The grid connection, with the least capital expenses, has been found to have the least EAC, which is in tandem with the model developed by Hamedi *et al.*, (2009).

Table 6: List of Assets, Lifespan, and Annual Maintenance Costs

S/No	**Asset**	**Lifespan (years)**	**Annual maintenance cost; series (₦)**	**Annual maintenance cost; parallel (₦)**	**Annual maintenance cost; grid (₦)**
1	Gas Vessel	60	100,000.00	100,000.00	100,000.00
2	Pipes	15	303,600.00	295,075.00	282,350.00
3	Industrial Gauges	15	130,200.00	130,200.00	130,200.00
4	Valves	15	257,200.00	257,200.00	257,200.00
5	Vehicle	5	200,000.00	200,000.00	200,000.00
6	Generating Set	5	25,000.00	25,000.00	25,000.00
7	Fire Extinguishers	5	103,700.00	103,700.00	103,700.00

Table 7: Equivalent Annual Cost (EAC) for Assets

S/No	**Asset**	**Lifespan (years)**	**Equivalent annual cost; series (₦)**	**Equivalent annual cost; parallel (₦)**	**Equivalent annual cost; grid (₦)**
1	Storage vessel	60	300,659.02	300,659.02	300,659.02
2	Pipes	15	912,800.78	887,169.60	848,910.74

3	Pressure regulators	15	391,458.04	391,458.04	391,458.04
4	Valves	15	773,295.00	773,295.00	773,295.00
5	Vehicle	5	400,659.02	400,659.02	400,659.02
6	Generating set	5	50,082.38	50,082.38	50,082.38
7	Fire extinguishers	5	207,741.70	207,741.70	207,741.70
	Total		**3,036,695.93**	**3,011,064.75**	**2,972,805.89**

4.2.3 Net Present Value (NPV)

With the aid of Excel software (2007), the NPV (at 10% discount rate) was found to be ₦6,862,078.46 for grid connection (See Table 9). The NPV (at 10% discount rate) for the grid connection was computed using equation 3.15 and based on the cash flow forecast presented in Table 8. A positive NPV is an indication of a viable project, while a negative NPV is an indication of a bad project in which there should be no investment.

4.2.4 Internal Rate of Return (IRR)

The IRR was computed using Equation 3, and with the aid of Excel software (2007), the IRR was found to be 15.57% for grid connection (See Table 9). For a project to be considered viable, the IRR must be higher than the cost of capital. In this case, the project is profitable and acceptable since the IRR for the three (3) connections is higher than the Cost of Capital (Discount Rate) of 10%.

The grid connection, with the highest IRR, is the most profitable of the three (3) connections. This trend is in tandem with the results obtained by Adamu *et al.,* (2017), in which the Warri-Shagamu pipeline route option with an IRR of 50.38% was said to be more economically viable.

For this project, an NPV at 10% discount rate for the three (3) connections is positive; however, the grid connection has the highest NPV. The project can be said to be viable and investment-worthy. The results can be reported to be reliable when compared with the results obtained by Adamu *et al.,* (2017), in which the Warri-Shagamu pipeline route option with an NPV of ₦878.4 billion was found to be more economically viable.

4.2.5 Payback Period

The payback period was calculated using Equation 4, and with the aid of Excel Software (2007), the payback period was found to be 4.29 years for the grid connection (See Table 9). This result implies that the project, which has a life span of 15 years, is expected to be making a profit from the 3rd month of the 5th year (grid connection) that the project commences.

This favourable economic factor is an indication of a viable project, and grid connection with the shorter payback period should be given the highest consideration. The result of the payback period is in agreement with a payback period of 2.60 years obtained by Adamu *et. al.* (2017), and what was said by David *et al.,* (2013), and Boardman *et al.,* (2006).

Table 8: The cash flow projections Option 3

PROJECT CASH FLOW								
YEAR	0 2019	1 2020	2 2021	3 2022	4 2023	5 2024	6 2025	7 2026
REVENUE (₦)								
Annual Gas Sales	0.00	5,062,176.00	5,062,176.00	5,062,176.00	5,062,176.00	5,062,176.00	5,062,176.00	5,062,176.00
Industrial Gauges/Regulators	0.00	1,240,000.00	1,240,000.00	1,240,000.00	1,240,000.00	1,240,000.00	1,240,000.00	1,240,000.00
Annual Maintenance Cost	0.00	6,200,000.00	6,200,000.00	6,200,000.00	6,200,000.00	6,200,000.00	6,200,000.00	6,200,000.00
TOTAL REVENUE (₦)	**0.00**	**12,502,176.00**	**12,502,176.00**	**12,502,176.00**	**12,502,176.00**	**12,502,176.00**	**12,502,176.00**	**12,502,176.00**
CUMULATIVE REVENUE (₦)	**0.00**	**12,502,176.00**	**17,564,352.00**	**22,626,528.00**	**27,688,704.00**	**32,750,880.00**	**37,813,056.00**	**42,875,232.00**
EXPENDITURE (₦)								
Capital Expenditure (₦)								
Cost	22,402,560.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maintenance Cost	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total CAPEX	**22,402,560.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Cumulative CAPEX (₦)	**22,402,560.00**	**22,402,560.00**	**22,402,560.00**	**22,402,560.00**	**22,402,560.00**	**22,402,560.00**	**22,402,560.00**	**22,402,560.00**
Operating Expenditure (₦)								
Fixed Costs	0.00	4,240,000.00	4,240,000.00	4,240,000.00	4,240,000.00	4,240,000.00	4,240,000.00	4,240,000.00
Variable Costs	0.00	3,374,784.00	3,476,027.52	3,580,308.35	3,687,717.60	3,798,349.12	3,912,299.60	4,029,668.59
Total OPEX	**0.00**	**7,614,784.00**	**7,716,027.52**	**7,820,308.35**	**7,927,717.60**	**8,038,349.12**	**8,152,299.60**	**8,269,668.59**
Cumulative OPEX	**0.00**	**7,614,784.00**	**15,330,811.52**	**23,151,119.87**	**31,078,837.46**	**39,117,186.59**	**47,269,486.18**	**55,539,154.77**
Contingency (1%)	224,025.60	380,739.20	385,801.38	391,015.42	396,385.88	401,917.46	407,614.98	413,483.43
Cumulative Contingency	224,025.60	604,764.80	990,566.18	1,381,581.59	1,777,967.47	2,179,884.93	2,587,499.91	3,000,983.34
TOTAL EXPENDITURE (₦)	**22,626,585.60**	**7,995,523.20**	**8,101,828.90**	**8,211,323.76**	**8,324,103.48**	**8,440,266.58**	**8,559,914.58**	**8,683,152.01**
CUMULATIVE EXPENDITURE (₦)	**22,626,585.60**	**30,622,108.80**	**38,723,937.70**	**46,935,261.46**	**55,259,364.93**	**63,699,631.51**	**72,259,546.09**	**80,942,698.11**
Gross Profit (₦)	-22,626,585.60	4,506,652.80	4,400,347.10	4,290,852.24	4,178,072.52	4,061,909.42	3,942,261.42	3,819,023.99
PROFIT BEFORE TAX (₦)	**-22,626,585.60**	**4,506,652.80**	**4,400,347.10**	**4,290,852.24**	**4,178,072.52**	**4,061,909.42**	**3,942,261.42**	**3,819,023.99**
CUM. PBT (₦)	**-22,626,585.60**	**-18,119,932.80**	**-13,719,585.70**	**-9,428,733.46**	**-5,250,660.93**	**-1,188,751.51**	**2,753,509.91**	**6,572,533.89**
TAX (11%) - VAT (5%), WHT (5%) STAMP DUTY (1%) (₦)	0.00	495,731.81	484,038.18	471,993.75	459,587.98	446,810.04	433,648.76	420,092.64
PROFIT AFTER TAX (₦)	**0.00**	**4,010,920.99**	**3,916,308.92**	**3,818,858.49**	**3,718,484.55**	**3,615,099.38**	**3,508,612.67**	**3,398,931.35**
CUMULATIVE PAT (₦)	**0.00**	**4,010,920.99**	**7,927,229.91**	**11,746,088.41**	**15,464,572.95**	**19,079,672.34**	**22,588,285.00**	**25,987,216.35**
PROJECT CASH FLOW								
	8	9	10	11	12	13	14	15

YEAR	2027	2028	2029	2030	2031	2032	2033	2034
REVENUE (₦)								
Annual Gas Sales (₦)	5,062,176.00	5,062,176.00	5,062,176.00	5,062,176.00	5,062,176.00	5,062,176.00	5,062,176.00	5,062,176.00
Industrial Gauges/Regulators (₦)	1,240,000.00	1,240,000.00	1,240,000.00	1,240,000.00	1,240,000.00	1,240,000.00	1,240,000.00	1,240,000.00
Annual Maintenance Cost (₦)	6,200,000.00	6,200,000.00	6,200,000.00	6,200,000.00	6,200,000.00	6,200,000.00	6,200,000.00	6,200,000.00
TOTAL REVENUE (₦)	**12,502,176.00**	**12,502,176.00**	**12,502,176.00**	**12,502,176.00**	**12,502,176.00**	**12,502,176.00**	**12,502,176.00**	**12,502,176.00**
CUMULATIVE REVENUE (₦)	**47,937,408.00**	**52,999,584.00**	**58,061,760.00**	**63,123,936.00**	**68,186,112.00**	**73,248,288.00**	**78,310,464.00**	**83,372,640.00**
EXPENDITURE (₦)								
Capital Expenditure								
Cost	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maintenance Cost	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total CAPEX	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Cumulative CAPEX (₦)	**22,402,560.00**	**22,402,560.00**	**22,402,560.00**	**22,402,560.00**	**22,402,560.00**	**22,402,560.00**	**22,402,560.00**	**22,402,560.00**
Operating Expenditure								
Fixed Costs	4,240,000.00	4,240,000.00	4,240,000.00	4,240,000.00	4,240,000.00	4,240,000.00	4,240,000.00	4,240,000.00
Variable Costs	4,150,558.64	4,275,075.40	4,403,327.66	4,535,427.49	4,671,490.32	4,811,635.03	4,955,984.08	5,104,663.60
Total OPEX	**8,390,558.64**	**8,515,075.40**	**8,643,327.66**	**8,775,427.49**	**8,911,490.32**	**9,051,635.03**	**9,195,984.08**	**9,344,663.60**
Cumulative OPEX	**63,929,713.41**	**72,444,788.81**	**81,088,116.48**	**89,863,543.97**	**98,775,034.29**	**107,826,669.32**	**117,022,653.40**	**126,367,317.00**
Contingency (1%)	419,527.93	425,753.77	432,166.38	438,771.37	445,574.52	452,581.75	459,799.20	467,233.18
Cumulative Contingency	3,420,511.27	3,846,265.04	4,278,431.42	4,717,202.80	5,162,777.31	5,615,359.07	6,075,158.27	6,542,391.45
TOTAL EXPENDITURE (₦)	**8,810,086.58**	**8,940,829.17**	**9,075,494.05**	**9,214,198.87**	**9,357,064.84**	**9,504,216.78**	**9,655,783.28**	**9,811,896.78**
CUMULATIVE EXPENDITURE (₦)	**89,752,784.68**	**98,693,613.85**	**107,769,107.90**	**116,983,306.77**	**126,340,371.61**	**135,844,588.39**	**145,500,371.67**	**155,312,268.45**
Gross Profit (₦)	3,692,089.42	3,561,346.83	3,426,681.95	3,287,977.13	3,145,111.16	2,997,959.22	2,846,392.72	2,690,279.22
PROFIT BEFORE TAX (₦)	**3,692,089.42**	**3,561,346.83**	**3,426,681.95**	**3,287,977.13**	**3,145,111.16**	**2,997,959.22**	**2,846,392.72**	**2,690,279.22**
CUM. PBT (₦)	**10,264,623.32**	**13,825,970.15**	**17,252,652.10**	**20,540,629.23**	**23,685,740.39**	**26,683,699.61**	**29,530,092.33**	**32,220,371.55**
TAX (11%) - VAT (5%), WHT (5%) STAMP DUTY (1%) (₦)	406,129.84	391,748.15	376,935.01	361,677.48	345,962.23	329,775.51	313,103.20	295,930.71
PROFIT AFTER TAX (₦)	**3,285,959.59**	**3,169,598.68**	**3,049,746.94**	**2,926,299.65**	**2,799,148.94**	**2,668,183.71**	**2,533,289.52**	**2,394,348.50**
CUMULATIVE PAT (₦)	**29,273,175.94**	**32,442,774.61**	**35,492,521.55**	**38,418,821.20**	**41,217,970.13**	**43,886,153.84**	**46,419,443.36**	**48,813,791.86**

Table 9: Cumulative cash flow and cost analysis – Option 3

CUMULATIVE CASH FLOW, EAC, NPV, IRR, PAYBACK PERIOD AND PROFITABILITY INDEX								
	0	1	2	3	4	5	6	7
YEAR	2019	2020	2021	2022	2023	2024	2025	2026
REVENUE (₦)	0.00	12,502,176.00	12,502,176.00	12,502,176.00	12,502,176.00	12,502,176.00	12,502,176.00	12,502,176.00
EXPENDITURE (₦)	22,626,585.60	7,995,523.20	8,101,828.90	8,211,323.76	8,324,103.48	8,440,266.58	8,559,914.58	8,683,152.01
NET CASH FLOW (₦)	-22,626,585.60	4,506,652.80	4,400,347.10	4,290,852.24	4,178,072.52	4,061,909.42	3,942,261.42	3,819,023.99
CUMULATIVE CASH FLOW (₦)	-22,626,585.60	-18,119,932.80	-13,719,585.70	-9,428,733.46	-5,250,660.93	-1,188,751.51	2,753,509.91	6,572,533.89
DISCOUNTED NET CASH FLOW OR NPV @ 10% (₦)	-20,569,623.27	4,096,957.09	3,636,650.50	3,223,780.79	2,853,679.75	2,522,126.17	2,225,303.80	1,959,763.16
CUMULATIVE NPV @ 10% (₦)	-22,626,585.60	-18,529,628.51	-14,892,978.01	-11,669,197.22	-8,815,517.46	-6,293,391.29	-4,068,087.49	-2,108,324.33
RESULTS								
ITEM	**AMOUNT**	**UNIT**	**ITEM**	**AMOUNT**	**UNIT**	**ITEM**	**AMOUNT**	**UNIT**
EQUIVALENT ANNUAL COST (EAC)	1,598,695.01	Naira	CUMULATIVE DISCOUNTED NET CASH FLOW OR NPV @ 10%	6,862,078.46	Naira	CUMULATIVE CASH FLOW	32,220,371.55	Naira
PAY BACK PERIOD	4.29	Years	INTERNAL RATE OF RETURN (IRR)	15.57	Percentage	PROFITABILITY INDEX (PI)	1.30	Ratio

CUMULATIVE CASH FLOW, EAC, NPV, IRR, PAYBACK PERIOD AND PROFITABILITY INDEX

	8	9	10	11	12	13	14	15
YEAR	2027	2028	2029	2030	2031	2032	2033	2034
REVENUE (₦)	12,502,176.00	12,502,176.00	12,502,176.00	12,502,176.00	12,502,176.00	12,502,176.00	12,502,176.00	12,502,176.00
EXPENDITURE (₦)	8,810,086.58	8,940,829.17	9,075,494.05	9,214,198.87	9,357,064.84	9,504,216.78	9,655,783.28	9,811,896.78
NET CASH FLOW (₦)	3,692,089.42	3,561,346.83	3,426,681.95	3,287,977.13	3,145,111.16	2,997,959.22	2,846,392.72	2,690,279.22
CUMULATIVE CASH FLOW (₦)	10,264,623.32	13,825,970.15	17,252,652.10	20,540,629.23	23,685,740.39	26,683,699.61	29,530,092.33	32,220,371.55
DISCOUNTED NET CASH FLOW OR NPV @ 10% (₦)	1,722,386.97	1,510,358.71	1,321,134.23	1,152,415.93	1,002,129.34	868,402.00	749,544.16	644,031.46
CUMULATIVE NPV @ 10% (₦)	-385,937.37	1,124,421.34	2,445,555.57	3,597,971.50	4,600,100.84	5,468,502.84	6,218,047.00	6,862,078.46
RESULTS								
ITEM	**AMOUNT**	**UNIT**	**ITEM**	**AMOUNT**	**UNIT**	**ITEM**	**AMOUNT**	**UNIT**
EQUIVALENT ANNUAL COST (EAC)	1,598,695.01	Naira	**CUMULATIVE DISCOUNTED NET CASH FLOW OR NPV @ 10%**	6,862,078.46	Naira	**CUMULATIVE CASH FLOW**	32,220,371.55	Naira
PAY BACK PERIOD	4.29	Years	**INTERNAL RATE OF RETURN (IRR)**	15.57	Percentage	**PROFITABILITY INDEX (PI)**	1.30	Ratio

4.2.6 Break-even (Sales)

The break-even, in terms of sales, was calculated using Equation 8. The Break-even (Sales) for the three (3) connections was found to be 39,535.59 kg. This result implies that 39,535.59 kg is the break-even in terms of quantity of gas that must be sold to ensure that the total revenue and the total cost would be equal. Sales above this quantity take the project into a profit-making regime. This result is in tandem with what was said by David *et. al.* (2013).

4.2.7 Contribution Margin

The contribution margin was computed using Equations 9 and 10. The contribution margin per unit was found to be ₦70/kg, while the contribution margin was found to be ₦1,674,000.00 for the three (3) connections. This value computed for the contribution margin shows the aggregate amount of revenue available after variable costs to cover fixed expenses have been deducted and hence provide profit to the investor.

The value obtained is a further indication that the project is worth investing in as it is a profitable venture. This result shows a substantial amount of available revenue (referred to as profit) after deducting the variable costs, a trend that conforms to what was stated by David *et. al.* (2013).

4.2.8 Profitability Index (PI)

The profitability index was computed using Equation 11, and with the aid of Excel software (2007), the PI was found to be 1.30 for the grid connection (See Table 9). For a project to be acceptable for investment, the PI must be greater than 1.

Investing in this project based on the three (3) connections can be said to be worthwhile and profitable; however, the grid connection with the highest PI is considered the most beneficial, as stated by David *et. al.* (2013) and Rangel *et. al.* (2016).

5. Conclusion and Recommendations

This study was on ascertaining the economic viability of the gas pipeline distribution network for the University of Abuja Staff Quarters, Giri, Abuja, which was successfully carried out. The results of the economic analysis showed that the grid connection has an equivalent annual cost of ₦1,568,694.64, the net present value of ₦6,862,078.46, and the internal rate of return of 15.57%. The grid connection also has a payback period of 4.29 years, break-even of 39,535.58 kg sales of LPG, a contribution margin of ₦1,674,000.00, and a profitability index of 1.30. Therefore, the grid connection is the most viable of the three (3) connections analysed.

Furthermore, based on the results of the economic analysis, it could be concluded that the project is profitable and investment-worthy and that the grid connection could be adopted for the gas pipeline layout of the University of Abuja staff quarters and other estates in Nigeria.

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