TECNO ECONOMICS AND DISSEMINATION ANALYSIS OF LPG POWER GENERATION IN NIGERIA

Nnadikwe Johnson[1] Samuel H. Kwelle[2] Ewelike Asterius Dozie [3] Chuku Dorathy E. Jerry [4]

[1]Department of Petroleum and Gas Engineering Imo State University, Owerri, Nigeria

[2] First Independent Power Limited, Rivers State, Nigeria

[3] H.O.D, Department of Agriculture and Environmental Engineering, Imo State University, Owerri, Nigeria

[4]Department of Petroleum and Gas Engineering Federal University Otuoke, Bayelsa State

ABSTRACT

LPG may replace fuel-oil for electricity production in Nigeria. LPG is a versatile, low-emission alternative to conventional power generating fuels like LNG or CNG. LPG's key benefits are its wide distribution in Nigeria and its cheaper and safer handling, as it does not need to be delivered at cryogenic temperatures like LNG or high-pressure tanks like CNG. LPG may be a potential answer for gasification programs for fuel-oil-driven power stations, which face barriers in the high cost of LNG regasification infrastructure, a key worry in long-term power sector investment. This study contains a techno-economic and dissemination analysis, beginning with a feasibility matrix for converting a power plant to LPG and ending with the calculation of capital and operating costs, as well as a clustering scheme for the LPG supply chain. Existing power plants were categorized into 13 clusters; 5 clusters are extremely viable with energy prices less than 5 USD/MMBTU, 4 clusters are normal viable with energy prices between 5 to 7 USD/MMBTU, and 4 clusters are not viable with energy prices above 7 USD/MMBTU.

Keywords: *Energy, LPG/ LNG Price, LPG power generation*

1. INTRODUCTION

1.1. Transition of Energy

In line with the National Energy Policy [1], which aims to decrease petroleum consumption, enhance natural gas use, increase renewable energy, and transform coal into energy supplies, the Nigerian government is speeding up the electrical gasification program. This initiative reduces carbon emissions and other greenhouse gases per Kyoto Protocol [2].

The Government of Nigeria in pursuance of its National Energy Policy, of reducing the use of refined oil, and while enhancing natural gas use, commenced the implementing supply and advancement of LNG facilities, and modification of petroleum use. The rising price of LNG refuelling terminal facilities hinders the LNG conversion program for power plant that currently use diesel. This affects the electrical industry's long-term investment calculations.

The gasification initiative also accelerates the spread of power stations for equitable electricity distribution, particularly on islanded communities where individuals, companies and even government agencies use oil-fired (diesel) power plants since LNG distribution and storage infrastructure is limited and costly. The government's power plant gasification initiative risk huge LNG terminal infrastructure costs. In Nigeria, fuel oil produces 16% of total power but costs 53.8% of total fuel [3]. Gas Turbines and Gas Engines, whose initial idea utilizes natural gas, are often run with costly fuel oil, reducing engine productivity and enhance carbon emissions.

1.2. The Use of LPG as a Primary Energy Source

In 2019, global LPG consumption reached 317 million tons [4]. With almost half (43.5%) of all LPG use coming from homes. It is clear that this is the sector with the greatest demand [4]. The petrochemical industry is the world's second-largest LPG consumer, accounting for about 25% of the total use. Transportation and manufacturing use up the remainder. LPG has widespread use throughout the economic spectrum.

1.2.1. Real Estate Market

LPG works effectively as a heating source, both for the space heating at home and for hot water. It is also utilized for illumination in certain third world nations where power is not widely accessible. It may also be used for camping and barbecuing at outdoor events.

1.2.2. Agriculture

The use of LPG in agricultural processes like powering machinery for harvesting of crops, and crop drying has been shown to boost both yield and quality in the food processing sector. It's also used to heat pig and poultry barns and run irrigation pump motors.

1.2.3. Business and commerce

Commercial kitchens (both big and small-scale catering operations) and commercial buildings (both buildings and water) use LPG food processing systems for a variety of purposes.

1.2.4. Industry

LPG is employed in a broad variety of industrial processes and operations, especially those that demand powerful flames and pinpoint temperature control. The straight firing of ceramics kiln, glass manufacturing, textile/paper/paint processing, and high temperature furnaces are all common uses.

1.2.5. Manufacturing of Energy

Back-up fuel for power generators, such as hybrid systems of renewable energy in outlying areas, may also be provided by LPG. The first power plant to run on LPG began operations in 2014, [5], and it had full backing from the engine and turbine manufacturer, both of which made their products easily accessible for use with LPG as the fuel source. In 2017, a consortium involving General Electric commenced the construction of a 400 MW LPG Power Plant in Tema, Ghana. [6]

1.2.6. Transport

Natural Gas Liquids such as LPG are becoming more popular as a low-emissions substitute for gasoline and diesel in public transportation vehicles and personal vehicles.

1.2.7. The Petrochemical Sector

Ethylene is the principal bulk petrochemical intermediate material utilized in the creation of several polymers and specialized chemicals; LPG may be substituted for ethane, naphtha, and middle distillates in this process.

1.3. Superior Market for LPG-Based Power Plants

The goal of this research is to help the LPG sector by identifying the features of a market that make it suitable for LPG power production.

- It is essential that the best markets for LPG power production should be identified, thus it is important to create a plan for doing so.

- There is also need to create a plan to specifically optimize these areas.

It is important to keep in mind that not every one of the features highlighted in this research will be present in every given market (and in any case, there is a possibility for having a place, where the listed criteria are met). We would rather see these traits as a desire list outlining the qualities of an ideal environment for LPG power production.

2.MATERIAL AND METHODS

2.1. The Sustainability of the Market

The prospects of the Nigerian LPG power generating market:

- Nigeria relies heavily on fuel oil for electricity production, particularly on the dispersed islands in Eastern Nigeria, and as a result, diesel prices have risen and diesel subsidies have been cut. Since fuel oil accounts for more than half of the overall fuel cost in power production, LPG presents a promising alternative fuel option.

- LPG Energy Production deployment may be bolstered in the near future by rising electricity demand and efforts to incentivize and speedup deployment of generation capacity, especially to address short-term power deficits in distant locations with no natural gas infrastructure.

LPG has an excellent chance due to high fuel costs and decreasing legislative support for diesel. Nigeria's current energy price of USD 0.09/kWh [4] is mostly attributable to the country's heavy reliance on biomass in its power generating mix. Gasoline is a more cost-effective alternative to fuel oil, which is used to power small homes generator sets (gensets) throughout the nation.

LPG has a great chance of replacing or competing with newer, lower-carbon-emissions power facilities. This window of opportunity may be threatened if the government pushes hard to expand the natural gas system, as for the time being, natural gas will steadily be used to replace coal and biomass.

With increasing population, the country's power system is struggling to keep up with the needs of a booming economy and rising energy consumption. As a result, there is a pressing demand for distributed energy power across the nation, which is presently plagued by frequent power outages. The Nigerian government predicts that annual energy demand growth of 4-5% would need more power production, particularly in outlying regions, and the expansion of electrical system coverage.

A majority of the gas produced will be used domestically, so the current administration plans to upgrade the natural gas grid and increase gas supplies.

Energy supply security is a top priority for the government of Nigeria, which is why they are encouraging the development of power plants and making use of indigenous materials. With fuel subsidies decreasing, LPG power generation may become more competitive.

The two primary factors that the LPG power plant analysis techniques take into account are as follows:

2.2. Technology

Gasoline, Propane, or Natural Gas (LPG)-Powered Engines or Turbines. The usage of LPG as gas engine fuel poses no technical problems. The LPG must be compressed and converted to a gaseous state before use. Some manufacturers of dual-fuel engines have designed their products such that switching fuels requires no adjustments and may be done while the engine is in operation. [6]

As the diesel engine is different from the gas engine, several changes and modifications are necessary for the LPG conversion. For a Diesel engine, LPG may be used in one of two ways today:

- Combustion chamber upgrades including spark ignition.
- Combustion chamber spraying of a mixture of liquid petroleum gas and fuel oil (diesel).

2.3. Site Evaluation and Potential Selection

The feasibility of a power plant's conversion to gas is evaluated across four (4) distinct priority criteria:

First criterion: the ability to convert gas, the absence of close gas sources, and proximity to a supply channel.

Second Criterion: Gas conversion potential, undefine gas supply, no close gas sources, and a far distance from a logistic supply route.

Third criterion: There is no potential for Gas conversion, since the availability of gas is known.

Fourth Criterion: Since the power station is already being supplied with gas or will be supplied with gas in the near future, there is no opportunity for gas conversion, and the power station will not be substituted by any of the other technology anytime soon.

If you want to go further with gasification modeling, you can only use power plants meeting requirements 1 and 2 from the market. This selection's outcomes are summarized in the table below**.**

At this time, the power plant ranked first in priority is doing a simulation of LPG dissemination. According to the simulated spread route, the plants have been divided into 13 distinct groups:

- Cluster 1: Alaoji in Abia State
- Cluster 2: Benin (1 hovor) in Edo State
- Cluster 3: Calabar in Cross Rivers State
- Cluster 4: Egbema in Imo State
- Cluster 5: Gbarain Bayelsa State
- Cluster 6: Geregu in Kogi State
- Cluster 7: Olorunsogo in Ogun State
- Cluster 8: Shiroro Power, in Niger State
- Cluster 9: Omoku Rivers State
- Cluster 10: Sapele Power, Delta State
- Cluster 11: Ugheli Power , Delta State
- Cluster 12: Jebba Power Plant

3.RESULT

The LCOE will be broken down into three price points to determine which cluster may be serviced by additional LPG delivery.

- Viable: <5 USD/MMBTU
- Normal: 5-7 USD/MMBTU
- Not-viable: >7 USD/MMBTU

Competitive LPG-fueled power generating clusters have an LCOE of less than 7 USD Per MMBTU. The research gathered data from 13 LPG distribution hubs and came to the conclusion that,

- Viable cluster: Cluster 1, Cluster 4, Cluster 6, Cluster 7, Cluster 9.
- Normal cluster: Cluster 2, Cluster 8, Cluster 10, Cluster 12: are average.
- Not viable cluster: Cluster 3, Cluster 5, Cluster 11, Cluster 13.

4.DISCUSSION

4.1. Mathematical Modeling of Finance

The LPG Net Present Cost of Electricity pricing is tested in order to achieve the expected lucrative and cautious IRR. The optimal and cautious internal rate of return for this financial model is close to 16 percent. Because of this, the LPG mid-stream pricing should be modified using the same financial model across all clusters, taking into account all cluster-specific operational assumptions.

The discount rate will be determined by use of the Capital Asset Pricing Model (CAPM). A discount rate based on the weighted average cost of capital (WACC) may be calculated using this approach.

$$WACC = (Proportion\ of\ Equity\ x\ Cost\ of\ Equity) + (Proportion\ of\ Debt\ x\ Cost\ of\ Debt) \quad \text{.....[2]}$$

The financial viability will be determined using the WACC value as a benchmark. WACC should be greater than the financial feasibility indication represented by the Internal Rate of Return (IRR) figure. The greater the gap between the IRR and the WACC, the more likely it is that the project will be carried out. The bare minimal Internal Rate of Return (IRR) that may be tolerated should also be included in the company plan. Equally important, the MARR value must be greater than the discount rate (WACC).

All the sub-segments will have the same 20-year financial forecast. Consequently, the market for LPG supplies is anticipated to continue to thrive in the year 2036. We will assume a debt to equity ratio of 70% for the venture. The financial forecast will include a computation of interest payment, including a 12-month grace period and Interest During Construction (IDC). All of the predicted IDC will come from sources other than the investment fund, and all of the working capital needs are expected to be met by investor contributions alone.

The correct LPG mid-stream price estimation is one of the primary goals of this analysis, along with identifying a viable pricing and a lucrative business strategy. The LPG mid-stream pricing is tested in order to reach the expected conservatively profitable IRR value. The financial model determines the cluster-average midstream price for each distribution method. For the sake of this virtual costing exercise (in US dollars), we've included the following items:

- Major Expenditures;
- Income forecasting
- Funds used for everyday operations;
- Statement of income;
- Money coming in;

- Liquefied Petroleum Gas (LPG) storage
- Regasification Unit Price;
- Inflation of pipeline prices;
- Gas meter installation fees;
- Cost of using the jetty for berthing;
- The price of using a port;
- Charter fees and gasoline prices;
- Exorbitant cost (correction factor).

5. CONCLUSION

Results of the investigation led to the following inferences,

- Seventy percent (70%) of the sample are determined to be competitive in the studied market.
- The lower the price of electricity is, the greater the total MW and the lower the investment cost of each cluster.
- When compared to the cost of using fuel-oil, the price of electricity generated using LPG is a viable option.
- Lower prices for LPG and the commercial mining of shale gas mean cheaper power generated by LPG.

ACKNOWLEDGEMENT

The authors would like to give a special thanks to the Johnson and Sylvester Centre for African Research Engineer Library, for their Assistance in utilizing of the centre for Africa Research Engineering Library equipment to actualize our detailed results.

REFERENCES

[1] Arifin Z, "Konsumsi BBM Untuk Pembangkit Listrik Di Nigeria", Researchgate, Publication 337672003, 2015.

[2] Berry Sg, Betterton Ce, Karagiannidis I, "Understanding Weighted Average Cost of Capital: A Pedagogical Application",
Researchgate, Publication 289530651, 2014. [3]Kuba S, Lare R, Asai T, Kamino K, "Lpg Burning Gas Turbine Technology", Mitsubishi Hitachi Power Systems, Ltd, 2016.

[4] Pemerintah Republik Nigeria, "PP No.79 Tahun 2014 Tentang Kebijakan Energi Nasional", ESDM, 2014.

[5] Wartsila Technical Journal, "Wartsila delivers the first propane-fired power plant, Energy In Detail", 2014 Available: wärtsilä-delivers-the-first-propane-fired-power-plant.pdf (wartsila.com)

[6] Power Technology, "Bridge Power Project", 2020 Available: Bridge Power Project, Tema - Power Technology (power-technology.com)

[7] Pemerintah Republik Nigeria, "UU No.17 Tahun 2004 Tentang Pengesahan Protokol Kyoto Atas Konvensi Kerangka Kerja Perserikatan BangsaBangsa Tentang Perubahan Iklim", Esdm, 2004.

[8] PT. Perusahaan Listrik Negara (Persero), "Rencana Usaha Penyediaan Tenaga Listrik PT. PLN (Persero) 2019-2028", PLN, 2019.

[9] World LPG Association, "Annual Report 2019", WPLGA, 2019.

[10] World LPG Association, "Global LPG Power Generation – Market Development & Recommendations for Future Growth", WLPGA, 2019.
[11] Dewan Energi Nasional, Nigeria Energy Outlook 2019, ESDM, 2019.
[12] PT. Perusahaan Listrik Negara (Persero), "Laporan Tahunan 2019", PLN, 2019.