PRINT ISSN 1119-8362
Electronic ISSN 2659-1499

Full-text Available Online at
https://www.ajol.info/index.php/jasem
https://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 28 (11) 3559-3563 November, 2024

Cost-Benefit Analysis of Propane-fueled Portable Generator Conversion Kit in Warri, Nigeria

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ABSTRACT: A cost-benefit analysis is the process of comparing the projected or estimated costs and benefits (or opportunities) associated with a project decision to determine whether it makes sense from a business perspective. Hence, the objective of this paper is to assess the cost-benefit analysis (CBA) of propane-fueled portable generator conversion kit in Warri, Nigeria using appropriate standard techniques. Based on the cost-benefit analysis, the conversion kit yields a $1.92 return for every dollar invested, as shown by the CBA. It is evident from the computed payback period of 0.52 years how quickly the initial expenditure is recovered. Over a three-year period, the predicted savings on maintenance costs is $7.78, and an annual fuel cost savings of $42. The results show that propane-powered generators offer substantial benefits over conventional gasoline generators. Propane burns cleaner, leaves fewer carbon deposits, needs less frequent maintenance, and is less expensive to maintain and use as fuel. Transitioning to propane has a net positive environmental impact since it reduces greenhouse gas emissions and other pollutants, helping to achieve long-term sustainability goals. Our results confirm that propane conversion kits are a viable, sustainable, and affordable choice for portable generators in both residential and commercial settings.

DOI: https://dx.doi.org/10.4314/jasem.v28i11.8

Cite this Article as: EBOIGBE, C. I; JEMIRIAYIGBE, G. O. (2024). Cost-Benefit Analysis of Propane-fueled Portable Generator Conversion Kit in Warri, Nigeria. *J. Appl. Sci. Environ. Manage.* 28 (11) 3559-3563

Dates: Received: 18 September 2024; Revised: 20 October 2024; Accepted: 05 November 2024; Published: 15 November 2024

Keywords: cost-benefit analysis; portable generator; propane conversion kit; economic viability; environmental impact

The reliance of portable generators on gasoline, a conventional fossil fuel, poses a serious problem. Price fluctuations and air pollution lead to a search for greener and more sustainable options. Propane, a clean-burning liquefied petroleum gas (LPG), emerges as an intriguing alternative. Innovative solutions like propane conversion kits allow generators to run on LPG, reducing reliance on traditional fuels.

These kits, which minimize generator emissions and vary fuel alternatives, offer potential cost savings and environmental benefits. Propane conversion kits provide a promising solution by enabling portable generators to run on a cleaner and more affordable fuel – propane gas otherwise called liquefied petroleum gas (LPG). These kits not only save gasoline expenses but also have a minimal environmental impact. The core components of a propane conversion kit include the carburetor adapter and the fuel controller. The adapter, essentially a mixer, allows the generator's carburetor to utilize propane effectively.

The fuel controller, also known as a diaphragm-regulated valve, acts similarly to a carburetor's float and needle valve, regulating propane flow based on engine demand and preventing excess fuel. This on-

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demand functionality eliminates fuel waste and potential safety hazards. A high-pressure regulator plays a crucial role in maintaining consistent fuel pressure, ensuring optimal engine performance by delivering a stabilized propane flow regardless of variations in demand. In this study, we adopted the methodologies used by Olaoye *et al.* (2016) and Nwaokocha and Okezie (2016).

Additionally, we designed and incorporated an automatic priming feature for the generator to ensure smooth startup. To determine the most economical fuel option for portable generators, gasoline and propane will be compared using a cost-benefit analysis (CBA). A Cost-Benefit Analysis (CBA) considers both tangible and intangible factors, ensuring a well-rounded decision. While quantifying intangible benefits and costs can be challenging, a comprehensive approach is crucial to evaluating all aspects of the investment (Gibson and Wallace, 2016).

For gasoline and LPG (liquefied petroleum gas) powered generators, tangible costs will require the evaluation of several key expenses, including fuel, maintenance, initial setup, and operational costs. Fuel costs are a major consideration, encompassing the price per unit of each fuel as well as the expense of storage containers. Maintenance costs differ between the two fuels. Gasoline generators require regular servicing due to carbon buildup and potential fuel system clogging, leading to higher expenses.

LPG, on the other hand, burns cleaner, resulting in less carbon accumulation and clogging, and consequently lower maintenance needs (Budiyanto *et al.*, 2020). Initial setup costs are minimal for gasoline generators. LPG generators, however, incur additional expenses for the conversion kit. These costs encompass the components required for the conversion and the labor involved in developing the kit.

For gasoline generators, the environmental impact is a major concern. When gasoline burns, it releases pollutants that contribute to air pollution, leading to long-term environmental problems and even public health issues (Susan, 2021).

Additionally, gasoline fumes and potential spills pose direct health risks to users. While difficult to assign a dollar value to these consequences, they are important factors to weigh. Switching to LPG brings its own set of intangible considerations.

There's a learning curve involved, especially for users unfamiliar with handling and operating propane systems. This translates to time spent learning or potential training expenses.

Tangible benefits when choosing between LPG and gasoline include savings on fuel costs and maintenance expenses. Intangible benefits include significant environmental advantages, as propane burns cleaner than gasoline, emitting fewer pollutants and greenhouse gases (Zulfan *et al.*, 2020). This contributes to long-term sustainability goals.

Additionally, propane's lower risk of spills and contamination makes it a safer option, reducing health risks and safety concerns—important factors for users, even though they are intangible. This introduction provides a comprehensive overview of the need for cleaner and more sustainable energy solutions, the advantages of propane conversion kits, and the methodology used in the study to evaluate the economic and environmental benefits of switching to propane-powered generators. Hence, the purpose of this article is to evaluate the cost-benefit analysis (CBA) of a conversion kit for propane-fueled portable generators in Warri, Nigeria.

Choosing between propane and gasoline for generators requires a comprehensive analysis that considers both the measurable and less quantifiable factors. While fuel costs, maintenance needs, and setup kits are readily comparable, intangible considerations like environmental impact, health risks, and user experience significantly influence the decision.

Consequently, the objective of this paper is to assess the cost-benefit analysis (CBA) of propane-fueled portable generator conversion kit in Warri, Nigeria

MATERIALS AND METHODS

Data for this study were gathered from various sources, including test results, industry reports, government publications, and academic research papers. Fuel prices can vary regionally and seasonally, influenced by factors such as supply and demand, production costs, and regulatory policies. For this study, the fuel price was obtained in Warri, Nigeria, on June 6, 2024. Fuel consumption rates depend on generator size, load profile, operating conditions, and other factors.

The generator used for this study is a Sumec 2.5KVA generator running a load of 1000W for one hour. Maintenance costs also vary by region.
Fig. 1 shows the cost and benefits analysis of gasoline alternatives.

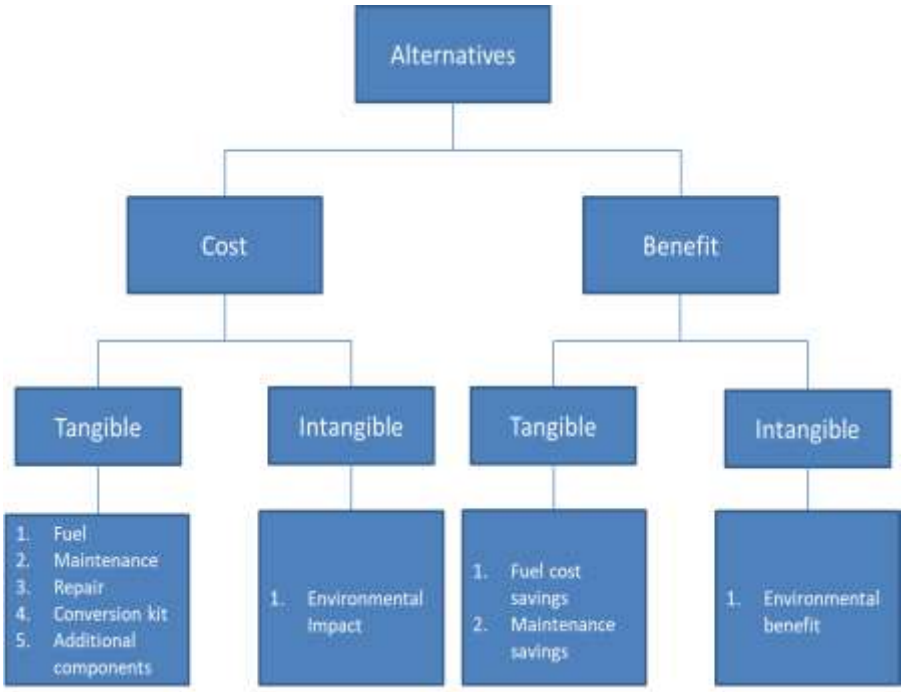

Fig. 1: Cost and Benefits chart

RESULTS AND DISCUSSION

Cost of conversion kit and related components: The cost of the conversion kit encompasses all expenses related to its development. This can be divided into two parts: the cost of procuring materials for fabricating the gas mixer and the associated labor costs, and the cost of obtaining other necessary items for LPG storage and piping to the generator.

Fuel Cost: This data was collected after installing a custom-built LPG conversion kit on a 2.5KVA Sumec generator and operating it for one hour at a constant load of 1000W. The performance was then compared to running the same generator on gasoline.

Table 1: Items procured for LPG powered generator

Components Procured			
Components	Cost in Naira	Conversion Factor as at 6/6/2024	Cost in Dollar
12.5kg Gas Tank	₦ 25,000.00	1,495.00	$16.72
High Pressure Regulator	₦ 4,500.00	1,495.00	$3.01
Gas Tubing x 2m length	₦ 5,000.00	1,495.00	$3.34
3Solenoid Valve	₦ 12,000.00	1,495.00	$8.03
Gas Controller	₦ 16,000.00	1,495.00	$10.70
Isolation Valve	₦ 5,000.00	1,495.00	$3.34
Total	₦ 67,500.00		$45.15

Table 2: Items procured for Gas Mixer Fabrication

Items Procured for Gas Mixer Fabrication			
Gas Mixer Fabrication	Cost in Naira	Conversion Factor as at 6/6/2024	Cost in Dollar
Stainless Steel blank - 10cm x 10cm x 3cm	₦ 6,000.00	1,495.00	$4.01
Nipple	₦ 1,000.00	1,495.00	$0.67
Steel Tubing x 0.5m	₦ 5,000.00	1,495.00	$3.34
Workmanship	₦ 10,000.00	1,495.00	$6.69
Total	₦ 22,000.00		$14.72

$Total\ cost\ of\ items\ procured = \$45.15$

$Total\ cost\ of\ materials\ procured\ for\ fabricating\ the\ gas\ mixer = \$14.72$

Table 3: Cost of using Gasoline/LPG

Output Power	Gasoline			LPG		
	Runtime (Hours)	**Cost (Naira)**	**Cost (Dollar)**	**Runtime (Hours)**	**Cost (Naira)**	**Cost (Dollar)**
1000W	0.25	541.8	$0.36	0.25	497.28	$0.33
	0.5	617.4	$0.41	0.5	645.12	$0.43
	0.75	825.3	$0.55	0.75	813.12	$0.54
	1	1039.5	$0.70	1	947.52	$0.63

$$Total\ runtime\ in\ a\ year\ will\ be\ assumed\ to\ be\ 600\ hours$$
$$Gasoline\ annual\ cost = 0.7 * 600\ hours = 420\ dollars$$
$$LPG\ annual\ cost = 0.63 * 600\ hours = 378\ dollars$$
$$Annual\ Fuel\ cost\ savings = 420\ dollars - 378\ dollars = 42\ dollars$$

$$As\ of\ June\ 6, 2024, the\ current\ interest\ rate\ in\ Nigeria\ is\ 24.75\%$$
$$Present\ value\ (PV) of\ fuel\ cost\ savings\ for\ each\ year = S/(1+r)^n$$

$$Where\ S\ is\ the\ annual\ fuel\ cost\ savings,\ r\ is\ the\ interest\ rate, and\ n\ is\ the\ number\ of\ years$$
$$S = \$42$$
$$r = 24.75\%$$
$$n = 3\ years$$
$$PV_1 = 42/(1+0.2475)^1 = 33.67$$
$$Fuel\ cost\ savings\ for\ first\ year = 33.67\ dollars$$
$$PV_2 = 42/(1+0.2475)^2 = 26.99$$
$$Fuel\ cost\ savings\ for\ second\ year = 26.99\ dollars$$
$$PV_3 = 42/(1+0.2475)^3 = 21.63$$
$$Fuel\ cost\ savings\ for\ third\ year = 21.63\ dollars$$
$$Total\ PV_{fuel\ cost\ savings} = PV_1 + PV_2 + PV_3$$
$$Total\ PV_{fuel\ cost\ savings} = 33.67 + 26.99 + 21.63 = 82.29\ dollars$$

Maintenance cost: Gasoline generators demand more frequent maintenance because of fuel deposits and impurities. For this analysis, let's assume annual maintenance involves an oil change, filter change, spark plug replacement, carburetor cleaning, etc. In contrast, propane generators, with their cleaner combustion, incur lower maintenance costs. Here, we will assume maintenance is required only every eighteen months.

Table 4: Maintenance Cost

Maintenance Requirements			
Items	Cost in Naira	Conversion Factor as at 6/6/2024	Cost in Dollar
Spark Plugs	₦ 5,000.00	1495.00	$3.34
Oil Change	₦ 4,000.00	1495.00	$2.68
Filter Change	₦ 1,000.00	1495.00	$0.67
Manpower	₦ 6,000.00	1495.00	$4.01
Total	₦ 16,000.00	Total	$10.70

$$Present\ value\ (PV) of\ maintenance\ cost\ savings\ for\ each\ year = S/(1+r)^n$$

$$Where\ S = annual\ maintenance\ cost\ savings, r = interest\ rate, n = number\ of\ years$$
$$S = \$10.70$$
$$r = 24.75\%$$
$$n = 3\ years$$
$$PV_{gasoline\ maintenance\ 1} = 10.70/(1+0.2475)^1 = 8.58$$
$$PV_{gasoline\ maintenance\ 2} = 10.70/(1+0.2475)^2 = 6.88$$
$$PV_{gasoline\ maintenance\ 3} = 10.70/(1+0.2475)^3 = 5.51$$
$$PV_{gasoline\ maintenance} = 8.58 + 6.88 + 5.51 = \$20.97$$

$$PV_{LPG\ maintenance\ 1.5} = 10.70/(1+0.2475)^{1.5} = 7.68$$
$$PV_{LPG\ maintenance\ 3} = 10.70/(1+0.2475)^3 = 5.51$$
$$PV_{LPG\ maintenance} = 7.68 + 5.51 = \$13.19$$
$$Total\ PV_{maintenance\ cost\ savings} = 20.97 - 13.19 = 7.78\ dollars$$

Payback/Cost-Benefit

Table 2. Cost-Savings for LPG

Initial Costs		Operational Costs/Savings	
Total cost of components procured	$45.15	Fuel Cost Savings	$82.29
Total cost of items procured for fabricating the gas mixer	$14.72	Estimated Maintenance Savings	$7.78
Total	$59.87	Total	$90.07

$$Total\ Savings = \$47.00$$
$$Total\ Costs = \$90.07$$
$$\text{Payback period} = \$47.00/\$90.07$$
$$\text{Payback period} = 0.52\ \text{years}$$
$$\text{Cost\_Benefit ratio} = \$90.07/\$47.00$$
$$\text{Cost\_Benefit ratio} = 1.92$$

Conclusion: The cost-benefit analysis of the LPG conversion kit for portable generators demonstrates significant economic and environmental advantages. The analysis reveals that LPG-powered generators offer substantial benefits over traditional gasoline generators. These benefits include lower fuel costs and reduced maintenance expenses due to the cleaner combustion properties of propane, which contribute to fewer carbon deposits and less frequent servicing needs. The study underscores the importance of considering both tangible and intangible factors in the decision-making process. While tangible factors such as fuel and maintenance costs are straightforward to measure, intangible benefits like environmental

sustainability and health safety are equally crucial. The environmental impact of switching to LPG is notably positive.

Propane's cleaner burning process results in fewer emissions of pollutants and greenhouse gases, aligning with broader sustainability goals and contributing to a reduction in long-term environmental degradation. This transition to a cleaner energy source not only benefits the environment but also reduces health risks associated with gasoline fumes and potential spills.

In conclusion, the adoption of LPG conversion kits for portable generators presents a cost-effective, environmentally friendly, and sustainable solution. By promoting the use of propane generators, stakeholders can significantly contribute to the transition towards cleaner energy systems, achieving benefits that extend beyond immediate financial gains to include long-term environmental and public health improvements. This study supports the widespread adoption of LPG conversion kits as a prudent investment for both residential and commercial applications, enhancing energy security and resilience while fostering a more sustainable future.

Declaration of Conflict of Interest: We certify that I have reported any affiliations that are needed to be disclosed under the Conflict of Interest laws, and aside from what we have stated, we don't believe any of the affiliations to cause a conflict of interest. Regarding the publishing of this paper, we hereby declare that there is no conflict of interest.

Declaration of conflict of interest: The authors declare no conflict of interest.

Data availability statement: Data are available upon request from the corresponding author.

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