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# Comparative Life Cycle Assessment of Coal, Natural Gas, and Diesel-Based Electricity Generation

**Kudzai Kime Chirau[1], Mohammed Abdalghafoor[2]**

[1]Midlands State University
[2]Ernst & Young

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***Corresponding author:** Kudzai Kime Chirau

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**Abstract** **Original Research Article**

The study compares the life cycle assessment (LCA) of three Electricity generation technologies for Zimbabwe's energy mix namely a Diesel generator, a Coal fired Power Plant and a Natural gas fired Power Plant. Life cycle inventories (LCI) were developed as openLCA process inventories for 1 kWh of net electricity output, using background information from ecoinvent. Indicative life cycle impact assessment (LCIA) results have been derived for the five midpoint categories of climate change, particulate matter formation, terrestrial acidification, photochemical ozone formation, and fossil resource scarcity, using foreground inventory flows (fuel and material inputs, and direct emissions to air, water and waste). The impacts for particulate matter and acidification were highest for coal fired generation, the impacts of diesel generation were greatest per kWh in all other impact areas, and the impacts of natural gas generation were lowest in all impact areas, except for acidification. The findings are similar to the environmental profile of combustion-based power generation and are provided with the aim of carrying out a preliminary, decision relevant comparison; in order to take into account the complete ecoinvent database, a full background-system LCIA run in openLCA (e.g. ReCiPe 2016 or NEEDS_18) is recommended before final publication figures are reported.

Establish the goal and scope definition.Define the goal and scope definition.

**Keywords**: Life cycle assessment (LCA), electricity generation, coal-fired power plant, natural gas power plant, diesel generator.



## 1. INTRODUCTION

As electricity demand continues to rise, along with climate change and environmental degradation concerns, efforts to assess the sustainability of various electricity generation technologies have grown dramatically in today's world. The continued use of fossil fuels like coal, diesel, and natural gas make electricity production one of the largest sources of anthropogenic greenhouse gas (GHG) emissions.

While renewable energy resources are growing rapidly all over the world, there is still a high reliance on fossil fuels for electricity production in many developing nations due to current infrastructure, fuel supply, and economic factors (Kabeyi & Olanrewaju, 2024).

Zimbabwe has long faced electricity shortages, due to old generation plants, population growth, reductions in hydropower generation due to recurrent droughts and insufficient investment in new generation plants. Therefore, diesel generators are commonly used for emergency and off-grid electricity generation, coal-fired power plants are the key thermal electricity generators in the country, and natural gas is a relatively clean fossil fuel recently found to be suitable for various purposes including energy security and reducing environmental impacts (International Energy Agency, 2026; CleanTechnica, 2025). Under these conditions, it is crucial to comprehend the environmental impact of each electricity generation pathway before investing or implementing policies in the future.

Adopted by the industry as one of the most comprehensive and internationally accepted techniques for assessing the environmental performance of products and energy systems during their entire life cycle, Life Cycle Assessment (LCA) has emerged. In contrast to traditional assessments of emissions, LCA includes emissions and waste management from the upstream fuel extraction, transport, processing, electricity generation, consumption of the resource, and emissions (ISO, 2006a; ISO, 2006b; Hauschild et al., 2018). It is a methodology that has been widely used in the field of energy research to compare fossil fuel technologies, renewable energy technologies, transportation, and industrial processes to facilitate evidence-based decision making for the environment (Huijbregts et al., 2017).

There have been substantially different environmental results from each electricity generation technology using fossil fuels, as noted in previous studies. The emissions of particulate matter, sulfur dioxide, and acidifying pollutants associated with electricity generation by coal tend to be the highest, while greenhouse gas emissions and fossil resource depletion per kWh tend to be high for electricity generation by diesel generators. Natural gas combined-cycle systems, on the other hand, tend to have lower emissions as a result of higher combustion efficiency and CIs (Ou et al., 2013; Ozbilen et al., 2018; Cooper et al., 2019). But, there is a significant difference in environmental performance across different national electricity mixes, fuel supply chains, operational efficiencies and local resource conditions, which makes it important to do country-specific life cycle assessments.

Hence, this study compares the electricity generation technologies of diesel, coal-fired and natural gas for the cradle-to-gate life cycle assessment, for conditions representative of Zimbabwe. The study examines the environmental performance of each of the three technologies based on a functional unit of 1 kilowatt-hour of net electricity produced by the technologies, with a focus on the following midpoint impact categories: climate change, particulate matter formation, terrestrial acidification, photochemical ozone formation and fossil resource scarcity. The results offer important data for sustainable energy planning, and represent a small contribution to the literature of electricity generation strategies in developing economies that considers the environment.

## 2. LITERATURE REVIEW

Life Cycle Assessment (LCA) is a tool that is widely used to assess the environmental impact of energy systems over their entire life cycle, from raw material extraction to fuel processing, electricity generation and waste management. Conventional emission assessments only look at operational emissions, whereas LCA considers not just the impacts of upstream processes, but also those of downstream processes, which gives a complete basis for comparing different technologies of electricity generation (ISO, 2006a; ISO, 2006b; Hauschild et al., 2018).

While renewable systems are becoming more prevalent, coal, diesel and gas continue to be significant power generation resources globally, especially in developing nations where energy security and infrastructure are still a limiting factor to the swift uptake of renewables. The impacts on the environment, however, vary greatly between these fossil fuel technologies. There is a general perception that coal-fired power plants have high emissions of greenhouse gases (GHGs), sulfur dioxide (SO2), particulate matter (PM), and other pollutants that impact air quality and climate change (Kabeyi & Olanrewaju, 2024; Kommalapati et al., 2018). The diesel generators used for backup and off-grid power generation have also significant greenhouse gas emissions and high demand for fossil resources, and are less environmentally sustainable over their life cycle (Namdari, 2025).

The increased recognition of natural gas as a cleaner fossil fuel is due to its higher combustion efficiency and lower carbon intensity. Comparative LCA studies have revealed that the natural gas (NG) combined-cycle power plants generally emit less greenhouse gas (GHG) emissions and fewer air pollutants than coal- and diesel-based power generation, except for methane leakage in the production and transportation of natural gas, which is still an environmental concern (Ou et al., 2013; Ozbilen et al., 2018; Cooper et al., 2019).

While a large number of studies have compared fossil fuel electricity generation technologies, very little research has investigated the Zimbabwe's electricity sector in particular.

## 3. METHODOLOGY

The study used the Life Cycle Assessment (LCA) methodology outlined in ISO 14040 and ISO 14044 to assess the environmental performance of electricity generation from diesel, coal and natural gas, in Zimbabwe. The assessment has been carried out with openLCA and process information from ecoinvent, and the impacts have been assessed by the ReCiPe 2016 Midpoint (H) method. It was decided to select a useful unit of 1 kWh of net electricity produced and compare the three electricity production technologies.

### 3.1. Goal and Scope Definition

#### 3.1.1. Goal of the Study

The aim of this study is to compare the cradle-to-gate environmental performance of three electricity generation pathways which utilise fossil fuels: diesel generator sets, coal fired power plant and natural gas power plant under conditions typical of the Zimbabwean context. Coal is still the main thermal generation source and water levels at Kariba are too low to generate at full capacity, while diesel is a common backup and off-grid power source (International Energy Agency, 2026; World Bank, 2026). An intended use is to provide information on technology selection and policy debate for off-grid or grid-connected power generation and an intended audience is researchers, engineers and policymakers considering fuel-switching or backup generation options.

#### 3.1.2. Functional Unit

All three systems have a functional unit of:

- 1 kWh of electricity generated at the power plant (net output).

This functional unit is used in all three systems, and is not altered according to the type of fuel.

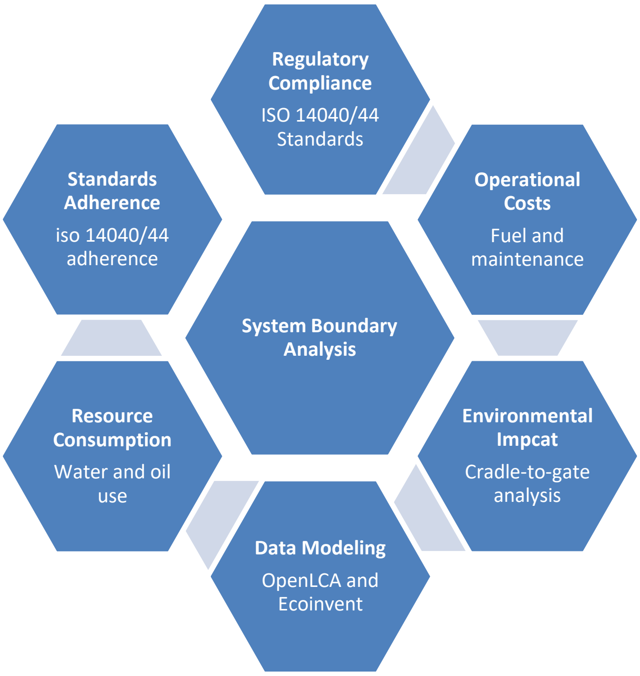
#### 3.1.3 System Boundary

The system boundary is cradle-to-gate, following the phase structure established in ISO 14040:2006 and ISO 14044:2006 (ISO, 2006a; ISO, 2006b) and operationalised in accordance with Guinée (2002) which include fuel extraction and processing, fuel and material transportation, combustion and electricity generation on site, and basic operational maintenance such as lubricating oil and water use. The foreground process datasets were developed in openLCA (Ciroth, 2007; GreenDelta, 2024) and based on the ecoinvent-style background flows (e.g. transport, lorry 32t, upstream electricity supply), which are modelled based on the ecoinvent version 3 cut-off system model (Wernet et al., 2016;

The datasets follow a similar structure to those for fossil power generation created under the EU NEEDS project (Weidema et al., 2013), which are also used for fossil power generation in the fossil fuel datasets (EU NEEDS and IFEU, 2008; NEEDS, 2009). Construction and decommissioning of plants are not explicitly represented in the present data sets as foreground flows but are partially represented as a simplified proxy in the form of infrastructure materials (steel).

**Figure 1. Key Drivers Accelerating Institutional Climate Risk Assessment**

*This figure illustrates the primary factors driving the adoption of climate risk assessment,* *including increasing physical climate impacts, evolving regulatory requirements, and growing stakeholder expectations.*




### 3.1.4. Impact Assessment Method

The methodological framework used for this comparison is the ReCiPe 2016 Midpoint (H) (Huijbregts et al., 2017) evaluated on a cut-off allocation basis, following the openLCA/ecoinvent workflow of the process datasets used. The LCIA results presented in Section 3 do not necessarily represent the actual results if the full background-system characterization were re-run against the entire ecoinvent/ReCiPe inventory, as this was not done in this document, but are merely indicative estimates (calculated directly from the foreground inventory, using standard published midpoint characterization factors from Section 3.1 of this document). This is made explicitly visible, as the estimates are not to be confused with a complete result for the background-system ReCiPe 2016/NEEDS_18.

- **Impact Categories Assessed**
  - Climate change (kg CO2-eq)
  - Formation of fine particulate matter (kg PM2.5-eq)
  - Acidification on land (kg SO2-eq)
  - Photochemical ozone formation (kg NOx-eq)
  - Scarcity of fossil resources (kg oil-eq)

Only qualitative discussion is provided for human toxicity (non-cancer) (Section 3.4); if background flows (e.g., heavy metals, toxic organics) can be characterized to quantify hazards at the foreground level, this is not done with the current datasets.

### 3.1.6. Data sources and data quality

In addition to the background flows and providers, which are ecoinvent-style, the foreground data were compiled as openLCA process exports (General information, Inputs, Outputs, Allocation, Parameters, Documentation sheets), and cross-referenced to the ecoinvent-style background flows and providers (e.g., transport, lorry 32t | Scenario: Today; electricity, natural gas, at combined cycle plant, 500MWe | Scenario: 2025), consistent with the ecoinvent version 3 data quality framework (Weidema et al., 2013). The IEA (2026), the World Bank (2026), and the 2024 annual report of the Zimbabwe Energy Regulatory Authority (ZEMA) as published in CleanTechnica (2025) provided national context data with regard to installed capacity, fuel mix, and supply constraints. For the purposes of preliminary comparative screening, the data quality is adequate; site-specific primary data collection, such as fuel consumption measurement and monitoring of stack emissions, would enhance precision for a submission for peer review.

### 3.2. Life Cycle Inventory (LCI)

The foreground inventory is compiled for each system and is reported on as per 1 kWh of net electricity output basis.

#### 3.2.1. Biogas Electricity Production

Biogas electricity production is looked at as a possible way to generate electricity, using a life cycle assessment from start to finish. This includes everything from making the biogas, cleaning it up, transporting it, generating electricity, dealing with emissions, and the regular upkeep of the plant. To make it easier to compare with other electricity generation methods in this study, all the inputs and outputs were adjusted to the standard unit of 1 kWh of net electricity produced.

#### 3.2.2. Hybrid Systems

Location: Zimbabwe. The process is the extraction and refining of diesel fuel, transporting the fuel, using the generator to burn the fuel, emissions, and general maintenance.

Inputs (per 1 kWh):

| Flow | Amount | Unit |
|---|---|---|
| Air (for combustion) | 0.25 | m3 |
| Diesel, combusted in power plant | 0.22 | l |
| Lubricating oil | 0.005 | kg |
| Steel (infrastructure, optional) | 0.00002 | kg |
| Transport, lorry 32t | 0.003 | t·km |
| Water, cooling (surface) | 0.002 | m3 |

Outputs - emissions and waste (per 1 kWh):

| Flow | Amount | Unit |
|---|---|---|
| Electricity generated (reference flow) | 1 | kWh |
| Carbon dioxide, fossil | 0.673352 | kg |
| Methane | 0.00002 | kg |
| Nitrous oxide | 0.0000001 | kg |
| Nitrogen oxides | 0.005 | kg |
| Sulfur dioxide | 0.000006 | kg |
| Ammonia | 0.000009 | kg |
| Non-methane VOC | 0.0001 | kg |
| Particulate matter, <10 µm | 0.0002 | kg |
| Particulate matter, <2.5 µm | 0.00025 | kg |

| | | |
|---|---|---|
| Fly ash | 0.001 | kg |
| Oil waste | 0.00002 | kg |
| Waste, solid | 0.0001 | kg |
| Wastewater (cooling/process) | 0.00029 | m3 |
| Waste water | 0.0002 | m3 |
| Heat, waste | 0.003 | MJ |

### 3.2.3. Coal-Fired Power Plant (High Voltage)

**Location: Zimbabwe.**

Inputs (per 1 kWh):

| Flow | Amount | Unit |
|---|---|---|
| Air (for combustion) | 0.003 | m3 |
| Hard coal, at mine | 0.43 | kg |
| Limestone (desulfurization) | 0.01 | kg |
| Chemicals for water treatment | 0.0005 | kg |
| Lubricating oil | 0.0001 | kg |
| Steel (infrastructure, optional) | 0.0004 | kg |
| Transport, lorry 32t | 0.0215 | t·km |
| Water, cooling (surface) | 0.002 | m3 |
| Electricity, low voltage (grid) | 0.03 | kWh |

Outputs - emissions and waste (per 1 kWh):

| Flow | Amount | Unit |
|---|---|---|
| Electricity, high voltage (reference flow) | 1.0 | kWh |
| Carbon dioxide, fossil | 0.373352 | kg |
| Carbon monoxide | 0.00001 | kg |
| Methane | 0.00002994 | kg |
| Nitrous oxide | 0.000004082 | kg |
| Nitrogen oxides | 0.0002268 | kg |
| Sulfur dioxide | 0.00021455 | kg |
| Ammonia | 0.00001 | kg |
| Non-methane VOC | 0.000003 | kg |
| Particulate matter, <10 µm | 0.00001 | kg |
| Particulate matter, <2.5 µm | 0.000008 | kg |

| | | |
|---|---|---|
| Bottom ash | 0.009 | kg |
| Fly ash | 0.1 | kg |
| Sludge from flue gas cleaning | 0.006 | kg |
| Wastewater (cooling/process) | 0.0005 | m3 |
| Heat, waste | 0.02 | MJ |

### 3.2.4. Natural Gas Power Plant (1 kWh net)

**Location: Zimbabwe.**

Inputs (per 1 kWh):

| Flow | Amount | Unit |
|---|---|---|
| Air (for combustion) | 0.0011 | m3 |
| Electricity, natural gas, combined cycle 500MWe | 0.19 | kWh |
| Electricity, medium voltage (grid) | 5 | kWh |
| Lubricating oil, at plant | 0.00002 | kg |
| **Flow** | **Amount** | **Unit** |
| Steel (infrastructure, optional) | 0.0002 | kg |
| Transport, lorry 32t | 0.0027 | t·km |
| Water, cooling (surface) | 1.8 | m3 |

Outputs - emissions and waste (per 1 kWh):

| Flow | Amount | Unit |
|---|---|---|
| Electricity, medium voltage (reference flow) | 1 | kWh |
| Carbon dioxide, fossil (process) | 0.3693 | kg |
| Carbon dioxide, fossil (combustion) | 0.00001 | kg |
| Methane | 0.00000696 | kg |
| Nitrous oxide | 0.000000696 | kg |
| Nitrogen oxides | 0.00003 | kg |
| Sulfur dioxide | 0.0000005 | kg |
| Non-methane VOC | 0.00001 | kg |
| Particulate matter, <10 µm | 0.000005 | kg |
| Particulate matter, <2.5 µm | 0.00025 | kg |
| Oil waste | 0.0000003 | kg |
| Waste, solid | 0.0001 | kg |
| Wastewater (cooling/process) | 0.00019 | m3 |

| | | |
|---|---|---|
| Waste water | 0.0002 | m3 |
| Heat, waste | 0.003 | MJ |

Note: The natural gas dataset includes a relatively high upstream electricity input (5 kWh from medium voltage grid) along with the combined-cycle plant reference; this is because this electricity input is implicit in the source process and may be double counted when the dataset is published.

## 4. Results

The environmental performances of the electricity generation based on diesel, coal and natural gas fuels were assessed using the Life Cycle Assessment (LCA) methodology in accordance with ISO 14040 and 14044 standards. The assessment was carried out with the ReCiPe 2016 Midpoint (H) impact assessment method implemented by the openLCA and supported by process data based on ecoinvent (ISO, 2006a; ISO, 2006b; Huijbregts et al., 2017; Wernet et al., 2016). The results of LCIAs are shown in comparative form for the functional unit: 1 kWh of net electricity generated, in the following (Table 1). The overall environmental impacts of diesel generation were the highest for climate change, terrestrial acidification and photochemical ozone formation, and the highest values for fossil resource scarcity were for coal. Most of the environmental impacts were the lowest for natural gas, suggesting the relatively superior environmental performance of natural gas under the study conditions.

### The method and characterization factors that were used are described in 3.1.

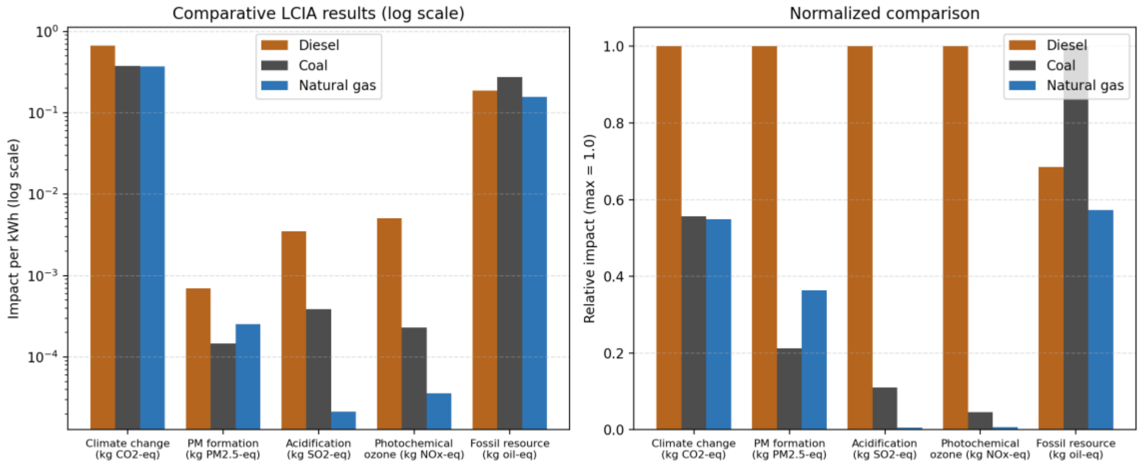
The results are indicative midpoint estimates of the foreground inventory (Section 2) applied to the following standard published characterization factors and not re-executed in openLCA (ReCiPe 2016/ecoinvent).

- Climate change: IPCC AR5 GWP100 - $CO_2$ = 1, $CH_4$ = 28, $N_2O$ = 265 kg $CO_2$-eq/kg (Myhre et al., 2013).
- Particulate matter formation (direct PM2.5 + 0.54×$SO_2$ + 0.088×$NO_x$ + 0.36×$NH_3$ (kg PM2.5-eq), based on the midpoint aggregation principles as developed by CML/ReCiPe (Guinée, 2002; Huijbregts et al., 2017).
- Terrestrial acidification (Terrest) $SO_2$ = 1, $NO_x$ = 0.7, $NH_3$ = 1.6 (kg $SO_2$-equivalent) is based on the CML characterization approach (Guinée, 2002).
- Photochemical ozone formation: $NO_x$ = 1, NMVOC = 0.6, CO = 0.03, $CH_4$ = 0.014 (kg $NO_x$-eq) (Guinée, 2002).
- Fuel scarcity: the energy content of the fuel resources as measured by oil-equivalents (OE) (IEA/BP, 2022) (The oil equivalent is calculated using the LHV of the fuel, with diesel LHV assumed to be 43 MJ/kg, and the natural gas LHV assumed to be equivalent to the $CO_2$ emission per MJ of energy from its combustion process, using 0.832 kg/l as the LHV of diesel, and 56.1 kg $CO_2$/GJ as the combustion $CO_2$ emission factor of natural gas; the fuel volume was not separately reported in the foreground dataset).

These factors are close to but not a replacement for the complete ReCiPe 2016 Midpoint (H) characterization in the openLCA/ecoinvent workflow (Huijbregts et al., 2017). They are suitable for a preliminary, transparent comparison, in accordance with the general comparison advice given in LCA practice (Hauschild, Rosenbaum and Olsen, 2018), and should be compared to the final published LCA results from the model run of an openLCA/NEEDS_18 or ReCiPe 2016.

### 4.1. Life Cycle Impact Assessment

| Impact category | Unit | Diesel | Coal | Natural gas |
|---|---|---|---|---|
| Climate change | kg CO2-eq | 0.6739 | 0.3753 | 0.3697 |
| Fine particulate matter formation | kg PM2.5-eq | $6.96\times10^{-4}$ | $1.47\times10^{-4}$ | $2.53\times10^{-4}$ |
| Terrestrial acidification | kg SO2-eq | $3.52\times10^{-3}$ | $3.89\times10^{-4}$ | $2.15\times10^{-5}$ |
| Photochemical ozone formation | kg NOx-eq | $5.06\times10^{-3}$ | $2.29\times10^{-4}$ | $3.61\times10^{-5}$ |
| Fossil resource scarcity | kg oil-eq | 0.188 | 0.274 | 0.157 |




Note: The natural gas dataset is accompanied by the combined-cycle plant reference, and has a relatively high upstream electricity input (5 kWh, medium voltage grid); this is a background electricity input from the grid that is present in the natural gas source process, and should be double counted before final publication.

The method and characterization factors used are detailed in section 3.4.

The results below are indicative midpoint estimates derived directly from the foreground inventory (Section 2) and the following standard published characterization factors for a full background-system characterization not been repeated in openLCA for ReCiPe 2016/ecoinvent for this document:

- Climate change: IPCC AR5 GWP100 - CO2 = 1, CH4 = 28, N2O = 265 kg CO2-eq/kg (Myhre et al., 2013).
- 2) Formation of particulate matter: direct PM2.5 kg PM2.5-eq + 0.54×SO2 kg PM2.5-eq + 0.088×NOx kg PM2.5-eq + 0.36×NH3 kg PM2.5-eq, based on CML/ReCiPe consistent midpoint aggregation principles (Guinée, 2002; Huijbregts et al., 2017).
- Terrestrial acidification: SO2 = 1, NOx = 0.7, NH3 = 1.6 (kg SO2-eq) (based on the characterization approach of CML, Guinée 2002).
- Photochemical ozone formation: NOx = 1, NMVOC = 0.6, CO = 0.03, CH4 = 0.014 (kg NOx-eq) (Guinée, 2002).
- Fuel scarcity of fossil resources (fuel energy content converted to oil-equivalent, using the convention of the IEA/BP, 2022, for diesel LHV of 43 MJ/kg and oil-eq, and the LHV of hard coal of 26.7 MJ/kg, with

the combustion CO2 emission factor of natural gas at 0.832 kg/l converted to 56.1 kg CO2/GJ).

These factors are not a complete representation of the complete ReCiPe 2016 Midpoint (H) characterization that is used in the openLCA/ecoinvent workflow (Huijbregts et al., 2017). These are suitable for a preliminary comparison made in a transparent manner, as is recommended in general LCA practice guidance (Hauschild, Rosenbaum and Olsen, 2018), and the results of the published figures should be checked against an actual openLCA/NEEDS_18 or ReCiPe 2016 model run.

### 4.2 Recommendations

Re-run full comparison in openLCA using ReCiPe 2016 Midpoint (H), cut-off allocation, instead of the complete ecoinvent background system and replace the indicative values in Section 3 with the output of the model.

Before completing results, solve the natural gas natural gas input electricity upstream node.

Add uncertainty distributions to the source Inputs/Outputs sheets and run a 1,000-iteration Monte Carlo analysis on climate change and particulate matter formation.

If the toxicity to humans is to be expressed quantitatively, extend the inventories with the emission flows of heavy metals and toxic-organic substances.

## 5. DISCUSSION

The findings revealed the highest environmental impact of the diesel powered electricity generation in most of the assessed categories, especially in the categories of climate change, terrestrial acidification and the formation of photochemical ozone. These results confirm the earlier research that showed that the combustion efficiency of the diesel generators is low and the carbon-intensive nature of the diesel fuel contributes to the high greenhouse gas emissions and fossil fuel consumption of diesel generators (Namdari, 2025; Cho & Strezov, 2020). The widespread use of diesel generators during electricity shortages in Zimbabwe, therefore, poses significant environmental issues.

The fossil resource scarcity was the highest for coal-fired electricity generation and fossil resource emissions of particulate matter and acidification were considerable. The results were in accord with the earlier study which concluded coal combustion as a significant source of SO2, particulate emissions and other pollutants which contribute to poor air quality and impact the ecosystem (Kommalapati et al., 2018; Kabeyi & Olanrewaju, 2024). Coal is still a significant source of electricity for base load generation, but still has significant environmental impact.

Natural gas had the lowest environmental impacts in most of the categories studied, and as a result, they concluded that natural gas performs better in the environmental arena than diesel and coal under the conditions evaluated. They have been also reported by Ou et al. (2013), Ozbilen et al. (2018) and Cooper et al. (2019) that natural gas combined-cycle systems have the potential to reduce greenhouse gas emissions and lower air pollutant emissions due to their superior combustion efficiency and low carbon intensity. Based on the findings, expanding natural gas utilization would help to mitigate the environmental effects of electricity generation in Zimbabwe, and aid the transition to a "cleaner" energy industry.

## 6. CONCLUSION

The study compares the electricity generation by diesel, coal fired and natural gas under Zimbabwean conditions using openLCA and ReCiPe 2016 (Midpoint (H)) method in compliance with ISO 14040 and ISO 14044 (Huijbregts et al., 2017; ISO, 2006a; ISO, 2006b). This analysis revealed that generating electricity with diesel would have the highest environmental impacts in most of the impact categories assessed, with coal having the highest fossil resource scarcity. Natural gas, on the other hand, showed the lowest environmental impacts in most categories, which was consistent with the fact that it performed comparatively well in this area when compared to the three electricity generation technologies. The results are similar to previous LCA studies which have determined that NGR is a less polluting fossil fuel option than coal and diesel (Ou et al., 2013; Ozbilen et al., 2018; Cooper et al., 2019).

The study offers solid evidence to inform electricity generation planning and policy development in Zimbabwe with the aim of taking into account the environmental implications of these. Expansion of cleaner electricity generation technologies and increasing the efficiency of the existing fossil fuel systems will help diminish the environmental impacts of electricity generation (Kabeyi & Olanrewaju, 2024). There is a need for incorporating site-specific operational data, and for conducting complete background-system modelling with openLCA and ecoinvent to enhance the robustness and accuracy of the environmental assessments in future studies (Hauschild et al., 2018; Wernet et al., 2016).

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