Journal of
Energy, Environment &
Carbon Credits

ISSN: 2249-8621
Volume 15, Issue 3, 2025
September–December
DOI (Journal): 10.37591/JoEECC

https://journals.stmjournals.com/joeecc

Review JoEECC

# A Carbon Assessment Framework for the Estimation of Carbon Footprint by the Usage of Liquified Petroleum Gas

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***Abstract***

*Various higher educational universities around the globe have tried to compensate for their carbon footprints, and awareness of ecology and environmental responsibility have increased. The primary motive of this work is to provide a recent study about the carbon emission accounting of carbon emission in higher education and enhance the mitigation techniques. Carbon footprint can be measured by using various methodologies like input-output analysis, hybrid models, and life cycle assessments (LCA). This estimation of carbon emission can be done with the help of mathematical formulation technique; this work tries to determine the carbon footprint of LPG gas for K R Mangalam University. The study also provides the linear relationship between the usage of LPG gas and carbon emissions by gathering and analyzing data to calculate the annual $CO_2$ emissions from LPG gas consumption. It was also noted that the LPG emits approximately 11.01 t/annum $CO_2$ in a year.*

**Keywords:** LPG, carbon emission, GHG protocol, life cycle assessment

## INTRODUCTION

According to Greenhouse Gas (GHG) Protocol standards, Scope 1 of the GHG standards covers LPG which includes various greenhouse gases which are directly released by a company or an organization that it owns or controls. LPG is a common, transportable fuel that burns cleanly. It is mostly created as a product of natural gas and crude oil being extracted and refined.

Around the world, LPG also called propane and butane, or a fusion of these two is required for a variety of purposes. Because LPG comes from different sources, there is a broad oversupply which is expected to last for the next 10 years. Global LPG production was around six million metric tons greater than global consumption in 2017, indicating both potential and present misuse.

A portion of this excess flows out or flared in different oil and gas-producing plants, releasing carbon into the environment (Figure 1). Various Low- and middle-income countries may make better use of this limited fuel source if they switched to LPG for clean cooking.

Global population expansion is linked to an increase in greenhouse gas emissions caused by humans. The metrological concentrations of carbon dioxide, nitrogen oxide, and methane have recently reached record highs. Since the middle of the 20th century, the climate has changed if the temperature increases and gets automatically warm.

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Received Date: July 05, 2025
Accepted Date: July 15, 2025
Published Date: September 19, 2025

**Citation:** Manju Rani, Vineet Dahiya, Bhavesh Vyas, Puja Acharya. A Carbon Assessment Framework for the Estimation of Carbon Footprint by the Usage of Liquified Petroleum Gas. Journal of Energy, Environment & Carbon Credits. 2025; 15(3): 1–5p.

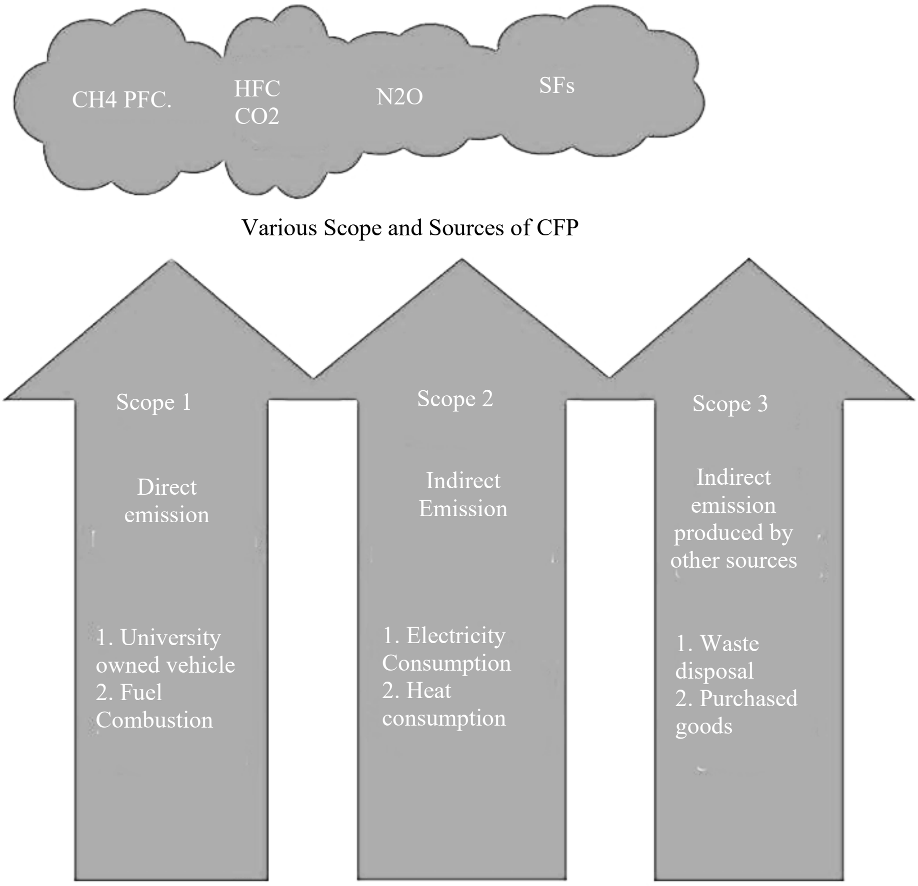


**Figure 1.** Scopes and sources of carbon footprint.

According to the IPCC's Sixth Assessment Report (AR6), the activities which are performed by humans caused atmospheric $CO_2$ levels to rise by 50% since pre-industrial times. Industry and fossil fuel account for about 36.4 Gt emissions while changes in land use producing 6.6 Gt carbon emissions in 2019. During the COVID-19 pandemic, the emissions have not fallen considerably. Net-zero $CO_2$ emissions must be achieved by the middle of the century if we keep global warming to 1.5 or 2°C, which will force a fast move to renewable and low-carbon energy technologies. The high need for worldwide action required to mitigate adverse effects on the climate, conditions, ecosystems, and biodiversity is emphasized in the AR6.

## BACKGROUND STUDY

Kiehle *et al*. investigated enhanced carbon emission and estimated the carbon emission to enhance the accounting of carbon emission in northern Europe. This estimation was completed for the Oulu University in 2019 by a hybrid model which results in 40% coming from district heating, at 19,072 t $CO_2$ e/year. Carbon neutrality is the main target of this university by 2030. Other universities like Leeds and Eastern Finland University have also implemented this terminology [1]. Da Silva *et al*. examined that out of 228 items, only 33 were found during the first search to be eligible for carbon emission detection. The greenhouse gas protocol serves as the basis for the computation [2]. Guvenc *et al*. studied the carbon footprint of Yildiz Technical University (YTU). The IPCC and DEFRA methods are used in this research for the reputable years 2019 and 2020. The CFP was found to be 15244.4 t of $CO_2$ in 2019 and 7213.3 t of $CO_2$ in 2020. 2020 had a decrease in carbon emissions compared to 2019 due only to the COVID-19 online education policy. Transportation and electricity consumption account for the majority of emissions [3]. Adamas *et al*. researched two main aspects of Scope 3. One is procured goods and services and the second is university commuting. It was noticed that 34% of emissions are related to commuting, whereas 46.5% are related to goods and services. The GHG Protocol was used in this study in addition to baseline carbon footprint (CFP) measurements [4]. Herth *et al*. observed the various direct and indirect emissions that constitute Delft University of Technology's carbon footprint. A process analysis technique was used which covered both monetary and physical activity, and economic input-output. A total of 106000 t $CO_2$ eq were emitted annually by TU Delft. 17% of the total carbon emissions are emitted by Scope 1 and Scope 2, whereas 83% are attributed to Scope 3 [5]. Hoyos *et al*. calculated the Technological University of Pereira's (UTP) 2017 organizational carbon footprint. This research shows that UTP produced 8969 t $CO_2$ eq/year in 2017. 97% of these $CO_2$ emissions were created by Scope 3 as a result of infrastructure and daily travel. It was observed that, as compared to other colleges, each student on campus only released 0.4 t of $CO_2$ eq annually in 2017. GHG protocol is used for the completion of research. UTP has a low carbon emission per person when compared to other universities. This outcome is comparable to that of several other colleges in Europe and North America as well as those in Latin America [6]. Valls-Val *et al*. conducted a study to provide a concise overview of the carbon footprint assessment of higher education institutions (HEIs) utilizing a range of parameters and limits (namely, Scope 1, Scope 2, and Scope 3) as well as emission variables. Comparing HEI to other universities, it was found that Scopes 2 and 3 contribute the most to the carbon footprint. Reduced carbon emissions from HEI are the main goal of this research [7]. Naderipour *et al*. conducted a research and it was observed that the total amount of carbon emissions from the three sources throughout 4 years was 48.442 Mt. From the total transportation used, students accounted for 34.74%, employees for 19.37%, and electricity consumption was 18.19%. University Teknologi Malaysia's (UTM) emissions are computed by using a unique evaluation method [8]. Budihardjo *et al*. provided the carbon emissions from non-academic activities at Diponegoro University in 2019 by using a variety of categories. The carbon emission of Diponegoro University is 13945.55 t $CO_2$ eq. The carbon emissions of every building were computed in three stages. Scope 1 has 0.21%, Scope 2 has 99.37%, and Scope 3 has 0.41% [9]. Ullah *et al*. utilized the GHG methodology which was developed by the IPCC in 2007 to compute carbon. This research comprises three objectives. Scope 1 covers seven sectors, Scope 2 includes one, and Scope 3 includes two sectors to estimate carbon emissions. 38% of the total overall carbon emissions is produced by energy which is a total of 578,898 kg $CO_2$ eq [10].

Clabeaux *et al*. did an LCA-based study on carbon emissions for Clemson University. The university emits 93,000 Mt of $CO_2$ equivalent annually; where electricity accounts for 46500 Mt of $CO_2$ equivalent or half of the emissions. As a result of this research, each student uses 4.2 Mt of $CO_2$ equivalent [11]. Misni *et al*. propose to drive a study to determine the carbon footprint assessment techniques employed by University Teknologi MARA (UiTM) Malaysia's higher education establishments while abiding by the Greenhouse Gas (GHG) Protocol Corporate Standard for creating a GHG inventory in a university. The primary sources of carbon footprint were found to be the production of energy, transportation, and products and services [12]. Wahid *et al*. calculated the carbon emissions of 21 highways in several countries and determined the main emission sources using life cycle assessment, a Microsoft Excel-based program, and the bid and unit engineering techniques. The Excel tool is great for highway building calculations, according to this research, which also looked at these methods to observe which works best for the computation [13].

## CARBON ASSESSMENT TECHNIQUES

Various carbon emission estimating technologies are available that can be utilized for the calculation of carbon emissions caused by LPG that are mentioned below:

1. *Life Cycle Assessment (LCA): It* is considered as a standard, and is governed by the international standards ISO 14040 and ISO 14044. It estimates the potential long-term effect of technology throughout its life. It is a process that provides how a technology, good, or service will affect the environment at every step of its life from raw material to production and processing to manufacturing, distribution, and use, to recycling or disposal at the end of life.
2. *Machine Learning and AI Models:* Various types of machine learning and Artificial intelligence Algorithms can be deployed like MLP (Multi-Layer Perceptron), neural networks, and SVM (Support Vector Machine) for the quantification of carbon footprint for various organizations.

 

Regression techniques, gradient boosting machines, and K-nearest neighbours can also be deployed for the estimation of carbon footprint.

3. *Emission Factors and Carbon Accounting:* for the estimation of carbon footprint, we use mainly two factors according to the LCA process which are consumption of carbon accounting and emission factors. Consumption of fuel or an industrial process's amount of greenhouse gas emissions per unit of activity is represented by an emission factor. It was used for the computation of carbon footprint from a variety of sources, like transportation and energy use, etc. By adopting life cycle assessment, environmental input-output analysis, carbon accounting, and monitoring and documenting these emissions. They help to calculate carbon footprints, establish reduction goals, and track nations' and organizations' advancements in climate change mitigation.
4. *Energy and Emission Models:* The quantities of utilized energy and the GHG emissions from various ends and areas are determined using these analytical tools.

## METHODOLOGY USED FOR THE ESTIMATION

Carbon emission by LPG can be calculated by using a simple formulation which is nothing but just like LCA (Life Cycle Assessment), and by using a Python-based GUI self-trained machine learning module. The carbon emission calculation for a month and for summer and winter seasons and the usage of LPG cylinders in K R Mangalam University campus has been made by using simple formulation as per the real-time data collection, which consists of two factors:

1. Cylinders used in Canteen, and
2. Cylinders used in mess.

Calculation of carbon emission by LPG usage is done by this formula:

$$E_{LPG} = LPG\ Consumption \times Emission\ Factor_{\ LPG}.$$

The calculation table of the carbon emission by LPG is shown in Tables 1 and 2 which is separately shown for the summer and winter seasons. In this table, number of cylinders used in mess and canteen is 4 and 18 for summer season and 6 and 24 for winter season.

## RESULT

By adopting simple carbon emission formulation techniques, it was observed that approximately 11.01 t $CO_2$ is emitted per year by the LPG usage in the K R Mangalam University.

**Table 1.** Carbon emission for summer season (January to May).

| Sr. No. | University Defined Area | LPG consumption (kg) |
|---|---|---|
| 1 | Canteen | 56.8 |
| 2 | Mess | 255.6 |
| Total LPG consumption in kg=312.4 | | |
| $CO_2$ emission =931.8892 t | | |
| $CO_2$ emission in Tones =0.932 t/month | | |
| $CO_2$ emission in Tones for a season =4.66 t | | |

**Table 2.** Carbon emission for summer season (July to November).

| Sr. No | University defined area | LPG consumption (kg) |
|---|---|---|
| 1 | Canteen | 85.2 |
| 2 | Mess | 340.8 |
| Total LPG consumption in kg=426 | | |
| $CO_2$ emission =1270.758 t | | |
| $CO_2$ emission in Tones =1.270 t/month | | |
| $CO_2$ emission in Tones for a season =6.35 t | | |

 

This LPG carbon emission is for the predefined zone for the Mess and Canteen area of the KRMU campus. It was also focused that the carbon emission in winter is high as compared to the summer session since more LPG consumption take place in the winter session.

## CONCLUSION AND FUTURE SCOPE

To evaluate the environmental impact of liquefied petroleum gas (LPG) it is necessary to analyze its carbon emissions. While LPG is frequently considered a cleaner option than other fossil fuels, it also contributes to greenhouse gas emissions. By using real-time data, we can also enhance and improve our approach to monitoring our environmental impact, user behavior, and new technologies. We can move from this formulation method to another programming language like Python. The Carbon Capture and Utilization (CCU) method can be used in the future to convert the calculated emission into another synthesis fuel. Bio LPG systems can be installed to reduce carbon emissions. Solar-based and electricity-based cooking components can be used to lower purposes of carbon emissions.

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