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Transition to sustainable mobility: Analysis of the environmental impact of the use of electric motorcycles as substitutes for gasoline-powered motorcycles in Honduras.

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Abstract*– Addressing the environmental impact associated with the transportation sector with a 45% increase in the registration of gasoline-powered motorcycles in the country's vehicle fleet by 2021. The objective of this study was to determinate the environmental impact in terms of Gigagrams of CO_2 of the transition from internal combustion motorcycles (ICM) to electric motorcycles (EM). The CO_2 emissions of motorcycles in the city of San Pedro Sula, Cortes, were analyzed using the GreenHosue Gas Protocol (GHG), and 30 CO_2 measurements were taken with their respective interviews, and the CO_2 emissions emitted by electric motorcycles were also calculated for comparison. It was estimated that the CO_2 emissions generated by internal combustion motorcycles represent 38% of the total CO_2 emissions related to transportation, however, replacing them with electric motorcycles resulted in a total of 5% in CO_2 emission per year, therefore, the transition to electric motorcycles could generate a significant reduction of 34% in CO_2 emissions from transportation in Honduras, marking a significant reduction for environmental sustainability. It can be concluded that the replacement of gasoline motorcycles by electric motorcycles in Honduras would have a positive impact on the environment by promoting environmental awareness in society.

Keywords—Motorcycles, Air Pollution, Climate change, Energy efficiency, Road safety.

I. INTRODUCTION

Today's rapid population growth has resulted in a significant increase in the demand for motor vehicles worldwide. This has led to an increase in Greenhouse Gas Emissions and environmental degradation. The following research sets out to closely examine the feasibility and impact of transitioning to electric motorcycles that can contribute to more sustainable mobility in Honduras.

Honduras is facing problems due to the high concentration of motorcycles in its vehicle fleet causing traffic congestion which generates pollution, all this affecting the natural environment of the country so we are looking for a cleaner and more efficient option that will benefit the country, the environment and health.

Motorcycles are common on the roads and trails of this Central American country and are an essential means of transportation for many Hondurans, whether in urban or rural areas[1]. However, gasoline-powered motorcycles have historically been associated with environmental and economic problems. The transition to electric motorcycles, with their silent operation and no direct emissions, emerges as a promising alternative that can address mobility needs in all areas of Honduras.

This paper sets out to explore previous research, studies and advances in the field of electric motorcycles in Honduras, based on studies and articles related to the topic, and also by measuring greenhouse gas emissions on the most widely circulated motorcycles in the country using an Atmospheric Emissions Analyzer, in order to determine the typical emissions of a gasoline-powered motorcycle.

Honduras presents a variety of challenges and opportunities related to sustainable mobility, throughout the research will recognize the importance from an environmental perspective of addressing a critical problem related to greenhouse gas emissions, and in doing so, contribute to a more sustainable and healthy future. The results of this study could have a significant impact on the adoption of electric motorcycles in Honduras.

The environmental impact of replacing gasoline-powered motorcycles with electric motorcycles in Honduras will be evaluated in depth[2].

II. CONTEXT

A. Background Research

The World primary energy consumption increased by 5.52% in 2021, most of the consumption growth came from gasoline and diesel, according to bp's World Energy Statistical Review in June 2022. Oil remains, the main source of energy consumed in the world [3]. The main source of CO_2 corresponds to the burning of fossil fuels for energy supply and transportation.

Globally, the energy sector (electricity production, heating and industrial energy use) accounts for 48% of emissions, while the transport sector accounts for 23%. Of the latter, 75% corresponds to land transport. In the case of Honduras. 37.5% of CO_2 emissions come from the transport sector [4].

In Honduras, the evolution of the country's vehicle fleet is recorded every year, with its different classifications. According to the National Institute of Statistics (INE) with information obtained from the registry of the Property Institute (IP) the category that has had the greatest increase is motorcycles with a growth rate of 69.2% from 2017-2021[5].

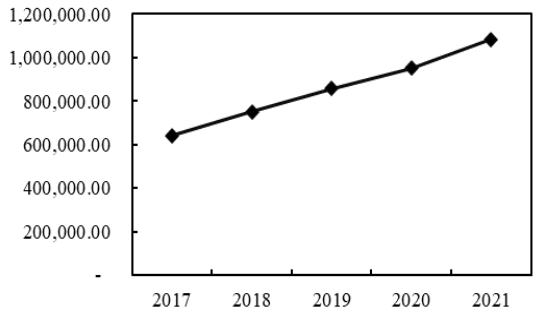

Figure 1. Motorcycle Fleet 2017-2021

The vehicle fleet in Honduras, according to the IP [6], is currently undergoing a marked transformation. The choice of motorcycles as the preferred means of transportation is increasingly reflected in the importation and sale of these vehicles, with an estimated average of three motorcycles per car in Honduras, as more and more Hondurans make use of two-wheelers. This process has been taking place over the last 10 years, but has accelerated in the last couple of years, triggered especially by the COVID-19 pandemic, which caused the increase in home delivery services.

B. Justification

In Honduras, CO_2 emissions increased by 1,309 megatons in 2021, 11.93% more than in 2020. CO_2 emissions in 2021 were 9,751 megatons, placing Honduras 77th in a ranking of 184 countries from least to most polluting. Honduras' per capita CO_2 emissions have increased in 2021, by 0.99 tons per capita [7].

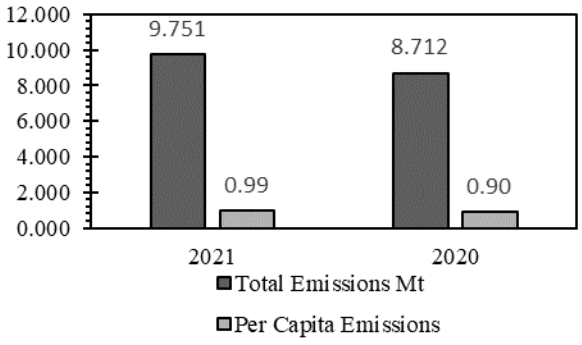

Figure 3. CO2 Emissions 2020-2021

C. Current Situation

Major cities in Honduras, such as San Pedro Sula, La Ceiba and Tegucigalpa, are confronted with the problem of traffic congestion, which has experienced a significant increase of 45%, even during the pandemic period. In this region, numerous manufacturers and dealers have been identified who are actively promoting the commercialization of electric motorcycles as a viable alternative[8].

III. Methodology

This chapter will present the procedures and methods necessary to define the research variables, as well as the instruments to be used, research programs and the schedule of activities.

The methodological approach combines quantitative data collection, as the research requires data to be observed and measured, and will involve calculations that will give us the CO_2 emissions associated with internal combustion motorcycles (ICM) compared to electric motorcycles (EM).

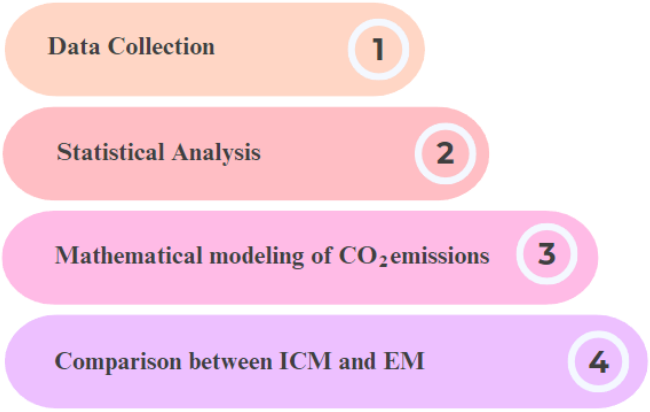

Figure 2. Process Summary

A. Applied Techniques and Instruments

- CO_2 Analyzer: is an instrument for calculating the carbon dioxide content in the air, a visual notification will be received when using the meter when measuring CO2 in ppm (parts per million)[9]. At least 30 measurements will be taken.
- Excel: will be used as a calculation memory in which averages, projections and calculations will be developed, as well as for the creation of graphs and tables that will be used to visualize the research.
- Data base: Data and information is obtained from various authors of scientific journal articles, technical sheets of gasoline and electric motorcycles, theses from a variety of universities.

- GreenHouse Gas Protocol: is a tool for measuring and managing greenhouse gas emissions from operations, value chains and mitigation actions of the public and private sectors[10]. GHG Protocol provides the most widely used GHG accounting standards in the world.

B. Location to Investigate

The investigation covers the entire Honduran territory; we are going to focus on the municipality of San Pedro Sula, in the four most popular gathering points for gasoline-powered motorcycles.

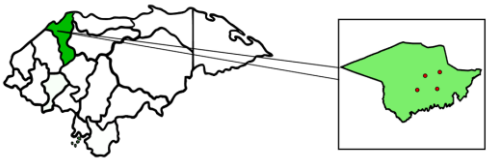

Figure 3. Municipality of San Pedro Sula

C. Data Collection

Once the main objective of the research was defined, the necessary data collection began, which will be used for calculations on CO_2 emissions with the CO_2 meter that will be read in parts per million (ppm) caused by internal combustion motorcycles and with a calculation of the emissions caused by electric motorcycles to finally obtain the viable result or not of the transition.

C. Statistical Analysis

With the responses from the surveys and CO_2 measurements, an average of the total responses obtained will be defined for the final calculations that will be displayed later.

E. Equations

In this stage, based on the data collected, an analysis will be made by means of calculations of CO_2 emissions caused by gasoline motorcycles with the formulas that will be shown below, as well as calculations of CO_2 emissions caused by electric motorcycles.

$$\frac{gCO_2}{year} = \left(\frac{gCO_2}{km}\right)\left(\frac{km}{day}\right) \times (\boldsymbol{Quantity}) \times (\boldsymbol{365\ days}) \quad (1)$$

$$\frac{Gg\ CO_2}{year} = \left(\frac{gCO_2}{year}\right) \times \left(\frac{1\ Ton}{1\times10^6 g}\right) \times \left(\frac{1Gg}{1000ton}\right) (2)$$

$$EUME = DPDU[km] \times \frac{V \times Ah}{Battery\ life[km]} \times EF \ (3)$$

Equations (1) and (2) will be used to calculate CO2 emissions from ICM and equation 3 will be used to calculate CO2 emissions from EM.

F. Comparison between ICM and EM

With the data collected on emissions through the mathematical model that was developed in the research, a final comparison in kilograms of CO_2 will be defined between the Internal Combustion Motorcycles and the Electric Motorcycle in which results and conclusions will be provided as to whether the transition is environmentally viable or not in a noticeable way.

III. Results

In this section, we will present a series of tables made in the Excel spreadsheet with their respective explanation[11].

A. Analysis on Internal Combustion Motorcycles

A calculation will be made of the grams of CO_2 per year emitted by an ICM and converted to Giga grams of CO2 per kilometer caused per year by the approximate number of deliveries currently in Honduras. This calculation requires the following data:

To obtain a more reliable measurement of the emissions in grams of CO2 caused by ICMs, we opted for the GreenHouse Gas Protocol simulation tool which, by filling in the corresponding data, indicates the average CO2 emissions caused by gasoline motorcycles, which is 1.259E-04 metric tons of CO2 per kilometer,125 grams of CO2 per kilometer.

GREENHOUSE GAS PROTOCOL

Summary: Emissions by Scope

Calculation Method	Greenhouse gas	Fossil Fuel Emissions		Biofuel CO2 Emission (metric tonnes)
		100km (metric tonnes)	km (metric tonnes)	
Distance	CH4	0	0	0
	N2O	0	0	
	CO2	0.013	1.259E-04	
	CH4	0	0	
	N2O	0	0	
Total (metric tonnes CO2e)		0.013	1.259E-04	0

***Table 1**.Calculation of ICM on delivery's*

CO2 EMISSIONS FROM INTERNAL COMBUSTION MOTORCYCLES	
g CO2/km	125.00
km/day	100.00
Number of delivery's	100,000.00
Days of the year	365.00
g CO2/year	4.56E+11
Ton CO2/year	456,250.00
Gg CO2/year	**456.25**

Then the same calculation will be made as in Table 2 but with the remaining number of conventional motorcyclists in the country, who travel an average of approximately 30km per day.

***Table 2**. Calculation of ICM on conventional motorists*

CO2 EMISSIONS FROM INTERNAL COMBUSTION MOTORCYCLES	
g CO2/km	125.00
km/year	30.00
Number of motorists	984,706.00
Days of the year	365.00
g CO2/year	1.35E+12
Ton CO2/year	1,347,816.34
Gg CO2/year	**1347.82**

***Table 3.** ICM Results*

Gg CO2 of MCI	**1804.05**

B. Analysis on Internal Combustion Motorcycles

1. The first YADEA electric mobility[12] store was inaugurated in Honduras in the year 2023, the Yadea Z-6 was chosen to achieve a comparison, a motorcycle adapted to the aesthetics of the ICM in which within its catalog is the one with the highest maximum speed.

2. According to the National Energy Balance (2021), [13] during 2021, an electricity production of 11,159 GWh was registered.
3. According to the Energy Information System in Honduras (2021), CO_2 emissions from electricity generation in 2021 was 5,180.99 Gg.
4. With point 2 and 3 we can obtain our emission factor with the following formula: EF= X/Y

***Table 4**. Emission Factor*

X	Annual emissions from electricity generation	5180.99	Gg CO_2
Y	**Annual electricity generation**	11159	GWh
FE	**Emission Factor = X/Y**	**0.46**	kg CO_2/kWh

Table 5 below shows the calculation in kilograms of CO_2 per year emitted by an ME and we will convert it to Giga grams of CO_2 per kilometer caused per year by the approximate number of deliveries currently being made in Honduras.

***Table 5**.Calculation of EM on delivery's*

CO2 EMISSIONS FROM ELECTRIC MOTORCYCLES	
DPDU [km]	100
FE [kgCO2] [Kwh]	0.46
V*Ah [Wh]	2304
Battery life [km]	70
EUME[KgCO2]	1.528
Kg CO2/100km	1.52
Number of delivery's	100,000.00
Days of the year	365.00
Kg CO2/year	55,480,000.00
Ton CO2/year	55,480.00
Gg CO2/year	**55.48**

***Table 6**.Calculation of EM on conventional motorists*

CO2 EMISSIONS FROM ELECTRIC MOTORCYCLES	
DPDU [km]	30
FE [kgCO2/Kwh]	0.46
V*Ah [Wh]	2304
Battery life[km]	70
EUME[KgCO2]	0.458
Kg de CO2/30km	0.45
Number of motorists	984,706.00
Days of the year	365.00
Kg CO2/año	161,737,960.50
To CO2/año	161,737.96
Gg CO2/año	161.74

***Table 7**. EM Results*

Gg CO2 of ME	**217.22**

C. Comparison and results

Next, we will present the final results obtained from the CO_2 emissions caused by internal combustion motorcycles and

electric motorcycles. According to SIEhonduras [14], CO_2 emissions caused by the transportation area are 4,726.75 Gg of CO_2.

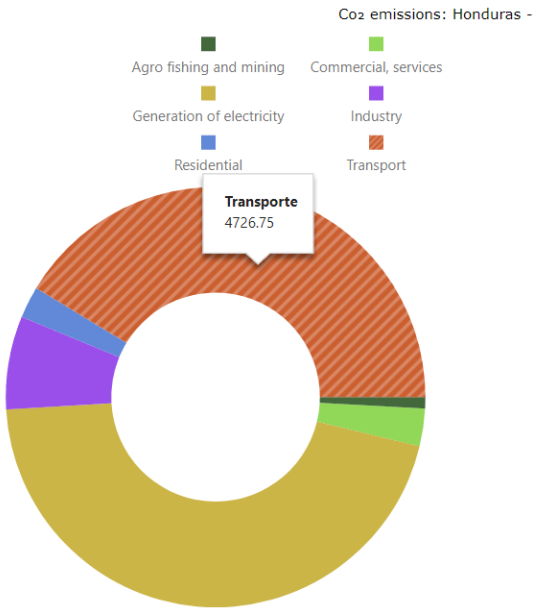

Figure 4. CO_2 emissions from transportation

CO_2 emissions generated by internal combustion motorcycles were estimated to account for 38% of total transportation-related CO_2 emissions.

Table 8. *Percentage of emissions by ICM*

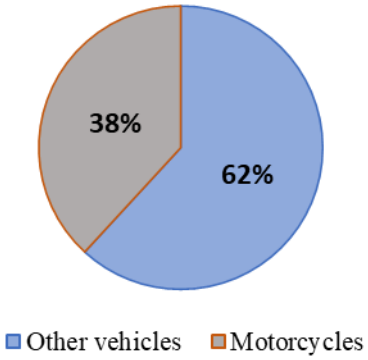

Figure 5. Emissions pie chart by ICM

An assessment was conducted to determine the CO_2 emissions that would be generated by replacing internal combustion motorcycles with electric motorcycles. The results indicated that electric motorcycles would contribute 5% of the emissions, thus achieving a 34% reduction in total emissions by transitioning from internal combustion to electric motorcycles.

Table 9*. Transition to ME*

CO2 Emissions		
Gg for transportation	4726.75	62%
Gg for MCI	1804.05	38%
Gg transition a ME	217.22	5%
Emissions Reduction		**34%**

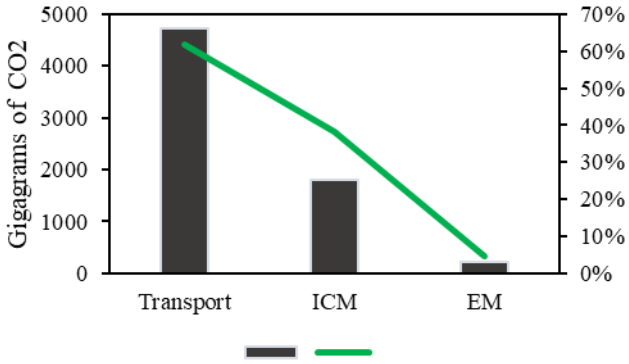

Figure 6. Final CO_2 reduction

IV. Conclusions

- Based on the results of the research, it can be concluded that replacing gasoline motorcycles with electric motorcycles in Honduras would have a positive impact on the environment. Currently, gasoline-powered motorcycles are a major source of greenhouse gas emissions, including carbon dioxide (CO_2). CO_2 is a gas that contributes to global warming. It is common to see how the installation of photovoltaic systems [15]is being used in the commercial sector to minimize costs in the electricity bill, so you can take advantage of creating charging stations with such a system in the country.
- Electric motorcycles do not produce a high amount of CO_2 emissions compared to gasoline motorcycles, which means that replacing gasoline motorcycles with electric motorcycles could help reduce greenhouse gas emissions and combat climate change. The research results showed that electric motorcycles would cause 5% of CO_2 emissions in the transportation area, which indicates that replacing gasoline motorcycles with electric motorcycles would achieve a 34% reduction in CO_2 emissions.

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