

# Approximation of the Impact of the Implementation of Work at Home in the Reduction of GHG Greenhouse Gases in the City of Bogotá – Colombia

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## ABSTRACT

The adoption of remote work by businesses in Colombia due to the declaration of a health emergency and the requirement for preventive isolation due to COVID-19 resulted in a reduction in the volume of traffic on the main roadways of Colombian cities, as is the case in Bogotá. For this reason, the desire arises to make an approximation of the impact of the implementation of Work at Home in the reduction of Greenhouse Gases GHG, in which a survey is applied to 402 people among employees, public servants, and independent workers, to know the means of travel and days of attendance at work centers. Subsequently, the calculation of CO<sub>2</sub> equivalent emissions was carried out according to the fuel consumption and factors indicated in the United States Environmental Protection Agency equations. Finally, the emissions result is compared against the frequency of use of means of transport by employees.

**Keywords:** Sustainability; Greenhouse Gases GHG; Work at Home; COVID 19

## Introduction

Through this study, it is hoped to examine the effects that the adoption of the “Work at Home” modality, a remote work modality, has had on employees of Colombian organizations, on air quality, in particular on GHG greenhouse gases, from the declaration of mandatory and preventive quarantine or social isolation brought on by the COVID pandemic 19. That is how telework, remote work, or work at home is done [1,2]. Its implementation in Colombia resulted from the declaration of a Health Emergency in the country. It has allowed several companies to continue developing their activities, taking into account the mandatory preventive asylum that the National Government applied for in several cities of the Colombian territory. In this sense, non-attendance at the offices managed to prevent the spread of the COVID-19 virus by maintaining social isolation and simultaneously generated an indirect effect on the reduction of environmental impacts, such as the mitigation of Greenhouse Gases worldwide and, of course, in Colombia.

## Literature Review

In the first instance, the definition of GHG Greenhouse Gases should be brought up, which are the gaseous components of the atmosphere that are characteristic of absorbing and emitting radiation at specific wavelengths. These are those mentioned below: H<sub>2</sub>O, CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>, and O<sub>3</sub> [3]. It is essential to bring up some definitions stipulated in Colombia to implement the different methodologies related to remote work. Thus, according to Law 2121 of 2021 of the Congress of the Republic of Colombia, remote work was defined like this:

“The employment relationship must be carried out remotely through information and telecommunications technologies or another means or mechanism from its inception to its termination. During the contractual relationship, the employer and employee do not physically interact. In any case, this form of execution does not share the constituent and regulated elements for teleworking and work at home and the rules that modify it” [4,5]. In the case of work at home, the Colombian Government defined it under Law 2088 of 2021 as follows:

“It is understood as work at home the room to the public servant or private sector worker to temporarily perform their functions or activities outside the place where they usually perform them, without modifying the nature of the contract or employment relationship, legal and regulatory respective” [6]. Some authors state that the COVID-19 virus indirectly affected social life since there may be some negative impacts on people’s physical activity, physiological state, and ability to master the effects that confinement to homes can cause in the short and long term [7,8].

GHG Greenhouse Gases cause a more significant proportion of global warming, which is generated by agriculture and the consumption of fossil fuels by industry and automobiles [9]. According to the GHG Emissions Inventory report in Bogotá, a total of emissions for the year 2017 of 11,421,724.32 tons of CO<sub>2</sub> was registered, which generated 48% by the transport sector [10]. That is to say, of the total value, the transport sector generated 5,419,433 tons of carbon dioxide for that year [11]. However, it is essential to mention that although CO<sub>2</sub> is the gas with the highest atmospheric concentration, it is not the one with the most significant warming potential, which corresponds to sulfur hexafluoride [12]. Likewise, the average generation of Carbon Dioxide and the total GHG Greenhouse Gases are highlighted, which was 0.994 for 2019, according to the United States Environmental Protection Agency (EPA) [13]. According to that entity, this is how the amount of CO<sub>2</sub> emitted per gallon of burned engine gasoline is 8.89\*10<sup>-3</sup> metric tons for the United States of America.

## Design and Methods

The present study focused on analyzing the impact of “Work at Home” implementation due to the COVID-19 virus pandemic under an approach to reducing GHG Greenhouse Gases. It is important to emphasize that the application of the “Work at Home” modality during the contingency originates from the issuance of Circular No. 0021 of March 17, 2020, where work at home is mentioned as a mechanism to be adopted in companies to avoid contagion [14]. The research approach is of a mixed type [15,16]. This type of research is based on three elements: conceptualization and operationalization of the variables, the degree of intervention or application by the researcher, and a solution proposed to a practical problem. In this case, is the approach to the qualitative determination of the reduction of Greenhouse Gases GHG in the workers of several companies when performing their duties from home.

To determine an approximation to the reduction of negative environmental impacts, specifically the decrease in Greenhouse Gases GHG, by the implementation of work at home that over time generated the possibility of alternation, which implied working some days at home and others in the offices, a survey was applied through Google Forms, eleven questions that allowed to investigate aspects such as means of transport used and the type of fuel used, travel time, use of main roads, travel mileage, among others. The sample corresponds to 402 people between employees and independent workers. This survey was applied virtually for two months (October and November)

in 2021, considering Colombia was under a health emergency due to the COVID-19 pandemic following Decree 1026 of 2022 [17]. Subsequently, the annual GHG Greenhouse Gas emissions per passenger vehicle were determined, highlighting that these vehicles are those with two axles and four tires, such as cars, vans, and some buses of the SITP Integrated Public Transport System [18]. For this, equation (1) proposed by the Federal Highway Administration of the United States FHWA [C] was taken to determine the gallons of gasoline consumed per vehicle per year:

$$\text{Issuance of GEI} = \text{Amount of CO}_2 \frac{\text{Metric tons}}{\text{gallon gasoline}} \cdot \text{VMT} \cdot \frac{1}{\text{Average gasoline yield} \frac{\text{millas}}{\text{gallon}}} \cdot \frac{1 \text{CO}_2 \cdot \text{CH}_4 + \text{N}_2\text{O}}{0.994 \text{ de CO}_2}$$

Where,

VMT = average vehicle miles traveled in units of miles/year

CO<sub>2</sub> = Carbon Dioxide

CH<sub>4</sub> = Methane

N<sub>2</sub>O = Nitrous Oxide [18]

It is important to note that the applicable values for Colombia were used according to Colombia’s First Useful Energy balance and the Quantification of related energy Losses and the energy efficiency gap of 2019 [19]. Likewise, the air quality map of the city of Bogotá was consulted, according to the data provided by the Environmental Observatory of Bogotá OAB and the District Secretariat of Environment [20].

## Results

According to the questionnaire, the following information was obtained: 20% of the respondents correspond to independent workers (80 people), and the remaining 80% are employees or workers. It is worth highlighting that 205 people stated that they own a vehicle with a gasoline-based operation, while ten people own hybrid cars and 0<sub>2</sub> people use an electric vehicle. Likewise, according to the adoption of alternation by several companies to reactivate their mission processes, this modality was implemented according to the results of the respondents; 62% had to attend the office at least two times a week (Figures 1-4). In comparison, 30% never heard, and only 7.7% attended thrice weekly. Now, concerning the determination of Greenhouse Gases GHG for the research project in Bogotá, we proceeded to calculate the average value of miles traveled per vehicle according to the answers obtained from the surveys. In this context, taking into account that the result of the question “Number of kilometers traveled or traveled by 2-axle 4-wheeled motor vehicle” was contemplated considering the following options:

Between 0 -10 Km

Between 10 Km – 20 Km

Between 20 Km – 30 Km

Between 30 Km – 40 Km

More than 40 Km

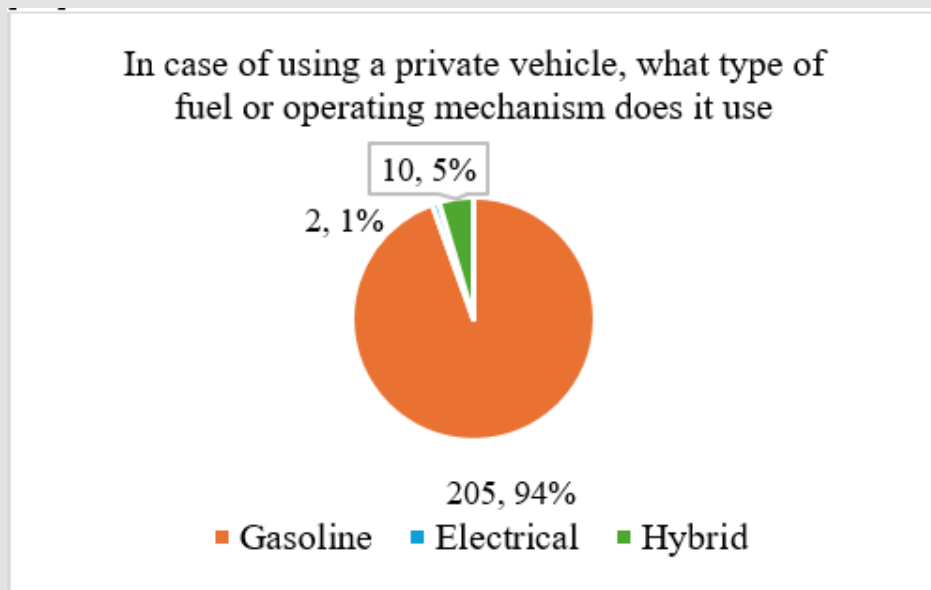


Figure 1: Type of fuel used by an employee and independent vehicles.

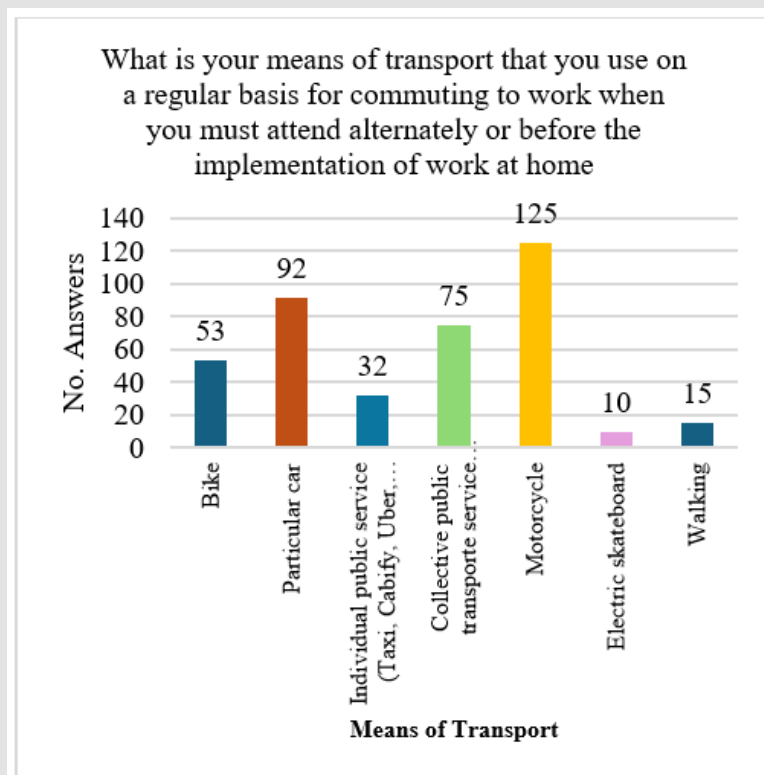


Figure 2: Means of transport during alternation or before mandatory preventive isolation.

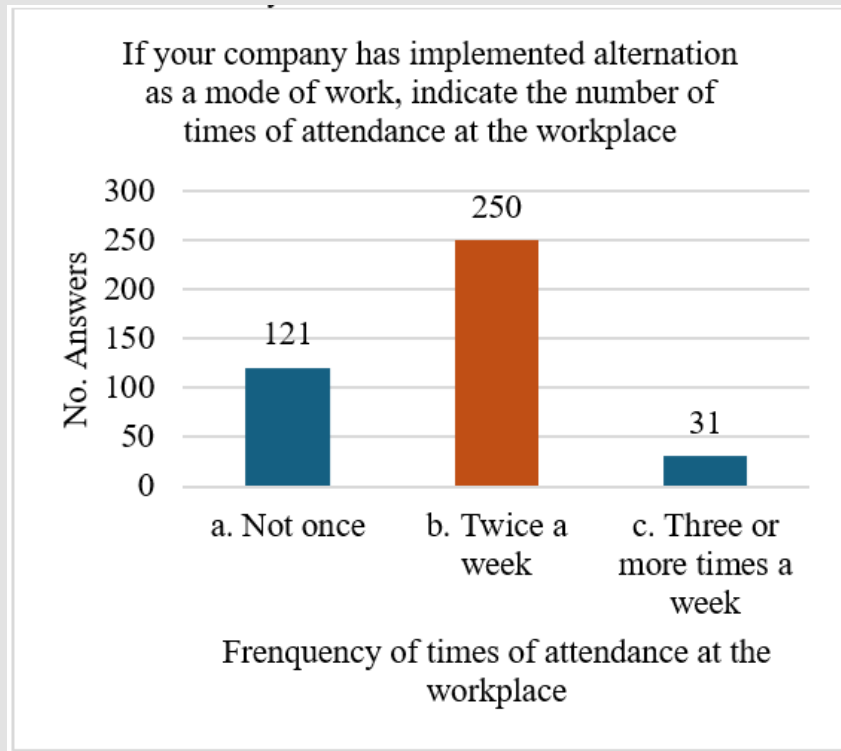


Figure 3: Number of times of attendance at the workplace.

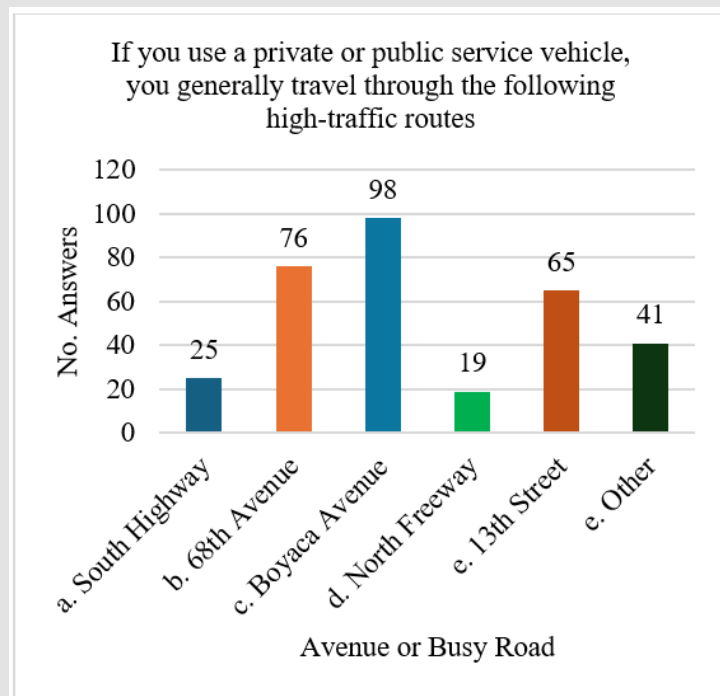


Figure 4: Avenue or Busy Road.

A calculation was made for the average value of each of the selected distance options. Subsequently, the average gasoline performance established by the UPME was calculated [18], taking the values of cars, vans, taxis, buses, Busta, and Microbus. To determine the amount of Carbon dioxide produced by the combustion of gasoline, it was carried out as stipulated by the EPA [13], taking a standard conversion factor of 8,887 grams of CO<sub>2</sub> emissions per gallon of gasoline consumed, if the car models range between the years 2012 and 2016. By having this value in grams, the conversion to metric tons is carried out, so a value of 8.87 \* 10<sup>-3</sup> metric tons of CO<sub>2</sub> / gallon of gasoline is obtained (Table 1). Now, concerning the use of main roads that you should use to move from your place of residence to work, it is essen-

tial to highlight that 98 people say they use Avenida Boyacá, a high vehicular traffic road [21]. Of course, the use of main roads is mentioned considering that these corridors have high concentrations of atmospheric pollutants, as is the case of Avenida 68, the South Highway

Where:

DPUT: Average distance (km) in one way

DPIR: Average distance (km) in round trip

VMT: Average miles traveled or traveled in units of miles/year.

RPG: Average gas mileage (miles/gallon)

CCO<sub>2</sub>G: CO<sub>2</sub> equivalent emission (metric tons CO<sub>2</sub>/vehicle/year)

**Table 1:** Calculation of Greenhouse Gas emission GEI.

Calculation of GHG Emission for the Study Project						
DISTANCE (Km)	DPUT	DPIR	VMT	RPG	CCO <sub>2</sub> G	ECO <sup>2</sup> E NO <sub>2</sub> y CH <sub>4</sub>
Between 0 - 10	5	10	0,017	25,58	0,00887	5,9E-06
Between 10 - 20	15	30	0,051			1,7E-05
Between 20 - 30	25	50	0,085			2,9E-05
Between 30 - 40	35	70	0,119			4,1E-05
More than 40	45	90	0,153			5,3E-05

ECO<sub>2</sub>NO<sub>2</sub> and CH<sub>4</sub> = Emission of CO<sub>2</sub> Equivalents (Metric Tons CO<sub>2</sub> E /vehicle/ year) of Nitrous Oxide and Methane. It is essential to highlight that, to calculate the emission of Carbon Dioxide Equivalents of Nitrous Oxide and Methane, Carbon Dioxide emissions were divided by the proportion of CO<sub>2</sub> emissions and total GHG emissions. It is also highlighted that the average value of gasoline corresponds to the information reported by the Mining Energy Planning Unit for Colombia [18]. Likewise, it is highlighted that of the total respondents, 23.6% work in companies dedicated to technological services, while 18.2% are linked to advisory and consulting entities. In this sense, according to the object or economic activity of the organization, it is feasible to increase or maintain remote work, thus continuing with a low contribution from the said guild in the generation of Greenhouse Gases GHG. In the same way, when mentioning the type of company, it is possible to show that 32.1% belong to Simplified Joint Stock Companies, while 18.4% are from the state sector. That is to say, there is a greater probability of continuing with remote work, whether teleworking, working at home, or remote work in the private sector since in the public sector, fundamental activities such as customer service and other series of actions that have currently led to the majority of the state sector have returned face-to-face to the facilities of the public sector must be guaranteed.

## Discussion

The adoption of Work at Home worldwide has presented a variable in implementing alternation by organizations, as highlighted in

a study conducted by WeWork in 2020 [2]. In this sense, an appreciable percentage of workers want to return to company facilities at least three days a week since, according to Oracle and Workplace [17], 78% of 12,000 employees indicated that quarantine negatively affected their mental health. In several countries of the world, the measurement of CO<sub>2</sub> is carried out through the Carbon Monitor [11]; for example, in the year 2020, when the first wave of the COVID-19 pandemic occurred, a decrease in Carbon dioxide was identified in the countries of the United States, France, and India [21]. According to the results obtained, it is essential to highlight that Colombia issued Law 2169 on December 22, 2021[22]. "Using which the Low-Carbon Development of the Country is promoted through the establishment of minimum goals and measures in the field of Carbon Neutrality and Climate Resilience and other provisions are dictated," where article 12 makes references to the measures of the Transport Sector, among which the following can be mentioned:

1. "Actions to accelerate the transition to electric mobility, designing and implementing policies to establish regulatory and technical standards for the commercialization and operation of electric vehicles with 2, 3, and 4 wheels or more, as well as the promotion of financial instruments that encourage the entry of electric cars.

2. Development of financial instruments that generate enabling conditions for the circulation of at least 600,000 electric vehicles in the country by 2030" [21].



Now, when comparing the percentage of vehicles by category that transit in Bogotá, it is essential to analyze the statistics presented by the District Secretariat of Environment in the annual Air Quality report for the year 2019 for the city of Bogotá [20], approximately 90% of the vehicles that transit in Bogotá is cars (cars, campers, and vans), which represents almost 1,601,744 of the total number of cars that move around the Colombian capital.

A lower generation of CO<sub>2</sub> Equivalent Emissions is highlighted at a shorter travel distance of employees from their homes or places of residence to companies, as exposed by the concentration emitted up to 10 km away (Figure 5). It is also important to note that at a longer distance, there is a higher concentration of metric tons of Carbon Dioxide, so it can be deduced that a smaller number of vehicles can emit a lower amount of Greenhouse Gases GHG.

## Conclusion

The adoption of remote working modalities, such as working at home, teleworking, and remote work at the time of starting the mandatory preventive isolation in several countries to prevent the spread of COVID-19 has allowed for a reduction in the generation of Greenhouse Gases by avoiding the displacement of officials or employees from the place of residence to offices or workplaces. In this sense, it is essential to highlight that according to the Bogotá Cómo Vamos Foundation, approximately 2,400,000 vehicles are circulating in the Colombian capital, of which 50% correspond to cars, 20% to motorcycles and 14% to vans, while only 5% is related to public transport [23]. Likewise, according to the Climate Action Plan for Bogotá, it is contemplated within the zero (0%) reduction goals for reducing vehicle kilometers traveled. In other words, in the face of the Paris agreement. Today, in Bogotá, there are about 2'400.000 vehicles circulating. Of these, 50% are cars, 20% are motorcycles, and 14% are pickup trucks. Only 5% corresponds to public service transport and 2% to yellow taxis. This means that there is a motor vehicle for every three inhabitants, and for every motorcycle, four cars. In other words, given that 125 of the respondents own the vehicle above, motorbikes are the group where the output of greenhouse gases has decreased most significantly, according to the report. In the last five years, the car fleet has grown by 24%, pickup trucks by 62%, and motorcycles by 23%. In contrast, public service vehicles have barely grown by 2 (Bogotá cómo vamos, 2022) [23].

Although it is true that in Colombia and especially in the city of Bogotá, the use of electric skateboards as a means of transport has increased, it is essential to highlight that their use is still reduced considering the safety factor and transport distances. Since the generation of guidelines by the National Government of Colombia, the use of electric vehicles has been encouraged to reduce the generation of Greenhouse Gases GHG. However, it must establish a policy that allows tax relief and access to facilities for people with limited economic resources.

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