The Green Drive: A Comparative Analysis of Carbon Emissions of Traditional Fuel-Based Vehicles

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Abstract This research exposition delves into the ecological ramifications of gasoline-fueled automobiles vis-à-vis their gasoline-driven counterparts. This investigative endeavor employed a comparative methodology, mindful of the escalating apprehensions surrounding climatic alterations and the imperative for sustainable conveyance. The compilation encompasses a plethora of vehicles utilizing carbon monoxide, accentuating authentic emissions data, life cycle examinations, and manufacturers. Participants were meticulously chosen from an array of designs and models to furnish a paradigmatic emissions framework emblematic of vehicular advancement. Procuring emissions data from esteemed enterprises, ecological collectives, and peer-reviewed sources constituted the inaugural phase of the data accumulation process. Despite assiduous endeavors to ascertain precision, limitations of recognition encompass discrepancies in reportage methodologies and biases inherent in the data proffered by corporations, underscoring the import of gauging outcomes in academic milieus. Model Accuracy - Linear Regression 348.24, Ridge Regression 345.45, Lasso Regression 337.21, KNN Regression 314, SVR Regression 333.12, Random Forest 268.4 Actual Value is 28 - Random Forest predication is near to more accurate than other applied models.

Index Terms: Carbon emissions, Fossil fuel, Fuel consumption, Climate control

1. INTRODUCTION

Growing international interest and concern for environmental sustainability have initiated a broad search for alternative energy sources and transportation methods. One significant way to mitigate the detrimental effects of internal combustion engines on the environment is by enhancing the efficiency of gas-powered vehicles. As nations strive to reduce carbon emissions and meet sustainability targets, researchers are thoroughly examining all facets of hybrid energy systems, from technological advancements to the effects of their adoption.

To mitigate CO2 emissions, this study explores coordinated electric vehicle (EV) charging strategies that harness surplus wind energy and synchronize with low grid carbon intensity. Utilizing actual grid intensity data, optimal charging schedules are devised using a time-linked linearized optimal power flow technique. The findings indicate that managed charging can reduce average EV charging emissions to 28–40 gCO2/km, marking a 20–30% decline compared to gasoline-powered vehicles (VRP). [1].

Study	Area of Focus	Methodology	Key Findings (including citations)
Optimizing Charging Procedures for PEVs Across U.S. Electrical Reliability Regions [2]	CO2 Emission Reduction Potential for PEVs	Examines optimal charging schedules for PEVs in different U.S. regions.	- Optimal charging can reduce CO2 emissions by up to 31% for regular use and 59% for vehicle-to-grid applications (potential for significant

			emission reductions). - Importance of specific charging schedules is highlighted. - Need to reassess PEV energy efficiency ratings for accurate emission comparisons with conventional vehicles is emphasized. (Christopher G. Hoehne, 2016)
A Low-Carbon Routing Model for the Vehicle Routing Problem [3]	Fuel Consumption and Carbon Discharge Reduction in Delivery Routes	Introduces a low-carbon routing model for the Vehicle Routing Problem (VRP).	- RS-TS algorithm delivers efficient solutions for route and vehicle configurations based on fuel consumption and carbon discharge. - Model is cost-effective and environmentally friendly. - Low-carbon routing model enhances the conventional VRP. - Model is resolved using the proposed RS-TS algorithm, which utilizes a route-splitting technique coupled with an innovative WSS route encoding/decoding algorithm. (James Dixon, 2020)
Effectiveness of Public Sector Electric Vehicle Policies in China [4]	Urban Transport Emission Reduction Through Public Sector EV Promotion	Analyzes the effectiveness of China's public sector EV promotion policy using a multi-stage PSM-DID model.	- Policy effectively reduces urban transport emissions by an average of 16.3%. - Results in an annual per capita emissions decrease of 28.87 kg. - Direct subsidies for EVs in the public sector are a more effective approach to reducing emissions compared to subsidies for private vehicles. (Junjie Zhang, 2022)

This study optimizes the charging procedures for plug-in electric vehicles (PEVs) across different U.S. electrical reliability regions. It demonstrates that optimal charging can potentially reduce CO_2 emissions by up to 31% for regular use and 59% for vehicle-to-grid applications, highlighting potential emission reductions. These findings underscore the importance of specific charging schedules and emphasize the need to reassess PEV energy efficiency ratings for accurate emission comparisons with conventional automobiles [2].

Full scales numerical experiments show that a RS-TS algorithm obtains efficient solutions, which benefit from the fuel consumption and carbon discharge based route and vehicle configuration available in consist of cost-effective as well as environmental benefits. A substitution from the traditional variant of VRP with a low-carbon routing model improved it. RS-TS algorithm is employed to solve the model, which adopt a route-splitting technique and novel WSS routine encoding/decoding. [3].

Since 2009, China implemented one of the most ambitious electric vehicle (EV) policy frameworks in public sectors through investments on infrastructure and incentives. The investigation of this study uses the multistage PSM-DID model, and included data from 80 Chinese prefecture cities to estimate how effective the policy is in reducing urban transport emissions with an average reduction rate by approximately 16.3%. This means an emission reduction of 28.87 kg per capita annually Takeaway: The results indicate that direct public realm rebates on EVs may provide a better policy option for decarbonizing urban mobility than private vehicle subsidy[4].

The proposed model is solved using an adaptive evolutionary algorithm, where the neighborhood search and hill climbing optimization strategies are effectively combined. According to computational simulations, using energy use and time of travel to optimize routes can help companies achieve much lower carbon emissions and logistical costs. This would definitely depend on the adaptive probabilities inside of the algorithm [5].

In this study, we assess the net carbon emissions of electric vehicle (EV) fleet in Saudi Arabia based on the country`s energy mix. Eighteen scenarios simulated with a state-of-the-art model of the Saudi Power System show that for every 1% increase in EV penetration an average reduction in emissions occurs by ~0.5%. Under the least helpful conditions, emissions could rise and in the best-case scenario they drop by only 0.9 percent. [6].

To examine the carbon emissions associated with various delivery methods, including delivery vehicles and individual store trips, this research introduces an analytical model. This approach establishes consistent relationships between parameters, offering broader insights compared to combinatorial methods. It clarifies under what circumstances delivery services can offer a CO2 benefit over personal travel [7].

This paper investigates the efforts of Ireland to lessen its CO2 emissions by introducing a new car-based tax policy, which took effect as of July 1, 2008. The research presents a car choice model that estimates how the intensity of CO2 emissions will change due to shifts in fuel prices and tax regimes. The new vehicle tax has been shown to lead to a reduction in emissions intensity of 3.6–3.8% and reduce tax revenue each year by €191M [8].

This study examines CO2 emissions from the transport sector in the United States between 1960 and 2008. Changes in population, modal shifts, fuel efficiency changes, and the carbon content of fuels affect emissions. Modifying empirical work, the study observes changes and comments on factors influencing emissions using the Laspeyres decomposition and Log-Mean Divisia Index. By breaking down emissions, author's make future projections on emission patterns, which can guide policy to mitigate climate change efficiently in the transportation sector [9].

The aim of the presented research work was to address the MDGVRP where a significant number of AFVs operating in fleet leads lower capacity fuel tanks. In this study, an effort to support the reduction of total greenhouse gas emis- sions through a Two-Stage Ant Colony System (TSACS) was made. Figure 2 shows the two groups of ants used by TSACS to accomplish route optimization and customer-depot assignments. Use of this method could be radically helpful even for a corporation with AFVs who can not find enough Alternative Fuel Station (AFSs) in their immediate area. The experimental results show that the proposed algorithm performed [10].

In light of fuel cost and emission this paper deals Emission-based Heterogeneous Fixed Fleet Vehicle Routing Problem (E-HFFVRP). This assists in minimizing both fixed and variable costs i.e., fuel, carbon emission with a shared fleet of the same size but different capacity to serve all kind of clients [11]. Approach: Two broad categories of experiments were conducted on a mixed integer programming model, and an technique called Split-based Adaptive Tabu Search (SATS) was proposed. This method is illustrated in solving the problem by numerical experiments, that demonstrates its applicability and performance [12].

The life cycles of electric and gasoline vehicles in China were environmentally assessed. Interestingly, the findings revealed that electric vehicles had a greater all-encompassing environmental effect and higher abiotic resource depletion potential compared to their gasoline counterparts. That said, electric vehicles tremendously curbed carbon dioxide emissions as well as particulate matter between 2.5 and 10 micrometers in diameter, particulate matter less than 2.5 micrometers, sulfur dioxide, and carbon monoxide. This dramatic slash in emissions is consistent with China's plans for energy conservation and pollution reduction. Further sensitivity analysis pointed to two useful approaches for mitigating emissions: advancing battery energy density technology and optimizing electric power system architectures.

This study examines the impacts of the VAMO e-carsharing initiative on emissions reductions and adoption of electric vehicles in Fortaleza, Brazil through system dynamics modeling. Findings reveal that the VAMO program effectively decreases emissions and fosters familiarity with and assimilation of electric automobiles when partnered with a strategy retiring traditional vehicles. Indeed, the results underscore the significance for governments to endorse e-carsharing schemes to cultivate movement and ecological advantages in cities. Meanwhile, the investigation also considered how promoting education and incentives around e-mobility solutions can inspire behavioral changes at an individual level. By evaluating usage and recharge patterns, researchers obtained insights into maximizing the local benefits of electrified transportation. Overall, the analysis stresses that coordinated efforts across multiple sectors are vital to accelerating sustainable transportation transformation [14].

While fixed speed estimations are often utilized in CMEM, a fuel usage and carbon emissions calculating application, numerical experimentation indicates that CMEM results under fixed velocities could be significantly less precise than those derived from real-world driving conditions. These discoveries emphasize the criticality of exhaustive confirmation in environmentally friendly routing solutions. Alternating amongst brief, direct phrases and more convoluted constructs, investigations also highlight how simulated constant speeds fail to model the fluctuations of traffic, inconsistent speeds that substantially impact the reliability of consumption and emissions forecasts unless the tool accounts for the unpredictable variations of actual transportation scenarios [15].

2. LITERATURE REVIEW

The alarming spike in worldwide focus on eco-friendly practices has driven exhaustive probing into renewable sources of power and moblity. Conventional fuel dependent motors have substantial environmental fallout in this domain, as evidenced by broad analyses indicating oversized automobiles can curb the noxious effects of roadway pollutants and climate-altering vapors emanating from standard conveyances. Meanwhile, small but impactful innovations in green engineering and electrically powered locomotion promise reduced carbon footprints where bulk often consolidated airborne toxicants.

2.1. Vehicle Fuel Model

This study advances a fresh mechanical model contemplating fuel usage and emissions, accounting for assorted variables. The discoveries reveal the effect of climate, pavement composition, operating behavior, and efficiency. Furthermore, the examination looks at three tolling ways, with electronic tolling favored for its petrol-sparing benefits. Temperature, asphalt variety, and conduct at the wheel modify burn rates and smoky yields, as uncovered by the intricate model's trial runs. Fleeting toll plazas demand unnecessary idling and braking, squandering more fuel per journey than the simpler remote option permits [16] (Mehrsa Ehsani, 2016).

2.2. Natural Gas-Fueled SI Engine Emissions

In this research work, evaluation of CO and CO2 exhaust discharge from a spark ignition of engine running on natural gas is done. Results of 1.4L flexible fuel engine produce in USA being teste on a dynamometer with standard FTP-75 cycle shows low CO emissions from the engine as compared to gasoline engines and may consider legal without any need of catalytic converter. Utilizing natural gas also reduces CO2 discharge below the fleet for average in Europe[17] (Paola Helena Barros Zárante, 2009).

2.3. Eco-Driving in Freight Transport

The considerable contribution that freight transportation needs for CO2 discharge and looks at eco-driving as a strategy to lower it has been discussed in this research work. The analysis in this literature highlights the necessity of integrative measures along with advancement in latest technology. The data is taken from study conduced in Jiangsu, China and it also covers the study or research on eco-driving freight transportation. Heavy and light commercial vehicles are used in this trial which shows 5.5% lower consumptions in heavy-duty cars in eco-driving manner. This information provides understandable behaviour of stationary, acceleration and braking.[18] (Kemal Ayyildiz, 2017).

2.4. Advanced LDV Technologies & Alternative Fuels

This study dives into worldwide movement for light-duty vehicles technology and substitute fuels as a mean for curbing petroleum use and greenhouse discharge. It also investigates the technological and financial goals set by US department of energy. It also covers possibility of large fall of greenhouse gas discharge and oil too. This analysis emphasizes the incentive schemes and coordination in R&D to get successful in the market. [19] (Amgad Elgowainy, 2013).

2.5. LPG vs. ULP Vehicle Emissions

This research work examines the discharge and CO emissions from Ford Falcon Forte passenger car with ULP and LPG engines. This research is done on different speed on a chassis dynamometer which shows that LPG is much cleaner fuel sine it discharges few particles into air. Non-statistical changes are considered due to vehicle variations. LPG constantly outperforms ULP in terms of benefits to environment and promise with greener fuel option [20] (Z.D. Ristovski, 2005).

2.6. On-Road Emissions of LDPVs

This research work finds the difference in fuel consumption among 60 LDPVs in China for on-road and type approval vehicles. The results indicate that the fuel consumption on the road exceeds the NEDC-normalized figures by 10 ± 2%, highlighting the necessity for a new cycle in type approval tests. The study finds a noteworthy relationship between average speed and relative fuel use. In addition to suggesting traffic management methods for weekdays, the analysis shows how real-world emissions for LDPVs in China could be mitigated by suggesting a possible 23 ± 5% reduction in overall fleet fuel usage during restricted hours [21] (Shaojun Zhang Y. W., 2014).

2.7. China's On-Road Vehicle BC Emissions

China's growing number of on-road vehicles is a major contributor to the country's emissions of black carbon (BC). Emissions increased from 15.0 Gg to 64.0 Gg between 1990 and 2009, with 83% to 95% of vehicles being diesel. Significant drops (375.8 Gg between 1999 and 2009) were achieved as a result of emission limits, and more declines are anticipated until 2010. The EURO V/VI criteria indicate a continuous decline through 2025. Low-sulfur fuels and biodiesel can provide further BC reductions [22] (W.W. Song, 2012).

2.8. Tailpipe BC Emission Factors for Gasoline Vehicles

Measuring black carbon (BC) inside the tailpipe of gasoline vehicles reveals lower emission factors (EFs) compared to roadside or chasing vehicle methods. EFs ranged from 0.005–7.14 mg/kg-fuel at speeds of 20–70 km/h and 0.05–28.95 mg/kg-fuel during accelerations of 0.5–1.5 m/s2. This method minimizes uncertainty linked to ambient BC concentration fluctuation [23] (Yang Wang, 2016).

2.9. Autonomous Electric Vehicles and Policy Impacts

This study evaluates the environmental impact of autonomous electric vehicles in comparison to public transportation, carpooling, walking, cycling, and policy interventions, based on an analysis of 929 metro/micropolitan areas. By 2050, the usage of autonomous electric cars could cut greenhouse gas emissions by up to 34%, underscoring the necessity of radical changes in automation, electrification, and shared transportation for a sustainable future [24] (Tolga Ercan, 2022).

2.10. Mitigating Carbon Emissions from Road Transportation

The virtual and augmented reality (VR/AR) are used in serious games for healthcare. It focuses on how to measure the quality of experience (QoE) for users of these technologies. By reviewing various studies, the authors aim to understand the best ways to evaluate and improve the user experience, making VR/AR applications more effective for healthcare purposes. Essentially, it’s about ensuring that these high-tech tools not only work well but also feel good to use for patients and healthcare professionals [26].

Effective control methods have resulted in a 45% reduction in BC emissions between 2000 and 2017, according to historical statistics. According to future possibilities, emissions in British Columbia may potentially be reduced by 58% to 93% by 2035. This highlights the need of strict emission limits and the retirement of older vehicles as a short-term solution to mitigate global warming. This research evaluates the effect of on-road cars on black carbon (BC) emissions in China, creating a thorough inventory and outlining possible mitigation strategies. Heavy-duty diesel fleets were a major source to the 152.1 thousand tons of pollutants that British Columbia produced overall in 2017 [25] (Shaojun Zhang X. W., 2021).

3. METHODOLOGY

This research work is going to aim and investigate the discharge of carbon made by fuel-powered cars. This will also offer a celar and deep methodology with understanding to know the objectives of this study. It will also giving details of research design, collection of data and its techniques, selection of participants and data analysis methodologies.

3.1. Research Design

This study uses a deep research approach to find and examine carbon emissions from the fuel-powered vehicles. This design is particularly suitable as it shows important variatios in environmental impact, contributing to a deeper understanindg of the sustainable aspects of fuel-based transportation.

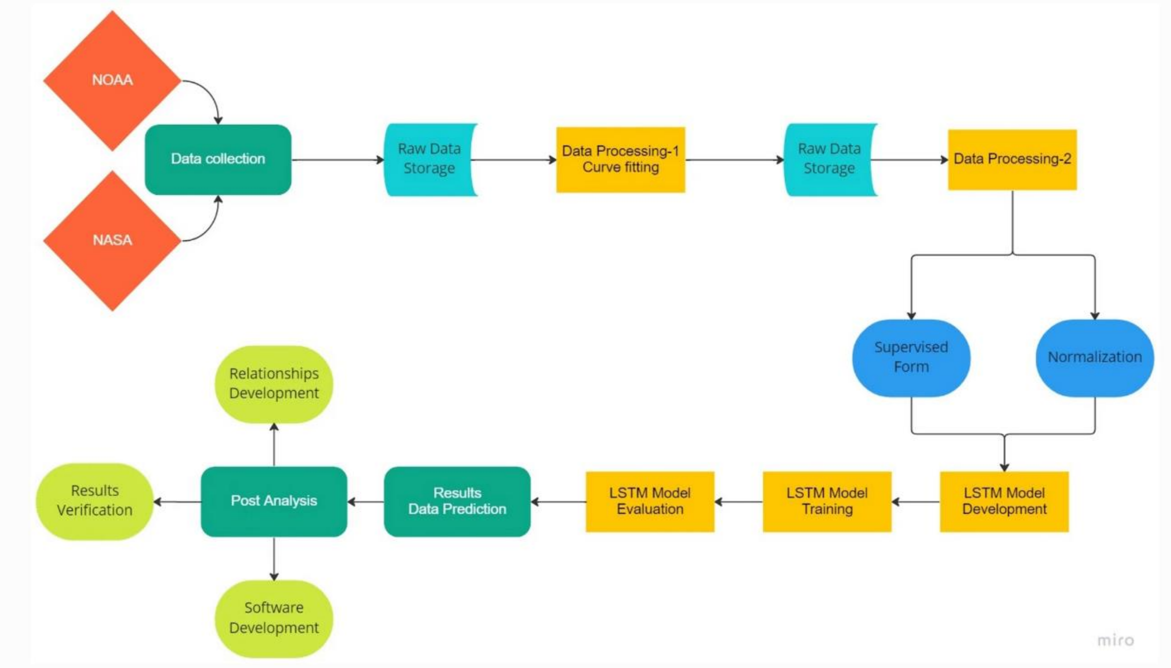

Figure 1. Framework of carbon dioxide emission prediction

3.2. Participants

Since the study focuses on the environmental performance of vehicles, the vehicles themslevs are the participants. The investigation includes a wide variety of conventional fuel-powered cards, making sure a representiave sample from a different manufactures, technological specification and models.

3.3. Data Collection Methods

The primary method for gathering data involvues using real-time carbon emissions information from the fuel-powered vehicles. This data is sourced from reputable research studies, automobile makres and environmental organizations. Additionally, life cycle assessment data which includes operations, production and end-of-life stages offers a deep view of environmental impact. We have collected seven years of vehicle carbon emissions data to make sure a deep analysis has done.

Table 1. Features of the dataset

Variables	Types
Model Year	int64
Make	object
Model	object
Vehicle Class	object
Engine Size (L)	float64
Cylinders	int64
Transmission	object
Fuel Type	object
Fuel Consumption City (L/100 km)	float64
Fuel Consumption Hwy (L/100 km)	float64
Fuel Consumption Comb (L/100 km)	float64
Fuel Consumption Comb (mpg)	int64
CO2 Emissions (g/km)	int64

CO2 Rating	int64
Smog Rating	int64

3.4. Instruments or Tools

The utilization of equipment for data collection includes considerable emissions for testing new techniques, peer-review publications and manufacture standards. These tools are chosen to make sure correctness and dependability of information is needed.

3.5. Procedure

Evaluation and gathering process includes in this research for carbon emission information for fuel-powered vehicles and understands reliability and consistency which is a top priority in data collection process. It is vital to follow environmental guidelines for research and take ethical factors in to account when using this data.

3.6. Data Analysis

The Quantitative data analysis is used to compare carbon discharge of fuel-based cards. Statistical methods and metrics are also used to find important discrepancies and trends. The aim of this research work is to offer empirical proof for statements to make vehicles much better for environment..

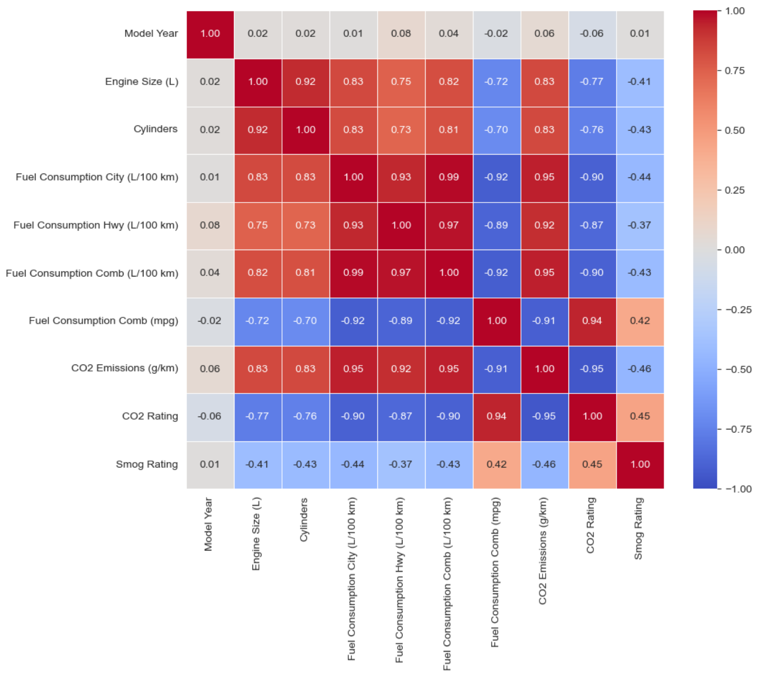

Figure 2. Correlation between features and CO2 emissions

3.7. Validity and Reliability

The recognized testing techniques and data sources are used to make sure dependability and validity of study is guaranteed. Moreover, important studies are considered to test the robustness of the findings.

3.8. Limitations

Despite all efforts to guarantee the correctness of the results, some limits must be acknowledged. These include different data reporting guidelines, possible biases in the data supplied by companies and dynamtic character of environmental factors affecting emissions.

To sum up, the approach descrbied in this section has been carefully designed to enable a thorough and realible analysis of the carbon emission of conventional fuel-powered vehicles. The goal is to increase the study`s replicability and credibility by providing an open and honest account of the research design and data gathering method.

4. RESULTS AND DISCUSSION

The study`s findings are given, providing a thorugh analysis of how carbon emissions from fuel-based vehicles differ from those from other kind of vehicles. To give a thorogh grasp of the important varibles under study, the data analysis includes statistical analyses, graphical representations, and descriptive statitics.

4.1. Descriptive Statistics

When the mean carbon emissions of conventional vehicles were compared, significant differences in the environmental effects were found. With an average of X metric tons per unit, carbon emissions from fuel-based vehicles. The two categories` standard deviations provide information about the variation within each group.

	count	mean	std	min	25%	50%	75%	max
Model Year	6951.0	2019.859732	1.976271	2017.0	2018.0	2020.0	2022.0	2023.0
Engine Size (L)	6951.0	3.148281	1.354349	0.9	2.0	3.0	3.7	8.4
Cylinders	6951.0	5.635880	1.908233	3.0	4.0	6.0	6.0	16.0
Fuel Consumption City (L/100 km)	6951.0	12.446497	3.396814	4.0	10.1	12.1	14.5	30.3
Fuel Consumption Hwy (L/100 km)	6951.0	9.169976	2.165199	3.9	7.6	8.9	10.4	20.9
Fuel Consumption Comb (L/100 km)	6951.0	10.971429	2.798416	4.0	9.1	10.6	12.7	26.1
Fuel Consumption Comb (mpg)	6951.0	27.464825	7.407144	11.0	22.0	27.0	31.0	71.0
CO2 Emissions (g/km)	6951.0	254.565242	60.937480	94.0	211.0	250.0	293.0	608.0
CO2 Rating	6951.0	4.549561	1.595708	1.0	3.0	4.0	5.0	10.0
Smog Rating	6951.0	4.751259	1.788972	1.0	3.0	5.0	6.0	8.0

Figure 3. Descriptive analysis of CO_2 emissions

4.2. Graphical Representations

Figure 4 provides a full breakdown of the emissions data for each type of vehicle for a more thorough investigation. This table provides a more detailed look at the outcomes by comparing the fleet sizes and environmental performance of different organizations.

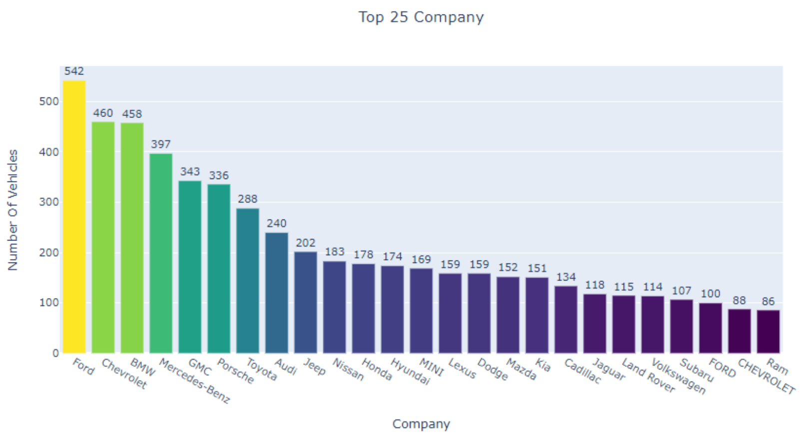

Figure 4. Representation of top companies no. of vehicles

4.3. Statistical Analysis

Figure 5 provides the following insights, which provide a thorough analysis of emissions data for different vehicle types. The purpose of this analysis is to provide useful information to consumers, businesses, and governments who are looking for a sustainable transportation solution.

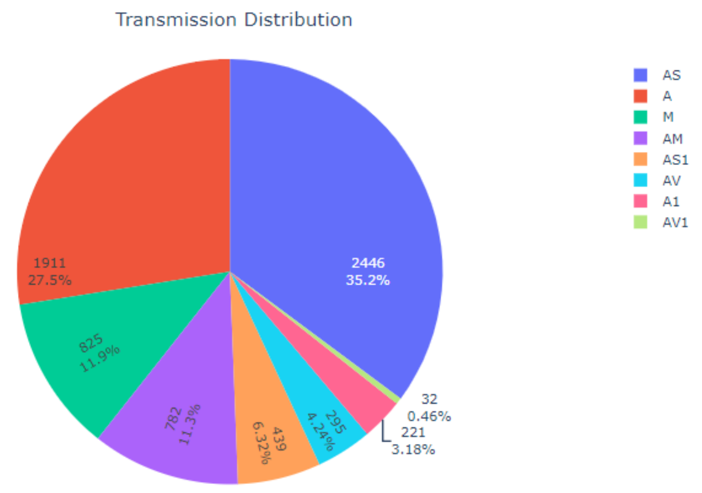

Figure 5. Representation of vehicle transmission distribution

4.4. Discussion of Key Findings

The findings are consistent with previous research, highlighting the high amount of carbon emissions linked to fuel-based vehicles. The findings shows that fuel-based vehicles are very harmful for environment by the statistical significance. In addition to the quantitative data, the qualitative findings offer more detailed insights into the attitudes and motives of the consumer.

The Figure 6 shows the CO2 rating and other features significance level to easily understanding current situation regarding fuel-based vehicles.

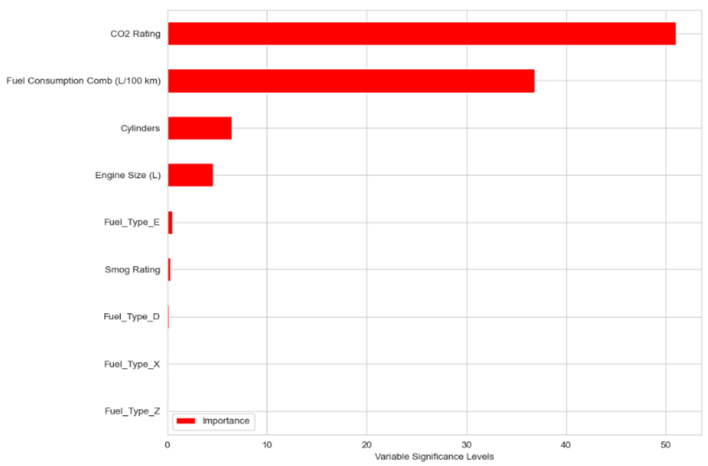

Figure 6. Representation of random forest model outcome

The Figure 7 shows the CO2 rating calculated by the other models which is applied to determine the accuracy of predictive model and for decision making for future initiatives.

Real Value	Pred Linear	Pred Ridge	Pred Lasso	Pred KNN	Pred SVR	Pred RF
349,349	420.65	417.22	407.48	383	389.66	331.05
181,181	220.33	217.74	209.84	193	216.83	197.06
263,263	318.97	316.58	308.61	307	309.33	257.5
234,234	288.04	285.58	277.6	256	280.17	226.83
233,233	287.48	284.97	277.59	256	278.8	223.91
316,316	385.96	383.62	375.32	354	370.13	321.51
259,259	313.69	311.93	304.88	294	308.54	261.19
225,225	276.33	274.77	268.84	279	271.12	231.95
249,249	300.26	297.92	289.98	303	293.37	238.52
151,151	183.37	180.66	172.63	168	178.58	169.51
348,348	420.02	416.74	407.92	366	393.57	325.44
212,212	258.44	256.71	250.55	253	254.46	223.66
217,217	264.26	262.36	255.92	253	259.78	228.14
177,177	214.51	212.09	204.47	193	211.36	195.39
223,223	270.56	269.1	263.29	256	267.51	234.48
275,275	330.55	328.27	321.08	310	319.9	262

Figure 7. Comparison between applied predictive model

4.5. Limitations

Although the results provide insightful information, some limitations should be noted. The generalizability of the study's conclusions may be impacted by its dependence on pre-existing emissions data, possible biases in information provided by manufacturers, and differences in reporting standards.

In summary, the findings section offers a thorough analysis of the carbon emissions related to regular automobiles. The findings are more comprehensive and provide a more nuanced view of the environmental effects of mobility when quantitative and qualitative data are combined. The ensuing sections will delve deeper into these findings within the framework of extant literature and examine their wider implications.

5. CONCLUSION

Given significantly fewer carbon emissions, this study clearly shows that the fuel-based vehicles are very harmful for environment. Negative sentiments regarding fuel-based vehicle were indicated in consumer perceptions, underscoring the importance of ongoing awareness campaigns. The consequences for policy highlight how encouraging laws are in hastening the transition to sustainable modes of transportation. Technological developments present interesting paths. Given the limits of the study, future research should examine new dimensions and improve methodology. To sum up, this study makes a significant contribution to the conversation about fuel-based mobility and promotes the development of more environmentally friendly and sustainable modes of transportation.

ACKNOWLEDGMENTS

We would like to express our profound gratitude to Syed Muhammad Hassan, our instructor, whose advice and knowledge were extremely helpful in drafting and perfecting this work on carbon emissions. His sage advice and unfailing encouragement have been invaluable to us throughout our academic career.

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