STUDY OF FUEL CONSUMPTION AND GHG EMISSION OF MOTORCYCLES IN DHAKA TO OFFSET POLLUTION BY USE OF AN ALTERNATIVE BIOFUEL

A Thesis by

Muhaimin Wasif Anindo

Md Khaledun Newaz Shefat

MD. Mustakim Abtahi

Department of Mechanical and Production Engineering

Islamic University of Technology

May (2022)

STUDY OF FUEL CONSUMPTION AND GHG EMISSION OF MOTORCYCLES IN DHAKA TO OFFSET POLLUTION BY USE OF AN ALTERNATIVE BIOFUEL

Muhaimin Wasif Anindo, 170011042

Md Khaledun Newaz Shefat, 170011046

MD. Mustakim Abtahi, 170011047

A graduation exercise submitted to

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

in partial fulfillment of the requirements
for the Degree of

Bachelor of Science in Mechanical Engineering

May (2022)

CERTIFICATE OF RESEARCH

*This thesis titled "**STUDY OF FUEL CONSUMPTION AND GHG EMISSION OF MOTORCYCLES IN DHAKA TO OFFSET POLLUTION BY USE OF AN ALTERNATIVE BIOFUEL**" submitted by **MUHAIMIN WASIF ANINDO** (170011042), **MD KHALEDUN NEWAZ SHEFAT** (170011046) and **MD. MUSTAKIM ABTAHI** (170011047) has been accepted as satisfactory in partial fulfillment of the requirement for the Degree of Bachelor of Science in Mechanical Engineering.*

Supervisor

____

Prof. Dr. Shamsuddin Ahmed

Professor

Head of the Department

____

Prof. Dr. Md. Anayet Ullah Patwari

Professor

Department of Mechanical and Production Engineering (MPE)

Islamic University of Technology (IUT)

DECLARATION

I hereby declare that this thesis entitled *"STUDY OF FUEL CONSUMPTION AND GHG EMISSION OF MOTORCYCLES IN DHAKA TO OFFSET POLLUTION BY USE OF AN ALTERNATIVE BIOFUEL"* is an authentic report of our study carried out as requirement for the award of degree B.Sc. (Mechanical Engineering) at Islamic University of Technology, Gazipur, Dhaka, under the supervision of Prof. Dr. Shamsuddin Ahmed, MPE, IUT in the year 2022.

The matter embodied in this thesis has not been submitted in part or full to any other institute for award of any degree.

____

Muhaimin Wasif Anindo
170011042

____

Md Khaledun Newaz Shefat
170011046

____

MD. Mustakim Abtahi
170011047

Abstract

The recent decade has been a prosperous period for Bangladesh's economic growth, which has elevated the country's economic position to developing or emergent. The accelerating expansion of this country's GDP from the Indian subcontinent is especially noticeable among the economic growth and rising living standards of the wealthier segments of the population. This implies that private automobiles are preferred for everyday commuting in the capital city of Dhaka, which is home to the majority of vital government offices, business hubs, renowned educational institutions, and hospitals. Private automobiles positively improve lifestyle. However, the engine emissions have severe effects on the environment and the local population. Dhaka is one of the cities with the lowest air quality index rankings. This necessitates an investigation of the role of automotive exhausts to Dhaka's total air pollution. In this research, a survey of private motorcycles operating in the city of Dhaka was done to collect data that could be used to analyze the fuel consumption, energy need, and GHG emission of various kinds of private vehicles. The survey performed in various areas of the city of Dhaka and through internet platforms yielded crucial information that was useful for analyzing the situation from several angles. Comparative analyses of fuel efficiency, average annual fuel consumption, average yearly energy demand, and average annual carbon dioxide emissions of various vehicle models were conducted, with a sample size ensuring a confidence level of 95 percent for the overall population size, in case of gasoline and also ethanol blend fuel. In compared to the capacity of Dhaka's highways, the total number of motorcycles that use them every day is astronomical, resulting in terrible traffic congestion virtually every weekday. Traffic congestion has a negative impact on fuel consumption, and the resulting energy waste and GHG emissions must be detected prior to making remedial decisions. In this research, the traffic congestion factor that results in extra losses and emissions has been measured for motorcycles of various makes and years. On the basis of the survey, the yearly fuel and energy requirements and carbon dioxide emissions of the total number of private cars have been determined. Also, alternate fuel E10 has been studied with respect to gasoline as a viable alternative, and lower emission was observed as per calculations.

Keywords: GHG emission, fuel consumption, motorcycle, alternative fuel, ethanol blend, E10

Acknowledgment

We would like to admit our gratitude and submission to Almighty Allah for granting us the ability to finish our work within time with appropriateness. Without His constant blessings our total thesis work could have been more difficult. We are deeply indebted to Prof. Dr. Shamsuddin Ahmed, Department of Mechanical and Production Engineering for his constant support and guidance. We are also grateful to Prof. Dr. Mohammad Ahsan Habib and Mahmood Hasan, Lecturer, Department of Mechanical and Production Engineering as their past research helped significantly in our work. Finally, we appreciate and thank every survey participant who provided us with significant data in online and offline platforms.

Table of Contents

List of Figures

List of Tables

List of Symbols and Abbreviations

GHG	Green House Gas
CO_2	Carbon Dioxide
CO	Carbon Monoxide
NO_x	Nitrogen Oxide
CH	Hydrocarbon
GWP	Global Warming Potential
M_{avg}	Average Annual Mileage of the Vehicle
M	Current Mileage of the Vehicle
Y_C	Current Year
Y_R	Registration Year of the Vehicle
FC_{avg}	Average Annual Fuel Consumption for Gasoline
FC	Fuel Consumption Rate of the Motorcycle
E_{avg}	Annual Energy Consumptions
$CO_{2, avg}$	Yearly CO_2 Emission from Gasoline
Eq_{CO2}	Amount of equivalent CO2 emissions

Chapter 1: Introduction

1.1 Background of study

There are currently more than 8.09 lac motorcycles registered in Dhaka, which is 48.9% of the total registered motor vehicles and 77% of the motorcycles have higher emissions than the standard value, which is significantly worsening the air quality index.

As Dhaka's population expands, so does the number of motor cars, which is one of the most convenient modes of transportation. However, the growing number of automobiles has created traffic congestion on Dhaka's roadway. As a result, people are gravitating toward motorbikes since they are less expensive, more fuel efficient, and take up less space on the road. If the main route is congested, motorcycles can take the smaller roads, lanes, and alleyways. As a result, we're seeing an inflow of customers looking to acquire motorcycles. Since 2016, the number of motorcycles manufactured and registered has increased at an exponential rate. As the number of motorbikes grows at an exponential rate, so does the amount of pollutants produced by motorcycles.

Hybrid or electric bikes are not feasible since battery packs demand a lot of room, which is not available on motorcycles due to their tiny size. Installing a smaller battery pack is also not an option because the mileage would be significantly reduced, which would be undesirable. As a result, we must develop an alternate fuel to decrease or eliminate the GHG emissions created by motorbikes. To comprehend the differences in emissions for alternative fuels, we must first compute the emissions for present fuels and then compare the findings. As a result, to maximize the quantity of sample data collected, a survey would have to be conducted both online and offline. This would give us an idea about the trends in existing fuel, motorcycle brands and their engine capacity along with their mileage. The different calculated parameters would be the annual average mileage, annual average fuel consumption, annual average energy consumption, GHG emission and Global warming potential (GWP). Then the calculated data can be shown graphically to compare between the different types of fuels

1.2 Problem statement

Because the number of motorcyclists on Dhaka's roads is growing, traffic is growing as well, which implies that average vehicle speeds are dropping dramatically. This results in increased fuel usage and greenhouse gas emissions. This increases the carbon footprint and has a significant impact on not just general global warming but also local air quality.

Due to a lack of major study, field data on motorbike fuel consumption and GHG emissions in Dhaka is not easily available. Because poor-grade gasoline is used by the majority of motorbikes, emissions are greater and fuel economy is low. Although most bikes built after 2010 can operate on biofuel, the future of these fuels has not been studied, and no other fuel is used on motorcycles save gasoline, therefore the viability of utilizing a biofuel like E10 in lieu of gasoline is uncertain.

Our key challenge is to compute motorcycle fuel usage so that we can calculate and compare GHG emissions from gasoline and biofuels, and then suggest an alternate fuel for motorcycles to minimize total emissions from motorcycles.

1.3 Objectives of the study

The goal of the research is to compare the energy consumption and greenhouse gas output of a single-fuel (gasoline) and a biofuel (gasoline and ethanol) system.

The study's strategies include the following:

- Conduct a survey on motorbike fuel usage and performance in Dhaka.
- To calculate the energy consumption and greenhouse gas emissions of all gasoline-powered motorcycles.
- To calculate energy usage and GHG emissions using E10 and compare them.
- To determine the CO2 equivalent of GHG emissions.

1.4 Scopes of the study

The study focuses on the fuel consumption of motorcycles so that we can calculate the energy consumption and GHG emissions from the fuels. The scopes of this study are:

- Conducting a survey to collect sample data.
- Calculation of GHG emissions.
- Results and analysis of data to publish a comprehensive report showing the comparisons of the fuels.

- The Python Script developed as part of the project can be integrated into a mobile application using which users can provide input data and find emission and fuel consumption values for their vehicles directly.

1.5 Limitations of the study

Different grades of gasoline (petrol & octane) are available in the country. The study considers standard gasoline energy density and emission values based on MIT datasheet and also standard E10 of 98RON.

- E10 fuel is not commercially available in the country so its cost analysis with respect to gasoline was not possible.
- The conducted survey has some extent of human error as the participants might have assumed or approximated fuel consumption rate or mileage data.
- The study is standardized for CO, CH and NOx emissions considering average traffic speed of Dhaka, but as vehicles travel at variable speeds, the real values may slightly differ from standard values.
- The study does not include micro-emissions like particulate matter and SO_x

1.6 Methodology

- At first, we have determined the sample size for a valid research by using the Krejcie & Morgan method.
- We have created and circulated a survey form for sample data collection. Data was collected by circulating the form online and on-field survey by interacting with motorcyclists.
- All the collected data was sorted accordingly and the invalid data were discarded.
- Calculations were done to determine the annual average mileage, annual average fuel consumption, annual average energy consumption, GHG emissions (CO_2, CO, HC, NO_x) and the Global warming potential (GWP).
- Then the results were tabulated and graphically presented to show a comparison between Gasoline and the proposed Biofuel.

1.7 Contributions of the study

The study was conducted based on some fixed parameters such as type of motor vehicle (motorcycle), grade of fuel, blend of biofuel and types of emission. But the same methodology can be followed to perform researches by including many more parameters. Some of them are:

- Similar research model can be modified and applied on performance analysis of other vehicles like bus, trucks, CNG auto rickshaw etc.
- The study can be applied to a wide range of bio-ethanol blends for feasibility analysis like E15, E20 and E30.
- Using data collected in the study, micro-emissions of motor vehicles can be evaluated further.

Chapter 2: Literature Review

2.1 Automotive Industry

The automobile industry is still one of the world's greatest industrial sectors, but it suffers from a strong emphasis on technology and a short-term orientation. The industry and its network of consultants and analysts place little attention on the larger social and economic effects of automobility and the sector that delivers it.

The automobile sector is distinguished by its highly concentrated company structure: a small number of enormous corporations have a disproportionate degree of influence on smaller enterprises. Eleven leading companies from Japan, Germany, and the United States dominate manufacturing in the major markets. In the 1990s, a tidal wave of mergers and acquisitions and equity-based partnerships expanded the worldwide reach of both leading corporations and the biggest suppliers.

Due to political sensitivity, a second distinguishing characteristic of the automobile industry is that final vehicle assembly and, by extension, components manufacture have been generally maintained close to end markets.

A third distinguishing characteristic is its robust regional organization. Since the mid-1980s, the automobile sector has grown increasingly interconnected on a worldwide basis, but it has also created robust regional patterns of integration.

A fourth distinguishing characteristic of the automobile sector is the scarcity of totally generic components and subsystems that can be used to a broad range of final products without considerable customization.

A larger degree of global integration has evolved at the level of design in the automobile sector, as multinational corporations have tried to leverage design efforts across products marketed in numerous end markets. The design and development of vehicles continues to be centered in or near the headquarters of market-leading companies.

Since 1975, the global automobile manufacturing has more than quadrupled, from 33 million to approximately 73 million in 2007. From 1975 to 1990, global vehicle production expanded at an average yearly rate of around 2 percent; from 1990 to 2005, this pace increased to approximately 3 percent. Table 1 displays the motor vehicle production for selected nations from 1996 to 2006 in thousands of units and as a percentage of increase in thousands of units and percentages. [1]

Table 1 Compound Annual Growth Rate (CAGR). [2]

	1996	*1998*	*2000*	*2002*	*2004*	*2006*	*Growth rate (%)*
China	1,240	1,628	2,009	3,251	5,071	7,272	19.3
India	541	535	867	892	1,511	1,876	13.2
Republic of Korea	2,354	1,787	2,858	3,148	3,469	3,840	5.0
France	2,359	2,923	3,352	3,693	3,666	3,164	3.0
Brazil	1,813	1,547	1,671	1,793	2,210	2,597	3.6
Mexico	1,222	1,460	1,923	1,805	1,555	2,043	5.3
Russian Federation	1,029	1,021	1,203	1,220	1,388	1,495	3.8
Germany	4,843	5,727	5,527	5,145	5,570	5,818	1.8
Spain	2,412	2,826	3,033	2,855	3,012	2,776	1.4
Canada	2,397	2,570	2,962	2,629	2,712	2,544	0.6
Japan	10,346	10,050	10,141	10,258	10,512	11,484	1.0
United States	11,832	12,003	12,774	12,280	11,988	11,351	–0.4
United Kingdom	1,924	1,976	1,814	1,821	1,856	1,650	–1.5
Italy	1,545	1,693	1,738	1,427	1,142	1,212	–2.4

2.2 Automobiles in Bangladesh

With approximately 2.5 automobiles per 1,000 inhabitants, the country's automotive sector, particularly the passenger vehicle market, remains small in comparison to other Asian countries. The market has grown over the years and is now a $1 billion business (BDT 84,969 million).

According to the Bangladesh Road Transport Authority (BRTA), 377,660 cars were registered in Bangladesh in 2020, however only 20,093 belonged to the passenger vehicle category, accounting for just 5.3% of the automotive industry volume, while motorbikes controlled the remaining 82.7%.

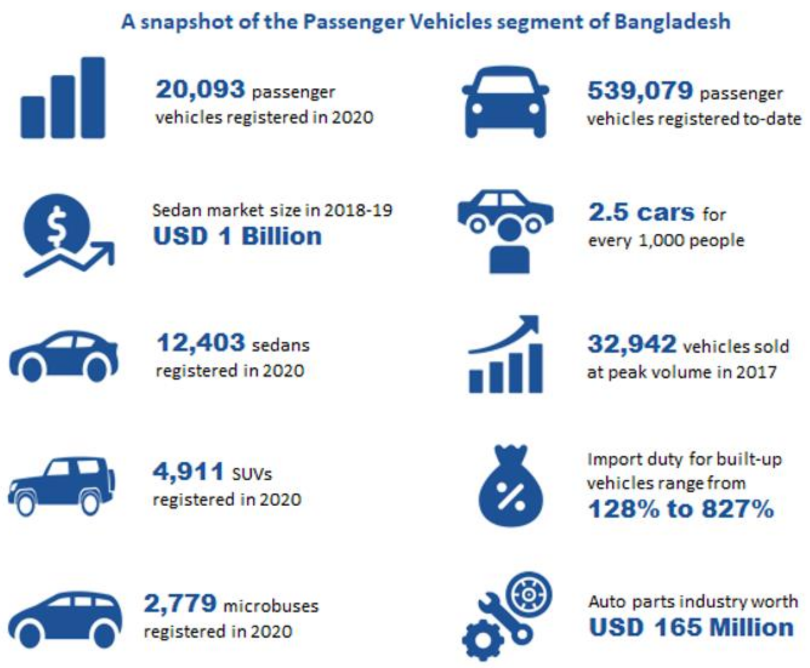

Figure 1 Snapshot of the Passenger Vehicle Segment of Bangladesh / Source: PRI, BRTA Data and The Business Standard [3]

Sedans or private automobiles, sport utility vehicles (SUV) or jeeps, and microbuses or multipurpose vehicles are examples of passenger vehicles (MPV). With 12,403 units registered in 2020, sedans (commonly known as private vehicles) accounted for about 55 percent of the passenger vehicle market. SUVs and microbuses took the balance of the passenger vehicle market with 4,911 and 2,779 units, respectively. [4] Despite its growing affluent middle-class population and increasing purchasing power of the general mass, Bangladesh's automobile industry has remained somewhat of an anomaly.

Table 2 NUMBER OF REGISTERED MOTOR VEHICLES IN BANGLADESH (YEARWISE)[5]

Sl. No	Type of Vehicles	2014	2015	2016	2017	2018	2019	Up to June 2020	Grand Total
1	Ambulance	338	480	378	495	564	667	311	6669
2	Auto Rickshaw	19897	20000	11173	9168	21638	30967	10217	309488
3	Auto Tempo	500	1095	1322	1592	609	228	42	20850
4	Bus	1488	2391	3833	3760	2755	3606	1501	51419
5	Cargo Van	608	399	1017	1413	1280	4	1	9702
6	Covered Van	2869	2354	3340	5176	5729	3042	792	35006
7	Delivery Van	1176	1719	2181	2410	2100	1531	515	31367
8	Human Hauler	225	1142	3487	3393	1423	510	91	19043
9	Jeep (Hard/Soft)	1870	3601	4892	5425	5555	5630	1943	66219
10	Microbus	4313	5224	5804	5575	4137	3683	1149	105896
11	Minibus	256	323	472	492	436	837	285	29418
12	**Motor Cycle**	**90685**	**240358**	**332057**	**326550**	**395603**	**406897**	**138193**	**2991612**
13	Pick Up (Double/Single Cabin)	9554	10257	11371	13512	13097	11952	4372	130993
14	Private Passenger Car	14699	21062	20304	21959	18227	16783	5009	370519
15	Special Purpose Vehicle	172	296	620	993	1339	1182	330	12152
16	Tanker	362	324	394	319	529	419	166	5957
17	Taxicab	374	88	44	15	161	11	6	45377
18	Tractor	1522	1699	2576	2777	3553	2561	856	46723
19	Truck	8136	6330	7275	10353	12663	8326	2229	154974
20	Others	1595	2073	3870	5021	5976	5294	2007	28241
TOTAL		160639	321215	416410	420398	497374	504130	170015	4471625

These figures have also altered over the last several years, with SUVs and MPVs generally seeing a modest growth in demand while sedan registrations have fluctuated or even declined.

In the last decade, the vehicle market in Bangladesh has expanded significantly, particularly between 2015 and 2017. BRTA recorded 32,942 registered passenger cars in 2017 at its peak, although this number has subsequently declined. The number of registered passenger cars has decreased by over 39 percent between 2018 and 2020.[3]

2.3 Energy Sources

Energy sources are prospective energy types that may be used to do tasks. Renewable energy sources are those that continually and swiftly regenerate themselves for consistent and dependable usage. All other energy sources are deemed nonrenewable. Fossil fuels, such as coal, peat, crude petroleum, and natural gas, are nonrenewable energy sources. Solar, hydro, tidal, wind, ocean, geothermal, and biomass energy are examples of renewable energy sources. Fusion and fission are the two forms of nuclear energy.

Energy may be derived from a variety of resources and is categorized into two sorts depending on this fact:

1. Renewable energy and

2. Non-renewable energy

A source of energy that may be used to generate heat, light, or electricity. Energy is used to express the quantity of labor accomplished. There are two forms of energy: kinetic energy, which refers to the work produced by the motion of matter, and potential energy, which refers to the work stored or at rest. In the kinetic and potential states, energy may exist in one of the following five forms:

(1) Chemical energy is the outcome of changes in the chemical structure of substances, such as during the burning of fuel.

(2) Electrons and protons in motion inside an electric current or temporarily stored in a battery or fuel cell provide electrical energy.

(3) Mechanical energy arises from the application of force to liquid, solid, or gaseous matter, or its impending application.

(4) Thermal energy is the outcome of applying heat to matter.

(5) Nuclear fission is the splitting of an atom's nucleus into two or more fragments by impact with neutrons, resulting in the release of the force that holds the protons and

neutrons of the nucleus together. All life on Earth is dependent on one or more of these energy sources and must use a vast array of energy sources.

Nonrenewable stored-over-time (capital)	Fossil:	coal peat crude petroleum natural gas	Combustion process
	Nuclear:	uranium thorium deuterium lithium beryllium	Noncombustion process
Renewable daily	Solar:	solar thermal conversion, photoelectric energy conversion — direct photochemical conversion, stored solar heat with heat pumps — indirect	
	Hydro:	river–reservoir energy conversion	
	Tidal:	tidal energy conversion	
	Wind:	windmill energy conversion	
	Oceans:	ocean heat conversion ocean current conversion wave energy conversion	
	Geothermal:	natural steam hot water hot dry rocks	
	Biomass:	wood and other vegetation	Combustion process

Figure 2 Renewable & Non-renewable sources

Renewable energy sources are types of potential energy that continually and swiftly regenerate themselves for consistent and dependable usage. Renewable energy sources include solar and wind power. Nonrenewable energy is any type of potential energy that does not fit inside the established definition of renewable energy.

2.3.1 Fossil fuels

Over millions of years, crude petroleum, natural gas, and coal originated in the Earth's crust and now reside in underground regions. Crude petroleum is discovered trapped in the pores of rock (sandstone, limestone, or dolomite) or sand overlain with an impermeable cap rock that keeps the liquid from spreading. Natural gas is often found trapped in the Earth alongside or in conjunction with crude petroleum.

2.3.2 Nuclear energy

Fusion and fission are the two forms of nuclear energy. During fission, heavy atoms are divided into two primary elements that form the nucleus of two new, lighter atoms. During fusion, the nuclei of two tiny atoms combine to form a bigger nucleus. In both instances, significant amounts of energy are released.

2.3.3 Nuclear fission

Fission reactions involve the disintegration of the nucleus of atoms with a high mass. They provide an energy release that is almost a million times larger than chemical processes that include the combustion of a fuel. The fission process requires bombarding atoms with neutrons such that a significant number of statistically predicted collisions will occur, splitting the atoms into two or more distinct nuclei while releasing large amounts of thermal energy.

2.3.4 Nuclear fusion

The opposite of the fission process is fusion. Instead of dividing atoms into two or more parts, the fusion process induces the collision of two atoms with sufficient force that their inherent electrical repulsion is overcome and their nuclei fuse into one. Interest in the nuclear fusion process stems from the possibility that it may one day be used to generate useful energy. Deuterium, the primary fusion fuel, occurs naturally and is virtually inexhaustible (by separating heavy hydrogen from water, 1 atom of deuterium occurs for every 6500 atoms of hydrogen), so solving the fusion power problem would permanently solve the problem of the rapid depletion of chemically valuable fossil fuels. In contrast to uranium fission, the absence of radioactive waste products from the fusion process is another reason in favor of fusion for energy generation. Although this energy source has enormous promise for the twenty-first century, it must first overcome great obstacles before it can be employed.

2.3.5 Solar energy

The Sun is by far the most appealing energy source since it is free, clean, non-polluting, and does not need the use of depleting, limited fossil fuel supplies. Solar energy is used for space comfort conditioning of buildings, industrial activities, and power generation. Photovoltaics directly convert solar energy to electricity. By utilizing a collector to capture solar radiation, solar energy may also be transformed to usable work or heat, with the majority of the Sun's radiant energy being converted to heat. This heat may be transformed into electricity. This is known as solar power concentration (CSP).

2.3.6 Hydro energy

One of the earliest energy-producing systems employs water flowing in a river or dropping from a height to spin work equipment, from ancient waterwheels to current hydroelectric dams with enormous electricity-generating turbines.

2.3.7 Tidal energy

The first significant operational tidal energy project was the Rance River project in Brittany, France. The French project utilizes a barrage-style dam over a river estuary. When the tide rises, turbines in this barrage pump water into the estuary. When enough water has accumulated in the estuary, the water is allowed to run back through the turbines to generate energy.

2.3.8 Wind energy

Wind energy is a renewable form of electricity that has almost no environmental risks. However, wind energy has its limits. Wind turbines can only be installed when there is sufficient wind. These high-wind regions may not be readily accessible or located near existing high-voltage transmission lines for the transmission of wind-generated electricity. Another problem is that the need for power fluctuates over time, and the generation of energy must match the demand cycle.

2.3.9 Ocean energy

Future energy sources may include ocean power, either as wave power or ocean temperature difference. In Scandinavia, a wave-power system was created to utilize the wave motion of the ocean, so that ocean waves force large amounts of water to flow into the device, which then creates electricity as the water attempts to escape back into the ocean. The ocean thermal energy conversion (OTEC) system is based on the temperature difference in the oceans around the Equator, where the surface water is about 20°C (40°F) warmer than the water several thousand feet below. This temperature differential may be used to evaporate a working fluid (such as ammonia) that can then be pumped through a turbine that generates energy.

2.3.10 Geothermal energy

The thermodynamic basis for geothermal energy generation is the temperature differential between a mass of subterranean rock and water and a mass of water or air at the Earth's surface. This temperature differential permits the generation of thermal energy, which may be used directly or turned into mechanical or electrical energy. Several reasons have contributed to the broad use of geothermal energy for electricity production. Countries with abundant geothermal resources have aspired to develop their own resources as opposed to importing fuel for electricity production. Geothermal steam has become an interesting alternative to conventional power production due to its environmental advantages.

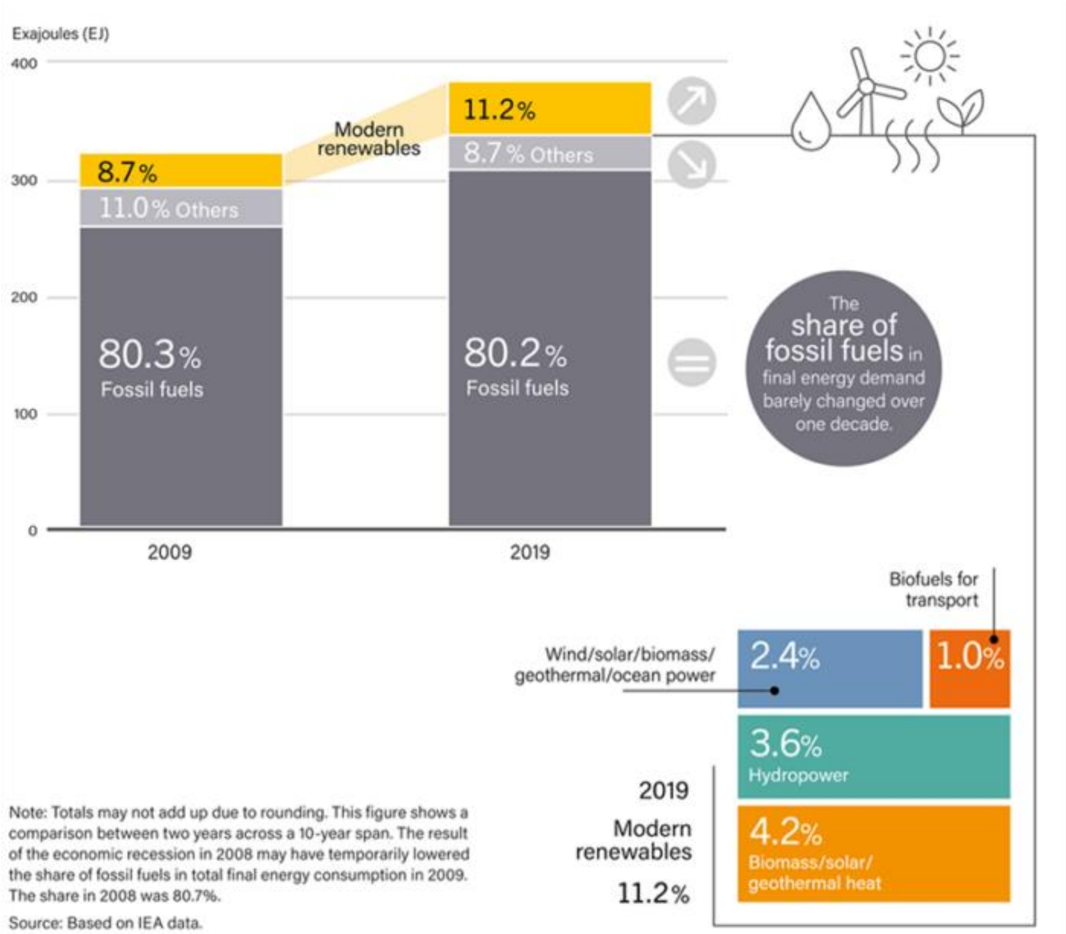

Figure 3 Estimated Global Renewable Energy Share of Total Final Energy Consumption (2009-2019)[6]

2.3.11 Biomass energy

As applied to the field of energy, the term biomass energy encompasses a wide variety of energy sources: Any and all forms of living matter that can be converted into a form of energy are considered biomass. This includes wood, wood waste, coffee grounds, corn husks, peanut shells, rice hulls, garbage, animal and human waste, sugarcane waste (bagasse), and organic effluent from streams and ponds. Biomass may be transformed into liquid fuels that can be burnt to create heat or power.

2.4 Overview of Fossil Fuels

Fossil fuels are derived from plants and animals that have decomposed. These fuels are found in the crust of the Earth and include carbon and hydrogen that may be burnt to produce energy. Examples of fossil fuels include coal, oil, and natural gas. Approximately 84 percent of the world's energy consumption demands are satisfied by fossil fuels in 2019, with oil accounting for 33.05 percent, natural gas for 24.2%, and coal for 27.3%. Back millions of years, when plants, animals, and other organisms perished and were buried, fossil fuels were generated. Due to heat and pressure in the earth's crust, their remnants eventually transformed into coal, oil, and gas over the course of time. These are the three primary kinds of fossil fuels, all of which were created from the decomposition of plants and animals. Since their formation required millions of years, they are often known as nonrenewable energy sources. This implies that after they have expired, they cannot be used again. Over the course of a number of years, these decomposing plants and animals were transformed into coal, a black crystalline material, oil or petroleum, and natural gas. Fuels are substances that release energy when burned, and the act of burning is known as combustion. Heat is the mechanism that facilitates the release of energy during combustion. A fuel may be a solid, liquid, or gas, and its energy can be utilized either directly, as in heating a home, or indirectly, by passing it through a boiler to create steam for operating an engine. Occasionally, the gasoline is used in the engine.

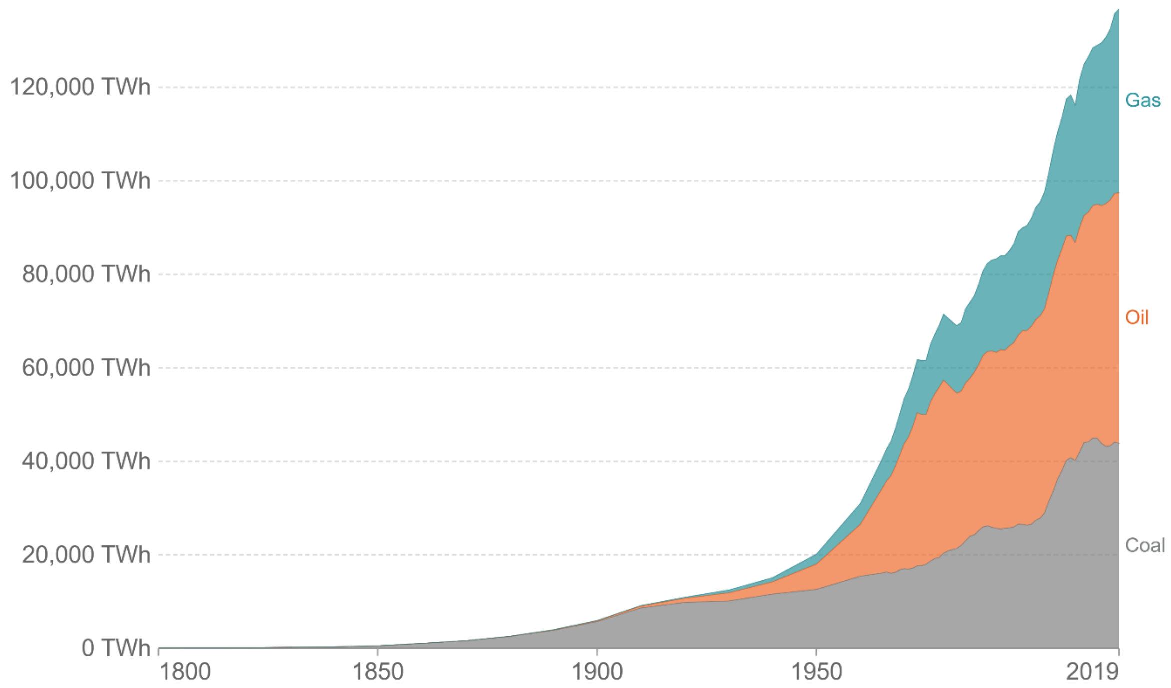

Figure 4 Global fossil fuel consumption[7]

Coal

Water, carbon, hydrogen, sulfur, nitrogen, oxygen, and ash are the primary chemical elements of coal (noncombustible mineral residue). Coal is not, however, a uniform material. Its composition is almost endlessly diverse from one site to another, even within the same mining location. Coal is used for electricity generation, metal manufacture, general industrial operations, home and commercial applications, and synthetic fuels. The majority of coal is burnt in fire-tube or water-tube boilers to produce steam for generating power, heating industries and buildings, and facilitating manufacturing processes.

Peat

In the earliest phases of coal production, accumulations of decomposed and partly decomposed plants, trees, ferns, and mosses in a damp, cold, and anaerobic (oxygen-deficient) environment are expected to transform into peat at a pace of around 7.5 centimeters (3 inches) every 100 years. Since just a portion of the cellulose and other organic elements in peat are converted to carbon and hydrocarbons, peat has between one-third and one-half the heating value of coals. After being extracted from the ground and compressed into briquettes, it is utilized in extremely small amounts as a fuel source.

Crude petroleum

Similarly, oil is a complex chemical formed from the decomposed remnants of trees, ferns, mosses, and other sorts of plant matter. Carbon, hydrogen, and sulfur are the primary chemical ingredients of oil. Crude petroleum produced from the ground will burn and create thermal energy, but practically all crude oil is refined into a variety of useful fuels and specific goods (such as feedstock for chemicals, plastics, food, medications, and tires, as well as tar and asphalts). Jet fuel, gasoline, kerosene, diesel fuel, and heavy fuel oils are the many fuels that may be produced from crude oil. Transportation, residential-commercial usage, industry boilers and other industrial uses, and electricity generation account for the majority of oil use.

Natural gas

This energy source is composed of 83–93 percent methane (CH_4), with carbon and hydrogen as its primary chemical elements. Natural gas is often found in close proximity to crude oil, however some natural gas wells do not produce oil. Natural gas may be the most ideal chemical or mineral source of energy since it can be piped directly to the consumer, does not need storage vessels or air-pollution control equipment, generates no ash for disposal, and combines efficiently with air to achieve full combustion at low excess air. Natural gas is primarily used for residential, commercial, industrial, transportation-related, and electric power generation purposes.

It took millions of years for fossil fuels to form, yet they dissipate in seconds. They are taken from various corners of the globe. Coal is one of the fossil fuels that is widely utilized to generate power. Our automobiles are powered by petroleum. We all utilize fossil fuels in some capacity every day. Just like anything else, fossil fuels have a detrimental impact on the ecosystem. Carbon dioxide is a result of the combustion of fossil fuels. They emit carbon dioxide and other gases when burned. Carbon dioxide is one of the main causes of global warming. By quickly collecting and burning these fossil fuels, we are harming the ecosystem. They cannot be reused since they are nonrenewable. Using renewable energy sources, such as solar, wind, and geothermal, is the answer to the aforementioned issues.

2.5 Energy Consumption of Conventional Vehicles

A life cycle of a conventional car can be distributed into four steps, according to Fysikopoulos et.al [8] They are raw material processing, car manufacturing, car use, and car recovery.

Depending on the kind of gasoline used in a typical automobile, the energy consumption varies. Even for the same vehicle, energy usage varies based on distance traveled, driving experience, and environment. Automobiles are always being improved by automakers to lower their energy usage.

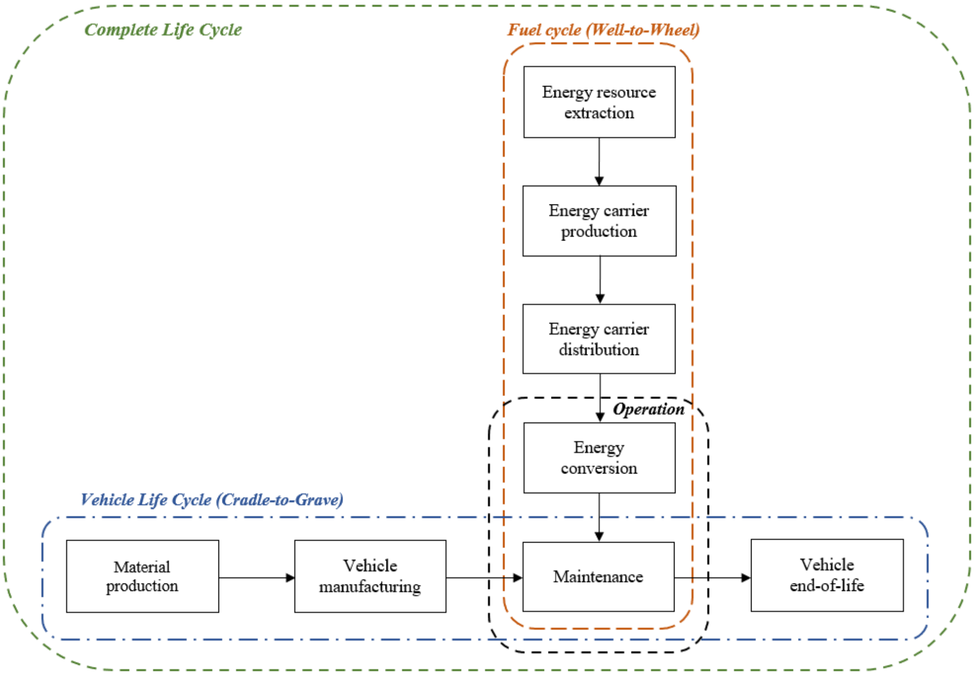

Figure 5 Energy Consumption Life Cycle of Conventional Vehicles[9]

2.6 Overview of Motorcycle Engines

Motorcycles are motorized transport vehicles for one or two people. Motorcycles typically have two wheels, however any vehicle with less than four wheels in contact with the ground may be considered a motorbike.

Modern motorcycle design was founded in 1914 and has remained substantially unaltered since then. A motorcycle's construction and operation are rather straightforward. It contains a gasoline engine that turns the reciprocating action of pistons into rotational motion, similar to an automobile's engine. This motion is transferred to the rear wheel through a transmission system. The turning of the rear wheel moves the motorbike ahead. By spinning the front wheel with the handlebars and leaning the bicycle to one side or the other, the rider may steer the bicycle. Two hand levers control the clutch and front brake, while two-foot pedals allow the rider to change gears and handle the rear brake.

A motorbike engine is capable of producing tremendous amounts of power.

They include pistons, a cylinder block, and a head that houses the valve train. The pistons rise and fall in the cylinder block as a result of the explosions of a fuel-air combination ignited by a spark. To enable the fuel-air combination to enter the combustion chamber, valves open and shut. As the pistons rise and fall, they rotate the crankshaft, which converts the pistons' energy into rotational motion. The gearbox transmits the rotational force of the crankshaft to the rear wheel of the motorbike.

Motorcycle engines are often categorized based on one of three characteristics: the number of cylinders, the volume of their combustion chambers, or the number of power strokes.

Single-Cylinder Motorcycle Engines, Parallel Twin Motorcycle Engines, V-Twin or L-Twin Motorcycle Engines, and Inline Motorcycle Engines are among the most prevalent motorcycle engines.

2.7 Gasoline-Ethanol blends

The creation of engines that can operate on gasoline, ethanol, or any combination of the two is one of the most recent developments in the vehicle industry. Among the several alcohols, ethanol is the most suited fuel for spark-ignition (SI) engines. Ethanol's ability to be produced from renewable energy sources, such as agricultural feedstock, plus its high-octane number and flame speed make it an attractive SI engine fuel.[11]

These engines are known as "flex-fuel" engines, and they have gained popularity since car owners are no longer dependent on the price and availability of ethanol. The phrase "flex-fuel" suggests that the engine can operate on a variety of fuel types, hence providing fuel flexibility.

Ethanol is an eco-friendly fuel since it is derived from renewable sources of energy. It aids in reducing CO2 levels in the atmosphere via the photosynthesis of plant life. Anhydrous ethanol has a maximum water mass content of 0.7% at 20 degrees Celsius and is utilized as an antiknock additive in amounts ranging from 20% to 25% in normal gasoline. Hydrous ethanol has a maximum of 7.4 percent water and is used to fuel automobiles and light trucks.

In SI engines, ethanol may be used directly or combined with gasoline. Pure ethanol necessitates engine and fuel system modifications; however, it may be used in SI engines without modification if blended with gasoline in small amounts. Using gasoline–ethanol mixes with small levels of ethanol may improve engine performance and reduce emissions, according to some sources. Despite the fact that pure ethanol has a low vapor pressure, the Reid vapor pressure (RVP) of gasoline–ethanol mixes increases with increasing amounts of ethanol.

Clemente et al. [12] detailed the overall gains made in the creation of an engine that runs on hydrous ethanol (water content 7%) or a 22 percent ethanol/78 percent gasoline combination. When compared to an ethanol-gasoline combination, hydrous ethanol boosted peak torque and peak power by 9 and 14 percent, respectively.

Li et al.[12] converted a gasoline-fueled motorbike spark ignition engine to run on ethanol. When ethanol was employed as a fuel, the authors saw an increase in torque and power. The results revealed that using oxygenated gasoline reduced HC and CO emissions while increasing NOX emissions at full load. Reduced HC and NOX emissions, but also reduced power production, were the results of delayed ignition timing. The physical–chemical properties of hydrous ethanol and the gasoline-ethanol mix are shown in Table 3.

Table 3: Properties of Biofuel[13]

Parameter	**78% Gasoline 22% ethanol**	**Hydrous ethanol**
Density (kg/l)	0.74	0.81
Lower heating value (kcal/kg)	9400	5970
Stoichiometric air/fuel ratio	13.1	8.70
Chemical structure	$C_{6.39}H_{13.60}O_{0.61}$	$C_2H_{6.16}O_{1.08}$
Carbon mass (%)	76.7	50.59
Hydrogen mass (%)	13.6	12.98
Oxygen mass (%)	9.7	36.42
Sulphur mass (%)	0.09	0
Self-ignition temperature (°C)	400	420

Vaporization Temperature (°C)	40-220	78
Vaporization heat (kcal/kg)	105	237
Research octane number (RON)	-	106
Motor Octane Number (MON)	80	87
Vapor pressure	27.5	29
Laminar flame speed (m/s)	0.30	0.42

Because gasoline and ethanol are immiscible, phase separation can occur in gasoline–ethanol mixes. The use of semi-polar cosolvents (solubility improvers) like isopropanol can help overcome this problem.

2.8 Alternate Fuel scenarios

Fuel requirements

The following Are some of the requirements for gasoline fuels, as Well as for alternative fuels for SI applications.

• Octane number

• Flammability related to lean limit and combustion stability

• Laminar burning velocity

• LHV (of air–fuel mixture)

• Volatility; boiling curve; vapor pressure

The octane value influences the knock resistance of a fuel and is a determining factor in determining if an alternate fuel is suitable for SI combustion. Depending on the measurement technique, the octane Number may be presented as either Research Octane Number (RON) or Motor Octane Number (MON). Standard (regular) gasoline has RON and MON values of 91 and 82.5, respectively, for the given market. [14]

Biodiesel

Biodiesel is a substitute fuel derived from bio-origin feedstock. Several oil feedstocks may be converted into fuel. Included in this category are vegetable Oil, animal fat, and used cooking oil. The most prevalent raw sources for biodiesel fuel are rapeseed and soybean oils. In 2013, soybean oil alone accounted for almost 65 percent of U.S. output.

The LHV of biodiesel is lower than that of regular diesel fuel, although its cetane number is often higher. Additionally, biodiesel has a greater flash point than normal diesel, which is favorable for fuel storage and transportation safety. Due to the greater proportion of saturated fatty acids, biodiesel has higher cloud and pouring points than normal diesel. The cloud and pour points indicate the lowest temperatures at which a fuel may be pumped before crystallizing. Higher cloud and pour points are an impediment to the usage of blends containing substantial amounts of biodiesel, since they hinder cold-start performance. [15]

Compressed Natural Gas

Natural gas was often produced as a byproduct of crude oil processing. Typically, the unneeded Gas was burnt. The supply of natural gas, followed by the development of technology for mining shale gas, has become another factor favoring the increased use of the fuel in ICEs. The sources of natural gas presently include oil fields, coal beds, and shale gas-storing gas fields. Natural gas has the highest LHV per unit of mass of all fuels. [15]

Liquefied Petroleum Gas

There are now three different LPG production sources. First, light component fuels such as propane and butane are produced as a byproduct of crude oil refining via distillation, reforming, and other processes. These gases are collected and have been extensively employed as alternative fuels in the passenger car sector in some regional markets. The second source is the Processing during the extraction of natural gas (or non-associated Gas). The last source comes from the oil extraction process.

LPG is essentially a combination of propane, propylene, iso-butane, and n-butane, despite the fact that its composition varies widely around the world. Each of the four species has an octane rating more than RON 100, which is greater than that of gasoline. Therefore, increasing the Engine's compression ratio using LPG fuel is also achievable. The high-octane number of LPG is advantageous for boosting the thermal efficiency of the brakes by optimizing the ignition timing without knocking and raising the compression ratio.

Methanol and Ethanol based fuel

As a fuel for automobiles, alcohol gained popularity. Attention has been drawn to the possibility for greater thermal efficiency and reduced GHG emissions as a result of its unique features and renewable generation by plants. As automobile fuels, methanol

(CH_3OH), ethanol (C_2H_5OH), propanol (C_3H_7OH), and butanol (C_4H_9OH) are recognized to be among the alcohol fuels. The introduction of methanol and ethanol as alternative fuels was a success. For traditional spark ignition engines in the form of fuel additives, blended fuels, and bi-fuels, owing to technical and economic considerations.[16]

There are two primary industrial manufacturing methods for ethanol. One method involves the interaction of ethane with steam, while the other involves the fermentation of alcohol. Ethanol is commonly referred to as bio-ethanol due to the fact that it is manufactured from renewable bio-organic materials that may function as carbon sinks over its existence.

Compared to gasoline, methanol and ethanol have much lower LHVs. However, alcohol fuels have higher octane ratings, which is beneficial for achieving greater thermal efficiency. Between 300 and 400 K, the vapor pressure of gasoline is greater and its boiling point is lower than that of ethanol. In order to use ethanol fuel, it is necessary to address engine stability and emission issues during cold-start conditions. [17]

There are various types of Ethanol-gasoline blends commercially available in the market depending on the amount of Ethanol and the Research octane number (RON) of the blend.

For the same composition of blend, a higher RON means a fuel that can provide more energy. On the other hand, for the same RON, a higher percentage of ethanol in the fuel means the fuel has more energy.

For our study, we have chosen the E10 fuel which is a blend of 10% ethanol in gasoline. In an experiment conducted by Leone[16], we can see that E10 fuel with different RON, exhibit different properties. The blend with higher RON has more energy and less emissions after combustion.

In another experiment, Leone used E10, E20 & E30 fuel with the same RON number to find out the significance of ethanol percentage and how it effects the performance.

The knocking behavior of the fuels depend on the engine condition, RON and sensitivity of the fuel in a certain RPM range of the engine Operation. [16][17]

The emission changes based on the percentage of ethanol. Thus, E10 has a higher CO_2 emission compared to E30 fuel. However, E30 has much higher HC emission compared to the E10 fuel. [18]

2.9 Effect of Ethanol

1. Air fuel ratio:

The equivalence air–fuel ratio decreases as the E% increases to 20%. This effect is attributed to two factors:

- The decrease in the stoichiometric air–fuel ratio of the fuel blends, since the stoichiometric air–fuel ratio of ethanol fuel is usually lower than that of the unleaded gasoline fuel
- The increase of actual air–fuel ratio of the blends as a result of the oxygen content in ethanol. [18]

2. Brake torque and brake power

Torque (T) and Brake Power (Bp) both rise with increasing E percent at all engine speeds. This growth will continue until E percent reaches 20%. Following this moment, T and Bp begin to drop. This behavior is consistent with the volumetric and thermal brake Efficiencies. In general, the braking torque depends significantly on the volumetric efficiency and just little on the engine speed. Consequently, the impact of engine speed on T is comparable to its impact on volumetric efficiency. [20][18]

3. Exhaust emissions:

It can be seen that as the E% increases to 20%, the CO and HC concentrations decrease and then increases for all engine speeds. The CO2 concentrations have an opposite behavior when compared to the CO concentrations. This is due to improving the combustion process as a result of the oxygen content in the ethanol fuel.[20]

2.10 Exhaust Emissions and GHG

Total VOCs minus methane equals non-methane organic gases (NMOG). The EPA defines VOCs as "any carbon molecule that participates in air photochemical processes, except carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate."

Wallington et. Al[21] has concluded in his study that, neutral or favorable emission changes with increasing ethanol content over the cycles tested. However, starting engines at very low ambient temperatures has historically been problematic with high ethanol content fuel (E85 and hydrous E100) with PFI engines, resulting in excessive cranking and high unburned HC emissions.

According to the U.S. EPA, "alcohol fuels are inherently cleaner than conventional gasoline because they do not contain toxics such as benzene. In addition, they are made of simpler chemical compounds which yield lower levels of complex combustion by-products.

Hasan et al[22] has described the effect of ethanol blends as per his experiments and stated that with the increase of E% in fuel, the power output increases slightly while the CO_2, CO, NOx, HC, THC emissions reduced significantly.

Costagliola et. al [23] has summarized in his studies that the emission of particulate matters reduced by almost 90% in alcohol blend biofuels compared to gasolines. Also, a 50% reduction of benzene and 1,3-butadiene emissions, classified as carcinogenic to humans was achieved with E85 blend.

Aleksandra et. al[24] stated that by using biofuel blends in IC engine, polycyclic aromatic hydrocarbons (PAH) emissions has also reduced significantly.

Many studies have been done on SI engines as well as flex-fuel vehicles using either pure ethanol or ethanol–gasoline blends as a fuel and they have concluded that the emissions depend on the percentage of ethanol (E%) in the fuel. However, Masum et. al [25] has found out the emissions can change depending on various engine parameters such as engine load, compression ratio, cold starting condition, equivalence ratio and engine speed.

NOx Formation:

Thermal NOx

During combustion, at temperatures above 1800 K, atmospheric nitrogen reacts with oxygen through a series of chemical steps known as the Zeldovich mechanism.[22]

$$\mathrm{O + N_2 \rightarrow NO + N}$$
$$\mathrm{N + O_2 \rightarrow NO + O}$$
$$\mathrm{N + OH \rightarrow NO + H}$$

Prompt NO_x

The presence of a second mechanism leading to NOx formation was first identified by Fenimore [26] and was termed "prompt NOx". During combustion of hydrocarbon fuels, some NOx is quickly formed before formation of thermal NOx, in the laminar premixed flame zone, which is known as prompt NOx.

$$
\begin{aligned}
&\mathrm{CH + N_2 \leftrightarrow HCN + N} \\
&\mathrm{CH_2 + N_2 \leftrightarrow HON + NH} \\
&\mathrm{N + O_2 \leftrightarrow NO + O} \\
&\mathrm{HCN + OH \leftrightarrow CN + H_2O} \\
&\mathrm{CN + O_2 \leftrightarrow NO + CO}
\end{aligned}
$$

Intermediate NO_x

The NOx formation by this pathway is another essential mechanism in a combustion process under high pressure and lean air–fuel ratio or low temperature condition compared to Fenimore NO, and a minor contribution to the formation of NOx related to the thermal NO mechanism. [27]

$$
\begin{aligned}
&\mathrm{O + N_2 + M \leftrightarrow N_2O + M} \\
&\mathrm{H + N_2O \leftrightarrow NO + NH} \\
&\mathrm{O + N_2O \leftrightarrow NO + NO}
\end{aligned}
$$

Chapter 3: Experimental Design

The study focuses on identifying motorcycle-related issues and important metrics in Dhaka. Prior to doing the study, extensive research was undertaken in a variety of publications, theses, books, and websites.

The purpose of this study is to collect data on the fuel consumption and greenhouse gas emissions of motorbikes licensed in the Dhaka Metropolitan region. The purpose of this research is to determine the link between engine capacity, manufacture year, registration year, mileage, starting mileage, fuel consumption rate, yearly fuel consumption, annual emission, and related cost, among other variables. The survey is conducted both online and offline. As noticed throughout the survey period, offline data collection has been more effective and informative. Field survey was done in several areas of Dhaka, including Azimpur, Nilkhet, Dhanmondi, Mirpur, Motijheel, Gulshan and Uttara.

After the completion of data collection through online and field survey, invalid data has been filtered out and not regarded within the sample size. The reasons for rejecting data scenarios where the data can be considered invalid, for instance, mileage is not viable considering registration year, consumption of fuel is too deviant from normal value, unusual or incomplete data, etc.

After filtering and sorting of collected data, required calculations are done which are elaborated in 'Calculation' section. Aforementioned parameters are compared and interpretation is given based on the obtained results.

3.1 Data Sampling

The sample size is the total number of observations included in any statistical study or research. This figure is typical of the whole population studied. Sample size is critical in qualitative research. The sample size is determined by a variety of population characteristics. Numerous established approaches exist for determining the optimal sample size for every population. Among these, we used the Krejcie and Morgan sample size table in our study. [28]

The population size in this study is 8,09,189, derived from Bangladesh Road Transport Authority (BRTA) data. According to the updated registered motor vehicle chart of February, 2021, this this the number of total registered motorcycles in Dhaka Metropolitan area till date and showed in Table 4.

We considered a 95% confidence level while determining the appropriate sample size for this study. The confidence level is used to incorporate the real population parameter. It is the proportion of all tests that can be predicted to yield accurate result. Our 95% confidence level indicates that the sample size chosen will accurately reflect the population's real parameter within the 95% confidence range. This degree of confidence grows as the sample size increases. However, outcomes with a higher value, like 99%, which is greater, will be more accurate. To get that degree of precision, the sample size must be quite large, around 663, but gathering so much information is very challenging in the present environment. As a result, we picked a 95% confidence interval, which is nearly adequate to a precise result.

Table 4: Registered vehicles in Dhaka based on type [Source: BRTA Website] [29]

SI. No	Type of Vehicles	Grand Total (Up to February, 2021)
1	Ambulance	4702
2	Auto Rickshaw	20609
3	Auto Tempo	1406
4	Bus	36349
5	Cargo Van	9062
6	Covered Van	29784
7	Delivery Van	24252
8	Human Hauler	4752
9	Jeep (Hard/Soft)	50854
10	Microbus	80772
11	Minibus	9701
12	Motor Cycle	**809189**
13	Pick Up (Double/Single Cabin)	96888
14	Private Passenger Car	302993
15	Special Purpose Vehicle	2335
16	Tanker	2584
17	Taxicab	30136
18	Tractor	32963
19	Truck	74330
20	Others	28662
	TOTAL	1652323

Table 5: Table for determining sample size [28]

Population size (N)	**Sample size (S)**	**Population size (N)**	**Sample size (S)**	**Population size (N)**	**Sample size (S)**
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	**1000000**	**384**

The number of motorcycles registered in Dhaka is 8,09,189 as per BRTA, which falls between 75000 and 1000000 in Table 2. So, at 95% confidence interval, considering a 5%

margin of error, 50% population proportion and 1 degree of freedom, the sample size for this study will be 384 as per Table 5.

Although sufficient measures are taken after the survey to filter out the data which are invalid, there may still remain some discrepancy. So, after finalizing the sample size, another filtering can be done to exclude data sets with missing information, or those which do not have valid registration number.

Valid data from the survey are in Appendix 1, and invalid data that have been rejected from the scope of the study are in Appendix 2.

3.2 Research Survey

The survey has been designed based on standard survey regulations. The questions are set in such a way that they can be easily answered in a few minutes both in online platform and offline. The response to the questions directly contributes data to carry out the research objectives.

3.2.1 - Question 1: Motorcycle Model

In order to sort and classify motorcycles effectively, manufacturer model provides a significant tool. Based on model, after classification, performance of different motorcycles can be compared. Also, customer preference can be well understood.

3.2.2 - Question 2: Registration Year

Registration year marks the period when the motorcycle was registered in Bangladesh. For calculation of fuel consumption and GHG emissions, this is the primary criteria because all such calculations are done taking the registration year as reference as the motorcycle started running in this country from the year of registration. Even if it was manufactured years back, it is not relevant for those calculations as it is not a valid criterion in that sense.

3.2.3 - Question 3: Manufacturing Year

Manufacturing year marks when the motorcycle was first manufactured, be it in Bangladesh or anywhere else. For performance analysis, this is very important as a comparative relationship can be easily developed based on the manufacturing year. A motorcycle with an earlier manufacturing year is more susceptible to performance drop such as increased fuel consumption, decreased traction, higher emission and so on. But is does not provide insight into the current calculation of fuel consumption and GHG emission values.

3.2.4 - Question 4: Engine Capacity

Engine capacity is the displacement area inside the piston cylinder of engine between TDC and BDC. It has a direct relationship with fuel consumption and GHG emission, and so a graphical correlation may be established between these quantities to understand the scenario. It is measured in cubic centimeters (c.c.). As per study, motorcycles having 80-165 c.c. engine capacity are running in the streets of Dhaka, and among these, 150 c.c. bikes are the most common.

3.2.5 - Question 5: Fuel Preference

In Dhaka, currently the only widely used fuel in motorcycles is gasoline, and it comes in two different variations, identified locally by "Petrol" and "Octane". In reality, "Octane" has higher octane number and "Petrol" has lower octane number, but they are both gasolines. The octane number here is the ability of the fuel to resist knocking when ignited, higher octane number indicates better fuel quality. This question is required in order to differentiate and also develop a cost model of motorcycles. Here, more people tend to use Octane over Petrol because of superior quality and fuel economy, but price of Octane is also higher.

3.2.6 - Question 6: Current Mileage

Mileage denotes the total kilometers run by the motorcycle till date. Using this data, yearly fuel consumption, GHG emission and other data can be calculated. Mileage also gives an idea about the condition of the vehicle; the higher the mileage, the older is the motorcycle and performance of the vehicle is supposed to deteriorate over time. Also, the mileage can be cross checked with registration and manufacturing year to analyze validity of the collected data.

3.2.7 - Question 7: Initial Mileage

The initial mileage is the mileage of the vehicle when it was handed over to the current owner. Since motorcycles are usually not reconditioned, the current mileage is the true mileage and the initial mileage as defined here can be used to identify if a vehicle is purchased in new condition and then to conduct a comparative performance analysis between new and old vehicles.

3.2.8 - Question 8: Fuel Consumption Rate

Fuel consumption rate signifies the distance travelled by the vehicle when is has burned 1L of fuel. This can vary based on engine capacity, engine type, condition of vehicle, traffic condition and other factors. For example, a motorcycle that may be driven 50 kilometers for every 1-liter fuel consumed may only go 35 kilometers when driven in traffic congested Dhaka, where a lot of fuel is wasted. Using this data, yearly fuel and energy consumption values can be calculated.

3.2.9 - Question 9: Opinion on Alternative Fuel

The people in Dhaka, and also in the entire Bangladesh are used to gasoline-based fuel derived from fossil sources like petrol and octane as known locally. Even if an alternative, greener fuel is available, they might not be ready to accept the change or can be hesitant. To understand their stance on changing their preferred fuel if a better and greener fuel was available for use, the opinion of users is important.

3.2.10 - Question 10: Motorcycle Registration Number

The registration number is not required for any data-driven calculation but it is required to ensure the validity of data and to prevent the interpretation of data from the same motorcycle more than once. Furthermore, many people drive motorcycles registered in other areas in Dhaka and it may cause error in study results.

3.3 Parameters for Calculation

3.3.1 Average Annual Mileage

The annual average of motorcycle mileage can be found by dividing the current mileage of the vehicle with the difference between current year and registration year of the vehicle.

Equation 1

$$M_{avg} = \frac{M}{Y_C - Y_R}$$

w here, M_{avg} = Average Annual Mileage of the Vehicle (km/Year)

M = Current Mileage of the Vehicle

Y_C = Current Year (2022)

Y_R = Registration Year of the Vehicle

3.3.2 Average Annual Fuel Consumption (AAFC)

The fuel consumption rate data taken in the survey shows the distance that can generally be covered by the motorcycle when it uses 1L of its fuel. Dividing it by the average annual mileage, the yearly fuel consumption value can be calculated. [30]

Equation 2

$$FC_{avg} = \frac{M_{avg}}{FC}$$

where, FC_{avg} = Average Annual Fuel Consumption for Gasoline (L/Year)

FC = Fuel Consumption Rate of the Motorcycle

3.3.3 Average Yearly Energy Consumption (AYEC)

The annual energy consumption from gasoline can be found from the product of AAFC and energy density of gasoline.

1 L Gasoline = 29 MJ/L

Equation 3

$$E_{avg} = FC_{avg} \times 29$$

E_{avg} = Annual Energy Consumptions (MJ/Year)

All calculated values of fuel and energy consumption for gasoline and alternate fuel E10 (calculation in later parts) are in Appendix 3.

3.3.4 Green House Gas Emission – CO_2

The yearly CO_2 emission from gasoline can be found from the product of CO2 Emission Factor from MIT Units and Conversion Data Sheet; that is based on emission per unit of energy and the AYEC.

1 GJ Energy = 6.72 kg CO_2, 1 MJ Energy = 0.0672 kg CO_2

Equation 4

$$CO_{2,avg} = E_{avg} \times 0.0672$$

where, $CO_{2,\,avg}$ = Yearly CO_2 Emission from Gasoline (kg/Year)

3.3.5 Alternate Fuel

The study also covers estimation on GHG emission, fuel and energy consumption when alternative fuel E10 is used in place of commonly used gasoline in the form of commercially named octane and petrol. [31]

Alternative Fuel Property Table

Table 6: Properties of Alternative Fuel [31]

Fuel	**E10- 91RON**	**E20- 91RON**	**E30- 91RON**	**E10-98RON**
Ethanol (0/ov)	10.0	20.5	29.5	9.8
NHV (MJ/kg)	42.0	40.1	38.6	42.5
HoV (MJ/kg)	0.41	0.48	0.54	0.41
H/C (mole)	2.11	2.11	2.20	2.18
O/C (mole)	0.035	0.075	0.111	0.035
Specific gravity	0.735	0.749	0.760	0.725
Carbon intensity (gC02/MJ)	71.3	71.6	71.3	70.2
RON	91.8	90.6	90.7	99.0
MON	84.1	83.2	82.7	91.4
AKI	87.9	86.9	86.7	95.2
Sensitivity	7.7	7.4	8.0	7.6
n NHV (1) (MJ/kg basis)	+1.2%	-3.4%	-7.0%	+2.3%
n NHV (1) (MJ/L basis)	0.0%	-2.6%	-5.0%	-0.3%

For the estimations in this study, E10-98RON is considered as the test alternative fuel. From the book on petroleum by Viswanathan the energy density of E10 can be obtained,

1L E10 = 28.06 MJ/L [32]

If E10 is used in place of petrol/octane, E10 fuel consumption for producing same energy.

Equation 5

$$FC_{avgE} = E_{avg}/28.06$$

And, in this case, 1 MJ Energy = 0.0702 kg CO_2

Equation 6

$$CO_{2,avgE} = E_{avg} \times 0.0702$$

where, FC_{avgE} = Average Annual Fuel Consumption for E10 (L/Year)

$CO_{2,\ avgE}$ = Yearly CO_2 Emission from E10 (kg/Year)

3.3.6 Other GHGs

Although accurate measure of CO, CH and NOx emissions cannot be determined due to the lack of experimental data, estimations can be made based on previous research projects concerning similar objectives. For this estimation, emission factors from a research based on 4-stroke engine driven motorcycles in another Asian country are taken into consideration. There, the factors are available as the amount of GHG released for each kilometer travelled by the motorcycle. [33]

Table 7: GHG emission factors based on average vehicle speed in terms of mg/km [Idle in mg/min] [34]

GHG	Idle		15 kmph		32 kmph		35 kmph		50 kmph	
	Gasoline	E10	Gasoline	E10	Gasoline	E10	Gasoline	E10	Gasoline	E10
CO	412	351	866	830	786	761	865	861	144	120
CH	40	24	74	68	40	42	50	46	22	14
NOx	8	7	21	18	25	24	27	25	70	65

The average speed of traffic in Dhaka is 6.4 kmph. Interpolating emission factors for motorcycles in Dhaka, a gross estimation may be achieved but this data cannot be considered accurate as experimental analysis has not been done. This estimation will only serve to provide the comparison between GHG pollution from gasoline and alternative E10 fuel. [35]

Table 8: GHG emission factors for 6.4 kmph in terms of mg/km

GHG	6.4 kmph	
	Gasoline	E10
CO	906	864
CH	90	81
NOx	19	15

Product of these emission factors with the average annual mileage of the motorcycles gives the estimation of yearly emission, in case of both gasoline and E10.

Equation 7

$$(CO, CH, NO_x)_{avg} = M_{avg} \times EF(CO, CH, NO_x)$$

where, (CO, CH, NOx) $_{avg}$ = Amount of GHG emission in terms of (kg/Year)

EF (CO, CH, NOx) = Emission Factors of CO, CH and NOx from Table 5. (kg/km)

3.3.7 Cost of Fuel

Bangladesh is a developing country, so the fuel and hence energy sector is partially subsidized in order to keep the fuel costs within the reach of common people. As per PetroBangla, the current price of 1L Octane is BDT 89 while the price of 1L Petrol is BDT 86. Also, E10 fuel is used in this study for estimation, however E10 fuel or any other gasoline-ethanol blend fuel is not commercially available or listed by the government, so economic analysis of E10 fuel in Bangladesh perspective will not be possible. Still, a comparative model may be developed based on the price of this fuel and also the price of gasoline in U.S. or a globally accepted value.

Table 9: Fuel Prices in Bangladesh (2022), PetroBangla

Fuel	Price (BDT/L)	Date of Approval
Diesel	80	04/11/21
Kerosene	80	04/11/21
Octane	89	24/04/16
Petrol	86	24/04/16

The annual energy cost can be determined by multiplying the fuel price with average annual mileage in order to obtain the average annual fuel cost, which is a direct indication of the energy cost incurred.

3.3.8 Global Warming Potential

The long-term impact of GHG emission on climate is given by the GWP factors. Generally, this impact is calculated with respect to CO2 emissions where CO2 is taken as a reference. It is calculated in 20-year, 100-year or 500-year timeframe of which the first two are more significant for discussion.

Equation 8

$Eq_{CO2} = E_X \times GWP$ [36]

where, Eq_{CO2} = Amount of equivalent CO2 emissions (tonne CO2e)

X = Amount of emission of X gas

GWP = Global Warming Potential Factor

As per this study, emissions are CO2, CO, CH and NOx. So the equivalent CO2 emission becomes,

Equation 9

$$Eq_{CO2} = [(CO2 \times GWP_{CO2}) + (CO \times GWP_{CO}) + (CH \times GWP_{CH}) + (NOx \times GWP_{NOx})]$$

3.3.9 GWP Factors

The GWP factor values to be used in equation 9 to calculate the CO_2 equivalent is given in Table 10.

Table 10 GWP factors for 20-year and 100-year time period [37], [38]

Greenhouse Gas	20 Year GWP	100 Year GWP
CO_2	1	1
CH_4 (fossil)	82.5	29.8
CH_4 (non-fossil)	80.8	27.2
NO_x	273	273
CO	10	3

Chapter 4: Results and Discussion

4.1 Sample Distribution

1. Based on Brand

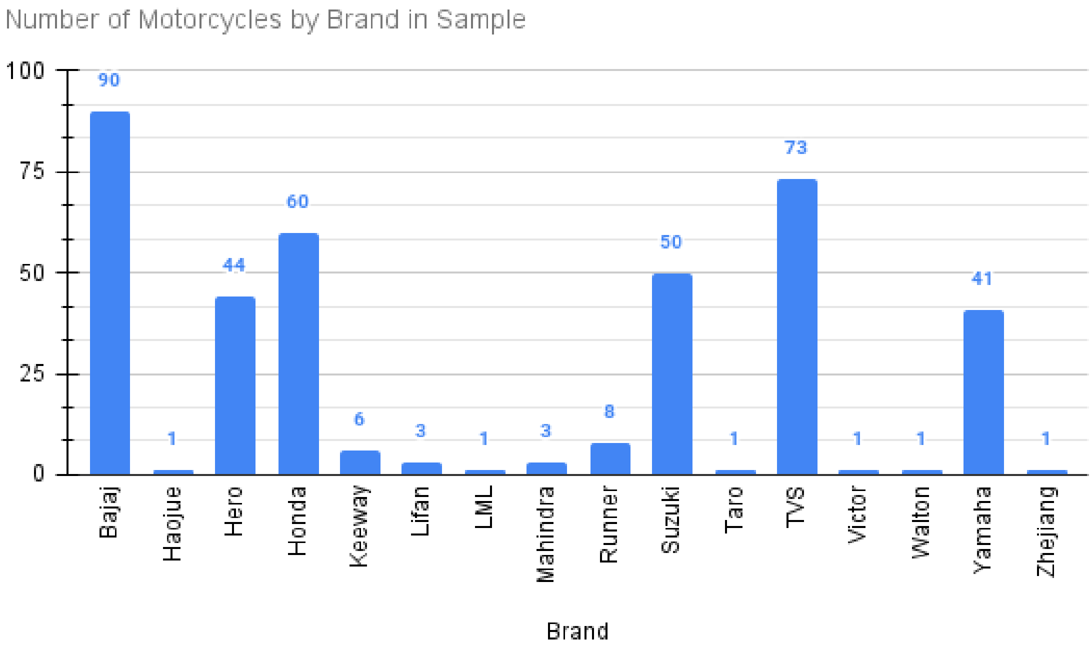

Figure 6: Distribution of motorcycles by brand

16 distinct motorcycle brands were a part of the survey responses. Among these, Bajaj, TVS, Hinda, Suzuki, Hero and Yamaha occupy the significant market share in our sample and Bajaj is the market leader. Out of 384 analyzed and documented data, 90 motorcycles belonged to Bajaj. In terms of percentage, Bajaj holds 23.4% while TVS holds 19% in the second position.

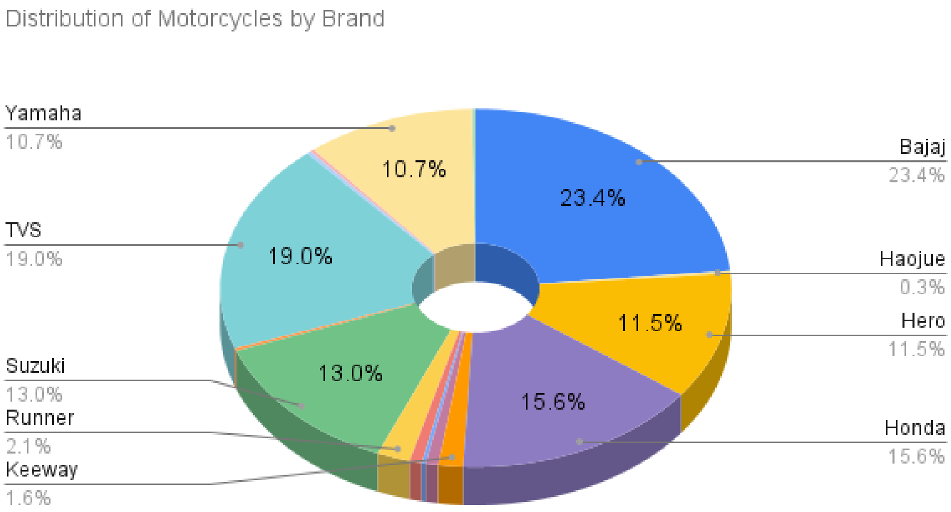

Figure 7: Percentage of motorcycles in sample by brand

2. Based on Registration Year

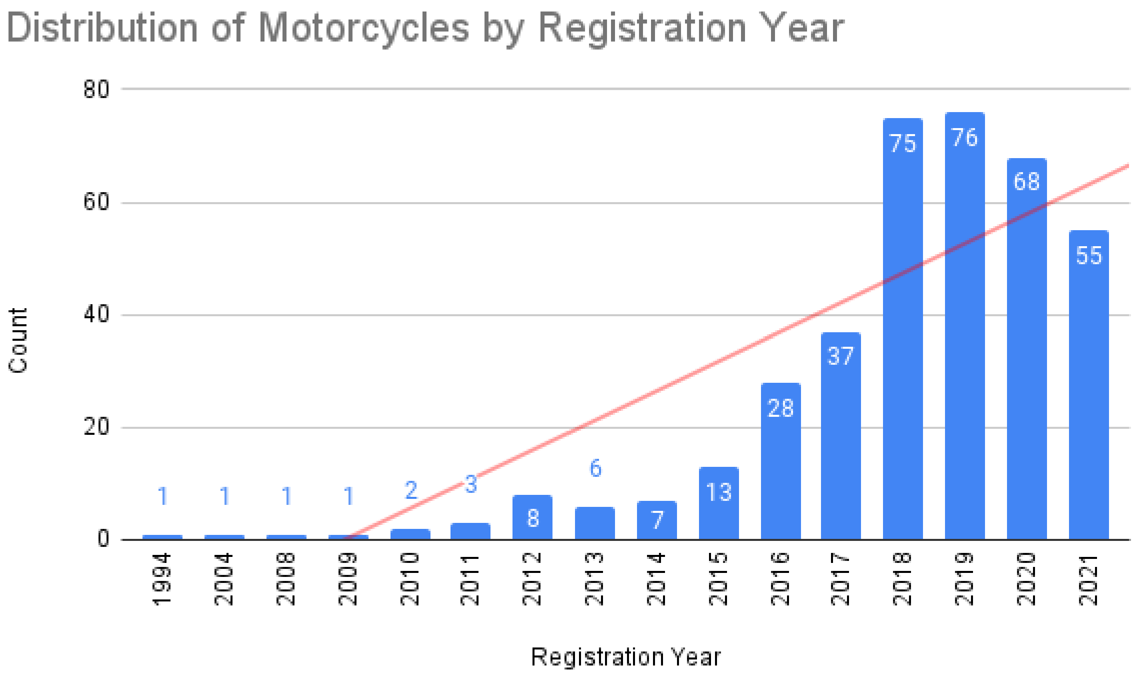

Figure 8: Distribution of motorcycles by registration year

The survey responses indicate that motorcycle registrations saw a sharp rise starting from 2015, and continued until 2019, where it reached its peak. Since then, it has slightly reduced, this might have occurred due to the reduction of purchasing power of general people who were affected by the COVID-19 pandemic. Also, production processes across the world were also halted for a significant period of time owing to the worldwide lockdowns.

In terms of sales in Bangladesh, registrations exponentially increased in 2021, however this might not have reflected in the survey as the survey has mainly focused on vehicles registered within February, 2021 since at least one year of operational period was necessary in order to extract and calculate annual data parameters for the motorcycles.

3. Based on Manufacturing Year

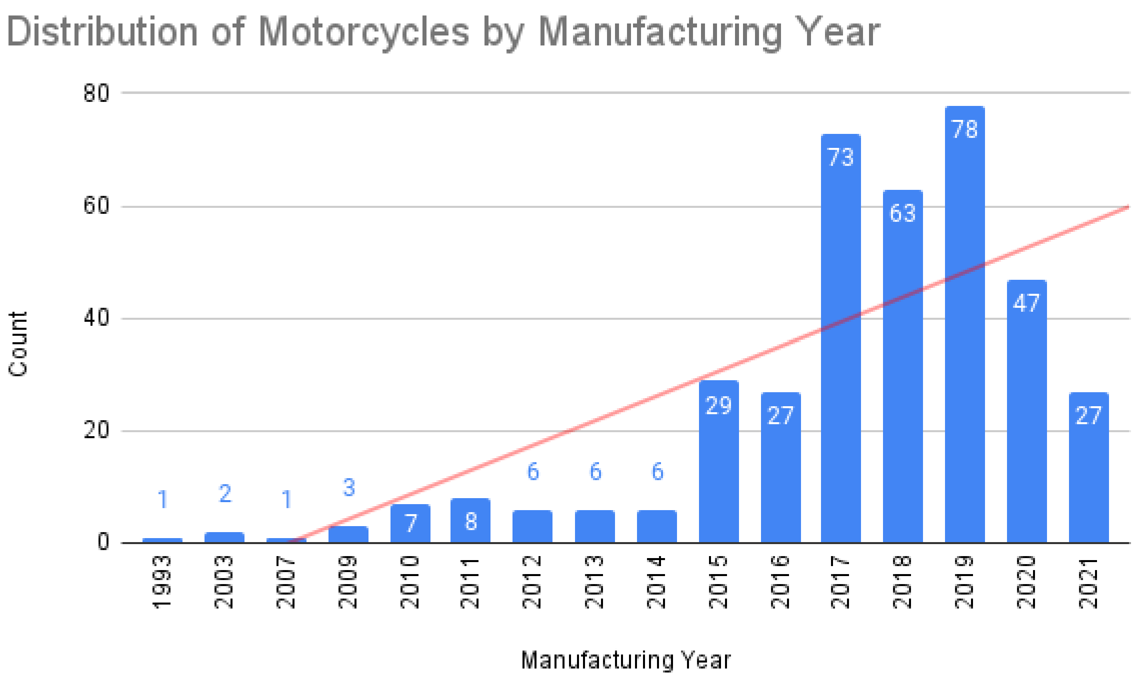

Figure 9: Distribution of motorcycles by manufacturing year

In our sample, most of the motorcycles have been manufactured in the years 2018-2021. Although there is a sharp rise in production from 2015, from the graph it is evident that manufacturing has receded from after 2019, where it was at a peak. The reason behind this recession can be the COVID-19 pandemic, which limited the production capacity throughout the world and also limited the purchasing power of general people, thus creating a drop-in demand.

In reality, motorcycle sales boomed even after the pandemic, however, it was mostly the motorcycles manufactured previously that were sold during this time period. The production processes reached their usual pace starting from 2021.

4. Based on Engine Capacity

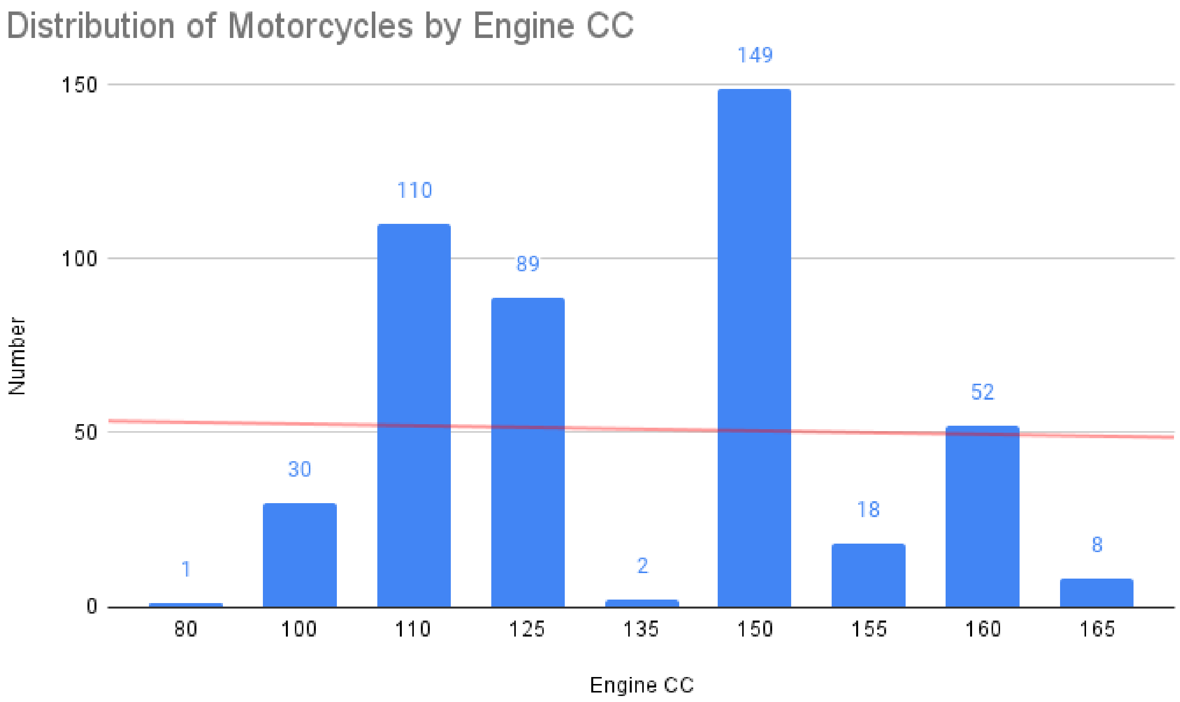

Figure 10: Distribution of motorcycles by engine capacity

Among the survey responses, 9 different engine c.c. values were encountered ranging from 80-165 c.c. The most common is the 150 c.c. motorcycles, and in our 384 data, they constitute 149. Fuel consumption is generally higher in motorcycles with higher engine capacity. According to general preference it can be observed that users who prefer a more economic and fuel-efficient option go for 110 c.c. and 125 c.c. bikes, although their power output can be lower; while those who have a higher-end budget commonly prefer 150 c.c. bikes.

5. Based on Fuel Choice

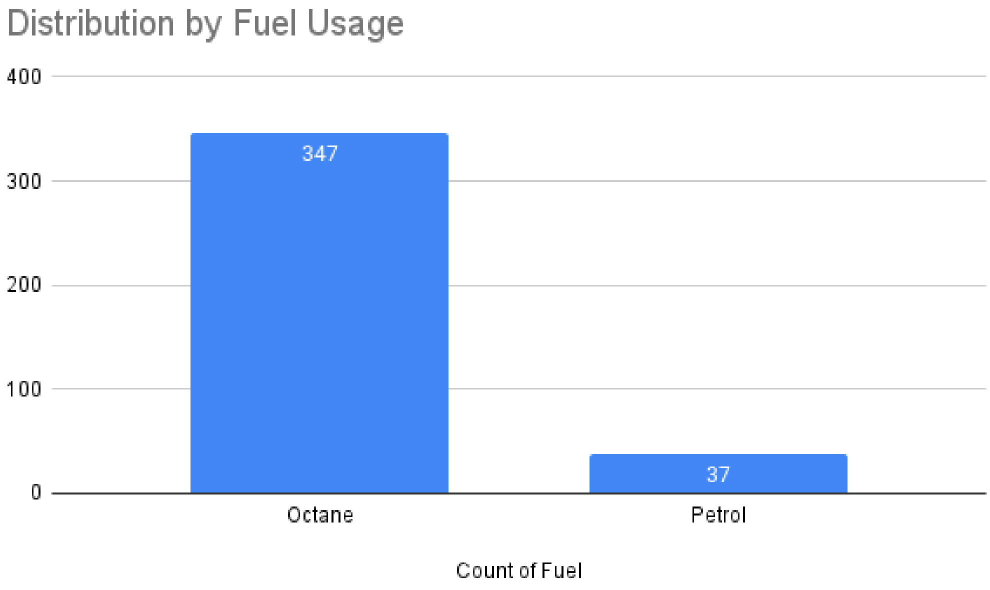

Figure 11: Distribution of motorcycles in sample by fuel usage

Of the 384-survey data collected, 347 motorcycles use octane and 37 use petrol. In terms of percentage 90.4% vehicles use octane while 9.6% use petrol. Octane has better knocking properties and is considered a better alternative for engine parts compared to the low grade petrol available in our country. It is also more fuel efficient, although the cost is higher than petrol.

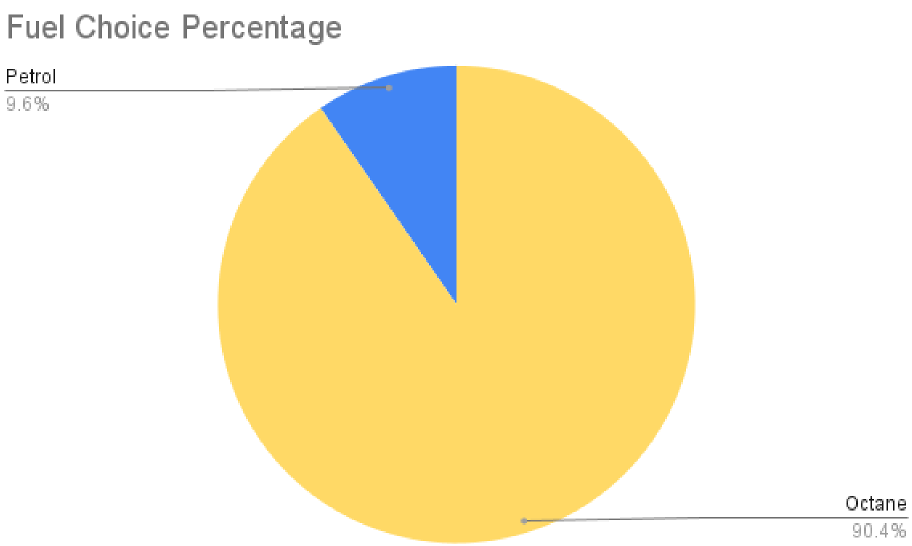

Figure 12: Percentage of fuel choice in sample

6. Mode of Data Collection

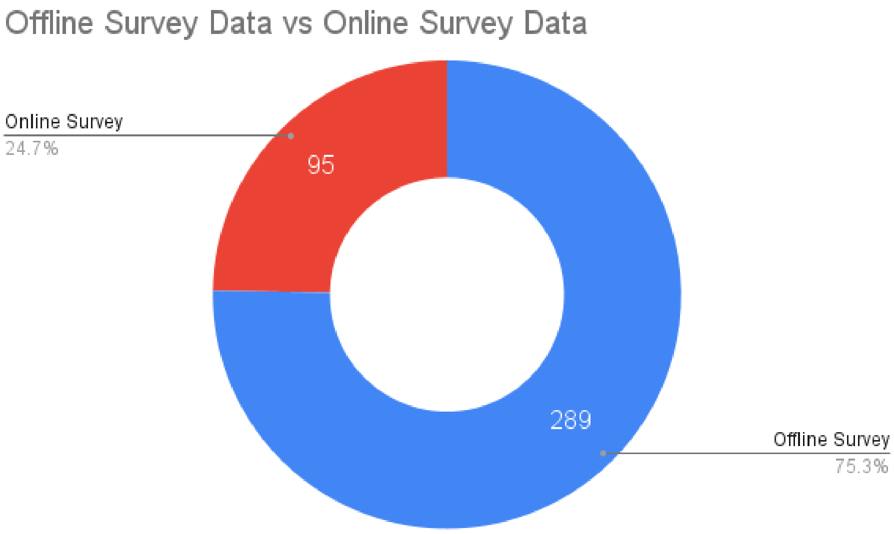

Figure 13: Data collection mode (online vs. offline)

The survey was conducted both in online and offline platforms. 75.3% of the valid data considered for the survey, amounting to 289 entries were collected through field survey while 95 of the data sets were collected online. In general, offline survey was more efficient and the participants also preferred direct data collection on field. Also, it was possible to gain deeper insight on motorcycle usage and costs incurred by offline survey. Field survey was done in Dhanmondi, Mirpur, Nilkhet, Azimpur, Motijheel, Gulshan and Uttara areas of Dhaka.

4.2 Fuel Consumption Comparison

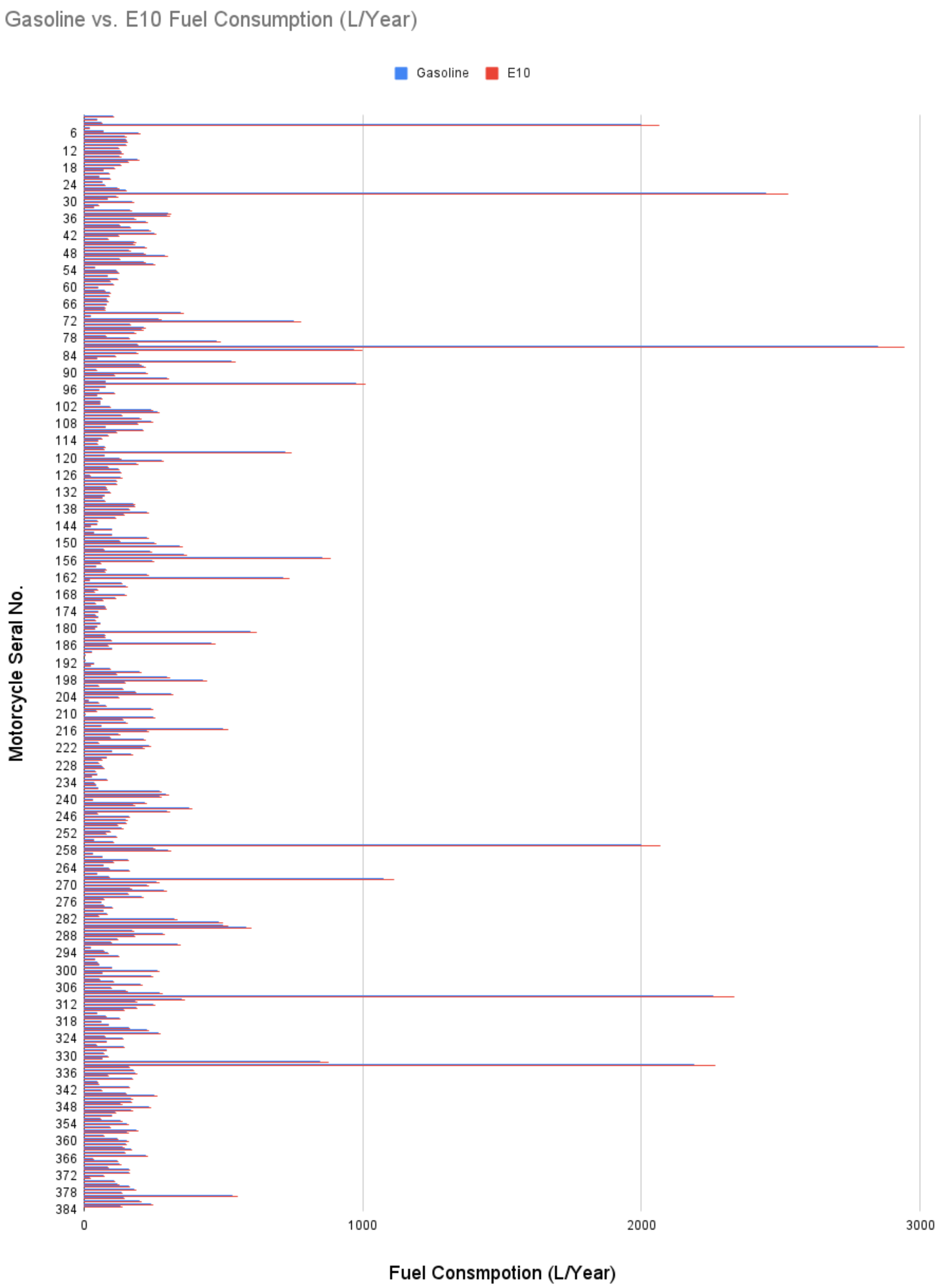

Figure 14 Motorcycle Sl. No. vs Fuel Consumption Rate, (Gasoline vs E10)

As per the chart obtained in Fig. 14 from the calculated values tabulated in Appendix 3, the consumption of E10 fuel is significantly higher than gasoline for producing the same amount of energy. So E10 has lower fuel economy.

4.3 GHG Emission

1. CO2 Emission

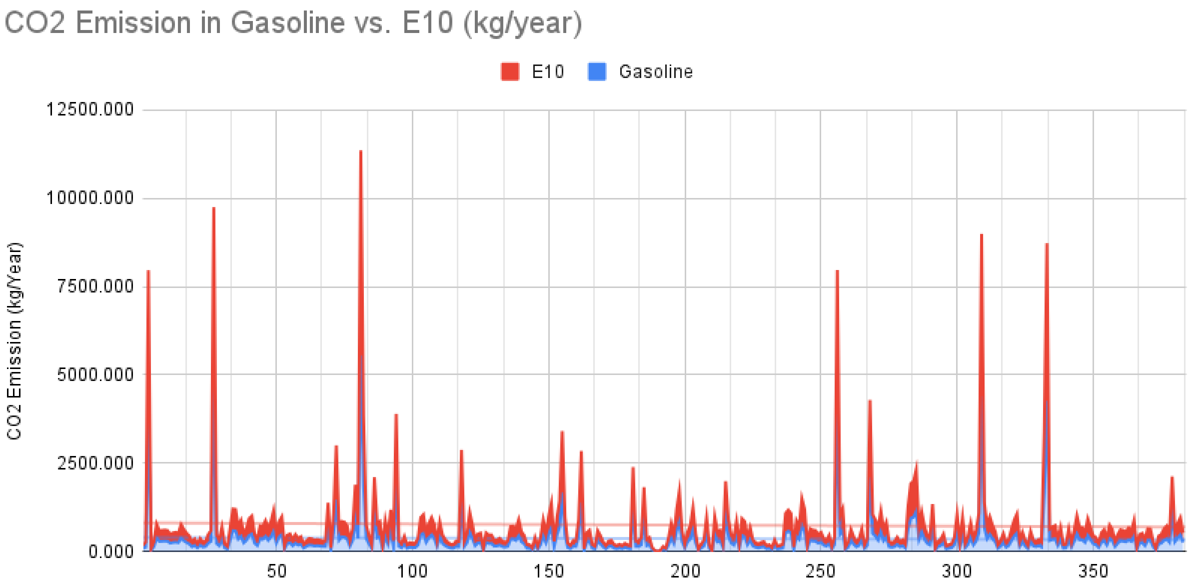

Figure 15 Comparison of CO2 emission between gasoline and E10

From the obtained data tabulated in Appendix 4, a comparative area plot shows that CO2 emission from E10 fuel is roughly 4% higher than that from gasoline. This value is in line with other experimental and theoretical studies concerning ethanol blend fuels. Ethanol has higher oxidation capacity compared to gasoline so more carbon is oxidized in biofuel blends.

2. CO Emission

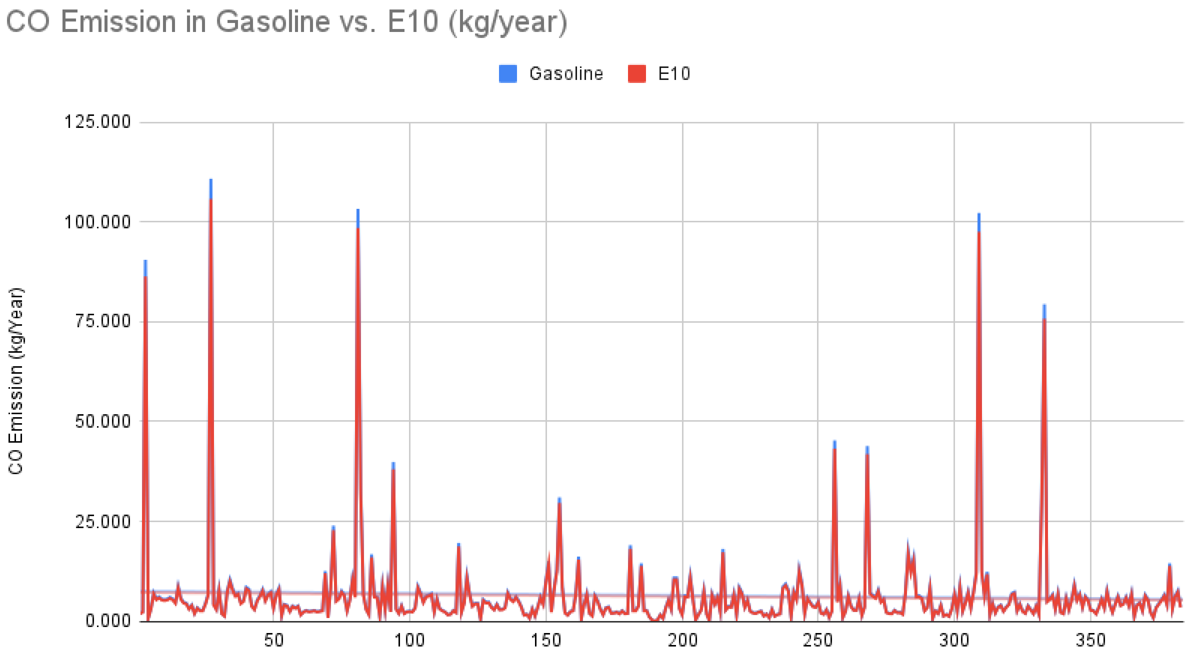

Figure 16 Comparison of CO emission between gasoline and E10 fuel

From the obtained data tabulated in Appendix 4, a comparative area plot shows that CO emission from gasoline fuel is roughly 4% higher than that from E10. CO emission is slightly lower in case of E10, and it is more harmful for the overall air quality and environment.

3. CH Emission

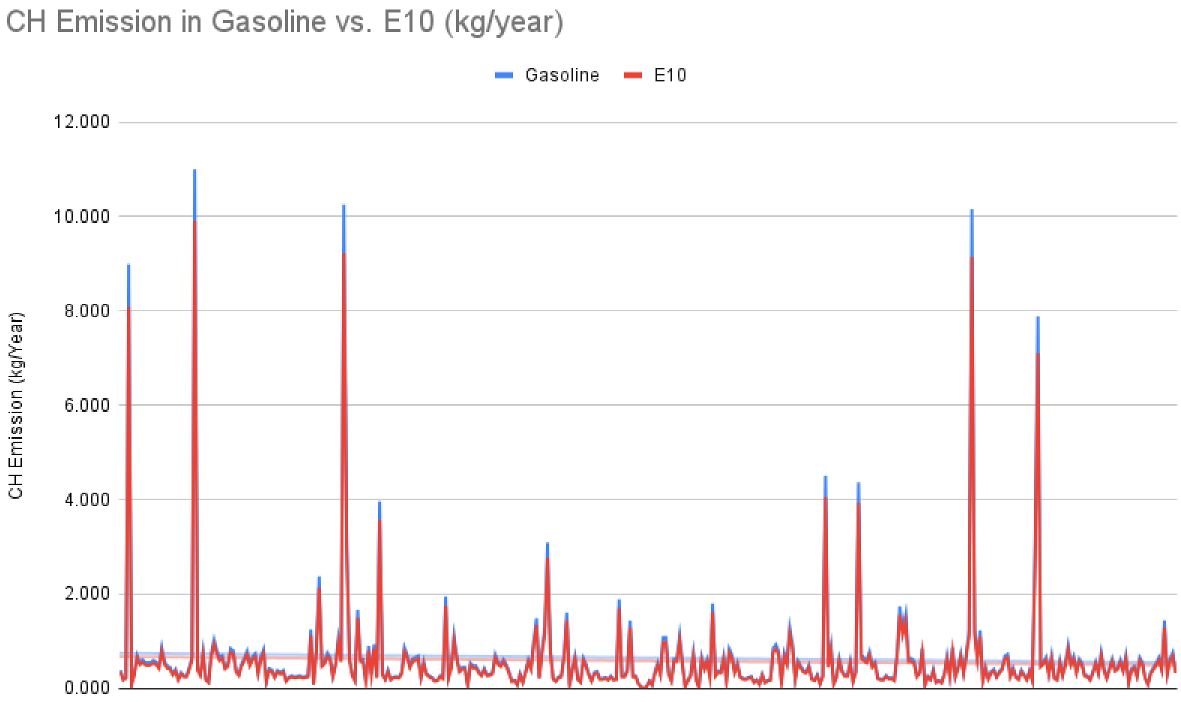

Figure 17 Comparison of hydrocarbon emission between E10 and gasoline fuel.

As per the calculated data tabulated in Appendix 4, hydrocarbon emission for gasoline is about 10% higher than that in case of E10 fuel. This is a significantly high deviation and E10 is significantly better than gasoline in this aspect.

4. NOx Emission

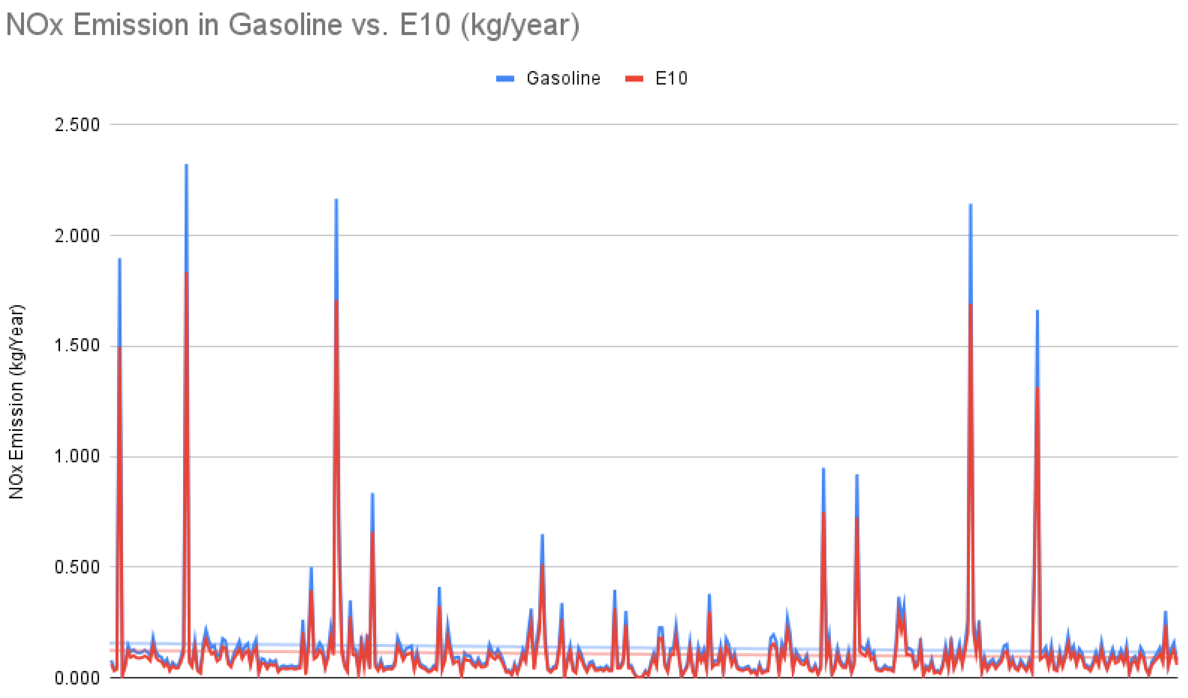

Figure 18 Comparison of NOx emission between gasoline and E10 fuel

NOx emission for combustion of gasoline fuel is about 20% higher than that in case of E10 fuel. This also gives an insight about the better emission properties of E10 over conventional gasoline.

4.4 Comparative Analysis between Common Motorcycles Models

4.4.1 Distribution of Common Models

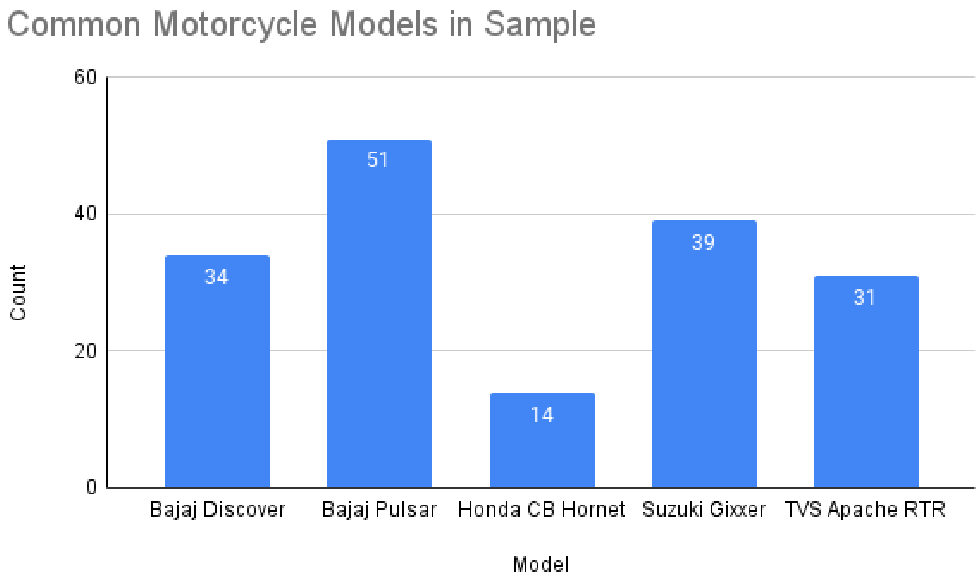

Figure 19 Distribution of common motorcycle models

Among the most common motorcycles un our sample, Bajaj Pulsar holds the highest number of motorcycles with a count of 51.

4.4.2 Fuel Preference Comparison

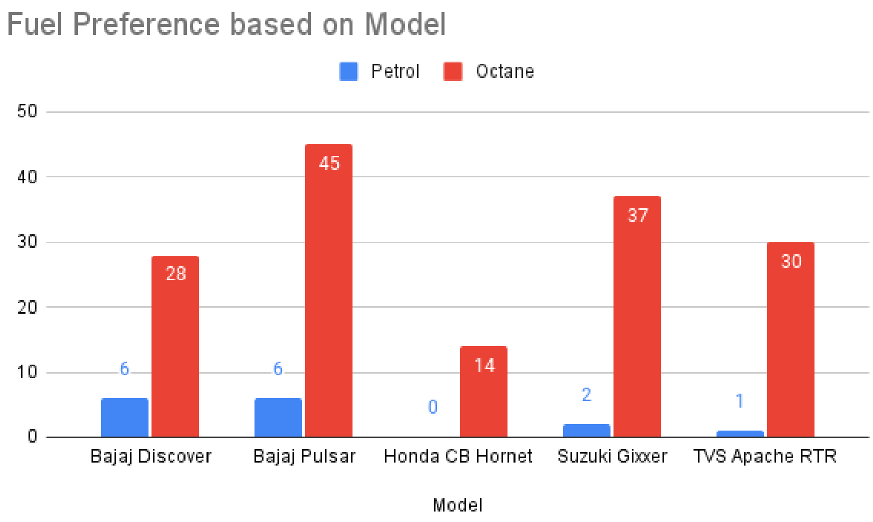

Figure 20 Fuel preference comparison among common motorcycle models

As per Fig. 20, most of the participants with the popular motorcycles prefer octane over petrol, because of its better fuel economy and knocking properties.

4.4.3 Fuel Consumption Rate Comparison

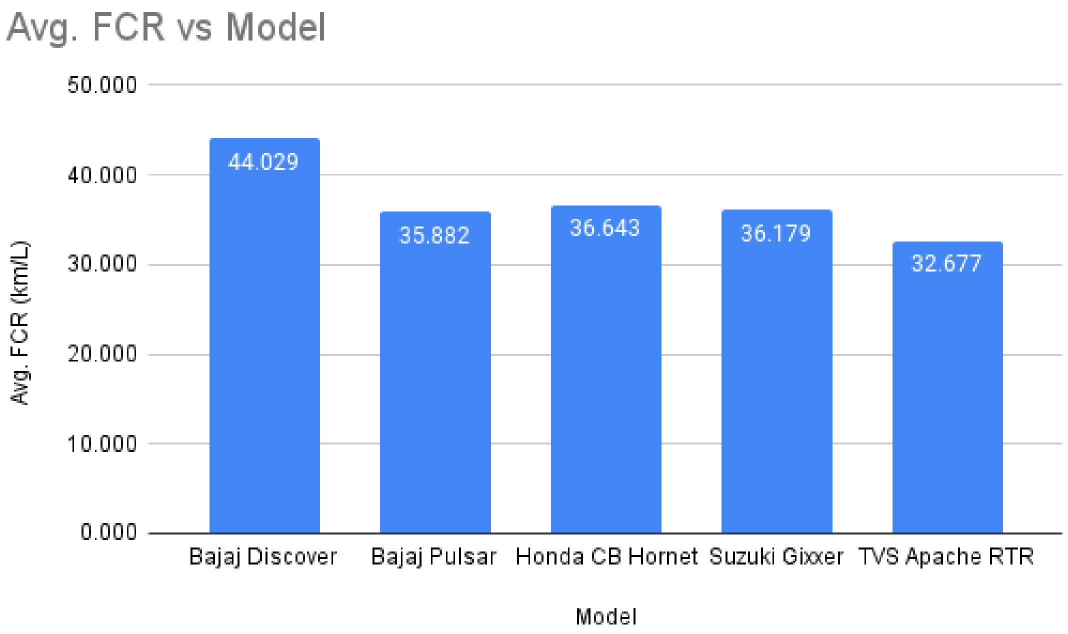

Figure 21 Comparison between fuel consumption rate of various models.

The average FCR of the motorcycles indicate that Bajaj Discover has the highest distance covered for every liter of fuel consumed while the TVS Apache RTR goes about 32 km for every liter that is the lowest encountered in Fig. 21.

4.4.4 GHG Emission Comparison

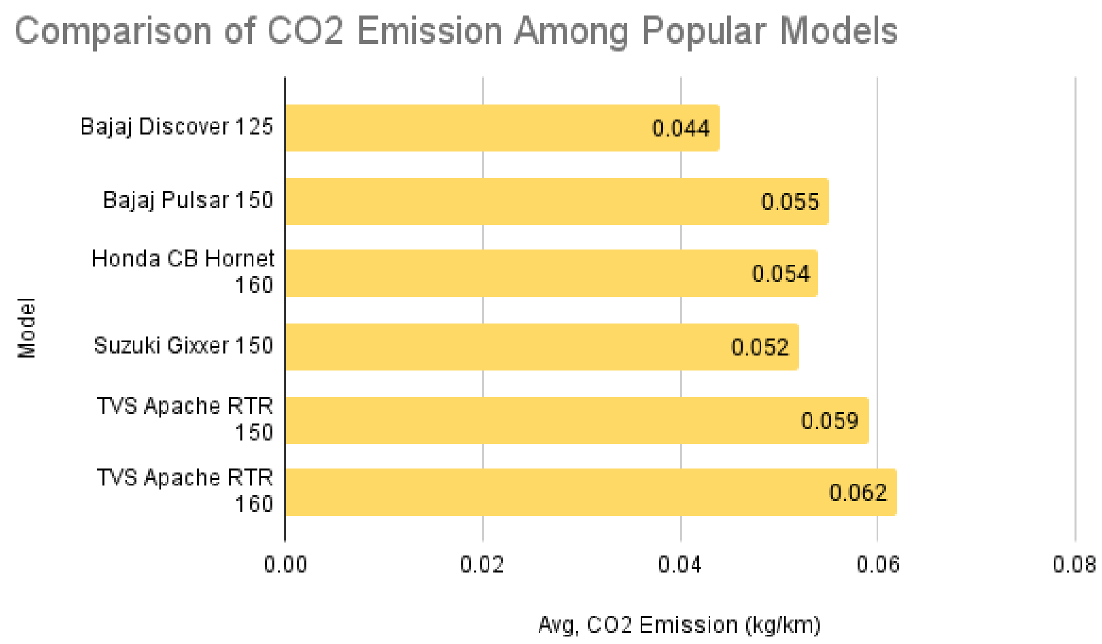

Figure 22 Comparison of CO2 emission based on unit distance travelled

4.4.6 Fuel Cost Comparison

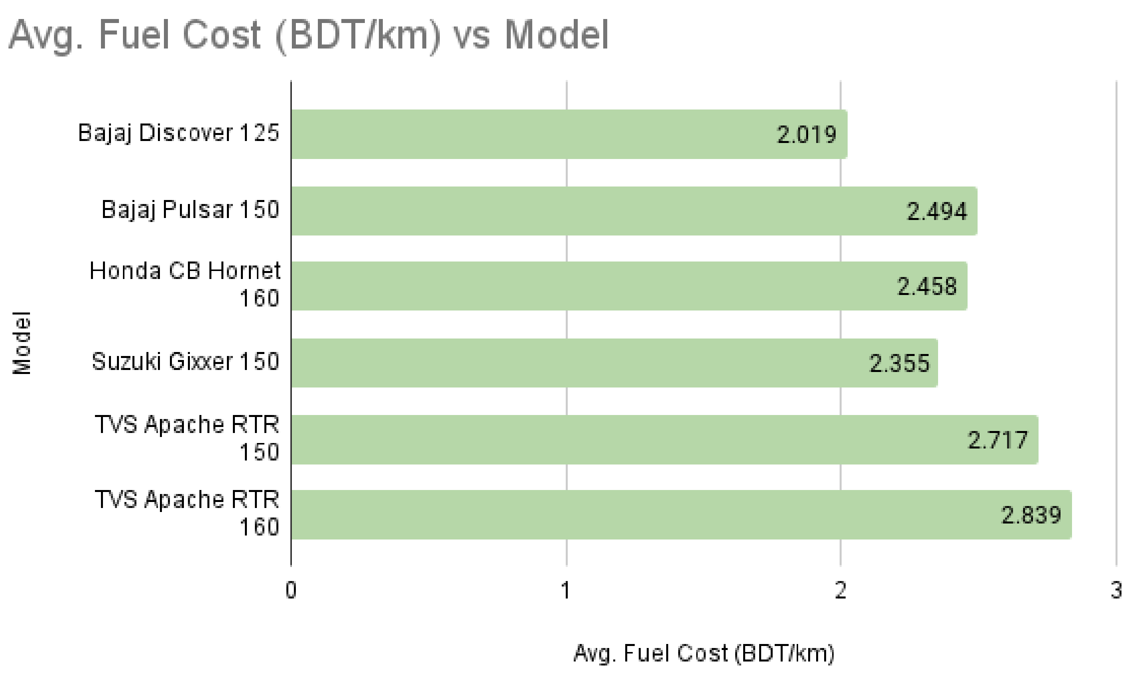

Figure 23 Comparison of fuel cost per kilometer for popular models in sample

The comparison done in Fig. 22 and Fig. 23 shows that motorcycles with low engine capacity like Bajaj Discover of 125 c.c. has the lowest CO2 emission per kilometer and also lowest fuel cost per kilometer. While 160 c.c. TVS Apache RTR has the highest CO2 emission and fuel cost per unit distance. Upon closer inspection of the two plotted graphs it is evident that engine capacity is linearly dependent with emission and fuel cost, when considered in unit distance basis.

4.5 CO_2 Equivalent

The calculated values for CO2 equivalents based on 20 year and 100 year time period are tabulated in Appendix 5. As per the calculations, based om the 20-year GWP, CO2 equivalent of gasoline is 0.33% higher than E10 fuel.

It means that the long-term impact of emissions from gasoline will be 0.33% higher than the impact of emissions from E10 fuel for providing the same energy output in motorcycles.

Chapter 5: Conclusion and Recommendation

A performance study of sample motorbike data was carried out, and the values for fuel and energy consumption were analyzed as well. Estimates of E10 fuel in comparison to gasoline in order to determine its viability for carbon footprint reduction revealed that E10 produces around 4% higher CO_2 emissions than gasoline, according to the study. The CO emissions from gasoline are roughly 4 percent greater than those from E10. Gasoline emits around 10% more hydrocarbons than E10, as well as approximately 20% more nitrogen oxides (NOx) than E10. Based on a 20-year GWP, the CO_2 equivalent of gasoline emissions is 0.33 percent greater than the E10 standard. The increased engine capacity of typical motorbikes results in increased greenhouse gas emissions as well as increased fuel costs.

Based on study findings, emission properties of E10 fuel as an alternative for carbon footprint reduction is definitely better than currently used gasoline. However, cost analysis on commercial perspective could not be conducted due to lack to significant data on local ethanol production. Also, most motorcycles marketed after 2002 can run on ethanol blend fuel without problems but long-term damage or performance test in the perspective of our country is not possible. So, E10 fuel may only be considered as a viable alternative after considering the performance and engine efficiency of local motorcycles and also the commercial cost of E10 fuel in Bangladesh.

References

[1] X. Li and K. M. Nam, “Environmental regulations as industrial policy: Vehicle emission standards and automotive industry performance,” *Environmental Science & Policy*, vol. 131, pp. 68–83, May 2022, doi: 10.1016/J.ENVSCI.2022.01.015.

[2] 2009j Memedovic, O. van Biesebroeck, and J. v Gereffi, “Globalisation of the automotive industry: main features and trends,” 2009. [Online]. Available: www.globalvaluechains.org

[3] “Bangladesh Automobile Industry Overview and Emerging Trends - LightCastle Partners.” https://www.lightcastlebd.com/insights/2021/05/bangladesh-automobile-industry-overview-and-emerging-trends/ (accessed Apr. 22, 2022).

[4] V. -i, “BANGLADESH AUTOMOBILE INDUSTRY.”

[5] Sl, “NUMBER OF REGISTERED MOTOR VEHICLES IN BANGLADESH (YEARWISE).”

[6] “Renewable Energy | Center for Climate and Energy Solutions.” https://www.c2es.org/content/renewable-energy/ (accessed Apr. 22, 2022).

[7] “Fossil Fuels - Our World in Data.” https://ourworldindata.org/fossil-fuels (accessed Apr. 22, 2022).

[8] A. Fysikopoulos, D. Anagnostakis, K. Salonitis, and G. Chryssolouris, “An empirical study of the energy consumption in automotive assembly,” in *Procedia CIRP*, 2012, vol. 3, no. 1, pp. 477–482. doi: 10.1016/j.procir.2012.07.082.

[9] K. Petrauskienė, A. Galinis, D. Kliaugaitė, and J. Dvarionienė, “Comparative environmental life cycle and cost assessment of electric, hybrid, and conventional vehicles in Lithuania,” *Sustainability (Switzerland)*, vol. 13, no. 2, pp. 1–17, Jan. 2021, doi: 10.3390/su13020957.

[10] H. Bayraktar, “Experimental and theoretical investigation of using gasoline-ethanol blends in spark-ignition engines,” *Renewable Energy*, vol. 30, no. 11, pp. 1733–1747, 2005, doi: 10.1016/j.renene.2005.01.006.

[11] R. C. Clemente, E. Werninghaus, E. P. D. Coelho, and L. A. Sigaud Ferraz, “Development of an internal combustion alcohol fueled engine,” *SAE Technical Papers*, 2001, doi: 10.4271/2001-01-3917.

[12] L. Li *et al.*, “Combustion and emissions of ethanol fuel (E100) in a small SI engine,” *SAE Technical Papers*, no. 724, 2003, doi: 10.4271/2003-01-3262.

[13] R. C. Costa and J. R. Sodré, “Hydrous ethanol vs. gasoline-ethanol blend: Engine performance and emissions,” *Fuel*, vol. 89, no. 2, pp. 287–293, 2010, doi: 10.1016/j.fuel.2009.06.017.

[14] Y. Li *et al.*, “Combustion, performance and emissions characteristics of a spark-ignition engine fueled with isopropanol-n-butanol-ethanol and gasoline blends,” *Fuel*, vol. 184, pp. 864–872, 2016, doi: 10.1016/j.fuel.2016.07.063.

[15] C. Bae and J. Kim, “Alternative fuels for internal combustion engines,” *Proceedings of the Combustion Institute*, vol. 36, no. 3, pp. 3389–3413, 2017, doi: 10.1016/j.proci.2016.09.009.

[16] T. G. Leone, E. D. Olin, J. E. Anderson, H. H. Jung, M. H. Shelby, and R. A. Stein, “Effects of Fuel Octane Rating and Ethanol Content on Knock, Fuel Economy, and CO2 for a Turbocharged DI Engine,” *SAE International Journal of Fuels and Lubricants*, vol. 7, no. 1, pp. 9–28, 2014, doi: 10.4271/2014-01-1228.

[17] P. Iodice and A. Senatore, “Influence of ethanol-gasoline blended fuels on cold start emissions of a four-stroke motorcycle. Methodology and results,” *SAE Technical Papers*, vol. 6, 2013, doi: 10.4271/2013-24-0117.

[18] M. Al-Hasan, “Effect of ethanol-unleaded gasoline blends on engine performance and exhaust emission,” *Energy Conversion and Management*, vol. 44, no. 9, pp. 1547–1561, 2003, doi: 10.1016/S0196-8904(02)00166-8.

[19] M. Koç, Y. Sekmen, T. Topgül, and H. S. Yücesu, “The effects of ethanol-unleaded gasoline blends on engine performance and exhaust emissions in a spark-ignition engine,” *Renewable Energy*, vol. 34, no. 10, pp. 2101–2106, 2009, doi: 10.1016/j.renene.2009.01.018.

[20] M. O. El-Faroug, F. Yan, M. Luo, and R. F. Turkson, “Spark ignition engine combustion, performance and emission products from hydrous ethanol and its blends with gasoline,” *Energies (Basel)*, vol. 9, no. 12, 2016, doi: 10.3390/en9120984.

[21] R. A. Stein, J. E. Anderson, and T. J. Wallington, “An overview of the effects of ethanol-gasoline blends on SI engine performance, fuel efficiency, and emissions,” *SAE International Journal of Engines*, vol. 6, no. 1, pp. 470–487, 2013, doi: 10.4271/2013-01-1635.

[22] H. Köten, Y. Karagöz, and Ö. Balcı, “Effect of different levels of ethanol addition on performance, emission, and combustion characteristics of a gasoline engine,” *Advances in Mechanical Engineering*, vol. 12, no. 7, pp. 1–13, 2020, doi: 10.1177/1687814020943356.

[23] M. A. Costagliola, L. De Simio, S. Iannaccone, and M. V. Prati, “Combustion efficiency and engine out emissions of a S.I. engine fueled with alcohol/gasoline blends,” *Applied Energy*, vol. 111, pp. 1162–1171, 2013, doi: 10.1016/j.apenergy.2012.09.042.

[24] A. Jedynska, P. C. Tromp, M. M. G. Houtzager, and I. M. Kooter, “Chemical characterization of biofuel exhaust emissions,” *Atmospheric Environment*, vol. 116, pp. 172–182, 2015, doi: 10.1016/j.atmosenv.2015.06.035.

[25] B. M. Masum, H. H. Masjuki, M. A. Kalam, I. M. Rizwanul Fattah, S. M Palash, and M. J. Abedin, “Effect of ethanol-gasoline blend on NOx emission in SI engine,” *Renewable and Sustainable Energy Reviews*, vol. 24, pp. 209–222, 2013, doi: 10.1016/j.rser.2013.03.046.

[26] C. P. Fenimore, “Formation of nitric oxide in premixed hydrocarbon flames,” *Symposium (International) on Combustion*, vol. 13, no. 1, pp. 373–380, 1971, doi: 10.1016/S0082-0784(71)80040-1.

[27] M. A. Galbiati, A. Cavigiolo, A. Effuggi, D. Gelosa, and R. Rota, “Mild combustion for fuel-NOx reduction,” *Combustion Science and Technology*, vol. 176, no. 7, pp. 1035–1054, 2004, doi: 10.1080/00102200490426424.

[28] S. Abdul, R. Bukhari, and M. Ali, “Sample Size Determination Using Krejcie and Morgan Table Islamic Banking View project The Enron Case Study: History, Ethics and Governance Failures View project”, doi: 10.13140/RG.2.2.11445.19687.

[29] M. Vehicles, “Number of vehicles registered in Dhaka,” 2019. http://brta.portal.gov.bd/sites/default/files/files/brta.portal.gov.bd/page/5818c2d3_c813_4cdf_8c89_971036fe83b3/2021-03-01-14-10-7c8dfa8d01f9c919b5412c11bd3877c3.pdf

[30] K. S. Chen *et al.*, “Motorcycle emissions and fuel consumption in urban and rural driving conditions,” *Science of the Total Environment*, vol. 312, no. 1–3, pp. 113–122, 2003, doi: 10.1016/S0048-9697(03)00196-7.

[31] T. G. Leone, E. D. Olin, J. E. Anderson, H. H. Jung, M. H. Shelby, and R. A. Stein, “Effects of Fuel Octane Rating and Ethanol Content on Knock, Fuel Economy, and CO2 for a Turbocharged DI Engine,” *SAE International Journal of Fuels and Lubricants*, vol. 7, no. 1, pp. 9–28, 2014, doi: 10.4271/2014-01-1228.

[32] B. Viswanathan, “Chapter 2 – Petroleum,” *Energy Sources*, pp. 29–57, 2017, doi: 10.1016/B978-0-444-56353-8.00002-2.

[33] M. Wen *et al.*, “Effects of Gasoline Octane Number on Fuel Consumption and Emissions in Two Vehicles Equipped with GDI and PFI Spark-Ignition Engine,” *Journal of Energy Engineering*, vol. 146, no. 6, p. 04020069, 2020, doi: 10.1061/(asce)ey.1943-7897.0000722.

[34] L. W. Jia, M. Q. Shen, J. Wang, and M. Q. Lin, “Influence of ethanol-gasoline blended fuel on emission characteristics from a four-stroke motorcycle engine,” *Journal of Hazardous Materials*, vol. 123, no. 1–3, pp. 29–34, 2005, doi: 10.1016/j.jhazmat.2005.03.046.

[35] R. Gallagher, “Cost-Benefit Analysis: Dhaka’s Future Urban Transport Bangladesh Priorities,” p. 75, 2016, [Online]. Available: www.copenhagenconsensus.com

[36] T. Conference, vol. 25, no. 13, pp. 2285–2288, 2010.

[37] International Energy Agency, “Emission Factor for Greenhouse Gas Inventories,” *Iea*, vol. 40, no. 6, pp. 590–615, 2017.

Appendix

Appendix 1

Collected Survey Data

Table 11: Collected Survey Data

Sl.	Brand	Model	RY	MY	EC	Mileage	Fuel	FC	Reg. No.
1	Bajaj	Bajaj Discover 100	2018	2017	100	17000	Octane	40	DM-HA-51-6204
2	Bajaj	Bajaj Discover 100	2018	2017	100	8700	Octane	45	HAB-HA-11-2816
3	Bajaj	Bajaj Discover 100	2018	2017	100	10500	Octane	40	DM-HA-22-1419
4	Bajaj	Bajaj Discover 100	2019	2017	100	299750	Octane	50	DM-HA-50-2557
5	Bajaj	Bajaj Discover 110	2020	2019	110	1700	Octane	40	DM-HA-68-2797
6	Bajaj	Bajaj Discover 125	2016	2015	125	21000	Octane	50	DM-HA-90-3867
7	Bajaj	Bajaj Discover 125	2018	2016	125	31400	Octane	40	DM-HA-29-5964
8	Bajaj	Bajaj Discover 125	2013	2013	125	56000	Octane	42	DM-HA-50-1029
9	Bajaj	Bajaj Discover 125	2013	2012	125	61000	Octane	45	DM-HA-360365
10	Bajaj	Bajaj Discover 125	2018	2018	125	24500	Octane	40	DM-HA-14-0654
11	Bajaj	Bajaj Discover 125	2019	2019	125	18000	Petrol	40	DM-HA-64-4342
12	Bajaj	Bajaj Discover 125	2016	2015	125	36900	Octane	50	DM-HA-61-8281
13	Bajaj	Bajaj Discover 125	2018	2018	125	26500	Petrol	50	DM-HA-59-1384
14	Bajaj	Bajaj Discover 125	2016	2014	125	37000	Octane	45	DM-HA-19-6738
15	Bajaj	Bajaj Discover 125	2019	2019	125	15600	Octane	40	DM-HA-56-5479
16	Bajaj	Bajaj Discover 125	2016	2015	125	58000	Octane	50	DM-HA-16-7731
17	Bajaj	Bajaj Discover 125	2019	2019	125	19000	Octane	40	DM-HA-22-5430
18	Bajaj	Bajaj Discover 125	2018	2017	125	21000	Octane	40	DM-HA-61-5296
19	Bajaj	Bajaj Discover 125	2017	2016	125	25000	Octane	45	DM-HA-22-6478
20	Bajaj	Bajaj Discover 125	2016	2016	125	21000	Octane	50	DM-HA-61-3093
21	Bajaj	Bajaj Discover 125	2016	2015	125	27000	Octane	50	DM-HA-56-1433
22	Bajaj	Bajaj Discover 125	2018	2017	125	8800	Petrol	40	DM-HA-66-6894
23	Bajaj	Bajaj Discover 125	2018	2017	125	15000	Octane	40	DM-HA-64-5384
24	Bajaj	Bajaj Discover 125	2018	2017	125	12000	Octane	45	DM-HA-16-5178
25	Bajaj	Bajaj Discover 125	2018	2017	125	12000	Octane	40	DM-HA-66-3312
26	Bajaj	Bajaj Discover 125	2021	2021	125	4900	Octane	40	DM-HA-66-5366
27	Bajaj	Bajaj Discover 125	2020	2019	125	15000	Octane	50	DM-HA-65-2248
28	Bajaj	Bajaj Discover 125	2019	2018	125	367000	Octane	50	DM-HA-58-1343
29	Bajaj	Bajaj Discover 125	2018	2017	125	19000	Octane	40	DM-HA-46-3964

30	Bajaj	Bajaj Discover 125	2021	2020	125	3400	Petrol	40	DM-HA-67-1568
31	Bajaj	Bajaj Discover 125	2011	2011	125	96506	Octane	50	DM-HA-12-6863
32	Bajaj	Bajaj Discover 125	2015	2014	125	15200	Petrol	40	DM-HA-51-0961
33	Bajaj	Bajaj Discover 125	2020	2020	125	3000	Petrol	40	DM-HA-65-3852
34	Bajaj	Bajaj Discover 125	2019	2018	125	25000	Octane	50	DM-HA-58-7813
35	Bajaj	Bajaj FI VS	2021	2020	160	11500	Octane	38	DM-LA-53-2534
36	Bajaj	Bajaj Platina	2010	2009	100	108000	Octane	30	DM-HA-46-7243
37	Bajaj	Bajaj Platina	2018	2017	100	29000	Octane	40	DM-LA-64- 9512
38	Bajaj	Bajaj Platina	2017	2017	100	38890	Octane	35	DM-HA-47-5731
39	Bajaj	Bajaj Pulsar	2021	2018	150	5100	Octane	40	DM-LA-53-9615
40	Bajaj	Bajaj Pulsar	2020	2020	150	11500	Octane	35	DM-LA-19-4348
41	Bajaj	Bajaj Pulsar	2017	2017	150	47000	Octane	40	DM-LA-32-0604
42	Bajaj	Bajaj Pulsar	2013	2012	150	79800	Petrol	35	DM-LA-11-6342
43	Bajaj	Bajaj Pulsar	2012	2010	150	43000	Octane	35	DM-LA-25-8174
44	Bajaj	Bajaj Pulsar	2020	2020	150	6700	Octane	38	DM-LA-41-0052
45	Bajaj	Bajaj Pulsar	2020	2019	150	11700	Octane	32	DM-LA-51-0272
46	Bajaj	Bajaj Pulsar	2018	2017	150	28500	Octane	40	DM-LA-250400
47	Bajaj	Bajaj Pulsar	2017	2016	150	44000	Octane	40	DM-LA-27-6336
48	Bajaj	Bajaj Pulsar	2014	2013	150	47000	Octane	36	DM-LA-36-1151
49	Bajaj	Bajaj Pulsar	2018	2017	150	30000	Octane	35	DM-LA-14-4786
50	Bajaj	Bajaj Pulsar	2018	2017	150	32800	Octane	28	DM-LA-54-3480
51	Bajaj	Bajaj Pulsar	2020	2020	150	7600	Petrol	30	DM-LA-51-1994
52	Bajaj	Bajaj Pulsar	2018	2018	150	30000	Petrol	35	DM-LA-33-1515
53	Bajaj	Bajaj Pulsar	2013	2012	150	82500	Octane	37	DM-LA-19-2574
54	Bajaj	Bajaj Pulsar	2014	2010	150	13225	Octane	40	DM-LA-29-0954
55	Bajaj	Bajaj Pulsar	2019	2017	150	14000	Octane	40	DM-LA-35-0580
56	Bajaj	Bajaj Pulsar	2017	2016	150	22000	Octane	35	DM-LA-27-7680
57	Bajaj	Bajaj Pulsar	2017	2017	150	14000	Octane	33	SHP-LA-11-3763
58	Bajaj	Bajaj Pulsar	2018	2018	150	17000	Octane	35	DM-LA-20-9608
59	Bajaj	Bajaj Pulsar	2017	2017	150	18700	Octane	40	DM-LA-40-0379
60	Bajaj	Bajaj Pulsar	2018	2017	150	17000	Octane	40	DM-LA-50-7460
61	Bajaj	Bajaj Pulsar	2019	2019	150	5500	Octane	35	DM-LA-31-7248
62	Bajaj	Bajaj Pulsar	2020	2019	150	5300	Octane	35	DM-LA-1272125
63	Bajaj	Bajaj Pulsar	2018	2018	150	12000	Octane	32	DM-LA-25-9741
64	Bajaj	Bajaj Pulsar	2018	2017	150	10900	Octane	30	DM-LA-39-3095
65	Bajaj	Bajaj Pulsar	2019	2019	150	8500	Octane	35	DM-LA-18-7451

66	Bajaj	Bajaj Pulsar	2018	2018	150	12000	Octane	35	DM-LA-25-5149
67	Bajaj	Bajaj Pulsar	2018	2017	150	10700	Octane	33	DM-LA-11-9316
68	Bajaj	Bajaj Pulsar	2019	2018	150	8500	Octane	37	DM-LA-39-3822
69	Bajaj	Bajaj Pulsar	2021	2021	150	3000	Octane	40	DM-LA-53-8086
70	Bajaj	Bajaj Pulsar	2004	2003	150	250000	Octane	40	DM-LA-11-0039
71	Bajaj	Bajaj Pulsar	2018	2017	150	4001	Petrol	38	DM-LA-19-4330
72	Bajaj	Bajaj Pulsar	2016	2014	150	56682	Octane	35	DM-LA-26-6314
73	Bajaj	Bajaj Pulsar	2017	2015	150	132000	Octane	35	DM-LA-11-3244
74	Bajaj	Bajaj Pulsar	2013	2011	150	52000	Petrol	35	DM-LA-23-0780
75	Bajaj	Bajaj Pulsar	2008	2009	150	90000	Octane	30	DM-LA-11-9811
76	Bajaj	Bajaj Pulsar	2018	2015	150	33500	Octane	40	DM-LA-14-7818
77	Bajaj	Bajaj Pulsar	2011	2011	150	80000	Octane	40	DM-LA-11-0464
78	Bajaj	Bajaj Pulsar	2020	2019	150	6000	Octane	38	DM-LA-51-5745
79	Bajaj	Bajaj Pulsar	2019	2018	150	18000	Octane	37	DM-LA-34-9386
80	Bajaj	Bajaj Pulsar	2014	2013	150	95000	Petrol	25	DM-LA-11-0950
81	Bajaj	Bajaj Pulsar	2011	2010	150	76000	Octane	36	DM-LA-11-3646
82	Bajaj	Bajaj Pulsar	2021	2021	150	114000	Octane	40	DM-LA-40-5689
83	Bajaj	Bajaj Pulsar LS	2019	2018	135	110325	Octane	38	DM-LA-21-3187
84	Bajaj	Bajaj Pulsar LS	2012	2011	135	75500	Octane	40	DM-LA-61-6694
85	Bajaj	Bajaj Pulsar NS	2020	2019	160	6800	Octane	30	DM-LA-56-5999
86	Bajaj	Bajaj Pulsar NS	2018	2018	160	7800	Octane	40	DM-LA-26-3089
87	Bajaj	Bajaj Pulsar NS	2018	2018	160	74000	Octane	35	DM-LA-37-4902
88	Bajaj	Bajaj Pulsar NS	2020	2020	160	14000	Octane	35	DM-LA-51-6219
89	Bajaj	Bajaj Pulsar NS	2019	2019	160	20631	Octane	32	DM-LA-44-6102
90	Bajaj	Bajaj Vikrant 15	2019	2019	150	4800	Octane	35	DM-LA-38-3602
91	Haojue	Haojue Cool	2015	2015	150	70000	Petrol	45	DM-LA-18-0751
92	Hero	Hero Extreme	2016	2016	150	20,000	Petrol	30	DM-LA-32-1963
93	Hero	Hero Glamour	2017	2016	125	52000	Petrol	35	DM-LA50-4521
94	Hero	Hero Glamour	2012	2010	125	27000	Octane	35	DM-HA-43-7511
95	Hero	Hero Glamour	2017	2015	125	220084	Octane	45	DM-HA-22-6804
96	Hero	Hero Glamour	2020	2019	125	7000	Octane	45	DM-LA-66-6751
97	Hero	Hero Glamour	2017	2016	125	11200	Octane	40	DM-HA-53-4864
98	Hero	Hero Glamour	2016	2015	125	26000	Octane	40	DM-HA-51-1337
99	Hero	Hero Glamour	2017	2017	125	11000	Octane	45	DM-HA-54-9765
100	Hero	Hero Glamour	2017	2016	125	13500	Octane	42	DM-HA-49-9024
101	Hero	Hero Glamour	2017	2017	125	14000	Octane	47	DM-HA-64-3297

102	Hero	Hero Glamour	2016	2016	125	16000	Octane	45	DM-HA-61-5533
103	Hero	Hero Glamour	2017	2015	125	18900	Octane	40	DM-HA-532776
104	Hero	Hero Honda	2019	2019	125	29000	Octane	40	DM-HA-43-1037
105	Hero	Hero Honda Hunk	2015	2015	150	55187	Octane	30	DM LA 27 1702
106	Hero	Hero Honda Hunk	2017	2016	150	27000	Octane	40	DM-LA-29-3836
107	Hero	Hero Honda Hunk	2018	2018	150	28000	Octane	35	DM-LA-24-3578
108	Hero	Hero Honda Hunk	2019	2019	150	21800	Octane	30	DM-LA-11-3029
109	Hero	Hero Honda Hunk	2019	2019	150	23000	Octane	40	DM-LA-36-1326
110	Hero	Hero Honda Hunk	2021	2021	150	2700	Octane	35	DM-LA-41-1038
111	Hero	Hero Honda Hunk	2019	2019	150	18900	Petrol	30	DM-LA-35-5601
112	Hero	Hero Honda Hunk	2017	2017	150	17700	Octane	30	DM-LA-35-8915
113	Hero	Hero Honda Hunk	2017	2015	150	15000	Octane	35	DM-LA-51-6471
114	Hero	Hero Honda Hunk	2018	2017	150	10500	Octane	40	DM-LA-35-4323
115	Hero	Hero Honda Hunk	2019	2018	150	5500	Octane	35	DM-LA-44-0537
116	Hero	Hero Honda Hunk	2019	2019	150	6000	Octane	40	DM-LA-32-4081
117	Hero	Hero Honda Hunk	2019	2018	150	9000	Octane	40	DM-LA-27-1748
118	Hero	Hero Honda Hunk	2019	2018	150	7500	Octane	35	DM-LA-26-4778
119	Hero	Hero Honda Hunk	2019	2018	150	65000	Octane	30	DM-LA-29-0502
120	Hero	Hero Honda Hunk	2018	2015	150	10400	Octane	35	DM-LA-38-0259
121	Hero	Hero Ignitor	2020	2020	125	10400	Octane	40	DM-HA-68-9046
122	Hero	Hero Ignitor	2018	2018	125	50108	Octane	45	DM-HA-36-4222
123	Hero	Hero Motor	2017	2015	125	38000	Octane	40	DM-HA-58-6862
124	Hero	Hero Pleasure	2016	2016	100	25800	Octane	50	DM-HA-31-5048
125	Hero	Hero Pro	2014	2013	100	40000	Octane	40	DM-HA-45-7748
126	Hero	Hero Splendor Pro	2012	2011	100	50000	Petrol	38	DM-HA-12-0058
127	Hero	Hero Splendor 100	2015	2016	100	5000	Petrol	30	DM-HA-26-5569
128	Hero	Hero Splendor 100	2018	2017	100	24000	Petrol	45	DM-HA-51-5507
129	Hero	Hero Splendor 100	2015	2014	100	37000	Octane	45	DM-HA-36-3038
130	Hero	Hero Splendor 110	2014	2012	110	42600	Octane	45	DM-HA-22-9332
131	Hero	Hero Splendor 110	2019	2018	110	12000	Octane	50	DM-HA-45-3877
132	Hero	Hero Splendor 110	2016	2016	110	19700	Octane	40	DM-HA-32-2143
133	Hero	Hero Splendor 110	2017	2016	110	23700	Octane	50	DM-HA-33-5394
134	Hero	Hero Splendor 110	2017	2017	110	16500	Octane	45	DM-HA-64-2044
135	Hero	Hero Splendor Plus	2019	2019	100	10000	Octane	50	DM-LA-65-2406
136	Honda	Honda Activa	2020	2020	110	7600	Octane	50	DM-HA-14-8243
137	Honda	Honda CB Hornet	2020	2020	160	16000	Octane	45	DM-LA-29-8323

138	Honda	Honda CB Hornet	2021	2021	160	6300	Octane	35	DM-LA-53-2949
139	Honda	Honda CB Hornet	2019	2018	160	17000	Octane	35	DM-LA-38-8023
140	Honda	Honda CB Hornet	2018	2018	160	27300	Octane	30	DM-LA-39-4168
141	Honda	Honda CB Hornet	2019	2019	160	17000	Octane	40	DM-LA-39-8075
142	Honda	Honda CB Hornet	2017	2016	160	20000	Octane	35	DM-LA-46-1977
143	Honda	Honda CB Hornet	2020	2020	160	3500	Octane	35	DM-LA-22-0953
144	Honda	Honda CB Hornet	2020	2019	160	3900	Octane	40	DM-LA-22-6567
145	Honda	Honda CB Hornet	2020	2019	160	1800	Octane	35	DM-LA-53-7828
146	Honda	Honda CB Hornet	2020	2020	160	7000	Octane	35	KHG-LA-11-1376
147	Honda	Honda CB Hornet	2020	2019	160	3000	Octane	40	DM-LA-51-4829
148	Honda	Honda CB Hornet	2018	2017	160	16000	Octane	40	DM-LA-36-7783
149	Honda	Honda CB Hornet	2020	2018	160	13550	Octane	30	DM-LA-20-9486
150	Honda	Honda CB Hornet	2018	2018	160	19500	Octane	38	DM-LA-37-1532
151	Honda	Honda CB Shine	2019	2018	125	34007	Octane	45	DM-HA-39-2820
152	Honda	Honda CB Shine	2019	2019	125	49645	Octane	48	DM-HA-60-4397
153	Honda	Honda CB Shine	2019	2019	125	7800	Octane	36	DM-HA-50-7297
154	Honda	Honda CB Shine	2016	2015	125	54600	Octane	38	DM-HA-66-5067
155	Honda	Honda CB Trigger	2019	2019	150	43000	Octane	40	DM-LA-44-5816
156	Honda	Honda CB Trigger	2018	2017	150	137,000	Octane	40	DM-LA-33-1721
157	Honda	Honda CB Trigger	2018	2017	150	39100	Octane	40	DM-LA-35-5302
158	Honda	Honda CB Trigger	2021	2020	150	2400	Petrol	40	DM-LA-31-1268
159	Honda	Honda CB Trigger	2020	2020	150	3500	Octane	40	DM-LA-27-4732
160	Honda	Honda CB Trigger	2020	2019	150	5500	Octane	35	DM-LA-18-7322
161	Honda	Honda CB Trigger	2020	2019	150	6000	Petrol	40	DM-LA-36-0126
162	Honda	Honda CB Unicorn	2010	2009	150	94600	Octane	35	DM-LA-15-4415
163	Honda	Honda CBI HS100	1994	1993	125	500000	Octane	25	DM-LA-02-0368
164	Honda	Honda CBR 150R	2021	2021	150	700	Octane	34	DM-LA-53-7350
165	Honda	Honda CBZ	2021	2020	150	4700	Octane	35	DM-LA-14-0832
166	Honda	Honda CD80	2018	2017	80	30500	Octane	50	DM-HA-47-5547
167	Honda	Honda Dio	2018	2017	110	9000	Octane	45	DM-HA-59-5777
168	Honda	Honda Dream	2018	2018	125	6245	Octane	40	DM-HA-57-0192
169	Honda	Honda Dream Neo	2015	2015	110	50000	Octane	48	DM-HA-60-5293
170	Honda	Honda Livo	2021	2020	125	5700	Octane	50	DM-HA-67-1445
171	Honda	Honda Livo	2018	2017	125	13750	Petrol	50	DM-HA-48-6349
172	Honda	Honda Livo	2018	2018	125	7500	Octane	45	DM-HA-55-9132
173	Honda	Honda Livo	2018	2018	125	15000	Octane	50	DM-HA-32-5790

174	Honda	Honda Livo	2019	2018	125	12000	Petrol	50	DM-HA-47-3349
175	Honda	Honda Livo	2019	2018	125	6900	Octane	45	DM-HA-32-7681
176	Honda	Honda Livo	2019	2019	125	7000	Octane	55	DM-HA-32-1288
177	Honda	Honda Livo	2019	2018	125	7800	Octane	50	DM-HA-91-7597
178	Honda	Honda Livo	2019	2018	125	6400	Octane	50	DM-HA-46-0284
179	Honda	Honda Livo	2019	2018	125	8800	Octane	50	DM-HA-68-4255
180	Honda	Honda Livo	2019	2019	125	6500	Octane	45	DM-HA-65-1520
181	Honda	Honda Optimax 125	2020	2020	125	4500	Octane	55	DM-HA-33-0141
182	Honda	Honda Repsol	2019	2017	160	63000	Octane	35	DM-LA-50-3317
183	Honda	Honda SP	2016	2016	125	18000	Octane	40	DM-HA-65-8294
184	Honda	Honda Splendor	2016	2015	110	18000	Octane	40	DM-HA-60-6657
185	Honda	Honda Splendor	2017	2017	110	22000	Octane	45	DM-HA-50-4734
186	Honda	Honda Thriller	2020	2019	150	32000	Octane	35	DM-HA-30-4912
187	Honda	Honda Thriller	2018	2018	150	12000	Octane	35	DM-LA-55-0737
188	Honda	Honda Unicorn	2016	2015	150	18000	Octane	30	DM-LA-13-3473
189	Honda	Honda Unicorn BS6	2021	2020	125	1200	Octane	40	DM-HA-67-3493
190	Honda	Honda X Blade	2021	2021	160	325	Octane	40	DM-LA-56-4798
191	Honda	Honda X Blade	2021	2020	160	50	Octane	45	DM-HA-40-2568
192	Honda	Honda X Blade	2021	2021	160	400	Octane	50	DM-LA-56-2250
193	Honda	Honda X Blade	2021	2021	165	1800	Octane	50	DM-LA-55-8631
194	Honda	Honda X blade	2020	2019	160	1700	Octane	35	DM-HA-29-6508
195	Honda	Honda X blade	2019	2019	160	11500	Octane	40	DM-LA-46-2473
196	Keeway	Keeway Benelli	2020	2019	165	12000	Petrol	30	DM-HA-50-1668
197	Keeway	Keeway Benelli	2020	2018	165	7000	Octane	30	DM-LA-22-4435
198	Keeway	Keeway RK	2018	2018	100	48000	Octane	40	DM-HA-34-9025
199	Keeway	Keeway RKR	2021	2019	165	12000	Octane	28	DM-LA-52-0306
200	Keeway	Keeway RKS	2016	2016	125	22000	Octane	25	DM-HA-57-7908
201	Keeway	Keeway RKS	2021	2020	150	1900	Octane	35	DM-LA-53-4887
202	Lifan	Lifan Glint	2018	2018	100	28000	Octane	50	DM-HA-52-9469
203	Lifan	Lifan KPR	2021	2021	165	7000	Octane	38	DM LA 52-4565
204	Lifan	Lifan KPR	2020	2019	165	25000	Octane	40	DM-LA-50-0480
205	LML	LML Freedom	2018	2017	110	24700	Octane	50	DM-HA-24-5604
206	Mahindra	Mahindra Centuro 110	2015	2015	110	3000	Octane	25	DM-HA-482293
207	Mahindra	Mahindra Rodeo 110	2018	2018	110	7500	Octane	35	DM-HA-26-8627
208	Mahindra	Mahindra Rodeo 125	2017	2017	125	16000	Octane	40	DM-HA-487146
209	Runner	Runner Bolt 165	2021	2021	165	8500	Octane	35	DM-LA-31-6868

210	Runner	Runner Bullet	2021	2020	100	2100	Octane	45	DM-HA-32-0429
211	Runner	Runner Commando	2019	2019	150	700	Octane	35	DM-LA-40-6894
212	Runner	Runner Knight Rider	2018	2017	150	29800	Octane	30	DM-LA-23-2232
213	Runner	Runner Knight Rider	2020	2019	150	9800	Octane	35	DM-LA-11-5678
214	Runner	Runner Royal Plus	2018	2017	110	27300	Octane	45	DM-HA-48-8499
215	Runner	Runner Royal Plus	2020	2020	110	5600	Octane	45	DM-HA-32-2548
216	Runner	Runner Turbo	2019	2019	125	60000	Octane	40	DM-HA-42-5912
217	Suzuki	Suzuki AX100	2012	2010	100	32000	Octane	14	DM-HA-30-1201
218	Suzuki	Suzuki Gixxer 150	2016	2016	150	25000	Octane	33	DM-LA-32-4308
219	Suzuki	Suzuki Gixxer 150	2020	2020	150	8050	Octane	42	DM-LA-50-2135
220	Suzuki	Suzuki Gixxer 150	2019	2018	150	22700	Petrol	35	DM-LA-37-7753
221	Suzuki	Suzuki Gixxer 150	2019	2019	150	5700	Octane	35	DM-LA-36-4531
222	Suzuki	Suzuki Gixxer 150	2018	2017	150	37500	Octane	40	DM-LA-35-8868
223	Suzuki	Suzuki Gixxer 150	2017	2015	150	39500	Octane	37	DM-LA-53-9635
224	Suzuki	Suzuki Gixxer 150	2019	2019	150	12000	Octane	40	DM-LA-44-6155
225	Suzuki	Suzuki Gixxer 150	2021	2018	150	6000	Octane	35	DM-LA-53-6785
226	Suzuki	Suzuki Gixxer 150	2019	2019	150	8600	Octane	35	DM-LA-39-0645
227	Suzuki	Suzuki Gixxer 150	2020	2020	150	4750	Octane	37	DM-LA-31-9466
228	Suzuki	Suzuki Gixxer 150	2020	2019	150	4500	Octane	42	DM-LA-51-1043
229	Suzuki	Suzuki Gixxer 150	2019	2018	150	7800	Octane	40	DM-LA-47-5769
230	Suzuki	Suzuki Gixxer 150	2020	2019	150	5700	Octane	40	DM-LA-3968
231	Suzuki	Suzuki Gixxer 150	2020	2019	150	3000	Octane	35	DM-LA-35-3988
232	Suzuki	Suzuki Gixxer 150	2020	2019	150	4100	Octane	42	DM-LA-20-3512
233	Suzuki	Suzuki Gixxer 150	2020	2019	150	2000	Octane	35	DM-LA-38-2363
234	Suzuki	Suzuki Gixxer 150	2020	2019	150	6700	Octane	40	DM-LA-56-5402
235	Suzuki	Suzuki Gixxer 150	2020	2019	150	2900	Octane	37	DM-LA-46-3229
236	Suzuki	Suzuki Gixxer 150	2020	2019	150	3800	Octane	42	DM-LA-50-6722
237	Suzuki	Suzuki Gixxer 150	2020	2019	150	4200	Octane	40	DM-LA-41-9060
238	Suzuki	Suzuki Gixxer 150	2020	2016	150	19000	Octane	35	DM-LA-24-8788
239	Suzuki	Suzuki Gixxer 155	2019	2016	155	31000	Octane	35	DM-LA-39-0065
240	Suzuki	Suzuki Gixxer 155	2019	2017	155	26000	Octane	32	DM-LA-46-2935
241	Suzuki	Suzuki Gixxer 155	2021	2016	155	1450	Octane	44	DM-LA-40-7099
242	Suzuki	Suzuki Gixxer 155	2018	2016	155	33,400	Octane	38	DM-LA-20-0809
243	Suzuki	Suzuki Gixxer 155	2018	2017	155	25000	Octane	35	DM-LA-41-3771
244	Suzuki	Suzuki Gixxer 155	2019	2019	155	43000	Octane	38	DM-LA-41
245	Suzuki	Suzuki Gixxer 160	2018	2017	160	42000	Octane	35	DM-LA-52-3430

246	Suzuki	Suzuki Gixxer SF 150	2020	2020	150	4500	Octane	45	DM-LA-49-3141
247	Suzuki	Suzuki Gixxer SF 150	2021	2021	150	6500	Octane	40	DM-LA-52-9057
248	Suzuki	Suzuki Gixxer SF 150	2019	2019	150	16000	Petrol	35	DM-LA-46-7446
249	Suzuki	Suzuki Gixxer SF 155	2017	2017	155	21000	Octane	28	DM-LA-35-4965
250	Suzuki	Suzuki Gixxer SF 155	2017	2017	155	20000	Octane	33	DM-LA-46-8928
251	Suzuki	Suzuki Gixxer SF 155	2020	2019	155	11000	Octane	40	DMP AI 3652
252	Suzuki	Suzuki Gixxer SF 160	2020	2020	160	4700	Octane	25	DM-LA-52-1726
253	Suzuki	Suzuki Gixxer SF 160	2020	2020	160	4000	Octane	25	DM-LA-31-9729
254	Suzuki	Suzuki Gixxer SF 160	2020	2020	160	6500	Octane	28	DM-LA-52-4833
255	Suzuki	Suzuki Gixxer SF 160	2020	2020	160	2200	Octane	30	DM-LA-50-2848
256	Suzuki	Suzuki Gixxer SF 160	2020	2020	160	5900	Octane	28	DM-LA-55-8441
257	Suzuki	Suzuki GN	2021	2017	125	50000	Petrol	25	DM-HA-68-2131
258	Suzuki	Suzuki GSX	2018	2017	150	22000	Octane	22	DM-LA-33-7571
259	Suzuki	Suzuki GSX	2021	2017	150	10000	Octane	33	DM-LA-55-2716
260	Suzuki	Suzuki GSX	2019	2019	150	3200	Octane	32	DM-LA-46-4777
261	Suzuki	Suzuki Hayate	2021	2021	110	2846	Octane	43	DM-HA-67-3714
262	Suzuki	Suzuki Hayate	2014	2012	110	57000	Octane	45	DM-HA-34-7156
263	Suzuki	Suzuki Hayate	2016	2015	110	25600	Octane	40	DM-HA-59-4604
264	Suzuki	Suzuki Hayate	2015	2015	110	22000	Octane	45	DM-HA-61-9139
265	Suzuki	Suzuki Hayate	2015	2015	110	22000	Octane	35	DM-HA-58-1134
266	Suzuki	Suzuki Hayate	2015	2015	110	45000	Octane	40	DM-HA-46-2708
267	Taro	TARO GP1	2021	2021	150	1700	Octane	35	DM-LA-55-1069
268	TVS	TVS 125 ES	2012	2011	125	40750	Octane	45	DM-HA-41-9029
269	TVS	TVS 4V	2019	2018	160	145343	Octane	45	DM-LA-39-5015
270	TVS	TVS Apache RTR	2018	2018	150	31500	Octane	30	DM-LA-41-9868
271	TVS	TVS Apache RTR	2016	2015	150	43358	Octane	32	DM-LA-26-5987
272	TVS	TVS Apache RTR	2016	2015	150	40000	Octane	40	DM-LA-11-3835
273	TVS	TVS Apache RTR	2019	2018	150	26000	Octane	30	DM-LA-39-4168
274	TVS	TVS Apache RTR	2021	2021	150	5500	Octane	35	DM-LA-33-8711
275	TVS	TVS Apache RTR	2018	2017	150	25000	Octane	30	DM-LA-34-8050
276	TVS	TVS Apache RTR	2017	2017	150	12500	Octane	35	DM-LA-36-6374
277	TVS	TVS Apache RTR	2018	2017	150	8800	Octane	35	DM-LA-38-5542
278	TVS	TVS Apache RTR	2018	2017	150	8600	Octane	30	DM-LA-29-3824
279	TVS	TVS Apache RTR	2018	2017	150	12300	Octane	30	DM-LA-34-8620
280	TVS	TVS Apache RTR	2018	2017	150	9800	Octane	35	DM-LA-32-5567
281	TVS	TVS Apache RTR	2018	2017	150	10000	Octane	30	DM-LA-39-7351

282	TVS	TVS Apache RTR 165	2021	2021	165	2000	Octane	38	DM-LA-40-4440
283	TVS	TVS Apache RTR 4V	2015	2012	160	57000	Octane	25	DM-LA-11-4877
284	TVS	TVS Apache RTR 4V	2019	2017	160	58000	Octane	40	DM-HA-32-1712
285	TVS	TVS Apache RTR 4V	2021	2021	160	14000	Octane	28	DM-LA-52-60-46
286	TVS	TVS Apache RTR 4V	2020	2020	160	35000	Octane	30	DM-LA-55-5991
287	TVS	TVS Apache RTR 4V	2021	2021	160	7000	Octane	40	DM-LA-52-8225
288	TVS	TVS Apache RTR 4V	2021	2021	160	7083	Octane	25	DM-LA-520771
289	TVS	TVS Apache RTR 4V	2020	2020	160	13000	Octane	36	DM-LA-31-6535
290	TVS	TVS Apache RTR 4V	2021	2021	160	3000	Petrol	25	DM-LA-50-4521
291	TVS	TVS Apache RTR 4V	2020	2019	160	7800	Octane	40	DM-LA-29-5688
292	TVS	TVS Apache RTR 4V	2020	2019	160	18900	Octane	28	DM-LA-47-9978
293	TVS	TVS Apache RTR 4V	2021	2020	160	789	Octane	30	DM-LA-50-6889
294	TVS	TVS Apache RTR 4V	2021	2019	160	2900	Octane	40	DM-LA-39-0792
295	TVS	TVS Apache RTR 4V	2021	2021	160	2200	Octane	25	DM-LA-52-9824
296	TVS	TVS Apache RTR 4V	2021	2020	160	4500	Octane	36	DM-LA-19-1104
297	TVS	TVS Apache RTR 4V	2021	2020	160	1500	Octane	37	DM-LA-20-7219
298	TVS	TVS Apache RTR 4V	2021	2020	160	1900	Octane	38	DM-LA-46-8054
299	TVS	TVS Apache RTR 4V	2021	2020	160	1400	Octane	25	DM-LA-50-1469
300	TVS	TVS Apache RTR 4V	2021	2021	160	3500	Octane	35	DM-LA-34-2064
301	TVS	TVS Apache RV	2019	2018	160	23000	Octane	29	DM-LA-49-4906
302	TVS	TVS Centra	2018	2018	100	12000	Octane	45	DM-HA-26-9004
303	TVS	TVS Duralife	2019	2018	110	29100	Octane	40	DM-HA-66-5666
304	TVS	TVS Flame	2018	2017	125	11600	Octane	50	DM-HA-36-0103
305	TVS	TVS Metro	2019	2019	100	15600	Octane	50	DM-HA-56-2744
306	TVS	TVS Metro	2017	2016	100	41000	Octane	40	DM-HA-24-1337
307	TVS	TVS Metro	2017	2017	100	19400	Octane	40	DM-HA-36-7594
308	TVS	TVS Metro	2021	2020	100	8340	Octane	55	DM-HA-65-5208
309	TVS	TVS Metro	2019	2019	100	41000	Petrol	50	DM-HA-58-2794
310	TVS	TVS Metro Plus	2017	2017	110	564299	Octane	50	DM-HA-50-6474
311	TVS	TVS Metro Plus	2016	2014	110	84000	Octane	40	DM-HA-32-0313
312	TVS	TVS Metro Plus	2018	2017	110	29900	Octane	40	DM-HA-52-2450
313	TVS	TVS Metro Plus	2016	2016	110	82000	Octane	55	DM-HA-28-0642
314	TVS	TVS Metro Plus	2018	2019	110	7500	Octane	10	DM-HA-55-5276
315	TVS	TVS Metro Plus	2016	2017	110	30000	Octane	35	DM-HA-345137
316	TVS	TVS Pleasure	2017	2017	110	12000	Petrol	50	DM-HA-28-2015
317	TVS	TVS Radeon	2021	2020	110	4000	Octane	50	DM-HA-66-5462

318	TVS	TVS Splendor Plus	2009	2007	100	58560	Petrol	35	DM-HA-33-3047
319	TVS	TVS Splendor pro	2015	2013	100	20000	Octane	45	DM-HA-20-9646
320	TVS	TVS Stryker	2019	2019	125	12000	Octane	45	DM-HA-42-4697
321	TVS	TVS Stryker	2019	2018	125	14500	Octane	30	DM-HA-64-9514
322	TVS	TVS Stryker	2017	2017	125	38300	Octane	34	DM-HA-60-2991
323	TVS	TVS Stryker	2014	2013	125	64500	Octane	30	DM-HA-67-3322
324	TVS	TVS Stryker	2017	2017	125	15000	Petrol	40	DM-HA-68-1116
325	TVS	TVS Stryker	2019	2019	125	14500	Octane	35	DM-HA-16-8584
326	TVS	TVS Stryker	2019	2019	125	8500	Octane	35	DM-HA-67-4206
327	TVS	TVS Stryker	2019	2018	125	6800	Octane	50	DM-HA-58-1452
328	TVS	TVS Stryker	2018	2017	125	17300	Octane	30	DM-HA-61-2402
329	TVS	TVS Stryker	2019	2019	125	9800	Octane	40	DM-HA-16-4046
330	TVS	TVS Stryker	2019	2018	125	6500	Octane	30	DM-HA-32-7137
331	TVS	TVS Stryker	2019	2018	125	13000	Octane	50	DM-HA-57-5599
332	TVS	TVS Stryker	2021	2020	125	2000	Octane	30	DM-HA-67-4886
333	TVS	TVS Stryker EX	2019	2017	125	102000	Octane	40	DM-HA-30-1204
334	TVS	TVS Stryker EX	2019	2018	125	262866	Octane	40	DM-HA-50-5194
335	TVS	TVS Stryker	2018	2018	125	22500	Octane	35	DM-HA-12-2725
336	TVS	TVS Turbo 125	2016	2016	125	38000	Octane	36	DM-LA-24-6628
337	TVS	TVS Victor	2016	2003	110	44500	Octane	40	DM-HA-17-6892
338	TVS	TVS Weego	2016	2014	110	21000	Octane	40	DM-HA-22-8871
339	TVS	TVS Weego	2020	2018	110	15500	Petrol	45	DM-HA-34-3400
340	TVS	TVS XL 100	2017	2017	100	12600	Octane	50	DM-HA-50-8466
341	Victor	Victor-R Classic 100	2019	2018	100	6500	Octane	40	DM-HA-57-3584
342	Walton	Walton Fusion	2020	2019	110	13000	Octane	40	DM-HA-51-4022
343	Yamaha	Yamaha Cruiser	2015	2015	100	23000	Octane	50	DM-HA-25-8500
344	Yamaha	Yamaha Enticer	2018	2018	125	24000	Octane	40	DM-HA-33-2904
345	Yamaha	Yamaha Enticer	2017	2016	125	51000	Octane	40	DM-HA-21-3165
346	Yamaha	Yamaha Fazer	2019	2017	150	18000	Octane	35	DM-LA-44-3564
347	Yamaha	Yamaha Fazer	2018	2018	150	30500	Octane	45	DM-LA-37-8579
348	Yamaha	Yamaha Fazer	2020	2020	150	8000	Octane	30	DM-LA-50-8602
349	Yamaha	Yamaha Fazer	2018	2017	150	28000	Petrol	30	DM-LA-20-6503
350	Yamaha	Yamaha Fazer	2020	2019	150	12000	Octane	35	DM-LA-19-7979
351	Yamaha	Yamaha Fazer	2016	2015	150	19000	Octane	28	DM-LA-12-2048
352	Yamaha	Yamaha Fazer	2019	2018	150	9000	Octane	30	DM-LA-35-2310
353	Yamaha	Yamaha Fazer	2018	2018	150	8500	Octane	35	DM-LA-39-0247

354	Yamaha	Yamaha Fazer FI V2	2019	2019	150	12000	Octane	30	DM-LA-39-0653
355	Yamaha	Yamaha FZ	2018	2018	150	25000	Octane	40	DM-LA-43-7801
356	Yamaha	Yamaha FZ	2021	2020	150	3800	Petrol	40	DM-LA-33-0255
357	Yamaha	Yamaha FZ	2018	2018	150	34000	Octane	45	DM-LA-46-2905
358	Yamaha	Yamaha FZS	2012	2011	150	47000	Petrol	30	DM-LA-19-6325
359	Yamaha	Yamaha FZS	2011	2010	150	28000	Petrol	35	DM-LA-17-5502
360	Yamaha	Yamaha FZS	2019	2019	150	14500	Octane	40	DM-LA-43-8208
361	Yamaha	Yamaha FZS	2020	2020	150	14000	Octane	45	DM-LA-21-4295
362	Yamaha	Yamaha FZS	2021	2019	150	4500	Octane	30	DM-LA-51-9620
363	Yamaha	Yamaha FZS	2020	2019	150	9900	Octane	35	DM-LA-39-8493
364	Yamaha	Yamaha FZS	2020	2019	150	13500	Octane	40	DM-LA-55-1498
365	Yamaha	Yamaha FZS	2019	2017	150	13277	Octane	30	DM-LA-33-0480
366	Yamaha	Yamaha FZS	2013	2011	150	70000	Octane	35	DM-LA-17-3199
367	Yamaha	Yamaha FZS	2010	2018	150	16550	Octane	40	DM-LA-38-0895
368	Yamaha	Yamaha FZS V3	2021	2020	150	4600	Octane	38	DM-LA-55-2405
369	Yamaha	Yamaha FZS V3	2020	2020	150	10400	Octane	40	DM-LA-47-8644
370	Yamaha	Yamaha MT 15	2019	2019	155	9000	Octane	35	DM-LA-31-7777
371	Yamaha	Yamaha MT 15	2021	2021	155	7300	Octane	45	DM-LA-56-1625
372	Yamaha	Yamaha MT 15	2021	2020	155	6100	Octane	38	DM-LA-51-5199
373	Yamaha	Yamaha MT 15	2020	2020	155	5000	Octane	35	DM LA 55-6554
374	Yamaha	Yamaha R15	2021	2021	155	1000	Octane	42	DM-LA-56-3039
375	Yamaha	Yamaha R15	2021	2021	155	3843	Octane	35	DM LA 53-8041
376	Yamaha	Yamaha R15	2021	2021	150	4900	Octane	40	DM-LA-52-7997
377	Yamaha	Yamaha R15	2021	2021	150	6000	Octane	37	DM-LA-55-7209
378	Yamaha	Yamaha R15 Monster	2020	2019	155	14600	Octane	40	DM-LA-44-9150
379	Yamaha	Yamaha R15 V2	2018	2015	155	19000	Octane	35	DM-LA-24-5584
380	Yamaha	Yamaha R15 V3	2017	2017	155	80000	Octane	30	DM-LA-34-2971
381	Yamaha	Yamaha RX100	2012	2010	100	36008	Octane	25	DM-LA-11-2203
382	Yamaha	Yamaha YZF R15	2020	2019	150	14000	Octane	35	DM-LA-47-4205
383	Yamaha	Yamaha YZF R15	2020	2019	150	16900	Octane	35	DM-LA-20-0681
384	Zhejiang	Zhejiang Caesar	2020	2019	150	8000	Octane	30	DM-LA-46-0613

Appendix 2

Invalid Data Excluded from Study

Table 12: Invalid Data

Sl.	**Brand**	**Model**	**RY**	**MY**	**EC**	**Mileage**	**Fuel**	**FC**	**Reg. No.**

1	Bajaj	Bajaj Discover 110	2019	2019	110	17000	Octane	45	
2	Bajaj	Bajaj Discover 125	2018	2017	125	8000	Octane	45	FENI-LA-11-2140
3	Bajaj	Bajaj Discover 125	2018	2017	125	11000	Octane	40	COM-HA-14-3988
4	Bajaj	Bajaj Discover 125	2017	2016	125	17700	Octane	40	CM-HA-15-3296
5	Bajaj	Bajaj Pulsar	2018	2018	150	12000	Octane	40	DM-LA-50-7460
6	Bajaj	Bajaj Pulsar	2020	2020	160	5300	Octane	35	CHP-LA-11-5555
7	Hero	Hero Extreme	2017	2014	150	107000	Petrol	40	.
8	Hero	Hero Splendor 120	2010	2010	120	6000	Octane	60	.
9	Hero	Hero Splendor 125	2017	2017	125	14000	Octane	45	NAR-HA-11-1679
10	Honda	Honda CB Hornet	2020	2020	160	3400	Octane	30	DM-LA-22-0953
11	Honda	Honda CB Hornet	2020	2020	160	3500	Octane	35	DM-LA-41-0225
12	Honda	Honda CB Hornet	2021	2020	160	3700	Octane	35	DM-LA-55-6017
13	Honda	Honda CB Hornet	2020	2018	160	16000	Octane	30	DM-LA-36-7783
14	Honda	Honda Livo	2018	2018	125	8500	Octane	50	DM-HA-60-7678
15	Honda	Honda Livo	2019	2018	125	9500	Octane	45	DM-HA-48-9017
16	Honda	Honda Livo	2019	2018	125	7000	Octane	45	DM-HA-52-2016
17	Honda	Honda Livo	2018	2017	125	7500	Octane	50	DM-HA-16-3351
18	Honda	Honda Passion	2017	2016	110	22000	Petrol	50	DM-HA-39-2820
19	Honda	Honda Prima	2019	2018	110	60000	Petrol	60	.
20	Honda	Honda Unicorn BS6	2021	2020	125	1500	Octane	35	DM-HA-68-4255
21	KTM	KTM Duke 165	2017	2016	165	132000	Octane	40	
22	Suzuki	Suzuki Access	2021	2021	125	310	Octane	35	Not yet received
23	Suzuki	Suzuki Gixxer 150	2017	2017	150	35000	Octane	35	.
24	Suzuki	Suzuki Gixxer 150	2019	2019	150	5600	Petrol	42	DM-LA-44-6155
25	Suzuki	Suzuki Gixxer 150	2020	2019	150	3900	Octane	35	JAS_LA_12-4503
26	Suzuki	Suzuki Gixxer 150	2020	2019	150	6000	Petrol	42	DM-LA-18-3726
27	Suzuki	Suzuki Gixxer 150	2020	2019	150	5600	Octane	40	DM-LA-47-4247
28	Suzuki	Suzuki Gixxer 150	2020	2019	150	4500	Octane	40	DM-LA-35-8157
29	Suzuki	Suzuki Gixxer 150	2020	2019	150	5600	Petrol	35	DM-LA-29-5512
30	Suzuki	Suzuki Gixxer SF 150	2020	2020	150	4100	Octane	30	DM-LA-29-1381
31	Suzuki	Suzuki Gixxer SF 150	2020	2020	150	4600	Octane	28	DM-LA-52-8820
32	Suzuki	Suzuki gixxer SF 150	2020	2020	150	2600	Octane	32	DM-LA-47-2114
33	TVS	TVS Apache RTR	2012	2012	150	45000	Petrol	28	Bogra LA-113656
34	TVS	TVS Apache RTR	2020	2017	150	9000	Octane	40	NET-LA-11-2386
35	TVS	TVS Apache RTR	2018	2017	150	32000	Octane	35	DM-LA-18-7978
36	TVS	TVS Apache RTR	2020	2019	150	4500	Octane	40	DM-LA-43-0286

37	TVS	TVS Apache RTR	2018	2017	150	8800	Octane	37	DM-LA-40-4456
38	TVS	TVS Apache RTR 4V	2021	2021	160	2200	Octane	40	DM-LA-40-7437
39	TVS	TVS Apache RTR 4V	2021	2020	160	2300	Octane	28	DM-LA-43-7687
40	TVS	TVS Apache RTR 4V	2021	2020	160	2600	Octane	40	DM-LA-40-4225
41	TVS	TVS Apache RTR 4V	2019	2018	160	97700	Octane	45	
42	TVS	TVS Stryker	2017	2017	125	70000	Petrol	40	RAJ-HA-14-7893
43	TVS	TVS Stryker	2018	2018	125	22000	Octane	40	DM-HA-65-8294
44	TVS	TVS Stryker	2020	2020	125	3500	Octane	36	DM-HA-66-9423
45	TVS	TVS Stryker	2019	2019	125	8600	Octane	40	DM-HA-56-7815
46	TVS	TVS Stryker	2019	2019	125	7800	Octane	40	DM-HA-42-0255
47	Yamaha	Yamaha Fazer	2018	2018	150	8500	Octane	30	DM-LA-27-3092
48	Yamaha	Yamaha Fazer	2018	2017	150	11000	Octane	40	DM-LA-33-7795
49	Yamaha	Yamaha Fazer	2018	2017	150	9000	Octane	35	DM-LA-33-9363
50	Yamaha	Yamaha FZ	2018	2017	150	16000	Octane	30	DM-LA-43-8101
51	Yamaha	Yamaha FZ	2018	2017	150	9500	Octane	40	DM-LA-40-5517
52	Yamaha	Yamaha FZ	2018	2017	150	19000	Octane	35	DM-LA-55-1846
53	Yamaha	Yamaha FZ	2018	2017	150	18700	Octane	36	DM-LA-47-2198
54	Yamaha	Yamaha FZ	2018	2017	150	16000	Octane	40	DM-LA-35-4240
55	Yamaha	Yamaha FZ	2018	2017	150	7900	Octane	40	DM-LA-29-7032
56	Yamaha	Yamaha FZ	2018	2017	150	10000	Octane	45	DM-LA-25-8024
57	Yamaha	Yamaha FZ	2018	2017	150	9900	Octane	50	DM-LA-20-3843
58	Yamaha	Yamaha FZS	2018	2017	150	14600	Octane	40	DM-LA-53-2643
59	Yamaha	Yamaha FZS	2018	2017	150	9800	Petrol	40	DM-LA-56-0640
60	Yamaha	Yamaha FZS	2018	2017	150	12000	Octane	35	DM-LA-56-5304
61	Yamaha	Yamaha FZS	2018	2017	150	7800	Octane	40	DM-LA-43-3683
62	Yamaha	Yamaha FZS	2018	2017	150	9000	Octane	30	DM-LA-53-7330
63	Yamaha	Yamaha FZS	2018	2017	150	7400	Octane	35	DM-LA-51-3735
64	Yamaha	Yamaha FZS V2	2019	2019	150	4500	Octane	30	
65	Yamaha	Yamaha RX100	1995	1995	100	88000	Octane	25	Rangpur A 02-1230

Appendix 3

Average Yearly Mileage, Yearly Fuel and Energy Consumption Calculations

Table 13: Calculated values for annual mileage, fuel and energy consumption

Sl.	Avg. Yearly Mileage (km/Year)	FC Gasoline (L/Year)	FC E10 (L/Year)	Energy Consumption (MJ/Year)	Fuel Cost (Gasoline) (BDT/Year)
1	4250.000	106.250	109.809	3081.250	9456.250
2	2175.000	48.333	49.952	1401.667	4301.667

3	2625.000	65.625	67.823	1903.125	5840.625
4	99916.667	1998.333	2065.277	57951.667	177851.667
5	850.000	21.250	21.962	616.250	1891.250
6	3500.000	70.000	72.345	2030.000	6230.000
7	7850.000	196.250	202.824	5691.250	17466.250
8	6222.222	148.148	153.111	4296.296	13185.185
9	6777.778	150.617	155.663	4367.901	13404.938
10	6125.000	153.125	158.255	4440.625	13628.125
11	6000.000	150.000	155.025	4350.000	12900.000
12	6150.000	123.000	127.120	3567.000	10947.000
13	6625.000	132.500	136.939	3842.500	11395.000
14	6166.667	137.037	141.628	3974.074	12196.296
15	5200.000	130.000	134.355	3770.000	11570.000
16	9666.667	193.333	199.810	5606.667	17206.667
17	6333.333	158.333	163.637	4591.667	14091.667
18	5250.000	131.250	135.647	3806.250	11681.250
19	5000.000	111.111	114.833	3222.222	9888.889
20	3500.000	70.000	72.345	2030.000	6230.000
21	4500.000	90.000	93.015	2610.000	8010.000
22	2200.000	55.000	56.842	1595.000	4730.000
23	3750.000	93.750	96.891	2718.750	8343.750
24	3000.000	66.667	68.900	1933.333	5933.333
25	3000.000	75.000	77.512	2175.000	6675.000
26	4900.000	122.500	126.604	3552.500	10902.500
27	7500.000	150.000	155.025	4350.000	13350.000
28	122333.333	2446.667	2528.629	70953.333	217753.333
29	4750.000	118.750	122.728	3443.750	10568.750
30	3400.000	85.000	87.847	2465.000	7310.000
31	8773.273	175.465	181.343	5088.498	15616.425
32	2171.429	54.286	56.104	1574.286	4668.571
33	1500.000	37.500	38.756	1087.500	3225.000
34	8333.333	166.667	172.250	4833.333	14833.333
35	11500.000	302.632	312.770	8776.316	26934.211
36	9000.000	300.000	310.050	8700.000	26700.000
37	7250.000	181.250	187.322	5256.250	16131.250
38	7778.000	222.229	229.673	6444.629	19778.343

39	5100.000	127.500	131.771	3697.500	11347.500
40	5750.000	164.286	169.789	4764.286	14621.429
41	9400.000	235.000	242.872	6815.000	20915.000
42	8866.667	253.333	261.820	7346.667	21786.667
43	4300.000	122.857	126.973	3562.857	10934.286
44	3350.000	88.158	91.111	2556.579	7846.053
45	5850.000	182.813	188.937	5301.563	16270.313
46	7125.000	178.125	184.092	5165.625	15853.125
47	8800.000	220.000	227.370	6380.000	19580.000
48	5875.000	163.194	168.661	4732.639	14524.306
49	7500.000	214.286	221.464	6214.286	19071.429
50	8200.000	292.857	302.668	8492.857	26064.286
51	3800.000	126.667	130.910	3673.333	10893.333
52	7500.000	214.286	221.464	6214.286	18428.571
53	9166.667	247.748	256.047	7184.685	22049.550
54	1653.125	41.328	42.713	1198.516	3678.203
55	4666.667	116.667	120.575	3383.333	10383.333
56	4400.000	125.714	129.926	3645.714	11188.571
57	2800.000	84.848	87.691	2460.606	7551.515
58	4250.000	121.429	125.496	3521.429	10807.143
59	3740.000	93.500	96.632	2711.500	8321.500
60	4250.000	106.250	109.809	3081.250	9456.250
61	1833.333	52.381	54.136	1519.048	4661.905
62	2650.000	75.714	78.251	2195.714	6738.571
63	3000.000	93.750	96.891	2718.750	8343.750
64	2725.000	90.833	93.876	2634.167	8084.167
65	2833.333	80.952	83.664	2347.619	7204.762
66	3000.000	85.714	88.586	2485.714	7628.571
67	2675.000	81.061	83.776	2350.758	7214.394
68	2833.333	76.577	79.142	2220.721	6815.315
69	3000.000	75.000	77.512	2175.000	6675.000
70	13888.889	347.222	358.854	10069.444	30902.778
71	1000.250	26.322	27.204	763.349	2263.724
72	9447.000	269.914	278.956	7827.514	24022.371
73	26400.000	754.286	779.554	21874.286	67131.429
74	5777.778	165.079	170.609	4787.302	14196.825

75	6428.571	214.286	221.464	6214.286	19071.429
76	8375.000	209.375	216.389	6071.875	18634.375
77	7272.727	181.818	187.909	5272.727	16181.818
78	3000.000	78.947	81.592	2289.474	7026.316
79	6000.000	162.162	167.595	4702.703	14432.432
80	11875.000	475.000	490.912	13775.000	40850.000
81	6909.091	191.919	198.348	5565.657	17080.808
82	114000.000	2850.000	2945.474	82650.000	253650.000
83	36775.000	967.763	1000.183	28065.132	86130.921
84	7550.000	188.750	195.073	5473.750	16798.750
85	3400.000	113.333	117.130	3286.667	10086.667
86	1950.000	48.750	50.383	1413.750	4338.750
87	18500.000	528.571	546.278	15328.571	47042.857
88	7000.000	200.000	206.700	5800.000	17800.000
89	6877.000	214.906	222.106	6232.281	19126.656
90	1600.000	45.714	47.246	1325.714	4068.571
91	10000.000	222.222	229.667	6444.444	19111.111
92	3333.333	111.111	114.833	3222.222	9555.556
93	10400.000	297.143	307.097	8617.143	25554.286
94	2700.000	77.143	79.727	2237.143	6865.714
95	44016.800	978.151	1010.919	28366.382	87055.449
96	3500.000	77.778	80.383	2255.556	6922.222
97	2240.000	56.000	57.876	1624.000	4984.000
98	4333.333	108.333	111.962	3141.667	9641.667
99	2200.000	48.889	50.527	1417.778	4351.111
100	2700.000	64.286	66.439	1864.286	5721.429
101	2800.000	59.574	61.570	1727.660	5302.128
102	2666.667	59.259	61.244	1718.519	5274.074
103	3780.000	94.500	97.666	2740.500	8410.500
104	9666.667	241.667	249.762	7008.333	21508.333
105	7883.857	262.795	271.599	7621.062	23388.776
106	5400.000	135.000	139.522	3915.000	12015.000
107	7000.000	200.000	206.700	5800.000	17800.000
108	7266.667	242.222	250.337	7024.444	21557.778
109	7666.667	191.667	198.087	5558.333	17058.333
110	2700.000	77.143	79.727	2237.143	6865.714

111	6300.000	210.000	217.035	6090.000	18060.000
112	3540.000	118.000	121.953	3422.000	10502.000
113	3000.000	85.714	88.586	2485.714	7628.571
114	2625.000	65.625	67.823	1903.125	5840.625
115	1833.333	52.381	54.136	1519.048	4661.905
116	2000.000	50.000	51.675	1450.000	4450.000
117	3000.000	75.000	77.512	2175.000	6675.000
118	2500.000	71.429	73.821	2071.429	6357.143
119	21666.667	722.222	746.416	20944.444	64277.778
120	2600.000	74.286	76.774	2154.286	6611.429
121	5200.000	130.000	134.355	3770.000	11570.000
122	12527.000	278.378	287.703	8072.956	24775.622
123	7600.000	190.000	196.365	5510.000	16910.000
124	4300.000	86.000	88.881	2494.000	7654.000
125	5000.000	125.000	129.187	3625.000	11125.000
126	5000.000	131.579	135.987	3815.789	11315.789
127	714.286	23.810	24.607	690.476	2047.619
128	6000.000	133.333	137.800	3866.667	11466.667
129	5285.714	117.460	121.395	3406.349	10453.968
130	5325.000	118.333	122.297	3431.667	10531.667
131	4000.000	80.000	82.680	2320.000	7120.000
132	3283.333	82.083	84.833	2380.417	7305.417
133	4740.000	94.800	97.976	2749.200	8437.200
134	3300.000	73.333	75.790	2126.667	6526.667
135	3333.333	66.667	68.900	1933.333	5933.333
136	3800.000	76.000	78.546	2204.000	6764.000
137	8000.000	177.778	183.733	5155.556	15822.222
138	6300.000	180.000	186.030	5220.000	16020.000
139	5666.667	161.905	167.329	4695.238	14409.524
140	6825.000	227.500	235.121	6597.500	20247.500
141	5666.667	141.667	146.412	4108.333	12608.333
142	4000.000	114.286	118.114	3314.286	10171.429
143	1750.000	50.000	51.675	1450.000	4450.000
144	1950.000	48.750	50.383	1413.750	4338.750
145	900.000	25.714	26.576	745.714	2288.571
146	3500.000	100.000	103.350	2900.000	8900.000

147	1500.000	37.500	38.756	1087.500	3337.500
148	4000.000	100.000	103.350	2900.000	8900.000
149	6775.000	225.833	233.399	6549.167	20099.167
150	4875.000	128.289	132.587	3720.395	11417.763
151	11335.667	251.904	260.342	7305.207	22419.430
152	16548.333	344.757	356.306	9997.951	30683.368
153	2600.000	72.222	74.642	2094.444	6427.778
154	9100.000	239.474	247.496	6944.737	21313.158
155	14333.333	358.333	370.337	10391.667	31891.667
156	34250.000	856.250	884.934	24831.250	76206.250
157	9775.000	244.375	252.561	7086.875	21749.375
158	2400.000	60.000	62.010	1740.000	5160.000
159	1750.000	43.750	45.216	1268.750	3893.750
160	2750.000	78.571	81.204	2278.571	6992.857
161	3000.000	75.000	77.512	2175.000	6450.000
162	7883.333	225.238	232.783	6531.905	20046.190
163	17857.143	714.286	738.214	20714.286	63571.429
164	700.000	20.588	21.278	597.059	1832.353
165	4700.000	134.286	138.784	3894.286	11951.429
166	7625.000	152.500	157.609	4422.500	13572.500
167	2250.000	50.000	51.675	1450.000	4450.000
168	1561.250	39.031	40.339	1131.906	3473.781
169	7142.857	148.810	153.795	4315.476	13244.048
170	5700.000	114.000	117.819	3306.000	10146.000
171	3437.500	68.750	71.053	1993.750	5912.500
172	1875.000	41.667	43.062	1208.333	3708.333
173	3750.000	75.000	77.512	2175.000	6675.000
174	4000.000	80.000	82.680	2320.000	6880.000
175	2300.000	51.111	52.823	1482.222	4548.889
176	2333.333	42.424	43.845	1230.303	3775.758
177	2600.000	52.000	53.742	1508.000	4628.000
178	2133.333	42.667	44.096	1237.333	3797.333
179	2933.333	58.667	60.632	1701.333	5221.333
180	2166.667	48.148	49.761	1396.296	4285.185
181	2250.000	40.909	42.280	1186.364	3640.909
182	21000.000	600.000	620.100	17400.000	53400.000

183	3000.000	75.000	77.512	2175.000	6675.000
184	3000.000	75.000	77.512	2175.000	6675.000
185	4400.000	97.778	101.053	2835.556	8702.222
186	16000.000	457.143	472.457	13257.143	40685.714
187	3000.000	85.714	88.586	2485.714	7628.571
188	3000.000	100.000	103.350	2900.000	8900.000
189	1200.000	30.000	31.005	870.000	2670.000
190	325.000	8.125	8.397	235.625	723.125
191	50.000	1.111	1.148	32.222	98.889
192	400.000	8.000	8.268	232.000	712.000
193	1800.000	36.000	37.206	1044.000	3204.000
194	850.000	24.286	25.099	704.286	2161.429
195	3833.333	95.833	99.044	2779.167	8529.167
196	6000.000	200.000	206.700	5800.000	17200.000
197	3500.000	116.667	120.575	3383.333	10383.333
198	12000.000	300.000	310.050	8700.000	26700.000
199	12000.000	428.571	442.928	12428.571	38142.857
200	3666.667	146.667	151.580	4253.333	13053.333
201	1900.000	54.286	56.104	1574.286	4831.429
202	7000.000	140.000	144.690	4060.000	12460.000
203	7000.000	184.211	190.382	5342.105	16394.737
204	12500.000	312.500	322.969	9062.500	27812.500
205	6175.000	123.500	127.637	3581.500	10991.500
206	428.571	17.143	17.717	497.143	1525.714
207	1875.000	53.571	55.366	1553.571	4767.857
208	3200.000	80.000	82.680	2320.000	7120.000
209	8500.000	242.857	250.993	7042.857	21614.286
210	2100.000	46.667	48.230	1353.333	4153.333
211	233.333	6.667	6.890	193.333	593.333
212	7450.000	248.333	256.652	7201.667	22101.667
213	4900.000	140.000	144.690	4060.000	12460.000
214	6825.000	151.667	156.747	4398.333	13498.333
215	2800.000	62.222	64.307	1804.444	5537.778
216	20000.000	500.000	516.750	14500.000	44500.000
217	3200.000	228.571	236.228	6628.571	20342.857
218	4166.667	126.263	130.492	3661.616	11237.374

219	4025.000	95.833	99.044	2779.167	8529.167
220	7566.667	216.190	223.433	6269.524	18592.381
221	1900.000	54.286	56.104	1574.286	4831.429
222	9375.000	234.375	242.226	6796.875	20859.375
223	7900.000	213.514	220.666	6191.892	19002.703
224	4000.000	100.000	103.350	2900.000	8900.000
225	6000.000	171.429	177.171	4971.429	15257.143
226	2866.667	81.905	84.649	2375.238	7289.524
227	2375.000	64.189	66.340	1861.486	5712.838
228	2250.000	53.571	55.366	1553.571	4767.857
229	2600.000	65.000	67.177	1885.000	5785.000
230	2850.000	71.250	73.637	2066.250	6341.250
231	1500.000	42.857	44.293	1242.857	3814.286
232	2050.000	48.810	50.445	1415.476	4344.048
233	1000.000	28.571	29.529	828.571	2542.857
234	3350.000	83.750	86.556	2428.750	7453.750
235	1450.000	39.189	40.502	1136.486	3487.838
236	1900.000	45.238	46.754	1311.905	4026.190
237	2100.000	52.500	54.259	1522.500	4672.500
238	9500.000	271.429	280.521	7871.429	24157.143
239	10333.333	295.238	305.128	8561.905	26276.190
240	8666.667	270.833	279.906	7854.167	24104.167
241	1450.000	32.955	34.059	955.682	2932.955
242	8350.000	219.737	227.098	6372.368	19556.579
243	6250.000	178.571	184.554	5178.571	15892.857
244	14333.333	377.193	389.829	10938.596	33570.175
245	10500.000	300.000	310.050	8700.000	26700.000
246	2250.000	50.000	51.675	1450.000	4450.000
247	6500.000	162.500	167.944	4712.500	14462.500
248	5333.333	152.381	157.486	4419.048	13104.762
249	4200.000	150.000	155.025	4350.000	13350.000
250	4000.000	121.212	125.273	3515.152	10787.879
251	5500.000	137.500	142.106	3987.500	12237.500
252	2350.000	94.000	97.149	2726.000	8366.000
253	2000.000	80.000	82.680	2320.000	7120.000
254	3250.000	116.071	119.960	3366.071	10330.357

255	1100.000	36.667	37.895	1063.333	3263.333
256	2950.000	105.357	108.887	3055.357	9376.786
257	50000.000	2000.000	2066.999	58000.000	172000.000
258	5500.000	250.000	258.375	7250.000	22250.000
259	10000.000	303.030	313.182	8787.879	26969.697
260	1066.667	33.333	34.450	966.667	2966.667
261	2846.000	66.186	68.403	1919.395	5890.558
262	7125.000	158.333	163.637	4591.667	14091.667
263	4266.667	106.667	110.240	3093.333	9493.333
264	3142.857	69.841	72.181	2025.397	6215.873
265	3142.857	89.796	92.804	2604.082	7991.837
266	6428.571	160.714	166.098	4660.714	14303.571
267	1700.000	48.571	50.199	1408.571	4322.857
268	4075.000	90.556	93.589	2626.111	8059.444
269	48447.667	1076.615	1112.681	31221.830	95818.719
270	7875.000	262.500	271.294	7612.500	23362.500
271	7226.333	225.823	233.388	6548.865	20098.240
272	6666.667	166.667	172.250	4833.333	14833.333
273	8666.667	288.889	298.567	8377.778	25711.111
274	5500.000	157.143	162.407	4557.143	13985.714
275	6250.000	208.333	215.312	6041.667	18541.667
276	2500.000	71.429	73.821	2071.429	6357.143
277	2200.000	62.857	64.963	1822.857	5594.286
278	2150.000	71.667	74.067	2078.333	6378.333
279	3075.000	102.500	105.934	2972.500	9122.500
280	2450.000	70.000	72.345	2030.000	6230.000
281	2500.000	83.333	86.125	2416.667	7416.667
282	2000.000	52.632	54.395	1526.316	4684.211
283	8142.857	325.714	336.626	9445.714	28988.571
284	19333.333	483.333	499.525	14016.667	43016.667
285	14000.000	500.000	516.750	14500.000	44500.000
286	17500.000	583.333	602.875	16916.667	51916.667
287	7000.000	175.000	180.862	5075.000	15575.000
288	7083.000	283.320	292.811	8216.280	25215.480
289	6500.000	180.556	186.604	5236.111	16069.444
290	3000.000	120.000	124.020	3480.000	10320.000

291	3900.000	97.500	100.766	2827.500	8677.500
292	9450.000	337.500	348.806	9787.500	30037.500
293	789.000	26.300	27.181	762.700	2340.700
294	2900.000	72.500	74.929	2102.500	6452.500
295	2200.000	88.000	90.948	2552.000	7832.000
296	4500.000	125.000	129.187	3625.000	11125.000
297	1500.000	40.541	41.899	1175.676	3608.108
298	1900.000	50.000	51.675	1450.000	4450.000
299	1400.000	56.000	57.876	1624.000	4984.000
300	3500.000	100.000	103.350	2900.000	8900.000
301	7666.667	264.368	273.224	7666.667	23528.736
302	3000.000	66.667	68.900	1933.333	5933.333
303	9700.000	242.500	250.624	7032.500	21582.500
304	2900.000	58.000	59.943	1682.000	5162.000
305	5200.000	104.000	107.484	3016.000	9256.000
306	8200.000	205.000	211.867	5945.000	18245.000
307	3880.000	97.000	100.249	2813.000	8633.000
308	8340.000	151.636	156.716	4397.455	13495.636
309	13666.667	273.333	282.490	7926.667	23506.667
310	112859.800	2257.196	2332.811	65458.684	200890.444
311	14000.000	350.000	361.725	10150.000	31150.000
312	7475.000	186.875	193.135	5419.375	16631.875
313	13666.667	248.485	256.809	7206.061	22115.152
314	1875.000	187.500	193.781	5437.500	16687.500
315	5000.000	142.857	147.643	4142.857	12714.286
316	2400.000	48.000	49.608	1392.000	4128.000
317	4000.000	80.000	82.680	2320.000	7120.000
318	4504.615	128.703	133.015	3732.396	11068.484
319	2857.143	63.492	65.619	1841.270	5650.794
320	4000.000	88.889	91.867	2577.778	7911.111
321	4833.333	161.111	166.508	4672.222	14338.889
322	7660.000	225.294	232.841	6533.529	20051.176
323	8062.500	268.750	277.753	7793.750	23918.750
324	3000.000	75.000	77.512	2175.000	6450.000
325	4833.333	138.095	142.721	4004.762	12290.476
326	2833.333	80.952	83.664	2347.619	7204.762

327	2266.667	45.333	46.852	1314.667	4034.667
328	4325.000	144.167	148.996	4180.833	12830.833
329	3266.667	81.667	84.402	2368.333	7268.333
330	2166.667	72.222	74.642	2094.444	6427.778
331	4333.333	86.667	89.570	2513.333	7713.333
332	2000.000	66.667	68.900	1933.333	5933.333
333	34000.000	850.000	878.475	24650.000	75650.000
334	87622.000	2190.550	2263.933	63525.950	194958.950
335	5625.000	160.714	166.098	4660.714	14303.571
336	6333.333	175.926	181.819	5101.852	15657.407
337	7416.667	185.417	191.628	5377.083	16502.083
338	3500.000	87.500	90.431	2537.500	7787.500
339	7750.000	172.222	177.992	4994.444	14811.111
340	2520.000	50.400	52.088	1461.600	4485.600
341	2166.667	54.167	55.981	1570.833	4820.833
342	6500.000	162.500	167.944	4712.500	14462.500
343	3285.714	65.714	67.916	1905.714	5848.571
344	6000.000	150.000	155.025	4350.000	13350.000
345	10200.000	255.000	263.542	7395.000	22695.000
346	6000.000	171.429	177.171	4971.429	15257.143
347	7625.000	169.444	175.121	4913.889	15080.556
348	4000.000	133.333	137.800	3866.667	11866.667
349	7000.000	233.333	241.150	6766.667	20066.667
350	6000.000	171.429	177.171	4971.429	15257.143
351	3166.667	113.095	116.884	3279.762	10065.476
352	3000.000	100.000	103.350	2900.000	8900.000
353	2125.000	60.714	62.748	1760.714	5403.571
354	4000.000	133.333	137.800	3866.667	11866.667
355	6250.000	156.250	161.484	4531.250	13906.250
356	3800.000	95.000	98.182	2755.000	8170.000
357	8500.000	188.889	195.217	5477.778	16811.111
358	4700.000	156.667	161.915	4543.333	13473.333
359	2545.455	72.727	75.164	2109.091	6254.545
360	4833.333	120.833	124.881	3504.167	10754.167
361	7000.000	155.556	160.767	4511.111	13844.444
362	4500.000	150.000	155.025	4350.000	13350.000

363	4950.000	141.429	146.166	4101.429	12587.143
364	6750.000	168.750	174.403	4893.750	15018.750
365	4425.667	147.522	152.464	4278.144	13129.478
366	7777.778	222.222	229.667	6444.444	19777.778
367	1379.167	34.479	35.634	999.896	3068.646
368	4600.000	121.053	125.108	3510.526	10773.684
369	5200.000	130.000	134.355	3770.000	11570.000
370	3000.000	85.714	88.586	2485.714	7628.571
371	7300.000	162.222	167.657	4704.444	14437.778
372	6100.000	160.526	165.904	4655.263	14286.842
373	2500.000	71.429	73.821	2071.429	6357.143
374	1000.000	23.810	24.607	690.476	2119.048
375	3843.000	109.800	113.478	3184.200	9772.200
376	4900.000	122.500	126.604	3552.500	10902.500
377	6000.000	162.162	167.595	4702.703	14432.432
378	7300.000	182.500	188.614	5292.500	16242.500
379	4750.000	135.714	140.261	3935.714	12078.571
380	16000.000	533.333	551.200	15466.667	47466.667
381	3600.800	144.032	148.857	4176.928	12818.848
382	7000.000	200.000	206.700	5800.000	17800.000
383	8450.000	241.429	249.516	7001.429	21487.143
384	4000.000	133.333	137.800	3866.667	11866.667

Appendix 4

Calculated Values of Yearly GHG Emission

Table 14: Calculated values for GHG emission

Sl.	**CO2 Emission (kg/Year)**		**CO Emission (kg/Year)**		**CH Emission (kg/Year)**		**NOx Emission (kg/Year)**	
	Gasoline	**E10**	**Gasoline**	**E10**	**Gasoline**	**E10**	**Gasoline**	**E10**
1	207.060	216.304	3.851	3.672	0.383	0.344	0.081	0.064
2	94.192	98.397	1.971	1.879	0.196	0.176	0.041	0.033
3	127.890	133.599	2.378	2.268	0.236	0.213	0.050	0.039
4	3894.352	4068.207	90.525	86.328	8.993	8.093	1.898	1.499
5	41.412	43.261	0.770	0.734	0.077	0.069	0.016	0.013
6	136.416	142.506	3.171	3.024	0.315	0.284	0.067	0.053
7	382.452	399.526	7.112	6.782	0.707	0.636	0.149	0.118

8	288.711	301.600	5.637	5.376	0.560	0.504	0.118	0.093
9	293.523	306.627	6.141	5.856	0.610	0.549	0.129	0.102
10	298.410	311.732	5.549	5.292	0.551	0.496	0.116	0.092
11	292.320	305.370	5.436	5.184	0.540	0.486	0.114	0.090
12	239.702	250.403	5.572	5.314	0.554	0.498	0.117	0.092
13	258.216	269.744	6.002	5.724	0.596	0.537	0.126	0.099
14	267.058	278.980	5.587	5.328	0.555	0.500	0.117	0.093
15	253.344	264.654	4.711	4.493	0.468	0.421	0.099	0.078
16	376.768	393.588	8.758	8.352	0.870	0.783	0.184	0.145
17	308.560	322.335	5.738	5.472	0.570	0.513	0.120	0.095
18	255.780	267.199	4.757	4.536	0.473	0.425	0.100	0.079
19	216.533	226.200	4.530	4.320	0.450	0.405	0.095	0.075
20	136.416	142.506	3.171	3.024	0.315	0.284	0.067	0.053
21	175.392	183.222	4.077	3.888	0.405	0.365	0.086	0.068
22	107.184	111.969	1.993	1.901	0.198	0.178	0.042	0.033
23	182.700	190.856	3.398	3.240	0.338	0.304	0.071	0.056
24	129.920	135.720	2.718	2.592	0.270	0.243	0.057	0.045
25	146.160	152.685	2.718	2.592	0.270	0.243	0.057	0.045
26	238.728	249.386	4.439	4.234	0.441	0.397	0.093	0.074
27	292.320	305.370	6.795	6.480	0.675	0.608	0.143	0.113
28	4768.064	4980.924	110.834	105.696	11.010	9.909	2.324	1.835
29	231.420	241.751	4.304	4.104	0.428	0.385	0.090	0.071
30	165.648	173.043	3.080	2.938	0.306	0.275	0.065	0.051
31	341.947	357.213	7.949	7.580	0.790	0.711	0.167	0.132
32	105.792	110.515	1.967	1.876	0.195	0.176	0.041	0.033
33	73.080	76.343	1.359	1.296	0.135	0.122	0.029	0.023
34	324.800	339.300	7.550	7.200	0.750	0.675	0.158	0.125
35	589.768	616.097	10.419	9.936	1.035	0.932	0.219	0.173
36	584.640	610.740	8.154	7.776	0.810	0.729	0.171	0.135
37	353.220	368.989	6.569	6.264	0.653	0.587	0.138	0.109
38	433.079	452.413	7.047	6.720	0.700	0.630	0.148	0.117
39	248.472	259.565	4.621	4.406	0.459	0.413	0.097	0.077
40	320.160	334.453	5.210	4.968	0.518	0.466	0.109	0.086

41	457.968	478.413	8.516	8.122	0.846	0.761	0.179	0.141
42	493.696	515.736	8.033	7.661	0.798	0.718	0.168	0.133
43	239.424	250.113	3.896	3.715	0.387	0.348	0.082	0.065
44	171.802	179.472	3.035	2.894	0.302	0.271	0.064	0.050
45	356.265	372.170	5.300	5.054	0.527	0.474	0.111	0.088
46	347.130	362.627	6.455	6.156	0.641	0.577	0.135	0.107
47	428.736	447.876	7.973	7.603	0.792	0.713	0.167	0.132
48	318.033	332.231	5.323	5.076	0.529	0.476	0.112	0.088
49	417.600	436.243	6.795	6.480	0.675	0.608	0.143	0.113
50	570.720	596.199	7.429	7.085	0.738	0.664	0.156	0.123
51	246.848	257.868	3.443	3.283	0.342	0.308	0.072	0.057
52	417.600	436.243	6.795	6.480	0.675	0.608	0.143	0.113
53	482.811	504.365	8.305	7.920	0.825	0.743	0.174	0.138
54	80.540	84.136	1.498	1.428	0.149	0.134	0.031	0.025
55	227.360	237.510	4.228	4.032	0.420	0.378	0.089	0.070
56	244.992	255.929	3.986	3.802	0.396	0.356	0.084	0.066
57	165.353	172.735	2.537	2.419	0.252	0.227	0.053	0.042
58	236.640	247.204	3.851	3.672	0.383	0.344	0.081	0.064
59	182.213	190.347	3.388	3.231	0.337	0.303	0.071	0.056
60	207.060	216.304	3.851	3.672	0.383	0.344	0.081	0.064
61	102.080	106.637	1.661	1.584	0.165	0.149	0.035	0.028
62	147.552	154.139	2.401	2.290	0.239	0.215	0.050	0.040
63	182.700	190.856	2.718	2.592	0.270	0.243	0.057	0.045
64	177.016	184.919	2.469	2.354	0.245	0.221	0.052	0.041
65	157.760	164.803	2.567	2.448	0.255	0.230	0.054	0.043
66	167.040	174.497	2.718	2.592	0.270	0.243	0.057	0.045
67	157.971	165.023	2.424	2.311	0.241	0.217	0.051	0.040
68	149.232	155.895	2.567	2.448	0.255	0.230	0.054	0.043
69	146.160	152.685	2.718	2.592	0.270	0.243	0.057	0.045
70	676.667	706.875	12.583	12.000	1.250	1.125	0.264	0.208
71	51.297	53.587	0.906	0.864	0.090	0.081	0.019	0.015
72	526.009	549.492	8.559	8.162	0.850	0.765	0.179	0.142
73	1469.952	1535.575	23.918	22.810	2.376	2.138	0.502	0.396

74	321.707	336.069	5.235	4.992	0.520	0.468	0.110	0.087
75	417.600	436.243	5.824	5.554	0.579	0.521	0.122	0.096
76	408.030	426.246	7.588	7.236	0.754	0.678	0.159	0.126
77	354.327	370.145	6.589	6.284	0.655	0.589	0.138	0.109
78	153.853	160.721	2.718	2.592	0.270	0.243	0.057	0.045
79	316.022	330.130	5.436	5.184	0.540	0.486	0.114	0.090
80	925.680	967.005	10.759	10.260	1.069	0.962	0.226	0.178
81	374.012	390.709	6.260	5.969	0.622	0.560	0.131	0.104
82	5554.080	5802.030	103.284	98.496	10.260	9.234	2.166	1.710
83	1885.977	1970.172	33.318	31.774	3.310	2.979	0.699	0.552
84	367.836	384.257	6.840	6.523	0.680	0.612	0.143	0.113
85	220.864	230.724	3.080	2.938	0.306	0.275	0.065	0.051
86	95.004	99.245	1.767	1.685	0.176	0.158	0.037	0.029
87	1030.080	1076.066	16.761	15.984	1.665	1.499	0.352	0.278
88	389.760	407.160	6.342	6.048	0.630	0.567	0.133	0.105
89	418.809	437.506	6.231	5.942	0.619	0.557	0.131	0.103
90	89.088	93.065	1.450	1.382	0.144	0.130	0.030	0.024
91	433.067	452.400	9.060	8.640	0.900	0.810	0.190	0.150
92	216.533	226.200	3.020	2.880	0.300	0.270	0.063	0.050
93	579.072	604.923	9.422	8.986	0.936	0.842	0.198	0.156
94	150.336	157.047	2.446	2.333	0.243	0.219	0.051	0.041
95	1906.221	1991.320	39.879	38.031	3.962	3.565	0.836	0.660
96	151.573	158.340	3.171	3.024	0.315	0.284	0.067	0.053
97	109.133	114.005	2.029	1.935	0.202	0.181	0.043	0.034
98	211.120	220.545	3.926	3.744	0.390	0.351	0.082	0.065
99	95.275	99.528	1.993	1.901	0.198	0.178	0.042	0.033
100	125.280	130.873	2.446	2.333	0.243	0.219	0.051	0.041
101	116.099	121.282	2.537	2.419	0.252	0.227	0.053	0.042
102	115.484	120.640	2.416	2.304	0.240	0.216	0.051	0.040
103	184.162	192.383	3.425	3.266	0.340	0.306	0.072	0.057
104	470.960	491.985	8.758	8.352	0.870	0.783	0.184	0.145
105	512.135	534.999	7.143	6.812	0.710	0.639	0.150	0.118
106	263.088	274.833	4.892	4.666	0.486	0.437	0.103	0.081

107	389.760	407.160	6.342	6.048	0.630	0.567	0.133	0.105
108	472.043	493.116	6.584	6.278	0.654	0.589	0.138	0.109
109	373.520	390.195	6.946	6.624	0.690	0.621	0.146	0.115
110	150.336	157.047	2.446	2.333	0.243	0.219	0.051	0.041
111	409.248	427.518	5.708	5.443	0.567	0.510	0.120	0.095
112	229.958	240.224	3.207	3.059	0.319	0.287	0.067	0.053
113	167.040	174.497	2.718	2.592	0.270	0.243	0.057	0.045
114	127.890	133.599	2.378	2.268	0.236	0.213	0.050	0.039
115	102.080	106.637	1.661	1.584	0.165	0.149	0.035	0.028
116	97.440	101.790	1.812	1.728	0.180	0.162	0.038	0.030
117	146.160	152.685	2.718	2.592	0.270	0.243	0.057	0.045
118	139.200	145.414	2.265	2.160	0.225	0.203	0.048	0.038
119	1407.467	1470.300	19.630	18.720	1.950	1.755	0.412	0.325
120	144.768	151.231	2.356	2.246	0.234	0.211	0.049	0.039
121	253.344	264.654	4.711	4.493	0.468	0.421	0.099	0.078
122	542.503	566.721	11.349	10.823	1.127	1.015	0.238	0.188
123	370.272	386.802	6.886	6.566	0.684	0.616	0.144	0.114
124	167.597	175.079	3.896	3.715	0.387	0.348	0.082	0.065
125	243.600	254.475	4.530	4.320	0.450	0.405	0.095	0.075
126	256.421	267.868	4.530	4.320	0.450	0.405	0.095	0.075
127	46.400	48.471	0.647	0.617	0.064	0.058	0.014	0.011
128	259.840	271.440	5.436	5.184	0.540	0.486	0.114	0.090
129	228.907	239.126	4.789	4.567	0.476	0.428	0.100	0.079
130	230.608	240.903	4.824	4.601	0.479	0.431	0.101	0.080
131	155.904	162.864	3.624	3.456	0.360	0.324	0.076	0.060
132	159.964	167.105	2.975	2.837	0.296	0.266	0.062	0.049
133	184.746	192.994	4.294	4.095	0.427	0.384	0.090	0.071
134	142.912	149.292	2.990	2.851	0.297	0.267	0.063	0.050
135	129.920	135.720	3.020	2.880	0.300	0.270	0.063	0.050
136	148.109	154.721	3.443	3.283	0.342	0.308	0.072	0.057
137	346.453	361.920	7.248	6.912	0.720	0.648	0.152	0.120
138	350.784	366.444	5.708	5.443	0.567	0.510	0.120	0.095
139	315.520	329.606	5.134	4.896	0.510	0.459	0.108	0.085

140	443.352	463.145	6.183	5.897	0.614	0.553	0.130	0.102
141	276.080	288.405	5.134	4.896	0.510	0.459	0.108	0.085
142	222.720	232.663	3.624	3.456	0.360	0.324	0.076	0.060
143	97.440	101.790	1.586	1.512	0.158	0.142	0.033	0.026
144	95.004	99.245	1.767	1.685	0.176	0.158	0.037	0.029
145	50.112	52.349	0.815	0.778	0.081	0.073	0.017	0.014
146	194.880	203.580	3.171	3.024	0.315	0.284	0.067	0.053
147	73.080	76.343	1.359	1.296	0.135	0.122	0.029	0.023
148	194.880	203.580	3.624	3.456	0.360	0.324	0.076	0.060
149	440.104	459.752	6.138	5.854	0.610	0.549	0.129	0.102
150	250.011	261.172	4.417	4.212	0.439	0.395	0.093	0.073
151	490.910	512.826	10.270	9.794	1.020	0.918	0.215	0.170
152	671.862	701.856	14.993	14.298	1.489	1.340	0.314	0.248
153	140.747	147.030	2.356	2.246	0.234	0.211	0.049	0.039
154	466.686	487.521	8.245	7.862	0.819	0.737	0.173	0.137
155	698.320	729.495	12.986	12.384	1.290	1.161	0.272	0.215
156	1668.660	1743.154	31.031	29.592	3.083	2.774	0.651	0.514
157	476.238	497.499	8.856	8.446	0.880	0.792	0.186	0.147
158	116.928	122.148	2.174	2.074	0.216	0.194	0.046	0.036
159	85.260	89.066	1.586	1.512	0.158	0.142	0.033	0.026
160	153.120	159.956	2.492	2.376	0.248	0.223	0.052	0.041
161	146.160	152.685	2.718	2.592	0.270	0.243	0.057	0.045
162	438.944	458.540	7.142	6.811	0.710	0.639	0.150	0.118
163	1392.000	1454.143	16.179	15.429	1.607	1.446	0.339	0.268
164	40.122	41.914	0.634	0.605	0.063	0.057	0.013	0.011
165	261.696	273.379	4.258	4.061	0.423	0.381	0.089	0.071
166	297.192	310.460	6.908	6.588	0.686	0.618	0.145	0.114
167	97.440	101.790	2.039	1.944	0.203	0.182	0.043	0.034
168	76.064	79.460	1.414	1.349	0.141	0.126	0.030	0.023
169	290.000	302.946	6.471	6.171	0.643	0.579	0.136	0.107
170	222.163	232.081	5.164	4.925	0.513	0.462	0.108	0.086
171	133.980	139.961	3.114	2.970	0.309	0.278	0.065	0.052
172	81.200	84.825	1.699	1.620	0.169	0.152	0.036	0.028

173	146.160	152.685	3.398	3.240	0.338	0.304	0.071	0.056
174	155.904	162.864	3.624	3.456	0.360	0.324	0.076	0.060
175	99.605	104.052	2.084	1.987	0.207	0.186	0.044	0.035
176	82.676	86.367	2.114	2.016	0.210	0.189	0.044	0.035
177	101.338	105.862	2.356	2.246	0.234	0.211	0.049	0.039
178	83.149	86.861	1.933	1.843	0.192	0.173	0.041	0.032
179	114.330	119.434	2.658	2.534	0.264	0.238	0.056	0.044
180	93.831	98.020	1.963	1.872	0.195	0.176	0.041	0.033
181	79.724	83.283	2.039	1.944	0.203	0.182	0.043	0.034
182	1169.280	1221.480	19.026	18.144	1.890	1.701	0.399	0.315
183	146.160	152.685	2.718	2.592	0.270	0.243	0.057	0.045
184	146.160	152.685	2.718	2.592	0.270	0.243	0.057	0.045
185	190.549	199.056	3.986	3.802	0.396	0.356	0.084	0.066
186	890.880	930.651	14.496	13.824	1.440	1.296	0.304	0.240
187	167.040	174.497	2.718	2.592	0.270	0.243	0.057	0.045
188	194.880	203.580	2.718	2.592	0.270	0.243	0.057	0.045
189	58.464	61.074	1.087	1.037	0.108	0.097	0.023	0.018
190	15.834	16.541	0.294	0.281	0.029	0.026	0.006	0.005
191	2.165	2.262	0.045	0.043	0.005	0.004	0.001	0.001
192	15.590	16.286	0.362	0.346	0.036	0.032	0.008	0.006
193	70.157	73.289	1.631	1.555	0.162	0.146	0.034	0.027
194	47.328	49.441	0.770	0.734	0.077	0.069	0.016	0.013
195	186.760	195.098	3.473	3.312	0.345	0.311	0.073	0.058
196	389.760	407.160	5.436	5.184	0.540	0.486	0.114	0.090
197	227.360	237.510	3.171	3.024	0.315	0.284	0.067	0.053
198	584.640	610.740	10.872	10.368	1.080	0.972	0.228	0.180
199	835.200	872.486	10.872	10.368	1.080	0.972	0.228	0.180
200	285.824	298.584	3.322	3.168	0.330	0.297	0.070	0.055
201	105.792	110.515	1.721	1.642	0.171	0.154	0.036	0.029
202	272.832	285.012	6.342	6.048	0.630	0.567	0.133	0.105
203	358.989	375.016	6.342	6.048	0.630	0.567	0.133	0.105
204	609.000	636.188	11.325	10.800	1.125	1.013	0.238	0.188
205	240.677	251.421	5.595	5.335	0.556	0.500	0.117	0.093

206	33.408	34.899	0.388	0.370	0.039	0.035	0.008	0.006
207	104.400	109.061	1.699	1.620	0.169	0.152	0.036	0.028
208	155.904	162.864	2.899	2.765	0.288	0.259	0.061	0.048
209	473.280	494.409	7.701	7.344	0.765	0.689	0.162	0.128
210	90.944	95.004	1.903	1.814	0.189	0.170	0.040	0.032
211	12.992	13.572	0.211	0.202	0.021	0.019	0.004	0.004
212	483.952	505.557	6.750	6.437	0.671	0.603	0.142	0.112
213	272.832	285.012	4.439	4.234	0.441	0.397	0.093	0.074
214	295.568	308.763	6.183	5.897	0.614	0.553	0.130	0.102
215	121.259	126.672	2.537	2.419	0.252	0.227	0.053	0.042
216	974.400	1017.900	18.120	17.280	1.800	1.620	0.380	0.300
217	445.440	465.326	2.899	2.765	0.288	0.259	0.061	0.048
218	246.061	257.045	3.775	3.600	0.375	0.338	0.079	0.063
219	186.760	195.098	3.647	3.478	0.362	0.326	0.076	0.060
220	421.312	440.121	6.855	6.538	0.681	0.613	0.144	0.114
221	105.792	110.515	1.721	1.642	0.171	0.154	0.036	0.029
222	456.750	477.141	8.494	8.100	0.844	0.759	0.178	0.141
223	416.095	434.671	7.157	6.826	0.711	0.640	0.150	0.119
224	194.880	203.580	3.624	3.456	0.360	0.324	0.076	0.060
225	334.080	348.994	5.436	5.184	0.540	0.486	0.114	0.090
226	159.616	166.742	2.597	2.477	0.258	0.232	0.054	0.043
227	125.092	130.676	2.152	2.052	0.214	0.192	0.045	0.036
228	104.400	109.061	2.039	1.944	0.203	0.182	0.043	0.034
229	126.672	132.327	2.356	2.246	0.234	0.211	0.049	0.039
230	138.852	145.051	2.582	2.462	0.257	0.231	0.054	0.043
231	83.520	87.249	1.359	1.296	0.135	0.122	0.029	0.023
232	95.120	99.366	1.857	1.771	0.185	0.166	0.039	0.031
233	55.680	58.166	0.906	0.864	0.090	0.081	0.019	0.015
234	163.212	170.498	3.035	2.894	0.302	0.271	0.064	0.050
235	76.372	79.781	1.314	1.253	0.131	0.117	0.028	0.022
236	88.160	92.096	1.721	1.642	0.171	0.154	0.036	0.029
237	102.312	106.880	1.903	1.814	0.189	0.170	0.040	0.032
238	528.960	552.574	8.607	8.208	0.855	0.770	0.181	0.143

239	575.360	601.046	9.362	8.928	0.930	0.837	0.196	0.155
240	527.800	551.363	7.852	7.488	0.780	0.702	0.165	0.130
241	64.222	67.089	1.314	1.253	0.131	0.117	0.028	0.022
242	428.223	447.340	7.565	7.214	0.752	0.676	0.159	0.125
243	348.000	363.536	5.663	5.400	0.563	0.506	0.119	0.094
244	735.074	767.889	12.986	12.384	1.290	1.161	0.272	0.215
245	584.640	610.740	9.513	9.072	0.945	0.851	0.200	0.158
246	97.440	101.790	2.039	1.944	0.203	0.182	0.043	0.034
247	316.680	330.818	5.889	5.616	0.585	0.527	0.124	0.098
248	296.960	310.217	4.832	4.608	0.480	0.432	0.101	0.080
249	292.320	305.370	3.805	3.629	0.378	0.340	0.080	0.063
250	236.218	246.764	3.624	3.456	0.360	0.324	0.076	0.060
251	267.960	279.923	4.983	4.752	0.495	0.446	0.105	0.083
252	183.187	191.365	2.129	2.030	0.212	0.190	0.045	0.035
253	155.904	162.864	1.812	1.728	0.180	0.162	0.038	0.030
254	226.200	236.298	2.945	2.808	0.293	0.263	0.062	0.049
255	71.456	74.646	0.997	0.950	0.099	0.089	0.021	0.017
256	205.320	214.486	2.673	2.549	0.266	0.239	0.056	0.044
257	3897.600	4071.600	45.300	43.200	4.500	4.050	0.950	0.750
258	487.200	508.950	4.983	4.752	0.495	0.446	0.105	0.083
259	590.545	616.909	9.060	8.640	0.900	0.810	0.190	0.150
260	64.960	67.860	0.966	0.922	0.096	0.086	0.020	0.016
261	128.983	134.742	2.578	2.459	0.256	0.231	0.054	0.043
262	308.560	322.335	6.455	6.156	0.641	0.577	0.135	0.107
263	207.872	217.152	3.866	3.686	0.384	0.346	0.081	0.064
264	136.107	142.183	2.847	2.715	0.283	0.255	0.060	0.047
265	174.994	182.807	2.847	2.715	0.283	0.255	0.060	0.047
266	313.200	327.182	5.824	5.554	0.579	0.521	0.122	0.096
267	94.656	98.882	1.540	1.469	0.153	0.138	0.032	0.026
268	176.475	184.353	3.692	3.521	0.367	0.330	0.077	0.061
269	2098.107	2191.772	43.894	41.859	4.360	3.924	0.921	0.727
270	511.560	534.398	7.135	6.804	0.709	0.638	0.150	0.118
271	440.084	459.730	6.547	6.244	0.650	0.585	0.137	0.108

272	324.800	339.300	6.040	5.760	0.600	0.540	0.127	0.100
273	562.987	588.120	7.852	7.488	0.780	0.702	0.165	0.130
274	306.240	319.911	4.983	4.752	0.495	0.446	0.105	0.083
275	406.000	424.125	5.663	5.400	0.563	0.506	0.119	0.094
276	139.200	145.414	2.265	2.160	0.225	0.203	0.048	0.038
277	122.496	127.965	1.993	1.901	0.198	0.178	0.042	0.033
278	139.664	145.899	1.948	1.858	0.194	0.174	0.041	0.032
279	199.752	208.670	2.786	2.657	0.277	0.249	0.058	0.046
280	136.416	142.506	2.220	2.117	0.221	0.198	0.047	0.037
281	162.400	169.650	2.265	2.160	0.225	0.203	0.048	0.038
282	102.568	107.147	1.812	1.728	0.180	0.162	0.038	0.030
283	634.752	663.089	7.377	7.035	0.733	0.660	0.155	0.122
284	941.920	983.970	17.516	16.704	1.740	1.566	0.367	0.290
285	974.400	1017.900	12.684	12.096	1.260	1.134	0.266	0.210
286	1136.800	1187.550	15.855	15.120	1.575	1.418	0.333	0.263
287	341.040	356.265	6.342	6.048	0.630	0.567	0.133	0.105
288	552.134	576.783	6.417	6.120	0.637	0.574	0.135	0.106
289	351.867	367.575	5.889	5.616	0.585	0.527	0.124	0.098
290	233.856	244.296	2.718	2.592	0.270	0.243	0.057	0.045
291	190.008	198.491	3.533	3.370	0.351	0.316	0.074	0.059
292	657.720	687.083	8.562	8.165	0.851	0.765	0.180	0.142
293	51.253	53.542	0.715	0.682	0.071	0.064	0.015	0.012
294	141.288	147.596	2.627	2.506	0.261	0.235	0.055	0.044
295	171.494	179.150	1.993	1.901	0.198	0.178	0.042	0.033
296	243.600	254.475	4.077	3.888	0.405	0.365	0.086	0.068
297	79.005	82.532	1.359	1.296	0.135	0.122	0.029	0.023
298	97.440	101.790	1.721	1.642	0.171	0.154	0.036	0.029
299	109.133	114.005	1.268	1.210	0.126	0.113	0.027	0.021
300	194.880	203.580	3.171	3.024	0.315	0.284	0.067	0.053
301	515.200	538.200	6.946	6.624	0.690	0.621	0.146	0.115
302	129.920	135.720	2.718	2.592	0.270	0.243	0.057	0.045
303	472.584	493.682	8.788	8.381	0.873	0.786	0.184	0.146
304	113.030	118.076	2.627	2.506	0.261	0.235	0.055	0.044

305	202.675	211.723	4.711	4.493	0.468	0.421	0.099	0.078
306	399.504	417.339	7.429	7.085	0.738	0.664	0.156	0.123
307	189.034	197.473	3.515	3.352	0.349	0.314	0.074	0.058
308	295.509	308.701	7.556	7.206	0.751	0.676	0.158	0.125
309	532.672	556.452	12.382	11.808	1.230	1.107	0.260	0.205
310	4398.824	4595.200	102.251	97.511	10.157	9.142	2.144	1.693
311	682.080	712.530	12.684	12.096	1.260	1.134	0.266	0.210
312	364.182	380.440	6.772	6.458	0.673	0.605	0.142	0.112
313	484.247	505.865	12.382	11.808	1.230	1.107	0.260	0.205
314	365.400	381.713	1.699	1.620	0.169	0.152	0.036	0.028
315	278.400	290.829	4.530	4.320	0.450	0.405	0.095	0.075
316	93.542	97.718	2.174	2.074	0.216	0.194	0.046	0.036
317	155.904	162.864	3.624	3.456	0.360	0.324	0.076	0.060
318	250.817	262.014	4.081	3.892	0.405	0.365	0.086	0.068
319	123.733	129.257	2.589	2.469	0.257	0.231	0.054	0.043
320	173.227	180.960	3.624	3.456	0.360	0.324	0.076	0.060
321	313.973	327.990	4.379	4.176	0.435	0.392	0.092	0.073
322	439.053	458.654	6.940	6.618	0.689	0.620	0.146	0.115
323	523.740	547.121	7.305	6.966	0.726	0.653	0.153	0.121
324	146.160	152.685	2.718	2.592	0.270	0.243	0.057	0.045
325	269.120	281.134	4.379	4.176	0.435	0.392	0.092	0.073
326	157.760	164.803	2.567	2.448	0.255	0.230	0.054	0.043
327	88.346	92.290	2.054	1.958	0.204	0.184	0.043	0.034
328	280.952	293.495	3.918	3.737	0.389	0.350	0.082	0.065
329	159.152	166.257	2.960	2.822	0.294	0.265	0.062	0.049
330	140.747	147.030	1.963	1.872	0.195	0.176	0.041	0.033
331	168.896	176.436	3.926	3.744	0.390	0.351	0.082	0.065
332	129.920	135.720	1.812	1.728	0.180	0.162	0.038	0.030
333	1656.480	1730.430	30.804	29.376	3.060	2.754	0.646	0.510
334	4268.944	4459.522	79.386	75.705	7.886	7.097	1.665	1.314
335	313.200	327.182	5.096	4.860	0.506	0.456	0.107	0.084
336	342.844	358.150	5.738	5.472	0.570	0.513	0.120	0.095
337	361.340	377.471	6.720	6.408	0.668	0.601	0.141	0.111

338	170.520	178.133	3.171	3.024	0.315	0.284	0.067	0.053
339	335.627	350.610	7.022	6.696	0.698	0.628	0.147	0.116
340	98.220	102.604	2.283	2.177	0.227	0.204	0.048	0.038
341	105.560	110.273	1.963	1.872	0.195	0.176	0.041	0.033
342	316.680	330.818	5.889	5.616	0.585	0.527	0.124	0.098
343	128.064	133.781	2.977	2.839	0.296	0.266	0.062	0.049
344	292.320	305.370	5.436	5.184	0.540	0.486	0.114	0.090
345	496.944	519.129	9.241	8.813	0.918	0.826	0.194	0.153
346	334.080	348.994	5.436	5.184	0.540	0.486	0.114	0.090
347	330.213	344.955	6.908	6.588	0.686	0.618	0.145	0.114
348	259.840	271.440	3.624	3.456	0.360	0.324	0.076	0.060
349	454.720	475.020	6.342	6.048	0.630	0.567	0.133	0.105
350	334.080	348.994	5.436	5.184	0.540	0.486	0.114	0.090
351	220.400	230.239	2.869	2.736	0.285	0.257	0.060	0.048
352	194.880	203.580	2.718	2.592	0.270	0.243	0.057	0.045
353	118.320	123.602	1.925	1.836	0.191	0.172	0.040	0.032
354	259.840	271.440	3.624	3.456	0.360	0.324	0.076	0.060
355	304.500	318.094	5.663	5.400	0.563	0.506	0.119	0.094
356	185.136	193.401	3.443	3.283	0.342	0.308	0.072	0.057
357	368.107	384.540	7.701	7.344	0.765	0.689	0.162	0.128
358	305.312	318.942	4.258	4.061	0.423	0.381	0.089	0.071
359	141.731	148.058	2.306	2.199	0.229	0.206	0.048	0.038
360	235.480	245.993	4.379	4.176	0.435	0.392	0.092	0.073
361	303.147	316.680	6.342	6.048	0.630	0.567	0.133	0.105
362	292.320	305.370	4.077	3.888	0.405	0.365	0.086	0.068
363	275.616	287.920	4.485	4.277	0.446	0.401	0.094	0.074
364	328.860	343.541	6.116	5.832	0.608	0.547	0.128	0.101
365	287.491	300.326	4.010	3.824	0.398	0.358	0.084	0.066
366	433.067	452.400	7.047	6.720	0.700	0.630	0.148	0.117
367	67.193	70.193	1.250	1.192	0.124	0.112	0.026	0.021
368	235.907	246.439	4.168	3.974	0.414	0.373	0.087	0.069
369	253.344	264.654	4.711	4.493	0.468	0.421	0.099	0.078
370	167.040	174.497	2.718	2.592	0.270	0.243	0.057	0.045

371	316.139	330.252	6.614	6.307	0.657	0.591	0.139	0.110
372	312.834	326.799	5.527	5.270	0.549	0.494	0.116	0.092
373	139.200	145.414	2.265	2.160	0.225	0.203	0.048	0.038
374	46.400	48.471	0.906	0.864	0.090	0.081	0.019	0.015
375	213.978	223.531	3.482	3.320	0.346	0.311	0.073	0.058
376	238.728	249.386	4.439	4.234	0.441	0.397	0.093	0.074
377	316.022	330.130	5.436	5.184	0.540	0.486	0.114	0.090
378	355.656	371.534	6.614	6.307	0.657	0.591	0.139	0.110
379	264.480	276.287	4.304	4.104	0.428	0.385	0.090	0.071
380	1039.360	1085.760	14.496	13.824	1.440	1.296	0.304	0.240
381	280.690	293.220	3.262	3.111	0.324	0.292	0.068	0.054
382	389.760	407.160	6.342	6.048	0.630	0.567	0.133	0.105
383	470.496	491.500	7.656	7.301	0.761	0.684	0.161	0.127
384	259.840	271.440	3.624	3.456	0.360	0.324	0.076	0.060

Appendix 5

Calculated Values of Global Warming Potential

Table 15: Calculated values for CO2 Equivalent

Global Warming Potential (tonne CO2e) - 20 year		**Global Warming Potential (tonne CO2e) - 100 year**	
Gasoline	**E10**	**Gasoline**	**E10**
0.299	0.298	0.252	0.254
0.141	0.140	0.117	0.118
0.185	0.184	0.156	0.157
6.060	5.995	4.952	4.956
0.060	0.060	0.050	0.051
0.212	0.210	0.173	0.174
0.553	0.551	0.466	0.469
0.424	0.422	0.355	0.357
0.440	0.437	0.365	0.367
0.431	0.430	0.363	0.366
0.422	0.421	0.356	0.359
0.373	0.369	0.305	0.305
0.402	0.397	0.328	0.329
0.401	0.398	0.332	0.334

0.366	0.365	0.308	0.311
0.586	0.580	0.479	0.480
0.446	0.444	0.376	0.379
0.370	0.368	0.311	0.314
0.325	0.323	0.269	0.271
0.212	0.210	0.173	0.174
0.273	0.270	0.223	0.223
0.155	0.154	0.130	0.132
0.264	0.263	0.222	0.224
0.195	0.194	0.162	0.162
0.211	0.211	0.178	0.179
0.345	0.344	0.291	0.293
0.455	0.450	0.372	0.372
7.419	7.339	6.063	6.068
0.334	0.333	0.282	0.284
0.239	0.239	0.202	0.203
0.532	0.526	0.435	0.435
0.153	0.152	0.129	0.130
0.106	0.105	0.089	0.090
0.505	0.500	0.413	0.413
0.839	0.838	0.712	0.718
0.780	0.784	0.680	0.691
0.510	0.509	0.430	0.433
0.602	0.602	0.515	0.522
0.359	0.358	0.302	0.305
0.445	0.445	0.381	0.386
0.662	0.660	0.557	0.562
0.686	0.687	0.588	0.595
0.333	0.333	0.285	0.288
0.244	0.244	0.207	0.209
0.483	0.485	0.418	0.424
0.502	0.500	0.423	0.426
0.619	0.618	0.522	0.526

0.445	0.446	0.380	0.384
0.580	0.581	0.497	0.503
0.748	0.754	0.658	0.669
0.329	0.331	0.287	0.292
0.580	0.581	0.497	0.503
0.681	0.681	0.580	0.586
0.116	0.116	0.098	0.099
0.328	0.327	0.277	0.279
0.340	0.341	0.292	0.295
0.226	0.227	0.195	0.198
0.329	0.329	0.282	0.285
0.263	0.262	0.222	0.224
0.299	0.298	0.252	0.254
0.142	0.142	0.121	0.123
0.205	0.205	0.176	0.178
0.248	0.249	0.214	0.218
0.236	0.237	0.206	0.209
0.219	0.219	0.188	0.190
0.232	0.232	0.199	0.201
0.216	0.217	0.186	0.189
0.211	0.211	0.179	0.181
0.211	0.211	0.178	0.179
0.978	0.975	0.824	0.830
0.073	0.073	0.062	0.062
0.731	0.732	0.626	0.633
2.042	2.045	1.749	1.770
0.447	0.447	0.383	0.387
0.557	0.560	0.486	0.493
0.590	0.588	0.497	0.501
0.512	0.510	0.431	0.435
0.219	0.219	0.186	0.187
0.446	0.446	0.380	0.383
1.183	1.196	1.051	1.073

0.524	0.524	0.447	0.452
8.025	8.000	6.761	6.816
2.683	2.679	2.275	2.297
0.531	0.530	0.448	0.451
0.295	0.296	0.257	0.261
0.137	0.137	0.116	0.117
1.431	1.433	1.226	1.241
0.541	0.542	0.464	0.469
0.568	0.570	0.492	0.499
0.124	0.124	0.106	0.107
0.650	0.645	0.539	0.541
0.289	0.290	0.252	0.256
0.804	0.805	0.689	0.697
0.209	0.209	0.179	0.181
2.860	2.840	2.372	2.383
0.227	0.226	0.189	0.189
0.158	0.157	0.133	0.134
0.305	0.304	0.257	0.259
0.143	0.142	0.119	0.119
0.184	0.183	0.154	0.155
0.177	0.175	0.146	0.146
0.173	0.172	0.144	0.144
0.266	0.265	0.224	0.226
0.680	0.678	0.573	0.578
0.683	0.687	0.596	0.605
0.380	0.379	0.320	0.323
0.541	0.542	0.464	0.469
0.630	0.633	0.549	0.558
0.540	0.538	0.455	0.458
0.209	0.209	0.179	0.181
0.546	0.549	0.476	0.484
0.307	0.308	0.267	0.272
0.232	0.232	0.199	0.201

0.185	0.184	0.156	0.157
0.142	0.142	0.121	0.123
0.141	0.140	0.119	0.120
0.211	0.211	0.178	0.179
0.193	0.194	0.166	0.168
1.877	1.888	1.637	1.663
0.201	0.201	0.172	0.174
0.366	0.365	0.308	0.311
0.814	0.808	0.675	0.678
0.535	0.533	0.451	0.454
0.261	0.258	0.213	0.213
0.352	0.351	0.297	0.299
0.365	0.364	0.309	0.312
0.062	0.062	0.054	0.055
0.390	0.387	0.323	0.325
0.343	0.341	0.285	0.286
0.346	0.344	0.287	0.288
0.243	0.240	0.198	0.198
0.231	0.230	0.195	0.196
0.287	0.284	0.235	0.235
0.214	0.213	0.178	0.179
0.202	0.200	0.165	0.165
0.230	0.228	0.188	0.189
0.520	0.516	0.431	0.433
0.487	0.488	0.417	0.422
0.438	0.439	0.376	0.380
0.591	0.595	0.516	0.524
0.399	0.398	0.336	0.339
0.309	0.310	0.265	0.268
0.135	0.136	0.116	0.117
0.137	0.137	0.116	0.117
0.070	0.070	0.060	0.060
0.271	0.271	0.232	0.235

0.106	0.105	0.089	0.090
0.282	0.281	0.237	0.239
0.587	0.590	0.512	0.520
0.356	0.355	0.302	0.305
0.737	0.731	0.611	0.614
1.030	1.021	0.847	0.849
0.197	0.197	0.168	0.170
0.664	0.663	0.563	0.568
1.009	1.006	0.850	0.857
2.411	2.403	2.031	2.048
0.688	0.686	0.580	0.584
0.169	0.168	0.142	0.143
0.123	0.123	0.104	0.105
0.213	0.213	0.182	0.184
0.211	0.211	0.178	0.179
0.610	0.611	0.522	0.529
1.779	1.798	1.581	1.613
0.055	0.055	0.048	0.048
0.364	0.364	0.311	0.315
0.462	0.457	0.378	0.378
0.146	0.145	0.121	0.122
0.110	0.110	0.093	0.093
0.445	0.441	0.366	0.366
0.346	0.342	0.283	0.283
0.208	0.206	0.170	0.171
0.122	0.121	0.101	0.101
0.227	0.225	0.186	0.186
0.243	0.240	0.198	0.198
0.149	0.148	0.124	0.124
0.133	0.131	0.107	0.107
0.158	0.156	0.129	0.129
0.129	0.128	0.106	0.106
0.178	0.176	0.145	0.146

0.141	0.140	0.117	0.117
0.128	0.127	0.104	0.103
1.624	1.626	1.392	1.408
0.211	0.211	0.178	0.179
0.211	0.211	0.178	0.179
0.286	0.284	0.237	0.238
1.238	1.239	1.060	1.073
0.232	0.232	0.199	0.201
0.260	0.261	0.227	0.230
0.084	0.084	0.071	0.072
0.023	0.023	0.019	0.019
0.003	0.003	0.003	0.003
0.024	0.024	0.020	0.020
0.109	0.108	0.089	0.089
0.066	0.066	0.056	0.057
0.270	0.269	0.227	0.229
0.520	0.523	0.453	0.461
0.303	0.305	0.264	0.269
0.845	0.842	0.712	0.717
1.095	1.104	0.962	0.979
0.365	0.369	0.325	0.331
0.147	0.147	0.126	0.127
0.425	0.420	0.347	0.347
0.511	0.510	0.433	0.437
0.880	0.877	0.741	0.747
0.375	0.370	0.306	0.306
0.043	0.043	0.038	0.039
0.145	0.145	0.124	0.126
0.225	0.225	0.190	0.191
0.657	0.658	0.563	0.570
0.136	0.135	0.113	0.114
0.018	0.018	0.015	0.016
0.645	0.649	0.563	0.572

0.379	0.379	0.325	0.329
0.443	0.440	0.368	0.369
0.182	0.181	0.151	0.152
1.408	1.403	1.186	1.196
0.515	0.527	0.479	0.494
0.336	0.337	0.290	0.294
0.274	0.273	0.229	0.231
0.585	0.586	0.501	0.507
0.147	0.147	0.126	0.127
0.660	0.658	0.556	0.560
0.587	0.587	0.500	0.505
0.282	0.281	0.237	0.239
0.464	0.465	0.398	0.402
0.222	0.222	0.190	0.192
0.177	0.176	0.150	0.152
0.153	0.152	0.128	0.129
0.183	0.182	0.154	0.155
0.201	0.200	0.169	0.170
0.116	0.116	0.099	0.101
0.140	0.139	0.117	0.118
0.077	0.077	0.066	0.067
0.236	0.235	0.199	0.200
0.108	0.108	0.092	0.093
0.129	0.129	0.108	0.109
0.148	0.147	0.125	0.126
0.735	0.736	0.630	0.637
0.799	0.800	0.685	0.693
0.716	0.718	0.620	0.628
0.096	0.095	0.080	0.080
0.609	0.608	0.517	0.522
0.483	0.484	0.414	0.419
1.046	1.044	0.887	0.895
0.812	0.813	0.696	0.704

0.146	0.145	0.121	0.122
0.458	0.456	0.385	0.389
0.413	0.413	0.353	0.358
0.383	0.386	0.337	0.343
0.323	0.324	0.279	0.282
0.387	0.386	0.326	0.329
0.234	0.237	0.208	0.212
0.199	0.201	0.177	0.181
0.297	0.299	0.261	0.265
0.095	0.096	0.083	0.084
0.269	0.271	0.237	0.241
4.981	5.036	4.427	4.516
0.606	0.615	0.545	0.558
0.807	0.810	0.696	0.706
0.088	0.088	0.076	0.077
0.191	0.190	0.159	0.160
0.463	0.460	0.384	0.386
0.300	0.299	0.253	0.255
0.204	0.203	0.169	0.170
0.243	0.243	0.208	0.211
0.453	0.451	0.381	0.384
0.131	0.132	0.113	0.114
0.265	0.263	0.220	0.221
3.148	3.126	2.611	2.622
0.682	0.686	0.595	0.604
0.597	0.599	0.517	0.524
0.469	0.468	0.395	0.399
0.751	0.755	0.655	0.665
0.425	0.426	0.364	0.369
0.541	0.545	0.472	0.480
0.193	0.194	0.166	0.168
0.170	0.170	0.146	0.148
0.186	0.187	0.162	0.165

0.266	0.268	0.232	0.236
0.190	0.190	0.162	0.164
0.217	0.218	0.189	0.192
0.146	0.146	0.124	0.125
0.811	0.820	0.721	0.735
1.361	1.357	1.147	1.156
1.278	1.288	1.123	1.142
1.516	1.525	1.322	1.343
0.493	0.491	0.415	0.418
0.706	0.713	0.627	0.640
0.493	0.493	0.421	0.425
0.299	0.302	0.266	0.271
0.275	0.274	0.231	0.233
0.863	0.869	0.758	0.771
0.068	0.069	0.060	0.061
0.204	0.204	0.172	0.173
0.219	0.222	0.195	0.199
0.341	0.341	0.291	0.294
0.112	0.111	0.095	0.096
0.139	0.138	0.118	0.119
0.139	0.141	0.124	0.126
0.271	0.271	0.232	0.235
0.681	0.686	0.596	0.606
0.195	0.194	0.162	0.162
0.683	0.681	0.575	0.580
0.176	0.174	0.144	0.144
0.315	0.312	0.258	0.258
0.577	0.575	0.486	0.490
0.273	0.272	0.230	0.232
0.476	0.469	0.384	0.383
0.829	0.820	0.677	0.678
6.845	6.771	5.594	5.599
0.985	0.982	0.830	0.837

0.526	0.525	0.443	0.447
0.780	0.769	0.629	0.627
0.406	0.418	0.385	0.398
0.387	0.387	0.331	0.335
0.146	0.144	0.119	0.119
0.243	0.240	0.198	0.198
0.348	0.349	0.299	0.302
0.186	0.184	0.154	0.155
0.260	0.258	0.216	0.217
0.419	0.421	0.365	0.371
0.605	0.606	0.520	0.527
0.698	0.703	0.609	0.619
0.211	0.211	0.178	0.179
0.374	0.374	0.320	0.324
0.219	0.219	0.188	0.190
0.137	0.136	0.112	0.112
0.375	0.377	0.327	0.332
0.230	0.229	0.194	0.195
0.188	0.189	0.164	0.166
0.263	0.260	0.215	0.215
0.173	0.174	0.151	0.154
2.393	2.386	2.016	2.033
6.168	6.149	5.197	5.238
0.435	0.436	0.373	0.377
0.480	0.480	0.410	0.414
0.522	0.520	0.440	0.443
0.246	0.246	0.208	0.209
0.504	0.500	0.418	0.420
0.153	0.151	0.125	0.125
0.153	0.152	0.128	0.130
0.458	0.456	0.385	0.389
0.199	0.197	0.163	0.163
0.422	0.421	0.356	0.359

0.718	0.716	0.605	0.610
0.464	0.465	0.398	0.402
0.495	0.492	0.411	0.413
0.347	0.349	0.302	0.307
0.606	0.610	0.529	0.537
0.464	0.465	0.398	0.402
0.289	0.291	0.254	0.258
0.260	0.261	0.227	0.230
0.164	0.165	0.141	0.142
0.347	0.349	0.302	0.307
0.440	0.439	0.371	0.374
0.267	0.267	0.225	0.227
0.552	0.548	0.458	0.460
0.407	0.410	0.355	0.361
0.197	0.197	0.169	0.171
0.340	0.339	0.287	0.289
0.455	0.452	0.377	0.379
0.390	0.392	0.340	0.345
0.383	0.383	0.328	0.332
0.475	0.474	0.400	0.404
0.383	0.386	0.334	0.340
0.602	0.602	0.515	0.522
0.097	0.097	0.082	0.082
0.336	0.335	0.285	0.287
0.366	0.365	0.308	0.311
0.232	0.232	0.199	0.201
0.474	0.471	0.393	0.395
0.445	0.444	0.377	0.381
0.193	0.194	0.166	0.168
0.068	0.068	0.057	0.057
0.297	0.298	0.255	0.258
0.345	0.344	0.291	0.293
0.446	0.446	0.380	0.383

0.514	0.512	0.433	0.436
0.367	0.368	0.315	0.319
1.386	1.394	1.209	1.228
0.359	0.363	0.319	0.325
0.541	0.542	0.464	0.469
0.654	0.654	0.560	0.567
0.347	0.349	0.302	0.307

CERTIFICATE OF RESEARCH

*This thesis titled "**STUDY OF FUEL CONSUMPTION AND GHG EMISSION OF MOTORCYCLES IN DHAKA TO OFFSET POLLUTION BY USE OF AN ALTERNATIVE BIOFUEL**" submitted by **MUHAIMIN WASIF ANINDO** (170011042), **MD KHALEDUN NEWAZ SHEFAT** (170011046) and **MD. MUSTAKIM ABTAHI** (170011047) has been accepted as satisfactory in partial fulfillment of the requirement for the Degree of Bachelor of Science in Mechanical Engineering.*

Supervisor

Prof. Dr. Shamsuddin Ahmed

Professor

Head of the Department

12/08/2022

Prof. Dr. Md. Anayet Ullah Patwari

Professor

Department of Mechanical and Production Engineering (MPE)

Islamic University of Technology (IUT)

DECLARATION

I hereby declare that this thesis entitled *"STUDY OF FUEL CONSUMPTION AND GHG EMISSION OF MOTORCYCLES IN DHAKA TO OFFSET POLLUTION BY USE OF AN ALTERNATIVE BIOFUEL"* is an authentic report of our study carried out as requirement for the award of degree B.Sc. (Mechanical Engineering) at Islamic University of Technology, Gazipur, Dhaka, under the supervision of Prof. Dr. Shamsuddin Ahmed, MPE, IUT in the year 2022.

The matter embodied in this thesis has not been submitted in part or full to any other institute for award of any degree.

Anindo

Muhaimin Wasif Anindo

170011042

Md Khaledun Newaz Shefat

170011046

Mustakim.

MD. Mustakim Abtahi

170011047