UTILIZATION OF BIOFUELS FOR DECREASING CO_2 EMISSIONS IN THE TURKISH TRANSPORTATION SECTOR

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Master's Thesis

Graduate School

İzmir University of Economics

İzmir

2020

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A Thesis Submitted to

The Graduate School of Izmir University of Economics

Master's Program in Sustainable Energy

İzmir

2020

ABSTRACT

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Bozbay, Utku

Sustainable Energy Master's Program

Advisor: Asst. Prof. Dr. Mine GÜNGÖRMÜŞLER

August, 2020

This thesis analyzes the consumption of oil and oil products in Turkey's transportation sector. Turkey depends on foreign oil supply so that the high rate of imported oil use in the transportation sector threatens Turkey's energy security due to dependency and environmental reasons. The high rate of imported oil used in the transportation sector and vehicles lead to a significant generation of CO_2 emission. For this reason, dependency on foreign oil and CO_2 emission are two major concepts that threaten Turkey's energy security. This thesis aims to assess the utilization of biofuels in Turkey to help to reduce the dependence on oil in the transportation sector together with the evaluation of the current situation and practice. Besides, the effect of biofuel use instead of oil on CO_2 emissions in the transportation sector is investigated.

Keywords: CO_2 emissions, biofuel, bioethanol, energy policies, the transportation sector

ÖZET

TÜRKİYE ULAŞTIRMA SEKTÖRÜNDE CO_2 EMİSYONLARININ AZALTILMASINDA BİYOYAKIT KULLANIMI

Bozbay, Utku

Sürdürülebilir Enerji Yüksek Lisans Programı

Tez Danışmanı: Dr. Öğr. Üyesi Mine GÜNGÖRMÜŞLER

Ağustos, 2020

Bu çalışma, Türkiye'nin ulaşım sektöründeki petrol ve petrol ürünleri tüketimini analiz etmektedir. Yüksek orandan ithalat edilen petrolün çoğunlukla ulaşım sektöründe kullanılması, Türkiye'nin enerji güvenliğini tehdit etmektedir. Yeterli petrol üretimi olmayan Türkiye'de, dışa bağımlılık ve ulaşım sektöründe tüketilen petrolün sonucunda havaya salınan CO_2 emisyon miktarı son yıllarda ciddi bir sorun oluşturmaktadır. Bu tezin amacı, Türkiye'nin ulaşım sektöründeki petrole olan bağımlılığını düşürmesine yardımcı olabilecek biyoyakıtların Türkiye'deki mevcut durumunu ve uygulamalarını değerlendirmektir. Ayrıca, ulaşım sektöründe petrolün yerine bioyakıtların kullanılmasının CO_2 emisyonlarına etkisi de araştırılmıştır.

Anahtar Kelimeler: CO_2 emisyonu, biyoyakıt, petrol, biyoetanol, enerji politikası, ulaşım sektörü

Dedicated to My Family,

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to Mine GÜNGÖRMÜŞLER for her guidance and insight throughout the research. I am also grateful to my mom, Gül Bedriye BOZBAY; my father, Süleyman BOZBAY; and my sister, Bilge BOZBAY for their invaluable support during my academic studies. Finally, I would like to express my sincere appreciation to my childhood friends who are Mert TURFAN and Onur ÇALIŞKAN.

PREFACE

Here the author informs the readers about their experiences during the writing of this thesis, all the stages from beginning to the completion of the thesis.

İZMİR

07/07/2020

Utku Bozbay

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CHAPTER 1: INTRODUCTION

In this thesis, bioethanol utilization in the transportation sector is analyzed from a perspective of energy security in terms of oil dependency and CO_2 emissions. To meet the significant portion of its domestic energy demand, Turkey relies heavily on imported fossil fuels. On the other hand, domestic oil source is very limited and mostly dependent on foreign sources. For this reason, Turkey has been importing much more oil because of the continuous increase in energy consumption. However, dependence on imports, from Russia, Iran, or any other country, creates a threat to energy security due to various reasons. Such energy use also resulted in a rapid increase in CO_2 emissions over the past decade while causing new problems regarding energy security since the number of vehicles and oil use in the transportation sector increased drastically. For this reason, such issues mainly affected the energy security of Turkey in terms of supply security and reliable supply.

The research in this thesis examines the characteristics of energy security in Turkey from the perspective of reliable supply and supply security. Specifically, the implementation of bioethanol utilization in the transport sector is examined in this regard by considering the oil dependency and CO_2 emission depending on it. The overall aim of the thesis is to examine to what extent the increase in oil dependence and CO_2 emissions impacts on Turkey's energy security. In this context, the positive influence of bioethanol use has been investigated via both national and international perspectives. When investigated perspective from international, it is focused on comparison with selected countries in terms of bioethanol utilization with Turkey's conditions. The success of bioethanol policies in comparator countries has been investigated. The contribution of different percentages of bioethanol use in the transport sector against petroleum dependency and its impact on CO_2 emissions for the future are presented and discussed. The contribution of bioethanol utilization mixed with gasoline in different percentages, imported foreign oil dependency, and CO_2 emissions in the transport sector is evaluated as well as presenting future predictions. For such purposes, linear regression, curve fit, and correlation analysis are used to analyze and present the research study.

In this study, the following main research questions are investigated:

- Is it possible to integrate the utilization of bioethanol in the transport sector to decrease the dependency of Turkey to oil production and to reduce CO_2 emissions?
- Which resources have the highest share in energy consumption in the transport sector for the selected countries, and what is the correlation between these resources and CO_2 emissions?
- Is there a country that uses bioethanol effectively so that it could be a role model for Turkey to reduce CO_2 emissions while increasing energy consumption yields?
- To contribute to Turkey's energy security with the utilization of bioethanol in the transport sector, what should the likely scenario be in short and long terms?

In order to find answers to the research questions mentioned above, the study in this thesis has been conducted by considering the total energy consumption, oil product consumption, biofuels consumption, bioethanol consumption, and CO_2 emission parameters. The security supply and reliability of supply, dependency on foreign sources, and CO_2 emission have been the pillars of the conceptual research framework. Following the literature review, bioethanol use has been examined in detail for Turkey and other countries. China, Brazil, and Sweden were selected to compare their energy consumption, CO_2 emissions, and bioethanol practices with Turkey and each other. While Sweden was chosen because it was thought to be a role model country to the world, China was chosen because it is one of the worst comparable countries in terms of bioethanol utilization. Moreover, Brazil was chosen because the country is the second-largest producer of bioethanol in the world. In this context, the thesis was examined with the best and worst examples of countries in terms of bioethanol utilization.

After analyzing the energy policies of the countries, the energy consumption rates, energy consumption resources, effects of these resources on emission amounts are examined. Then, a detailed study has been performed for Turkey where prospective energy consumption, number of vehicles, and emission estimates have been demonstrated mathematically for the transportation sector. The analysis of Turkey's bioethanol utilization has been introduced from a perspective on top reserve energy security.

The analysis in this study is performed by using an overview of parameters between l997-2017, linear regression, correlation, and forecast analysis which are introduced in Chapter 2. Detailed information about each method is provided accordingly in the same chapter.

The definition of energy security and the concepts of energy security are introduced in Chapter 3 by providing the literature review in this content. Besides, such concepts are introduced throughout the studies provided by other researchers. Their relationships within this study as well as the differences are examined in the same chapter. Furthermore, the concept of bioethanol is provided in Chapter 3. The development of bioethanol generation has been introduced in detail. The importance of bioethanol use in the transportation sector in terms of energy security is emphasized in the same chapter. Also, the current status of bioethanol use in other countries has been introduced.

In Chapter 4, the implementation of bioethanol in the transport sector for the selected countries has been compared. This evaluation has been carried out with the utilization of data in the transport sector for the oil demand, bioethanol consumption, CO_2 emission collected from the International Energy Agency (IEA) along with policies of countries regarding bioethanol use. The total energy consumption, oil product consumption, bioethanol consumption, biofuels consumption, and CO_2 emission parameters are examined in temporally as well cross-correlation amounts are introduced. Besides, the relationship between the CO_2 emission and the rest of the parameters is investigated. Moreover, oil consumption in the transport sector in Turkey has been analyzed. The outcomes of the utilization of oil on Turkey's energy security have been evaluated. The possible links between supply security and reliable supply have been discussed. Dependence on foreign oil consumption and the rate of increasing CO_2 emission has been analyzed from the perspective of energy security. Alternative fuel sources such as bioethanol have been introduced. The linear regression analysis is performed to determine any increasing or decreasing trend for the parameters considered while cross-correlation among the relevant parameters has been explained. Finally, CO_2 emissions in Turkey's transport sector have been analyzed by using linear regression analysis. The total number of vehicles in the transport sector concerning fuel type has been forecasted to estimate the CO_2 emissions in the next decade. The analysis is carried on by considering different amounts of bioethanol blend with gasoline to forecast the CO_2 emissions. Besides, the estimated CO_2 emission amounts concerning various bioethanol rates have been discussed.

The outcomes of the analysis from Chapters 4, is presented and discussed in Chapter 5. The results achieved from this study and the evaluation of the research question has been summarized as well. Furthermore, in Chapter 5, the studies and inferences are summarized and presented in general terms. Besides, a set of policy recommendations in terms of bioethanol use increase in the transport sector in Turkey has been introduced. Recommendations that would strengthen Turkey's energy security and actions that need to be taken in particular to reach the level of countries like Sweden in the use of bioethanol has been presented in this section.

CHAPTER 2: METHODOLOGY

This section provides detailed information on the statistical analysis applied to examine the dataset about the transport sector, oil demand, and supply along with the CO_2 emission analysis in Turkey. Such analyses are also applied to evaluate the corresponding parameters for the countries of China, Brazil, and Sweden. The illustrations and the statistical results are provided for discussion and comparisons among the countries considered. Moreover, the forecast for CO_2 emissions and dependence on oil for Turkey has been performed.

The main purpose of the analysis is to provide recommendations for political advice in terms of energy security for Turkey. Policy recommendations have been emphasized on oil dependency and CO_2 emissions in the transport sector. In this context, the amount of CO_2 emission in the transport sector due to the oil product use was analyzed. The relationship between oil consumption and CO_2 emission as well as the relationship between bioethanol consumption and CO_2 emission has been investigated. A proposed solution for energy security has been presented as the use of bioethanol in the transportation sector. Accordingly, the release of CO_2 emission and oil dependency are investigated with the increasing bioethanol use in the transport sector. The analysis is expected to contribute to Turkey's energy security since the forecast for oil dependency and CO_2 estimation is introduced.

To evaluate and create policy recommendations for Turkey, a comparison of bioethanol use in the transport sector among China, Brazil, Sweden, and Turkey has been conducted. While choosing the country, the focus was on countries on different continents. While Sweden was chosen because it was thought to be a role model country to the world, China was chosen because it is one of the worst comparable countries in terms of bioethanol utilization. Moreover, Brazil was chosen because the country is the second-largest producer of bioethanol in the world. In this context, the thesis was examined with the best and worst examples of countries in terms of bioethanol utilization. The reason why other countries in the world are not selected is that they do not have sufficient policy values and bioethanol production in terms of bioethanol utilization.

In addition, energy policies, especially renewable, are played an important role in pick the country because the success of bioethanol policies of the countries was taken into consideration while making the comparison. While introducing such comparison, the parameters of population, the number of vehicles per 1000 inhabitants, the total amount of energy consumed, oil products, biofuels, bioethanol, and CO_2 emission in the transport sector are considered. CO_2 emission was a dependent variable. Other parameters were accepted as an independent variable. The correlation between the CO_2 emission and the other parameters are examined to provide a possible dependency between the parameter pairs. The finding of significant correlations between using bioethanol and CO_2 emission in examined countries is provided to Turkey as a role model country.

First of all, in this study, the total energy consumption, oil product consumption, biofuels consumption, bioethanol consumption, and CO_2 emission parameters between the 1997-2017 period were examined. The overview of parameters between 1997-2017 issued to represent and examine the variations considered in the time domain. The parameter illustrations are provided for Brazil, Sweden, China, and Turkey to have an insight into the parameter variations and a better comparison among these countries (ITRCWEB, 2020).

Secondly, in this study, the Linear Regression (LR) analysis is used for testing the presence of any multiple linear relationships between the predictors of Xi (where i ranges from 1 to n) and the predicted variable of Y (Mathworks, 2020). In this study, relationships between the dependent variable, CO_2 emissions, and other independent variables are examined by linear regression for finding any correlations among them and then, predict the variations of these parameters for the upcoming years. While conducting this analysis, the correlations of bioethanol use in the transport sector on CO_2 emissions were emphasized. A prediction analysis is performed for such a purpose while the 2020-2030 period is chosen as the prediction period. As the first step, the regression fit is performed for modeling the parameters by using the observed data within the data coverage period (1997-2017). Secondly, the obtained fit function is used to forecast the future values of the parameter for the predefined prediction period of 2020-2030. In this analysis, the current trend and future expectation is determined and showed thanks to using this data set of parameters.

Lastly, the forecast for the number of vehicles has been analyzed in Turkey for the 2020-2030 period. According to the fuel type of the selected vehicle, the amount of CO_2 emitted amount is examined. Different blend rate of mixing of gasoline and bioethanol was analyzed with the estimation of the total number of vehicles on the road. In this context, a positive effect on the amount of CO_2 is investigated as a result of increasing ethanol percentages in mixed with gasoline.

The analysis and the visualizations are performed by Matlab, using the version of R2019a. The required codes are written in Matlab programming language depending on the analysis considered (Mathworks, 2019). The dataset used in this study has been obtained from open access web pages like iea.org, worldometer.info, countryeconomy.com, knoema.com. Information from these sites is gathered to provide different production processes of bioethanol for each country. The progress of the countries on decreasing CO_2 emission is used to shed light to give political advice towards Turkey.

CHAPTER 3: LITERATURE REVIEW

In the literature review, the definition of energy security, concepts of energy security, and utilization of bioethanol is examined. The main target of the thesis is reducing foreign oil dependency and CO_2 emissions in Turkey. Since these two subjects is a threat to Turkish energy security. In that context, the utilization of bioethanol in the transport sector is presented to a solution to these problems in the thesis. That's why there is established a link between concepts of energy security and the utilization of bioethanol.

It is agreed that defining energy security from a solitary perspective isn't sufficient. Accordingly, the energy security concept is required to be explained by considering the multidimensional framework which depends on issues like national securities and related policies. As a consequence, the historical development of energy security has been examined initially and then the definition and dimension of energy security have been explained by considering the studies in the literature.

The definition of energy security depends on not only from one country to another but also its context. For this reason, basic energy security definitions are rarely used than its contextualized discussions and various aspects (Yergin, 2006).

The idea of energy protection originated in the early 1900s as a concern to preserve the supply of fuel to oil and coal for military purposes. The first major move was made by Winston Churchill by changing the power supply of the British Navy from coal to oil. His decision provided the fleets to move faster than their German counterpart. As a result, the supply of the British Navy relied on oil sources from Persia instead of coal from Wales. It also caused energy security to become equal to national security (Yergin, 2006).

In the post-war period, the importance of oil for armies did not decrease either it becomes essential for industrial nations in other ways. Developed nations have become relied on oil-fueled motor vehicles. World energy demand reached more than double rates in the 1950s and 1960s, dominated by North America, Western Europe, the Soviet Union, and North-East Asia. Many developed countries have not produced sufficient oil to meet their needs at that time.

Among these regions, the US was still a net oil importer in 1970 as an exception. For this reason, economic development, electrification, improvement in living standards while motorization has increased in all areas of the world as they all depend on energy demand. More specifically, foreign trade in commodities, mostly oil, more than quadrupled at the same time (IES, 2015).

The international oil supply network has been dominated by the major Western oil companies. Since these companies supply relatively stable cheap oil, countries that oil-exporting are more unsatisfied with the distribution of wealth from oil exports. Consequently, the Organization of Petroleum Exporting Countries (OPEC) was formed by Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela in 1960 (Cherp et al., 2012).

In the midst of developments, the 1970s were portrayed as the beginning of the period of energy instability. With the oil emergency of 1973, the shortcoming of this component turned out to be clear when most Arab OPEC individuals, alongside some non-OPEC Arab nations, slice oil supplies to the US, the Netherlands, and later to numerous different nations in the challenge of US support for Israel. Over ten years, numerous OPEC districts have gradually nationalized their oil saves. Thus, oil costs fourfold, which started a monetary emergency and featured the shortcoming of the worldwide oil flexibly arrange (Cherp et al., 2012).

Energy security rose on worldwide strategy plans after the 1970s oil emergency. This questionable idea is observed distinctively in various settings and has become a typical term in the scholarly community. This has additionally started to be related to occurrences that have conceivably negative consequences for accessibility. In this way, until the last-quarters of the twentieth century, the most significant issue of energy security was the insurance of oil supplies, which was fundamental to current militaries and economies. The best threat to these assets was seen to be a forceful action inside or outside the proper military clash.

To clarify the 1973 oil ban, a military oil weapon allegory was immediately concocted. Energy security has been brought about by political investigators who consider war and harmony discretion as a feature of a similar great methodology (Cherp, and Mukhtarov, 2014). The focal piece of such a strategy to make sure about oil gracefully was created by outside systems, where it would be more averse to slice oil stream to industrialized nations. As depicted in the Carter Doctrine, the main thing was proposed by US military and political impact in oil-delivering territories (Biresselioğlu, Demir, and Kandemir, 2012). It is asserted that the United States would utilize military power in the Persian Gulf locale to protect its national advantages, particularly the free development of Middle Eastern oil. These angles were to advance a serious market for oil items, where a large number of players can ensure that no single player uses a lot of control. The worldwide way to deal with the oil showcase is a down to earth articulation of the world-celebrated perspective on Winston Churchill, which happens to the wellbeing and conviction of oil in assortment and assortment alone (Yergin, 2006). The third thing was the production of the International Energy Agency (IEA) with an order to compose the crisis reaction of OECD nations to oil flexibly disturbances (Cherp, and Jewell, 2014). During the 1980s and 1990s, when the cost of oil decline and the feelings of dread of a physical gracefully emergency at any rate quickly dropped, such factors additionally had a helpful impact and in the late 1980s and 1990s, as oil costs settled and the danger of worldwide bans diminished the scholarly enthusiasm for energy security decreased. The security of oil gracefully grabbed the eye of policymakers. However, it stood out in created nations like India and other developing economies in addition to China. The expansion sought after from new shoppers in Asia, particularly India and China, has expanded market unpredictability and prompted long haul cost increments. With the expanding request in Asia, energy security has likewise reappeared during the 2000s (Leung, 2011).

The discussion on energy security is a blend of numerous themes, as in setting. However, not a long way ahead is the worry that there will be plentifulness sources to meet the world's energy needs in the coming decades (Yergin, 2006). In this sense, the avoidance of these quickly developing economies from IEA systems, which will represent a significant part of the expansion in worldwide oil request, will empower buyers to be less sorted out to disintegrate oil gracefully. Moreover, oil saves in OECD nations and other significant utilization locales are running out, so oil creation is progressively thought by and by, particularly in just a couple of nations and districts in the Middle East and the previous Soviet Union (USSR). Pressures, which are portrayed as a scramble among new and old clients for the remaining and progressively focused assets, have raised interest from creating nations including China and India (Cherp, and Jewell, 2014).

The end of the 1990s is reached by the Gulf War and the fall of the Soviet Union. The base impact of the war on the world energy commercial center has produced good faith in energy security (Yergin, 2006). The fall of the Soviet Union has brought about cruel financial and social ramifications for the nations concerned. Such issues relate mainly to the Eurasian gas part, where gas is shipped by means of pipelines prevalently under long haul contracts. The Russian-Ukrainian gas emergency of 2009, trailed by a discussion over the value procedure, is the most recent case of a huge scope interference of the flexibly of gas with unmistakable outcomes in the European Union (IES, 2015). Eastern European nations, which utilize characteristic fuel for the majority of their power and warmth age as generally been imported from Russia through a completely kept scope of graceful courses, are a couple of the most helpless against such disturbances. Current energy security issues have secured late disagreements regarding Russian characteristic fuel supplies to Eastern Europe as well as the issues about the outrageous dependence of some European nations on a very little scope of energy gracefully choices (Cherp et al., 2012). Notwithstanding, in September 2001, fear-mongering and the harm brought about by Hurricane Katrina made significant worry about the powerlessness of fundamental energy foundation because of psychological militant danger to outrageous catastrophic events. Energy security has subsequently become a policy-driven issue, yet additionally a monetary and military issue (Biresselioğlu et al., 2012). Additionally, energy insurance issues are currently firmly connected with other significant energy issues, particularly, energy gets to and the atmosphere impact of energy frameworks (Cherp et al., 2012).

The concept of energy security in the academic literature shows that its importance varies from country to country depending on its content. As a result, abstract concepts of energy protection have been less tried than contextual discussions about their different aspects or dimensions. Classic energy conservation concept Yergin (1988) parallels this approach by referring to energy stability, which guarantees adequate and secure energy supplies at fair prices in ways that do not risk key national values and objectives. The concept of energy security was described as the uninterrupted physical availability of energy products available on the market at a price that is affordable to all consumers through the European Commission (2000). Furthermore, energy security has been described as a loss of monetary well-being that could occur because of a change in the rate or availability of energy. Such definitions include notions of quality, sufficiency, affordability, welfare, supply, and interruption which might be difficult to unique interpretation (Bohi, and Toman, 2012). According to the IEA, it was described as the simplest type of energy protection, providing affordable access to energy resources, and uninterrupted access (Jewell, 2011). One of the most commonly cited meanings proposed by Yergin (2006) was the availability of ample materials at reasonable rates. Also, he addresses the various definitions of energy protection under his description of many different countries. About the traits of energy systems associated with their health, various studies propose and address different aspects of energy protection (Cherp et al., 2012).

There has been no traditional or consistent interpretation of the concepts of energy security, however, Yergin (2006) has introduced the idea of energy security to academic literature from a modern viewpoint. According to him, the current paradigm for energy security has been based on four principles: the diversification of supply, the security margin, the reality of integration, and the value of information. As important as these concepts, Yergin also stressed the importance of expanding the idea of energy protection to two essential dimensions. The first aspect has been highlighted as the acknowledgment of the defense of the energy supply chain as a whole while these condone is the understanding of the globalization of the energy security system. In addition, the importance of preventing problems with energy security that could occur in the future and the importance of how countries handle their bilateral and multilateral ties in foreign policy are both illustrated in his study (Biresselioğlu, 2015). On the other hand, Kendell (1998) and Gupta (2008) used two dimensions of energy security of which are physical and economic.

According to Kruyt (2009), another widely used taxonomy is the 4A's, which are accessible as a physical availability of resources; accessibility as a strategic dimension of access to resources; accessibility as an economic cost of energy; and acceptability as a social and sometimes environmental stewardship dimension of energy. According to Biresselioğlu (2015), it can be concluded that this concept is based on six main pillars when the creation of the definition of energy security was evaluated along with the examples described in the historical context and the conditions of the modern world. These include security of supply, the security of demand, reliability of supply, the security of critical infrastructure, diversification, will, and skills.

Despite the variety of concepts provided in the studies referred above, the precise definition of energy protection remains a challenge. Both interpretations of energy security have included aspects related to national security on the one hand while emerging principles of human rights, individual security, energy justice, sustainability, and sustainable development on the other. However, the term is dynamic and there can be no clear interpretation of how energy protection dimensions are viewed by energy users, households, and businesses (Biresselioğlu et al., 2017). Nowadays, energy security studies have shifted from a classical approach to an interdisciplinary field. The uncertain future of fossil fuels as a result of climate change and globalization has accelerated this transition. In this context, new dimensions such as sustainability, energy efficiency, reduction of CO_2 emissions, accessibility of energy services have added to energy security. Thus, it became interconnected with the concept of energy security with environmental, social, political, cultural issues (Jakstas, 2020). To sum up, energy security perspectives have also moved from a single-dimensional view of security of supply to a more multi-dimensional context that includes cultural, environmental as well as the security and policy dimensions. As the focus of this research is on the interrelationship between energy security and policymaking in terms of dependency and carbon emissions, the analysis is focused on a contemporary and expanded conceptualization of energy security, including key policy indicators. A multi-dimensional definition was there for necessary following the current literature and considering the focus of this study on the transport sector in terms of foreign oil dependency and CO_2 emissions.

The interpretation and conceptual advances in energy security are outlined in this chapter. An overview of the resulting principles, interactions, and interrelationships between the enables the creation of a Turkish energy security policy focused on the views of the transport sector while at the same time reducing carbon emissions and foreign oil dependency through the use of biofuels.

Moreover, the literature review of this thesis also includes bioethanol. In the thesis, the utilization of bioethanol is offered a solution proposal for decreasing CO_2 emissions and imported oil dependency in the transport sector. That's why after explained to concepts of energy security, bioethanol also is examined in that chapter.

Cleaner biomass energy era has been defined as one way to lessen overdependence on fossil fuels (Lozano and Lozano, 2018). Bioethanol also enables decrease CO_2 emissions by up to 80% relative to the usage of petrol and thereby encourages a safer climate for the future (Lashinsky, and Schwartz, 2006). According to the US Energy Information Administration (EIA) 2017 survey, oil, and different liquid fuels are the dominant resources of transportation worldwide (USA EIA, 2017). The use of those fossil-based fuels as transport energy sources has contributed notably to the emission of CO_2 and other greenhouse gasses (GHGs) (Fan et al., 2018). The use of biomass-derived biofuels is considered as a green approach in the transport sector (Ayodele et al., 2020). As a result, demand for biofuels in the form of bioethanol, biobutanol, and biodiesel has increased by driving to an inevitable growth in production (Uría-Martínez et al., 2018). The use of these fossil-based fuels as transport energy sources has contributed significantly to the emission of CO_2 and other GHGs (Fan et al., 2018). The use of these fossil-based fuels as shipping energy resources has contributed significantly to the emission of CO_2 and different GHGs (Fan et al., 2018). The use of biomass-derived biofuels is taken into consideration as a green approach for the transportation sector (Ayodele et al., 2020). As a result, demand for biofuels in the form of bioethanol, biobutanol, and biodiesel has risen, leading to an inevitable boom in its production (Uría-Martínez et al., 2018).

Biofuels market has reached the modern stage for the sake of parallel developments that have boosted its worldwide demand increase over the last ten years. Specifically, the bioethanol industry has been a vital contributor to economies and their energy security strategies, as properly as playing a big role in climate change and dependence issues. Ethanol is a grain alcohol that may be combined with gasoline and used in motor vehicles. Bioethanol growth has relied on robust policies which include flex-fuel cars, along with ethanol and gasoline, policy mandates for increased use of biofuels, and subsidies (Araujo, 2016).

The large proportion of bioethanol production takes place in the United States, Brazil, the European Union, and China (Statista, 2020). The findings showed that the United States contributed the largest amount of fuel ethanol in the world in 2019 by generating a total output of 15.8 billion gallons. Brazil is ranked second with almost 8.6 billion gallons. The European Union ranked third with 1.4 billion gallons while China ranked fourth with 800 million gallons. As the most requested biofuel, its production has gone through several technological advances that have increased global production capacity (Gavahian et al., 2019).Plenty of commercial bioethanol production plants rely on sugar and starch-based feedstocks, like maize in the USA (Mohanty and Swain, 2019), sugar cane in Brazil (Paulino et al., 2018) while it is wheat, sugar beet, and barley in Europe (Friedl, 2019). China was frequently used as raw material for plant corn and wheat. Corn accounted for 82% of these cereal-based bioethanol plants while wheat accounted for 18% of the feedstock (Scott and Junyang, 2013).

Bioethanol production based on starch, sugar, vegetable oil, and animal fats is known as first-generation bioethanol (1 G) (Damay et al., 2018). Sugar utilization in 1 G bioethanol has the greatest capacity to replace fossil fuel as a transport fuel because of low production costs, low carbon emissions, and higher yields in liters of bioethanol per hectare compared to starch-based crops used for bioethanol production (Marzo et al., 2019).1 G production of bioethanol has various advantages, such as low cost of production, familiar feedstock, and energy-efficient production methods which result in lower requirements for fossil fuel in the biofuel value chain by helping from the mitigation of GHG emissions (Naik et al., 2010). Notwithstanding the global successes in commercializing 1 G bioethanol production, there are still some constraints, which include food versus fuel debate. Since sugar is a supply of human nutrition, there is concern about the use of land appropriate for food production for bioenergy crop production (Tokgöz, 2019). However, the issue of 1 G bioethanol production competing with food has bred serious arguments for its sustainability (Rudel, 2013), in particular, due to the demand for highly fertile soils with high rainfall or sugarcane irrigation (Finkbeiner, 2014). Moreover, there are limitations on 1 G bioethanol produced from sugar or starch directly extracted from biomass. It offers only modest savings in GHG emissions compared to petrol (Ayodele, 2020). Substantial concerns have been expressed about the impact of large-scale production of 1 G feedstocks on food availability, food and feed prices, deforestation and water resources, as well as the net impacts of some biofuel pathways on climate change and air pollution. These limitations have stimulated intensive research in the production of bioethanol from alternative feedstocks such as lignocellulosic biomass, which is also known as second-generation (2 G) bioethanol production (Tan, Lee, and Mohamed, 2008).

Lignocellulosic biomass is the number one feedstock for 2 G production. It may be also grouped into agricultural residues such as sweet sorghum bagasse, sugar cane bagasse and straw, corn stalk, forest residues, and energy crops like herbaceous or woody plants (Ayodele, 2020). Lignin, cellulose, and hemicellulose are the main chemical components of lignocellulose biomass that may be transformed into biofuel through thermochemical or biological processes (Ma et al., 2019). As a result, the next-generation ethanol economy focuses on non-food feedstocks. Consequently, second-generation biofuels have been offered advantages such as the use of waste residues and abandoned land especially in rural areas (Rastogi, and Shrivastava, 2017). Innovations, including dedicated energy crops, waste raw materials, and algae, are rising on the market because of technical feedstock options (Araujo, 2016). Lignocellulosic and starchy materials are convertible into fermentable sugars which can be further processed as it results in bioethanol as the final product.

Biofuels of second-generation is created by means that of 2 different conversion routes for bio-chemical and thermo-chemical approaches. The biochemical route includes the transformation of cellulose and hemicellulose elements of biomass feedstock into a mix of possible reducing sugars exploitation protein or acid hydrolysis in the midst of the fermentation of sugars into alcohol, primarily ethyl alcohol by using microorganisms (Mohammadi et al., 2016). This transformation process is based on the use of biocatalysts as well as enzymes and microorganisms. The thermochemical conversion process makes use of high-temperature gasification or pyrolysistechnology to transform the lignocellulosic structure of biomass into intermediate gas or liquid. As a result, this intermediate can be transformed into various synthetic biofuels, such as synthetic diesel, aviation fuel, and ethanol (Dutta, and Phillips, 2009). There are usually some important variations between the two conversion methods. First of all, the biomass lignin element is converted into gas along with cellulose and hemicellulose in thermochemical conversion. The biochemical route can hardly break down the lignin element as it makes up 10–40% of biomass by fermenting or enzymatic reactions to possible fermentable compounds (Datar et al., 2004). Secondly, ethanol is the major fermentation product obtained through the biochemical pathway while a broad range of biofuels can be produced from syngas through a thermochemical approach. Nevertheless, the biochemical conversion pathway is likely the most mature process for generating ethanol from lignocellulosic biomass transformation (Piccolo, and Bezzo, 2009). On the other opposite, the thermochemical conversion process has somehow been neglected in the scientific literature. The thermochemical conversion of lignocellulose biomass integrates the process of biomass gasification and biofuel synthesis. Biofuel production from syngas is performed either by an inorganic or metal-based catalyst known as the Fischer – Tropsch (FT) process or by microbial catalysts known as syngas fermentation (Burk et al., 2010). Even though biomass gasification has been broadly studied, there is little information available in the literature on its integration with the resulting biofuel fermentation process.

The performance of bioethanol produced depends largely on the production routes. As bioethanol production is generally a combination of several sequential processes, namely pretreatment, hydrolysis, fermentation, and distillation stages are divided to produce different results in the quality of ethanol as well as the overall cost of production. Moreover, the technologies currently available enrich the potential of bioethanol production routes (Basile, and Dalena, 2019). One of the major constraints of 2 G bioethanol production is the pre-treatment phase, which accounts for 18 % of the total cost of production (Rajendran et al., 2018). Other parameters affecting 2 G bioethanol production are plant capital costs, feedstock, enzyme, and energy costs (Erdei et al., 2013). One of the methods proposed to reduce 2 G production costs is through high yield and concentration of ethanol (Rajendran et al., 2018). Apart from pre-treatment, the energy consumption of distillation is also a major concern (Oliveira et al., 2016). It is often hard to get a minimum concentration of 40 g/L or more of bioethanol in standalone 2 G processes while a concentration of bioethanol up to 80 to 115 g/L can be obtained from the fermentation broth of the 1 G process (Della-Bianca et al., 2013). The biological constraints of the 2 G process result in a more diluted ethanol product so to increase the cost of distillation compared to the 1 G process. Mixing 1 G and 2 G sugar streams or fermentation products increase the concentration of ethanol in feed for distillation to reduce energy consumption (Macrelli, Mogensen, and Zacchi., 2012).

On the other hand, microalgae are by and by being created as a perfect third-age biofuel feedstock because of their fast development rate, their ability to fix GHGs (net-zero emanation balance), and their high lipid (fat) creation limit. They likewise don't rival food or feed crops and can be developed on non-arable land and saltwater. Microalgae can gracefully various sorts of inexhaustible biofuels. This incorporates methane, biodiesel, and bio-hydrogens. There are numerous additions to generate biofuel from green growth. For instance, microalgae can deliver somewhere in the range of 15 and multiple times more biodiesel than customary yields on a territory premise. The microalgae gathering cycle is short and the development rate is extremely high. Moreover, an excellent farming area isn't required for the creation of biomass microalgae. Then again, delivering microalgae biomass is generally more costly and mechanically testing than developing harvests. That is why, most of the government did not prefer to use algae for the production of bioethanol in its renewable energy policies (Alam, Mobin, and Chowdhury, 2015).

Production of bioethanol from 1 G feedstock is a proven technology that has been broadly studied. The method has the advantage of high ethanol productivity and yield. Still, there are issues of food-to-fuel debate and high environmental consequences. Bioethanol production from 2 G feedstocks has received significant attention due to the abundance of lignocellulosic biomass resources and its potential as a means of producing cleaner and environmentally sustainable biofuel. However, the development of the 2 G process still faces many difficulties, mainly from the pre-treatment stage (Mupondwa, Li, and Tabil, 2018). It is also known that the 1 G bioethanol production process has achieved an advanced technological stage in terms of development and processing while the 2 G bioethanol production process is still at an early stage of development. Integrating these processes could reduce high investment risks and uncertainties by providing an incentive for the commercialization of a viable bioethanol production process. Advancing biofuels delivered from syngas bioconversion can give answers for energy security issues and add to ozone-depleting substance alleviation plans. A few fruitful investigations and patent writing have affirmed the high capability of microbial impetuses to change over syngas and waste gas substrates into significant biofuels and biochemicals (Bušić et al., 2018). Despite the studies and ongoing headway, huge endeavors should keep making the procedure financially savvy and solid for enormous scope arrangements. In any case, then again, the third era has indicated that algal biofuel is perfect, feasible, and sustainable while it is costly contrasted with petroleum products at the same time. In any case, enormous scope creation ought to be arranged at a sensible expense to rival or even supplant non-renewable energy sources. In this regard, imaginative methods are intended to improve enormous scope incorporated the development of green growth at a sensible expense.

Bioethanol production has not only advantages but also disadvantages. Its biggest advantage is that it reduces CO_2 emissions. However, it should be kept in mind that CO_2 emissions occur while producing bioethanol. The 1st generation is the oldest method and has the cheapest cost among them. However, the nutrient shortage after the destruction of fertile agricultural lands has revealed the necessity of new technologies. While producing bioethanol with the 2nd and 3rd generations, the use of wastes is more environmentally positive. However, the biggest disadvantage at this point is that new production facilities are quite expensive. It can be difficult for developing countries to use these technologies. As a result, producing bioethanol is an advantage for any country. In particular, the elimination of waste materials from the nature and conversion of these fuels to clean fuel and the use of these fuels in the transportation sector will positively affect both fossil fuel and CO_2 emissions.

CHAPTER 4: REVIEW OF THE SELECTED COUNTRIES

In this section, the implementation of bioethanol in the transport sector for the selected countries is discussed. The countries are selected due to bioethanol utilization in transport sector applications. Three countries which are China, Brazil, and Sweden were compared in terms of bioethanol utilization in the transport sector. Bioethanol production requires expensive technology therefore acquiring this technology is challenging. On the other hand, when renewable energy sources are examined, the bioethanol utilization is lower than others. Therefore, most countries in the world do not have sufficient infrastructure and knowledge of bioethanol. The reason why other countries in the world are not selected is that they do not have sufficient policy values and bioethanol production in terms of bioethanol utilization. In the country selection in this thesis, countries that set positive and negative examples to the world in terms of bioethanol utilization were taken into account. in this context, while Sweden is the best example due to being the country with the second lowest CO_2 emissions, China was a negative example in terms of bioethanol utilization. The main reason for this negative implementation was due to China using first-generation bioethanol. This situation created problems associated with food security. Furthermore, Brazil is chosen because the country is the second-largest producer of bioethanol in the world. Also, differences and similarities in energy policies between Turkey and Brazil were comparable considering both of them being developing countries.

On the other hand, countries' energy policies also are examined in terms of sustainability. While selecting countries, the amount of use of biofuels in the transportation sector, the number of vehicles on road, environmental policies, economic conditions, and populations were taken into consideration. In that context, countries of oil dependency rate, oil demand in the transport sector, consumption of bioethanol in the transport sector, the amount of CO_2 emission by vehicles, and bioethanol policies have been analyzed. Accordingly, the energy policies of countries are evaluated in terms of bioethanol utilization. The contribution of bioethanol utilization to energy security in terms of CO_2 emissions in these countries is also investigated. Subsequently, correlation analysis was conducted among the parameters of total energy consumption, oil product consumption, biofuel consumption, bioethanol consumption, and CO_2 emissions. The relationships between CO_2 emission rest of the parameters is also introduced. After assessed, the success of the country was selected to investigate whether it is appropriate to Turkey.

4.1 Overview of parameters between 1997-2017

The variation of the total energy consumption, oil product consumption, biofuel consumption, bioethanol consumption, and CO_2 emissions since 1997 are presented in this section. The parameter variations concerning countries are compared with each other and discussed accordingly. The parameters' ranges differ for each country, thus, the amounts were normalized by per million population by dividing the parameter quantity by the corresponding population of the country for the considered year. For this reason, the overview of the parameters charts created in this section were based on data per million people. The reason for this is to focus on the ratio of consumption rather than the amount. This method places the analysis on a more solid basis and allows for a more accurate assessment by focusing on consumption and emission rates.

The overview of parameter variation concerning total energy consumption in Brazil, Sweden, China, and Turkey is presented in Figure 1. Except for Sweden, there is a slightly positive trend for each country.

Since the rates in Figure 1 is presented concerning per million population, Sweden is located above China considering the total energy consumption parameter. For this reason, Sweden appears to be the leading country in the total energy consumption rate. It is three times larger than the consumption of Brazil. Brazil and Turkey represent an increasing trend starting from 2007. On the other hand, China has a nearly constant linearly increasing rate since 1997. The surprising point here is that although China constitutes 18% of the world's population with a population of 1.4 billion, it takes place at the bottom of the chart in terms of energy consumption per million population.

For the oil product consumption parameter, there is a significant negative trend for Sweden while a positive trend is observed for the other countries (Figure 2).

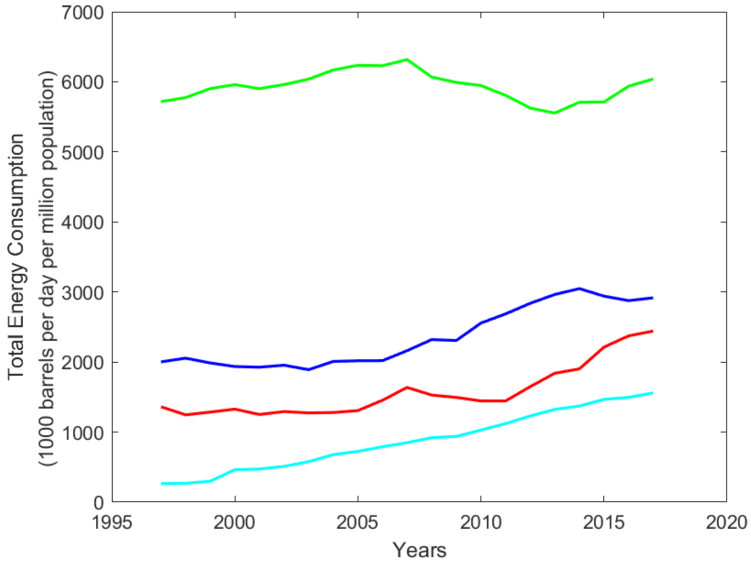

Figure 1. Total energy consumption (1000 barrels per day per million population) in Brazil (blue line), Sweden (green line), China (turquoise line), Turkey (red line) between 1997-2017 (Source: IEA, 2018).

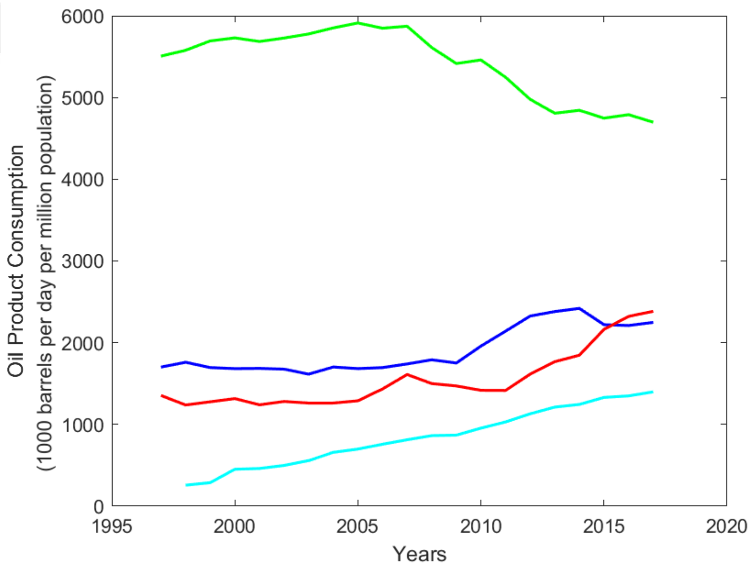

Figure 2. Oil product consumption (1000 barrels per day per million population) in Brazil (blue line), Sweden (green line), China (turquoise line), Turkey (red line) between 1997-2017 (Source: IEA, 2018).

There is a consumption behavior in petroleum and petroleum products consumption that almost matches the energy consumption rates until 2005. After 2005, the match continues for other countries except for Sweden. This shows that countries meet most of their energy needs from petroleum and petroleum products. However, it is clear for Sweden that a significant part of its energy need counts from sources other than petroleum especially after 2005.

The biofuels and bioethanol parameter variations are provided in Figure 3 and Figure 4. Even the amounts are scaled with the population, significant differences are observed between countries. Among them, Brazil takes place in the first place while Turkey is the last among other countries.

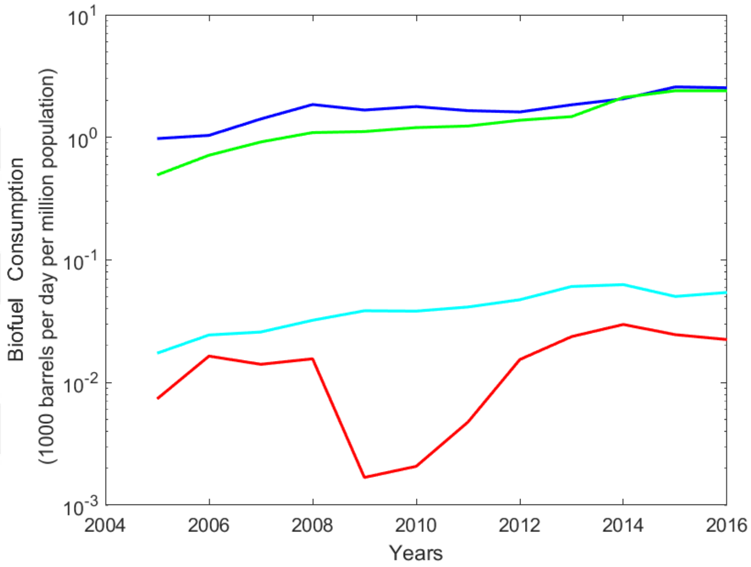

Figure 3. Biofuel consumption (1000 barrels per day per million population) in Brazil (blue line), Sweden (green line), China (turquoise line), Turkey (red line) between 1997-2017 (Source: IEA, 2018).

Although the biofuel consumption rate is very low compared to general energy consumption for all countries, Brazil and Sweden have the highest biofuel use amounts compared to other countries. For the 2004-2016 period, China has a nearly stable biofuel use rate. This implies either China does not have a policy of improving biofuel consumption or has an inefficient policy about it. Turkey represents a sharp decrease between the years 2008 and 2010 but a positive trend is achieved after then (Figure 3).

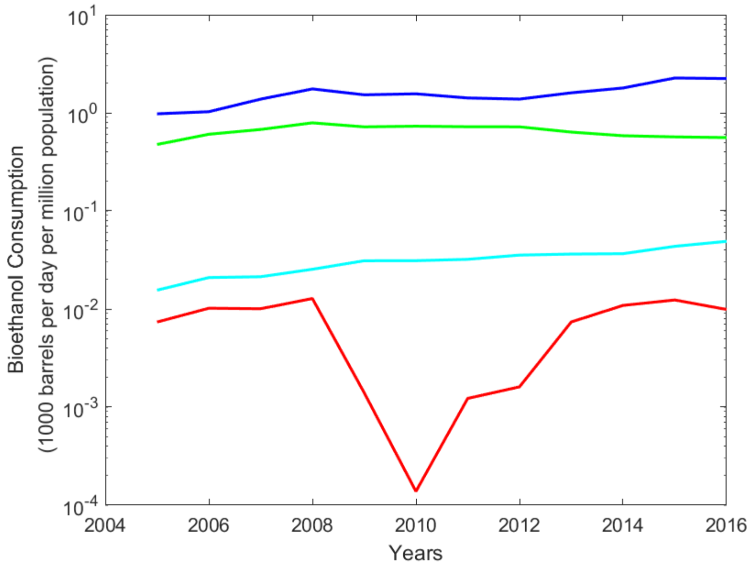

Figure 4. Bioethanol consumption (1000 barrels per day per million population) in Brazil (blue line), Sweden (green line), China (turquoise line), Turkey (red line) between 1997-2017 (Source: IEA, 2018).

Figure 4 represents that each country performed the same trend in biofuel consumption rates. Overall performance is very poor compared to total energy consumption while Brazil and Sweden seem to have higher rates than the other two countries. Turkey's bioethanol consumption varies considerably. It decreased for the 2008-2010 period and partially increased after 2010.

The CO_2 emission variation is presented in Figure 5. Sweden takes first place by far but it has a negative trend in the last years. On the other hand, CO_2 emissions tend to increase for other countries.

CO_2 emission rates are parallel with overall energy consumption rates. Sweden is the country with the highest CO_2 emission rate per million population. Given that the vast majority of energy needs are met from petroleum and petroleum products, such trend result is expected. On the other hand, since 2015, Turkey achieved a higher CO_2 emission rate compared to Brazil. It also lags behind Brazil in the oil product consumption rate (Figure 2) so that such a case indicates insufficient CO_2 emission policies in Turkey.

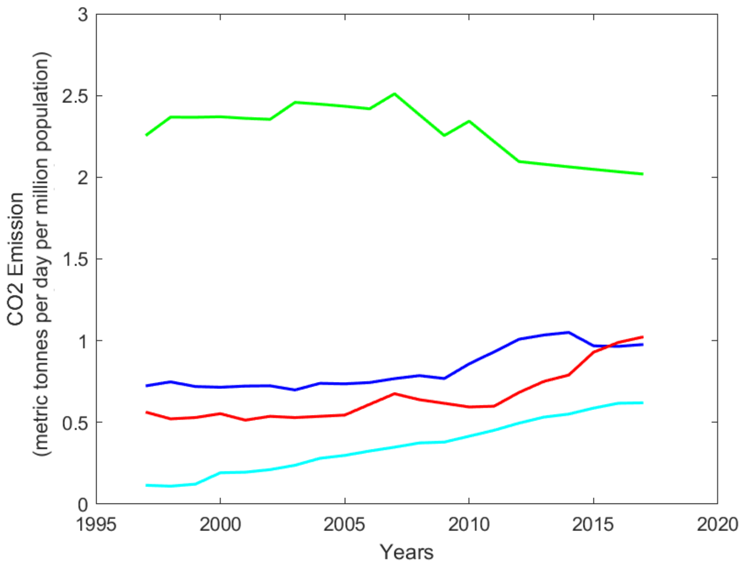

Figure 5. CO_2 emission (metric tonnes per day per million population) in Brazil (blue line), Sweden (green line), China (turquoise line), Turkey (red line) between 1997-2017 (Source: IEA, 2018).

4.2 China

In this section, China's energy policies and CO_2 emission rates are examined. while bioethanol applications are examined and summarized in. Subsequently, correlation analysis was conducted among the parameters of total energy consumption, oil product consumption, biofuel consumption, bioethanol consumption, and CO_2 emissions. The relationships between CO_2 emission rest of the parameters are also introduced.

Energy security assumes a noteworthy job in steady and maintainable social turn of events. It additionally assumed a significant job in the political and strategic work of governments around the globe. China has been the world's biggest energy buyer, driven by its continued financial development since 2009. In 2018, China's complete energy utilization added up to 3 490 million tons of oil comparable, representing 23% of worldwide energy utilization (Enerdata, 2019). Oil is the driving force behind China's economic and social development. Nevertheless, as oil consumption increases year after year, oil and its related industries, such as transport, cause serious damage to dependence on oil imports and the environment. As a result, China's energy security has been affected by this situation. Having consumed 618 million tons of oil in 2018, China has been the world's second-largest oil consumer as well as the world's first-largest oil importer continuously increasing oil consumption and import rates over the years. China had to import more to meet the increasing energy consumption as oil dependence has been exceeded by 71%, which was 56% in 2010 (BP, 2019). Increasing dependency on oil has been a threat to China's national energy security.

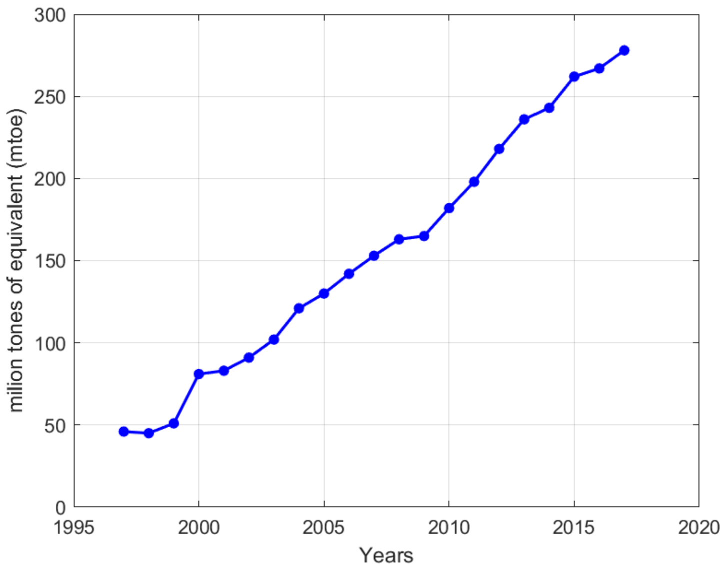

Figure 6. Oil product consumption of China in the transport sector (Source: IEA, 2018).

In 2017, the total final consumption by oil product sources has been 513 million tonnes of oil equivalent while the total final energy consumption in the transport sector has been 310 million tonnes of oil equivalent. Figure 6 shows that total oil product consumption in the transport sector has been 278 million tonnes of oil equivalent (IEA, 2018).

Moreover, with the rapid improvement of the Chinese economy and noteworthy increments in rush hour gridlock organizes, the quantity of vehicles has been developed at a disturbing rate. China has been the biggest armada of engine vehicles on the planet by 340 million engine vehicles in 2019 including 250 million vehicles (Monika, 2019). Also, the quantity of engine vehicles in China has developed quickly lately, arriving at 184 million of every 2016, of which 163 million were light-obligation fuel vehicles (LDGVs). This number has been corresponding to a 16% expansion over the earlier year (Wu et al., 2017).

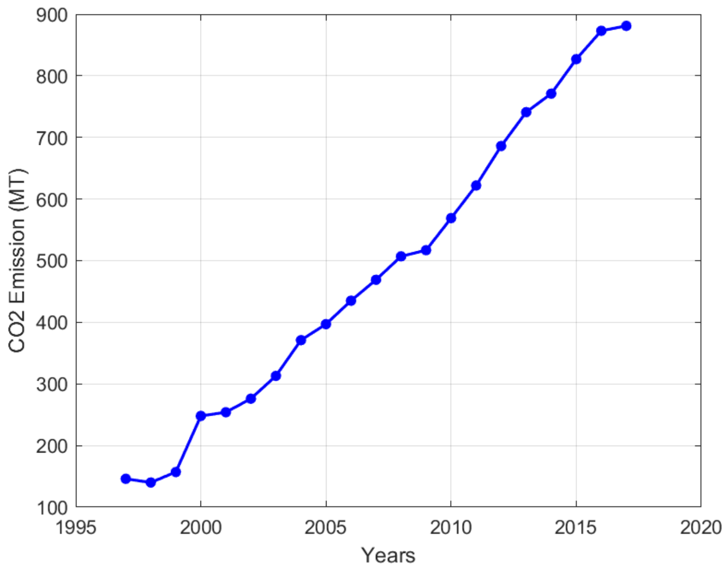

Figure 7. CO_2 emission by the transport sector in China (Source: IEA, 2018).

Besides, the expanding number of vehicles in China has prompted an expansion in CO_2 discharges in the vehicle area from 94 million tons (Mt) in 1990 to 881 million tons of CO_2 in 2017 (Li, and Yu, 2019) as appeared in Figure 7. Because of quick industrialization and urbanization, the quantity of vehicle proprietors keeps on expanding as it makes the urban traveler transport division a significant supporter of oil utilization and CO_2 discharges in China (Li, and Yu, 2019). Thus, China's vehicle segment has pulled in a lot of consideration for its over the top energy utilization and expanding outflows of contamination. Diminishing energy power was one of the main concerns of China's vehicle segment (Zha, et al., 2019). Accordingly, China's race to lessen import reliance and improve air quality has developed as the primary driver of expanded fuel ethanol creation and use. Bioethanol has been a piece of China's drawn-out key intend to secure nature, ration assets, and decrease reliance on imported energy.

China was the world's fourth-largest fuel ethanol producer with 3 750 million liters after the United States, Brazil, and the European Union (Statista, 2020). An estimated 87% of China's fuel ethanol production was corn-based in 2018, with only 2% derived from cellulose feedstocks (Fuels, and Lubes, 2020).

According to the Global Agricultural Information Network (GAIN) report published by the USDA Foreign Agriculture Service in 2019, the estimated blending rate for ethanol was 2.5%. China is expected to achieve a mixing ratio of 3.0-3.5% by 2020. However, this rate remains below the government's efforts to achieve the national E10 target by 2020 (Kim, 2019).

At the beginning of the 2000s, China began to make arrangements for production, consumption targets, and raw material priorities for the development of the biofuels market. The immense majority of ethanol production relied on existing corn supplies in China. As global grain prices rose rapidly at the beginning of 2005, the government of China promoted the production of 1.5 ethanol from non-food fuel. China's 11th Five-Year Plan for 2006-2011 outlined a new policy that prohibited the construction of any new grain-based ethanol production facility, such as maize and maize mixed with wheat due to food security concerns (Hongzhou, 2015).Be that as it may, when China stopped the advancement of age 1 ethanol in 2006, it moved help to "age 1.5" feedstocks, such as cassava and sweet sorghum. In any case, it is hard to develop enough 1.5 feedstock locally as cassava processing plants in China despite everything that depends vigorously on imports (IEA Bioenergy, 2016). In addition to issues of land availability, limited water supply is also a challenge for the 1.5 generation. (Yang, Zhou, Lui, 2009). Recently, China has encouraged the production of ethanol using cellulosic feedstock (called generation 2). But, the production of cellulose ethanol can not reach sufficient production until 2025 (Li et al., 2017).

The creation and dispersion of ethanol in China have been significant to the E10 preliminary program. Beginning in 2006, eleven regions including Heilongjiang, Henan, Jilin, Liaoning, Anhui, Guangxi, Hebei, Shandong, Jiangsu, Inner Mongolia, and Hube were settled on as pilot zones for the creation of gas ethanol and the mandatory utilization of E10 mixes. Preliminary regions settled on, based on vicinity to creation, reached out from a few towns in 2006 to 11 territories and more noteworthy than 30 towns today. Government-approved ethanol treatment facilities are unprecedented providers inside the close by check regions. They offer ethanol to explicit state-claimed gas organizations at 91.11 as indicated by a penny of the discount cost of petroleum available. Fuel organizations then combo ethanol with gas and convey the resulting E10 fuel in the investigate territories where the best E10 gas can be sold (Li et al., 2017). China's usage of biofuels blending targets has restricted its capability to answer to commercial center costs, their gainfulness, and the long-term time frame maintainability of its associations to fight their execution. Because of these worries, a few zones had not been carefully authorized by methods for the common E10 mixing necessities.

Past focal government sponsorships for the creation of fuel ethanol were upheld by the two feedstocks and information sources. During the time of high maize costs in 2008, China was limited to the development of new ethanol plants. Beginning in 2010, focal government sponsorships for regular ethanol plants started to be eliminated, tumbling from $0.03 per liter in 2009 to focus in 2016. Sponsorships to ethanol creation utilizing non-food grain feedstocks were additionally eliminated by 2018 (Ge, and Lei, 2017). Accordingly, China was constrained to developing corn use for fuel ethanol when rising local grain costs activated food value concerns with the goal that China turned into a corn shipper.

In 2012, China launched its National Five-Year Clean Air Plan (FYP 2013 to 2018) to improve air quality. This plan has been involved in limiting production in industrial installations, limiting the traffic in private vehicles, and replacing coal with clean energy (Kim, 2019). So, in 2013, the State Council issued a timetable for China V's standards to upgrade China's fuel quality nationwide. This time table has been referred to as for national desulfurization of gasoline and diesel gas to a most sulfur content of 10 ppm by way of the stop of 2017. Besides, the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ), and the Standardization Administration of China (SAC) unveiled China VI gas first-rate requirements for fuel and diesel motors in 2016. China VI gasoline requirements were divided into two phases of VIA and VIB. China's National Development and Reform Commission (NDRC) and 6 other government businesses have announced the national implementation of China's VIA fuel, including E10 and China VI diesel fuel, which include B5, effective 1 January 2019 (He, and Yang 2017). The new emission standards have been reported among the world’s most stringent emissions standards by China. Compared to the current China V emissions standards, which have been implemented on January 1, 2016, vehicles would be subject to further limitations for particulate and greenhouse gas emissions.

The bioethanol consumption variation concerning years is provided in Figure 8. The figure represents that fuel ethanol consumption in 2016 was 69.19 thousand barrels per day. Fuel ethanol consumption of China increased from zero to 69.19 thousand barrels per day from 1997 to 2016 with a growing average annual rate of 25.28% (Knoema, 2020).

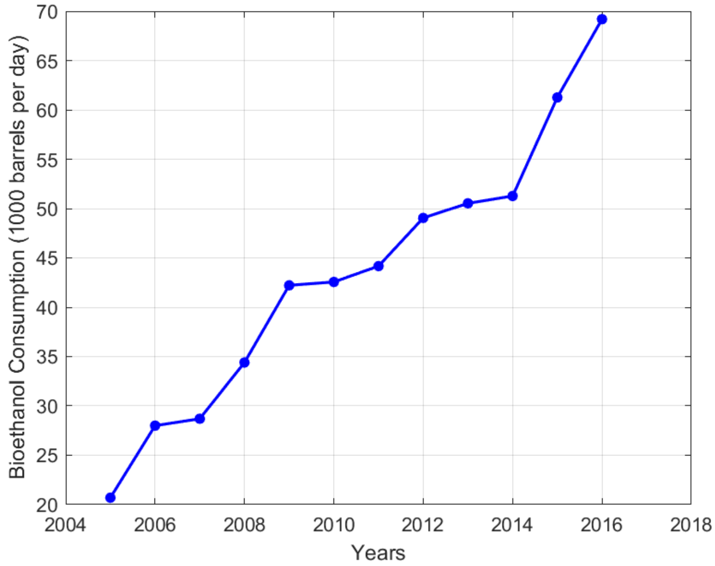

Figure 8. Bioethanol consumption in the transport sector in China (Source: IEA, 2018).

In November 2015, the thirteenth FYP for Economic and Social Development (2016-2020) was propelled by the Chinese State Council, which centers around the decrease of energy utilization, ecological assurance, and the utilization of sustainable and biomass energy. The Energy Development Strategy Action Plan (2016-2020) was likewise propelled by the State Council. It intended to top yearly energy use and set the objective of accomplishing 15% of non-petroleum product based energy use in the nation's essential energy blend by 2020 (Kim, 2019).

Biofuels have been viewed as a basic part of this arrangement. What's more, China focused on topping its all-out ozone harming substance discharges from substantial trucks and traveler vehicles by 2030 under the Paris Agreement on Climate Change in 2016. China at that point conceded to diminishing CO_2 discharges per unit of GDP by 60 to 65% contrasted with the 2005 outflows benchmarks (NRDC, 2019).

In 2016, the Chinese State Council reported its thirteenth FYP objective of creating 5,068 million liters of ethanol by 2020. Government strategies presented in 2016 made ready for a recovery of the fuel ethanol industry through the end of a transitory corn save strategy (Kim, 2019). These arrangements included stricter vehicle eco-friendliness and emanation guidelines and the re-foundation of VAT discounts on ethanol products. Besides, it has been accounted for that China's common corn preparing endowments and an across the country mixing strategy bolster ethanol makers' edge. In such a manner, the National Development and Reform Commission of China (NDRC), the National Energy Administration (NEA), the Ministry of Finance, and 12 different Ministries mutually reported a usage plan for the extension of ethanol creation and transport advancement in 2017 (NDRC, 2016).

According to this plan, a national objective of 10% ethanol (E10) mixing into gas fuel by 2020 was incorporated while a proposed move to business scale cellulose ethanol by 2025 (NRDC, 2019). The pace of extension of fuel ethanol creation limit has been quickened. However, a few headwinds were identified with ecological guidelines and specialized confinements. For instance, sanitation has now been defied.

In 2017, China propelled the world's first ethanol creation office in the territory of Shaanxi. The Shaanxi Yanchang Petroleum office was a solitary creation line that changes over coal into engineered gas and afterward into ethanol. The office utilizes 99.17% anhydrous ethanol creation and is on target to grow yearly creation to 1,268 million liters by 2020 (Zhihao, 2017).

In 2018, it has been announced that synthetic gas projects are about to produce fuel ethanol in China. Deals and agreements totaling several billions of U.S. dollars were signed to fund a total of seven synthetic gas to ethanol and waste gas to ethanol projects in Shanxi, Henan, and Xinjiang provinces. The total capacity for the cities of projects is estimated to reach nearly 3.0 billion liters. The projects will begin operating over the period from 2019 to 2035. Feedstock sources include municipal wastewater, industrial flue gas, and fossil fuels like coal. Industry sources project that, by 2020 or 2021, China's acetic acid and waste gas could contribute an additional 3 294 million liters of annual production capacity to ethanol projects under construction (NRDC, 2019).

On the other hand, the strategic value of energy independence has been recognized in China and biofuels have been accepted to reduce dependence on imports of fossil fuel supplies. China's decrease in raw petroleum imports and its household call to improve air quality are driving the reception of expanded fuel ethanol utilization while New Electric Vehicles (NEVs) has expanded interest for elective vehicle choices. China depicts New Energy Vehicles (NEVs) as modules for electric and diesel-electric half breed vehicles (Zheng et al., 2020). Presently, NEVs make up under 1% of China's traveler vehicle showcase. In October 2018, the Ministry of Public Security (MPS) detailed that China's national NEV armada had arrived at 2.61 million vehicles, or under 0.1% of complete vehicles (Li et al., 2020).

As a result, ethanol production has been projected to rise four-fold from current levels by solid focal government support through arrangements and budgetary sponsorship. Even then, China's ethanol sector has faced near-term structural challenges and long-term food supply challenges in producing sufficient fuel ethanol to meet ambitious food security E10 targets. Numerous different specialists consider China's E10 utilization focus to be practically unreachable at the current pace of market improvement. Since China has suspended its arrangement to execute an across the nation fuel mix containing 10% ethanol this year, following a sharp decline in the country's corn stock and limited biofuel production capacity. At a gathering toward the finish of December with ethanol makers and oil majors, the Chinese National Development and Reform Commission (NDRC) declared that it would now stop the turnout of ethanol-fuel supplies past the current bunch of territories that have just made full or fractional mixes since the advancement of ethanol-gas must be founded on a precondition for guaranteeing sanitation. Accomplishing the 2020 objective would require around 15 million tons of biofuel every year, multiple occasions the current yield, or somewhere in the range of 45 million tons of maize, which is around 16% of the nation's present utilization. As per a government expert, corn stocks dropped from more than 200 million tons of temporary reserves to about 56 million tons in 2017, although China did not reveal current grain reserves.

The possible relationship between the CO_2 emissions and the other parameters are investigated in this section by linear regression analysis. As a result of the analysis, a very high correlation of 0.9997, 0.9994, 0.9674, and 0.9244 are obtained between the CO_2 emission and the total energy consumption, oil product consumption, biofuel consumption, bioethanol consumption parameters respectively (Table 1). On the other hand, *p-value*s are obtained to be less than 0.05 for correlation pairs for the total energy consumption, oil product consumption, biofuels consumption parameters, and bioethanol consumption parameters (Table 2).

Table 1. Pearson correlation coefficients of parameters for China.

	Total Energy Consumption	**Oil Product Consumption**	**Bioethanol Consumption**	**Biofuels Consumption**	**CO_2 Emission**
Total Energy Consumption	1.0000	-	-	-	-
Oil Product Consumption	0.9995	1.0000	-	-	-
Bioethanol Consumption	0.9320	0.9306	1.0000	-	-
Biofuels Consumption	0.9635	0.9603	0.8770	1.0000	-
CO_2 Emission	0.9997	0.9994	0.9244	0.9674	1.0000

Table 2. *p-values* of the correlation coefficients for China.

	Total Energy Consumption	**Oil Product Consumption**	**Bioethanol Consumption**	**Biofuels Consumption**	**CO_2 Emission**
Total Energy Consumption	0.00E+00	-	-	-	-
Oil Product Consumption	2.01E-28	0.00E+00	-	-	-
Bioethanol Consumption	1.02E-05	1.13E-05	0.00E+00	-	-
Biofuels Consumption	4.79E-07	7.25E-07	1.80E-04	0.00E+00	-
CO_2 Emission	7.75E-32	4.52E-28	1.71E-05	2.75E-07	0.00E+00

The results in Table 1 and Table 2 indicate that CO_2 emission is statistically correlated with the total energy consumption, oil product consumption, biofuels consumption, and bioethanol parameters. CO_2 emission is obtained to be one-to-one correlated with total energy consumption by the correlation coefficient of 0.9997. The results show that CO_2 emission depends on the total energy consumption. More importantly, the correlation coefficient between CO_2 emission and oil consumption rate is 0.9994. This result shows that almost all of the total energy consumption is covered by oil products and that CO_2 emissions are directly related to it.

4.3 Brazil

This section summarizes the energy policies and bioethanol implementations in Brazil as well as the CO_2 emission rates related to the parameters considered. Energy security and energy policy issues are addressed in that section while the history of bioethanol applications is introduced also in this section along with the future bioethanol policies are given. Moreover, correlation coefficients between the total energy consumption, oil product consumption, biofuel consumption, bioethanol consumption, and CO_2 emissions parameters are provided. Furthermore, represents the relationship between CO_2 emission rates and the rest of the parameters.

The energy security issue varies depending on each country. For this reason, the energy-security problem in Brazil is different than China. Brazil, as the largest country in South America and the leading energy consumer, has been confronted with the economic and environmental security aspects of energy. Providing safe, affordable, and clean energy was Brazil's main concern for energy security. (The WWF, 2020)

Brazil is the second-largest manufacturer of hydroelectric power in the world. Hydropower accounts for more than 63% of the country's electricity generation at 370 906 GWh in 2017 (IEA, 2018). Even though most of Brazil's hydroelectric plants are located in the north of the country, most of the energy demand occurs in the south of the country. Over the most recent couple of years, the nation has been confronting genuine dry seasons that have caused power deficiencies and power outages. Dry spells were brought about by changes in the hydrological cycle brought about by normal atmosphere inconstancy and environmental change, which diminished the normal water levels in the water reservoirs. As an outcome, the high dependence on hydropower jeopardizes the nation's energy security as far as power and flexibly joined with the remote and different areas of its interest communities have introduced difficulties as far as the unwavering quality of power, especially in the Southeast region (EPE, 2017). Another outcome of the high reliance on the power part about the age of hydropower was the expansion in power costs for the purchaser. The low normal water levels in the hydro dam stores make it important to expand the flexibly of warm energy to fulfill the nation's need for power in dry seasons. This wellspring of power isn't just terrible for the earth but it produces ozone harming substance discharges that have recently been stayed away from while it is additionally substantially more costly than hydroelectricity. Additionally, worries about the accessibility of gaseous petrol that Brazil as of now expends more petroleum gas than it produces. It is an indication that Brazil imports flammable gas from Bolivia. However, the relationship between Brazil and Bolivia has been unstable and has a negative impact on the trade-in natural gas. As a result, electricity prices in Brazil have been quite high in the last 4 years and people are always dependent on rainy summers to pay a fair price for electricity (EPE, 2017).

Concerning petroleum and oil products, some points have been worth highlighting in Brazil. Oil was the first major source of energy supply and oil supply in Brazil's total primary energy supply was 38% to 110 million tonnes in 2017. On the other hand, oil products accounted for a large part of the total energy consumption while the consumption of oil products accounted for 45% by 102 million tonnes in 2017.

Brazil was severely affected by the oil crisis of the 1970s, as net imported oil accounted for about 70% of Brazil's gross domestic supply, and serious dependence was reported. Aggressive policies have therefore been adopted to minimize Brazil's dependence on imported oil (Luciana, 2018). Efforts to grow domestic oil production have been made to reduce the external dependence of crude oil in Brazil in the 1970s when two global oil crises occurred in 1973 and 1979.As a result, Brazil has become a crude oil net exporter since 2006 (except for 2007) so that the country is self-sufficient in the quantity of crude oil (Deloitte, 2019a). According to figures from the April 2019 monthly newsletter of the National Petroleum Agency (Agência Nacional de Petróleo, Gás Natural e Biocombustíveis) (ANP), oil creation has arrived at a normal of 2.6 million barrels for every day (ANP, 2019). Petrobras is by a wide margin the biggest oil maker in Brazil, representing 94.9% of the absolute oil and flammable gas created. In this way, it is important to note that imports accounted for 70% of the gross domestic supply of crude oil in 1970 while it was only 8.3% by 2017 (Deloitte, 2019b). In terms of dependence, this number has not been negatively affected by energy security.

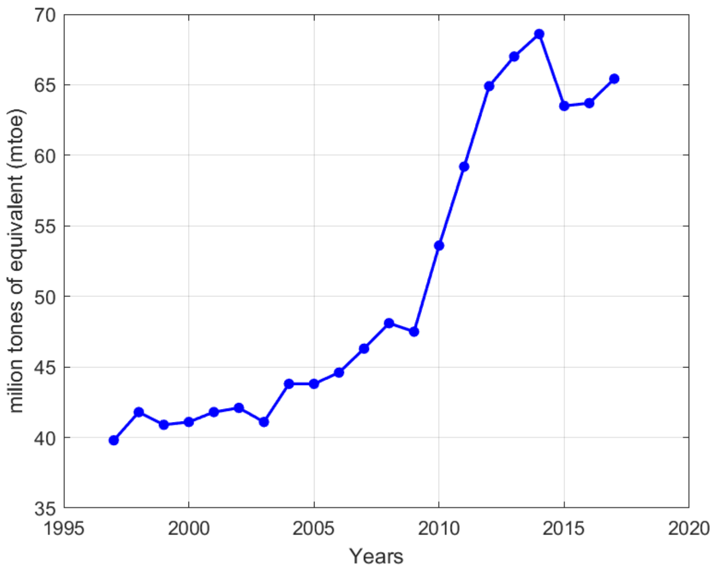

Figure 9. Oil product consumption in the transport sector in Brazil (Source: IEA, 2018).

Figure 9 represents the oil product consumption in the transport sector. In 2017, the consumption of oil products in the transport sector has been accounted for 63.7% via 65 million tonnes in total energy consumption. It indicates that the largest sector of oil product consumption has been the transportation sector in Brazil (IEA, 2018). This consumption rate in the transport sector has been affected by energy security negatively in terms of CO_2 emissions. Figure 10 also refers to the CO_2 emission emitted into the atmosphere by the transportation sector for the 1997-2017 period (IEA, 2018). CO_2 emission in 2017 was 47.4% with 203 million tons CO_2.

Brazil endorsed the Paris Agreement in September 2016, with a promise to diminish ozone-depleting substance emanations by 37% by 2025 and 43% by 2030 in view of 2005 levels, as demonstrated by the INDC (FRB, 2020). As per Martinez et al. (2015), potential energy fates for the following 30 years in Brazil are connected to moderate and thorough alleviation of environmental change impacts. The Intergovernmental Panel on Climate Change (IPCC, 2013) reports demonstrate the significance of utilizing and creating sustainable power sources to decrease GHG outflows (Macdonald et al., 2016; Ali et al., 2019).

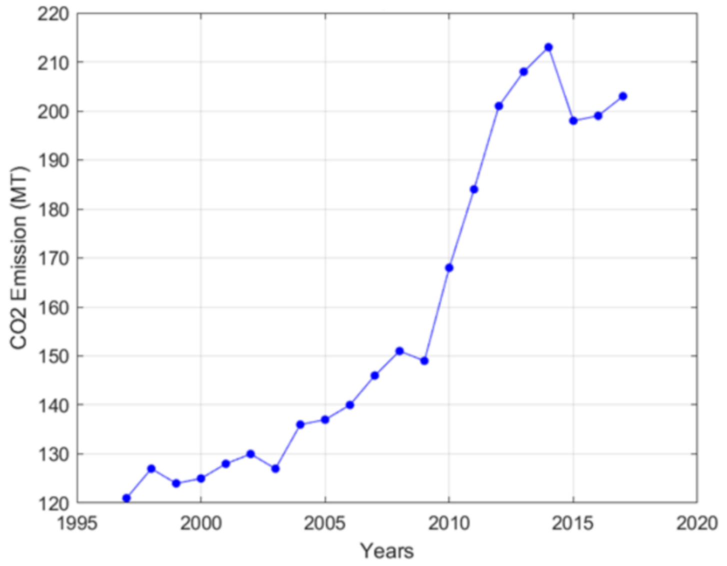

Figure 10.CO_2 emission by the transport sector in Brazil (Source: IEA, 2018).

The attempt to expand domestic oil production was not the only policy adopted to reduce foreign dependence on crude oil in Brazil. Alternative renewable energy sources and the integration of energy with the country's neighbors have also been highlighted among these policies. According to Pereira et al. (2012) and Silva et al. (2016), bioethanol offers an energy security solution in Brazil. Brazil wants to use alternative energy sources to start the process of transition to a low-carbon economy and to encourage the use of ethanol-powered vehicles in the transport sector. Furthermore, given the boom in global common temperatures and the use of fossil fuels, the destiny situation could pose risks to the Brazilian strength supply gadget due to feasible water crises. This should hinder electricity protection and increase carbon emissions, affecting the outcomes anticipated from the adoption of the Paris Agreement with the aid of Brazil. The study in this thesis therefore also examines possible government strategies to stimulate the market for funding in renewable resources of biofuels to replace fossil fuels within the transport area. It is why the use of bioethanol in the shipping quarter has been investigated to meet Brazilian energy necessities and ensure that the emission objectives promised with the aid of the INDC are met. In this context, a program to increase the development of a new fuel source called ProÁlcool by Brazil was launched in 1975 to reduce the energy reliance of crude oil (Walter, Dolzan, and Piacente, 2006).

The legacy of ethanol fuel in Brazil has started since the 1970s. It is connected to Brazil's sugar stick-based ethanol fuel program, which permitted the nation to turn into the world's second-biggest ethanol maker and the world's biggest exporter. Brazil generated nearly 30 billion liters of ethanol in 2018 (Statista, 2020). In response to the oil crisis of 1973, the Brazilian government began to promote the use of bioethanol. In 1975, with Decree No 76.593, the Alcohol Program (Proalcohol) was established in Brazil to reduce oil imports through the production of cane-derived ethanol (Biodieselbr, 2006). The Brazilian government also made it compulsory for ethanol fuel and gasoline to be blended in varying amounts between 10% and 22% between 1976 and 1992 (IBP USA, 2007). The goal of this program was to guarantee the flexibility of ethanol to the drawback of gas to help the innovative advancement of the sugar business in the nation. The choice to create ethanol from sugar stick depended on the minimal effort of sugar at that point, the inactive refining limit at sugar plants, and the nation's convention and involvement in this feedstock. The Government of Brazil has given three significant starting sparks to the ethanol business. These incorporate ensured buys by the state-possessed oil organization Petrobras, endowments to makers, and expense motivations for purchasers. Since impetuses and guidelines prompted a sharp increment underway beginning around 1975 (Glickman, 2012). The industry followed the incentives and rapidly introduced ethanol-powered vehicles while the Fiat 147 was the first in the world. It was the first modern commercial ethanol-powered vehicle (E100) to be launched on the market in 1979 (Meyer et al., 2012).

After reaching more than four million pure ethanol-powered cars and light trucks in the late 1980s, it accounted for 33% of the fleet of motor vehicles. Since then and until 1994, Brazil underwent successive economic and political crises, including a 1992 president, characterized by high external debt and hyperinflation. Throughout this period, oil prices have been low enough to discourage alternative fuels most of the time. Besides, prices of sugar increased in international markets by the end of the 1980s. The sum of these factors led the Brazilian government to change its ethanol policy in 1989 and to reduce state support for production. As a result, some shortages caused the public to lose confidence in the program. Sales and production of clean ethanol vehicles dropped sharply. The percentage of clean ethanol vehicle sales decreased to 10% in 1990 (ANFAVEA, 2008).

The economic and political recovery that followed after 1994 helped to create the conditions for better government and industry planning. With deregulation, producers built on accumulated knowledge and became more efficient and independent from government subsidies. The next relevant event was the launch in 2003 of the first flex-fuel vehicles that could run on hydrated ethanol, gasoline, or a mixture of the two. This was stimulated by the government's offer of tax breaks. These cars have been well received by consumers. Since 2006, more than 80% of the light vehicles sold in Brazil are flexi-fuel vehicles (Lima et al., 2020).

The Brazilian model, which began in 1975, includes several mechanisms for regulating the demand for and supply of fuel ethanol. Three flexibility schemes can be used as control mechanisms. Adaptability I: the plant may deliver more sugar when the cost is high and this assists with creating more affordable ethanol. Generally, Brazilian factories, all exclusive, can alter their creation to process somewhere in the range of 40% and 60% of their sugar or ethanol sucrose relying upon the market circumstance. Adaptability II: two ethanol powers are accessible in Brazil: hydro ethanol and anhydrous ethanol. Water ethanol (92%) is utilized legitimately in E100 vehicles and flex-fuel vehicles. Anhydrous ethanol is mixed with gas to make E20-25 fuel, locally known as C gas. Adaptability III: gas vehicles can be fueled with mixes from the earliest starting point of the ethanol program. Unadulterated fuel has once in a while been sold in Brazil since the 1970s. After 1979, E100 vehicles, otherwise called ethanol vehicles, were presented requiring extra siphoning all things considered service stations. Both E20-25 and E100 have dispersed the nation over to 7000 corner stores. Flex-fuel vehicles presented in 2003 gave Brazilian shoppers the alternative of utilizing any extent of ethanol (E100) and gas (E20-25). As a dependable guideline, if the cost of hydrous ethanol is beneath 70% of the cost of E20-25, it merits utilizing E100. This third degree of adaptability, which is intended to fulfill the shopper, is viewed as an advertising accomplishment for the general utilization of ethanol in the nation (Cruz, Souza, and Cortez, 2014).

Since 2009, the Brazilian ethanol United States has undergone economic stress because of the credit score crunch resulting from the 2008 financial crisis. Poor sugar cane harvests due to adverse weather and high sugar fees on the sector marketplace have made it greater reasonable to produce sugar rather than ethanol. Those certain domestic factors that have led to a decline in annual production despite developing demand in the local marketplace. As a result of supply shortages and high gasoline fees for ethanol, the authorities have ordered a temporary 90-day combo discount from E25 to E20 starting on 1 February 2010 (Rudnick, 2013). Brazilian ethanol fuel manufacturing in 2011 amounted to 21,1 million liters compared to 26,2 million liters in 2010 (Renewable Fuels Association, 2019). A supply shortfall took place for several months in 2010 and 2011 so that prices rose to the point that ethanol fuel was now not attractive to proprietors of flex-fuel vehicles. The authorities reduced the minimal blend of ethanol in gasoline so one can lessen call for and maintain ethanol gas fees from growing further. Ethanol fuel has been imported from the United States for the first time in the 1990s (BB, 2012). In April 2011, the government reduce the minimum mandatory blend to 18% via leaving the necessary blending range between E18 and E25. As a result of higher ethanol prices caused by the crisis in the Brazilian ethanol industry, government subsidies are set to maintain the price of gasoline underneath the international marketplace value. In 2013, only 23% of Flex-fuel vehicle owners used ethanol regularly and this rate was 66% in 2009 (Ciarelli, 2013). E25 was reintroduced in June 2012 while Brazil's resolution in 2015 called for a 27% blend of ethanol in gasoline (Transport Policy Brazil, 2020).

Figure 11 represents the bioethanol consumption between 2005-2016. Brazil's fuel ethanol consumption in 2016 was 460.89 thousand barrels per day. Although Brazil's fuel ethanol consumption has fluctuated significantly in recent years, it has tended to increase to 460.89 thousand barrels per day in 2016 over the period 1997-2016 (Knoema, 2020). It has accounted for 23% of transport energy consumption in 2018 (IEA, 2018).

The RenovaBio Program is designed to support Brazil's COP21 objectives. RenovaBio was launched in December 2016 by the Ministry of Mines and Energy (MME) and was established as the "National Biofuels Policy." The program is expected to be effective by the end of December 2019 (Barros, 1919).

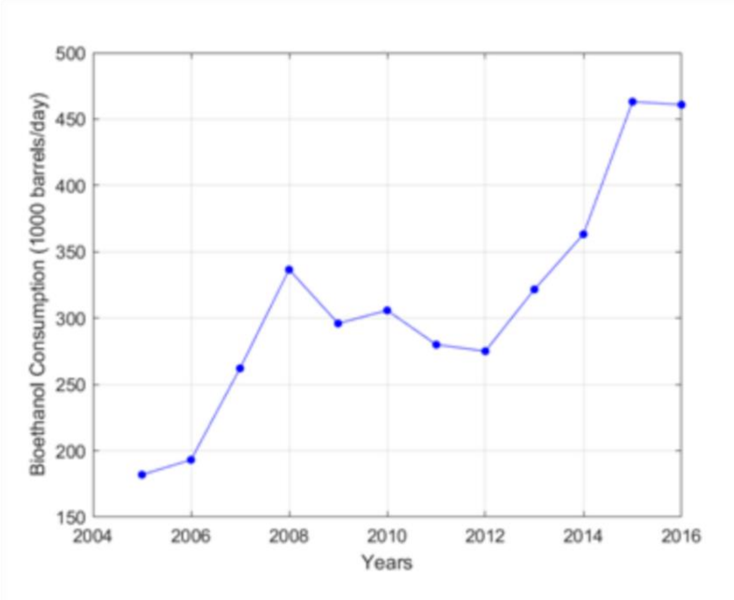

Figure 11. Bioethanol consumption in the transport sector in Brazil (Source: IEA, 2018).

On the other hand, the Brazilian vehicle emission control program, Programa de Controle da Poluição do Ar para Veículos Automotores (PROCONVE), reflects the Euro V standards for heavy-duty vehicles and has separate standards for light-duty vehicles. Besides, Brazil has prohibited the sale of diesel cars nationwide and promotes biofuels through minimum blending requirements and fiscal measures. The PROCONVE L6 standards, which are currently in force and which came into force in 2013, apply to all sales of new cars and light commercial vehicles. PROCONVE Regulations tend to be more relaxed than the relevant EU standards. For example, PROCONVE L6based on Euro 5does not include PM mass-forced particulate filters or emission standards. The L-7 standards will enter into force in 2022 and the L-8 standards will be phased-in from 2025 to 2031. The Regulation also includes stricter noise limits for passenger cars and light commercial vehicles, which are phased in between 2022 and 2032 (Dieselnet, 2020).

The Light Duty Vehicle (LDV) segment of passenger vehicles has five primary dimensions, namely petrol, ethanol, Flexible Fuel (FFV), Hybrid, and Electric. The LDV amounted to 35.4 million in 2016. The trend of increasing FFVs began to rise sharply in 2003 and stems from the Pro-Alcool program that began in 1975 to combat oil dependence. Since FFVs can run on ethanol or gasoline, they offer a unique 'non-dependence' of a single source of energy. The FFVs, on the other hand, offer the enduser the ability to benefit from any price differential in fuel. In 2007, the accumulated fleet of flex-fuel vehicles amounted to 4.5 million units and rose to 26 billion units by 2016. According to the annual fuel type sales report by ANFAVEA, sales of flexible-fuel vehicles increased by 12.5% y / y to 2 million units in 2018 with a market share of 87.6% (ANFAVEA, 2020). This large expansion has led Brazil to have the largest biofuel transport program in the world.

The possible relationship between the CO_2 emissions and the other parameters are investigated in this section by linear regression analysis. As a result of the analysis, a very high correlation of 0.9997 and 0.9998 are obtained between the CO_2 emission and the total energy consumption and oil product consumption parameters while 0.6626 and 0.7373 were obtained for biofuels consumption and bioethanol consumption parameters (Table 3). On the other hand, the corresponding *p-value*s for the estimated correlation coefficients are less than 0.05 so that each of them is statistically significant within a 95% confidence interval (Table 4).

Table 3. Pearson correlation coefficients of the parameters for Brazil.

	Total Energy Consumption	**Oil Product Consumption**	**Bioethanol Consumption**	**Biofuels Consumption**	**CO_2 Emission**
Total Energy Consumption	1.0000	-	-	-	-
Oil Product Consumption	0.9898	1.0000	-	-	-
Bioethanol Consumption	0.8337	0.7284	1.0000	-	-
Biofuels Consumption	0.7676	0.6525	0.9925	1.0000	-
CO_2 Emission	0.9926	0.9990	0.7373	0.6626	1.0000

The estimated correlation coefficients indicate that especially there is relatively a higher correlation between CO_2 emission and the other parameters while biofuel and bioethanol are in a weaker relationship with the other parameters. The correlation coefficient between the CO_2 emission and the total energy consumption parameters is calculated to be 0.9926 while it is 0.9990 between the CO_2 emission and the oil product consumption parameter. The correlation coefficient between the consumption of bioethanol and the CO_2 emission rate is obtained to be as high as 0.7373. This is because bioethanol use increase recently since bioethanol also emits CO_2 but this is much less than oil products.

Table 4. *p-values* of the correlation coefficients for Brazil.

	Total Energy Consumption	**Oil Product Consumption**	**Bioethanol Consumption**	**Biofuels Consumption**	**CO_2 Emission**
Total Energy Consumption	0.00E+00	-	-	-	-
Oil Product Consumption	1.52E-17	0.00E+00	-	-	-
Bioethanol Consumption	7.52E-04	7.22E-03	0.00E+00	-	-
Biofuels Consumption	3.56E-03	2.14E-02	1.89E-10	0.00E+00	-
CO_2 Emission	7.35E-19	3.98E-27	6.21E-03	1.89E-02	0.00E+00

4.4 Sweden

In this chapter, energy policies in Sweden and its CO_2 emission relationships are investigated. The past and future of energy policies, practices, and objectives for Sweden are briefly summarized while bioethanol applications, their place in total energy consumption, and future targets are examined in this section. The cross-correlations between the total energy consumption, oil product consumption, biofuel consumption, bioethanol consumption, and CO_2 emission parameters are provided and discussed in the section. Finally, CO_2 emission concerning other parameters is introduced.

Taking into account the rapid and suffering environmental change on the planet, there is a pressure for the petroleum derivatives from sustainable power sources and to improve energy effectiveness (IEA, 2015). By then, the Paris Agreement is an achievement in the worldwide atmosphere strategy because of its expansive universal help (Fragkos et al., 2017). Even at that point, the discharge decreases guaranteed by the gatherings lead to an unnatural temperature change of 2.6–3.1°C above pre-modern levels in 2100 while further activity by an assortment of entertainers at various levels will be expected to meet the objective of remaining admirably under 2 °C seeking after endeavors to diminish an Earth-wide temperature boost to 1.5°C (Rogelj et al., 2016). Part States of the European Union (EU) have conceded to outflow decrease targets and focus on energy effectiveness and the portion of sustainability to relieve environmental change (Strambo et al., 2015).

Moreover, the Swedish Parliament embraced another atmosphere strategy structure in June 2017 while further propelling Sweden's environmental change moderation aspirations (Wretling et al., 2018). With the yearning targets set in the Energy Agreement and the Climate Framework, Sweden aims to turn into a net carbon economy by 2045. The nation as of now has the second-most minimal CO_2 outflows per GDP and per capita among IEA part nations as of 2017 (IEA, 2018). The Swedish objective is to decrease ozone-depleting substance emanations by 63% from 1990 to 2030 and by 70% from the worldwide vehicle, barring outside flights (Wretling et al., 2018).

The Swedish official power stability accounts for the country's energy delivery and intake in a single year. The power balance is made up of the delivery part and the intake component. The deliver component includes all forms of power sources, consisting of nuclear, wind, hydro, crude oil, and biofuel to fulfill Sweden's power needs. Supply additionally includes energy imported into the country, such as natural gas.

The total energy consumption in Sweden was 33 million tonnes in 2017. Electricity has accounted for a large part of the total energy consumption. In 2017, the consumption of electricity accounted for 33.2% via 11 million tonnes. The energy consumption of oil products takes second place in overall consumption. The oil crisis of the early 1970s forced Sweden to embark on a search for alternative sources of energy. Its phase-out of oil continued smoothly in 1970 by oil accounting for 77% of Sweden's energy. However, by 2017 it dropped to 30% by an average of 10 million tonnes (IEA, 2018).

Figure 12 shows the consumption of oil products in the transport sector in Sweden. From 1997 to 2017, there was a slight decline in the transport sector. Besides, the final consumption of oil products by sector has been examined while a large portion of the consumption of oil products has occurred in the transport sector. In 2017, the consumption of oil products by 6 million tonnes accounted for 65.9% (IEA, 2018). Mona Sahlin, a previous Minister of Sustainable Development, stated that their reliance on oil ought to be broken by 2020 and that there ought to consistently be better choices to oil, which implies that no house should require oil for warming and that no driver ought to need to go to fuel alone (Nesheiwat, 2013).

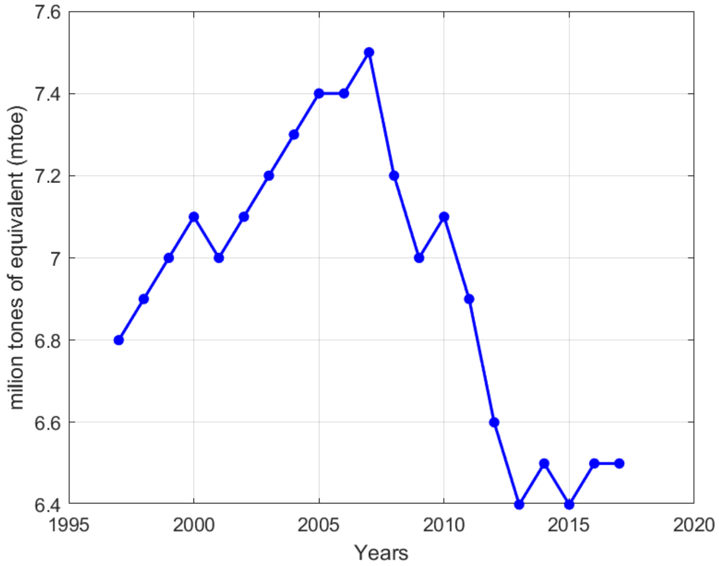

Figure12. Oil product consumption in the transport sector in Sweden (Source: IEA, 2018).

In this context, the aim is to reduce transport CO_2 emissions by 70% from 2010 to 2030 (IEA, 2018). Total passenger vehicle traffic was reported 4.8 million cars in 2019. Passenger vehicle fueled by gasoline was reported to be 2.6 million while diesel vehicle was 1.7 million. On the other hand, the fuel type of the electric vehicle, the plug-in vehicle, the gas vehicle, and the ethanol vehicles were in use in traffic (Transport Analysis, 2020).

Figure 13 represents the CO_2 emission released by the transport sector from 1997 to 2017. The peak is observed in 2007 while it decreased after then. By the year 2017, the released CO_2 emission from the transport sector was accounted for 54.1% via 20 million tons CO_2 in total CO_2 emissions (IEA, 2018).

Renewables, especially biofuels, is every so often described inside the policy region as a method of decreasing greenhouse gas (GHG) emissions and at the identical time increasing strength security, particularly inside the shipping sector as it relies upon on oil products (Viju, and Kerr, 2013)

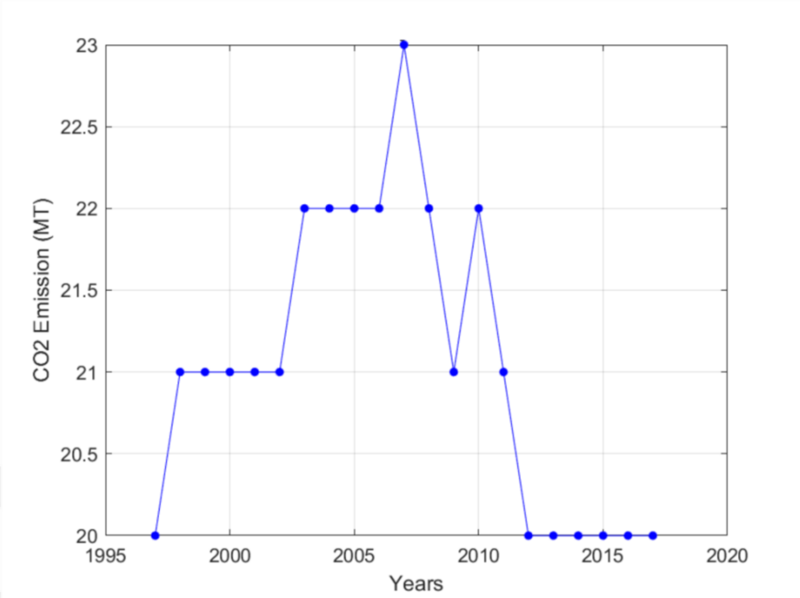

Figure13. CO_2 emission by the transport sector in Sweden (Source: IEA, 2018).

Swedish policymakers have the yearnings to additionally expand the utilization of inexhaustible and to make the Swedish street transport part free of non-renewable energy sources by 2030 (SW, 2009). Sweden's energy strategy has effectively centered around energy effectiveness and moving from petroleum products to a residential sustainable power source. The utilization of biofuels for street transport in Sweden has expanded in the course of the most recent 10 years as policymakers are invigorating interest because of environmental change and petroleum product autonomous concerns. By supplanting vehicles requiring ethanol, less petroleum and diesel are being utilized to support nature. The objective presently is to decrease transport discharges by 70% by 2030 and afterward totally switch to traffic without fossil use. This can be accomplished through a mix of improved energy effectiveness and a move from non-renewable energy sources to biofuels (Svebio, 2020). More E85 stations are now being used by people buying vehicles running on ethanol. Sweden has one of the highest biofuel consumption rates in Europe, at 32%, mainly due to the widespread commitment to E85 (ICCT, 2018).

Ethanol-powered ED95 busses were introduced as fuel for two busses in Örnsköldsvik in 1986 on a trial basis. SEKAB provided the fuel, called ED95, comprises of a mix of 95% ethanol and 5% start enhancer while itis employed in changing diesel motors where high pressure is utilized to touch off the fuel. Today, different nations have this innovation being investigated under the support of the Bioethanol for Sustainable Transport (BEST) venture, which is being facilitated by the City of Stockholm. Portage Focus was likewise the first FFV to be presented in Sweden in 2002. Until 2008, the presentation of flex-fuel vehicles on the Swedish new vehicle showcase appeared to be a triumph. Deals shares expanded every year, reaching practically 25% of the market in 2008. From that point forward, in any case, deals have dropped to 5% of recently sold vehicles in 2011 (SEKAB, 2020).

In 2006, the role of ethanol was highlighted in a report aimed at making Sweden an oil-free society by 2020 to create an independent fossil fuel fleet by 2030 (Commission on Oil Independence, 2006). As a result, ethanol or rather alternative fuels received a great deal of support from the Swedish authorities, from mandating alternative fuels at gas stations to subsidizing the sale of vehicles. Despite this major support, FFVs have not been able to create a sustainable market share.

The development of FFV sales has been influenced by means of the charge ratio between E85 and gasoline as well as the countrywide incentive structure in addition to by using the exemption from congestion fees in Stockholm. When the market proportion decline came about in 2009, first of all, the incentive shape for private owners modified from a factor of sale rebate to a smaller subsidy dispersed over 5 years. In the case of enterprise automobiles, the incentive was nevertheless in place, but the uncertainty regarding its renewal reduced its influence. At the identical time, vehicle rules of groups have rather begun to move away from opportunity fuels to carbon emission limits. The fees of gas fell at the same time as the fees of E85 did not and precipitated the fueling of E85 to be much less economically attractive. The exemption from congestion charges became eliminated in Stockholm as one of the foremost markets for FFVs and automobiles in Sweden in general. Moreover, the picture of ethanol in the media has modified from Ecofuel with the capacity to create easy cars, domestic jobs, and decrease driving costs to alternative fuel, which has multiplied food charges and the environmental performance of which has been strongly questioned. At the identical time, diesel motors that met the standards of green started to go into the marketplace and provided the opportunity of replacing FFVs. As a result, the changes inside the rebate structure confirmed that E85 had lost its economic gain and that the elimination of the congestion charge exemption in Stockholm was the most sizable factor within the decline (Sprei, 2013).

In Sweden, the all-out ensured energy kind of transport of biofuel has for the most part been separated into three sections. These are ethanol, hydrolyzed vegetable oil (HVO), and unsaturated fat methyl ester (FAME). Premium-quality, HVO-type inexhaustible diesel is created principally from waste and buildups. The Swedish HVO maker utilizes nearby pine oil, deposits from the mash, and paper industry. In the creation procedure, the polluting influences are expelled from the crude materials which are then hydro-rewarded at high temperatures. The outcome is an even-quality, vapid, and scentless fuel with a similar substance arrangement as fossil diesel. It is likewise frequently alluded to as cutting edge biofuel or second-age biofuel (Grahn, and Hansson, 2015). Conventional original FAME-type biodiesel, then again, is created by esterifying vegetable oils or fats. The procedure of esterification limits the utilization of crude materials of low quality or polluting influence like waste and buildups. The nature of customary biodiesel likewise differs in different regards relying upon the crude materials utilized (Neste, 2016). Retailers and makers of biofuel for the fluid vehicle have provided ethanol and biodiesel to the Swedish energy transport framework. Aggregate sums have kept on developing since 2003, while the biggest increment to date has been for the most part in HVO biodiesel. However numerous biodiesel is mixed and dispersed to customers by existing petroleum organizations, yet some FAME makers likewise offer concentrated items to close by stations (Mansson, Sanches-Pereira, and Hermann, 2014). Bioethanol and FAME mixes in Sweden are at present 5% per fuel volume, yet the Government has permitted up to 10% bioethanol in petroleum and up to 7% FAME in diesel since May 2011 (Government Offices of Sweden, 2009). There is no roof for HVO. Ethanol, then again, is utilized in mix with gas in low-blend mixes just as significant levels like E85 and ED95 (Swedish Energy Agency, 2015).

Biodiesel is as of now at the cutting edge of sustainable powers utilized in the Swedish vehicle division. Its commitment is roughly 44%, trailed by bioethanol with around 28%, sustainable power (for example biomass, hydro and wind power) with 18%, and improved biogas with near 10% (Swedish Energy Agency, 2019).

The portion of E85 began to ascend as an upgrade to request in 2005 because of the National Climate Policy 2030 (Government of Sweden, 2009). Another significant factor is that the National Association for the Automotive Industry has given its help to the activity. Be that as it may, the pattern changed in 2009 as purchasers responded rapidly to changes in fuel strategy and value variances. In July 2009, the Swedish Government expelled the premium for the acquisition of a spotless vehicle. For instance, eco-friendly vehicles with CO_2 emanations not surpassing 120 g/km or equipped for utilizing elective energizes while the market reaction was a sharp decrease in the deals of flex-fuel vehicles that year (Swedish Energy Agency, 2011). Deals of biofuels are likewise profoundly reliant on the overall cost of oil items. For instance, bioethanol utilization in Sweden is alluring until it costs up to around 74% of the cost of petroleum per liter. This edge was surpassed in 2009 (with a normal expense of around 80% of the cost of petroleum per liter) by prompting a decreased utilization of bioethanol in Sweden. (Pacini, and Silveira, 2011).

In Sweden, the number of gasoline vehicles is decreasing and they are being replaced as it indicates the process of replacing the fuel in the fleet. In recent years, these changes have been observed in Sweden as a result of several policy instruments that promote low carbon emissions, such as low fuel tax and fuel-efficient diesel vehicles that affect the transport sector (Mansson, Pereira, and Hermann, 2014). Besides, the quick development of biofuels in Sweden as of late is predominantly due to the expanded utilization of hydro-rewarded vegetable oil (HVO) diesel, which is an inexhaustible diesel produced using distinctive bio-based crude materials. In the instance of biodiesel, the piece of the armada has affected the expanded utilization of the 5% mix. This reflects both the way toward supplanting fuel in the armada and the expanding reliance on diesel. Deliveries of diesel fuel for transport were reported for almost 170 m^3 in October 2017. HVO can be mixed in two ways that blend HVO and pure HVO and total HVO consumption has been reported to be approximately 140 m^3 (Sherrard, 2017).

Figure 14 represents the temporal variation of biofuel consumption. Biofuel consumption reached 23.6 thousand barrels per day in 2016. In 2017, the renewable share of transport fuel bought in Sweden was 20.4% on an electricity basis. It is a new document due to the fact the share was once 18.5% in 2016. The total share of biodiesel of all diesel also reached an electricity file of 28.2%, in accordance with an analysis with the aid of the Swedish Bioenergy Association (Svebio) using information from Statistics Sweden (SCB). HVO is a type of biodiesel that is chemically identical or very similar to fossil diesel and can, therefore, replace 100% fossil diesel.

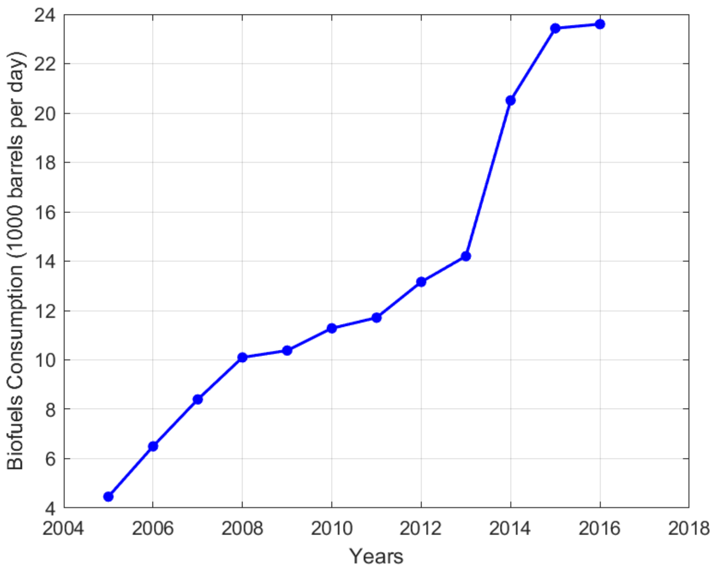

Figure14. Biofuel consumption in the transport sector in Sweden (Source: Knome, 2020).

The most effective actor in such an increase was the increase in the use of HVO, which is a type of biodiesel that is chemically identical or very similar to fossil diesel so that it can replace fossil diesel by 100%. However, a few challenges are facing the expansion of HVO as fuel. First of all, vehicle manufacturers need to supply vehicles that can run on HVO 100 if fossil-free fuel is to become mainstream. Secondly, equipment at petrol stations and other installations must be adapted as biofuel products do not behave like traditional fuels. Finally, if Sweden continues to pursue ambitious targets for the production of HVO, then the sources of feedstock must be identified (Mansson, Sanches-Pereira, and Hermann, 2014). E85 sales collapsed as fuel because of being more expensive. ED95 is a renewable fuel used for internal combustion engines in heavy-duty vehicles such as trucks and buses. In Sweden, the largest part of public transport in Stockholm was spent on ethanol-powered busses in the early 1990s. The number of ethanol busses has decreased since 2014. Stockholm public transport and Sweden in general are investing more in biodiesel, HVO, hybrid busses, and biogas. Many ethanol busses have been converted to be able to run on biodiesel.

The main reason why Stockholm public transport has withdrawn from investing in ethanol busses where the environmental objective is to improve energy efficiency, the overall cost (vehicle, fuel, and maintenance) and the discussion/criticism that ethanol production is stealing land from food production (but this is also a concern for some types of HVO depending on how it is produced) (Mansson, 2016).

The possible relationship between the CO_2 emissions and the other parameters are investigated in this section by linear regression analysis. As a result of the analysis, a high correlation of 0.9388 has been obtained between the CO_2 emission and oil product consumption parameter (Table 5). On the other hand, very low correlation coefficients are obtained between total energy consumption and the rest of the parameters. Besides, the *p-values* for these pairs are obtained to be greater than 0.05, which indicates that the total energy consumption parameter is statistically not correlated with the other parameters (Tables 5 and 6). A similar result is obtained for the biofuels consumption parameter with relatively lower correlation amounts. The *p-values* also indicate that this parameter is not in a relationship with the other parameters. Surprisingly, a strong negative relationship of -0.8564 is observed between oil product consumption and bioethanol consumption parameters. Also, another strong correlation of -0.7858 is obtained between CO_2 and bioethanol consumption with a statistical significance (Tables 5 and 6).

Table 5. Pearson Correlation coefficients of the parameters for Sweden.

	Total Energy Consumption	**Oil Product Consumption**	**Bioethanol Consumption**	**Biofuels Consumption**	**CO_2 Emission**
Total Energy Consumption	1.0000	-	-	-	-
Oil Product Consumption	0.0285	1.0000	-	-	-
Bioethanol Consumption	0.0067	-0.8564	1.0000	-	-
Biofuels Consumption	-0.3401	-0.0523	-0.0640	1.0000	-
CO_2 Emission	0.1900	0.9388	-0.7858	0.0536	1.0000

The correlation coefficient between total energy consumption and the CO_2 emission rate is obtained as low as 0.1900. On the other hand, the correlation coefficient between CO_2 emission and oil products was 0.9388 while it is -0.7858 concerning bioethanol use. So, it implies that the consumption of oil products has a great effect on the CO_2 emission while higher amounts of bioethanol use reduce the overall CO_2 emission.

Table 6. *p-values* of the correlation coefficients for Sweden.

	Total Energy Consumption	**Oil Product Consumption**	**Bioethanol Consumption**	**Biofuels Consumption**	**CO_2 Emission**
Total Energy Consumption	0.00E+00	-	-	-	-
Oil Product Consumption	9.02E-01	0.00E+00	-	-	-
Bioethanol Consumption	9.84E-01	3.77E-04	0.00E+00	-	-
Biofuels Consumption	2.79E-01	8.72E-01	8.43E-01	0.00E+00	-
CO_2 Emission	4.10E-01	3.07E-10	2.45E-03	8.68E-01	0.00E+00

4.5 Turkey

This section aims to identify the main challenges related to the security of energy supply in Turkey to make recommendations, in particular about the future. First of all, imported foreign sources of oil are evaluated. Then, the impact of CO_2 emissions on energy security is then examined. In this context, environmental concerns and dependence on oil consumption in the transport sector, the total number of gasoline vehicles, and CO_2 emission values released into the atmosphere are discussed as a result of oil use in the transport sector. The recommendation for the substitution of bioethanol for oil in the transport sector has therefore been examined. In that context, firstly, the energy overview of Turkey is investigated. Then, current energy policies and practices for Turkey are briefly summarized in terms of bioethanol applications. The total status of oil demand and CO_2 emissions in the transport sector is estimated for the future. Moreover, correlation coefficients between the total energy consumption, oil product consumption, biofuel consumption, bioethanol consumption, and CO_2 emissions parameters are provided. Furthermore, represents the relationship between CO_2 emission rates and the rest of the parameters.

Since oil turned into a typical wellspring of energy about a century back, energy has become a key issue in financial matters, governmental issues, and universal relations in industrialized nations as well as in creating nations that hold characteristic stores. These days, the worldwide energy condition is a predominant issue for any nation. From one viewpoint, new energy assets and as of late found energy saves are influencing different locales of the world. Then, the world has become more energy subordinate since it has advanced into an essential piece of present-day life (Roehrkasten, Thielges, and Quitzow, 2016).

The topographical appropriation of energy stores and assets is significant on the grounds that oil and petroleum gas are the main impetus behind the world economy. Oil-based powers are originated from constrained stores. Shockingly, these constrained stores are moved in specific districts of the world. Center East and Russian Federation nations hold 70% of the world's diminishing oil and gas saves (Hacısalihoğlu, Kırtay, and Demirbaş, 2009). Some districts and nations are independent and some are very reliant, similar to Turkey. This reliance has built up the idea of energy security and, all the more profoundly, the idea of security of supply (Pasqualetti, and Sovacool, 2012).

Quick populace development and monetary improvements in Turkey have prompted a fast increment in energy utilization as of late. The constraints of Turkey's household energy sources, given its developing energy request, have brought about reliance on energy imports, specifically about oil and gas. Accordingly, this condition has prompted national energy and national security issue (Hacısalihoğlu, Kırtay, and Demirbaş, 2009).

As per the BP statistical review (2019), Turkey's total energy consumption in 2010 was approximately 107 million tonnes of oil equivalent. This amount of consumption was increased to 153.5 million tonnes in 2018. From the perspective of oil energy consumption in Turkey, oil was ranked first with 49.2 million tons of oil equivalent in 2017. Although this amount decreased to 48.6 million tonnes, oil remained stable in 2018 (BP, 2019). As of 2017, Turkey consumed an average of 141 million tonnes, compared to almost 7 million tonnes. Thus, the level of dependence on imports was therefore higher than 95% in 2017 (BP, 2019). Turkey imports mainly petroleum products from Iran (16.94%), the Russian Federation (18.87%), Iraq (16.55%), and India (8.23%). Crude oil and diesel oil account for more than 90% of Turkish imports of petroleum products (Paksoy, 2018). Thus, Turkey's imported oil is so significant because of the country's limited natural resources. It is emerging as a key factor contributing to the increase in the foreign trade deficit and a major threat to energy security (TSKB, 2019).

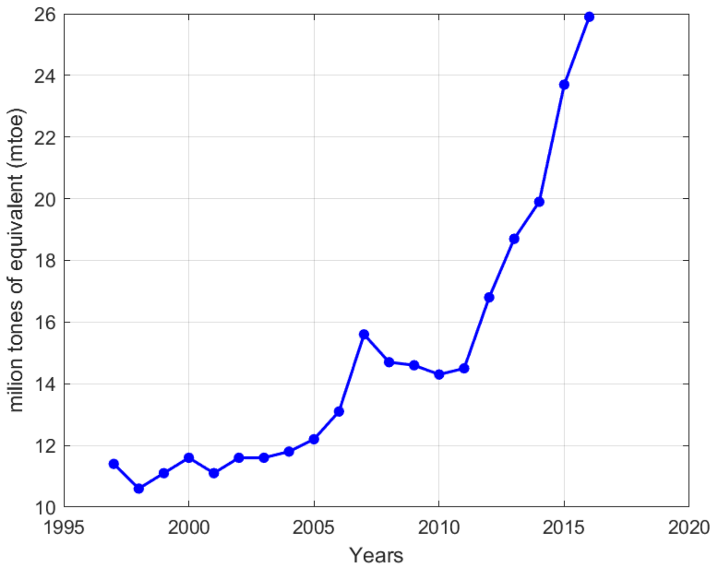

Figure15. Oil product consumption in the transport sector in Turkey (Source: IEA, 2018).

Turkey's oil consumption in the transport sector is illustrated in Figure 15 covering the 1997-2017 period. Oil consumption, which was approximately 10 million tons in 1997, in the transport sector reached 30 million in 2017 (IEA, 2018). From the sectoral distribution of Turkey's oil consumption in 2017, the transportation sector accounted for 65% of the total consumption (chiefly in road transport) as it was followed by the industrial sector (10%), agriculture (7%), and petrochemical and feedstock (5%) (TSKB, 2019).

The analysis in this chapter focused on the transport sector considering the number of vehicles. According to the Turkey Statistical Institute (TurkStat) 2020, the total number of vehicles registered to traffic by the end of November increased from

22 to 23 million (corresponding 1.4% increase) compared to the same period of last year. As of the end of November, 12 million vehicles registered in traffic where 38% was diesel, 37.4% was LPG, 24.2% was gasoline fuel, and 0.1% was electric or hybrid. The rate of vehicles with unknown fuel type was 0.3%. The number of gasoline vehicle was reported to be 3 million (TÜİK, 2020). Besides, the gasoline demand, which is increased by the number of vehicles in the transport sector, has been increased as well. According to EMRA's data, total fuel oil product sales in Turkey increased with an average of 7% each year in the last five years and reached 35 million tonnes (PETDER, 2017). It is clear that such increases in the transportation sector have a negative impact on CO_2 emissions.

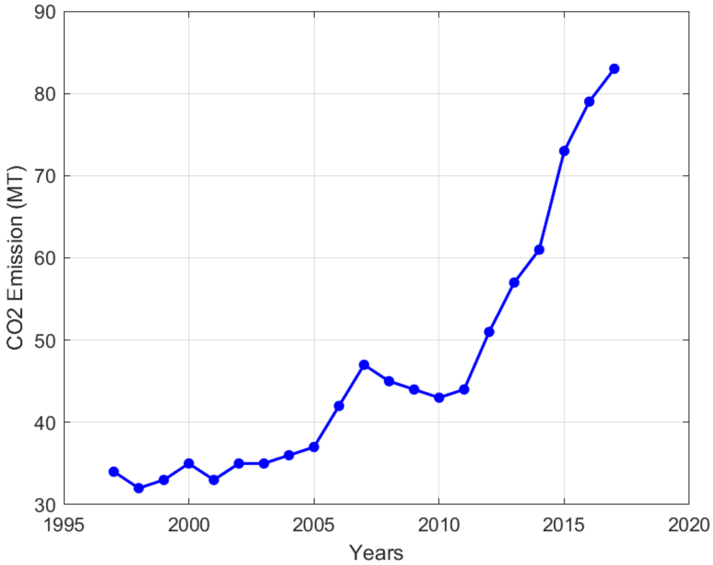

Figure16. CO_2 emission by the transport sector in Turkey (Source: IEA, 2018).

Figure 16 represents the CO_2 emission for the 1997-2017 period. The figure indicates a CO_2 emission increases released to the transport sector in Turkey. CO_2 emission levels of 34 million tons in 2017increased to 84 million tons in 2017. Such an increase has a negative effect on Turkey's energy security as well as the environment (IEA, 2018).

Turkey has emerged as one of the fastest-growing power markets in the world because of its rapidly growing economic system. The limits of Turkey's domestic energy sources, given its developing power demand, have resulted in dependence on electricity imports and oil in particular. The import fee of oil has reached a top and has led to a trade deficit. Exporting countries including Iraq and Iran have unstable conditions so that it is adversely affecting national strength security. Environmental worries have also arisen within the mid-2000s as the improved number of vehicles and oil use has multiplied inside the transportation sector. Turkey's energy policy has usually developed to serve the developing financial system and population to reduce rising import dependence, broaden renewable energy sources, sell electricity efficiency, and fulfill the country's environmental objectives, inclusive of at worldwide level. According to Brown (2014), opportunity transport fuel of bioethanol has the potential to significantly reduce dependence on imported petroleum to lessen CO_2 emissions in the transportation sector.

In light of its closeness to petroleum, bioethanol is a significant alternative through all biofuels. Additionally, it is recognized as a potential option in contrast to the decrease of non-renewable energy sources. As per Bayrakçı (2019), Turkey's potential produce bioethanol is roughly 800 000 l/day. There are 3 existing bioethanol creation plants of which are sugar beet, wheat, and maize. Furthermore, there are 12 bioethanol-delivering plants in Turkey. Eight of these bioethanol-creating plants can deliver biofuel. Currently, just three of them are used to produce bioethanol as fuel while others use ethanol for drinks. Moreover, biomass will be utilized to deliver second-age bioethanol by considering Turkey's farming assets and their incentive as lignocellulosic food. An auxiliary of Konya Sugar Factory, named Çumra Sugar Factory, produces 84 million liters of bioethanol every year and uses for the most part sugar beet. This plant produces 56% of the introduced bioethanol creation limit and conveys it to petroleum merchants (Akalın, and Seyrekbasan, 2016).

Toward the start of the 1990s, natural gas and petrol were extending in the utilization of intensity creation and private business division warming. Subsequently, the Turkish Government considers reducing the nation's reliance on petroleum-based street transport energizes by mixing biofuels with petroleum and diesel. CO_2 emanations were along these lines likewise expected to diminish.

As far as value, gas utilized in Turkey is the most costly petroleum utilized in OECD nations as imported energizes are exposed to high charges in Turkey (Bahar, and Sauvage, 2012). At present, bioethanol has once in a while been utilized in Turkey by Petrol Office (PO) as being the main organization that pre-owned ethanol until

2011. It was lawfully allowed to indicate 5% of ethanol as it was the measure of ethanol added to the gas while just 2% of ethanol could be added because of the significant level of expenses. Fuel costs are additionally high in Turkey, almost the most costly on the planet. Because of this explanation, the utilization of bioethanol as opposed to fuel ought to be thought of (Bayrakçı, and Koçar, 2014).

The Republic of Turkey Energy Market Regulatory and Authority (EPDK) has taken a path of action on using the agricultural product as a raw cloth for biofuel manufacturing to assist neighborhood biofuel production and decrease the modern shortage. According to the decision taken in 2013, it's miles increasingly obliged to incorporate biofuels from regional agricultural merchandise over the years. As of one January 2013, the nearby fuel content price is predicted to be 2% while the local gas content rate is anticipated to be at least 3% as of 1 January 2014 (EPDK, 2014).

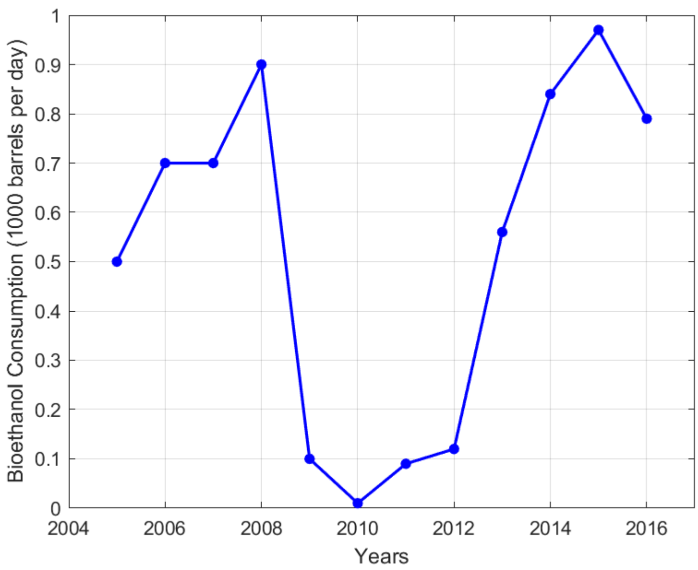

Figure17. Bioethanol consumption in the transport sector in Turkey (Source: IEA, 2018).

As shown in Figure 17, Turkey's fuel ethanol consumption was at the level of 0.79 thousand barrels per day in 2016. It was 0.97 thousand barrels per day in the previous year so that the change amount is 18.57%. On the other hand, these consumption levels are relatively very low, especially when compared with other countries.

In this section, the status of the oil consumed in the transportation sector in Turkey is evaluated. Turkey's current situation in terms of dependence and CO_2 emissions on the energy security effect are discussed. Dependency and CO_2 emissions are supported by statistical analysis. The use of bioethanol in the transport sector has been proposed to reduce dependency and CO_2 emissions since it currently threatens energy security. In this context, Turkey's bioethanol policies were also analyzed.

The main objective in this section is to apply the LR analysis for the total energy consumption, oil product consumption, biofuels consumption, and bioethanol consumption, and CO_2 emission parameters in the time domain to see if they represent any significant trend or not. By using the period of 1997-2017, the LR analysis is performed concerning each parameter where the variable of year is considered as the estimator and the parameter itself is the estimated. The LR results for the corresponding parameters are provided in Table 7.

Table 7. The LR analysis results concerning parameter types.

Parameters	**Predictor**	**Coefficient (β)**	**Std. Error (SE)**	**tStat**	***p-Value***
Total energy consumption	*Intercept*	-1.0586E+07	1.2292E+06	-8.6122	5.5113E-08
	X_1	5330.5	612.46	8.7035	5.5113E-08
Oil product consumption	*Intercept*	-1.0136E+07	1.2052E+06	-8.4103	7.9106E-08
	X_1	5105.4	600.51	8.5017	6.7121E-08
Biofuels consumption	*Intercept*	-261.94	98.743	-2.6528	0.024197
	X_1	0.13084	0.049114	2.664	0.023735
Bioethanol consumption	*Intercept*	-34.906	61.219	-0.57019	0.58113
	X_1	0.017622	0.03045	0.57874	0.57557
CO_2 emission	*Intercept*	-4418.3	523.69	-8.4369	7.5413E-08
	X_1	2.2247	0.26093	-8.4369	6.4277E-08

Results in Tables 7 indicate that the estimated *p-values* for the β_0 and β1 parameters are smaller than the critical *p-value* of 0.05 for the total energy consumption, oil product consumption, biofuels consumption, and CO_2emission parameters. For this reason, there is a statistically significant temporal trend for these parameters. On the other hand, the *p-value* for the bioethanol consumption parameter is obtained as 0.57557. This result indicates that there is not a statistically significant temporal trend for this parameter. It implies that bioethanol use is not increasing in time but there is a significant increase for the rest of the parameters.

In this section of the study, the CO_2 emission is compared concerning the parameters of total energy consumption, oil product consumption, biofuels consumption, bioethanol consumption.

The Pearson correlation coefficients between CO_2 emission and the other parameters of the total energy consumption, oil product consumption, biofuels consumption, and bioethanol consumption, are provided in Table 8 as well as the corresponding *p-values* of each estimation.

Table 8. The correlation coefficient and corresponding *p-values* with respect to the CO_2 emission parameter.

	Total energy consumption	**Oil product consumption**	**Biofuels consumption**	**Bioethanol consumption**
Correlation Coefficient	0.9997	0.9998	0.7778	0.5225
p-value	0.0000	0.0000	0.0029	0.0814

Very high correlations (0.9997 and 0.9998) are obtained between the CO_2 emission and the total energy consumption and oil product consumption parameters while 0.5225 and 0.7778 were obtained for biofuels consumption and bioethanol consumption parameters. On the other hand, less than 0.05 *p-values* are obtained for the total energy consumption, oil product consumption, and biofuels consumption parameters while it was greater than 0.05 for the bioethanol consumption parameter. So, the results in Table 8 indicate that CO_2 emission is dependent on the total energy consumption, oil product consumption, and biofuels consumption parameters but not bioethanol consumption.

The results indicate that current bioethanol use does not affect CO_2 emission rates. It is better to keep in mind that bioethanol use in Turkey is very low (Figure 4). If it is used at higher rates, then we would expect a negative effect on the CO_2 emission rates as it is the case in Sweden.

In this section, the transportation parameters of total energy consumption, oil product consumption, biofuels consumption, bioethanol consumption, and CO_2 emission are analyzed to provide predictions for the upcoming years. For each parameter, the dataset period of 1997-2017 is considered for the forecast analysis. Second-order polynomial fit is applied to determine the model parameters for the 1997-2017 period since it corresponds to the least error amount and represents the parameter variations better. Then the polynomial models are used to determine the forecast of the parameters from 2020 to 2030 in two years intervals. The forecasted parameter values are provided in Table 9.

Table 9. The forecast amounts for the transportation parameters (in thousands of barrels per day).

Parameter	2020	2022	2024	2026	2028	2030
Total energy consumption	238098.5	272719.8	310764.1	352231.2	397121.2	445434.1
Oil product consumption	231728.1	265311.2	302233.2	342494.1	386093.8	433032.5
Biofuels consumption	4.35	5.68	7.22	8.96	10.90	13.05
Bioethanol Consumption	2.25	3.12	4.14	5.33	6.68	8.18
CO_2 Emission	99.48	114.06	130.09	147.56	166.49	186.86

According to the forecasting data in Table 9, total energy consumption, petroleum products consumption, and consequently emissions will double from 2020 to 2030. Biofuel and bioethanol consumption are expected to be creased by 300-400%. However, such a predicted increasing amount is very below the international standards. The main reason for this is that the current biofuel and bioethanol use are relatively very low when compared to other countries (Figure 4).

The oil production and demand dataset used in this study for Turkey are provided in Table 10. According to oil production and demand data in Table 10, oil production increased by time. However, a significant increase is observed in oil imports as consumption increased more than the production amount.

Table 10. The oil production and demand for Turkey between2010-2018 in thousands of barrels per day (BP, 2020).

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Production	48337	45652	44757	46244	47671	48510	49500	49173	54932
Demand	693644	672767	703599	756966	774617	911962	977922	1013281	1002885
Net Import	645307	627115	658842	710722	726946	863452	928422	964108	947953

Using the oil production and demand data in Table 10, second-order polynomial fits are performed for the oil product and demand parameters' dataset to determine the convenient model for each parameter. The obtained models are used to project values for oil production and demand parameters between 2020-2030. The projected amounts are provided in Table 11.

Table 11. The forecast amounts for the dependency analysis in thousands of barrels per day (BP, 2020).

Parameter	2020	2022	2024	2026	2028	2030
Oil production	60702.2	69507.6	80365.0	93274.5	108236.1	125249. 7
Oil demand	1193535.9	1352542.8	1528769.2	1722215.3	1932881.0	2160766.3
Net import	1132833.7	1283035.2	1448404.3	1628940.8	1824645.0	2035516.6
Import dependency (%)	94.91	94.86	94.74	94.58	94.40	94.20

The forecasted results in Table 11 show that Turkey's oil import dependency will not vary much for the next decade. It will stay almost constant around the 94% dependency amount where it will remain the same in 2030. This tends to increase the current energy security problem as well. Even the foreign dependency in energy is expected to remain stable, it will be much larger in quantity considering the population growth.

4.5.1 Evaluation of CO_2 emission rates in Turkey

The analysis in this section focused on the CO_2 emission variations in Turkey. The number of vehicles according to the fuel types are considered for this purpose.

CO_2 emission amount depends mainly on the number of vehicles and the fuel type used. For this reason, the vehicle numbers concerning fuel types are the main parameters. The number of vehicles as well as the estimated CO_2 emissions are forecasted for the 2020-2030 period. Finally, the impact of varying amounts of bioethanol blend with gasoline on total CO_2 emissions released is evaluated.

The total number of vehicles used in the transportation sector between 2004-2019 is presented in Table 12.

Table 12. The number of vehicles and amounts (%) concerning fuel types between 2004-2019 (Source: TÜİK,2020).

		Gasoline		**Diesel**		**LPG**	
Year	**Total**	**Number**	**(%)**	**Number**	**(%)**	**Number**	**(%)**
2004	5 400 440	4 062 486	75.2	252 629	4.7	793 081	14.7
2005	5 772 745	3 883 101	67.3	394 617	6.8	1 259 327	21.8
2006	6 140 992	3 838 598	62.5	583 794	9.5	1 522 790	24.8
2007	6 472 156	3 714 973	57.4	763 946	11.8	1 826 126	28.2
2008	6 796 629	3 531 763	52.0	947 727	13.9	2 214 661	32.6
2009	7 093 964	3 373 875	47.6	1 111 822	15.7	2 525 449	35.6
2010	7 544 871	3 191 964	42.3	1 381 631	18.3	2 900 034	38.4
2011	8 113 111	3 036 129	37.4	1 756 034	21.6	3 259 288	40.2
2012	8 648 875	2 929 216	33.9	2 101 206	24.3	3 569 143	41.3
2013	9 283 923	2 888 610	31.1	2 497 209	26.9	3 852 336	41.5
2014	9 857 915	2 855 078	29.0	2 882 885	29.2	4 076 730	41.4
2015	10 589 337	2 927 720	27.6	3 345 951	31.6	4 272 044	40.3
2016	11 317 998	3 031 744	26.8	3 803 772	33.6	4 439 631	39.2
2017	12 035 978	3 120 407	25.9	4 256 305	35.4	4 616 842	38.4
2018	12 398 190	3 089 626	24.9	4 568 665	36.8	4 695 717	37.9
2019	12 503 049	3 020 017	24.2	4 769 714	38.1	4 661 707	37.3

The LR analysis is performed to determine the tendency of the vehicle numbers in the time domain concerning the fuel types of gasoline, diesel, and LPG. The parameters of the total number of vehicles, the number of vehicles that use gasoline, diesel, and LPG are analyzed separately. Considering the 2004-2019 period, the LR analysis results for each parameter are provided in Tables 13

Table 13. The LR analysis results for the corresponding parameter type

Parameters	Predictor	Coefficient (β)	Std. Error (SE)	tStat	*p-Value*
Total vehicle number	*Intercept*	-1.018E+09	3.6003E+07	-28.288	9.3782E-14
	X_1	5.107E+05	17898	28.531	8.3355E-14
The vehicle number for gasoline type	*Intercept*	1.45E+08	2.449E+07	5.9124	3.7857E-05
	X_1	-70354	12175	-5.7785	4.7798E-05
The vehicle number for diesel type	*Intercept*	-6.459E+08	2.817E+07	-22.93	1.6729E-12
	X_1	3.222E+05	14004	23.009	1.5964E-12
The vehicle number for LPG type	*Intercept*	-5.458E+08	2.6412E+07	-20.665	6.898E-12
	X_1	2.729E+05	13131	20.785	6.3782E-12

The results in Tables 13 show that the parameters of the total vehicle number, vehicle number for diesel type, and vehicle number for LPG type have a positive trend since the estimated *p-values* for these parameters are less than 0.05. On the other hand, the estimated *p-value* for the vehicle number for the gasoline type parameter is less than 0.05. However, unlike the other parameters, the trend for this parameter is negative. So, it implies that there is a significant negative trend for the vehicle number for gasoline type while it is positive for the others.

In this thesis, the transport sector, which constitutes an important part of the energy needs, was discussed to reduce Turkey's CO_2 emissions in line with the Paris Treaty. In this context, the number of vehicles in the Turkish transport sector and the subclasses of these numbers (Gasoline, Diesel, LPG) were used for the years 2004-2019. These results of the forecasting analysis and future expectations for vehicle growth. The forecast analysis showed that the total number of vehicles and subclass numbers (LPG, diesel, etc.) will double by 2030 (Table 14). Estimates also showed that such an increase in the number of vehicles would also increase CO_2 emissions. These analyzes are based on the 3% gasoline and bioethanol blend requirement as stated in the Official Gazette (YVCDB, 2020).

As the first step of the analysis, the number of vehicles for the 2020-2030 period is forecasted. For this reason, the second-order polynomial fit is preferred as the model since it corresponds to the least error amount. Then the model fit for the total, gasoline, diesel, and LPG types are used to determine the forecast amounts for each parameter respectively.

Forecasted data for the period 2020-2030 are provided in Table 14for the total number of vehicles, the number of gasoline type vehicles, the number of diesel type vehicles, and the number of LPG type vehicles parameters. The data in the table shows that the number of vehicles is expected to increase in the next decade while vice versa is the case for the LPG type vehicles.

Table 14. The forecasted number of vehicles for 2020-2030

	Total	**Gasoline**	**Diesel**	**LPG**
2020	13 727 262.8	3 199 256.0	5 539 458.8	4 902 414.8
2021	14 463 281.2	3 311 128.2	6 068 844.1	4 973 207.6
2022	15 224 339.4	3 443 247.7	6 621 247.7	5 021 542.2
2023	16 010 437.4	3 595 614.6	7 196 669.7	5 047 418.6
2024	16 821 575.2	3 768 228.8	7 795 110.1	5 050 836.8
2025	17 657 752.8	3 961 090.4	8 416 568.8	5 031 796.7
2026	18 518 970.2	4 174 199.3	9 061 045.8	4 990 298.4
2027	19 405 227.4	4 407 555.6	9 728 541.2	4 926 341.9
2028	20 316 524.4	4 661 159.1	1 041 905.9	4 839 927.2
2029	21 252 861.1	4 935 010.1	1 113 258.0	4 731 054.3
2030	22 214 237.7	5 229 108.3	1 186 913.4	4 599 723.1

In order to estimate the total CO_2 emission amounts, the number of vehicles concerning fuel types and the corresponding emission rates provided in Table 15 is used. The estimations in this part of the study are performed for the total number of 100 vehicles for simplicity. Considering the 2004-2019 period in Table 12, the yearly vehicle percentages are used to determine the portion of each vehicle type within the 100 vehicles. Then by considering the emission amount in Table 15, the yearly total CO_2 emission amount is estimated by using the following equation:

$$1)\ \mathrm{CO2} = \mathrm{Percent(Fuel\ Type)} * \mathrm{Emission\ Amount\ (Fuel\ Type)\ (Equation.1)}$$

Table 15. Average emission amounts with respect to average consumption amount and fuel type (Source: Gazbir, 2018).

	Average consumption	Emission Amount (tons)
Gasoline	7.5 lt / 100 km	60 664
Diesel	7.5 lt / 100 km	79 86
LPG	7.5 lt / 100 km	48 803

As the first step, a second-order polynomial fit is performed to determine the model for the CO_2 emission considering the observations for the 2004-2019 period. Secondly, the same model is used to forecast the CO_2 emission for the 2020-2030 period.

The forecasted total CO_2 emission amounts covering the 2020-2030 period are provided in Table 16. The CO_2 emission amounts indicate the linear increase amount.

Table 16. Forecasted CO_2 emission amounts using the polynomial fit for the 2020-2030 period.

Year	CO_2 Emission
2020	6 399.3
2021	6 448.4
2022	6 497.8
2023	6 547.6
2024	6 597.6
2025	6 648.0
2026	6 698.7
2027	6 749.8
2028	6 801.2
2029	6 852.8
2030	6 904.9

The current bioethanol rate used in transportation is %3 (EVCDB, 2020). The main objective of this section is to forecast the CO_2 emission amounts considering the various bioethanol rates as well as considering the vehicle numbers concerning the fuel types. For this purpose, the bioethanol rates of 3, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100% are considered in this part of the study. For each rate amount, the CO_2 emission rate is estimated by performing Equation 1 for the 2020-2030 period.

The average CO_2 emission reduction rate of 35% is used in this study considering one over one ratio of fuel and bioethanol as defined in Bioethanol for Suitable Transport Report was supported by European Commission (SEKAB, 2020). The corresponding CO_2 emission reduction rate is estimated by performing Equation 1 for each of the bioethanol rates. The forecasted vehicle numbers concerning fuel types in Table 14 are used for estimating the total CO_2 emission.

The total CO_2 emission forecasts obtained for the 2020-2030 period is provided in Figure 18 concerning the varying bioethanol rates.

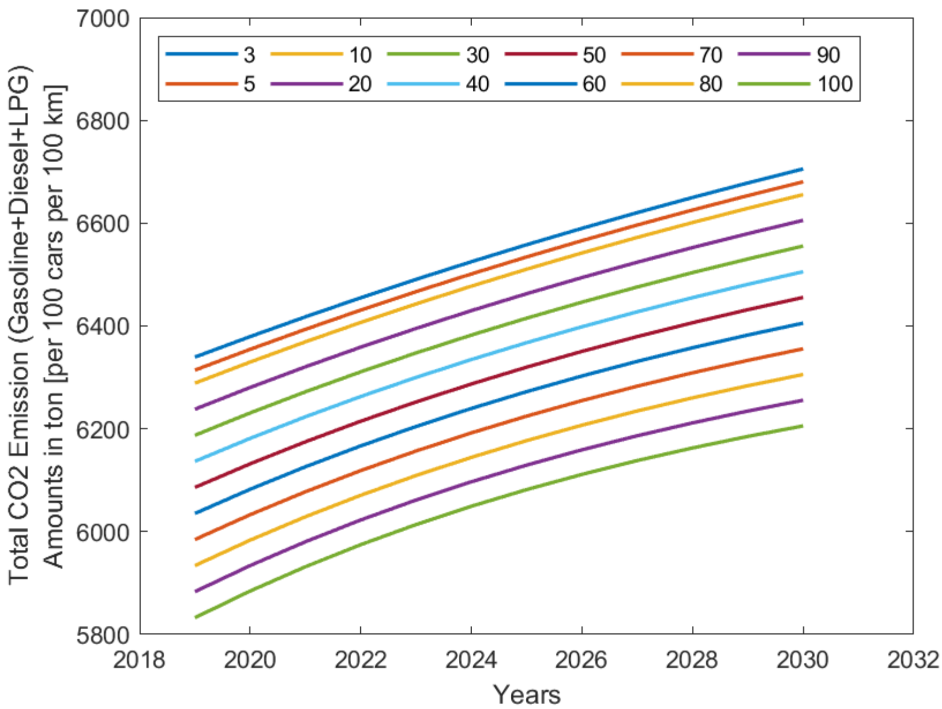

Figure18. Estimated total CO_2 emission for varying bioethanol rates.

The represented CO_2 emission amounts in Figure 18 corresponds to the total amount for 100 vehicles and per 100 km for the 1999-2030 period. The predicted vehicle numbers for the same period is used for the total CO_2 emission amounts. The figure represents that the CO_2 emission amounts gradually decrease as the bioethanol mixing rate increases since the higher mixing amount of bioethanol in fuels reduces the total CO_2 emission amount.

Table 17 represents the CO_2 emission amounts obtained from Figure 18. The predicted CO_2 emission amounts are provided concerning varying bioethanol mixing rates at each row.

To ensure Turkey's energy security and to reduce CO_2 emission rates, it is clearly shown that effective bioethanol use in fuels is the key factor. Currently, the bioethanol mixture ratio is 3% but increasing this amount will significantly reduce the total CO_2 emission amounts despite increasing energy consumption.

Table 17. The CO_2 emission forecast concerning bioethanol rates.

Bioethanol rates (%)	**2020**	**2022**	**2024**	**2026**	**2028**	**2030**
3	6 379.37	6 454.93	6 525.01	6 589.89	6 649.92	6 705.47
5	6 354.63	6 430.92	6 501.23	6 565.96	6 625.57	6 680.48
10	6 329.89	6 406.91	6 477.45	6 542.03	6 601.21	6 655.49
20	6 280.41	6 358.89	6 429.88	6 494.18	6 552.50	6 605.51
30	6 230.92	6 310.87	6 382.32	6 446.32	6 503.78	6 555.53
40	6 181.44	6 262.85	6 334.76	6 398.46	6 455.07	6 505.55
50	6 131.95	6 214.83	6 287.19	6 350.60	6 406.36	6 455.57
60	6 082.47	6 166.80	6 239.63	6 302.74	6 357.65	6 405.59
70	6 032.99	6 118.78	6 192.07	6 254.89	6 308.93	6 355.61
80	5 983.50	6 070.76	6 144.50	6 207.03	6 260.22	6 305.63
90	5 934.02	6 022.74	6 096.94	6 159.17	6 211.51	6 255.65
100	5 884.53	5 974.72	6 049.38	6 111.31	6 162.79	6 205.67

CHAPTER 5: DISCUSSION, POLICY RECOMMENDATIONS, AND CONCLUSION

The transport industry is facing serious difficulties caused by oil and climate crises all over the world. Countries should immediately focus on reducing unnecessary transport and developing more efficient transport systems where energy is used more efficiently while the market share of alternative fuels is increasing. As a new fuel type, biofuels are the most appropriate alternative that can be used in the transport sector since it has been shown that biofuels significantly reduce CO_2 emissions from transport and oil dependence (Mirzajanzadeh et al, 2015). It should be noted that CO_2 emissions and energy consumption have decreased significantly as a result of the Covid-19 pandemic. Covid-19 has caused the biggest drop in energy demand in the last 70 years. The significant decrease in demand for fossil fuels has increased the contribution of renewable energy sources. After a drop in energy consumption, there was a very serious reduction in CO_2 emissions worldwide so that the world could breathe (The Broom, 2020). Each country declares its national energy strategy on a periodic basis to regulate oil and climate dimensions that threaten its energy security. The issues relating to the transport sector have become more important every year in the energy reports prepared in line with the countries' visions and missions.

The study examines Turkey's dependency on imported foreign oil and the issue of CO_2 emissions as well as solutions for the transport sector. In this framework, the positive impact of alternative sources of bioethanol rather than oil products consumed in the transport sector on Turkey's energy security is investigated. The study in this thesis focuses on the idea of making bioethanol use common to increase Turkey's energy security while at the same time reducing foreign oil dependency and CO_2 emissions. The results of the research have shown that biofuel use in the world and its benefits represent biofuel use in Turkey. In line with this research, it is expected that CO_2 emissions will be reduced thanks to bioethanol utilization.

Studies, which tend to increase energy consumption in Turkey, have been detected by using both the linear regression and the forecasting analysis. On the other hand, the analysis showed that a large portion of its energy needs come from oil and oil products in Turkey. The evidence of this inference was given in Table 9. Turkey requires a large portion of the oil being imported since its national oil resources are not enough to produce oil. For this reason, Turkey relies mostly on unsafe sources of oil imports from Russia and Iran. This situation has a negative impact on Turkey's energy security. Besides, the forecast analysis showed that the need for oil imports will continue in the next decade (Table 10). On the other hand, Turkey's CO_2 emissions are expected to continue to rise sharply in the future. According to the INDC report, Turkey promised to reduce emissions by up to 21% by 2030 compared to the usual business-as-usual (BAU) scenario (INDC, 2020). According to the INDC report, Turkey's emissions in the BAU scenario will almost triple in the coming years, while 430 million tons CO_2 will rise from 2012 to 1 175 million tons CO_2 by 2030. The Treaty of Paris targets to reduce emissions to 929 million tons CO_2 by 2030 (Jocelyn, 2018). Thus, Turkey's forecast data represents a difference of 246 million tons more CO_2. According to the protocol, the CO_2 emissions are expected to be 929 million tons, but are expected to be 1 175 million tons. The Kyoto Protocol hosts have been affirmed through 192 countries, containing 191 States and one territorial monetary. In 2001, the US left it while China has been excluded from the Treaty as a creating nation (KPFF, 2020). Turkey joined the Kyoto Protocol in 2009, 4 years after its entrance into power. The Protocol obliges created nations especially to decrease their emissions. However, Turkey does now not make any move to fulfill its commitment to lessening discharges. As per the United Nations Framework Convention on Climate Change (UNFCC), Turkey has now not executed any activities sooner than 2020. Turkey has consented to the arrangement anyway has now not yet approved the Treaty of Paris to fulfill its commitments beneath the United Nations Framework Convention on Climate Change (RTMEU, 2018).

In the thesis, the total energy consumption, oil product consumption, biofuels consumption, bioethanol consumption, and CO_2 emission parameters as well as their cross-correlations are considered to determine possible relationships among them. Furthermore, countries of energy overview and bioethanol utilization also are examined. The results are provided for Brazil, Sweden, China, and Turkey to be able to make comparisons among them. After, possible scenarios for bioethanol use that are widespread or not widespread are identified and in this regard, countries that can be considered a role model are evaluated.

The results clearly showed that the parameter amounts and variations are subject to change due to various parameters like population, economical activities, and so on. For this reason, making a comparison between countries is quite challenging. However, there are clear indications that total energy and oil product consumption parameters are in increasing trend especially in last years for Brazil, China, and Turkey. On the other hand, it is vice versa for Sweden with decreasing total energy and oil product consumption.

Without an exemption, the biofuels and bioethanol consumption parameters have positive trend for all counties. However, there is a remarkable difference between Turkey and the others since biofuel use is relatively less in Turkey.

Because of the positive trend in total energy and oil product consumption, the CO_2 emission tends to increase lately for Brazil, China, and Turkey. On the other hand, CO_2 emission is about to decrease in Sweden. The negative trend in total energy and oil product consumption as well as the positive trend in biofuels and bioethanol consumption reflects on CO_2 emission reduction in Sweden. So, among the other countries, Sweden represents a very good example of how biofuels and bioethanol use can contribute positively to the CO_2 emission variations.

Such energy cases in China, Brazil, and Sweden are considered to maintain the desired levels of CO_2 emissions to consider reducing Turkey's energy dependence by effectively using bioethanol in the transport sector. The analyzes examined the country's energy policies, the amount of energy consumption, and the use of bioethanol and its impact on the problems identified. China, Brazil, and Sweden were selected to compare their energy consumption, CO_2 emissions, and bioethanol practices with Turkey and each other. While Sweden was chosen because it was thought to be a role model country to the world, China was chosen because it is one of the worst comparable countries in terms of bioethanol utilization. Moreover, Brazil was chosen because the country is the second-largest producer of bioethanol in the world. In this context, the thesis was examined with the best and worst examples of countries in terms of bioethanol utilization.

According to the analysis of total energy consumption, the lowest energy consumption in China is achieved. Although the rate is small, the amount of energy consumption and associated CO_2 emissions are relatively high for the population of China. The reason for such results is based on analyzes carried out as per capita energy consumption. Considering the statistical correlation analysis for China (Table 1), it is shown that a large amount of energy consumption from oil and oil products is met. Although the use of biofuels and bioethanol increases annually, it remains relatively low compared to the overall energy consumption. According to the graph shown in Figure 3, China has the lowest biofuel use among the countries assessed after Turkey. In other words, it also has the worst report card. Therefore, China is not a role model for Turkey to increase energy security and reduce CO_2 emissions with biofuel and bioethanol applications.

Brazil is the second country to Sweden in total energy consumption. According to Pearson's correlation analysis, oil and petroleum products have the largest share of energy consumption. However, Figure 3 and Figure 4 show that the rate of use of biofuels and bioethanol is almost higher than that of Sweden. Considering Brazil's large oil resources, it can be concluded that biofuel and bioethanol use policies are successful in Brazil. Of course, Brazil has a long way to go in this respect, and the overall energy consumption is expected to have a much higher percentage of bioethanol use. Brazil's energy consumption and CO_2 emissions have increased linearly, as illustrated in Figures 9 and 10. This is a clear indication that applications for biofuel and bioethanol should be applied immediately and efficiently to the energy industry, in particular to the transport sector.

Finally, Sweden's analyzes show that its overall energy consumption, oil consumption, and CO_2 emissions are by far the largest. In other words, emissions are very low compared to other countries. However, as shown in Figure 13, the rate of CO_2 emissions shows a slight increase, unlike in other countries. Besides, the temporal variation analysis in Figure 2 shows that Sweden's consumption of oil products has decreased significantly, especially in the last 5 years. The reason for this is that biofuel and bioethanol use have been successfully applied in Sweden. The results of the biofuel temporal variation analysis presented in Figure 3 support this inference. Also, Pearson's correlation analysis showed that even if overall energy consumption increased in Sweden, CO_2 emissions are significantly reduced because of the increased biofuel and bioethanol use. As a result, considering the use of bioethanol in the transport sector, the Swedish role model should be chosen to increase energy security and reduce CO_2 emissions.

In Turkey's forecast analysis, energy consumption, CO_2 emissions, and the number of vehicles with a significant share of energy consumption is set to increase dramatically over the next decade. This increase will further undermine Turkey's energy security, which is almost entirely dependent on external energy. To avoid this threat of energy security, the use of bioethanol in the transport sector has been proposed in this thesis. The case of bioethanol produced from different raw materials in 11 different countries is discussed based on SEKAB (2020) "Bioethanol for Sustainable Transport Report". The contribution of bioethanol produced from different raw materials to CO_2 emissions varies over the period from production to consumption. According to the study, it has been shown that a vehicle with 100% gasoline saves an average of 35% of CO_2 emissions when it is operated with 100% bioethanol (SEKAB, 2020). In this context, this information is used for the estimation of CO_2 emissions for the mixture of bioethanol and gasoline in different percentages. As shown in Figure 18, if the use of bioethanol in fuels is applied effectively, the emission rate of CO_2 will decrease significantly. Besides, import dependence on energy will not be at 94% in the next decade as shown in Table 11.

Considering the applications for bioethanol in China, Brazil, and Sweden, we can say that Sweden is one of the most successful countries. Although China's 10% bioethanol target may seem reasonable, China remained in the applicability class. The reason is that they can produce the first generation of bioethanol production. Because the targeted projects are about to be canceled if the corn used in the production of bioethanol decreases in stocks. In other words, bioethanol production would be suspended in a country where food safety is a threat to the country. As a result, China has not achieved the desired objectives.

Brazil is relatively better than China. While Brazil has become an exporter of oil imports over time, the laws put in place have increased the consumption of bioethanol in the country. Because the idea of developing ethanol as a national source of energy has prevailed in the face of petroleum products imported to a large extent in the country. In Brazil, bioethanol is produced from 1st generation sugar cane. The goal of the country is to increase sugar cane fields and increase production. Besides, Brazil's flexible-fuel vehicle fleet is one of the largest fleet vehicles in the world. For 2003, the total number of Flexible Fuel Vehicles in the country is 30.5 million. Another point is that the gasoline being sold in Brazil already has a contribution of 25% to ethanol. The ratio of ethanol to gasoline, as determined by the government, guarantees and protects the ethanol sector in a sense. The consumer prefers ethanol, the price of which is generally much lower (30-40% cheaper than petrol). As a result, the ethanol industry in Brazil is implementing state planning and support in such a way that the manufacturer chooses the advantages of ethanol while the consumer prefers these tools because they provide flexibility. In short, even Brazil follows successful policies by achieving 25% of the use of bioethanol and is expected to contribute to the reduction of CO_2 emissions, but the outcome is not clear. This may be due to the high number of vehicles and the large population in the country.

The situation in Sweden is slightly different. While first-generation bioethanol is produced in Brazil and China, second-generation bioethanol is produced in Sweden. Softwood residues are the main lignocellulose source available for the production of ethanol in Sweden, as they are mostly spruce. Besides, flex vehicles, which produce less population, are used in Sweden. Besides, the use of bioethanol and biodiesel has become widespread in recent years. The Swedish Government first made the public aware of this issue and then reduced oil consumption in the gradual transport sector. While emphasizing the use of public vehicles more often than not, they encouraged vehicles to use biofuel under the name of the green future. Under the pump act, the sale of biofuels at each station has become mandatory. The use of biofuels for the final consumer has become economically convenient, as well as a good balance of supply and demand. The increase in the number of busses working with bioethanol also contributed significantly to the reduction of CO_2 emissions. As a result, energy consumption increased in the transport sector while CO_2 emissions decreased, as provided in the regression analysis. Although there may be other reasons for this decline, the most important is the high level of use of biofuels in the transport sector.

As a result of the analyzes and examinations carried out, it has been established that Sweden is very successful in this respect in increasing energy security and in reducing CO_2 emissions by increasing the use of bioethanol. Sweden can certainly be a good example for Turkey to follow the same procedures. The majority of vehicles in

Sweden use diesel or petrol as fuel. In recent years, Swedish policymakers have used tax incentives to encourage higher sales of vehicles that can use alternative fuels. They also introduced a legal requirement for the sale of renewable fuels at fuel stations. Such regulations have resulted in a significant increase in the number of vehicles working with bioethanol on the market as they have reached the level of saturation. The government has therefore chosen to reduce incentives (Mansson, 2016).

Local authorities have recommended the use of public vehicles to reduce demand for transport and improve transport efficiency. They gave priority to pedestrians and bicycles, enabling vehicles to be parked. They have increased distance work and reduced the number of people who go to work every day. As a result of changing the standard of living after Covid-19, the most important changes in business life turned out to be working from home. Air pollution is reduced during the period when people work from home (Aktan, 2020). They have increased their commuter travel. As a result, they experienced a serious decline in vehicle use, which is estimated to be close to 30%. They were aimed at transporting freight by rail instead of trucks in the transport sector. The potential of this measure is therefore assumed to be a reduction of up to 27% in the transport of trucks. Lighter vehicles have been made available on the market to improve fuel efficiency. Rather than gasoline and diesel consumption, bioethanol consumption has been increased. They had to place alternative fuel pumps on gas stations. People have emphasized that a green world is our future (Mansson, 2016).

The Ministry of Energy and Natural Resources of Turkey announced its most recent strategic reports in 2019 and aims to cover the years 2019-2023. Turkey Ministry of Energy and Natural Resources has identified 7 targets and 31 sub-targets for the period 2019-2023. The strategic plan also identified the six-month follow-up and evaluation period by creating 113 performance indicators for the achievement of these objectives (ETKB, 2019). Given the objectives set out in the strategic plan, there are 2 objectives for the study carried out in the thesis. The first one is to ensure that oil and gas exploration and production activities continue, particularly in the seas, to ensure sustainable security of energy supply. If the goals are met, Turkey's dependence on foreign oil is expected to decrease. However, this objective is not specifically related to oil consumption in the transport sector in Turkey. Another objective of the study in this thesis was to increase energy efficiency. In this context, energy system planning has been carried out for electric vehicles to be used in the transport sector. As clearly stated above, the report included limited targets and targets for biofuels. As a result, the outputs of this thesis become even more important for Turkey to make policy recommendations and to draw up a road map for the use of biofuels in the transport sector to improve the objectives and to support them indirectly.

According to the European Commission (2010), valid fuels should be replaced in Europe by a 20% emission reduction target. In this regard, BEST (Bioethanol for Suitable Transport) has been financially supported for a four-year project supporting the introduction of bioethanol fuel into the European Union as a vehicle fuel and the introduction of ethanol-and flexible-fuel vehicles as well as the promotion of wider use of this type of vehicle. The project started in January 2006 and continued until the end of 2009 with nine international partners in Europe, including Brazil and China. The most important part of the BEST was FFV (Flexible Fuel Vehicles), which works with E85, a fuel mixture consisting of 85% bioethanol and 15% oil. (EUROPA, 2010) The BEST was launched with more than 77 000 FFV and 170 000 FFV pumps and 2 200 E85 pumps valid in 2008. 45% of the vehicles are working at BEST facilities and 80% of the pumps are located in the BEST countries. Besides, 70% of the FFV is located in Europe in Sweden. The BEST competently evaluated both the flex fuel and the E85 pumps and found almost no problem. Safety Storage Regulations for E85 have been established in Sweden and can be easily adapted to other EU countries. The project also includes two additional studies on the development of bioethanol powered busses, Scania busses working with ED95 (sugarcane ethanol fuel mixture) and Dongfend busses working with E100 (flexible fuel bus). When BEST was first introduced, bioethanol busses existed only in Sweden, and Swedish joints led and guided to other sites that wanted to develop the same technology. There have been some problems with the lack of information in regulations such as how to import and purchase bus fuel. BEST has introduced over 190 bioethanol busses and 12 ED95 pumps at its five facilities and has helped to improve information on bioethanol busses for Europe, Brazil, and China (SEKAB, 2020). In the BEST project, competitive pricing has been sought thru the creation of a low responsibility tariff or a gas tax system that takes into account electricity content and emissions to satisfy FFV drivers. Normal fuel motors can be effectively transformed to FFVs (E85) if they may be carried out by way of legal specialists. The conversion of fuel cars to FFVs has been legalized in Sweden and may be implemented in the other EU Member States.

In summary, this main objective of the project leads to the spread of bioethanol awareness in Europe. The project started in 2006 and ended in 2009. Important outputs within the scope of the BEST project were as follows:

- Promotion of more than 77 000 flexible fuel vehicles and 310 E85 pumps in nine regions.
- Introduction of more than 190 bioethanol buses and 12 ED95 pumps in five plants.
- Testing and demonstrating low mixtures, including ED-diesel, 1 ED-diesel pump, and two standard diesel buses operating on 14 E10 pumps.

In short, BEST has shown that bioethanol is a functional alternative. Gasoline or diesel low blends have shown that bioethanol can be used as an alternative. It also showed that existing gasoline vehicles could be converted to E85 FFVs. It was discussed that new fleets could be created with ED95 busses and trucks working with ED95. As a result, BEST has shown that bioethanol can achieve a significant reduction in GHGs from a life-cycle perspective when produced sustainably. As a result, it has been shown that this project can help the EU implement the '20-2020' strategy. The BEST project can make proposals to local and national governments as well as to the EU. In this context, the Turkish BEST project may also benefit from the national bioethanol use of this project. Legal regulations should be made to mix 10% of bioethanol with gasoline. Bioethanol use should also be introduced in selected pilot regions in Turkey. Particularly in cities with frequent use of public transport and electricity fleets, ED95 bus fleets should be set up. Also, the long-term use of bioethanol at the rate of E85 can be increased by making existing vehicle engines suitable for flexible vehicles with the help of engineers (European Commission, 2020).

In Turkey, even though the ratio of bioethanol to fuel is 3%, the emission rate of CO_2 decreases (Resmi Gazete, 2017:30098). However, the ratio of the mixture must be increased to be more effective in the use of bioethanol. On the other hand, vehicle engines will need to change if the bioethanol mixture ratio of more than 10% is used. For this reason, it will be appropriate to set the mixing ratio target at 10% in the long term. In the long run, the success of the 10% target mix will make a significant contribution to Turkey's energy security. In order to achieve this success, the current 3% blend of bioethanol should be increased to 5% in the medium and 10% medium and long term. It will also have a positive effect on energy imports, which is estimated at 94% of energy import dependence in the forecast analysis.

Flexible fuel vehicles have a very important place on the vehicle market in Sweden. Consumers prefer the use of bioethanol in their vehicles, as the vehicle's engine structures are allowed to mix more than 10% bioethanol and bioethanol is cheaper than petrol. Besides, the consumption of biodiesel in Sweden has increased in recent years. In addition to providing adequate incentives for both consumers and producers, the Swedish Government is also very good at informing people under the name of the green world. This strategy can also be followed in Turkey. There is a need to establish a link between bioethanol producers, vehicle engine manufacturers, and end-users.

The managing of all of the links in the bioethanol chain is another critical consideration. Producers and consumers need to be added together in an optimistic dialogue. All raw materials within the "bioethanol chain" – uncooked materials, manufacturing, tools, distribution, taxes and regulations, and end-users – need to be activated concurrently for a hit market development. BEST also recommends the growth of alternative gasoline supply infrastructure in parallel with other aspects of market development, such as gasoline manufacturing and vehicle sales.

To achieve success in the short and long term, the use of bioethanol should be expanded and encouraged. Consequently, the achievement of the objectives can be achieved gradually by selling bioethanol blended fuels cheaper than non-blended ones, by providing tax reductions to fuel companies that are leaders in the sale of bioethanol blended fuels, and by making the use of bioethanol blended fuels compulsory in public busses and public transport. These can be implemented as incentives in the short term, but long-term consideration should be given to opening up bioethanol production facilities. Such initiatives can also be promoted by granting or landing at very low-interest rates.

Fuel price is a very important issue. Incentives should be linked to the development of the market at a particular location. In this context, some regions may be selected as a pilot area for bioethanol applications in Turkey as a first step. Incentives for vehicle supply and fuel delivery should be promoted for the duration of the pre-marketing section in addition to the removal of legal obstacles and tax deterrents. In the improvement section of the market, monetary incentives and reliable statistics become effective equipment for end-users. A wide range of incentives was delivered in the course of the project, which includes motor tax refunds, local purchase grants, loose parking and get right of entry to restrained areas (Sprei, and Wickelgren, 2011). For instance, a statistical analysis of the impact of diverse incentives turned into accomplished in Stockholm/Sweden. According to the results of the research, the most essential incentive was to ensure that the rate of bioethanol is equal to or lower than that of fuel at the degree of marketplace development. Other incentives ought to be used to compensate so long as bioethanol is a concern to customs obligations and electricity taxes that are better than fossil fuels. Exempting congestion is the second most vital tool in Stockholm that promotes the use of easy automobiles and bioethanol. The Swedish market has additionally been strengthened with the aid of a new 'pumping law' and forced fuel stations to introduce special fuels for opportunity fuels (The Swedish Parliament, 2009/10: RFR7).

Furthermore, the utilization of bioethanol vehicles and energizes can assist with expanding the profile of national and nearby governments and improve the open impression of the open vehicle framework. Governments can evacuate boundaries to the presentation of clean vehicles and energizes, create environmental change activity designs and receive models for clean vehicle methodologies, for example, clean vehicle definitions and feasible vehicle fills. They ought to guarantee the acquisition of clean vehicles and fuel out in the open armadas and help out bigger EU and universal intends to help clean vehicles and powers. Unfriendly motivations to empower the utilization of petroleum derivatives ought to be expelled. Governments can request the advancement of energy proficient vehicles utilizing elective powers. Bioethanol can assist Turkey's with focusing to lessen its discharges by 21% under the Paris Agreement. Notwithstanding, to guarantee the advancement of bioethanol advertise, Turkey should deal with wellbeing orders, reflect enactment, charge on naturally perfect energy substance, and great administration of ozone-depleting substance outflows. A framework for affirmation of feasible biofuels ought to be propelled and actualized. Government and national bodies ought to urge E10 and FFVs to become standard vehicles for petroleum.

In addition to the use of bioethanol, the increase in the use of other renewable energy sources will increase the overall utilization rate of biofuel fuels and will have a positive effect on energy security. In this regard, the use of biofuels from waste, such as synthetic gas, will make an effective contribution to energy security to improve CO_2 emissions. In this context, the use of biofuel from waste, such as synthetic gas, to provide an effective contribution to energy security as well as to improve CO_2 emissions. The emission of harmful gasses released into the air will be prevented and the type of fuel that has a positive contribution to the environment will be produced as a result of the treatment of the blocked gases. Such an approach will provide a bilateral advantage to be considered across the country. In particular, synthetic gas can be collected in provinces with industrial zones. For the use of synthetic gas, which is also very effective in the disposal of carbon monoxide and methane gas, certain pilot regions can be selected and implemented within the country. Cities such as İstanbul, Ankara, Bursa, Kocaeli, and İzmir, where agriculture and industry are intensive, can be selected as pilot cities for the production and use of synthetic gas.

The overall recommended policies can be summarized as follows;

- Considering the utilization of bioethanol in the transportation sector as a serious goal in governmental policies and setting milestones to achieve it
- Making bioethanol blend fuels essential for public use vehicles (majors, governments, etc.)
- Increasing incentives for companies that are starting to sell bioethanol blend fuel
- Increasing or providing incentives for individuals that start using bioethanol blended fuel
- Increasing or encouraging start-ups to develop technologies (engine, pump, etc.) that support the use of bioethanol
- With the implementation of a tax reduction, providing bioethanol blended fuels that are cheaper than oil

Last of all, without a doubt, the study in this thesis has some shortcomings. In addition to the fact that this thesis may form the basis for future studies on this subject, such improvements are possible as a result of further research by increasing the number of countries examined. Besides, the ratio of fuel used in total energy consumption in the transport sector could be examined in detail as well as the ratio of bioethanol to biofuels in the industrial sector to provide recommendations. For instance, while developed countries such as Sweden can easily implement these recommendations, Turkey and other developing countries such as China and Brazil cannot initiate such approaches as fast as the developed ones. However, in the thesis, the utilization of bioethanol has been proven to decrease the CO_2 emissions and oil dependency. In this context, Turkey should start revising its energy policies regarding sustainability. Following, the government should encourage the production of bioethanol due to potential of increasing the current blended rate. In the short term, the blended rate can increase from 3% to 5% and in the long term, this rate could be 10%. Any increases in the blended rate will result in a decrease in imported oil dependency and CO_2 emissions.

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