# ETHANOL LIFE CYCLE COSTING AND LIFE CYCLE ANALYSIS

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**ABSTRACT**

As a result of activities such as rapid urbanization, high population growth, increases in production and consumption depending on technological developments, destruction of forests, excessive consumption of fossil fuels, industrialization and agricultural production; The shares of gases such as carbon dioxide ($CO_2$), methane (CH4), nitrogen oxide ($N_2O$), hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulfur hexafluoride (SF6), which are known as greenhouse gases, in the atmosphere are constantly increasing. Spread of these substances in the environment; It causes not only regional damages such as water and air pollution, but also global warming and its effects on climate changes. The gas that contributes the most to global warming is carbon dioxide, and it constitutes 77% of greenhouse gases in the atmosphere. On the other hand, carbon dioxide gases resulting from the use of fossil fuels correspond to 57% of the total carbon dioxide emissions. Decrease in forests and fires stand out as other important factors causing carbon dioxide emissions. After carbon dioxide, methane, the most abundant greenhouse gas in the air, constitutes 14% of the greenhouse gases in the atmosphere, while the share of nitrogen oxide is around 8%.

**Keywords:** Ethanol; GHG;

## INTRODUCTION

Since motor vehicle exhaust emissions contain many greenhouse gases such as carbon dioxide, methane and nitrous oxide, they play a role in warming the earth. About a quarter of $CO_2$ emissions related to energy activities around the world arise from transportation. The most interesting alternative fuels for gasoline engines; alcohols such as ethanol and methanol. Ethanol has better properties than methanol, such as higher calorific value and lower evaporation temperature. Various researchers also emphasize that adding certain proportions of ethanol to gasoline does not require any changes in engine design.

Although it is a definition that includes fuel alcohol, methyl alcohol and ethyl alcohol, this name is commonly used for ethyl alcohol (ethanol-bioethanol) obtained from biomass sources. The most widely used fuel among biofuels in the world is bioethanol and more than 95% of bioethanol production is obtained by processing agricultural products. production and use of bioethanol in the world to Turkey rates are quite high. In many countries of the world, the use of bioethanol in vehicles has become compulsory and its rate has varied according to its own production size in each country. There is also a requirement to use biofuels in EU countries. The minimum bioethanol addition was increased from 2% to 5.75% in 2010, it is expected to increase to 10% in 2020 and 25% in 2030.

The idea of using bioethanol in motors is mostly seen in countries with large agricultural areas. E80 fuel, which consists of a mixture of 80% bioethanol and 20% gasoline, has been used in automobiles for years in the states engaged in agriculture in the USA. In Brazil, where there is almost no oil reserves but especially sugar cane is abundant, cars have been working with bioethanol since 1988. The performance, combustion and exhaust emission characteristics of a vehicle using unleaded gasoline, ethanol-gasoline (E5, E10) and methanol-benzine (M5, M10) mixtures. In general, reductions in CO, HC, $CO_2$ and NOx emissions have been observed with the use of alcohol-gasoline mixtures. The effect of bioethanol use on the $CO_2$

emission value varies according to the perspective. (Jackstell *et al,* 2004) found that when E10 type fuel is taken into account and when the whole bioethanol production process is taken into account, a decrease of 1% to 5% compared to gasoline, and a decrease of 19% to 70% was detected in mixtures with high bioethanol content such as E85. Anonymous 2004, without considering the whole bioethanol production process; It states that when the exhaust emission values are taken into consideration, the $CO_2$ emission value is almost the same for bioethanol and gasoline. When the whole bioethanol process is mentioned, it includes the amount of $CO_2$ that the products hold from the atmosphere, the amount of fuel used during the growing process, the transportation of the products to the factory, the bioethanol production process at the facility and the distribution of bioethanol to the stations.

The data of another study, which calculates the greenhouse gas emission reduction rates of biofuels compared to fossil fuels, and published by FAO, are given below. When the figure 1 is examined, it is seen that second generation biofuels obtained from cellulosic materials and bioethanol using sugar cane as a raw material reduce greenhouse gas emissions by 70% to 90% compared to fossil fuels. It is understood that the effect of bioethanol produced from corn especially in the USA on the reduction of greenhouse gas emissions compared to fossil fuels is very small and is presented in figure 1.

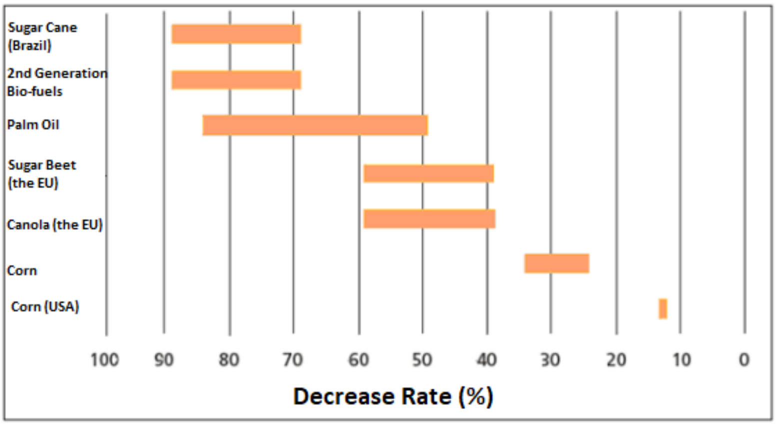
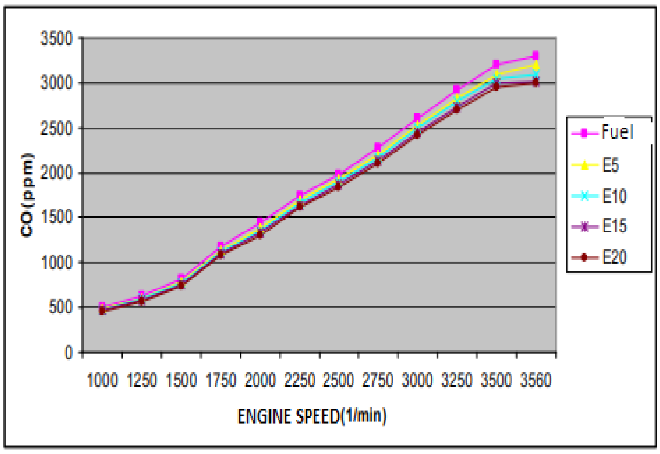



**Figure-1 Source: Anonymous 2008. The State of Food and Agriculture**

Food and Agriculture Organization of the United Nations, Rome. Exhaust emissions values for different raw materials and mixture ratios determined in engine trials are averaged at the same mixing ratios and compared with gasoline in Figures 2, 3 and 4.

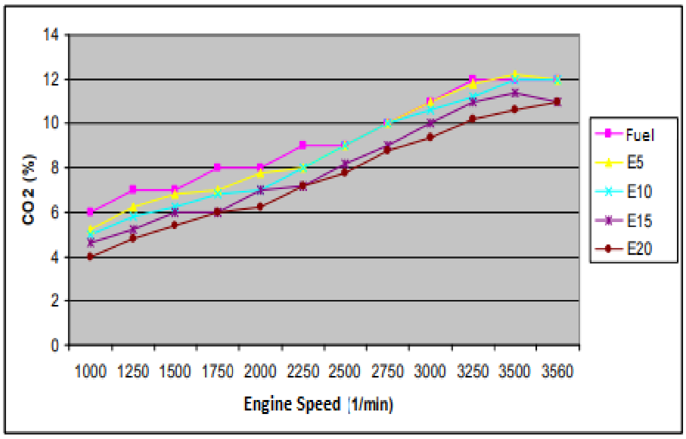
There is an increase in CO emission depending on the engine speed. The highest values of CO emission are the lowest values in gasoline; It was obtained in E20 fuels. As the amount of bioethanol increased in blended fuels, CO emissions decreased. This result supports previous studies (Al Farayedhi, 2002, Al-Hasan, 2003, Guerrieri *et al*., 1995, 2005; Özsezen *et al*., 2008 ,Wu *et al.* 2003). The highest CO emission value was achieved at 3560 1 / min, and the reduction in CO emission compared to gasoline; It is 2.8% in E5 fuel, 5.8% in E10 fuel, 8.6% in E15 fuel and 11% in E20 fuel.

**Figure-2 CO emission variation of bioethanol gasoline blended fuels**



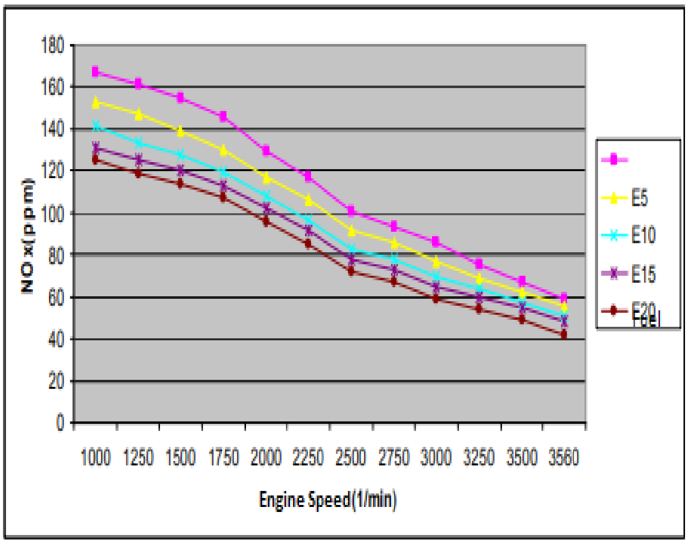

In the measurements made at different speeds of the engine, an increase in $CO_2$ emission is observed with the increase in the number of cycles. The highest $CO_2$ emission was achieved when working with gasoline and the lowest when working with E20 fuels. As the amount of bioethanol in blended fuels increased, $CO_2$ emissions decreased, supporting previous studies (Özsezen *et al,* 2008; Wu *et al,* 2003). The highest CO2 emission values were obtained at 3560 1 / min; In $CO_2$ emissions, E5 and E10 fuels have the same value as gasoline, while E15 and E20 fuels have decreased by 8.3% compared to gasoline.

**Figure-3 CO2 emission change of bioethanol gasoline blend fuels**




NOx emissions were the highest when working with gasoline and the lowest when working with E20 fuels. The fact that ethanol has lower flame temperatures than gasoline improves the combustion process and reduces the NOx in the combustion products. This result supports previous studies (Özsezen and Canakci, 2008). NOx emissions decreased as the amount of bioethanol increased in blending fuels. The lowest NOx emission value was obtained at 3500 1 / min, and the decrease compared to gasoline; It was 5% in E5 fuel, 13.5% in E10 fuel, 18.6% in E15 fuel and 28.8% in E20 fuel.

**Figure-4 NOx emission change of bioethanol gasoline blend fuels**




Performance and exhaust emission values measured in the trials are given in Table 1.

**Table-1 Change in engine performance and exhaust emission values of bioethanol blended fuels compared to gasoline**

| Fuels | Max. power (kw) | | Specific fuel consumption at maximum power | | Maximum power exhaust components | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 3560 l/min | Change according to gasoline (%) | 3560 l/min | Change according to gasoline (%) | CO (ppm) | Change according to gasoline (%) | CO (%) | Change according to gasoline (%) | Nox (ppm) | Change according to gasoline (%) |
| Gasoline | 368 | - | 0410 | - | 3290 | - | 12 | - | 59 | - |
| E5 | 360 | -22 | 0444 | (+) 80 | 3198 | -28 | 12 | - | 56 | -50 |
| E10 | 357 | -30 | 0454 | (+) 105 | 3099 | -58 | 12 | - | 51 | -135 |
| E15 | 354 | -38 | 0470 | (+) 146 | 3008 | -86 | 11 | -83 | 48 | -186 |
| E20 | 352 | -43 | 0482 | (+) 173 | 2928 | -110 | 11 | -83 | 42 | -288 |

Source: Ankara University Journal of Environmental Sciences 4 (2), 65-74 (2012)

As a result of engine tests with gasoline-bioethanol mixtures; With the addition of bioethanol to gasoline, the engine power decreases, and as the bioethanol ratio in the mixture increases, so does the power. The lower calorific value of ethanol compared to gasoline and a water content of 4% cause a decrease in power. As the amount of bioethanol in the mixture increased, fuel consumption and specific fuel consumption values increased compared to gasoline. Also in exhaust emissions; As the bioethanol amount in the mixture ratio increased, an increasing decrease was determined in the CO, $CO_2$ and NOx values. The results show that when bioethanol is used instead of gasoline in spark ignition engines, there is a reduction in CO, $CO_2$ and NOx emissions without a huge power loss in the engine. The reason why CO emission is lower in bioethanol operation compared to gasoline operation is that ethanols evaporate much more than gasoline and burn more cleanly since they have a single boiling point. In addition, the low flame temperatures of ethanols reduce the CO emission in the combustion products. Due to the cooling effect of bioethanol and its low flame temperature, its temperature decreases as a result of combustion, which causes a decrease in NOx emission. The fact that the carbon atom in the structure of ethanol is less than gasoline and its C / H ratio is lower than gasoline also reduces $CO_2$ emissions (Kızıltan 1988, Çolak 2006). By making use of the studies on environmental impact and given in the method section; Greenhouse gas emission reduction rates compared to gasoline in the life cycle of fuels;- 15% -40% reduction in bioethanol derived from corn (Childs *et al,* 2007) and 25% -35% (Anonymous 2008),

- 55% -90% reduction in sugar cane (Childs *et al,* 2007) and 68% 88% (Anonymous 2008),
- 60% -70% reduction in cellulosic (straw-straw) bioethanol (Childs *et al,* 2007)
- 65% -90% reduction in cellulosic (grass-grass) bioethanol (Childs *et al,* 2007)
- It is stated as a 39-59% reduction in bioethanol obtained from sugar beet (Anonymous 2008).

As seen in the studies on this subject; The rate of biofuels in reducing greenhouse gas emissions varies according to the raw material. It is emphasized that biofuels produced from sugar cane and cellulosic raw materials make the highest contribution to the reduction of greenhouse gas emissions, whereas biofuels produced from sugar beet and corn have a lower effect on greenhouse gas emissions.

## CONCLUSION

In a study conducted with gasoline-bioethanol mixtures in a spark ignition engine; Despite the reduction in power and increase in fuel consumption with increasing bioethanol mixing ratio, a significant reduction in exhaust emissions, particularly CO and NOx emissions, has been noted. In $CO_2$ emissions; There was no change in E5 and E10 studies compared to gasoline, and a decrease was found in E15 and E20 trials.

Since the chemical components of bioethanols obtained from different raw materials such as wheat, barley, sugar beet, corn and potato are the same; their calorific values are also the same, so there is no difference in the performance and exhaust emission values determined as a result of the measurements. However, considering the entire life cycle of bioethanols produced from different raw materials, differences arise in terms of their environmental impact. Bioethanol raw materials, which have the lowest greenhouse gas emissions in the life cycle, are cellulosic raw materials such as sugar cane and grass, straw, grass. Sugarcane and corn follow them.

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