What’s the Role Of Corn Ethanol Fuel in China: From the Life Cycle Cost View

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Abstract. China originally planned to use fuel ethanol gasoline nationwide in 2020, and taking corn as an important raw material of ethanol gasoline, this paper analyzed the life cycle cost model of corn fuel ethanol gasoline and traditional gasoline from production to consumption, including internal and external cost calculations. The internal cost is the actual cost of the industry chain, while the external cost is converted into the cost value by examining the environmental impact of pollutant emission levels in each stage of the life cycle of ethanol gasoline production. Based on this model, by selecting the project data of specific regions and manufacturers in China, it can be calculated as follows: The main links affecting the internal cost of ethanol gasoline production are crude oil procurement cost, refinery and ethanol plant construction cost; The main influencing link of external cost is the emission of ethanol gasoline combustion, including the fuel, power and other energy consumption factors in the production of ethanol and gasoline; The cost can be optimized from the perspective of production technology, technological process, energy material consumption and various labor costs. Assuming E10 is used in the whole Chinese market, the empirical results are as follows: among the pollutants produced by the use of ethanol-added gasoline in the whole region, CO₂ emission reduction is the largest, exceeding 53 million tons, followed by CO and wastewater emission reduction of 1.78 million tons and 1.58 million tons respectively. In terms of the conventional gasoline, the CO emission reduction of about 20% is the largest, followed by about 17% reduction of HC, about 15% reduction of SO₂ and about 9% reduction of CO₂ respectively. These results show that the promotion of ethanol gasoline (E10) usage in China has a considerable reduction effect of emissions if the availability of raw materials are sufficient. The life cycle external cost of ethanol gasoline is 11.45%, lower than that of conventional gasoline. In 2019, China's fuel ethanol production capacity was 4.15 million tons, and the actual production was about 3 million tons. Assuming that all of it were used to produce E10 ethanol gasoline, compared with traditional gasoline consumption, the emission reduction benefit of E10 gasoline would be nearly $84.7 million.

1. Introduction

Using bioenergy conversion technology to produce ethanol for gasoline additive can effectively reduce the demand for fossil energy and is also an important way to reduce the external dependency of crude oil. The goal of "achieving basic coverage of corn-based ethanol nationwide by 2020" was set out in the implementation plan on Expanding the Production of Biofuel Ethanol and Promoting the Use of Vehicular Corn-based Ethanol jointly issued by the National Development and Reform Commission.
and 15 other ministries and commissions in 2017. Most of the ethanol-based gasoline used in northern China is 10% corn-based ethanol (E10) mixed with 90% conventional gasoline, which can reduce emissions of carbon dioxide, vehicle exhaust particles, carbon monoxide, hydrocarbons and other harmful substances while increasing the octane number of gasoline. According to limited data, more than 40 countries or regions have promoted the use of biofuel ethanol and corn-based ethanol for vehicles, annually consuming about 600 million tons of corn-based ethanol, accounting for about 60% of the world's total gasoline consumption.

As early as in September 2017, China became the world's largest consumer and importer of oil and gas, the external dependency of crude oil reaching around 70%. The comprehensive promotion of corn-based ethanol depends on the increase of investment in ethanol production. However, in reality, various uncertainties of ethanol production lead to its poor economy and hence unattractive to produce, resulting in a large gap in China's ethanol production capacity. This paper takes fuel ethanol gasoline as the research object, focuses on the life-cycle cost analysis of ethanol-gasoline production with corn as the raw material, and puts forward the cost evaluation model for the life cycle of ethanol gasoline. The internal and external costs are estimated based on the data of actual operating ethanol production enterprises, the key cost points are found out and the relative cost composition is evaluated and compared with the life cycle cost of traditional gasoline.

2. Research review and boundary of ethanol gasoline production life cycle
The corn-based ethanol gasoline in this paper is blended with 10% regular gasoline, namely E10 gasoline. The general life cycle assessment is mainly divided into three steps, including "goal and scope determination," "list analysis" and "environmental impact assessment." Using the concept of life cycle, the paper analyzes the life cycle cost of corn-based ethanol gasoline, and studies its objective and scope determination, cost analysis and environmental impact assessment, and the internal and external costs of ethanol production life cycle and the cost structure, identifying the key cost points so as to propose the improvement measures.

2.1. A research review of life cycle cost of ethanol gasoline
The concept of life-cycle cost was first proposed by the US Department of Defense in the 1960s to save budget, and has been widely applied in various fields since then. Li Xiaohuan et al. used the life cycle evaluation method, established the life cycle inventory model of Fossil energy in China, and calculated the life cycle inventory of primary energy such as raw coal, crude oil and natural gas and several major secondary energy such as gasoline and coke. The inventory analysis showed that the main feature of China's fossil energy inventory was that 97% of the energy consumption comes from the production process. Xin Yue, on the basis of analyzing the problems existing in traditional cost management of wind power projects, established a complete cost accounting model for wind power projects based on the full life cycle theory, and proved the scientific nature of the model through actual case calculation. Soam et al. improved the dilute acid pretreatment by changing the biomass and alkali concentration in the water, and carried out life cycle assessment on the improvement schemes with different alkali concentrations. The results showed that compared with the conventional schemes, all the improved schemes had negative environmental impacts due to the use of alkali. Pazouki et al. through life cycle cost model explained in detail the life cycle capital and operation cost of the traditional SWRO desalination technology, the alternative osmotic dilution desalination technology in the forward osmosis (FO)-reverse osmosis (RO) hybrid system in seawater reverse osmosis (SWRO) desalination technology, and the ultrafiltration (UF)-RO system. The results showed that the total water cost of these two alternative processes was reduced by 4-5% compared to the traditional SWRO. Life cycle cost analysis has been widely used in the field of alternative fuels and new energy vehicles. Wang et al. conducted in-depth studies on emissions from vehicle fuel production and vehicle operation. Since the end of last century, relevant theories and traffic transport simulation (GREET) model have been constantly improved. For example, WTW was combined with vehicle cycle analysis to obtain the two main factors that affected the emission of the whole process, namely the
energy efficiency of fuel production and the technical fuel consumption of vehicle operation; The life cycle research results of hydrogen energy and gasoline production were applied to the environmental benefit analysis of hydrogen fuel electric vehicles and ordinary gasoline vehicles; Life cycle energy consumption and greenhouse gas emissions of fuel ethanol produced from corn, sugarcane, straw, willow and platycodon were simulated by using the GREET model. The results showed that the energy consumption and greenhouse gas emissions of cellulosic fuel ethanol from corn to sugar cane were decreasing. Ding Ning et al. [11] built a mixed life cycle evaluation model based on China's 2007 EIO-LCA model and PLCA and calculated the greenhouse gas emissions of cassava ethanol life cycle. The indirect emissions were decomposed into 43 industry sectors, and the results showed that the total net greenhouse gas emissions of cassava ethanol during its life cycle were 96.2 g/MJ, among which the direct and indirect emissions were 130.2 and 36.9 g/MJ respectively, and the CO₂ absorbed by photosynthesis was 70.9 g/MJ. Based on the full life cycle theory and present value analysis theory, Wang Zhen (2018) [12] established the full life cycle cost evaluation model of hybrid electric vehicles from the perspective of consumers. The research results showed that, with the continuous rise of oil price, in the medium and long term, the vehicle energy consumption cost advantage of hybrid electric passenger vehicles would compensate for its exorbitant manufacturing cost and on-board battery replacement cost, and reached an equilibrium point with the full life cycle cost of similar models of traditional internal combustion engine passenger vehicles. Ma Yihan (2020) [13] incorporated environmental governance costs into life cycle costs and constructed a difference evaluation model for battery electric vehicles (BEV) and internal combustion engine vehicles (ICEV). After empirical calculation, it was concluded that the total life cycle cost of BEV including environmental governance was less than the total life cycle cost of ICEV, and the total emissions of BEV in WTW were lower than the total emissions of ICEV.

2.2 Cost analysis boundary of ethanol gasoline life cycle
Based on the concept of life cycle, this study analyzes the life cycle cost of corn fuel ethanol gasoline, covering its target and scope determination, cost analysis and environmental impact assessment, the internal and external costs of ethanol production life cycle and the cost structure. The life cycle cost analysis is divided into four parts: initial costs; energy and water costs; operation, maintenance, and repair costs; product end-use costs.

Generally, the full life cycle of gasoline includes several items, such as raw material mining, processing, transportation, gasoline production, sale, use, recycling, and final disposal [14]. In this paper, the life cycle of corn ethanol fuel production takes corn planting as the initial stage, including corn transportation, corn processing to produce ethanol, and recycling; Then blending with gasoline, including the storage, transportation, sale, and consumption in automobiles. The details of the entire process are shown in Figure 1.
3. Methods and data

3.1. Model building

The full life cycle cost of corn ethanol gasoline and conventional gasoline is calculated, including internal cost and external cost. The calculation formula is as follows:

$$LCC = IC + EC$$  \hspace{1cm} (1)

IC stands for internal cost, EC for external cost. Internal costs include the following links:

$$IC = \sum_{i=1}^{10} IC_i$$ \hspace{1cm} (2)

IC$_1$ to IC$_{10}$ respectively represent corn production cost, corn transportation cost, and internal cost of ethanol production and construction, internal cost of ethanol storage/transportation, internal cost of ethanol sales, internal cost of refinery construction, internal cost of crude oil procurement, internal cost of crude oil transportation, internal cost of gasoline production, and internal cost of ethanol gasoline blending and sales.

External costs include the following links:

$$EC = \sum_{j=1}^{9} EC_j$$ \hspace{1cm} (3)

EC$_1$ to EC$_{9}$ respectively represent the external cost of corn planting, corn transportation, ethanol production and ethanol recovery and treatment, crude oil production, crude oil transportation, crude oil
distillation and atmospheric pressure reduction, gasoline production, and ethanol gasoline combustion emission, of which the internal and external costs of transporting gasoline from the manufacturer to the ethanol blending manufacturer is ignored.

The full life cycle cost of traditional gasoline includes the internal and external costs of 6 links, including crude oil extraction, refinery construction, crude oil purchase, crude oil transportation, gasoline production and gasoline combustion.

3.2. Data
This empirical research selects a company's fuel ethanol project in eastern China. The company, established in August 1998, is a large-scale backbone enterprise involved in the deep processing of agricultural products in the biochemical field. It boasts of a variety of product categories, of which the annual 320,000-ton corn fuel ethanol project used in this study has a total investment of $211.7 million dollars, jointly funded by ZLCO Biochemical (Anhui) Co., Ltd. and PCCO Anhui Corporation. Corn is used as a raw material to produce fuel ethanol in this project, and the advanced production technology is adopted. The production of this project is currently 256,000 tons per year, and the output of corn oil is currently 19,800 tons per year. In the gasoline stage, the refinery project of a refinery in Shandong province is selected as an example. Established in the early 1990s, the company takes petroleum refining as its core, extends its industrial chain to fine chemicals, and extends its business scope to logistics, transportation and thermal supply, etc. Now it has a total asset of about $1.2701 billion, and an annual comprehensive processing capacity of tens of millions of tons.

The study is aimed at the entire ethanol production process of the target enterprise. Part of the data is obtained by investigating the production process of the target enterprise, and some data is obtained by investigating relevant literature. These data include some data related to ethanol gasoline\cite{1, 19}, some data related to gasoline\cite{16, 18}, and some data related to fuel combustion emissions\cite{17, 19}. According to the assumptions and models, the cost accounting of the entire production life cycle of ethanol gasoline is carried out. Relevant value data are converted into us dollar value according to the average exchange rate of RMB against US dollar (7.086) in the nearly 90 days from XE.com until June 28, 2020.

4. Empirical results

4.1. Full life cycle cost of ethanol gasoline
In the internal cost accounting, the source of corn procurement is northeast China, and the average value of corn production cost there is used. The transportation cost is the railway long-distance freight cost; Ethanol and gasoline production, sales data from the selected enterprises; Blending and sales data of corn ethanol gasoline are from some project. Thus, corn production cost is $186 million, maize transport cost $38.7 million, ethanol production and construction internal cost $8.5 million, ethanol storage/transport $1.8 million, ethanol sales $20.2 million, refinery construction $431.8 million, crude oil procurement procedures $3.0529 billion, crude oil transportation $0.38 million, gasoline production $15 million, and ethanol gasoline blending and sales $1.6 million.

\[ IC = \sum_{i=1}^{10} IC_i = 4.022 \text{ billion dollars} \]  

(4)

In the external cost accounting, the environmental impact caused by pollutant emission levels in each stage of the life cycle of ethanol production is mainly investigated, and the environmental impact is converted into cost value. The ethanol-related external costs are mainly attributable to $1.1 million dollars of emissions from fertilizer use at the corn planting stage, $0.3 million of emissions from the use of fuel for long-distance rail transport, $5.1 million of emissions from ethanol production processes and electricity generation, and $27090 of emissions from waste disposal. The gasoline-related external cost mainly comes from the emission cost of crude oil production of $13.1 million dollars, the emission cost of crude oil transportation of $1.8 million, the emission cost of process emission and electricity generation of gasoline production of $74.5 million, and the emission cost of ethanol gasoline combustion of $71.4 million.
\[ EC = \sum_{j=4}^{9} EC_j = 0.167 \text{ billion dollars} \quad (5) \]

To sum up, 320,000 tons of ethanol result in about 2,983,600 tons of corn ethanol gasoline, and the full life cycle cost is:

\[ LCC = IC + EC = 4.022 + 0.167 = 4.189 \text{ billion dollars} \quad (6) \]

4.2. Cost of gasoline life cycle
In order to more clearly show whether ethanol gasoline has cost and emission advantages, the full life cycle cost of gasoline is calculated. The data is from a refinery in Shandong, and the total life cycle cost of producing 2.6636 million tons of gasoline is calculated as follows:

\[ LCC = IC + EC = 3.538 + 0.169 = 3.707 \text{ billion dollars} \quad (7) \]

5. Life cycle cost analysis and comparison between ethanol and conventional gasoline
Through empirical research, it is concluded that the production life cycle cost of ethanol gasoline from 320,000 tons of ethanol is about $4.189 billion, and the unit life cycle cost is about $1,404.001/ton, among which the internal cost is $1,347.901/ton, accounting for 96%, and the external cost is $56.1/ton, accounting for 4% as in Figure 2.

![Figure 2](image_url)

**Figure 2.** Proportion of internal and external costs of ethanol gasoline produced by 320,000 tons of ethanol.

5.1. Analysis of Life Cycle Internal Cost Structure
As shown in Figure 3, the life cycle cost structure of corn-based ethanol gasoline is the crude oil purchase accounts for 75.91% of the total cost, refinery construction 10.74%, ethanol plant construction and production 5.75%, corn production 4.63%, and corn transportation 0.96%, crude oil transportation 0.95%, ethanol sale 0.50%, gasoline production 0.37%, ethanol storage and transportation 0.15%, and ethanol gasoline blending ratio 0.04%.

Based on the operating process of one year, the crude oil purchase alone is 3.0529 billion dollars, accounting for 76%. In addition, the construction and production of refineries and ethanol plants reach 3.7162 billion dollars, accounting for more than 92 percent of the total internal cost. Obviously, the production and operation cost accounts for a considerable proportion.
Figure 3. Internal cost composition of corn fuel ethanol gasoline production.

In the production and processing stage, the production of ethanol and gasoline is related to various energy costs, labor costs and processing techniques as in Figure 4. The proportion of steam is the largest, accounting for more than half. In addition, the consumption of additives and electricity is more than 10%. To sum up, refinery construction has little room to reduce costs due to standardized project cost and strict budget. In the production, transportation and sales of ethanol and gasoline, the cost can be reduced through the improvement of production technology and technological process, efficient utilization of energy resources and other means.

Figure 4. Analysis on the proportion of energy and labor cost in ethanol production.

5.2. Analysis of life cycle external cost structure
Assuming that all 320,000 tons of ethanol is used to produce ethanol-based gasoline, and that all the ethanol-based gasoline produced is used, the external cost structure is shown in Figure 5. The gasoline production accounts for 44.54%, ethanol gasoline burning 42.64%, the crude oil extraction 7.83%, ethanol production 3.05%, crude oil transportation 1.06%, corn production 0.68%, corn transportation 0.17%, and ethanol recovery 0.02%. Both gasoline production and ethanol gasoline burning contribute most to the total external cost, while the emissions from crude oil processing processes in the gasoline production account for the vast majority. The proportion of fuel oil and gas burning emissions and
indirect emissions from coal-fired power generation is very small. In addition, the external costs of corn production and transportation are minimal.

![Graph showing internal cost composition of corn fuel ethanol gasoline production.](image)

**Figure 5.** Internal cost composition of corn fuel ethanol gasoline production.

According to the different processes of ethanol life cycle, the external cost composition and percentages of the different pollutants emitted are shown in Table 1.

| Pollutants | Corn plantation | Corn transportation | Ethanol production | Ethanol recycle | Crude oil extraction | Crude oil transportation | Gasoline production | Ethanol combustion | Total |
|------------|-----------------|---------------------|-------------------|----------------|---------------------|-------------------------|---------------------|-------------------|-------|
| CO₂        | 21.716          | 3.655               | 12.644            | 0.078          | 4.198               | 23.273                  | 176.525             | 3688.391         | 3930.483 |
| SO₂        | 5.833           | 1.164               | 25.146            | 0.433          | 9.143               | 7.413                   | 553.830             | 108.302          | 711.268 |
| NOₓ        | 9.149           | 21.275              | 16.202            | 0.253          | 49.810              | 135.450                 | 170.685             | 1136.382         | 1539.205 |
| CO         | 0.515           | 1.617               | 4.605             | -              | 1.475               | 10.296                  | 0.926               | 2165.248         | 2184.680 |
| HC         | 0.497           | -                   | -                 | -              | -                   | -                       | -                   | 28.064           | 28.561  |
| TSP        | 0.226           | 0.167               | 4.703             | 0.179          | -                   | 1.057                   | 111.314             | 12.085           | 129.732 |
| Waste water| -               | -                   | -                 | -              | -                   | -                       | -                   | -                | -      |
| Waste residue| -         | -                   | 297.284           | 2.494          | 1245.939            | -                       | 6.882               | -                | 1552.599|

Data source: *Empirical results*

From Table 1, the contribution of CO₂ to external costs is the highest, reaching 39.4 million dollars, followed by CO, 21.9 million dollars. The emission of CO₂ and CO are mainly concentrated in the burning of ethanol gasoline. The third place that contributes to external costs is the emission of waste residues, and over 80% of waste residue is emitted in the crude oil extraction process. The contribution of NOₓ to external costs also exceeds 14.1 million dollars. Except for ethanol gasoline burning, gasoline production and crude oil transportation account for 11.09% and 8.80% respectively. The vast majority
of wastewater and SO\textsubscript{2} emissions originate from gasoline production. TSP and HC contribute less to external costs. In conclusion, the ethanol gasoline consumption accounts for the majority of external cost. In addition, the external cost still includes the gasoline production. Because the consumption of fuel oil, fuel gas and other energy is more, ethanol, gasoline production process optimization and automotive engine technology upgrading can bring more emission reduction benefits, additionally using ethanol gasoline to replace gasoline can reduce pollutant emissions to a certain extent.

5.3. Cost comparison of the full life cycle of gasoline

In this paper, a full life cycle model of ethanol gasoline is constructed, and a similar model system is used to calculate the full life cycle cost of gasoline. It is calculated that the unit cost of gasoline’s full life cycle is $1391.504 per ton, about 0.89% less than that of corn ethanol gasoline, which is obviously related to the more mature refining and production technology of gasoline.

In the full life cycle cost of gasoline, the unit internal cost is $1328.151 per ton, accounting for about 95.45%, which is 1.47% lower than the $1347.907 per ton internal cost of corn ethanol gasoline. The main reason is that the internal cost of corn ethanol gasoline includes the cost of processes from corn planting to ethanol production, and the technology of the production and refining has not reached a certain level.

The external unit cost of gasoline throughout the life cycle is $63.353 per ton, 12.93% higher than the ethanol gasoline external cost of $55.676 per ton; and from the perspective of the unit cost of the life cycle, the external unit cost of gasoline accounts for 4.5% of the total cost, corn ethanol gasoline accounts for 3.99%. It can be seen that although gasoline has a lower full life cycle unit cost, it also has a higher unit external cost amount and proportion, and the pollutant emission problem is more serious in its life cycle. For the life cycle cost comparison between ethanol gasoline and traditional gasoline as shown in Figure 6 below.

![Figure 6. Comparison of the internal and external costs of ethanol gasoline and gasoline full life cycle.](image-url)

It can be reasonably assumed that with the future development of ethanol gasoline production technology, the reduction potential of its internal cost is greater; the external cost of gasoline’s life cycle is $63.353 per ton, which is 1.13 times that of ethanol gasoline, which is $55.676 per ton, and it is also the main advantage of gasoline. The following is a further analysis of the emission reduction potential of ethanol gasoline in China.

6. Emission reduction potential of ethanol gasoline in China
According to the researchers using the carbon balance method, the equivalent ratio of ethanol gasoline (E10) to ordinary gasoline is about 1.07. This empirical data is used to calculate the results, and the research scope is extended throughout China. China Mobile Source Environmental Management Annual Report (2019) released by the Ministry of Ecology and Environment shows that China's gasoline consumption in 2018 was 126.445 million tons. If ethanol gasoline is used to replace gasoline throughout China and calculated with the same proportion, the amount of ethanol gasoline needed will be 136.395 million tons. The total gasoline consumption in 2018 and the equivalent life-cycle consumption of ethanol gasoline equivalents over the entire life cycle are shown in Figure 7 below.

According to calculation results, after expanding the research scope to the entire range and replacing gasoline with ethanol gasoline, the effect of emission reduction is obvious from the perspective of the whole life cycle, and the emission reduction benefit can reach $423.4 million. In terms of the amount, CO$_2$ emissions are the largest, exceeding 43 million tons, followed by CO and wastewater with emission reductions of 1.68 million tons and 1.19 million tons, respectively. Due to their small base, the emission reductions of HC, SO$_2$, NO$_X$, and TSP are below 100,000 tons. From the perspective of the emission reduction ratio, CO emission reduction is about 20%, and the reduction is the largest. Secondly, HC emission reduction is about 17%, SO$_2$ emission reduction is about 6%, and then CO$_2$ emission reduction is about 7%. From the perspective of emission reduction economic benefit, the emission reduction benefit of CO and CO$_2$ both exceed $141.1 million, that of SO$_2$ is about $28.2 million, and that of wastewater is about $14.1 billion. But the emission of TSP, nitrogen oxide and waste residue increases compared with that of gasoline, mainly due to the production of ethanol from corn. This shows that in the future, with the production technology of ethanol gasoline and the development of vehicle engine technology, the emission reduction potential of ethanol gasoline is huge.

![Figure 7. Analysis of annual gasoline consumption and equivalent ethanol gasoline life-cycle emissions in 2018.](image)

Note: The unit of CO$_2$ is 10 million tons, wastewater 1 million tons, and all other units 100 thousand tons.

By the end of 2019, China's fuel ethanol production capacity would be around 4.15 million tons, an annual supply of about 3 million tons and the new construction and the expected production 4.05 million tons. If the annual supply of 3 million tons of fuel ethanol is all used for the production of E10 ethanol gasoline, the output will be about 27.713 million tons, equivalent to 25.9308 million tons of traditional gasoline, and the total emission reduction benefits will be close to $84.7 million.

7. Conclusion
At this stage and for a long time to come, China will continue to be dominated by fossil energy consumption, featuring large consumption of oil, gas, coal and other resources, and high pressure of carbon emission and environmental pollution. And fuel ethanol is renewable biomass energy, mainly
corn ethanol, cassava ethanol, etc. Judging from the current technological level, it can partially replace fossil energy, with relatively large emission reduction potential. In this paper, corn is used as the raw material for ethanol fuel production, and the full life cycle model of ethanol fuel gasoline and traditional gasoline is constructed. The internal and external costs of ethanol fuel gasoline and traditional gasoline in the full life cycle are compared and analyzed, and the main conclusion is as follows:

The results show that the internal cost of ethanol-fueled gasoline is mainly generated in the raw material procurement stage, accounting for about 75.91% of the total life cycle, followed by refinery construction (10.74%) and ethanol plant construction and production (5.57%). Therefore, internal cost optimization can start from the production, transportation and marketing of ethanol and gasoline, such as the optimization of production technology, process flow, energy consumption and various labor costs. In terms of external costs, the external costs of gasoline production (44.45%) and ethanol gasoline combustion (42.64%) account for about 87.18% of the total cost. From the emission results of pollutants at various stages of the life cycle, CO2 contributes the most to external costs (about $39.4 million), followed by CO ($219 million), which are mainly concentrated in the combustion of ethanol and gasoline. Compared with ethanol-gasoline, the emission from crude oil processing technology in the gasoline production process accounts for the vast majority. Therefore, ethanol-gasoline can replace gasoline to reduce pollutant emissions to a certain extent. In addition, the combination of ethanol and gasoline production process optimization and automobile engine technology upgrading and transformation can bring more emission reduction benefits.

The life cycle cost of corn ethanol gasoline is close to that of traditional gasoline, but the refining and production technology of gasoline is more mature, and its life cycle cost is about 0.89% less than that of ethanol gasoline. The per unit of gasoline internal cost accounts for about 95.45% of the total cost, which is 1.47% lower than the $1347.907/t of corn fuel ethanol gasoline, mainly because the internal cost of corn ethanol gasoline includes the cost from corn planting to ethanol production stage, and the production and refining technology level is not mature. The total life cycle unit external cost of gasoline is $63.353/t, 12.93% higher than that of ethanol gasoline. Therefore, although gasoline has a lower total life cycle unit cost, it also has a higher amount and proportion of unit external cost, and the pollutant emission problem is more serious in its whole life cycle. In addition, according to the carbon balance method, the total life cycle pollution emission after replacing gasoline with ethanol is calculated, and it can be concluded that the emission reduction effect after replacing gasoline is obvious, and the emission reduction benefit can reach $423.4 million, among which, CO2 emission reduction is the largest, exceeding 43 million tons, followed by CO and wastewater. In conclusion, at the present stage, the production technology level of corn ethanol gasoline is not mature, and the total life cycle cost is higher than that of traditional gasoline, but the pollutant emission and emission reduction benefit are lower than that of traditional gasoline. Improving the production technology of ethanol gasoline can greatly alleviate the use of fossil energy in China and reduce the degree of environmental pollution.

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