

# Research on Ethanol as an Alternative Fuel

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## ABSTRACT

Ethanol, a renewable biofuel derived primarily from plant-based sources such as corn, sugarcane, and cellulose, has gained significant attention as an alternative fuel in the face of rising environmental concerns and the depletion of fossil fuel resources. This paper explores the potential of ethanol as an alternative fuel for transportation and industrial applications, highlighting its benefits, challenges, and technological advancements. Ethanol's advantages include its lower carbon emissions compared to gasoline, its biodegradability, and its contribution to energy security by reducing dependency on imported oil. The paper also examines the economic, social, and environmental implications of large-scale ethanol production, focusing on land use, water consumption, and the food vs. fuel debate. Additionally, recent advancements in ethanol production technologies, such as second-generation biofuels and cellulosic ethanol, are reviewed. Finally, the paper provides an assessment of the sustainability and future potential of ethanol as a key player in the global transition to cleaner energy sources.

## Keywords:

Ethanol, fuel, Cell-powered Vehicles, low Pollution

**1.INTRODUCTION:** Ethanol, a renewable biofuel derived primarily from plant materials such as corn, sugarcane, and other biomass sources, has gained attention as an alternative to conventional fossil fuels. As concerns about climate change, air pollution, and the depletion of non-renewable energy resources grow, ethanol is seen as a promising solution to reduce greenhouse gas emissions and dependence on imported oil. Ethanol is typically blended with gasoline to create fuel mixtures, such as E10 (10% ethanol and 90% gasoline) and higher ethanol content blends like E85. This biofuel offers several advantages, including a lower carbon footprint, reduced harmful emissions, and the potential for energy independence. However, challenges such as production costs, land use, and food versus fuel debates continue to influence its widespread adoption. Research on ethanol as an alternative fuel focuses on improving production methods, increasing fuel efficiency, and exploring new feedstocks, positioning it as a key component of a more sustainable energy future.

**Background:** Ethanol is a colourless liquid that is both flammable and volatile. It can be used as both an alcoholic beverage and as an alternative biofuel. It is easy to manufacture as well as process ethanol through a process similar to the one used in the production of alcohol. One advantage of the use of ethanol as a source of energy is that large amount of it can be produced over a short time. In addition, its production is not complex as it involves the use of crops such as sugarcane or corn. For this reason, this type of biofuel is renewable. In the United States of America, ethanol has been adopted as a suitable alternative source of energy. Such an approach was attributable to the fact that using ethanol fuel can help in the reduction of oil imports and the provision of the necessary support to the agricultural sector by encouraging the growth of corn and other crops that can be used in the production of ethanol.

## 2. ANALYSIS:

As pointed above, ethanol can be produced from corn, sugar cane, algae, petroleum (hydrolysis of ethylene), or even cellulose. the process of producing ethanol using each of the above materials is described below.

### ETHANOL FUEL FOR CORN:

The United States of America is one of the major producers of corn in the world and hence, uses such opportunity to produce ethanol fuel. The initial process of making ethanol from corn starts with the selection of the

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right quality of corn for use in the fermentation process.<sup>2</sup> The corn is milled to form grain-like powder through either dry milling or wet milling. The fine powder obtained is allowed to mix with enzymes and water to enhance the formation of a slurry. The role of the enzymes at this stage is to help in the conversion of the available starch to dextrose, which is a simple sugar. The level of the PH is controlled through the addition of ammonia before the mash is heated and cooled to allow yeast to work on the sugars present to form ethanol.

The diagram below provides a summary of the ethanol production process using corn. The use of corn in the production of ethanol has a number of drawbacks. For example, there are concerns over the energy return available when ethanol is produced from corn. The production of ethanol from corn is associated with negative impacts on the environment. This is attributed to the fact that the production of high amount of ethanol requires corn in large quantities.

For this reason, such production of corn has a high probability of damaging the environment due to the approach used in growing this type of crop. The “fencepost to fencepost” way of planting subjects the soil to massive erosion. Additionally, the production of corn causes drops in the water level due to the fact that high quantity of water is used.

Secondly, the production of high quantities of ethanol from corn is subject to mandates as well as subsidies. The implication is that the price of corn ethanol can be quite high relative to the subsidies and labour required. Thirdly, the use of corn in the production of ethanol fuel requires a lot of resources including some which could be useful in the production of food. Such a scenario triggers increases in the prices of food this is attributable to the fact that the world is facing problems of food shortages. As such, any available resources ought to be channeled towards the production of food rather than being spent producing ethanol that is not economical.

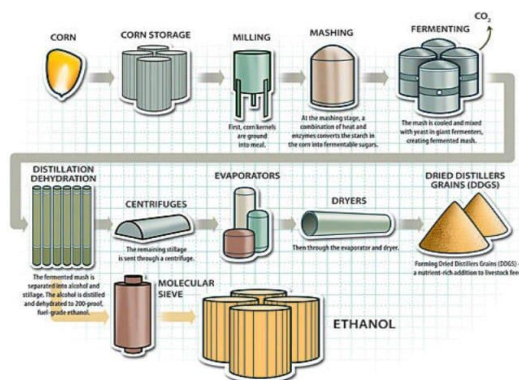


Figure 1: Process Diagram; production of ethanol from corn.

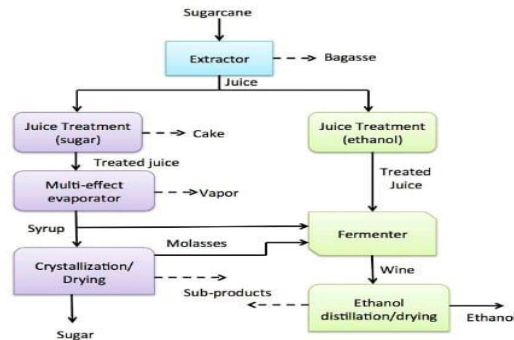
### 3.Ethanol production using sugar cane

The primary feedstock used in the production of ethanol is sugar cane molasses or the juice. These are by-products obtained from sugar milling factories and hence, make the production and use of ethanol sustainable. India relies heavily on sugar cane molasses for the production of ethanol. On the other hand, fresh sugar cane juice is commonly used in the production of most ethanol in Brazil.

The production of ethanol from sugar cane involves the extraction of sucrose from cane that has been cut and milled to produce juice. Then, treating it with sulfuric acid and lime for the purpose of removing any unwanted inorganic materials. This step is followed by the fermentation of the juice and molasses to obtain about 10-20% sucrose. During this stage, the clarification step involves heating of the juice to about 115°C reaction is maintained at fermentation conditions by cooling the mixture before adding yeast. The use of fossil fuels. When compared to ethanol from corn, sugarcane ethanol is 35% better in terms of avoided emissions.

Secondary given the limit in terms of land to grow crops for the production of ethanol a high yield of ethanol can be produced from sugarcane planted in a small piece of land. Sugarcane ethanol is considered highly productive when compared to other sources of ethanol such as corn. This is attributable to the superior sucrose yield from sugar juice of molasses. Additionally, the ethanol production from sugarcane contains the highest energy balance based on the amount of waste renewed in comparison to the energy inputs. For example, the energy balance of ethanol produced in Brazil from sugar is 9.0, while the ethanol produced from American maize has an energy balance of

2.0. Generally, sugarcane is considered to be an appropriate alternative for bio-fuel production with respect to environmental, energy, as well as economic impacts.



### Disadvantages of using sugar cane to produce ethanol

The production of ethanol from sugarcane faces a number of challenges that affect its efficiency as an alternative source of biofuel. First, the suitability of land for use in planting sugarcane is limited. This is especially the case for industrialized countries like China, since it is impossible for them to expand the existing land to cater for the production of sugarcane. In addition, harvesting the planted sugar is also a challenge due to the fact that such process requires a lot of investment in terms of capital and machinery. This challenge is most common for countries whose terrain is hilly since such type of lands requires the implementation of mechanized harvesting. On the other hand, cost and benefit issues are likely to affect the expansion of land for the production of sugar. This is attributable to the fact that such expansion can be labour and capital-intensive

### Advantages of using sugar cane to produce ethanol

The production of ethanol from sugar cane has both advantages and disadvantages. Some of the advantages are highlighted below.

First, sugar provides a significant balance in terms of greenhouse gas emissions during the

### Production of Ethanol from Algae

Algae can be described a Simple Organisms that contain chlorophyll and have the ability of growing both heterotrophically and phototrophic in the case of the phototrophic growth of algae, the carbon dioxide available in the atmosphere is converted to carbohydrates

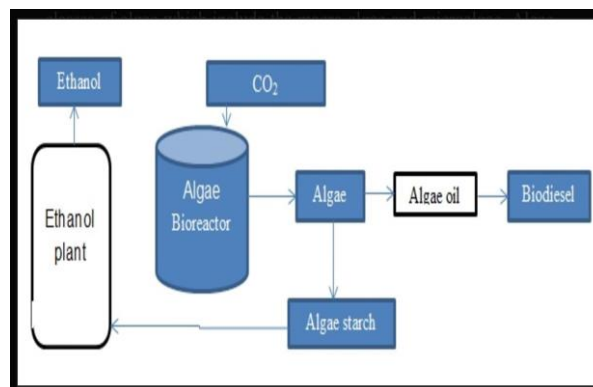


Figure 3: Process Diagram: production of ethanol from algae the production of ethanol from algae involves the formation of a biomass from algae and decaying the biomass. A fermentation solution is formed by using adding yeast to the biomass and then the ethanol is separated from the fermentation solution.

Algae can be described as Simple Organisms that contain chlorophyll and have the ability of growing both heterotrophically and phototrophic. In the case of the phototrophic growth of algae, the carbon dioxide available in the atmosphere is converted to carbohydrates. There are two classes of algae which include the macro-algae and microalgae. Algae can be used in the production of bioethanol and biodiesel. The micro-algae are a suitable feedstock in bioethanol production due to its capacity to produce lipids, as well as it has high photosynthetic efficiency.

The production of ethanol from algae involves the formation of a biomass from algae and decaying the biomass. A fermentation solution is formed by using adding yeast to the biomass and then the ethanol is separated from the fermentation solution.

### Ethanol Production Using Cellulose

The production of ethanol through the cellulosic process comprises of the pretreatment stage, the hydrolysis of enzymes, fermentation, as well as distillation<sup>6</sup>. The first stage is used to ensure that the cellulose is highly susceptible to breakage as a preparation for the hydrolysis.

It involves the removal of hemicellulose and lignin thereby exposing the inside part of the cell wall. The enzyme hydrolysis follows the pretreatment stage to enhance the conversion of polysaccharides to simple sugars that can be acted upon by yeast or bacteria. The third stage is the fermentation process where single sugars are converted into fuel ethanol. In this case, the major organisms used in the conversion of sugars to ethanol include bacteria and yeast.

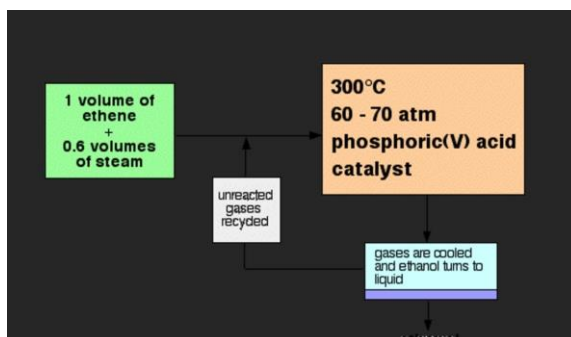
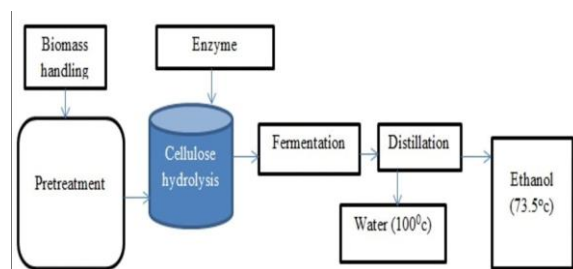


Figure 4: Flow Diagram: Cellulosic production of ethanol

The distillation step is used to recover ethanol from the fermentation broth by heating the broth up to the boiling point of water. Since ethanol has a low boiling point than water, it distils first.



### Ethanol Production Using Petroleum

Ethanol can also be produced from petroleum through the hydrolysis of ethylene. This is achieved through the reaction of ethylene with steam in an exothermic and reversible reaction.

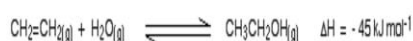


Fig. 5: Hydrolysis of ethylene to ethanol.

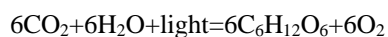
Ethylene is passed through a reactor containing steam that converts about 5% of it every time the substance is passed via the reactor. This process is successful due to the fact that the reaction between ethylene and steam is reversible. The implication is that the hydrolysis of ethylene can lead to 95% conversion since ethanol is constantly removed from the equilibrium. The flow chart below provides a summary of the formation of ethanol from ethylene.

The gases from the reaction undergo a cooling process to condense ethanol and any excess steam. After condensation, fractional distillation is used to separate water from ethanol. The use of the fractional distillation method is appropriate at this step because water and ethanol have different boiling points making it suitable for the liquids to be separated based on the fact that ethanol will distil off first (at 73.5°C). While the production from ethylene is simple and easy, it involves the use of high pressures which are quite costly due to the numerous requirements involved. On the other hand, such pressures cause the polymerization of ethane making it difficult to produce ethanol of the required quantity.

### **SYNTHESIS OF ETHANOL (REACTIONS):**

The production of ethanol fuel comprises of three process including fermentation, distillation, as well as dehydration. However, the primary process of producing ethanol can be described in three steps: photosynthesis, fermentation, and combustion as shown in the reactions below.

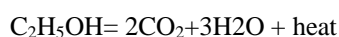
#### **Photosynthesis**



#### **Fermentation**



#### **Combustion**



The addition and balancing of the three equations give ethanol. During the photosynthesis reaction, light is converted to heat. In this step, the production of ethanol involves the fermentation of sugars by microbes. The second stage involves the removal of water from the ethanol. However, it is important to limit the purity of ethanol at 95% during the distillation stage to avoid forming water-ethanol azeotrope. The dehydration step is used primarily to remove any water molecules left.

### **Separation of Ethanol:**

The separation of ethanol based on the principle of separating liquid-liquid mixtures. As such, for the separation to be achieved, the liquid compositions should be immiscible. In most liquid-liquid extractions, the miscibility of the solvent is a significant factor of consideration. In the case of ethanol, its separation follows the principle of distillation where the process is possible due to difference in the boiling point of water and ethanol.

### **E-Factors of Ethanol Production:**

The use of corn in the production of ethanol fuel requires a lot of resources including some which could be useful in the production of food. On the other hand, the suitability of land for use in planting sugarcane is limited. This is especially the case for industrialized countries making it environmentally-demanding to expand the existing land to cater for the production of sugarcane.

Even though, the production of ethanol from ethylene is simple and easy, it involves the use of high pressures which are quite costly due to the numerous requirements involved, as well as has a high percentage of waste materials released to the environment.

### **Conclusions:**

In conclusion, ethanol derived from renewable sources such as sugarcane and corn presents a promising alternative to traditional fossil fuels, offering notable environmental and economic benefits. As a cleaner-burning fuel, ethanol reduces greenhouse gas emissions and air pollutants, contributing to improved air quality and mitigating climate change. The use of sugarcane, with its high energy efficiency, and corn, as a widely available

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feedstock, enables a diversified and scalable approach to biofuel production. However, challenges remain, including concerns about land use, food security, and the environmental impacts of large-scale agricultural practices. Technological advancements, such as improving crop yields and exploring second-generation ethanol from cellulosic materials, hold the potential to address some of these challenges. Ultimately, while ethanol from sugarcane and corn can play a significant role in the global transition to sustainable energy, a balanced approach that includes ongoing research, innovation, and policy support will be essential to maximizing its potential and ensuring its long-term viability as a key alternative fuel source.

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