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A REVIEW ON 2G ETHANOL PRODUCTION

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Abstract: Bioethanol is one of the promising bio-fuel to resolve the energy crisis. The importance of bioethanol has crossed its previous imagination levels as a result of its property to blend with petrol to give less pollution causing elements. Major countries are now focusing to chase the target to blend 20% of bioethanol in the fuels. One of the major reasons for these enormous targets is to protect the energy securities and reduce importing cost of fuels. The first generation of ethanol is derived from food crops like sugarcane, corn in Brazil. But for many countries this is not a viable solution as this may cause raise in food prices. Here, the second generation of bioethanol produced from agricultural waste like rice straw, wheat straw, sugar beets, sugarcane, corn, and many more lingo-cellulosic products are gaining traction. The drawback of bioethanol was lack of study supply of feedstock and fear of transporting costs and also new advancements. To commercialize the production and support small scale industries like rice mill, formers to provide new source of there is a need to develop strategic plans and technologies to help set up production ecosystem. Building a large supply chain which includes farmers and mills in a contributing factor. Loop reactor technology is proving new advancements where production rate has seen to increase. In the present review paper advances in production, importance and benefits of bio-ethanol are discussed.

Keywords: 2G Ethanol, Blending, Loop reactor technology, Biomass.

1.0 INTRODUCTION

13.9 billion gallons is the annual global consumption of ethanol worldwide. It depicts the importance of ethanol in our everyday life. It is used in the manufacture process of drugs, plastics, lacquers, polishes, plasticizers, and cosmetics. In recent years its importance grew exponentially because of its high-octane number and its blending property with fuel, which decreases the carbon emission of those fuels. This caught attention of many countries to try and reduce the dependency and cost of petroleum being imported. Major powers of the world aim to blend 20% ethanol by 2030. Such ambitious goal will be faced with many problems.

Ethanol is made of two carbons, six hydrogens and a single oxygen atom. As per its structure, it is termed as a organic alcohol also called as ethyl alcohol. It is volatile in nature with a boiling point of also flammable. The alcohol is a colourless liquid with a characteristic wine-like odour. Bioethanol is produced from plants such as sugar cane or maize. This is referred as first-generation bioethanol. But due to the changing dynamics, the feasibility of this ethanol is decreasing. 50% of sugarcane production in Brazil is consumed for ethanol which may lead to food shortages due to unequal crop distribution. Same situation is observed in countries like the USA. This created a perfect environment for all to search for alternatives and one of them is production via agricultural waste. In recent years improper disposal of agricultural has also led to carbon emissions. By using this inedible farm waste left over after harvest both the problems could be solved. The ethanol from it is known as second generation ethanol.

In the world of crude oil, Bioethanol is most preferred and believed biofuel that can substitute the current sources. The commercialization of this production process is emerging recently. Collection of raw material and consistency of these materials is a problem yet to be solved. The new advancements link loop reactor technologies are increasing the efficiency of processes.

By ethanol production and via its blending, it can not only reduce air pollution but also helps in generation of energy, additional income and green fuel. Annually India produces 30 million liters of ethanol just from various sources. This also includes thousands of tonnes rice straw produced from various parts of the country. These plants will also utilize maize and sugar cane waste besides paddy straw to produce ethanol. Currently, the country has 116 grain-based ethanol plants with an installed capacity of 268 crore liters. 16 plants with a capacity of 61.67 crore liters installed in Punjab. India is taking strong steps by building new bio-ethanol plant. Recently a plant was setup by IOCL a leading oil corporation in India, depicting the changes in industry. This project will have zero liquid discharge and will reduce the emissions equivalent to 63,000 cars on roads annually.

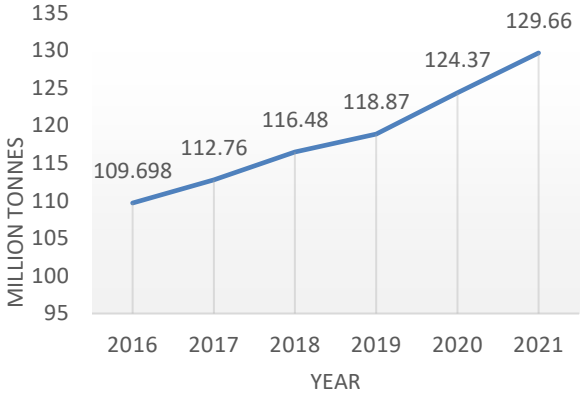

Fig 1.1 Production of rice in India

When all the left-overs of such huge crops are processed, large amounts of bio-ethanol can be produced.
Brazil, has a history of large forest areas and its huge farming potential because of its soil and other factors. This allowed the country to produce sugarcane in bulk quantities that are used in production of bioethanol. Due to this availability of raw material two companies from Brazil are leading the 2nd generation bioethanol production. They are GranBio and Raizen. They have started commercial process of bioethanol production as back as 8 years.[2]
This paper provides a overall review and explains the importance of second generation bioethanol production. It also provides the information and the various problems that are being faced on the ground. This paper also studies the different stages of bioethanol production and advanced technologies like loop reactor, plants established in India.

2.0 BIO ETHANOL FEEDSTOCK AND METHODS

2.1 First-generation production

In the first method to produce bioethanol, the fermentation comes at top. In this particular method the raw material containing sugars and carbohydrates are utilized. This process consumes direct food crops that are rich in sugars and carbohydrates so that they can be fermented directly. It is the most widely used process in the world right now. But it is being faced by own set of challenges because of its required raw material. Since they are edible food crops, it is leading to high prices of food products that's directly increasing the inflation. This is why the alternatives are being researched to the first-generation method.

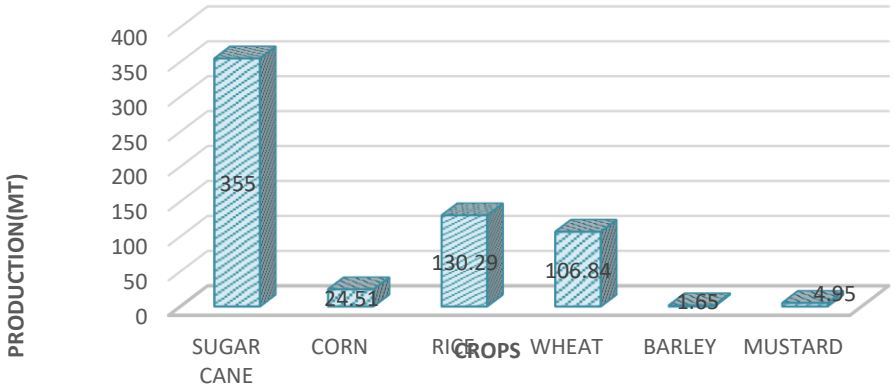

Fig 2.1 Production of Food Crops in India

2.2 Second-generation production

As to the limitation of first-generation that it uses the same food as a source for production, an alternative method is devised so as to produce bioethanol from inedible feedstocks, which contain lignocellulosic biomass. In this method it is also possible to convert crude glycerol by trans-esterification method. Lignocellulose is plants dry material and also called the renewable and sustainable carbon source. This lignocellulose is available in straw material of food crops and also the bagasse of sugarcane. These materials exclaimed as potential sources of fermented sugars which used in second-generation bioethanol production. In case of 2G bioethanol, the raw material can be grown on less nutrients land and also consume less water as this material is a by-product of a main crop. Thus, this would show no effect on food crops.

2.3 Third-generation production

In the above two methods, the processes are mainly focused on plant products. But in this method a rather different material – algae or micro derived from prokaryotes and eukaryotes is used for the production of bioethanol. This process using algae matter is known as third generation of bioethanol. The algae is fed on industrial waste streams which are nutrient rich in nature. As these streams may causes many problems to water bodies, they are treated with such algae which will convert them into useful bioethanol. These include nitrogen and carbon too. In a similar process, biofuels can also be produced by conversion and biological segregation of carbon dioxide. It this helps the countries to directly reduce the carbon emissions by capturing them from air. But the bioethanol produced from the 3rd generation of bioethanol is less stable on par with bioethanol produced from other methods.

2.4 Fourth-generation production

The carbon dioxide produced from industries is recycled by electrochemical process which produces carbon free energy (renewable or nuclear) source. The advanced technologies like electrochemical synthesis, oxide electrolysis, and petroleum hydro electro processing involved in recycling of CO_2 being produced from industries is termed as fourth-generation bioethanol production method. [24]

In consideration of all generations, the second-generation bioethanol production is most preferrable and advantageous. Because the ethanol production is carried out by utilizing agricultural biomass, non-food crops, and municipal biomass, etc. which tends to minimization of waste, reduced dependency on imported fuels. Thus, no impact on food cost.

3.0 BIOETHANOL PRODUCTION PROCESS

This paper focus on the second-generation bioethanol production through the crop residues. The crops residues can be categorized as two ways. The plant residues that are resulted during the harvesting and co-product of crops during the processing is one way. The by-products generated after post-harvesting of processing such as cleaning, delisting, sieving, crushing, and milling of crops comes under the industrial agricultural residues. The major Indian crop residues are available as straw (like rice, wheat, barley, etc), husk, bagasse (sugarcane, corn stoves), leaves, peels of fruits etc. The total energy potential of the major Indian agricultural residues has been reported, based on their annual availability and the higher heating values of the different residues. (Mosier et al., 2005) Approximately 1868 tons of crops residue produced primarily world widely.

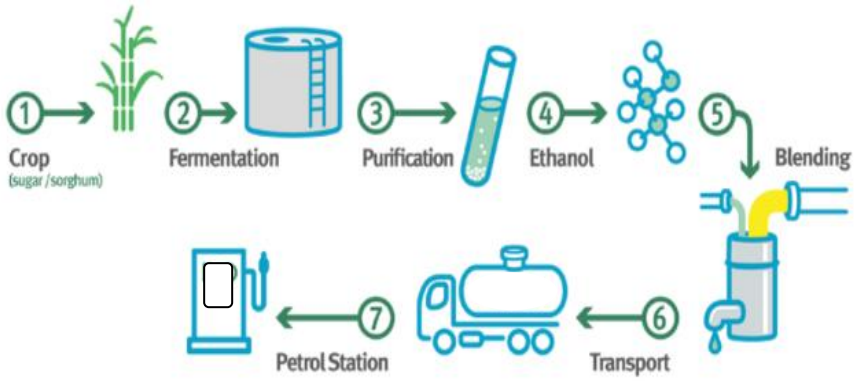

Fig 2.2 Bioethanol production process

The above is a simple representation of the bioethanol production process from crops to the blending station.

In India, the short-lived crops of kharif and rabi seasons in which rice is one of the crops which is water consuming crop that grows in semi-aquatic environment depending on the environmental conditions includes soil fertility, climate change many more. Whereas rice straw is the byproduct of rice production at harvest. By various harvesting methods such as machinery threshers or manual works as the result the rice grains are piled or spread out in fields. The ratio of rice straw to paddy is ranging between 0.7-1.4 depending on varieties of grow. 667 million tons of rice straw is produced in Asian countries annually to produce 281 billion litres of ethanol.[24] The production of rice has been increasing in recent years, by which the production of ethanol can also get increase by proper utilization of the rice straw.

The technology for metamorphosis of this feedstock to ethanol have been developed in 2 procedures. One is the sugar method and another is synthesis gas method. The basic step in sugar method is conversion of cellulose, hemi cellulose, and lignin to fermented sugars, which then fermentation to bring out ethanol. In synthesis gas method, the biomass is subjected to uninterrupted the process of gasification. In this process, the biomass heated in absence of oxygen or only with limited oxygen conventionally required for the combustion. This subsequently generates the synthesis gas which can be fermented to produce ethanol. first stage involves the collection of rice straw from the field to the production mills.

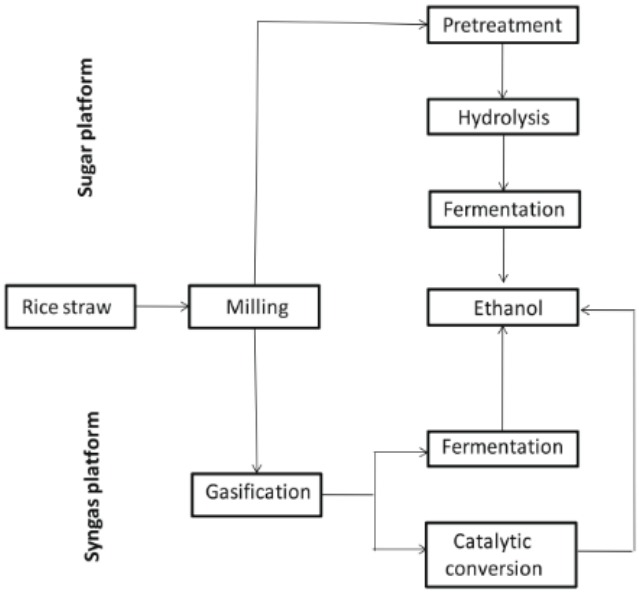

Fig 3.1 Conversion of rice straw to ethanol

3.1 Pre-treatment process

The collection of rice straw from the agricultural farms to the milling area to perform the required treatments is first stage of ethanol production. To get the required size of straw and enzymatic reaction, raw material requires pre-treatment, which is carried out in subsequent ways.

3.1.1 Physical pre-treatment

This process will increase the overall surface area and pore size by which the fermentation of sugar can be performed accurately. Due to the more surface area, there is decrease in degree of polymerization of cellulose. generally, the physical treatment includes the steaming, grinding, milling irradiation of feedstock under required pressure and temperature. To reduce the crystallinity of biomass and also to reduce the particle size the raw material will be subjected to the milling and grinding procedures.

3.1.2 Chemical pre-treatment

The conversion of lignocellulose to ethanol is not effective treatment without chemical pre-treatment. The chemical pre-treatment of raw material includes alkali and ammonia. Akali pre-treatment involves solutions like NaOH or KOH to remove the lignin. This abets to increase the exposedness of enzyme to the cellulose. This alkali pre-treatment can be implemented at low temperature but, proportionately long time and high consolidation of base are required, which leads to boom in sharp formation of saccharification. As per the researches studies two percent concentration of NaOH with twenty percent of solid loading at a temperature of 85 ^{o}C for 1hr decrease's 36% of lignin [moscow-(2009)]

As a pre-treatment reagent ammonia is preferred because of its suitable characteristics for the treatment process. Ammonia has a rather high affinity or selectivity towards lignin when put under a reaction than towards carbohydrates. Its volatility, non-corrosive with non-polluting nature makes it simple to recover it. This will reduce the costs as it can be reused again later on. The chemical pre-treatment of lignocellulose also involves the acid treatment with ambient temperature which predominately dominates the hemicellulose. This makes the cellulose readily available to enzymes to perform required action. Dilute hydrochloric acid and dilute sulphuric acid are the go-to materials for the acid pre-treatment process. This treatment is then followed by hydrolysis process.

3.1.3 Biological pre-treatment

After physical and chemical pre-treatment, the other procedure is biological pre-treatment. The objective of this method is same as to remove lignin from lignocellulose. But the biological method is safer and environment-friendly. This pre-treatment offers conceptual and advantageous. That is because of the low usage of energy and chemicals. Because of being a very slow system, it is also hard to control the process. The method also comes with it's own limitations like corrosion that makes feasibility of this method low.

3.2 Enzymatic hydrolysis process

This process is the second stage of the ethanol production from lignocellulosic material. It involves polymer cleavage of hemicellulose and cellulose using enzymes. The reason behind enzymatic hydrolysis is to separate the monosaccharide from polysaccharides such as cellulose and hemicellulose. Once these materials are separated, they are fermented to convert them to

ethanol. This method applies hydrolytic enzymes to convert cellulose and hemi cellulose into glucose chains and xylose chains by continuous agitation of enzymes with processed rice straw. These enzyme offers an opportunity to reuse the enzymes.

3.3 Fermentation process

After the completion of enzymatic hydrolysis process the generated sugars are needed to undergo fermentation process. It is also an important step. Microbes such as yeast which plays a major role in digesting enzymatic hydrolysed by products that are the glucose and xylose chains to ethanol by fermenting with microorganisms. Ethanol-producing microorganisms depends on various factors and conditions (temperature, pH, pressure, concentration). This total conversion process takes approximately 3-4 days to complete. In production of ethanol, the water is segregated by distillation. The separated ethanol from the distillation process is then purified to use.

3.4 Catalytic recovery process

The left-over solids after the distillation are known as stillage. These undergo catalytic recovery to remove the water present in it by means of solid-liquid separation. This process is used to collect any remaining lignin rich residue that is insoluble. It can be reused for generation of steam and electricity by burning is back at on-site.

3.5 Loop reactor technology

A loop reactor is a continuous reactors tube or pipe which connects the outlet of a circulation pump to the inlet of another reactor. Loops reactors are similar to continuously stirred batch reactor tanks used in variety of applications involving chlorination, hydrogenation and polymerization. Replacing the stirred tank reactor with a loop reactor, with lignocellulose mixture fed to circulate through reactors. Which tends to increase in mass transfer rate. Smaller reactor size can able to increase productivity of ethanol.

The ASN fuel Pvt Ltd in collaboration with IIT-Tirupati limited to try avenues to produce ethanol from lignocellulose biomass by establishing loop reactor technology which has comparative advantageous than batch reactors. Logistic cost is drawback, but this has easy quality maintenance and complex reducing technology. The researches had made advancement in technology to pipeline reactor technology due in presence high viscous fluids during fermentation of sugar.[24]

4.0 CRITICAL FACTORS IN PRODUCTION OF ETHANOL

India had saved almost 50000 crores in the last 10 years from ethanol blending. Thai is mixing ethanol with petrol instead of pure petrol. Even a small percent of mix has saved such huge amounts of money. But to scale it almost 20% of blending is not an easy task, many issues are to be solved. A continuous system of raw material, strong transport facilities and ethanol processing stations are to be established. This continues line ensures us to have a steady and stable output. There are many obstacles ahead to make this technology viable. Technological advancements and funding are required to scale up.

4.1 Raw material

Raw material cost has always been the major problem. Raw material for it consists of inedible energy crops, agricultural and municipal wastes, waste oils, cereal and sugar crops. From these crops cellulosic and lignocellulosic materials are extracted to convert to bio ethanol. In this process waste by-products, which were to cause land and air pollution when disposed and burned, are being converted to useful ethanol which is generally made from direct use of corn and sugarcane. Many countries are worried that such heavy production of ethanol just from crops might lead to acute food shortage. Many countries are already facing such problems. Thus, by moving to next generation of ethanol, the same land can be used for production of valuable food products that might reduce hunger.

Now after starting blending fuel with ethanol, the results are clearly visible. The savings made on less fuel used, less greenhouse gases produced and more importantly the reduced dependance on other countries for oil.

4.2 Geo-Politics

Nowadays for any war ‘trade’ has become a choice of weapon to win over other. In such geo-political situations these kinds of technologies shape our future. If countries depend on such important products totally on other countries, this will limit the decisions and the international stance they can take.

4.3 Price fluctuations

One more problem from crop-based blending is that when the fuel rates are high, these crop farmers make a ton of money but when the fuel prices drop there is no demand for such crops, thus in danger of facing heavy loses. Farmers should always live on the equation of which costs low as in some country’s hybrid cars are being used.

4.4 Technology

It’s also been noticed that to use blended fuel, there is a need for change that all vehicles should undergo. As the percentage of ethanol increases, to make it more efficient, the configurations of engines are bound to change. This will affect the up-coming vehicles and the ones that are already on road. It will be thin like on which proper decisions should be taken.

The involvement of farmers, scientists, engineers, scholars and government authorities makes it a rather hard one. Now each of these problems are to be solved to make 2G ethanol feasible. About the raw material supply there are many plans available based on the feedstock selected. For the municipal wastes from individual houses, there are many cities that already have a strong network of collecting wastes. At the same time many cities do not have proper disposal methods. Such wastes are also causing major environmental and health issues as improper methods are leading to problems. Instead of just disposing the wastes, it should be convinced to establish ethanol plants as based on their daily incoming wastage. This will reduce the stress on governments to find new disposal areas every time the old ones fill out and also governments can get another source of income by selling ethanol, or mix it with fuel to reduce carbon emissions

4.5 Support to farmers

Agricultural waste is the major source for the 2G ethanol. With 11% of the total surface on earth being used for farming, the quantity of crops and its waste cultivated is enormous. In many parts of the world the by products are burned as they have no monetary value thus causing pollution. But it has been understood that the wastes are of high carbon content. When burned they produce large quantites of polluting gases but when processed in other methods they give out useful compounds. Many have rejected the idea of using agricultural wastes as raw material for production of ethanol because of non-availability of such fodder all-round the year. They are partially correct but that's not the whole truth. Even though the fodder is produced at end of the crop season, there are many crops that are cultivated one after another. If the technologies are developed to make bio-ethanol from varied sources in same plant, the problem can be minimized. And there is also have a possibility to store this fodder at warehouses to be used later.
Establishing large scale ethanol plants near river basins, dams and agricultural clusters can reduce the transportation costs as the end product ethanol transportation is much cheap then transporting fodder itself. This also provides farmers a monetary value for what they assume as waste and help them to earn some extra money.

4.6 Other benefits

These establishments can also work as research centers on various crops. As they are established in agricultural areas, they can be connected to other relater departments of agricultural for better developments. They can work hand in hand to educate farmers on new methods of cropping. They can work as data centers and improve local agricultural hubs. Because of the close approximity to farmers, mutual trust can be built.

There is also a need for local ethanol collecting centers that can be done by these centers. As discussed earlier, the other sources of ethanol also do consist of materials like rich straw and husk. These products are largely available in rice mills. By supporting small businesses like rice mills, companies in food businesses, food processing agency's so on to produce ethanol from their waste material which will be supported by a minimum support price at government production centers. This will help to integrate the small businesses into the national achievement of E20 blending.

Research on such topics should also be supported as new technologies like usage of biochemicals, new enzymes, reactors to help improve the output owing to reduced costs of bioethanol. Such integration of all sectors of the nation will help us to with stand the oncoming energy problems.

5.0 SUMMARY

Today major sources of energy are electricity and crude. In terms of electricity some major changes are being witnessed as new technologies that can produce electricity without causing pollution are over-taking the age-old areas. But in terms of crude there is a lack of substituting source. It's looking like all crude based usage should also be converted to electricity-based outputs or it's usage should be reduced for better control. It might take years to just satisfy the current electricity needs from renewable like water, solar, thermal, nuclear, wave, tidal, geothermal etc. Thus, replacing crude with all this electricity might take decades.

As crude production is available in only few countries, they have a upper say in the world order. Even a small effect on these countries can ripple out major economies and race them to bottom creating major inflation and other crisis. This effect could be seen whenever oil producing countries fought a war. This has always feared as all the countries depend on them and exposing them to our energy security.

For any nation it will always be a major goal to maintain its economic, military and energy securities in control all the time. This led many countries to the conclusion that reducing its dependency on oil is absolutely necessary.

In such a sweet spot of time came a concept of biofuels, which is showing promising solutions to the above complicated equation. These allow us to produce the fuels from inhouse raw material. Although they haven't reached a stage to replace crude, they have started to show the significance of what they can do if developed carefully. Many countries reduced the barrels of crude imported thus saving billions of dollars in recent decades by blending it with other low-cost fuels. It led us to today's stage where many countries are trying to solve the equation a little better.

But blending refined crude with another material is not such a simple solution. It is found that many engines that are running now, are made to give maximum efficiency for a particular constitutes of oil. If the concentrations of any components of fuel are changed, the ability of engines will reduce drastically. To tackle, research is being done on hybrid systems that work on both crude and blended petrol are being designed. New components are being tested that can detect the concentration of the components in fuel and change the engine working accordingly to perform better. But these systems are facing their own challenges owing to research and cost of such components and also their performance.

On considering the impact of bio-ethanol on countries economy, it is showing a lot of positive one. As the amount of importing petrol is reduced, countries now enjoy a strong forex reserve. Recently many countries could not maintain the forex reserves and are seeking help with international helpers like IMF to bailout them. But by maintain strong balance sheet such reserves, it is possible to avoid such fate. If the cost of blending ethanol is brought to less than cost of petrol, people can actually enjoy a cheaper fuel. If the cost of fuel is reduced, it directly reduces costs of transportation, goods, products thus benefitting the economy. It will help show positive impact even on the poorest.

Some scholars have reviewed that same land will produce more energy when put to use to solar energy that a bio-fuel production. But many of them didn't consider the fact that it consumes waste material. 2G ethanol should not only seen as way to reduce fuel costs, but also as a method to convert the excess wastage produced my human activities daily into something useful. Only then we can understand the real picture of 2G ethanol production.

When compared to other renewable sources it should also be considers that many of them need a specific place to produce viable efficiency. Solar and wind plants can't be setup at every place. This also involves the cost of solar cells whose costs are on incline in recent years. But agricultural waste is readily available and abundant too. This will not depend on external environmental effects as much as other renewable sources.

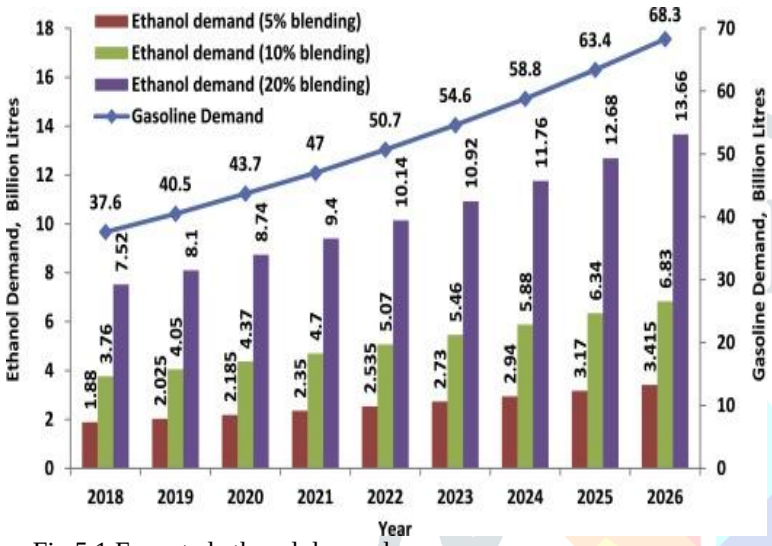

Fig 5.1 Expected ethanol demand

Such above growth is expected in the coming few years in support of adaption of this technology rapidly.

6.0 CONCLUSIONS

- The ethanol production form agricultural wastes and it's blending with petrol is very useful for growth of country's economy.
- It is predicted that ethanol will take a good part in every country's future energy security.
- It shall support rural parts of country by giving extra source of income to small scale farmers.
- By blending 20% ethanol with current regulations, dependency and cost of petrol will fall down.
- The amount of pollution released from vehicles shall see a decrease in quantity.
- The process will solve the problem of stable burning in many parts of the country.
- But to implement it on large scale, critical and fast decisions must be taken.
- Government should provide incentives for people working on such technologies.
- Creating awareness among farmers and small industries is of importance.
- Technologies that are trying to safe guard the environment must be supported and encouraged.

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