Biofuels

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Abstract

This report discuss what biofuels are, how they can be implemented in regards of the current Energy Crisis, its production from biomass characterization until the final products using different conversion processes, and some applications and utilizations highlighted on the energy market in accordance to the green and clean technologies that must be implemented as soon as possible.

The report is going to present the different ways of producing biofuels using biomass, submitting the bio matter to thermal and chemical conversion processes. At this point, the report will focus on the gasification in Brazil using sugar cane and other resources. Some advantages and disadvantages will be introduced and a criteria comparison will be made between the use of biofuels and the use of other fuels to produce energy.

Introduction to the World Crisis Panorama

The energy use has increased considerably along the years and the energy production has not followed the consuming at the same slope. Buying the service of requiring energy has become more expensive, and generating a cleaner production is therefore necessary. The increased use has accelerated the process of degrading several energy resources that are not renewable, so new methods that attend that requirement and, at the same time are sustainable, is now a challenge to all countries in the world.

The current energy resources are finite and not renewable and for that, became scarce. Consequently, the service fees have increased and the customer is paying for a service that is actually non beneficial to him since the fossil fuels that are currently burned pollute more than any other energy generation method.

The current means of producing energy include Hydro electrical, Thermo electrical, Nuclear, Wind Energy and other smaller processes. From the listed before, the only process that is clean and that negligibly pollute the ambient is the wind energy. Thermal production has been used since the Industrial Revolution in the 18th century. It consumes coal, oil or other hydrocarbons to generate energy at an efficiency of roughly 55 percent. The balance between the energy production and the amount of material burned/particles released into the atmosphere is completely unfavorable when analyzed from an environmental stand-point.

Nuclear generation although possessor of some great advantages when compared to hydrocarbon generation, has major security problems including where to deposit the radioactive material after its use and also the operation risks of having a nuclear power plant next to a city or populated area.

Hydro generation is one of the cleanest technologies being used once it does not release particles into the atmosphere nor has a product material to be safely housed after the generation. However, hydro plants have to inundate large portions of earth to create sufficient reservoir so generation becomes effective and cost-effective. The flooded areas usually are forests or plains and fauna and flora are harnessed.

Today, at least 90 percent of the world's energy generation comes from "dirt" and non renewable technologies such as coal, gas and oil burning. It is necessary to implement new technologies that meet all the clean requirements and also decrease the overall price of the production.

First Steps

Most of the energy consumption is not controlled and wrongly used by the consumers, so a large amount of kWh could be saved annually and some issues solved. It is important then to set some steps so better and more efficient power generation can be achieved.

The first important step is to identify how energy is being used by the customers. Great losses are also a major concerning, so investments on the transmission system are also welcome. Renewable and sustainable processes can be introduced, but if the energy use is not mapped, losses identified and customers oriented to act more responsibly, then no process will be sufficient to fulfill the demands.

The second step is to substitute the current supply methods for renewable and/or sustainable ones so most of the problems before discussed can be solved. There is no point on keep using the current processes in the future if not to compensate the introduction of the new generation processes and maintain a balanced power generation.

Along with the second step, and as a third step, small processes must be considered to replace the large ones that are used nowadays. Large amounts of energy can be generated from multiple cells of production instead of having all power centralized at one big plant. Small industries can also be beneficiated with those actions since more parts are going to be necessary, raising the employment rate and moving the economy. The governments have the chance to finance small processes and encourage small companies to take place and substitute the great conglomerates of the energy market.

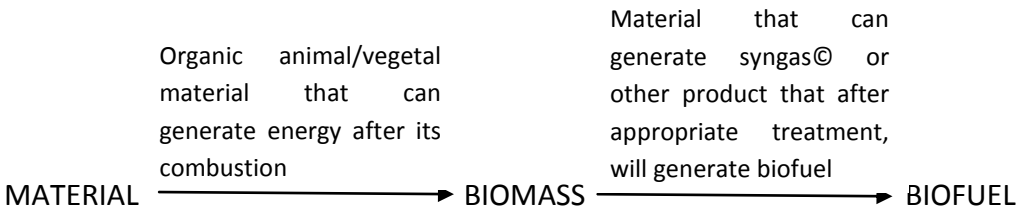
Following simple steps such as the three listed above, it is believed that the new energy technologies will assume a more efficient and clean position in the future and some issues will be partially resolved. It is not possible to solve all the problems at once, but in different steps it becomes a possibility.

Definitions

Biofuel or agrofuel is a fuel whose origins are biological and non fossil. They usually come from the treatment of a biomass source that produces a synthetic gas named syngas© which will be treated and turned into a biofuel.

It is produced in industrial scale from agro products such as sugar-cane, sugar, castor beans, soy, canola, cassava, corn, sugar-beets, algae, oilseeds, babassu and many other resources. Basically, the biofuel can be produced from any material that fits the definitions of biomass. Biomass is any organic, renewable substance or material that is compounded from animal and/or vegetal matter which produces energy after its combustion. So, if a specific material can be turned into biomass and does generate energy when combusted generating one of the products that will be used to produce syngas© or other final product, then this material has the potential to produce a biofuel.

The scheme below indicates how the process of identifying a material for biofuel matters work.



Once biofuels can be produced by any material that fits the definitions, it is easy and inexpensive to generate this fuel. Biomass can be generated by waste and by sewage and after an appropriate treatment, if the result does generate the necessary reactants for the biofuel production, then a great matter of what to do with all garbage and sewage from dense population areas is again partially solve. These promising technologies can not only generate energy for the city, but also cooperate with the good life standards, not mentioning all the direct and indirect employments and investments that will have to be made.

Ethanol

One of the main and most produced biofuels in the world is ethanol being produced from several types of raw materials. Given world's actual concern about fossil fuels, ethanol assumed the role of potential alternative for replacement. United States has the biggest ethanol production in the world extracting it mainly from corn. Brazil comes in second but using sugar cane as raw material instead. Both countries together have a total of 90% of world's actual production. The main benefits of this biofuel are lower pollution emitted when compared to fossil fuels, it is a renewable source and low production cost.

Ethanol is a transparent liquid, with strong smell and flammable. Beet, potato, corn and sugar cane are some examples of usable raw materials for ethanol production. Out of all the options, sugar cane is considered more reliable first because of its bigger production and lower price when compared to others tilth but mainly because it is not food. Also, after the broth is extracted from the cane, the bagasse left is burned in the boilers in order to generate electrical energy that runs the factory. These facts are not found in any other culture and make sugar cane the "greenest" culture.

Table 1 - Comparison between Sugar Cane and Corn

	Sugar Cane	Corn	
Chemical Raw Material	Saccharose	Starch	
Productivity per hectare	7000-8000	3500-4000	(liters of ethanol per produced hectare)
Energetic Production	8.3 – 10.2	1.3 – 1.6	(relation energy spent/energy obtained)
Green Gases Reduction	86 – 90%	10 – 30%	(% emission avoided by replacing gasoline with ethanol, without changing soil use)
Time to Replace Carbon	17 years	93 years	(Time to absorb carbon emitted by planting new areas)
Production Cost	0.83	1.14	(USD/gallon)

Some of the steps to produce ethanol out of the sugar cane:

1) The stalk is milled in the milling plant originating the broth;
2) The bagasse is burned in order to generate electricity used in the milling plant;
3) After filtered, the broth is fermented using yeast, sulfuric acid and water;
4) After fermentation the broth is centrifuged and sent to the distillation columns to produce ethanol.

Second Generation Ethanol

Since the stalk is the only part that is used to extract the broth and produce ethanol (corresponding to approximately 1/3 of the sugar cane) the rest was waste. This means that more than 50% of the cane was not used for production even that this "waste" holds a huge energetic potential. The leaves and top part of the cane correspond to 2/3 of the cane itself and are composed basically by celluloses that can be converted into biofuels.

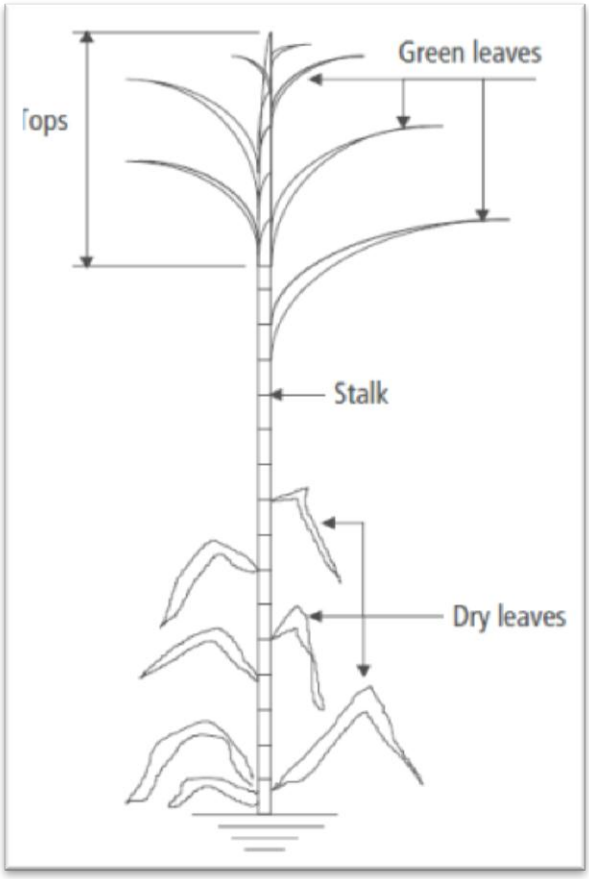


Figure 1 - Sugar Cane parts

The idea is to obtain the Second Generation Ethanol that means to use what was first thrown away to convert it into energy source. Anything that has celluloses in its composition can be used as raw material for the biofuel. Researches are been made on this field since there is a need for technology improvement. Talking about Brazil, the actual technology level allows milling plants to obtain 70 – 80 liters of ethanol (around 18 – 21 gallons) from 1 ton of sugar cane. The second generation ethanol would add extra 120 liters (32 gallons) per ton of waste to that account. This means the 1 ton of waste can generate 50% more ethanol than 1 ton of cane.

The Second Generation Ethanol is obtained mainly through a process called Gasification that consists in using any kind of solid biomass and burn it in an environment without oxygen, obtaining a gas that can be used either to run a turbine and be burned to generate electricity or can become biofuel/bioproduct. So, gasification allows turning what before was wasted into a variety of different products with different applications. Inside the Gasifier, three main things happen:

1) Dry the material in order to get the right humidity;
2) Submit the material to the pyrolysis that is the decomposition of the matter through high temperatures exposition;

3) Obtain the synthesis gas (Syngas) that can be converted to energetic products such as diesel, methanol, gasoline, hydrogen, synthetic natural gas and also chemical products and electricity.

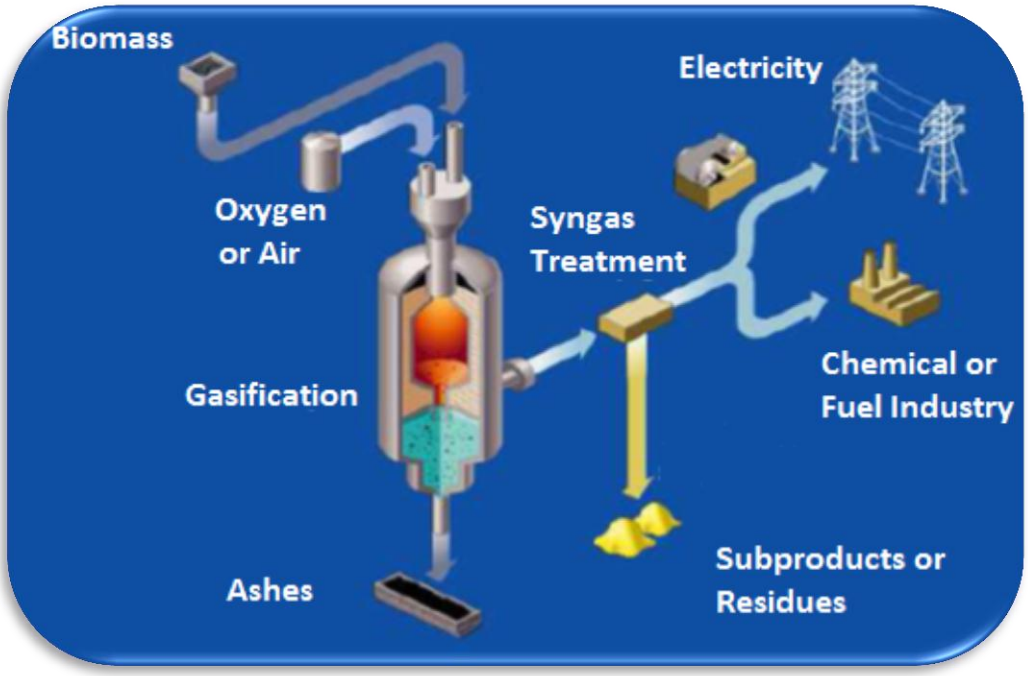


Figure 2 – Gasification

The Syngas consists of hydrogen and carbon monoxide meaning that has a big carbon chain in its chemical composition what allows it to be used to synthesize hydro carbonates. It can be used straight to be burned and generate electricity, can also be used to produce chemicals. This is one of the technologies researched to replace fossil fuels since it is possible to obtain biofuels such as biodiesel and bio kerosene from it.

Nowadays, 1 ton of sugar cane can provide 608 x 10^3 kcal just from the juice. Through the gasification, it is possible to use 100% of the sugar cane allowing obtaining total of 1718 x 10^3 kcal. As one oil barrel has potential of 1386 x 10^3 kcal, shows that 1 ton of cane has 1.2 oil barrel's primary energy. According to data from the 2007 harvest, Brazil produced ± 425 million tons of sugar cane what equals to ± 510 million oil barrels, approximately 1.39 million barrels/day. Enough for supplying 20% of world's demand for fuel.

World's actual scenario it is not favorable to the use of new lands to produce fuels, the second generation biofuels is a way to optimize the use of lands in order to get a more efficient process with bigger income.

Applications and Utilization of Biofuels

The use of vegetable oils as fuel for internal combustion engines is not new. Rudolph Diesel, the inventor of the diesel engine, used peanut oil to fuel one of his engines at the Paris Exhibition of 1900 and he wrote in 1912: "The use of vegetable oils for engines fuels may seem insignificant today. But such oils may become in the course of time as important as petroleum and the coal tar products of the present time" (Nitske and Wilson, 1965).

In the West, practically all farm machines are diesel-powered. Diesel engines have many advantages, such as they can last longer, they are more reliable than spark-ignited engines and also they are better adapted to harsh conditions. Diesel is also considered safer to store than gasoline. Because of the spread use of diesel engines, many countries are putting a big effort and conducting research in the use of vegetable oils as fuel for internal combustion engines

There are three types of Diesel engines:

- Direct-injected - the fuel is injected directly into the combustion chamber
- Indirect-inject - in this type the combustion begins in a pre-combustion chamber. It seems possible to use semi refined vegetable oil.
- Elsbett-engine - it employs the principle of the "duothermic combustion system" with a combustion chamber that works with the principle of turbulence.

Bioethanol

Ethanol can have very different uses such as nourishment and energy. It can be burned directly or used in internal combustion engines. Ethanol is also used in several conversion processes undertaken in the food, drug and cosmetic industries. Lacquers, varnishes, inks, hydraulic fluids, soaps/detergents, deodorants, perfumes and antiseptics. It has been used as a feedstock for the chemicals industry in Brazil, where 13% of the ethylene production capacity is based on ethanol.

The main differences of ethanol-fueled internal combustion engines in relation to gasoline-fueled engines are:

- Higher compression ratio.
- New pistons and shape of the combustion chamber

- Fuel tank needs a tin treatment.
- Fuel pump must be resistant to rust.
- Heating of the blend.
- New gauge and resistance to rust of the carburetor.

- New gauge of the distribution(variation of the ignition point).
- Match the materials of the valves.
- Spark plug with the appropriated thermic degree.
- Manufactured joints to be able to cope with the engine high compression ratio.
- Batteries of larger capacity, and alternators to propel the larger starting motor.
- Standard equipment to transistor injection.
- Carburetor with a nickel coating and alcohol pumps with chrome or cadmium to avoid rust.
- Nylon pipes and diaphragm of the combustion pipe of a material that cannot be attacked by alcohol.

Advantages

- A more complete combustion.
- Better overall performance(there are cases in Brazil, where the efficiency has reached 38%).
- Power and torque increase.
- Higher energetic value per volume unit of mixture.
- Various environmental advantages: decrease in several carbonated emissions(50% carbon monoxide), solid residues decrease.

Socioeconomic advantages:

- Increase in use of non-skilled labor.
- Creation of new jobs in agriculture.
- Improvement of the distribution of wealth.
- Decrease in the external energetic dependence.

Disadvantages

- Higher consumption, taking into account into calorific value(26900 kJ/kg) of ethanol.
- Reduction of mechanical performance

- Lower calorific value per kg
- Aldehyde emissions from the exhaust.
- Sulfuric acid content, due to some distillation processes.

Application in combustion engines

Methanol can be used as a fuel in a tertiary blend of ethanol and gasoline. This blend consists in 33% methanol, 60% ethanol and the 7% left of gasoline. The result is not as good as only ethanol. The advantages of the Methanol are its superior performance, higher power obtained in relation with its calorific power, higher engine efficiency, less pollution, lower combustion temperature and fewer risks. Compared with ethanol, methanol is much cheaper. Among its disadvantages we have corrosion, toxicity, the difficulty of cold starting and the emission of non burnt methanol and aldehydes, mainly formaldehyde. The advantages appear mainly at great speeds, while disadvantages can be imputed to the lack of study of methanol engines compared with others using other kinds of fuels.

What to conclude

Ethanol, no matter its origin, can be devoted to very different uses: the basic ones are nourishment and energy and, included in the last one, it can be burned directly or used in internal combustion engines. This versatility, similar to other biologically derived non-food products, is considered one of its main advantages.

Methanol is often mentioned as the best fuel for future surface transports, as it has a great versatility It is also an important raw material for plenty of chemical processes and can be obtained in very diverse ways, among which natural gas. Also, methanol is easier to handle, it is less volatile, less dangerous in case of traffic accident and combustion may be extinguished with water. Pipe transport of methanol is cheaper than that of natural gas when considering large distances.

Biofuel use in the airline industry

Bio kerosene has the potential to get in the international market faster than any other alternative fuels, even though it is among the newest and faces stricter quality standards because it is to be used in aviation. Airplanes have a useful lifespan of 30 to 40 years, and their manufacturers want to ensure they have fuel until the end. Since petroleum fuels are not desired anymore for obvious reasons. Investments are being made to develop, perfect and produce plant-based kerosene, fomented also by pressure to mitigate climate change.

The aeronautics industry is faced with a complicated situation. There are environmental pressures and petroleum based fuels are not a viable option. This requires strong investment in biofuels, the only alternative that seems viable.

EMBRAER, the Brazilian aeronautics company and one of the leading manufacturers of light and medium aircraft has designed the agricultural airplane EMBRAER EMB 202 Ipanema (showed on the figure below) which was the first certified to consume ethanol, in 2004. EMBRAER conducted the first demo-flight of this technology after extensive tests, and required more than 300,000 liters of the biokerosene developed by Expedito Parente(the father of Biokerosene). The demo-flight took place using an EMBRAER EMB-110 Bandeirante over 1,000 miles (~1,600 km), from São José dos Campos to Brasília. The flight, which took place on October 24, 1984 was considered to be historic, because was the first time that an aircraft flew with a vegetable-based fuel.

EMB 202 Ipanema

EMB-110 Bandeirante

Conclusion

All the technologies that have been shown in this document are promising and bright technologies since they meet all the requirements for a sustainable and cleaner future. The advantages of using renewable ways of producing energy go beyond any discussion that can be made and a full context has got to be implemented in order to have enough arguments for all the standpoints.

Nowadays these new means of producing energy cannot supply the entire world's energy demand since most of them are still under research. However, mathematically they can supply as much energy use as needed as long as appropriate care and heavy investments start

to be made. It take a big effort to implement new systems and bypass the old ones so in future, many can be beneficiated.

The benefits of the biofuels include a cleaner, renewable and sustainable way of producing power supply, the creation of multiple jobs in different areas, the substantial growth of several companies for a reasonable long period of time and the continuation of the current jobs since the transference of power supply from the current and dirty ones to the new and clean one is not fast.

Biofuels attend all the requirements for engines, generators, turbines and every other machine that require a fuel to run and produce energy. Biofuels have the same efficiency that other fuels have sometimes achieving greater values than the old ones. It is cost-effective since it can be produced using a small amount of money (when long term payments apply), but use a large amount of money to start producing.

They attend most of the requirements that the environmental departments demand and o not pollute as much as the old fuels since their production produced less particulates and the reactants are 100 percent natural.

Governments must invest in those new means of producing energy to move the economy and also solve part of the problems that the energy crisis deployed. As the reactants are 100 percent natural, as long as they attend the definitions, any material can be used so food supplies such as corn are not required to be largely used as it is currently.

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