23

Biofuels and Energy Self-Sufficiency: Colombian Experience

Elkin Alonso Cortés-Marín and Héctor José Ciro-Velázquez
Universidad Nacional de Colombia- Sede Medellín
Colombia

1. Introduction

The non-renewable nature of fossil fuels combined with the high level of participation within transportation sector in the total consumption of primary energy and atmospheric pollution, have become the primary forces propelling research of alternative sources for vehicles, mainly those sources derived from biomass. This has resulted in an increased environmental consciousness that seeks to replace fossil fuels or to provide blends that reduce their overall consumption. Mainly searching for these sources in agribusiness, and taking into account that tropical countries play lead roles here in Colombia is where the greatest variety of plant species can be found and where the environmental conditions make production of these more advantageous.

The global energy problem leads to express the scope, opportunities and threats that the use and partial replacement of conventional fossil fuels by biofuels or agrofuels represent for the development of a country, focusing in Colombia as a case study. The growing importance of new energy sources, (which can be derived from a variety of crops) and raw materials, which demands high biomass amounts, must generate some level of concern about the possible harmful effects of deforestation, jungle loss and replacement of crop fields essential for human diet (food safety). Not to mention the challenges in the climatic, geographical and physical fields, i.e. on whole nations' economies (Cortés et al., 2009) .

Today, these new energy sources are the new financial, political and even environmental strategies. Their importance is such that currently there are more than 30 raw materials being tested worldwide. Despite this big boost they still do not provide a solution to the global energy crisis (Cortés & Álvarez, 1998).

The possibility of using biofuels in the development of cars and engines, has been considered from the very beginning, but only as a result of the current energy and environmental situation, do conditions exist for the shaping of a global biofuels industry. The development of alternate energy has allowed the concepts of biofuel and energy crops gain importance every day, with greater strength in agricultural and energy policies of both industrialized and developing countries. The motivating factors have been, among others, the evident depletion of fossil fuels, the periodic oil crisis and the so-called greenhouse effect caused by the accumulation of CO2 in the atmosphere. Despite of this, it is important to recognize that biofuels will not end industrialized countries oil dependency, because there will not be enough land and water to meet the energy requirements of the automotive industry.

As a result, in order to prevent irreversible changes and reduce the impact of greenhouse gases on Earth's climate, many countries, including Colombia, have developed strategies to diversify energy production by using renewable sources. The first strategy has been replacing Oil-Derived Fuels with biofuels thus defining a reduction of CO2 emissions generated by mobile sources. It is therefore imperative to begin using alternative energies, that is to say those considered clean and renewable. For this reason biofuels could be a valid choice. Therefore, the use of renewable energy sources as an alternative to fossil fuels is a key strategy to reducing greenhouse gas emissions (Consejo Nacional de Política Económica y Social (CONPES, 2008)

It is at this stage that recently a dialogue, debate and confrontation regarding biofuels have been facilitated which allows for the development of new technologies and refineries to produce them. Such importance is not only the result of a sudden leap in scientific knowledge, although that has taken place, but rather it is a leap in governments funding, which seem concerned about oil prices rising and geostrategic dependence on them. Whatever the reason, if funding continues, in the short term a new generation of biofuels could be available.

Despite the enthusiasm, promotion and advocacy, there is a question: are biofuels a technical and economically viable energy and environmental option for replacing future fuel imports? But at the same time with the promotion and incentives (legal, regulatory, fiscal and financial framework), of alcohol fuels and bio-oils, employment rates will see a positive impact in farming regions. It is necessary not only to encourage biofuels production but also define programs that support the new refineries' biomass needs, so that the price of raw materials with dual purpose (food and biofuel) is not affected.

Certainly for Colombia it is necessary to diversify its raw materials portfolio for anhydrous alcohol and biodiesel production, incentivize the research and development of proprietary technology programs that produce biofuels at competitive levels for the domestic demand in the short and medium term and, in the long term to start exports.

In order to delay the depletion of reserves, to avoid the rising cost of imports, reduce gas emissions and the impact of particulate matter into the atmosphere, the policies of replacing energy sources, for the Colombian biofuel industry, provide an excellent opportunity due to the oil rising price, i.e. energy vulnerability risk decreasing.

In general, the text aims to illustrate the production and replacement of fossil fuels with bioenergy (ethanol, biodiesel), the progress, uncertainties and problems resulting from these processes for new energies generation and use, mainly with regards to the food safety and environmental consequences of poor countries. In particular, it presents the political, regulatory and legal framework, by which the Colombian government promotes the production and use of biofuels.

2. Energy replacement and consumption

For operating the machines, during this century and part from the previous: man has used greater amounts of energy from fuels. Fuels coming from forest resources like wood and natural energy coming from sun have not been enough to satisfy the energy appetite that this modern civilization has (Silvestrini, 2000).

This growing demand has created an energy crisis that has led to create programs, proposals, funding and research, to find processes for greater efficiency in energy generation, consumption reduction and uncover alternative sources that allow a diverse offering and increase life span of existing resources.

As long as societies develop, it is clear that energy dependence increases. As a result, the search for more efficient, cleaner, more economic new energy sources and fuels becomes a social need. Therefore, in many processes and business it is possible and feasible to replace oil with natural gas; electric power with solar power; firewood with biogas; tractors with animal traction, etc. At the moment, there is an increase and trend for the conversion of internal combustion engines (ICE) that use gasoline by replacing them with CNG (compressed natural gas). Several CNG dispensers have been installed in the main cities of Colombia. The introduction and claimed benefits have been linked with reductions in pollution and operation costs.

Mankind's welfare has always been associated with high-energy availability; unfortunately a society's progress is directly related to its level of consumption. Man needs energy to survive, manage his environment and produce goods. In distant times, at least, he needed energy to keep from starving. Over millions of years, the time it took to get from primitive forms to its present forms; mankind's evolution is closely linked to the different forms and quantities of energies that were available during each period. The energy consumption growth per capita and energy control has been a constant feature. Evolution changed Man from a gathering society, to a hunting society, an agriculture society, until today becoming a technological society, where per capita consumption in the U.S.A is close to 450 MBTU/inhab. Perhaps primitive man during his tenure in a gathering society consumed no more than 10 BTU/inhab. This growth in consumption is an indication of progress and risks as well as the complexities of the social organizations in which we live.

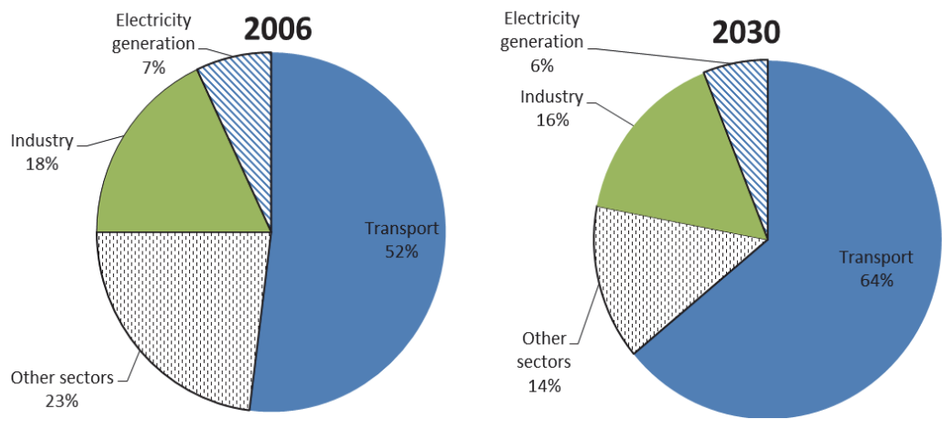
Although the safety and quality of our energy supply is of real concerns, we must avoid viewing the energy problem from a local perspective, surrounding countries, and in short term perspectives, now and in the near future. A realistic and deep approach regarding the energy issue must consider that a third of humanity lacks supply of electricity and any other form of advanced energy. It must take into account the safety of supplies for future generations and must be aware of the consequences of the environmental impact that energy production and consumption are having on the planet being passed on to our descendants. The amount of energy needed in the future mainly depends on its efficient production and use. With the purpose of evaluating energy efficiency, energy intensity may be applied as an indicator, i.e. energy consumption per GDP unit in each country. Along the way a trend in energy intensity reduction can be observed alongside the increase in economic development (Pérez, 2002).

Since the 70s it has been common to correlate the Gross Domestic Product (GDP) with countries' energy consumption. In the beginning it was an indicator of a developing country to see their energy consumption growing: more infrastructures and vehicles, appliances, heating and air conditioning systems, more power and better quality demand. It went from a traditional economy based on biomass combustion to an economy that makes a general use of electricity and fossil fuels, both for automotive and industrial use. On the other hand, increased consumption means more man-made fibers to fulfill clothing demands, larger workplaces and leisure trips, more housing space and in general more services. A country's welfare for better or worse is associated with increased income and this leads to an energy consumption increasing per capita (Valero, 2004).

In the last thirty years, global energy use has increased almost 70%, but this growth is uneven, because developing countries have almost tripled their energy consumption, while industrialized countries increased by 21%. The world's energy consumption grows faster than wealth or population because developing countries hold the 77% of the world's

population. On the other hand, since 1973 the countries belonging the Organization for Economic Co-operation and Development (OECD) have reduced their energy intensity or energy use by 24%per GDP unit. Energy demand has annually increased more than 2% since the 1973 crisis until today, and if current trends persist, this rate will continue over the next fifteen years (Brown et al., 2000).

Because the population is increasing and countries are getting industrialized, the global energy demand grows. That growth's projection classified by economic sectors can be seen in Figure 1. In addition, fossil fuels that are used are the main source of pollution in the atmosphere. The important role that energy plays in all human activities is widely recognized. Energy is not only transformed but it also transforms society. With its many developments and uses, energy has substantially changed modern life, by creating new services related to technological progress, and becoming the principal supply for the development and progress of any society.



Source: Perspectives énergétiques mondiales à long terme – le cas spécifique des transports. Agence Internationale de l´Energie. July 2007

Fig. 1. World oil consumption participation by sectors 2006 and 2030

According to the International Energy Agency (2006), dynamic growth in the biofuels market is associated with the evolution of the world's demand for primary energy, where fossil fuels have increased participation. Energy demand depends on factor's performance such as: a) world population increasing b) economic growth c) technological developments which allow maximize efficiency production and use d) implementation of measures towards climate change such as the development of alternative energy sources. Thus, the IEA estimates that by 2020 energy demand will be 16,000 Mtoe (Million Tonnes of Oil Equivalent), it means an annual growth rate of 1.7%.

The World Energy Council considers that in the next twenty years, world energy consumption shall approximately increase by 50%, which means it could be possible to provide energy to 4,000 million people (2,000 million that currently do not have it, plus the other 2,000 expected during this period).

But at the moment, energy has six considerable issues that must not be ignored in the scope any global economic analysis (Casilda, 2000).

First problem: production and consumption in unequal distribution around the world: large areas of primary energy production are different from the major consumption areas.

Second problem: has to do with the limited energy sources currently in use. Still nowadays, about 80% of the world's primary energy production comes from fossil fuels (coal, oil and natural gas), i.e. non-renewable sources and limited reserves.
Third problem: is the dominant role that oil plays within energy supply, oil where there is huge gap between production and consumption.
Fourth problem: comes from the relationship between energy and its development. The current energy consumption per capita is varied, as are the geographic levels of development. If in the coming years part of the developing world were come close to the level of energy consumption of industrialized countries, the world would face a long energy crisis, and Latin America would have an uneven behavior, as countries like Mexico and Venezuela would be favored, the two largest oil producers in the region and others would not, well most of them, due to their dependence . Likewise, developed countries would also be seriously affected.
Fifth major problem: production and energy consumption pose serious environmental problems that affect other productive resources worldwide, which could lead to climate change of irreparable consequences.
Sixth problem: is the ability to increase energy supply, which directly depends on the capital to be allocated for this purpose. In many Latin American countries capital is restricted due to regulations and low energy prices.
The use of different types of (electricity, motion, light or heat) and forms of energy (fossil fuels like coal, oil and natural gas, hydropower, nuclear energy or alternative energy) necessary for technologic and economic advancement, has produced the energy crisis that, since 1970, questions the possibility of keeping the current development model, in addition to other harmful effects, both because of the uneven development and the environmental consequences (pollution, global warming, etc.)
The nature of non-renewable fossil fuels and the high level of participation within transport sector of the total primary energy consumption and air pollution, have become the force behind promoting research of alternative sources for vehicles, mainly those sources derived from biomass. This has resulted in an increasing environmental consciousness, and seeks to replace fossil fuels or provide blends that reduce their consumption, mainly searching for those sources in agribusiness. Tropical countries play lead roles because it is where the greatest variety of plant species can be found and where the environmental conditions make production of these more advantageous.
Add to this the geopolitical crisis existing with the U.S.A and Iran, Iraq and Venezuela, and the decrease in global reserves that have influenced oil prices (over 75 U.S.D $/barrel), threatening the stability of many economies that do not have energy self-sufficiency. Under these circumstances, biofuels have become a strategic matter for the U.S.A: in 10 years they are seeking to replace 20% of oil consumption, and so does the European continent.
A technological solution to this problem is the use of biofuels; however, the price competitiveness of these compared to liquid fuels is still disputable. One of biofuels' restrictions is the cost of raw material and its transformation; so low-cost substrates are required to reach competitive price levels.
In practice, different raw materials can be used for industrial alcohol and biodiesel production; however, it is fair to consider that production cost of each liter or gallon strongly depends on geopolitical crisis the characteristics of the raw materials used and the type of process or technology used for their production.

Mainly in industrialized countries, biofuels supply behavior has been due to: biomass availability for their production, production costs and subsidies, and incentives for their production and use. In such respect, demand has been associated with fossil fuels dynamics and the growing interest for the reduction of greenhouse gases (GHGs), from major fossil fuel consuming countries, the latter being an opinion that is under discussion worldwide and must be evaluated in the country.

The contribution of biomass, wood, agricultural, livestock and urban-world residues to energy consumption is currently limited to traditional use as a fuel, especially in Least Developed Countries. However, advanced technologies like gasification, fermentation and anaerobic digestion for biomass exploitation, are increasing its important role as a sustainable energy source like liquid fuel or electricity production. When biomass is grown for burning , there are no net CO2 emissions in the whole process.

Current challenge with biomass is its sustainability management. By 2050 the calculated potential of energy production from biomass is about 10 times the current production, which would be enough to meet the current global energy needs. However, there are several factors that restrict this potential, among them the principal being water availability (UNDP, UNDESA, WEC, "World Energy Assessment, United Nations Development Program, 2000).

According to the growth projections from the International Energy Agency, it is estimated that biofuels participation within the energy market will be 4% by 2030 in comparison with the current 1%. The United States, the European Union and Brazil will be the leading countries in biofuels demand. On the other hand, developing countries will have an important role in such energy supply, so that it is estimated Asian and African countries participation for ethanol production, and Malaysian and Indonesian for biodiesel. Considering this, the expected biofuels demand by 2020 is estimated in 50 Mtoe, which is an annual increasing of 6.3%. Thus, it is estimated that ethanol production will be 524 mmba and biodiesel will be mmba 397.

It becomes important to reconsider current energy consumptions, given the evidence that free energy flows will be renewed as long as earth is habitable, unlike stored energy (oil, coal, gas), which is finite, or in constant decrease with increasing cost. This reason justifies the systematic capture of free energy flows (solar, wind, hydraulic, geothermal) or the use of biomass for generating biofuels. Thus, as long as man and society dominate and know the physical phenomena and natural contributions, the more energy that can be exploited. Therefore, it is not whether there is or is not enough energy to sustain human development, but the physical limits of energy use are going to be or have already been overcome.

Recently, within the scenario of energy generation from diversified sources, rises the clash of the feasibility for replacing crops for human consumption or for biofuels production in the automotive industry. The burden on agriculture for energy production seems to be very hard and biofuels promotion measures in many countries may trigger a very serious food conflict, with still unknown impacts on the poorest countries. In short term they could bring higher food costs.

The world faces complex challenges, it can not be considered the solution to life survival on Earth based on the alternative of renewable energy from biofuels, as it would increase food crops replacement by monocultures, deforestation for energy crops, would boost diversity extinction, cause reduction of fertile lands and water; plus social consequences caused by population displacement.

The use of a specific type of energy depends on two factors: availability for potential energy and technological capacity to turn it into heat or work. Of these two conditions, Colombia

has enough natural energy resources (coal, oil, gas, water falls, solar radiation, wind, biomass), being researched and developed in very early stages for its use. Therefore, replacing some conventional energy sources by renewable energies, with endless reserves, aims to reduce pollutant loads and is more environmentally friendly.

The kind or type of energy source used together with the application or purpose, varies over time within the countries, because the use of one or another depends on demand, pricing, availability in the same country or importation, technical reasons, international political situations, etc. In Colombia it can be said that most of current energy comes from burning fossil fuels, which are petroleum products processed in refineries.

Fossil fuels' finite and non renewable nature, plus the high air pollution from major population centers, automotive sector which has a high proportion in the total primary energy consumption; all this has promoted new energy or biofuels from organic resources (plants or animals). Colombia is a vulnerable country in regards to oil due to limited exploratory programs, lack of important new discoveries and decreasing reserves. As a result, the country is about to lose its oil self-sufficiency in the short term (2020), in the midst of high prices unfavorable situation. In addition there it is of poor quality due to its high sulfur content, especially in diesel which exceeds the international standards. Diversification of energy sources, preventing degraded climate change, and promoting social rejecting of polluting energy sources, constitute the challenges faced in order for science and technology to make a contribution for a development that is sustainable, recognized and supported by citizens

A condition for sustainable economic development is to ensure self-sufficiency in energy supply, which must be supported in a flexible and diversified energy structure; being at the same time, energy policy components. This policy should consider the agricultural sector's characteristics, pressed by other energy consumption patterns. Energy as a transformation, transference and accumulation process, should lead those communities to a more efficient use of the different available sources.

It must be a national goal to plan actions for replacing and optimizing the use of different energy forms. External energy inputs replacement by original sources in agricultural production units is one of the self-sufficiency energy objectives through the use of digesters, animal traction, solar, wind, mini stations and alternative fuels (alcohol, vegetable oils, natural gas, etc.)

The prospects resulting from energy optimization and replacement, will allow greater coverage of efficiency and economy of incorporated social benefits. Promoting this energy replacement, due mainly to higher oil prices in recent years, an increase that represents an onerous burden on the world's poorest countries' economies.

An energy program must be an integrated set of studies or research projects within biomass production, processing and the areas of energy consumption, linked to socio-economic studies and systems analysis, aimed to develop techniques and technologies on various energy sources (biogas digesters, gasifiers, solar cells, windmills, micro stations), bioenergy systems in rural areas, use of waste and design systems. Productivity and profitability paradigms that favor: high production values per unit of time, area and, invested money, must be accompanied by processes that also favor energy efficiency, in terms of consumption and savings.

Bioenergy is a rather broad term covering all energy products obtained from agricultural commodities or animal waste conversion processes, mainly required to meet automotive sector's demand in developed countries. Biofuels are a reality in several countries, including

Colombia. Biofuels have become an agro-industrial development model, which attempts to take part in the economic landscape and for this it has stimulus and a broad policy framework as well as multiple advocates and detractors.

Given the biofuels impressive growth (biodiesel and bioethanol) as a renewable energy source, it is necessary to consider in a more analytical and balanced way its options; benefits and limitations in a society that also requires increased food production. In any case, the use of these alternative fuels has negative effects both in natural and socio-economic levels. Despite some partial benefits, from the incorporation of new lands for the production of energy crops and agro-industrial development processes with the collateral effects on employment and possible exports as an added tax product. It is also necessary to face the nearly inevitable competition possibility between food and biofuels production, that within a high poverty levels society, it is worrying that production displacement in our food and agricultural system.

Biofuels present both opportunities and risks. The outcome would depend on the specific context of the country and the policies adopted. Current policies tend to favor producers in some developed countries over producers in most of developing countries. The challenge is to reduce or manage the risks while sharing the opportunities more widely. Biofuel production based on agricultural commodities increased more than threefold from 2000 to 2007, and now covers nearly two percent of the world's consumption of transport fuels. The growth is expected to continue, but the contribution of liquid biofuels (mostly ethanol and biodiesel) to transport energy, and even more so, for global energy use will remain limited. Despite the limited importance of liquid biofuels in terms of global energy supply, the demand for agricultural feedstocks (sugar, maize, oilseeds) for liquid biofuels will continue to grow over the next decade and perhaps beyond, putting upward pressure on food prices (FAO, 2008).

Today Colombia seeks different alternatives for solving the increasing difficulties set out by its development, mainly its population's diet in a natural sources panorama, especially when related to water and soil which may be eroded and contaminated. In order to prevent irreversible changes and reduce the impact of greenhouse gases on Earth's climate, many countries have decided to put their hopes on diversification of energy production strategies by using renewable sources. The first strategy has been replacing petroleum fuels with biofuels, achieving thereby a reduction in CO2 emissions generated by mobile sources (1). Therefore it is urgent to start using alternative energies, i.e. clean and renewable. For this reason biofuels can be a choice, not without question.

It is becoming more urgent to use other fuels in vehicles, mainly for replacing gasoline and diesel, diesel being the one that is gaining preference because of the costs (2). Therefore, it is advisable to research diesel replacements as opposed to gasoline.

The feasibility of using alcohol or biodiesel as automobile fuel in greater proportions than those currently stipulated is a proven fact. Even though there are great expectations, regarding hydrocarbon reserves existence underground in Colombian, the possibility that in a few decades the country has used all its oil must be. This consideration makes it necessary to pay attention to Brazil's experience, which aims to replace oil with other fuels. With optimism of our economy recovery, if new options are not found, the country will: increase its fossil fuels consumption of high priced products within the international market, that in the near future could consume our currency. No matter what, its price tends to increase as a result of the world demand and conflicts with governments in the Middle East and Venezuelan. For that reason, it is advisable to have a replacement from organic sources available, such as alcohol and biodiesel.

Unlike the oil industry, the new agro-energy industry involves a productive chain that impacts different economic sectors more directly, especially with regard to employment generation and agricultural and agribusiness development. The addition of Biofuels to blends helps to mitigate oil import requirements. This supports the national biofuel policy facing the balance of energy trade, and to some extent, defines security settings on the supply level.

Colombia has a great potential for establishing a big biofuel industry. Developing this industry gives the country an opportunity for exploiting its comparative advantages, as a tropical country with an agricultural tendency (biomass production) and suitable soils for feedstocks. Moreover, it becomes a technologically scientific challenge for research groups to focus their efforts on achieving proprietary technological developments by working together and interdisciplinary with public and private sectors. Unfortunately the substitution of conventional fuels with biofuels (ethanol and biodiesel) is also having ecological consequences.

Because of the current high demand, which is expected to increase in the coming years, many countries are cutting down large areas of tropical forests to cultivate biofuels. Although this is not the case in Colombia, as long as a favorable competition for energy feedstocks are shown (given the high government incentives and subsidies), against food without any government protection and also competing with the different free trade agreements. This is worrying given the large expanses of land necessary for feedstocks.

In conclusion, to really consolidate a coherent policy on new energy matter within the Colombian bucket, the following remarks must be considered:

- Environmental Ethics.
- The physical boundaries (finite resources).
- Climatic and geographical conditions.
- Crop Yields (kg/ha, l/ha, l/t).
- Energy intensity and energy return rate.
- Water requirements.
- Self Sufficient Process.
- Technology, return on investment (ROI) and profitability.

Not forget that compressed natural gas – natural gas vehicle (CNG-NGV) is another strong rival among the already diverse energy supply.

In that context, the National Government has promoted research and of new renewable energy sources that are sustainable with the increasing pace of life, while oil and its derivatives are partially replaced in different applications, mainly in transport sector. This promotion must also consider the implications when allocating millions of hectares for bioenergy production. This reality highlights the urgent need of fulfilling food needs or allocating those lands and feedstocks to meet the automotive industry energy requirements.

Energy is, undoubtedly, both a solution and a problem for sustainable development. As such, the hope is focused on the dilemma for fulfilling growing consumption needs while minimizing the social impact and ensuring resources. The world energy problem, fossil fuel reserves reduction, the air pollution problem and global warming, are matters of great importance for humanity without a global solution until now.

3. Precedents

Potential environmental and social benefits, among them; climate change mitigation and energy security contribution are mentioned as major support reasons from public sector for

biofuel industries, where growth has been fast. Therefore, in recent years fuel production as an f alternative to fossil fuels, from renewable materials, has acquired in recent years, a global push because global production of biofules has doubled and in the medium term it is expected to have strong growth due to high demand. Motivations have been, among others, the inevitable decrease in fossil fuels, the regular oil crisis and the greenhouse effect caused by the CO2 accumulation in the atmosphere.

In particular, in our country, diesel is in higher demand when in comparison to the quantities supplied by the crude oil processed in the refinery. For that reason it must be partially imported already manufactured. In addition to high oil prices, the agriculture crisis and low international oil trade rates are some of the factors that have contributed to give an additional role to biodiesel.

Liquid biofuels also known as biofuels, which are derived from agricultural raw materials, are products that are being used as replacements for gasoline and diesel in vehicles, they can also be used as blends. At the moment many countries encourage the idea of planting their own fuel, to lessen dependency on imports or exhaustible reserves, while generating stable and top-quality jobs. Biofuels are alcohols, ethers, esters and other chemical products made from cellulosic biomass such as grasses and woods, agricultural and forest waste and most of the municipal and industrial waste; as wells as vegetable oils. The term Biofuel refers both to fuels for electricity or transportation. Unlike oil which is a nonrenewable resource, biofuels are renewable and represent an inexhaustible fuel source. Both commercial and noncommercial, these fuels should always be considered as valuable products which can meet the growing demand.

The most important biofuels are ethanol (from sugar cane, sugar beet and corn) and biodiesel (from oil palm, soybeans and other oilseeds). Biofuel promoters highlight the ecological character of these fuels: they are renewable and are apparently environmentally friendly and produce less greenhouse gas emissions (GHG) in comparison to petroleum fuels.

It has been extensively spoken about biofuel models for more than a decade, and the opportunities and challenges that these oil substituting fuels can offer. This potential is not only related to environmental improvement, but it also includes economical, cultural and social aspects (Cortés, 2007).

In many countries (e.g. Brazil, USA and some European), including Colombia, have implemented policies favoring biofuels. Now these actions are having an effect: more and more agricultural commodities are for biofuel production. For this reason demand grows and causes these agricultural commodities in world market have high prices.

Biofuels apparently help to reduce greenhouse gas emissions, but most of the time it is not considered that for biofuels production, fossil fuels are used (diesel for machinery and products transportation, inputs production, etc.) It is also left aside that the expansion of agricultural frontiers (caused by the increasing demand of agricultural commodities) does not reduce greenhouse gas emissions. In the contrary, the forest is a carbon reserve and turning it into cropland releases this carbon as CO2 (the most important GHG). However, with the production of biofuels there are side effects that disturb an apparent prosperity. There are several scientists who defend that for true CO2 reduction re-forestation is vital as opposed to de-forestation for farming.

We must also consider that in large scale certain that biofuel inputs are produced by an agro industrial agriculture. This type of agriculture is supported in large monocultures; abuse of agrochemicals and the soil fertility overexploitation provokes water pollution (with pesticides), soil erosion, air pollution and loss of biodiversity.

On a national level, within the context of energy replacement policies, a delay in exhaustion of reserves, prevention in the rise of import costs and reduction in the impact of gas emissions and particulate matter into the atmosphere, present a great opportunity for the biofuel industry due to in part to the rise in oil prices. This opportunity is supported by a regulatory and legal framework of agro-energy production, including Act 693, of 2001 that proposes an initial 5% replacement of gasoline with alcohol. Later increased to 10% by 2010 and 12% by 2012; with similar proportions for replacing diesel with biodiesel. The same for the use of suitable lands for energy crops such as: sugar cane, cassava, sugar beet, oil palm , castor oil plant and jatropha, all of them with studies and different productivity levels (ton/ha, l/ton). Without denying the possibility of cellulosic biofuels from different sources.
In addition to the aforementioned, the National Government has promoted the development and search of new renewable energy sources, sustainable with the increasing pace of life, by partially replacing oil or its derivatives in different uses, especially within the transport sector. This promotion must also consider the implications when allocating millions of hectares for bioenergy production. This reality shows the urgent need for meeting food demands or allocating lands and feedstocks to meet the energy requirements of the automotive industry(Cortés, 2007). Within this context it is proposed that it will promote competition between the different biofuels, with criteria for financial sustainability and energy supply. For these purposes the feasibility and advisability of releasing biofuels prices and promoting removal of import duties on these products. Notwithstanding the aforementioned, the National Development Plan states that in any case the current pricing scheme based on opportunity costs of such energy, their replacements and raw materials used in its production must be considered. While simultaneously promoting strategies for prevention and control of air contamination, by promoting cleaner fuels, including those derived from crops with production potential for biodiesel and alcohol fuels.
The different types of biodiesel from the oil palm, castor oil plant, jatropha and sacha inchi, considered by the Ministerio de Agricultura y Desarrollo Rural (English: Ministry of Agriculture and Rural Development) as strategic for Colombia, have a wide range of chemical compositions and qualities. Oil palm biodiesel given its highly saturated chemical nature has excellent ignition and chemical stability qualities, but it has limitations as for its ease of flow at low temperatures. Oil palm biodiesel cloud point, i.e. the temperature at which crystals formation is visualized, is around 16°C. Crystals emerging and further agglomeration can clog fuel filters preventing the fuel to reach the engine. Castor oil biodiesel is characterized by high alkyl esters content from ricinoleic acid (about 90%), which are monounsaturated and have a hydroxyl group in its structure, giving the biodiesel a high viscosity. Jatropha biodiesel holds 80% of unsaturated alkyl esters from which 34.8% are di-unsaturated. Sacha inchi oil can reach an unsaturated level up to 94%, and it is the most unsaturated oil according to technical literature. Therefore, with jatropha biodiesel and, the oil obtained from sacha inchi, there could be problems in its chemical stability (Ministerio de Minas y Energía, 2007; Mesa, 2006).
Crops' biggest problem is that they can be expensive as raw materials, which makes the final product price high; so the State must allocate considerable tax resources to make these energies competitive. Aside from being expensive, these raw materials are crops' primary products, and only recently has the use of waste for biofuel production been taken advantage of. Faced with this adversity, many countries are researching and developing methods for producing ethanol from agricultural, forest and industrial waste, which are abundant and very cheap.

In this case, sugars shall be extracted from plant waste cellulose, such as banana or lumber industry. Today in Brazil there are technologies for the use of husks through fermentation processes. Are then biofuels a technically economic and environmental viable energy output for the nation, with sights to replace future fuel imports? Although after the laws regarding alcohol fuels and biological oils came to be, it can be surmised that employment rates in growing regions shall be positively influenced. It is necessary that the country not only encourage production of efficient biofuels and that from a cost perspective it can compete in the international market, but define programs that support need of new refineries for biomass production, so that the price of raw materials with dual purpose is not affected (for both, food and biofuel) (Cortés, 2007).
It is also necessary to define agricultural land management strategies in order to preserve forest areas and not turning them into biomass growing areas. According to previous observations, the country's agricultural industry can be articulated with the energy industry, without affecting food industry through price increases of raw materials, as it has been with sugar, wheat and corn.

3.1 Different energy issues

The correlation between development and energy consumption is well known. This is quite reasonable as we can consider the gross energy consumption from a society, as a way to amplify the human effort. Likewise, technological change allows for great development with a modest increased consumption of primary energy.
Energy access and its use strongly affect and are affected by population growth, urbanization, or development possibilities and poverty alleviation of a great part of the population. For example, energy consumption patterns of a third of humanity that use biomass as the sole source of energy, tend to reinforce their extreme poverty situation. Hundreds of millions of people, especially children and women, spend several hours a day looking for firewood or carrying water from considerable distances, this causes them to have fewer opportunities for education or more productive activities.
Current development and consumption model along with increased energy waste from rich people as well as consumption patterns from the most disadvantaged creates pollution and destruction that leads to poverty, and this poverty at the same time pollutes and destroys. This is the vicious circle: consumption - pollution - poverty. This is a complex relationship network, not always obvious, in which certain phenomena are cause and effect at the same time and no element can be considered separate or isolated. One of the most important challenges humanity has to face is to find how to produce and use energy in ways that in long term human development, in all its dimensions, is promoted: social, economic and environmental (Pérez, 2002).
It is expected that in the course of this century, the use of oil for producing electricity will be replaced by gas, clean burning coal , energy from renewable sources, and nuclear energy. However, the largest contributors to oil consumption and increased pollution is the transport sector, where in the medium term there is not yet a replacement, since current petroleum products are characterized by their high calorific value, they are also easy to store, carry and use.
The creation of liquid biofuels has been one of the ways that science has developed for replacing gasoline and diesel and preserving the environment. Modern bioenergy technologies are renewable energy sources that produce transportation fuels and are advancing very fast, mainly towards ethanol made from maize or sugar cane, which is

blended with gasoline in order to reduce both oil consumption and pollution. To use ethanol as fuel by blending it with gasoline, it is necessary to remove water for purity close to 99.9%, which requires special distillation methods.

Bioenergy competitiveness is associated with oil price, if price keeps current trends, there will be options for those trends. It must be considered if benefits and efficiency of these new fuels could survive without stimuli (subsidies) that now favor them. In a realistic framework it is necessary to avoid ambiguous positions that require a choice between biofuels or food production. It is important to combine both processes and add technology that improves production. But food safety issues cannot be jeopardized.

Security of supply is synonymous with the availability of all the energy needed, at an affordable price and for a long time, in fact indefinitely so it can be sustainable. If supply security is considered from a national perspective; dependence on external resources and the uncertainty of this non native supply becomes an important aspect.

"Opportunities for developing countries to take advantage of biofuel demand would be greatly advanced by the removal of the agricultural and biofuel subsidies and trade barriers that create an artificial market and currently benefit producers in OECD countries at the expense of producers in developing countries "said the director general of FAO, Jacques Diouf.

In the coming decades several challenges must be faced because of the energy and environmental problems arisen from it:

Energy efficiency: It will be necessary to radically increase the energy efficiency of processes and systems.

New technologies: It is necessary to develop and incorporate new technologies that achieve the above goal.

Diversify energy sources: At the moment we strongly depend on hydrocarbons as a primary energy source. It is necessary to incorporate new energy sources: natural gas, biomass, wind power, micro-hydro, solar energy and others.

Cogeneration: cogeneration as a means for energy efficiency and savings is not new. But incorporating it into the system on a grand scale may have a very large positive impact.

Then it is important to recognize that biofuels will not end industrialized countries' dependency on oil -not even Colombia-, because there will not be enough land and water to meet the high energy demand. In spite of this, the development of a national biofuel industry is an opportunity for the country. There are a number of technological, regulatory, economic and environmental restrictions or challenges that may affect critical links in the chain of biofuel production, and if they are not superseded they could lead to failure.

3.2 Energy Impact on the environment

There is no doubt that development and energy use are closely linked. In the coming years, a key matter will be how to ensure that energy sources are economical and reliable enough to guarantee us an adequate level of development. Energy availability is an obstacle for development; but environmental impacts may also limit or put the development at risk. However, this is not the entire problem. It is clear that all activities will have an impact on the environment. The issue is when this impact becomes negative or even irreversible. Throughout history there are a lot of examples of societies that made their environment collapse and in turn they collapsed.

At the global level the impact of energy activities on climate change must be highly considered, the so-called greenhouse effect. Climate change is not indeed the only global

threat to environmental sustainability, but many agree it is the most important. Its extent, complexity and direct connection with energy activities make climate change a paradigm. For example, the success or failure in the implementation of the Kyoto Protocol is still an excellent indicator of global community and each country's commitment with sustainable development (Pérez, 2002).

The impact of the production and use of energy has been observed for a long time. Deforestation of many areas and pollution associated with industrial processes are well known cases. But, although they were serious, it was about local impacts. In the last hundred years local effects have become global threats. The recognition of the association of energy with global environmental problems is a recent event that is affecting human health and quality of life, but especially that of future generations.

Undoubtedly, human activity has a big impact with respect to the environment. Today, Sustainable Development is mentioned a lot; in fact this is a contradiction of terms. Indeed, if we consider that development (which involves the permanent increase in the use of resources) must always increase. It is inevitable that within a long or short term we find crucial restrictions for development because of the inevitable shortages of resources. It is, therefore, essential to know the difference between growth and development. Indeed, a country can have strong growth, all the while achieving a high level of development simply at a slower pace. It is also possible to have large development increases with low growth rates. It is important to tell the difference between these two concepts as it allows taking a look at the evolution of a country from another perspective. In the last decade it is clear that Colombia has had enough growth; however our degree of development has been much lower. It is also clear that a finite growth is not viable because it involves having unlimited resources, which is not the case in our planet.

During the last century, impacts of human activity have been higher had taken place since the beginning of civilization. Footprints of human activity are changing the world at a rapid pace and energy has a lot to do with this impact.

Instead of detesting the technological development, it is necessary that some philosophical, ethical and social principles guide it. Not everything is good, cars have not given humans more freedom: because now travel time has increased, people need to work longer hours to pay it, cities have become uninhabitable, it is literally asphalting the living space, social conflicts are increasing because of the lack of communication, and due to noise and urban stress increasing, we move away from downtown and then our dependence on the car and our isolation increases. From that overview, it doesn't look like the car is synonymous with social development and welfare (Valero, 2004).

3.3 Biofuel, a sustainable energy?

In Colombia due to the act (693/2001), production of biofuel is it is expected to increase for use it in transportation as a measure to reduce greenhouse gas emissions. A target by 2010 is to replace 10% of fuels, used today for transportation, with biofuels that will increase up to 20%. With that, reduce CO2 emissions to the atmosphere that cause the greenhouse effect.

One of the main problems is that it causes higher prices for basic foods. Biofuels are produced from products like maize (corn), sugar cane, wheat or soybeans; and when the availability of them decreases in the food market, it drives up prices. At the same time, available area for food crops also decreases because most of these crops are for biofuels, which results in increasing the agricultural commodity's price in general.

Economic effects from this rising food prices are being felt in recent years, especially in some poor countries. For example the crisis that took place in Mexico because of the maize

tortillas rising price, which has doubled in recent years (similar to what is happening in our country with the rising price of bread and milk).

Replacement of conventional fuels with biofuels is also generating adverse ecological consequences. Most of the feedstocks needed for processing take place in developing countries, mainly in Latin America and Asia; most of these countries are cutting down large areas of tropical forests for growing biofuels.

For the production of clean fuels it is necessary to use dirty fuels as energy source. For instance, intensive sugar cane crops (for ethanol) or other oil crops (for biodiesel) will need petroleum products: fertilizers, insecticides, fuel pumps, transport and industrial processing. Therefore it is possible that pollution levels increase by using dirty energy sources for producing and exporting clean energy sources.

So far it is clear that bio in biofuels must have a question mark. Then, it can not be neither justified nor adopted policies for biofuels promotion and support, based on ecological arguments, or in industrialized countries (where people want to use agro-energy) or in developing countries (where people want to produce them).

To classify biofuels as bio, it would necessary to grow in degraded and poor soils that are unsuitable for food production (the so-called second generation biofuels). This prevents the rising prices of food and deforestation. An international certification scheme could ensure the sustainability of agricultural practices for the production of raw materials for biofuels.

In order to reduce possible impacts caused by biofuel production, certification for procedures of its production have been developed around the world; this is how the Dutch government, among others, aims that imported biofuels are certified according to environmental and social criteria. Certification of the entire process shall be necessary to ensure the world sustainability production and the use of biofuels (Testing framework for sustainable biomass, 2007).

Likewise, one of the most important factors for defining biofuel production feasibility is energy balance (the comparison between the energy used for producing biofuels and energy production). From the energy perspective, it is not enough to take into account the energy generated by a fuel, but it also must be considered the global energy balance, considering energy expenditures for fuel production and energy derived from it. Undoubtedly, for the production of that fuel to be profitable, the balance must be positive, i.e. it must generate more energy than consume.

Again the usefulness of biofuels as potential replacement for fossil fuels in the reduction of greenhouse gas emissions has been questioned. Several specialists have shown that the cultivation and use of, is not as efficient as a measure to slow down climate change as their advocates say.

Specifically deforestation, caused because of these feedstocks expansion, can have devastating effects in terms of climate, as well as from the ecological perspective. According to studies, forests from a particular area can reduce CO2 emissions nine times more than a biofuel feedstock with the same area, as well as the subsequent use of those biofuels for transportation.

If that wasn't enough, along the acquisition process of these fuels (including cultivation, processing, transportation and distribution), more CO2 is released than those crops can absorb while growing. This is because large amounts of fossil fuels are needed; resulting in emission of greenhouse gases, that in the case of bioethanol, these plants cannot entirety absorb. This, linked with the high water consumption required for producing them, especially biodiesel (for one liter of biodiesel 12 liters of water are consumed), makes them a non-sustainable alternative compared to fossil fuels.

Given the multiple problems shown by first generation biofuels, once again a technological solution is offered: liquid biofuels production (BtL, Biomass to Liquid), which can be obtained from lignocellulosic biomass such as straw or wood chips. These include bio-ethanol produced by hydrolyzed biomass fermentation and biofuels obtained via thermo chemistry, such as bio-oil obtained from pyrolysis (carbonization), gasoline and diesel oils produced by Fischer-Tropsch Synthesis, among others.

3.4 Biofuel programs in Colombia: objectives

It is mainly to promote the diversification of the energy basket through the use of biofuels, with the following criteria (Mesa, 2006):

- Environmental sustainability.
- Favor lignocellulosic crops replacement.
- Agricultural employee maintenance and development.
- Energy self-sufficiency.
- Agro-industrial development.
- Improving the quality of country's fuels, as a result of a blending between biofuels and fossil fuels.

To achieve these goals, Colombia faces the challenge of moving into strategic areas, among them are: a) consolidation of an institutional framework for the formulation of actions related to the handling of biofuels; b) reduction in the production of biofuels in the most critical points of the production chain, c) increasing the productivity of biofuels throughout all the production chain, d) research and development looking towards increasing biomass crop yields, develop new varieties adapted to different growing conditions and resistant to plagues, and develop changing processes of first and second generation e) price regulation in order to encourage the efficient production of biofuels, and f) differentiation of the Colombian product in order make easier the access to international markets by adding strategic environmental and social variables, besides food safety protection measures (Consejo Nacional de Política Económica y Social (CONPES, 2008).

As stated by the Consejo Nacional de Política Económica y Social (CONPES) (in English: National Council of Economic and Social Policy) of the Colombian government: This will enable the ability to take advantage, in a competitive and sustainable way, of economic and social development opportunities offered by biofuels emerging markets. At the same time it will allow: increasing competitive sustainable biofuels production by contributing to employment generation, rural development and population welfare; promoting an alternative productive development to the reliable rural land occupation; contributing to the formal employment generation within the rural sector; diversifying the country's energy basket throughout biofuels efficient production, by using current and future technologies; ensuring an environmentally sustainable performance throughout the addition of environmental variables when making decisions in the chain of biofuel production.

4. The most common raw materials

Energy crops are those developed only for fuel. These crops include fast growing trees, shrubs and grasses. These can be grown in agricultural land not needed neither for food, nor pasture nor fibers. In addition, farmers can grow energy crops along the banks of rivers, around lakes or in farms areas including, natural forests or swamps, for creating habitat for

wildlife, renewing and improving soil biodiversity. Trees can be grown for a decade and then being cut down for energy.

Thus, bioenergy covers all forms of energy derived from organic fuels (biofuels) form biological origin used for producing energy. It includes both crops intended to produce energy which are particularly grown and multipurpose crops and by-products (residues and wastes). The term By-products includes solid, liquid and gaseous byproducts derived from human activities. It can be considered biomass as a sort of converted solar energy.

It can be said that biodiesel production tends to come mainly from oils extracted from oilseeds plants, but any material containing triglycerides can be used for biodiesel production (sunflower, rapeseed, soybean, oil palm, castor oil, used cooking oils, animal fat). Here are the main raw materials for biodiesel production (Mesa, 2006).

Conventional vegetable oils: raw materials traditionally used for biodiesel production have been: oils from oilseeds such as sunflower and rapeseed (in Europe), soybeans (in The United States) and coconut (in The Philippines), and oils from oilseeds fruits such as oil palm (in Malaysia, Indonesia and Colombia).

Alternative vegetable oils: in addition to traditional vegetable oils, there are other species adapted to the conditions from the country where they are developed and better positioned within the field of energy crops: Jatropha curcas oil (Ministerio de Minas y Energia, 2007).

Biofuels have become very important because of the variety of crops from which they can be derived, but this energy supply demands a high production of them. This would have harmful effects because of the destruction of forests and jungles and replacement of crops that are essential to human diet; besides the drawbacks shown in the following fields: climatic, geographical and physical. The main supply sources of raw materials for biofuels production are shown in Table 1 and Figures 2, 3 and 4.

Crop	Efficiency (l/ha/year)	Efficiency (ton/ ha)	Estimated barrel price (US $)
Sugar Cane	9	100	45
Cassava	4,5	25	NA
Sugar Beet	5,000	NA	100
sweet sorghum	1,189	NA	NA
Cellulose	NA	NA	305
Maize	3,2	10	83
Oil palm	5,55	NA	NA
Coconut	4,2	NA	NA
Castor oil	2,6	NA	NA
Avocado	2,46	NA	NA
Jatropha	1,559	NA	43
Rapeseed	1,1	NA	NA
Peanut	990	NA	NA
Soybeans	840	NA	122
Rapeseed	NA	NA	125
Wheat	NA	NA	125
Sunflower	890	NA	NA
Oil	NA	NA	70-80

Table 1. Raw materials for biofuel production: Source: Ministerio de Agricultura y Desarrollo Rural, MADR (English: Ministry of Agriculture and Rural Development); Portafolio: Goldaman Sachs (2007)

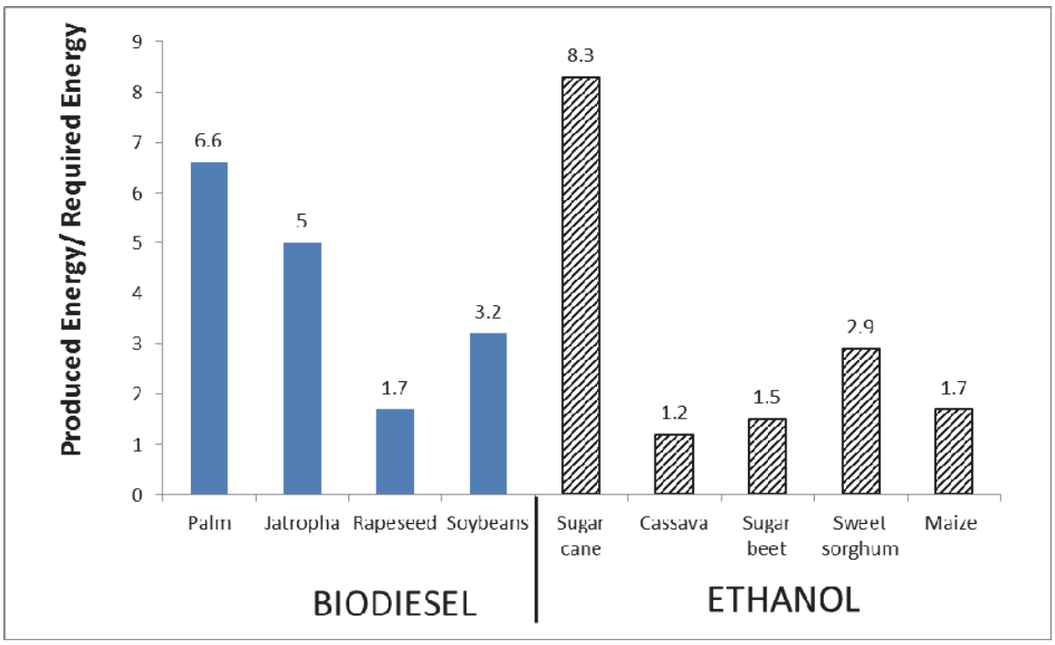
But not all the questions are clear and therefore the UN declares: if growing fields for biofuels production increase disproportionately, food and the environment could be at risk. Increased logging. Also food prices could increase.

For major producing countries, costs of ethanol production range between 32 and 87 USD/barrel (International Energy Agency, 2006). According to the available information, about 47% and 58% of this cost is raw materials, about 13% and 24% for inputs, about 6% and 18% for operation and maintenance costs and, about 11% and 23% to capital costs. It can be said that production costs widely vary between countries due to agro-climatic factors, land availability and labor cost that affect the kind of biomass used as raw material; this factor affects transformation technologies selection.

Figure 2 shows sources of raw materials sources for alcohol and biodiesel production and the corresponding efficiency. Figure 3 and 4 show ethanol efficiency from biomass sources in countries outstanding in their production. There is higher ethanol efficiency from sugar beet, in comparison with sugar cane and corn.

For every ton of cassava, 200 liters of ethanol can be obtained, when making the cassava calculations as a yield base of 25 ton/ha it can be obtained a yield of 5000 liters/ha can be obtained which is lower in comparison to sugar beet but higher compared to corn and sugar cane. With fertilization programs and cassava crops mechanization, yields can be increased to values of 70 ton/ha, which will triple cassava yield in liters/ha (Altin et al., 2001).

Another important factor is that biofuels do not work as well as petroleum fuels. In order to increase their production most of the fertile lands would have to be assigned for farming them, which could be counterproductive in a world where hungry and desertification are two problems with difficult solution.



Source: Ministerio de Minas y Energía (English: Ministry of Mines and Energy), based on Goldman Sachs and LMC

Fig. 2. Energy efficiency in biofuel production

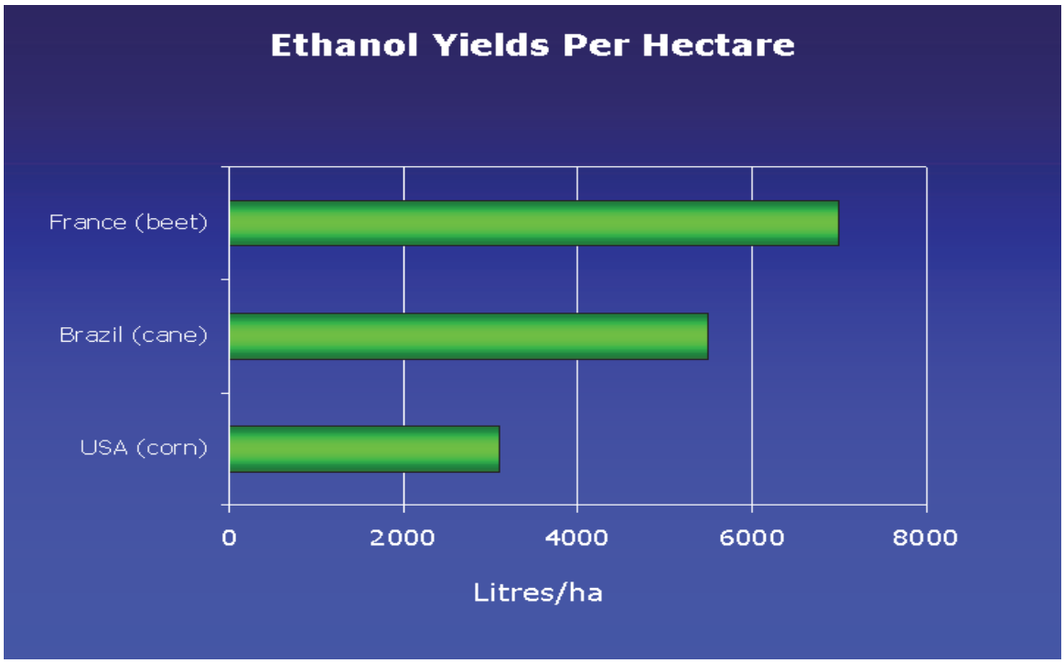


Fig. 3. Ethanol yields from biomass (Source: FAO, 2007)

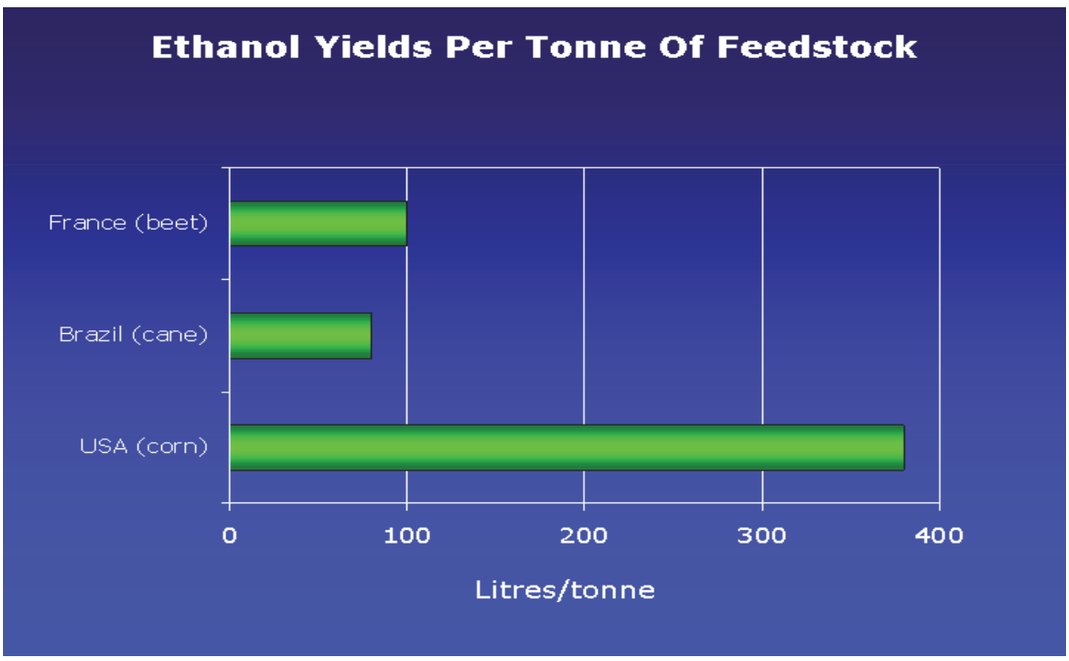


Fig. 4. Ethanol yields in liters per Tone of Feedstock. (Source: FAO, 2007)

5. Technical considerations

Biodiesel use in diesel engines is more limited. As well as ethanol, biodiesel is produced by fast pyrolysis of lignocellulosic biomass and mainly fermentation, because fast pyrolysis is a more expensive way (Bridgwater et al., 2002), it is a renewable oxygenated fuel with low cetane components (Ikura et al., 2003). Its heating value is about 60% of ethanol, but its high density makes up for its percentage. When using biodiesel in machines and engines there are some problems (Lopez & Salva, 2000) because of its higher viscosity and acidity, tar and fine particles resulting during working hours and solid residues during the combustion.
Following the direction of ethanol research, attempts have been made to overcome these problems by blending bio-oil with diesel to form an emulsion (Chiaramonti et al., 2003). In some success these efforts solve the operation with these fuels, however it is necessary to prove the feasibility and the additional cost of surfactant required to stabilize the blending which is a barrier for using it.
It must be considered that the blending of biodiesel and ethanol makes a stable blend and a fast pyrolysis, without using additives and surfactants. Current research on these blends is limited to gas turbines (López & Salva, 2000) and their use in these engines has shown positive results. Biodiesel blended with ethanol shall not exceed the problems of direct ethanol use in diesel engines without modification. However, using modified engines to use ethanol blends of ethanol/biodiesel could overcome the problems related to pure biodiesel combustion. As all new fuels, it is necessary to solve technical problems such as fuel storage, material compatibility, and procedures for turning engines on and off and long operation periods (Nguyen & Honnery, 2008).

5.1 Benefits

However, in Colombia, promotion of biofuels production may represent several benefits:
Energy sustainability: it will help to reduce the use of fossil fuels, thus protecting oil reserves. That is, a decreased risk of energy vulnerability. According to the Ministerio de Minas y Energía (English: Ministry of Mines and Energy) estimates show if new deposits are not found, known reserves will support the demand only for a few years. In this context, adding 10% of ethanol to gasoline helps to support fuel needs. Furthermore, Colombia has set the goal of increasing that percentage to 25% by 2020, which requires the new projects for ethanol production and the use of biomass sources other than sugar cane. In the short term the national program for Biofuels, seeks to improve fuel trade balance, and thus avoid wasting foreign reserves and spending at high prices by importing oil and petroleum products, that now tare close to 100 USD/barrel).
Environmental: biofuels are biodegradable, 85% is degraded in about 28 days.
Ethanol is a compound free of aroma, benzene and sulfur components, so the blending produces less smoke (particulates) and generate lower emissions (Stern, 2006). By using a 10% ethanol blending there is a reduction in CO emissions between 22% and 50% in carbureted vehicles, and a decrease of total hydrocarbons between 20% and 24% (Lopez & Salva, 2000).
With only a 10% blending of ethanol with gasoline, in new cars, 27% of carbon monoxide emissions decrease. In typical Colombian cars with 7-8 years of use it decreases 45%, and there is 20% reduction in hydrocarbons emissions. The effects of these reductions shall be reflected in the environmental emissions indices (Kumar, 2007), and in improve the citizens'

living conditions, for example Bogotá where acute respiratory diseases are public health problems. Diesel blending decreases vehicle emissions such as particulate matter, polycyclic aromatic hydrocarbons, carbon dioxide and sulfur dioxide (U.S. Environmental Protection Agency, 2003).

Biodiesel is biodegradable, nontoxic and sulfur and aromatic components free, no matter the source of the oil used in its production. It reduces the soot emission in 40%-60%, and CO between 10% and 50%. Biodiesel can replace diesel (diesel fuel) without changes in ICE. Emissions with primary pollutants; with the exception of nitrogen oxides NOx. Despite these obvious benefits, there is not enough information about the solution to by-products and waste generated from biethanol-vinasses-and biodiesel-glycerin production processes, which are a source of future contamination if they are not properly disposed.

Agricultural development: biofuels production from agricultural raw materials, can guarantee both jobs growth and the possibility of crops diversification, including those for biofuel production. Export expectation, if there is pipe dream with Free Trades Agreement implementation, where Colombia supposedly is able to export bioenergy to poor energy countries, or that require large amounts of fuel for supporting economic growth.

Advantages of Colombia: As a reference, the abundance and variety of raw materials could be pointed out; several regions suitable for cultivation in all the country; guaranteed domestic market; government incentives and appropriate legal framework; high-yield crops, uninterrupted interest in research and development.

5.2 Regulations

Colombia, in order to reduce gasoline and diesel consumption, has implemented policies to encourage domestic production of biofuels. This purpose is economically boosted compared to fuels consumption reduction by the automotive industry and the best environmental indicators of mobile source emissions given the oxygenating effect of biofuels in combustion. For that reason in 2001 it is passed the Act Nº 693 and in 2004 the Act Nº 939, which states regulations on alcohol fuels and vegetable oils in the country, and creates incentives for their production, marketing and consumption.

In this regard, the Government has promoted development of biofuels through different measures to encourage their production and use. In this matter there is a broad regulatory and incentives for bioenergy production in Colombia, namely (Ministerio de Minas y Energía, 2007; Cala, 2003):

Act 693/2001: the regulations about the use of alcohol fuels are thereby stated; Incentives are created for their production, marketing and consumption. This act makes obligatory the use of oxygenated components in fuels for vehicles from cities with more than 500,000 inhabitants. A deadline of 5 years was established for gradual implementation of this regulation.

Act 788/2002: tax reform where exemptions were introduced to the Value Added Tax (VAT), the income tax and surcharge on alcohol fuel blended with gasoline engine.

Act 939/2004: defines the legal framework for the use of biofuels, by which the production and commercialization of biofuels of plant or animal origin, are thereby encouraged for use in diesel engines and other purposes. Exempts biodiesel from VAT and the income tax and establishes a net income exemption for 10 years to new oil palm plantation. This exemption applies to all plantations to be developed before 2015.

Act 1111/2006: establishes a 40% income tax deduction of investments in real productive fixed assets of industrial projects, including financial leasing.
Act 1083 2006: some regulations on sustainable urban planning and other provisions are thereby stated.
Resolution 1289/2005: establishes biofuels criteria quality for their use in diesel engines, states the date of January 1st 2008 as a blending start of 5% of biodiesel with diesel fuel.
Resolution No. 180127/2007: the heading "MD" in Act 4 from Resolution 82439 from December 23th, 1998 is thereby amended and amends Act 1st from Resolution 180822 from June 29th, 2005 and, states the provisions relating to Diesel Fuel pricing structure.
Decree 383/2007: Amends the Foreign-Trade Zones Decree 2685 of 1999, regulates the set up of Special Foreign-Trade Zones for high economic and social impact.
Decree 3492/2007: Act 939 of 2004 is thereby regulated.
Decree 2328/2008: The Intersectoral Commission for Biofuels Management is thereby created.
Decree 4051/2007: Permanent Foreign-Trade Zones area requirements is thereby stated; requirements for stating the existence of a Special and Permanent Foreign-Trade Zone and Industrial User recognition.
Resolution No. 180158/2007: clean fuels are stated thereby in accordance with the Paragraph in Article 1, Act 1083.
Resolution No. 180782/2007: biofuels quality criteria for use in diesel engines as a component of the blending with fossil diesel fuel in combustion processes are thereby amended.
Resolution No. 180212/2007: Resolution 181780 December 29th, 2005 is thereby partially amended, regarding the pricing structure of diesel fuels blended with biofuel for their use in diesel engines.
Decree 2629/2007: provisions for promoting the use of biofuels in the country are thereby stated, as well as applicable measures for vehicles and other motorized devices that use fuels. From January 1st, 2010 timetable is thereby set up for extending the mandatory blending of biofuels of 10% and, 20% from 2012 as well as the requirement that from January 1st 2012, new vehicle parc and other new motorized devices should be Flex-fuel at least 20%, for both E-20 blending (80% of gasoline from fossil fuel, with 20% of alcohol fuel) and B-20 (80% of diesel fuel with 20% of biofuels).
Decree 1135/2009: In connection with the use of alcohol fuels in the country and applicable measures to motor vehicles using gasoline, decree 2629, 2007 is thereby amended. And which states in its article 1: from January 1st, 2012 motor vehicles up to 2000 cm3 manufactured, assembled, imported, distributed and marketed in the country and requiring gasoline to operate, must be soup up so that their engines run Flex-fuel system (E85), i.e. they can work normally by using either basic gasoline or blends composed of basic fossil fuel with at least 85% alcohol fuel. To meet the above, each brand shall sell vehicles in the Colombian market according to the following schedule and provisions:
From January 1st, 2012: 60% of its annual supply must support E85.
From January 1st, 2014: 80% of its annual supply must support E85.
From January 1st, 2016: 100% of its annual supply must support E85.
From January 1st, 2013: vehicles with engine cubic capacity greater than 2000 cm3 from all brands and models shall bear E85.
It is worth mentioning CONPES-3510/2008 document (in English: National Council for Economic and Social Policy document 3510/2008), where a policy to promote the

production of sustainable biofuels in Colombia is thereby established, by taking advantage of economic and social development opportunities which are offered by biofuels emerging markets. Thus, it intends to expand the known biomass crops in the country and diversify the energy basket within a framework of production that is financially, socially and environmentally efficient and sustainable, that makes possible to compete in domestic and international markets.

Likewise the promotion of biofuels is also done through: the National Development Plan (NDP), the establishment of a regulatory framework and the development of financial and tax incentives. Also, the National Government has policy guidelines in areas such as: agriculture, research and development, infrastructure and environment that influence biofuels development.

There are also other complementary policy developments in the form of decrees and ministerial decisions that define the technical regulations, quality standards, as well as pricing, margins and rate parameters for fuel ethanol and biodiesel transport. There is an applicable regime in the Foreign-Trade Zone and several soft loan sources for agricultural development (González, 2008).

Among them, in the framework of Agro Ingreso Seguro Program (AIS), financial instruments that provide soft loan sources for growing crops that produce biomass for ethanol and biodiesel production have been implemented. In addition, through the Incentivo a la Capitalización Rural, ICR (in English: Rural Capitalization Incentive) it is promoted, among others, oil palm crops establishment and renewal, and the construction of infrastructure for biomass processing (Consejo Nacional de Política Económica y Social (CONPES, 2008)

Despite this broad regulatory framework, there is uncertainty about changes in: regulation, raw material prices and emerging new technologies. In particular, with gallon prices as defined by state intervention (subsidies), that generates the discussion about how much does it mean for the national treasury, and whether it is advisable or heavy subsidies is fair to benefit a minority that supply biofuels, for even small domestic market and one that is difficult to be exported.

As shown, the Colombian Government has a fairly strong policy and information that allows for investment in projects, sustainable energy and biofuels plans and programs through a set of tools, studies and institutional strengthening.

Therefore, the Colombian Government has promoted assessments that seek to: a) study the implications of the biofuel industry, from planting crops for biofuel production to the final consumers of ethanol or biodiesel (flex-fuel or normal vehicles); b) analyze the current infrastructure requirements for the expansion of the biofuel market; c) know the sector current status, as well as the economic instruments, regulatory elements, policies and tax incentives required or recommended for promoting renewable energy, energy efficiency and biofuels; d) analyze the renewable energy potential, energy efficiency and carbon credits through the Clean Development Mechanism. Likewise, institutional strengthening assessment required by the Ministerio de Minas y Energía (English: Ministry of Mines and Energy) (MME), in energy efficiency, renewable energy, bioenergy and carbon financing.

This set of measures that promote the enthusiasm for liquid biofuels such as the mandatory blending of biofuels with fossil fuels and tax incentives, have created a fast artificial growth in biofuel production. These incentives have broad social impacts, as they are resources that do not come into the State, and are taken for solving important issues such as health, education and basic sanitation.

These measures entail high economic, social and environmental costs and should be monitored promptly.

5.3 Current projects under construction

Ethanol: In compliance with the provisions of Act 693/01, the country began to implement initiatives for alcohol fuel from sugar cane. At the moment 5 ethanol plants are running: Incauca, Providencia, Manuelita, Mayaguez and Risaralda refineries that produce about 1,050,000 liters of alcohol fuel a day and this production is mainly to supply the domestic market. It is estimated a domestic demand close to 1,500,000 liters per day to cover the 10% of blending needs.

Likewise, in the country several alcohol production projects are being implemented in several departments: Antioquia, Boyacá, Santander and the coast, derived from different raw materials such as sugar cane, sugar beet, banana and cassava.

Unfortunately, due to the economic crisis there is absence of new plants. Projects are standstill, and Ecopetrol plant would only come into operation in 2011, starting with a production of 385,000 liters a day. At the moment there is another project being developed in Magdalena, where an international company sowed a very large sugar cane area for producing an average of 300,000 liters a day. With this, the 20% blending could be reached by in 2012 without any problem.

Biodiesel: At the moment there are five projects under construction for producing biodiesel from oil palm (Oleoflores – already in production, Odin Energy, Biocombustibles Sostenibles del Caribe) and two in the eastern region (Biocastilla, Bio D. SA). In addition, they are other projects under development, one in the central region (ECOPETROL), one in the eastern region (Manuelita), one in the west region and another in the north region. In 2008 it is expected they shall enter into production, with a total amount of 400,000 t/year (19).

How are investments for biodiesel production doing? Construction of the Ecopetrol plant in Barrancabermeja is almost over. With this in total there will be seven plants in the country. A total installed capacity of 526,000 biodiesel tonnes a year may be achieved.

6. Conclusions

It must be accepted that the so-called modern man now has the same challenge our ancestors solved centuries ago, that life is not over. Availability of natural resources and the way we use them, force us to shape a scenario of technological innovations and social coexistence, in which the ethics of life prevails over money; this becomes more valid in this global world that requires new economic, lifestyle, consumption and value models.

Society needs energy for its development, but development does not necessarily imply a waste of energy. In any productive process, materials and water may or may not be wasted, but it is certain that it will consume energy and that energy consumption will be associated with a real environmental impact. If energy production takes on all costs, it would be much more expensive.

New energy sources are the new economic, political and even environmental strategy. Their importance is such that currently over 30 raw materials are being tested worldwide. Despite this big boost, they do not yet provide a solution to the global energy problems.

Biofuels should not be taken as the solution to the energy and environmental problem, but as part of a complex human and energy project where leading countries still disagree on a solution. If Bioenergy is properly used, it provides a historic opportunity to contribute to the growth of many of the world's poorest countries.

A reality must be emphasized; alcohol fuel is more expensive than gasoline and biodiesel. It is not good business that a market economy develops isolated and organically; the market must be intervened so these alternatives are viable, because rival fuel is cheaper. Oil is in the reservoir, while cassava, sugar cane, oil palm or other crops used as raw material must be planted, and in expensive lands. Then, by definition, we talk about a project that is viable only if the State intervenes so it can be operated outside the framework of the market.

The world faces complex challenges and life's survival on the planet can not be supported on the solution to the renewable energy alternative based on biofuels, as it would grow the replacement of food crops with monocultures, deforestation for energy crops, while it would boost the diversity extinction, fertile lands and water reduction, and the social consequences population displacement causes.

In that sense the FAO has declared: Biofuel policies and subsidies should be urgently reviewed in order to preserve the goal of world food security, protect poor farmers, promote broad-based rural development and ensure environmental sustainability. But also states: Growing demand for biofuels and the resulting higher agricultural commodity prices offer important opportunities for some developing countries. Agriculture could become the growth engine for hunger reduction and poverty alleviation, production of biofuel feedstocks may create income and employment, if particularly poor small farmers receive support to expand their production and gain access to markets.

It also requires a certification system that ensures that biofuels will be marketed only if they have the necessary environmental requirements.

Colombia is not and cannot be indifferent to the global market trend for crude oil and its derivatives. This fact gives the opportunity for goods production, such as biofuels, that allow diversity in the energy basket available in the domestic market and that can be exported to international markets. However, a necessary condition for competing in the international market is efficient conditions for the production of these goods.

Colombia has enough available land for growing biofuels, from 14 million hectares for agriculture business and 20 for livestock, only 5 million are currently in use and the remaining is for extensive cattle ranching; a better use could be biofuels which would provide plant cover and rural income opportunities. It also holds high productivity in sugar production from sugar cane, but such activity has been focused on agribusiness models, where production is held in few companies from renowned economic groups.

Although in Colombia ethanol has been a biofuel pioneer, biodiesel projects are gaining strength and this fuel can have a greater impact and national coverage.

In the country there is a poor use of natural resources and a high dependence on them; there is not full agreement between vocation or fair and the use of resources. Productivity paradigm boosts to predatory models and the economic efficiency and profitability fallacy as sole indicator, productive projects that do not consider social and environmental benefits are presented.

Then, in the previous horizon, it is required to develop a long-term sustainable agriculture that is compatible with the environment. The aim of this is a critical reassessment of the

current modernizing model, taking into account that different technological offers, articulated to a diverse set of socio-economic and environmental factors, require different technological solutions. Consequently, decisions about biofuels should consider the food safety situation but also land and water availability.

Energy has deep and broad relations with the three sustainability dimensions (economic, social and environmental); i.e., it must go into the integration, harmonization and optimization. The services energy provides help to meet several basic needs such as: water supply, lighting, health, ability for producing, transporting and processing food, mobility and information access so that access to a certain amount of advanced forms of energy such as electricity or liquid fuels and gaseous fuels, should be included among the inalienable human rights in the XXIst century. Energy supply safety and energy prices are crucial for economic development. On the other hand, it is clear that many ways of producing and consuming can reduce environmental sustainability. We must ask: is the current energy production and consumption sustainable? One of the most important challenges humanity faces is to find the way to produce and use energy so that in the long term human development is promoted, in all its dimensions: social, economic and environmental.

Finally, to balance the enthusiasm with objectivity: it is necessary to carefully study the economic, social and environmental bioenergy impact before deciding how fast it is desired to be developed, and what technologies, policies, investment and research strategies to follow.

7. References

Altin, Recep, Çetinkaya, Selim & Serdar Yücesu, Hüseyin. (2001). The potential of using vegetable oil fuels as fuel for diesel engines, Energy Conversion and Management, Vol. 42, No. 5, pp. 529-538, ISSN 01968904

Bridgwater, A.V., Toft A.J. & Brammer, J.G. (2002). A techno-economic comparison of power production by biomass fast pyrolysis with gasification and combustion, Renewable Sustainable Energy Reviews, Vol. 6, No. 3, pp. 181–246, ISSN 13640321

Brown, Lester R., Renner, Michael & Halweil, Brian. (2000). Signos vitales 2000: Las tendencias que guiarán nuestro futuro, GAIA Proyecto 2050, ISBN 9788493023225, Spain.

Cala, David F. (2003). Proyecto para producción de biodiesel a partir de palma africana en Colombia, Corporación para el Desarrollo Industrial de la Biotecnología y Producción limpia (CORPODIB), Bogotá, Colombia

Casilda, Béjar Ramón. (2002). Energía y desarrollo económico en América Latina. Boletín ICE Económico, No.2750, (December 2002), pp.31-43, ISSN 02102633

Chiaramonti, D., Bonini, M., Fratini, E., Tondi, G., Gart, K., Bridgwater, A.V., Grimm, H.P., Soldaini, I., Webster, A. & Baglioni, P. (2003). Development of emulsions from biomass pyrolysis liquid and diesel and their use in engines, part 1: Emulsion production, Biomass and Bioenergy, Vol. 25, pp. 85-99, ISSN 09619534

Consejo Nacional de Política Económica y Social (CONPES 3510). (2008). Lineamientos de política para promover la producción sostenible de biocombustibles en Colombia, Bogotá, Colombia

Cortés, Elkin Marin, Suarez, Héctor Mahecha & Pardo, Sandra Carrasco. (2009). Biocombustibles y autosuficiencia energética, Dyna, Vol.76, Nro. 158, pp. 101-110, ISSN 00127353

Cortés, M. E. (2007). Biocombustibles: ¿alternativa para la agricultura colombiana?, Memorias Agroexpo, Bogotá, Colombia

Cortés, Elkin & Álvarez, Fernando. (1998). Consumo energético y desarrollo agrícola sostenible, Ponencias de la III semana técnica Nacional de Ingeniería Agrícola, Medellín, Colombia, October 1998.

Food and Agriculture Organization of the United Nations (FAO). (2008). The state of food and agriculture, FAO, Retrieved from <ftp://ftp.fao.org/docrep/fao/011/i0100e/i0100e.pdf>

Gonzáles, M. César. (2008). Peor el remedio, In: Portafolio, 10.12.2010, Available from: http://www.portafolio.com.co/archivo/documento/MAM-2833067

Ikura M., Stanciulescu, M. & Hogan, E. (2003). Emulsification of pyrolysis derived bio-oil in diesel fuel, Biomass and Bioenergy, Vol. 24, No. 3, pp. 221 – 232, ISSN 09619534

International Energy Agency. (March 2006). Word Energy outlook 2006 In: International Energy Agency, 08.09.2010, Available from: http://www.iea.org/textbase/nppdf/free/2006/weo2006.pdf

Kumar, A.A. (2007). Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines, Progress in Energy and Combustion Science, Vol. 33, No.3, pp. 233–271, ISSN 0360-1285

López, Juste G. & Salva Monfort, J. J. (2000). Preliminary test on combustion of wood derived fast pyrolysis oils in a gas turbine combustor, Biomass Bioenergy, Vol. 19, No.2, pp. 119–128, ISSN 09619534

Mesa, Jens. (2006). Biocombustibles y Agricultura, Primer Congreso Grupo Empresarial del Campo, Bogotá, Colombia, November 15-17, 2006.

Ministerio de Minas y Energía-Unidad de Planeación Minero Energética. (2007). Desarrollo y consolidación del mercado de biocombustibles en Colombia, Bogotá, Colombia.

Nguyen, D. & Honnery, D. (2008). Combustion of bio-oil ethanol blends at elevated pressure, Fuel, Vol. 87, No. 2, pp. 232–243, ISSN 00162361

Pérez A., José Ignacio. (2002). In: Energía y desarrollo sostenible, 10.12.2010, Available from: http://www.oei.es/decada/portadas/MedAmbPDF4.pdf

Silvestrini, Vittorio. (2000). Qué es la entropía?, Colección Milenio/Norma, ISBN 9580438757, Colombia

Stern, D.I. (2006). Reversal of the trend in global anthropogenic sulfur emissions, Global Environmental Change, Vol. 16, No. 2, pp. 207–220, ISSN 09593780

Testing framework for sustainable biomass. (February 2007). In: Final report from the project group"Sustainable production of biomass", 16.11.2010, Available from: http://www.lowcvp.org.uk/assets/reports/070427-cramer-finalreport_en.pdf

U.S. Environmental Protection Agency. (2003). National Air Quality and Emissions Trends Report: 2003 Special Studies Edition, North Carolina, USA

Valero, Antonio. (March 2004). In: Energía y Desarrollo Social, 9.10.2010, Available from: http://habitat.aq.upm.es/boletin/n32/aaval.html.

Biofuel's Engineering Process Technology

Edited by Dr. Marco Aurelio Dos Santos Bernardes

ISBN 978-953-307-480-1
Hard cover, 742 pages
Publisher InTech
Published online 01, August, 2011
Published in print edition August, 2011

This book aspires to be a comprehensive summary of current biofuels issues and thereby contribute to the understanding of this important topic. Readers will find themes including biofuels development efforts, their implications for the food industry, current and future biofuels crops, the successful Brazilian ethanol program, insights of the first, second, third and fourth biofuel generations, advanced biofuel production techniques, related waste treatment, emissions and environmental impacts, water consumption, produced allergens and toxins. Additionally, the biofuel policy discussion is expected to be continuing in the foreseeable future and the reading of the biofuels features dealt with in this book, are recommended for anyone interested in understanding this diverse and developing theme.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Elkin Alonso Cortés-Marîn and Héctor José Ciro-Velázquez (2011). Biofuels and Energy Self-Sufficiency: Colombian Experience, Biofuel's Engineering Process Technology, Dr. Marco Aurelio Dos Santos Bernardes (Ed.), ISBN: 978-953-307-480-1, InTech, Available from: http://www.intechopen.com/books/biofuel-s-engineering-process-technology/biofuels-and-energy-self-sufficiency-colombian-experience

INTECH
open science | open minds

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

IntechOpen