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Energy from biomass: alternative for the reduction of atmospheric emissions

Biomasa: alternativa energética para la reducción de emisiones atmosféricas

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Abstract

Biomass produces the same amount of emissions of carbon dioxide absorbed during its growth that means that emits the same amount of CO_2 processing during part of its life cycle, making it neutral emissions of carbon compounds. The mass use of this energy source in developing countries with high agricultural potential is not considered feasible. This article from a research project describes the processes for biomass utilization and environmental benefits of using this energy resource that has been booming in different countries. It is concluded that although it is feasible the inclusion of biomass for energy supply, exists a lack of guidelines for sustainable use.

Keywords: Energy resources; Environmental effects; Climate change; Environmental pollution; renewable energy sources; Biomass energy; Carbon dioxide; Environmental policy; Cycle; Global warming

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Resumen

La biomasa produce la misma cantidad de emisiones de dióxido de carbono que absorbe durante su crecimiento, es decir, solo emite la misma cantidad de CO_2 que procesa durante parte de su ciclo de vida, haciéndola neutra en cuanto a sus emisiones de compuestos de carbono. La masificación de uso de este energético en países en vía de desarrollo y con alto potencial agrícola aún no se considera viable. Se presentan los procesos para aprovechamiento de biomasa y los beneficios ambientales del uso de este recurso energético que ha tenido auge en diferentes países. Se concluye que, aunque es viable la inclusión de biomasa para la oferta energética, faltan lineamientos para un uso sostenible.

Palabras clave: Consumo energético; Efectos ambientales; Cambio climático; Contaminación; Fuentes de energía; Energía de biomasa; Dióxido de carbono; Política ambiental; Ciclo; Efecto invernadero.

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1. INTRODUCTION

The significant population growth has led to the over-consumption of natural resources and fossil fuels, the latter being used mostly for industrial energy production and for transportation. The conditions of limited fossil reserves, either because of their quantity or due to the lack of economically available technologies for the extraction of these fuels, added to the environmental impacts that are generated during the production and use of these energies have motivated the search for new alternatives that minimize greenhouse gas production and mitigate environmental impacts.

Renewable energies are considered mostly clean energies, so there is a worldwide initiative to encourage their use. Biomass as a renewable source of energy allows energy generation and despite the lack of maturity in the technologies of certain countries to guarantee the reduction of negative impacts generated during the production and use of this energy, the energy storage capacity for later use contributes favorably to the carbon life cycle and makes it a viable technology for an inclusive mass flow process of electric fluid in non-interconnected areas as well as in areas connected to the main networks [1]. The objective of this article is to present the prospect of biomass consumption by 2050, demonstrating the viability of this energy for countries with high agricultural potential. This includes a summary of biomass production methods and the prospective analysis of atmospheric emissions of this energy.

Procedures for power generation from biomass

The methods of converting biomass to energy can be biochemical or thermochemical [2]. Precisely, the selection of the method is related to the type of biomass and the end of use of the product generated either for thermal, electrical or biofuel production applications [3]. As during the transformation can be used combustion, pyrolysis, gasification, co-combustion or fermentation, or a mixture of these (**Table 1.**)

Table 1. Procedures for power generation from biomass.

Environmental impact of activities associated with the production of energy from biomass

Thermochemical Methods	
They are used in the use of coal, peat and lignocellulosic materials, a volatile fraction is released [4].	A. Direct Combustion: Common practice in several economic sectors [5]. Multipass steam turbines are used that provide efficiency of 35 to 40%, for 1 MW 310 ha are required [6].
	B. Pyrolysis: Consists of thermal degradation of biomass [7]. Pyrolytic biofuels can be used as an additive for fossil fuels or as quality fuels [8]. Usable by-products are released [9].
	C. Co-combustion: Joint burning of biomass and fossil fuels such as coal being required for this an adequate selection of elements, equipment and capabilities of the power plant [10], [11].
	D. Gasification: raw materials are processed by throwing synthesis gases from which different types of energy can be obtained, such as thermal, electricity, hydrogens or biofuels. The calorific value of the synthesis gases is associated with the use of the different oxidizing agents [12].

Biochemical Methods	
Yeasts and enzymes that break up cellulose are used increasing the production of alcohols with the same amount of biomass [13].	A. Alcoholic fermentation: Enzymes synthesized by biocatalyst microorganisms that act on the sugars of the organic substrate generating the second generation bioethanol. The transformation takes place in two phases, an aerobic in which glucose is converted to carbon dioxide and an anaerobic in which ethanol is produced after dehydration of more than 99.4% of the substrate for mixing with gasoline [14].
	B. Metallic Fermentation Anaerobic microbial transformation that produces biogas mainly composed of methane. The process is carried out thanks to slow-growing bacteria that degrade the synthesized compounds transforming them into methane and carbon dioxide [15]. It can be done on a large scale and the temperature is not a limiting condition as long as it is between 0 to 55 ° C and there are no drops greater than 2 ° C [16].

Biomass-based energy is considered a potentially viable energy for electricity generation since in the production of one kW per hour (kW/h) 229 g less carbon emissions are produced than what is produced with

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pulverized coal-based energy (**Table 2.**) The same applies to energy based on wind or solar radiation. Even so, biomass-based energy systems produce environmental impacts on different natural resources.

Table 2. Comparison of CO emissions between energy systems [17].

	SOx	NOx	CO	PM 10 µm
Biomass technologies				
Boiler furnace, woody residue	0.08	2.1	12.2	0.5
Fluorized bed, biomass	0.08	0.9	0.17	0.3
Gasification of energy crops	0.05	1.10-2.2	0.23	0.01
Coal technologies				
Boiler furnace, bituminous coal	20.2	5.8	2.7	0.62
Pulverized coal boiler	14.3	6.89	0.35	0.32
Co-combustion with 15% biomass	12.2	6.17	0.35	0.32
Fluorized bed, coal	3.7	2.7	9.6	0.3
Natural gas technologies				
Alternative natural gas engine	0.006	7.96-38.3	2.98-35.0	0.09-0.18
Natural gas turbine	0.009	1.72	0.4	0.09
Combined natural gas cycle	0.004	0.91	0.06	0.14

Air resource

The combustion activity in the energy production process from biomass leads to an increase in the amount of greenhouse gases. Even so, biomass-based energy is considered carbon neutral, that is, only carbon collected during photosynthesis is released into the atmosphere. In the Table 3. it is observed that although biomass releases less NOx than coal, the emitted concentration is higher than that released by natural gas. While the complexity in the presence of NOx increases chronic respiratory disorders, the presence of SO_2 and NOx contributes to the appearance of acid rains and the formation of harmful particles.

Table 3. Comparison between the emissions resulting from different processes of electric power production, in lb/MW [17].

The particulate material reported comes from soot and ash from processing in biomass power plants where carbon monoxide emissions can also occur. To mitigate these impacts, there are currently available technologies such as fluidized beds, gasification systems and electrostatic precipitators that can help reduce NOx, CO and particulate emissions associated with biomass combustion [17], [18].

Water resource

The cultivation of energy can lead to an imbalance in the water system of the region where plantations are chosen. Logically, if the area has regular rainfall conditions, this imbalance cannot be noticeable, even so, it can affect the region´s water quality as a result of agricultural work and the loss of natural nutrients as well as the use of pesticides [19]. Likewise, the cooling techniques required in thermoelectric transformation technologies by wet circulation systems reuse the cooling water in a second cycle, which means that water withdrawal is between 500 and 900 gallons / mega watt-hour and consumption approximately 480 gallons / mega watt-hours [20]. Although the dry cooling alternative exists, this alternative generates an extra cost in the process and reduces efficiency, which means that more fuel is required per unit of electricity.

Type of power plant	Carbon Emissions (gC/kWh)	Emissions saved (gC/kWh)
Powdered coal–as base case	229	0
Integrated gasification in combined cycle-coal	190-198	31-40
Captured Powdered coal + captured CO2	40-50	179-189
Natural gas turbine with combined cycle	103-122	107-126
Natural gas turbine with combined cycle + captured CO2	14-18	211-215
Integrated gasification in combined cycle-Wood waste-biomass	0	229
Wind–good for medium sites	0	229
Thermal solar and photovoltaic solar	0	229

Soil Resource

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The impacts on the soil caused by the biomass-based systems are caused mainly because it can generate conflict in the use of the soil since the profitability associated with the benefit of the crops means that livestock soils can be used as agricultural soils by changing the use potential of the soil and generating conflict of use with the consequent detriment of the properties of the soil. Therefore, it is necessary that there are adequate practices for the use of soils and the benefit of crops, respecting the development of the food industry, and the natural habitat of native species [21].

Benefits of using biomass energy against greenhouse gas emissions

The implementation of biomasic energy becomes an inclusive program of energy supply for countries with agricultural capacity. In order to achieve sustainability in the use of this energy, strategies for mitigating impacts generated in water, soil and air such as controlled logging practices, verification of nutrient levels of the intervened soils, control programs of the soil must be advanced. erosion, alternatives for the use of waste from the benefit of biomass, among others, to which must be added policies for the reuse of water used in energy production processes. Another argument in favor of the use of biomass as energy is that the replacement of fossil fuels generates a saving in greenhouse gas emissions) which is evidenced by the carbon neutrality factor [22].

There are emissions that contribute to global warming, but they are associated with the cultivation and harvest of biomass feedstock and post-harvest activities, such as transportation to processing plants. Although emissions from transport and combustion are more or less equivalent in all types of biomass, those from raw material supply vary widely, so it is important to use one that reduces emissions. As an example, crops that do not compete with nearby land crops, portions of waste such as wheat straw or corn stubble, harvested sustainable wood, forest residues, and clean municipal and industrial waste and organic waste can be cited, highlighting that in the latter methane is released when discarded in landfills [23].

In the case of firewood, this can have a net value of zero emissions if proper crop management is carried out, as noted at the beginning, in a sustainable manner and replanting with fast-growing specimens. However, when best practices are followed, forest regeneration will not occur instantaneously, there will be a good time before resources reach carbon neutrality.

Due to all these factors, the range to estimate the life cycle of global warming emissions produced by bioenergy is wide. Excluding global warming emissions from changes in land use, most estimates place between 0.04 and 0.2 pounds of CO_2 equivalent per kilowatt-hour, which are lower values than those reported with natural gas that are between 0.6 and 2 pounds of CO_2 equivalent per kilowatt-hour or with coal are between 1.4 and 3.6 pounds of CO_2 equivalent per kilowatt-hour. [24]

Analysis of the emission cycle in biomass-based energy production

The energy efficiency of biomass varies depending on the origin and the transformation process used for energy production and in each of the stages the impacts are different [1]. During the cultivation of any kind of crop, regardless of its type or purpose, it is necessary that the plant receives a series of nutrients that have been prepared generating additional environmental pollution to that provided by the use of fertilizers. This contamination is part of the emissions produced by biomass within the sowing process and during its cultivation.

On the other hand, water consumption for tillage activities is high, which has an impact on pollution derived from the use of chemicals (herbicides and fungicides) that are used during planting and other processes, this being the main environmental implication on the resource water The same happens with the use of the land because the use of the land for agro-energy crops may be preferred instead of crops for food products, to the point that an occupation of the order of 1,182 GHa is expected in 2050 for this purpose [25].

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As expected, the biomass is produced in one area and the processing in a different one, which requires transportation to the collection centers and production and / or transformation plants. In this action, if the means of transport uses energy based on petroleum derivatives, pollutants are released into the atmosphere thereby increasing environmental deterioration.

2. DISCUSSION

The transformation of solar radiation into chemical energy allows the storage of fixed carbon with energy potential per unit of matter close to 470 kJ / gmol [26] and although this process has a solar energy capture efficiency of up to 15%, generally only 1% of species can store that amount [27]. After the drying process, the biomass stores between 17 and 21 MJ / kg [6].

As mentioned in this article, biomass can be obtained in different ways, either solid or as a wood or bagasse type whose caloric power depends on the percentage of fiber and moisture or in the form of pellets that are compressed sawdust pellets, wood shavings or other forest products that have energy applications that allow the supply for household, commercial or industrial purposes or as briquettes that offer the same advantages of the pellet but are larger and have lower humidity and higher density due to which is the cost / benefit ratio is greater because of the ease in transportation [8], [30].

Once the biomass is obtained in the form required for the production of energy, the process that can be gasification or combustion with the consequent emission of pollution in each case is selected. If direct combustion is chosen, particulate material is also generated which is a technically complex process since its efficiency is affected by the humidity and the amount of biomass that the material being used has. As for the combustion process, the use of multi-stage steam turbines produces high energy efficiency (from 35 to 40%), which is why 290 hectares are required per watt of energy production instead of 550 Ha / W [28].

Another alternative of biomass transformation is the pyrolysis in which the rupture of the molecular structure of the biomass to obtain biofuel, biogas and a solid fraction is produced by high temperature and moderate pressure so that the by-products obtained can be stored for later use as additives or fuels, reducing transport emissions and improving their efficiency [9], [8]. The same situation occurs during the transformation by biomass gasification, which is done using various raw materials and thermal, electrical, hydrogen, and biofuels are obtained [12].

There is also the process of transformation by co-combustion with which the reduction of emissions of environmental pollutants and an improvement in the energy production of the plants is sought by burning, together, the traditional fossil fuel with biomass for which an inspection of the traditional plant is required so that the evaluation of the current capacities is carried out and if necessary the adjustments of the case are made [10], [11].

Energy generation from biomass produces different pollutant gases and ash, waste that must be stored and controlled until its final disposal [4]. Solid carbon-rich wastes captured within combustion processes can have multiple uses since they represent a non-hazardous biological waste. As for the net carbon dioxide emissions, these are zero, since during the process of photosynthesis, the gas is captured and oxygen is released, the carbon being stored in the biomass which is subsequently transformed into energy [31].

The economic convenience that derives from the use of biomass as energy puts the food security of the countries at risk, so it is necessary to define the areas in which it is possible to advance these crops. In this way, the control that helps to guarantee food security can be established taking into account that 1,182 GHa of land is available worldwide, the probable use of which is for energy crops [32], [33].

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As mentioned, biomass is considered carbon neutral because the amount of CO_2 it emits is the same that it absorbs during its growth but during the transport process, processing and other phases of the life cycle CO_2 emissions increase [4], [34].

In addition to the availability of land suitable for energy crops, it is essential that in the area where they are developed there are hydroclimatological conditions that allow a rational use of water for irrigation and, it is expected that for pest control, fertilizers will be used organic instead of chemical pesticides.

Besides, biomass energy is cheaper compared to other ways of obtaining renewable energy and can be obtained from different crops. For example, it has been reported that the use of 70% of the rice husk residues could contribute to the production of electricity of 1328 GWh per year, and the cost per unit of electricity generated with the rice husk is 47.36 cents / kWh, compared to 55.22 cents / kWh of electricity generated by coal [35].

In countries such as Colombia, biomass is not perceived as a component that immediately enters the country's energy supply but, as indicated in this article, a biomass-based energy system is sustainable if regulations are designed to guide on the rational use of available resources and would be an appropriate option for the eradication of illicit crops, offering a complementary advantage to the rural economy [36]. Globally, the organization of the countries has allowed the development of biomass-based energy systems.

3. CONCLUSIONS

Biomass is an energy source used since ancient times. Although the global trend shows a sustained rise in the implementation of biomass as a source of energy, in some countries with high agricultural potential, projections of use are not favorable, which is explained by the absence of regulations and the implementation of sustainable practices of energy crops as well as incentives that allow investors to appropriate this energy source in order to increase the energy supply of countries, mainly in rural areas. In addition, energy crops can become a solution for the eradication of illicit crops in several areas offering a complementary advantage to the rural economy.

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5. CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest with an institution or commercial association of any kind.

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