CHAPTER 48

Sustainable solutions for clean energy production

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ABSTRACT
With the rampant increase of pollutants from various sources in recent decades, mainly fossil fuels, several negative consequences have been generated for the environment and human health. A sustainable alternative is to obtain energy through renewable sources such as biomass. of animal and/or vegetable origin used in the generation of energy and the manufacture of biofuels. The process of obtaining energy from biomass has two categories: traditional and modern. The main types of biofuels produced are biodiesel, biogas, bioethanol, biomethane, and vegetable oil. Biofuels can be grouped into first-generation, second-generation, third-generation, and fourth-generation. Because it is renewable, it is a potentially unlimited source, as well as less harmful to the environment, generating little pollution. The main advantages are low cost; easy storage; high energy efficiency; emission of fewer polluting gases; use of renewable resources. On the other hand, there is difficulty in the storage of solid biomass; collaborates for the formation of acid rain; high cost in the acquisition of industrial equipment; and deforestation at the production site. However, biomass is gaining traction worldwide as a sustainable alternative in clean energy production, as this is an important source of renewable energy. Countries such as the United States, China, India, and Germany are among those that use biomass to produce clean energy, mainly from agricultural and forestry waste. Brazil is one of the main producers of this type of energy in the world, due to its great potential for the production of renewable raw materials. Although it is a renewable and clean source, the implementation of projects for its use faces some challenges such as collection and transportation logistics, conversion technologies, financing, and regulation.

Keywords: Biomass, renewable energy, biofuels, waste, global warming.

1 INTRODUCTION

Addressing climate change may be one of the greatest health challenges of the twenty-first century since our climate has changed significantly in the last century and has become the most significant health threat. The impacts of climate change on human health are varied and are gaining more prominence, from the direct effects, such as heat waves, severe weather, drought, and floods, which are visible and frequent in the news, to the indirect or secondary effects, such as changes in ecosystems and the impact on health, which are less obvious but can have the greatest impact on allergies and respiratory diseases. In addition, environmental air pollution is an important risk factor for morbidity and mortality worldwide, with a direct impact on human health and being responsible for the increased incidence and number of deaths from cardiopulmonary, neoplastic, metabolic, as well as neurodegenerative diseases. Environmental air pollution also contributes to global warming and the consequent climate changes associated with extreme events and environmental imbalances (DEMAIN, 2018; BONGIOANNI, et al.; 2021; SANTOS et al., 2021).

One of the most evident problems of recent decades that has generated several consequences is precisely the obtaining of energy through fossil fuels because these have several negative impacts that affect both the environment and society. However, the current energy issue is of extreme importance for humanity, since energy is one of the fundamental pillars for economic and social development, since most human activities depend directly on energy, from the simplest tasks of everyday life to the most complex activities of industry. In contrast, the current energy model based on fossil fuels presents several environmental and economic challenges for humanity (JAISWAL et al., 2022).

Fossil fuels such as oil, coal, and natural gas are limited and non-renewable sources of energy, and their extraction and consumption generate significant negative impacts on the environment, such as air pollution, soil, and ecosystem degradation. Burning these fuels releases greenhouse gases into the atmosphere, contributing to global warming and climate change. In addition, oil and gas extraction can cause irreversible damage to marine and terrestrial ecosystems, as well as soil and water pollution. The dependence on these fuels can also lead to geopolitical and social conflicts, as well as economic uncertainties regarding the prices and availability of these resources, since many countries depend on the import of these resources to ensure their energy supply, consequently, which can lead to international conflicts and economic instabilities (JUNTUNEN; MARTISKAINEN, 2021; GULIYEV, 2022; ELASU et al., 2023).

In the face of these challenges, the transition from obtaining energy from fossil fuels such as coal, oil, and natural gas to clean energy sources is becoming increasingly urgent and necessary. Thus, it has become, in recent decades, fundamental to seek more sustainable and cleaner alternatives for energy generation, such as renewable energy sources (HARICHANDAN et al., 2022).

These sources, such as solar, wind, hydraulic, geothermal, and biomass energy, are abundant and can be used sustainably, as they have the main advantage of not generating carbon emissions in the processes of use, as well as without compromising natural resources and without generating pollution and negative impacts on the environment that, currently, in addition to being a trend, it is a major worldwide demand in the development of low-carbon economic development (LI; YAN; REN, 2023).

In addition, the development of technologies for the generation of renewable energy can generate new economic and employment opportunities, contributing to sustainable development and poverty reduction. Therefore, it is critical to take action to address both climate change and air pollution to protect human health and preserve the environment.

The review presented is directed to alternative technologies to contribute to the aspects related to the production of energy through the use of biomass, elucidating the great innovative and renewable potential in the search for clean and unlimited energy.

2 AN ALTERNATIVE FOR CLEAN ENERGY PRODUCTION: BIOMASS

Biomass is all organic matter of animal and plant origin used for energy production and in the manufacture of biofuels, which is obtained through the decomposition of a variety of renewable resources. The energy generated is also called green energy or bioenergy (GENOVESE, 2006).

Biomass is considered the most important source of clean energy in the world, however, its conversion into energy still depends on the development and implementation of sustainable processes and economically viable costs. As main sources of biomass, we can mention: green coconut shell; sugar cane (bagasse, straw, vinasse); eucalyptus; wood pellets; rice husks; Sapucaia hedgehog; soybean and corn straw; vegetable oils (sunflower, rapeseed, castor bean); waste from the timber industry; Biodegradable waste: urban, industrial, forestry and agricultural. When biomass is used for energy purposes it is classified depending on its origin into three categories:

2.1 FOREST ENERGY BIOMASS

The products and by-products either derive from forests, whether they are planted or the result of deforestation. The main resource is wood (VICHI and MANSOR, 2009; DHILLON and WUEHLISCH, 2013).

2.2 AGRICULTURAL ENERGY BIOMASS

Agricultural energy biomass is considered a waste product of agricultural activities, and can also be animal production (VICHI; Mansor, 2009; DHILLON; WUEHLISCH, 2013).

2.3 - MUNICIPAL WASTE

Municipal waste can be solid or liquid, being found in abundance in landfills, from where even the gases derived from combustion can be used (TANG et al., 2018).

The energy potential of each of these groups depends both on the raw material and the technology used in the processing to obtain them. According to Goldemberg and Coelho (2004), it is possible to classify the obtaining of energy from biomass into two main categories:

2.3.1 Traditional Combustion Process

It happens through the direct combustion of wood, firewood, agricultural waste, animal and urban waste, used in a rustic way, usually used to supply homes both in the heating of environments and in food, in small communities. Forest residues, deforestation wood, and animal waste can be emphasized (VICHI and MANSOR, 2009; DHILLON; WUEHLISCH, 2013).

2.3.2 Modern Combustion Process

The modern combustion process uses advanced technologies for the generation of electricity and the manufacture of biofuels (ethanol and biodiesel), derived from sugarcane bagasse, reforestation wood, and other sources, provided that they are used sustainably and with efficient and advanced technological methods. (GOLDEMBERG, 2017).

3 BIOMASSES AS AN ENERGY SOURCE

Biomass has been used since the beginning of humanity in the simplest form found in nature, wood (firewood). Only in the twentieth century did the use of modern biomass begin, with the alcohol program in Brazil and the practice of reforestation. The valorization of biomass for energy input began in the 70s, with the beginning of the collapse of oil, becoming considered a viable alternative in the replacement of fossil fuels. In the 90s, biomass again had worldwide evidence, because they had developed more advanced technologies of transformation, on the verge of ending the current energy and by the signing of the Kyoto Protocol in 1997 (NOGUEIRA et al., 2000). Saidur et al. (2011) address that research in the area of biomass is growing rapidly due to, above all, climate change. Being considered one of the largest agricultural producers, Brazil is the world's largest producer and consumer of bioenergy. Factors such as rich biodiversity, availability of area for cultivation, and adequate climatic conditions have contributed to achieving high levels of biomass utilization (VAN DER SELT, 2011).

4 BIOMASSES IN BRAZIL AND THE WORLD

In the global context, several countries, in the expectation of maintaining energy security and its balance with sustainable development, seek to adopt the so-called clean energies, coming from renewable sources with effective and ecological resources (YANG et al., 2019). Biomass, currently, for presenting promising innovations in its thermochemical conversions, for the use of energy, in recent years has been attracting many looks that, therefore, generated its constitution in the world consumption of energy by approximately 14%, causing the reduction of the use of non-renewable energy sources (MAMAEVA et al., 2016). It is worth noting, therefore, the estimates that point to more than 90% of the population living until 2050 in developing countries, which will cause an increase in the global energy demand, therefore, also, a high search for renewable energies to meet the energy, environmental and social demands (BERNARDO et al., 2022).

Brazil has great potential to act as a leader in the world market for agro-industrial and forestry products and, in particular, those related to trends in the renewable energy market. Therefore, two major programs can be mentioned, such as the National Biodiesel Production Program (PNPB) with the obligation of biodiesel to diesel, which provides more energy and socioeconomic security, as well as the Alcohol Program, through the use of sugarcane ethanol, being responsible for the growth of the sugar-alcohol sector and new technologies in industrial processes (BORGES et al., 2016). In this perspective, therefore, sugarcane is the second crop with the highest production value, as it serves exports and is currently linked to the demand for biofuels. According to the Energy Research Company (EPE) and its data provided by the Atlas of Energy Efficiency (2022), in the last 20 years, Brazil has remained stable in the share of the renewable energy matrix, when compared to other countries in the world, so in 2021, with growth in the supply of sugarcane, biodiesel, and wind derivatives, in this way, it was reflected in the trajectory of renewable sources that reached 45% in the energy matrix.

5 MAIN TYPES OF BIOFUELS PRODUCED BY BIOMASS

The main biofuels used today in Brazil are bioethanol; biodiesel; biogas, biomethane; vegetable oil. Currently, the two main ones are biodiesel and bioethanol, representing the production of about 50 billion liters produced annually (ALALWAN et al., 2019).

5.1 BIODIESEL

Biodiesel is the most produced biofuel in the country. Produced from vegetable oils, this fuel replaces the diesel used in automobiles, trucks, and even electricity generators (Ghazali et al., 2015), being safe, nontoxic and helping to reduce the number of pollutants released into the atmosphere, benefiting and protecting as a whole the air quality in our cities.

5.2 BIOETHANOL

Bioethanol is the fuel that is produced by extracting ethanol from plants such as sugarcane, corn, and cellulose. The most used waste in Brazil for the production of bioethanol is sugarcane bagasse to obtain more energy, alcohol is extracted from plant cellulosic matter in the production of bioethanol (DEMIRBAS, 2009b).

5.3 BIOGAS AND BIOMETHANE

Biogas and biomethane are a mixture of gases produced by the biological decomposition of organic matter; this decomposition must occur in the absence of oxygen, we find this source of energy in our household waste and the landfills of our cities, it has the characteristic of being extremely flammable, which can make it dangerous for some applications. It can also replace petroleum-derived gases such as cooking gas and natural gas (KONRAD et al., 2010). Biogas is obtained from the breakdown of organic matter, consisting of methane (CH4) and carbon dioxide (CO2), containing remnants of other gases (PEREIRA et al., 2015).

5.4 PURE VEGETABLE OIL

Oil of vegetable origin is a biofuel of low production and little use, due to the high cost, it is extracted from the oil of oilseed plants and is used to give rise to several products such as: biodiesel, gear oil, automotive glycerin, paints, etc. (COSTA NETO et al., 2000).

6 CLASSIFICATIONS OF BIOFUELS

In general, biofuel is determined to be derived from renewable biomass capable of replacing fossil fuels. Biofuels are classified into four generations, according to the biomass used and its production process:

6.1 FIRST-GENERATION BIOFUELS

It is manufactured from the vegetables produced by agriculture, sugarcane, corn, beets, etc. This generation is that obtained through the fermentation of sugars present in sugarcane juice for example (sucrose and reducing sugars). It has a low cost and a technology already known, the problem with this generation is that they end up competing with the cultivation of food, so at some point, they can harm the supply of food and generate high prices, they can also threaten biodiversity when made from palm oil, for example (ALALWAN., et al., 2019).

6.2 Second-Generation Biofuels

This fuel is originated from vegetable fibers and cellulose, and can come both from wood and other inedible parts of vegetables, sugarcane bagasse is the most used waste. Second-generation ethanol is that obtained by breaking down the polysaccharides (cellulose and hemicellulose) present in lignocellulosic biomass, to produce simpler sugars (Westensee et al., 2018). One of the positive points of this generation is not to compete with food production, but it has a higher cost in the process of producing fuels.

6.3 THIRD-GENERATION BIOFUELS

They are those that have origin from the plant species of rapid growth and short cycles of production, they are usually used in algae. According to Kose (2016), there are some essential points in the choice of the species of the microalgae such as tolerance to O2 levels; Resistance to photoinhibition; have high growth rates; have a low need for nutrients to develop; have high photosynthetic activity; ease in adapting under conditions of environmental stress (for open systems); high survival rates and genetic stability. Another great advantage is that they do not need large areas for their cultivation. When compared to the other generations, the 3rd generation has a higher calorific value, low density, and viscosity (SILVA; Smith, 2019).

6.4 FOURTH-GENERATION BIOFUELS IT IS THAT

Fuel that comes from the genetic modification of trees, the objective of this generation is to remove carbon dioxide from the atmosphere and leave it stored in its trunks and leaves, enabling the reduction of CO2 emissions, so we will have more quality of life, but the technology used is still unfeasible due to high costs. The methodologies used in this generation are still at the beginning of their development (BRANCO, 2014).

7 BIOMASSES: ADVANTAGES AND DISADVANTAGES

After understanding the utilities, and advances of each generation in the production of biofuels, this topic aims to clarify the advantages and disadvantages of adapting to this means of clean energy. When evaluating the benefits of the use of biomass represents the socio-economic valorization, low cost, possibilities of local development, and regional insertion, considering that it can be obtained from various renewable natural resources, abundance or even, environmental waste can be used (GOMES, et al., 2021).

The processes that involve the production of biomass are described as human activities that cause less impact on the atmosphere, considering that the processes are part of the biogeochemical cycle of carbon, which happens routinely and naturally in the ecosystem. To contextualize biomass in particular, the energy produced is easy to store when compared to the electrical energy obtained through thermoelectricity, from a combustion process, and mechanical energy. And yet, it is a great alternative for the generation of income, through energy independence (AVELINO et al., 2021).

On the other hand, in the disadvantages, biomass has a great negative potential when it comes to deforestation. The impact generated by biomass on the environment stands out in the vegetation cover, that its raw material can come from trees or agriculture. The search for such materials causes the replacement of native species of the biome, by large agricultural fields, the soil is exposed, harming its chemical and physical conditions. On the local fauna, the damage is immeasurable, considering that their habitat is destroyed. Making the survival of the species impossible. (MILIAN-LUPERON, et al., 2020).

However, Vale stress, that there must be an environmental study to avoid the rampant removal of trees from the forest, and it may be possible that the biomass process remains a source of clean energy, but not be seen as a source of renewable energy, considering the large time interval for there to be replenishment of the fauna and flora of the deforested site. For this damage to be avoided, it is necessary to follow up on an environmental impact plan, for specialists such as environmental technicians, biologists, environmental engineers, or forestry engineers. However, in cases where the damage has already been caused, the participation of trained professionals remains of fundamental importance so that there are adequate mitigating measures. In the production of biomass, another major problem is the storage of solid biomass. For this reason, it can be considered a less productive energy source when compared to others. And the difficulty is much worse when the process occurs in power plants, because they add organic materials and fossil fuels in the production process, generating more environmental impact (MARCUZZO; KOTKOSHI; WERNKE, 2020).

Therefore, biofuels are used in combustion engines and in this burning some gases that are pollutants in the layer of the atmosphere are released. Nitrogen and sulfur oxides are closely associated with consequences such as acid rain and various other environmental problems. For biomass to be produced in an amount that can supply large cities, a new difficulty arises, which is obtaining the expensive machinery (HERRERA-RENGIFO, et al., 2020).

And yet, to be considered the possibility of implementing any type of clean energy, one must evaluate the pros and cons, so that there is the choice of the best alternative for a given situation and place. Because it is one of the primary sources of obtaining energy, biomass has undergone all the technological advances of each generation and classification of production of biofuels. Thus, there are several possibilities for the cleanest possible production, which generates less environmental impact. The inspection the compliance with the environmental laws updated by qualified agencies is of great importance in encouraging the production of clean and renewable energies in appropriate ways (DAMIN; CARRIJO; COSTA, 2021).

8 FUTURE PROJECTIONS FOR BIOMASS IN BRAZIL

The evolution of the national scenario of the energy sector concerning the growth and development of society and demands generates long-term uncertainties. In this perspective, the 2030 agenda that encompasses the Sustainable Development Goals (SDGs), in particular, the seventh objective is directed to clean and affordable energies, has parameters focused on the social, economic, and ecological aspects of enterprises, which aims, therefore, to pay attention to the proposals for transformations of new development matrices. It is in this context that the instrumentalization of biomass for practice in the renewable energy modality becomes a great alternative of low impact and great socioeconomic value. (KOKKE, 2022).

The energy future involves some challenges, and one of these is the sustainable advance that incorporates economic and environmental efficiency, so it is in this parameter that biomass becomes an alternative and of great potential, given its renewable character, low cost (with other renewable sources), and great availability. However, biomass should stop being attributed as a palliative measure and start to be recognized, through long-term analysis and more efficient government policies and clarity, as a power to the energy matrix (MIRANDA et al., 2019).

Given this, there is an expectation related to the various types of biomasses in Brazil and consumption for the coming years, following until 2030, and these encompass the respective types with high growth in use, which are: forest biomass; sugarcane; residues from industrial, agricultural and urban productions (organic and inorganic); among others (BAESSO et al., 2021).

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