Tarım Makinaları Bilimi Dergisi

Journal of Agricultural Machinery Science

http://dergipark.org.tr/tr/pub/tarmak

Research Article / Araştırma Makalesi

e-ISSN: 2651-4230

20(2), 2024: 61-71

Biomass Energy Potential from Agricultural Production in Libya

Libya'da Tarımsal Üretimden Biyokütle Enerjisi Potansiyeli

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Article Info

Received date : 05.04.2024
Revised date : 27.07.2024
Accepted date : 02.08.2024

Keywords:

Agriculture
Renewable Energy
Residue
Calorific Value
Libya

Atıf için:

Eissa, M.O.S., Gürdil, G.A.K., Ghanem, L., Demirel, B. (2024). Biomass Energy Potential from Agricultural Production in Libya, Tarım Makinaları Bilimi Dergisi, 20(2): 61-71.

ABSTRACT

The purpose of this study is to assess the potential for agricultural residues in Libya in terms of type and quantity. Biomass resources in Libya include agricultural residues, such as crop residues and animal manure, as well as organic waste from industries and municipalities. Using production data from the Food and Agriculture Organization Statistical Databases of the United Nations (FAOSTAT) for the 2021 seasonal year, the amounts of crops grown in Libya measured in tons of dry matter annually, were computed and the residue to product ratio was used to calculate the annual gross potential of agricultural residues. The calorific values of agricultural residues were multiplied by the amount of residue that was available to determine the energy potential of crop residues. Roughly 4.5 kilo tons of agricultural crop waste were left over after harvest. It was discovered that for Libya's production season of 2021, the total calorific value of agricultural residues was around 17.7 TJ. Major crops that are included in the ratio of the total residue amount are potatoes (40.33%), wheat (33.9%), barely (22.5%), and maize (1.9%). This paper gives an overview of the agricultural waste that can be used in Libya as a source of biomass energy, utilizing waste as a feedstock lowers the pollution that comes from burning fossil fuels to produce energy.

Makale Bilgisi

Alınış tarihi : 05.04.2024
Düzeltilme tarihi : 27.07.2024
Kabul tarihi : 02.08.2024

Anahtar Kelimeler:

Tarım
Yenilenebilir Enerji
Atık
Isısal Değer
Libya

Eissa, M.O.S., Gürdil, G.A.K., Ghanem, L., Demirel, B. (2024). Biomass Energy Potential from Agricultural Production in Libya, Tarım Makinaları Bilimi Dergisi, 20(2): 61-71.

ÖZET

Bu çalışmanın amacı, Libya'da tarımsal atıkların türü ve miktarı açısından potansiyelini değerlendirmektir. Libya'daki biyokütle kaynaklarından bazıları tarımsal atıklar, örneğin mahsul artıkları ve hayvan gübresi, ayrıca endüstrilerden ve belediyelerden organik atıklardır. Birleşmiş Milletler Gıda ve Tarım Örgütü İstatistik Veritabanları'ndan (FAOSTAT) 2021 mevsimsel yılı için üretim verileri kullanılarak, Libya'da yetiştirilen mahsullerin ton cinsinden yıllık kuru madde miktarı hesaplandı ve artık ürün oranı kullanılarak tarımsal atıkların yıllık brüt potansiyeli hesaplandı. Tarımsal atıkların ısısal değerleri, kullanılabilir artık miktarıyla çarpılarak mahsul artıklarının enerji potansiyeli belirlendi. Hasattan sonra yaklaşık olarak 4.5 kiloton tarımsal mahsul atığı kaldığı bulundu. Libya'nın 2021 üretim mevsimi için tarımsal atığın toplam ısıl değerinin yaklaşık 17.7 TJ olduğu keşfedildi. Toplam atık miktarı oranına dahil olan başlıca mahsuller patates (%40.33), buğday (%33.9), arpa (%22.5) ve mısırdır (%1.9). Bu makale, Libya'da biyokütle enerjisi kaynağı olarak kullanılabilecek tarımsal atıkların genel bir değerlendirmesini sunar, atıkları bir ham madde olarak kullanmak, enerji üretmek için fosil yakıtların yakılmasından kaynaklanan kirliliği azaltır.

1. INTRODUCTION

Libya, spanning an expansive 1,750,000 m^2, is strategically located in the heart of North Africa (Yahya et al., 2020). Situated in the Maghreb region, this nation, officially referred to as the State of Libya, is bordered by the Mediterranean Sea to the north, Egypt to the east, Sudan to the southeast, Chad to the south, Niger to the southwest, Algeria to the west, and Tunisia to the northwest (Population of Libya, 2023). The climate in Libya varies, characterized by cold winters with occasional coastal rainfall. During the summer, the Sahara region experiences extreme dryness and high temperatures, while winters are relatively dry. Summer daytime highs can soar to 50 °C, with most days hovering around 40 °C. The average annual temperature is approximately 20.5°C. In the eastern part of the country, the mean annual rainfall is 180 mm, contrasting with the western region, where it is 90 mm (Hamad et al., 2014). As per the latest United Nations data presented by Worldometer, Libya's population stands at 6,910,904 as of October 18, 2023 (Libya Population, 2023). Over the past decade, the population of Libya has nearly doubled. This substantial population growth is contributing to increased waste and residue production, thereby exerting notable effects on the environment, as well as impacting the demands for energy and food.

Three primary categories of energy sources exist: nuclear, renewable, and fossil fuels, as identified by (Karaca, 2015). Solid biomass is emerging as a viable substitute for fossil fuels, contributing to the transition toward renewable energy sources. As the availability of fossil fuels diminishes over time, the significance of relying on renewable energy is expected to grow (Malaťák et al., 2020). Libya stands to benefit significantly from renewable energy sources such as solar, wind, and biomass energy, offering substantial potential for electricity generation (Yahya et al., 2020). The escalating population, improved comfort standards, and advancements in industry and technology are collectively contributing to a notable surge in energy consumption (Demirel et al., 2019). Biomass, referring to renewable organic material derived from plants and animals, has been a longstanding energy source for humanity, with historical use spanning thousands of years (Karaca et al., 2017). Biomass resources are commonly utilized for heating, cooking, and similar applications using traditional methods (Aktaş, 2022). Agricultural wastes generated during the harvest season, abundant in the food industry, represent one of many forms of biomass readily available. Repurposing these wastes for energy utilization stands as a constructive measure in addressing disposal concerns. Agricultural waste emerges as a significant biomass reservoir owing to its considerable potential. The escalating demand for energy and the consequential environmental impact have spurred research into harnessing renewable energy from agricultural waste and biological resources. However, the principal challenges in utilizing biomass for energy production lie in the logistics of collecting, transporting, and storing it. These factors introduce a considerable degree of unpredictability in biomass supply, rendering it unreliable for applications in energy production (Karaca, 2017).

One of the most critical global challenges in the realm of energy revolves around the escalating demand for energy and the sustainability of its resources. The predominant reliance on fossil fuels on a global scale has led to a significant upsurge in environmental pollution. The adoption of energy derived from renewable sources offers a flexible solution, presenting a promising avenue to mitigate the environmental impact associated with agricultural waste. This impact extends to sectors dependent on groundwater, food, and other natural resources (Elmnifi et al., 2023). The utilization of renewable energy sources not only enhances energy security but also contributes to the reduction of greenhouse gas emissions. In the context of Libya, energy policymakers grapple with the persistent rise in energy demand, making the adoption of renewable energy sources increasingly crucial. It becomes imperative for Libya to embrace renewable energy sources to meet the lifestyle demands of its population and fulfil the nation's growing energy needs (Mohamed et al., 2013). This focuses on estimating the quantity of energy generated from agricultural residues, emphasizing the energy value and biomass potential inherent in Libyan agricultural waste.

Agricultural lands in Libya

Despite its predominantly arid climate, Libya boasts fertile regions along its coastal plains and in oases scattered across the country. Agriculture plays a crucial role in the nation's economy, contributing to both food security and employment. Key crops cultivated in Libya include cereals, olives, dates, citrus fruits, and vegetables. Additionally, livestock farming, particularly sheep and goats, is prevalent in certain regions.

In term of agricultural only roughly 12% of Libya's total area of 15.4 million hectares is suitable for agriculture placing additional constraints on the country's ability to produce food (FAO, 2019). Farmers claim that their ability to cultivate land is still limited by power outages and the high cost of inputs like gasoline, seeds, water, and machinery. Despite the fact that 470 000 hectares are ideal for irrigation, only about 240 000 hectares are being irrigated at the moment because of worries about the depletion of subsurface water (FAO GIEWS Country Brief on Libya,2023). Cereals are grown in coastal areas, where it is possible to produce them using rainwater or by cropping with additional irrigation, and in some dry regions of the south, where full irrigation is used. Tomatoes, peppers, onions, and leafy greens are the most widely produced vegetables in Libya. (Figure 1)

Evaluation of the Biomass Potential of Agricultural Residues

The most common source of energy is biomass, which includes wood fuel, animal waste, and agricultural waste. Over the past few years, utilizing waste biomass has emerged as a viable alternative for generating clean energy (Tamelová et al., 2021). Agricultural waste is defined as undesired or unsalable materials that are entirely generated by agricultural operations that are directly related to the production of crops or the rise of animals with the goal of turning a profit or providing a living (e.g., food and vegetable refuse, fruit skins, stem of green, corncob, leaves, grass, and manure). And those agricultural waste represent 59% of the waste generated in Libya (Hamad et al., 2014). Crop residues left in the field after the crops are harvested are known as annual crop residues (Karaca, 2015). Although the idea of producing energy from waste is not new, this is a sector that needs to be given careful consideration.

Benefits of Biomass Energy Utilization:

Energy Security: Reducing reliance on fossil fuels by diversifying the energy mix enhances energy security, mitigating the impact of volatile oil markets and geopolitical uncertainties.

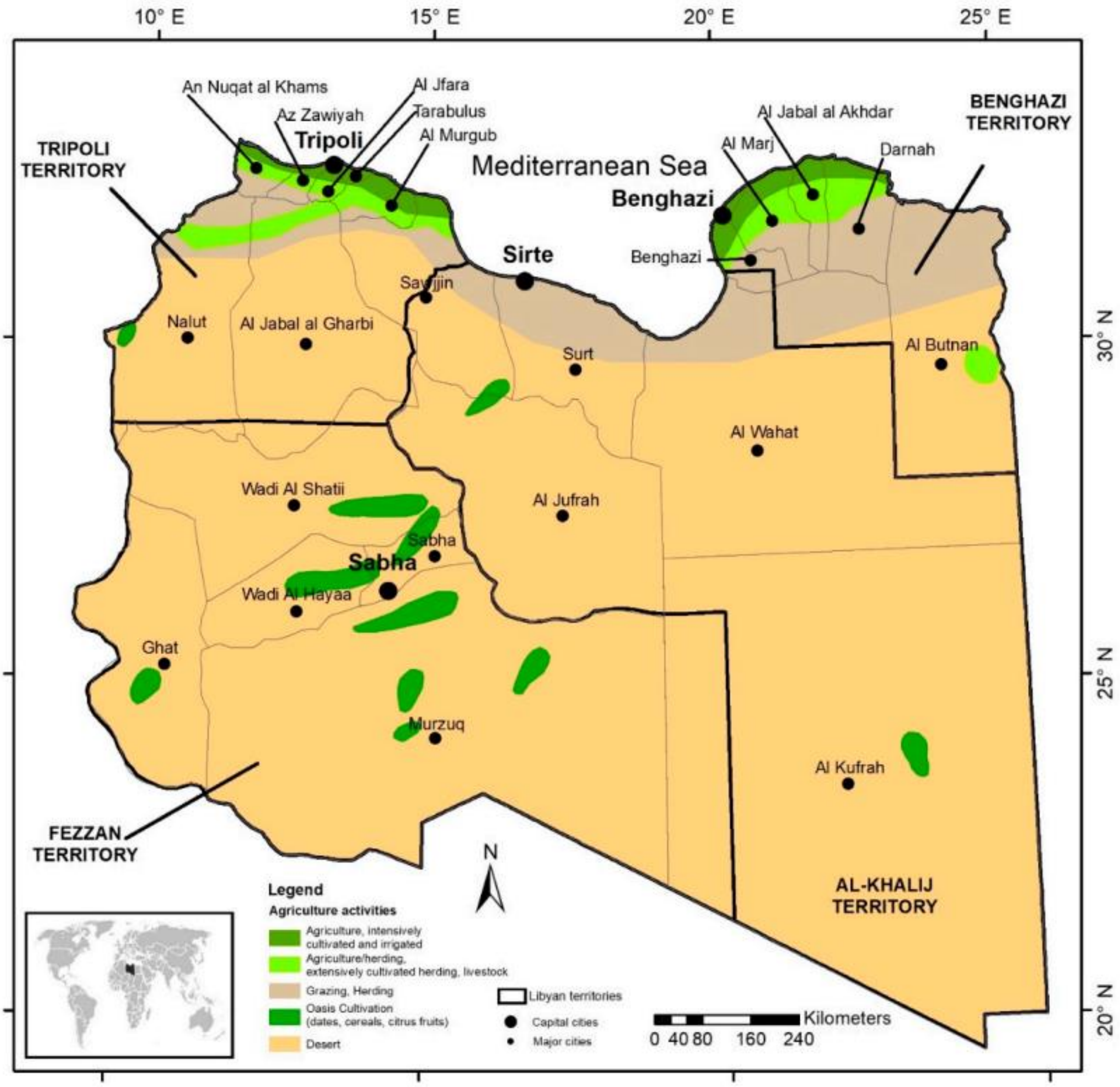

Figure 1. Locations of agricultural areas in Libya (Zurqani et al., 2019)

Environmental Sustainability: Biomass energy production emits fewer greenhouse gases compared to fossil fuels, contributing to mitigating climate change and reducing air pollution. Additionally, utilizing agricultural residues for energy helps manage waste and prevents open burning, which can have adverse environmental consequences.

Rural Development: Investments in biomass energy infrastructure stimulate rural economies by creating jobs along the biomass supply chain, from collection and processing to operation and maintenance of biomass facilities.

While the potential for biomass energy in Libya is substantial, several challenges and considerations must be addressed to realize its full benefits:

Infrastructure Development: Investments in biomass processing facilities, distribution networks, and technology transfer are essential to establish a robust biomass energy sector.

Policy Support: Clear policies and regulatory frameworks that incentivize biomass energy production and ensure market stability are crucial for attracting investment and fostering industry growth.

Technological Innovation: Research and development initiatives aimed at improving biomass conversion technologies and enhancing efficiency are essential for maximizing energy yields and reducing costs.

2. MATERIAL AND METHOD:

Using agricultural production statistics from the Food and Agriculture Organization Statistical Database (FAOSTAT) for the 2021, the amounts of residue from the main crops grown in Libya were determined. From the yearly production for every crop, the amount of agricultural residues was estimated by using the residue-to-product ration (RPR) (Karaca, 2015).

To calculate the amount of residues generated, one must be aware of the RPR. Surveys were used to calculate the RPR for each crop. The availability of residues was used to calculate their net potential. The residue's availability is unused, and its entirety is a waste.

The available potential of the agricultural residues in Libya was calculated based on Equation 1 (Karaca, 2015).

$$(\boldsymbol{AAR})_{\boldsymbol{i}} = (\boldsymbol{ACP})_{\boldsymbol{i}}\boldsymbol{x}(\boldsymbol{RPR})_{\boldsymbol{i}}\boldsymbol{x}(\boldsymbol{A})_{\boldsymbol{i}} \quad (1)$$

$(AAR)_i$: is the available amount of agricultural residues of i^{th} crop (ton)

$(ACP)_i$: is the amount of crop production (tons)

$(RPR)_i$: is the residue-to product ratio of the i^{th} crop.

$(A)_i$: is the availability of residues.

Table 1: Show the ratio of product to residue, availability and heating values of a selection of agricultural residues Crop production in Libya (Karaca, 2015), (Karaca, 2017), (Karaca et al., 2017).

FC	R	RPR	A (%)	LHV ($MJ\ kg^{-1}$)
Wheat	Straw	0.017	15	17.9
Barely	Straw	0.021	15	17.5
Millet	Straw	0.011	15	12.39
Potatoes	Stalk	0.002	60	18.61
Maize	Stalk	0.009	60	18.5
Beans dry	Shell	0.007	40	19.4

FC: Field Crop, R: Residue, RPR: Ratio of Product to Residue, A: Availability, LHV: Lower Heating Value ($MJ\ kg^{-1}$).

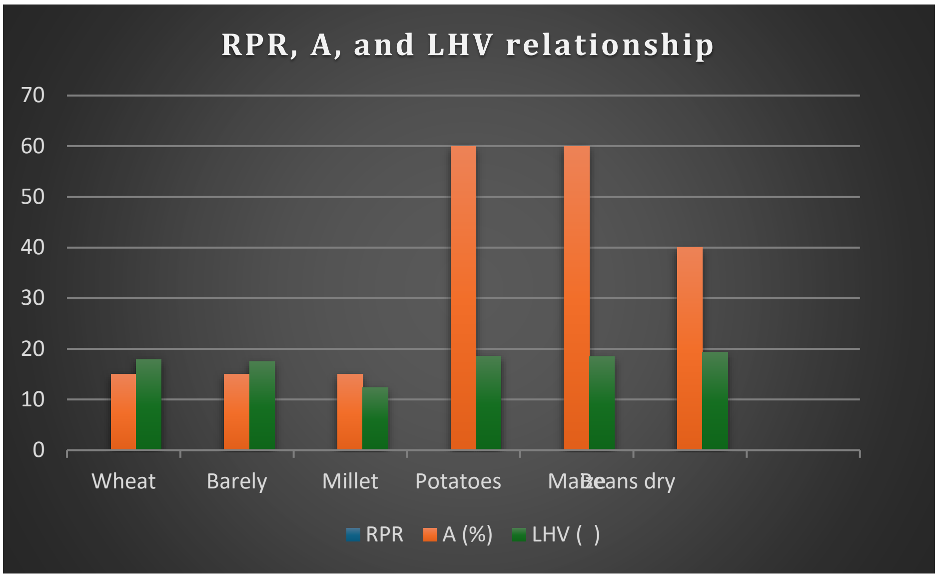

Figure 2. Relationship between RPR, A, and LHV

Materials left over in the field following agricultural production are referred to as residues. A portion of agricultural waste is already utilized for domestic Purpose heating, animal bedding, and other uses. The majority of the waste that remains after producing industrial agricultural products are left over in the field. These species include cereal straw, cotton, maize, sunflower, and so forth.

The heating values of a variety of agricultural residues, which were taken as the heating value per residue (Table 1), were multiplied by the amount of residue that was available to determine the energy potential of residues for each district (Eq. 2) (Karaca, 2015).

$$(\boldsymbol{THV})_i = (\boldsymbol{AAR})_i \boldsymbol{x} (\boldsymbol{LHV})_i \quad (2)$$

$(THV)_i$: Total heating value of agricultural residues of i^{th} crop (GJ).

$(AAR)_i$: Available amount of agricultural residues of i^{th} crop (tons).

$(LHV)_i$: lower heating value of air dried residues of i^{th} crop $(MJ\ Kg^{-1})$.

2. RESULTS AND DISCUSSION

In Libya, the total amount of agricultural residues was estimated to be 4.5 kilo tons, which included annual crop residues (wheat, barely, millet, potatoes, maize, and dry beans) (Table 2).

Table 2: Shows the amount of agricultural product and the available amount of residues in Libya.

FC	ACP	R	AR	AAR
Wheat	130000	Straw	2176.39	331.5
Barely	70000	Straw	1489.34	220.5
Millet	6000	Straw	70.22	9.9
Potatoes	328887.8	Stalk	685.88	394.66
Maize	3452.03	Stalk	32.39	18.64
Beans dry	1172.92	Shell	8.70	3.28
Total	539512.75	Residues	4462.94	978.48

FC: Field Crop, ACP: Amount of Agricultural Product (tons), R: Residue, AR: amount of Residue (tons) AAR: Available amount of Residue (tons).

Table 2 shows the amount of agricultural product, amount of residue and the available amount of residues in Libya. Major crops that are included in the ratio of the total residue amount are potatoes (40.33%), wheat (33.9%), barely (22.5%), and maize (1.9%).

It's evident that Libya has an abundance of raw materials available to produce energy from agricultural waste. For the production period 2021 in Libya, the total heating value of agricultural waste was estimated to be around (17.7 TJ). Table 3 displays the heating value of agricultural residues that were determined individually for each product.

Table 3: Shows the total heating values of agricultural residues in Libya.

Field crops	**Residues**	**Total heating value (GJ/kg)**
Wheat	Straw	5933.85
Barely	Straw	3858.75
Millet	Straw	122.66
Potatoes	Stalk	7344.62
Maize	Stalk	344.84
Beans dry	Shell	63.63
Total	**Residues**	**17668.35**

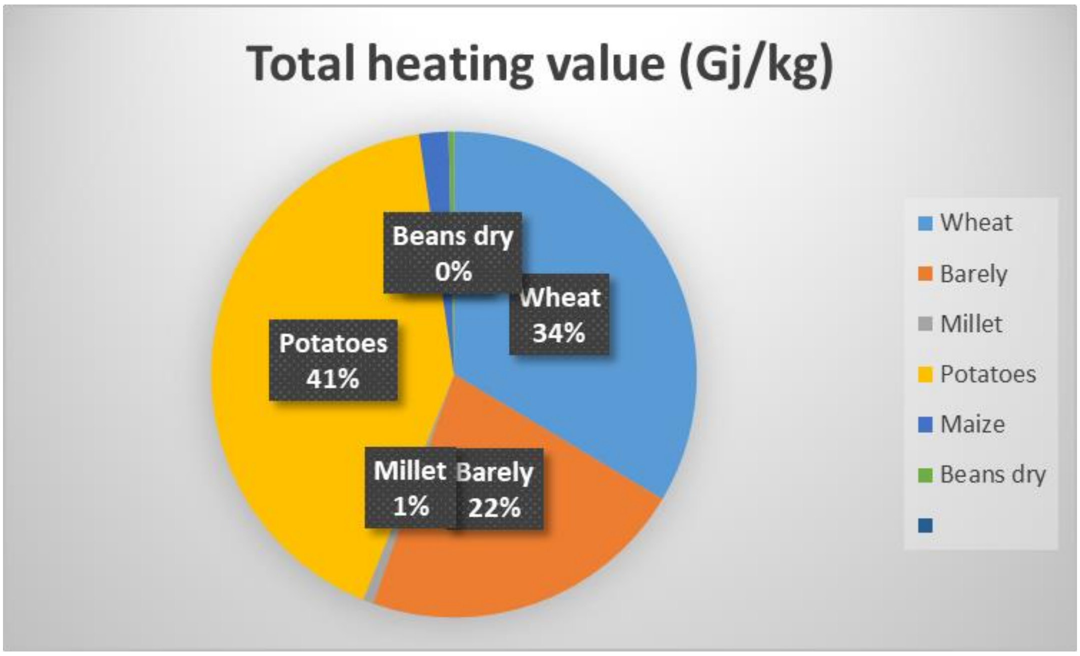

Figure 3. Total heating value from crop residues in Libya

3. CONCLUSION

Libya stands at a crossroads, faced with the dual imperatives of energy security and environmental sustainability. Utilizing the biomass energy potential from agricultural production offers a viable pathway towards achieving these objectives. By leveraging its abundant natural resources and investing in renewable energy resources, Libya can foster economic growth, enhance energy resilience, and pave the way for a greener and more sustainable future.

The purpose of this study was to estimate Libya's biomass energy from agricultural waste. Libya imports energy from other countries, which makes this article crucial. These days, converting agricultural waste into energy and using it to lessen energy constraint issues is the greatest course of action for developing nations. In this study crops like (wheat, barely, millet, potatoes, maize, and dry beans) have been identified for energy production. For the crops listed in this research above, the total heating value of agricultural wastes in Libya was approximately 17.7 TJ. It is noteworthy to remark that in Libya, the production of energy from agricultural waste is a significant and cost-effective source.

Any nation's primary sources of renewable energy are solar energy, wind, biomass, and geothermal resources. Because Libya is well-located and is seen to be the best place to use renewable energy, particularly biomass energy. In Libya, biomass energy has the potential to significantly contribute to the country's energy requirements and overall electrical energy demand, allowing for the use of biomass energy for a variety of mechanical, communication, and energy-generating applications. Through strategic planning, policy support, and international collaboration, Libya can position itself as a regional leader in biomass energy production, unlocking new opportunities for prosperity while safeguarding its natural environment for future generations.

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EXTENDED ABSTRACT

Libya, spanning an expansive 1,750,000 m2, is strategically located in the heart of North Africa. The climate in Libya varies, characterized by cold winters with occasional coastal rainfall. During the summer, the Sahara region experiences extreme dryness and high temperatures, while winters are relatively dry. Summer daytime highs can soar to 50 °C, with most days hovering around 40 °C. As per the latest United Nations data presented by Worldometer, Libya's population stands at 6,910,904 as of October 18, 2023. Over the past decade, the population of Libya has nearly doubled. This substantial population growth is contributing to increased waste and residue production, thereby exerting notable effects on the environment, as well as impacting the demands for energy and food.

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