ISSN: 0974-5823 Vol. 7 No. 10 October, 2022

International Journal of Mechanical Engineering

Direct and Indirect Applications of Nanotechnology in Biomass Energy Production in Algeria

Remache Leila [1]

[1] Laborаratoire de conception et modélisation avancée des systèmes mécaniques et thermofluides, Sciences and Applied Sciences Faculty, University of Oum El Bouaghi, Algeria.

***Abstract* -** 70% of renewable energy will be included in Algeria energy mix in 2030.

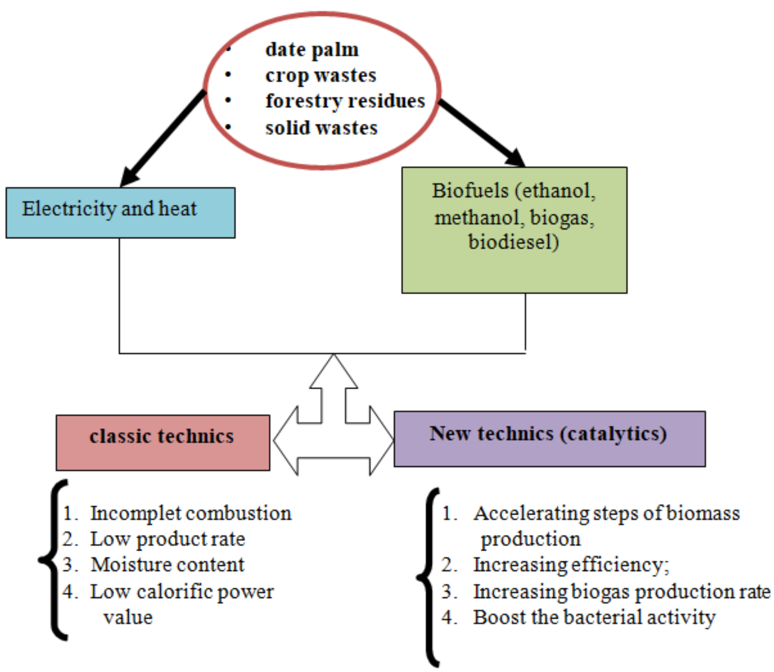
The target of renewable energy plan on solar, wind , geothermic and biomass is to replace the fossil fuel. The Algeria biomass energy potential is formed by solid wastes, date palm, crop wastes and forestry residues.

Integration of renewable energy into agricultural sector is necessary because the rural areas need biomass for cooking and lighting.

238 million hectares of Algerian grazing lands are neglected that can be used for energy purposes.

There are different technologies to convert biomass to renewable energy but the contribution of nanotechnology is limited.

This study reports direct and indirect applications of nanotechnology in the production of bioenergy and the technical problems that tackle this energy to compete with fossil fuels.



Index Terms : *biomass, nanotechnology, agriculture, Algeria.*

INTRODUCTION

The conventional fossil fuels (coal, oil and gas) dominate the Algerian consumption which has environmental impacts. Algeria's renewable energy program is one of the most progressive in last years. Its objective is development of solar, wind, geothermal and biomass technologies [1]. 70% of renewable energy will be included in Algeria energy mix in 2030. The solar energy has most interest. However, the availability and wide diversity of biomass resources have made them an important source of energy.

The indispensable energy sources, biomass accounts for around 80% of energy produced by global renewable energy carriers. It can be stored and employed to induce heating, energies and electricity when needed. It plays an important role to provide the necessary energy to rural areas for cooking and lighting.

There are various technical barriers to tackle for bio energy production so that it can compete with fossil fuels [2].

Nano materials are applied in bio energy production for their large surface areas and high catalytic activity.

CHALENGES OF BIOMASS ENERGY PRODUCTION

The major cause of searching new clean energy source is the exhaustive utilization of fossil fuels that produce annually 27 billion tons of CO_2, and this is predicted to increase about 60% by 2030[3].

Compared with fossil fuels, the biomass products as electricity and heat have low calorific power and their process production is complicated due to the problems of transport and storage [4].

PROCESSES OF ENERGY AND FUEL

The processes by which energy can be obtained from biomass are illustrated in (figure1):

- Burning solid fuel;
- Anaerobic digestion;
- Conversion to liquid or gaseous fuels.

ALGERIA BIOMASS ENERGY

Solid wastes, date palm biomass, crop wastes and forestry residues (table1) are the biomass energy resources in Algeria, [5, 6].

Table 1 showed that household wastes are the prominent fermentable resource. But, in fact the grazing lands that count 44millions ha i.e. 17% of the national territory (figure 2) are real neglected fortune that can be used for energy purposes.

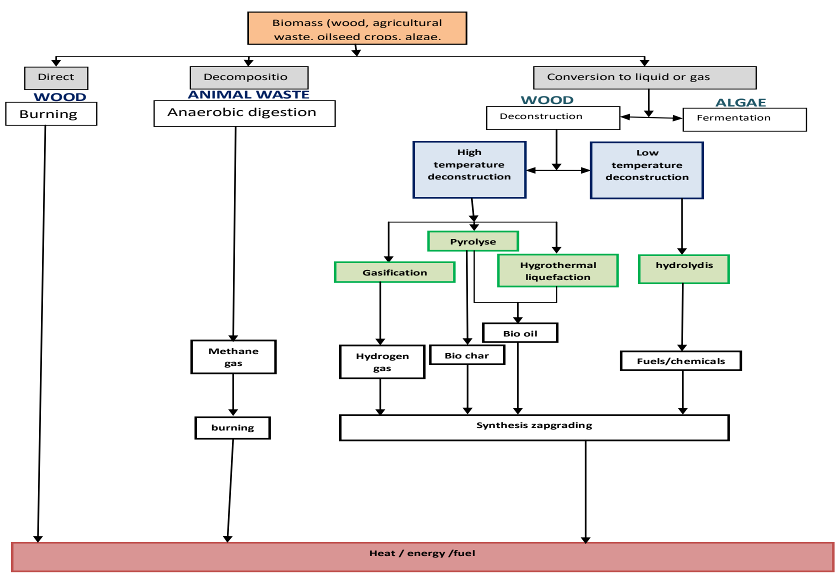


Figure 1 Biomass to biofuel processes

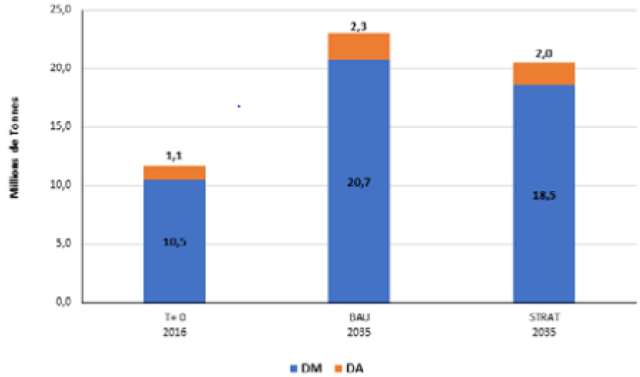


Figure 2 Evolution of the quantities of household waste generated between 2016 and 2035 [7].

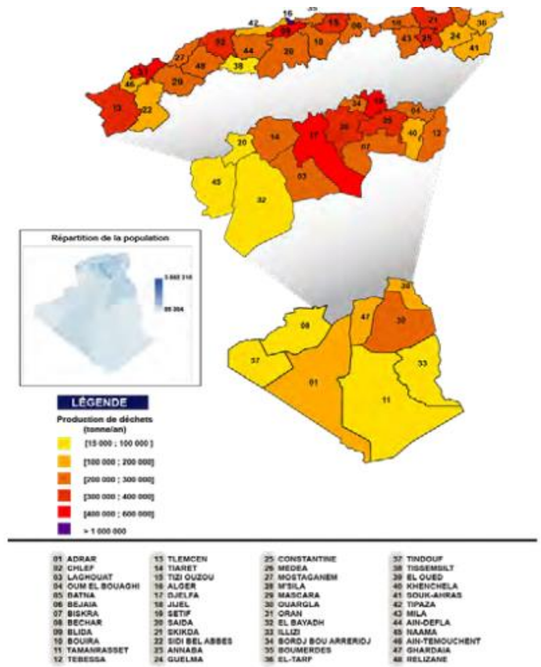


Figure 3 Representative map of the production of household waste in Algeria in 2020 [7].

Table 1: Potential bio power in Algeria [6]

Bio power resource	Biogas quantity (Million m^3/year)
Amurca (olive oil industry)	10.5
Whey (the dairy industry)	2.35
The organic fraction of household waste	974
Sewage from waste water treatment plants	22.91
Total	1009.76

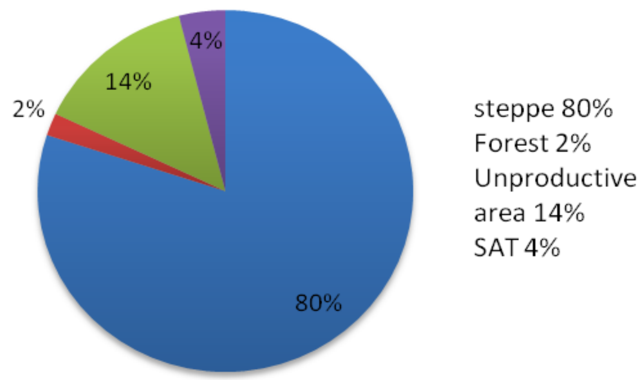


Figure 4: Repartition of national territory [8]

- Total agriculture area (TAA): 44 million ha i.e. 18.5% of national territory (N.T.);
- Pasture and rangelands (grazing animals): 32,75 million i.e. 74,5% of T.A.A.
- Unproductive farmland: 2652454ha i.e. 6% of T.A.A.;
- Useful agricultural area: 8,56 million ha i.e. 19,5%;
- Alfa area: 2,47million ha i.e. 1% of N.T.;
- Forest area: 4,1million ha i.e. 1,7% of N.T.;
- Unproductive area: 187,6million ha i.e. 78,8% of N.T.

Developing solar energy is the most aim for Algeria(figure 5). Therefore, the CDER (Centre de Développement des Energies Renouvelables) etablished a biopower research and development facility in the Ouled Fayet landfill. The bio – power generation in the country is 1GW by 2030 (figure5).

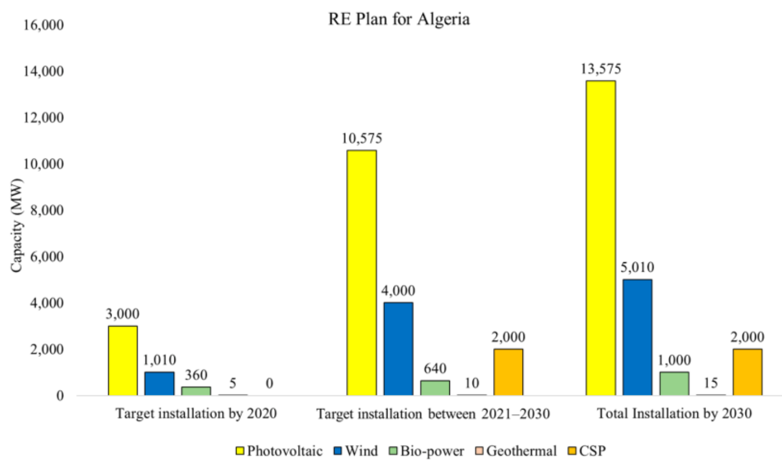


Figure5. Algeria renewable energy current and future generation plan [9, 10].

BIOMASS ENERGY TECHNOLOGIES AND CHARACTERISTICS OF BIO PRODUCTS

Biomass products (ethanol, methanol, biodiesel, and biogas) are obtained by thermo chemical, mechanical or biological processes, such as combustion, hydrolysis, fermentation, gasification or pyrolysis (table2).

The technologies for bioethanol are developing rapidly. For Algeria table 3 shows resources for bio ethanol production [11].

Table 2 Biomass products.

Product	resource	process	application
Methanol	Waste biomass materials	Fermentation and thermo chemical process (pyrolysis)	Biodiesel production
Bio ethanol (anhydrous alcohol)	Cellulosic materials	Pretreatment, hydrolysis and fermentation	Medical and food industries Flexible fuel vehicles
Biodiesel (methyl/ethyl/ester)	Vegetable oil	transesterification	fuel
biogas	Wood, algae, bagasse, sawdust, coconut shell	Pyrolysis Anaerobic digestion	Electricity and heat generation

Table 3 Lignocellulosic biomass resources and energy potential in Algeria

Biomass resources	Tone biomass/year	Tone biomass/hectare	l ethanol/t	Bio ethanol production million/year	**Energy estimation toe**
Alfa	60 000	1 – 0.2	100	6,25	3150
Olive pomace	165600	-	38	6,3	3500
Cereal straw	4315000	4,43	200 – 400	13,185	664,524
Corn straw	25720	7,5 – 11	250 -350	7,71	3888
total	-	-		13,205	675,062

Despite the diversity of products obtained from biomass and the large number of processes. But limitations arise during production or during use.

- Bio ethanol has less energy content than gasoline;
- Ethanol has an affinity for attracting water and therefore has a greater tendency to corrode the combustion chamber, hoses, pipelines and fuel systems than gasoline;
- Methanol has lower energy density (half that of petroleum) and lower vapor pressure;
- Moisture content inhibit the combustion and cause significant energy loss in the form of latent heat of steam for example moisture for agricultural residues 10 – 12% and wood residues and bagasse 50%

CONCLUSION

Bio-based products hold great potential to resolve the current energy and environmental crises. So, the development of advanced conversion technologies suitable for different types of biomass is likely to make bio-based products (energy and materials) competitive with petroleum based products.

APPLICATION OF NANOTECHNOLOGIE TO BIOMASS PRODUCTION

Nanotechnologies describe the creation, analysis and application of structures, molecular materials, inner interfaces and surfaces with at least one critical dimension or with manufacturing tolerances (typically) below 100 nanometers.

Table 3 Effect of Catalyst on Rate Constant Values

Rate constant. 10^3				Activation energy (cal.mol-1)		
Reactions	1% H_2SO_4 77°C	1% NaOBu 60°C	0.5% NaOBu 60°C	1% H_2SO_4 77-117°C	1% NaOBu 20-60°C	0.5% NaOBu 20-60°C
Triglyceride-diglyceride	3	3822	26626	14922	15360	15662
Diglyceride-monoglyceride	8	1215	3584	16435	11199	13053
Monoglyceride-glycerol	7	792	2373	15067	11621	13395
Diglyceride-triglyceride	0.02	121	439	19895	17195	15587
Monoglyceride-diglyceride	0.05	7	8	16885	-	13336
Glycerol-monoglyceride	0.03	11	7	12196	-	13110

Application of nanotechnology consists in use of the new properties and functionalities at nano scale for the improvement of existing products or the development of new products.

Nanotechnologies contribute to:

- the optimization of energetic biomass utilization, for example in the development of new conversion methods (catalysts, process technology and sensorics)
- The nano-optimized cultivation of bio-resources (e.g. efficient utilization of fertilizers and pesticides through nano-encapsulation and nano-sensors)[12].

- ***Application of catalytic in transesterification***

Trans-esterification of a vegetable oil with an alcohol were carried out with soybean oil and butanol at 117°C, using an alcohol/oil molar ratio equal to 30 shows that kinetic constants were determined in the case of acid catalysis with 1% H_2SO_4. In the case of a base catalysis, 0.5 and 1% sodium butoxide (NaOBu) should be used (figure7). The Table 3 presents the results in the case of catalyses, acid and base [15, 16]. The use of nano-catalysts for the trans-esterification of fatty esters from vegetable oils or animal fats into biodiesel and glycerol consists on the nano-catalyst spheres (figure6) replace the commonly used sodium methoxide. The spheres are loaded with acidic catalysts to react with the free fatty acids and basic catalysts to react with the oils. This approach eliminates several production steps of the conventional process, including acid neutralization, water washes and separations. All those steps dissolve the sodium methoxide catalyst so it can't be used again. In contrast, the catalytic nanospheres can be recovered and recycled. The overall result is a cheaper, simpler and leaner process.

As shown in table3 [15], the best efficiency of the reaction is obtained by using methanol as alcohol; this is due to its great reactivity, its solvent power, its low steric hindrance and its higher acid character compared to the others linear or branched alcohols used

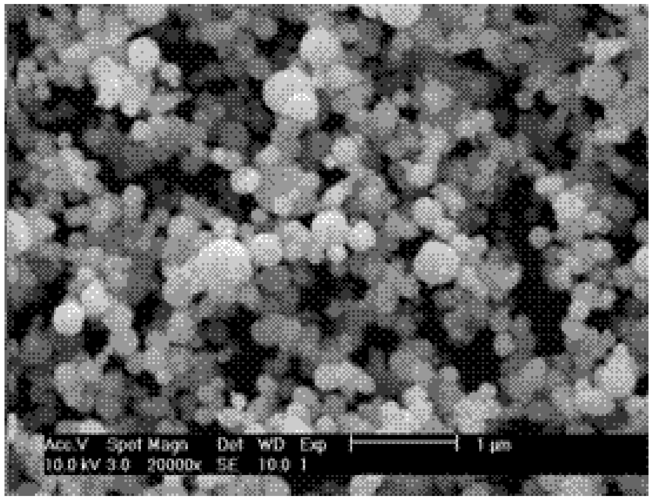


Figure 6 Nanoparticles by flame pyrolysis [16].

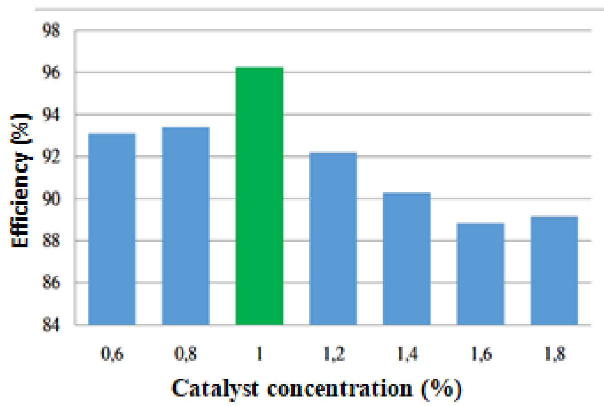


Figure7 Effect of catalyst quantity on trans-esterification [18]

- ***Application of catalytic in biodiesel production***

Table 4 shows that biodiesel yield increase with catalyst amount and type for reaction time and temperature.

- ***Application of catalytic in anaerobic digestion***

In Algeria, the most used process for biogas production is anaerobic digestion. This operation has four steps; hydrolysis, acidogenesis (primary fermentation), acetogenesis (secondary fermentation) and methagenesis.

Table 4 Effect of nanocatalysts on biodiesel yield [19].

Nanocatalyst	Mode of synthesis	Feedstock	Catalyst amount %	Reaction time (h) and reaction temperature (°C)	Biodiesel yield %
Na_2O/CNT	Impregnation method	Used cooking oil	3	3/65	97
Sulfonated biochar and activated carbon	Pyrolysis method	Vegetable oil	2 - 8	6/55 - 60	97

So, biogas production rate is decreased by the slowest step called the rate limiting step [20].

For accelerating this rate and increasing biogas production rate, nano particles are dispersed in anaerobic waste treatment reactor such as Fe_3O_4 with (15 – 22nm) and (50 - 125mg/l) at 37°C increase methane production 117%. This element is dissolved in form of Fe^{3+}/Fe^{2+} ions that boost the bacterial activity.

- ***Indirect applications of nanotechnology in biomass process***

Use nano particles as a machine to extract oils from algae directly without subjecting them to physical process.

CONCLUSION

Biomass energy is often the only accessible and affordable source of energy in rural areas. The availability and wide diversity of biomass resources in Algeria have made them an attractive and promising source of energy. But, it has limitations and there are some challenges in presenting them economically more viable. So, it is important to use nanoscience and nanotechnology in the development of biomass energy production schemes in form of nanocatalytics.

Its depend on type of waste, reactor temperature and the configuration of reactor.

Their characteristics such as high catalytic activities and high specific surface area have helped overcome some limitations.

In last, Algeria potential specially household waste must be burnt in an incinerateur or through anaerobic digestion or lanfilling to produce bioenergy to reduce the dependency of fuels, create new employment in rural area and in cities and for a cleaner environment.

REFERENCES

[1] Younes Zahraoui, & Al, “Current status, scenario and prospective of renewable energy, in Algeria. A review”, Energies 2021, 14, 2354.

[2] Kuan Shiong, Wen Y’chia & Al, “Nanomaterials utilization in Biomass for biofuel and bioenergy production”, Energies , 13, 892, 2020, doi:10.3390/cn13040892.

[3] Mandona, Farshad Yazdani, Elohe Motaee, Dezhi Han, Hamidreza Arandiyan, “A review on conversion of biomass to biofuel by nanacatalysts”, Biofuel Research Journal1, 16 – 25, 2014.

[4] Jason Kramb, “Potential applications of nanotechnology in bioenergy, Master’s thesis, University of Jyvaskyls, 2011.

[5] Amine Akbi, & Al, “An overview of sustainable bioenergy potential in Algeria”, Renewable and sustainable energy, Reviews, 72, 240-245, 2017.

[6] Eddine, B.T.Salah, MM, “Solid waste as renewable source of energy. Current and future possibility in Algeria”, Int. J. Energy. Environ, Eng., 3 – 17, 2012.

[7] Rapport sur l’état de la gestion des déchets en Algérie. Exercice 202O. Ministère de l’environnement.

[8] Statistique agricole superficies et production série”B”, 2019, Direction des statistiques agricoles et des systèmes d’information, Ministère de l’agriculture et du développement durable, Juillet 2021.

[9] Bouznit M., Pablo Romero, M.D.P., « CO2 emission and economic growth in Algeria », Energy Polycy, 96, 93 – 104, 2016.

[10] Dubley B., B.P. “Statistical Review of world energy”, BP Stat.Rev., London, U.K., 2019.

[11] Noreddine Kacem Chaouche, “Lignocellulosic biomass and industrial bioprocesses for the production of second generation bio ethanol, does it have a future in Algeria”, S.N. Applied Science, 2, 680, 2020.

[12] Moammed Barati, “From biomass to fuels: Nano catalytic proceses”, Green chemistry.

[13] S.Thanigarvil, Matias Soto Moscoso, “Role of nanotechnology for the conversion of lignocellulosic biomass into biopotent energy; A biorefinery approach for waste to value added products”, Fuel, volume 322, 1242 – 236, 2022;

[14] Y.X.Chen, A.Lavacchi, H.A.Miller, M.Bevilacqua, J.Filippi, M.Innocent, A.Marchionni, W.Oberhauser, L.Wang, F.Vizza, "Nanotechnology makes biomass electrolysis more energy efficient than water electrolysis", Nature Communications, Doi: 10, 1038/ ncomms 5036, 2014;

[15] J.Hill, "A nother solar module factory in Algeria", PV Magazine, 2020.

[16] Ayhan, Demirbas, "Combustion characteristics of different biomass fuels", Science, Volume 30, issue2, 219 – 230, 2004.

[17] K.Sivabalan, & Al, "A review on the characteristic of biomass and classification of bioenergy through direct combustion and gasification as an alternative power supply", Journal of physics, conf.ser.1831, 2020.

[18] Karim Khiari, "Contribution à l'étude des propriétés thermo – physiques des bio carburants de seconde génération et leur influence sur le comportement des moteurs", thesis, Ecole des mines de Nantes, 2017.

[19] Sayfa Bano & Al, « Fabrication and optimazation of nano catalyst for biodiesel production: An overview, Frontiers Energy Research, 2020.

[20] Hamed Baniamerian & Al, "Application of nano structured materials in anaerobic digestion: Current status and perspectives", Chemosphere 229, 188 – 199, 2019.