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Title

Biomass-based biofuel production : Potential and possible uses in Algeria - Ouargla

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In front of the jury :

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CHAPTER II : BIOGAS POTENTIAL IN ALGERIA - OUARGLA

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ABBREVIATIONS LIST

BFCV	Biogas Fuel Cell Vehicle
BDD	Biogas demand density
BU	Bottom-up
BV	Biogas vehicle
C_A	Conversion Coefficient Animal
CB	Consumption of biogas
CFV	Conventional Fuel Vehicle
C_M	Conversion Coefficient Municipal
C_P	Conversion Coefficient Palm
CSP	Concentrated Solar power Plant
DB	Demand for biogas
DEM	Digital elevation model
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GIS	Geographic information systems
IAM	Integrated Assessment Models
IIAG	Ibrahim Index of African Governance
IOCs	International oil companies
IPPs	Independent Power Producers
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LSI	Land suitability index
MPR	Market penetration rate
N_A	Number of livestock heads
N_P	Number of palms
Npop	Number of the population
NREP	National Renewable Energy Program
OM	Organic matter
PD	Population density
PPA	Power Purchase Agreements

ABBREVIATIONS LIST

PV	Photovoltaic
QOW_M	Quantity of organic waste
QW	Quantity of waste
QW_A	Quantity of animal waste
QW_M	Multiplying the quantity of city waste
QWO_M	Quantity of organic waste of urban origin
QW_P	Quantity of palm waste
RP_A	Rate of production per head
RP_c	Rate of production per capita
PR_P	Product ratio per palm
TD	Top-down
UNFCCC	United Nations Framework Convention on Climate Change
VB_A	Biogas Volume of Animal waste
VB_M	Biogas Volume of Municipal waste
VB_P	Biogas Volume of Palm waste
VH	Vehicles per inhabitant

LATIN LETTERS LIST

Bpd	Barrels of oil per day
cm	Centimeter
G	Giga
H	Hour
hab	Inhabitant
J	Joule
k	kilo
kg	kilogram
Mr	Million
M	Mega
m^2	Square meters
m^3	Cubic meters
mm	Millimeter
t	Tons
toe	Tons of oil equivalent
V	Volt
W	Watt

GENERAL INTRODUCTION

GENERAL INTRODUCTION

Burning fossil fuels raises the temperature of the Earth's atmosphere, which is known as the greenhouse effect, and contributes to climate change, which is a severe environmental problem, as well as rising oil prices. Biofuels, unlike fossil fuels, are considered a renewable energy source. Biofuels are frequently marketed as a low-cost, ecologically acceptable alternative to petroleum and other fossil fuels.

Algeria's position in this new global trend can be determined by two primary factors. The first concerns the consequences and ramifications on Algeria's economy, particularly given the country's heavy reliance on fossil fuels as a significant source of energy. The second component concerns the opportunities and limits connected with Algeria's admission into the biofuel system, given its abundance of all elements, including enormous agricultural areas and unexplored areas on the one hand, and water and forest resources on the other. As a transportation vehicle fuel, biogas can be produced a viable alternative to natural gas and used as an alternative transportation fuel in Algeria. Biogas was considered one of the renewable alternatives for meeting the greenhouse's heat load requirements.

Our main objective is to give the potential of biomass-based biofuels production in Algeria (Ouargla), and prospective study of integration of biogas in Algerian transportation sector for 2050. This assessment will be based on a GIS system to locate the geographically accumulated biofuels.

The present work consists of three main parts :

-The first chapter presents a overview about the global and Algerian energy situations (energy consumption, production, and exploitation of oil and gas, as well as greenhouse gas emissions resulting from these operations), as well as a study of Algeria's renewable energy, as well as the strategy adopted and concrete actions taken.

-The objective of the second chapter is to finding the potential of biogas from biomass and to using the wilaya of Ouargla as a case study.

-The third chapter presents a bibliographical study on CO_2 recovery and valuation, after which we apply a method that combines geographic information system (GIS) and energy modeling to estimate biogas demand potential in the Ouargla (Algeria) road transport sector during the period from 2020 to 2050.

And finally finish our work by conclusion and some perspectives.

CHAPTER I

ENERGY CONTEXT IN ALGERIA

I.1. Introduction

The Algerian economy is described as a renter economy based essentially on the revenue generated by the export of hydrocarbons. Until now, oil and gas have been considered as a vector of socio-economic progress, hence the importance particular attention paid to their enhancement. However, the Reserve and Production ratio of each of the resources gives natural gas an additional priority, which is that of covering the country's energy needs in the long term.

Algeria ranks fifth in the world for natural gas reserves. The strategic position of the islands of the Mediterranean region and the hydrocarbon resources of the planet to make them a key partner in the Mediterranean region and in Europe for meet its energy needs in natural gas and oil. Available energy, the sum of national production, imports and stocks, reached 160,4 Mtoe in 2019, up 3,7 % compared to 2018.

In this chapter, a overview about the energy reality of Algeria where will take a look about the reserves, production and consumption and some other energy realities in Algeria.

I.2. National energy situation

I.2.1. Reserve

The country has more than 12 billion barrels of proven oil reserves and 150 tons cubic feet of natural gas. Parliament has also approved a new energy law, which would make international oil and gas investment more appealing to avoid a production decline, while retaining the majority foreign ownership of projects in the industry [1].

Algeria boasts the largest land size on the African continent with a total area of 919,600 square miles. Algeria is a historical leader of oil and gas production in Africa and globally, with first petroleum discoveries made in the Sahara Desert in the southern region of the country in the 1950s. The country ranks sixteenth place in terms of proven oil reserves globally and contains the tenth-largest proven gas reserves in the world. Currently the sixth-largest exporter of natural gas, the country is increasingly developing the sector in order to generate further revenue and optimize production for its shale gas reserves, which are the third largest globally [1].

Algeria currently produces 1.1 million barrels of oil per day (bpd) of which 540,000 bpd are exported, just under 50%. National petroleum company, Sonatrach, owns the majority of that production, around 80%, while international oil companies (IOCs) are accountable for the remaining 20%. While exploration campaigns have led to a handful of gas discoveries in recent years, Algerian oil fields are mostly in mature or depletion phases. In order to sustain and even increase current output levels, operators are encouraged to introduce innovative production methods, such as enhanced recovery technology [1].

In line with the rise of global demand for liquefied natural gas (LNG), the country is showing immense natural gas potential. Algeria boasts 20 trillion cubic meters of technically recoverable shale gas, the third-largest globally. Unconventional resources extraction is an exciting prospect for many IOCs, some of whom have already signed cooperation agreements with Sonatrach to assess technical and commercial feasibility. Highly dependent on hydrocarbon revenue, which constitutes 95% of its exports and 60% of its national budget, Algeria's economy sits on $75 billion in foreign currency reserves. These reserves have dropped significantly since 2014 due to declining oil and gas prices and predictions reckon the reserves will continuously decrease until 2030 [1].

I.2.2. Production

I.2.2.1. Primary energy production

Commercial production of primary energy fell by -4.8 compared to 2018 achievements, reaching 157.4 M toe, driven by that of all products except electricity.

The structure of commercial primary energy production remains dominated by natural gas at 54%, as illustrated in the graph below [2] :

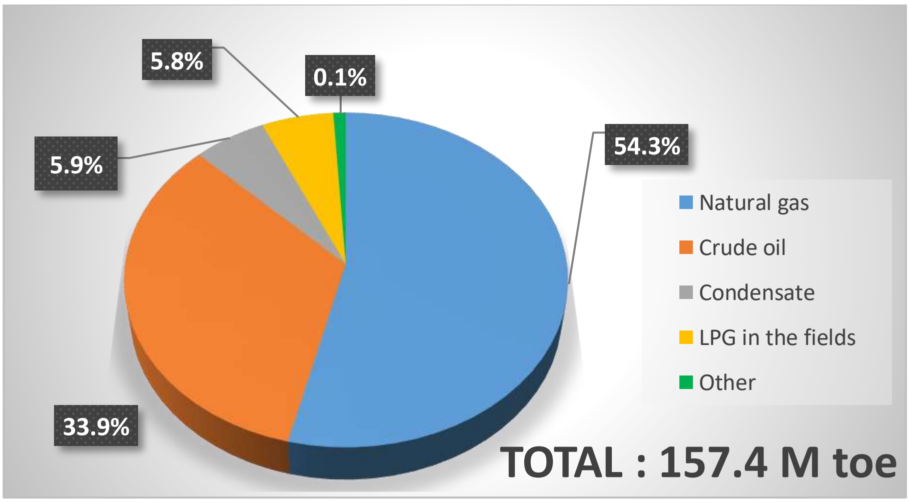


Figure I.1 : Structure of primary energy production [2].

Thus, primary electricity production increased from 783 to 835 GWh in 2019, driven by an increase (+30%) in the production of the hydraulic sector following favorable rainfall in 2019, when total production increased. summer of 152 GWh compared to 117 GWh in 2018 [2].

I.2.2.2. Derived energy production

Derived energy production reached 66.1 M toe, up (+2.2%) compared to 2018 achievements, driven by that of liquefied natural gas (LNG) production (+21.9%) and thermal electricity (+2.1%).

The structure of derived energy production remains dominated by petroleum products with 44%, as illustrated below [2] :

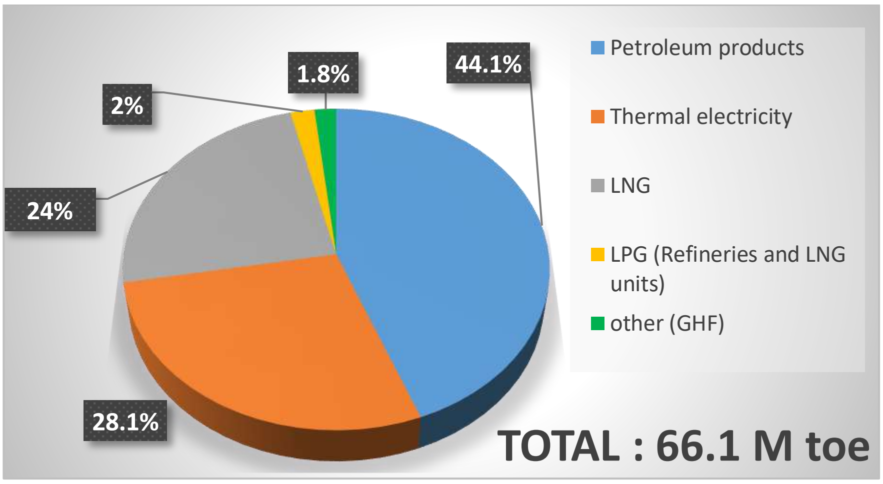


Figure I.2 : Structure of derived energy production [2].

Conversely, the production of petroleum products fell (-5.7%) compared to the same period of the previous year, to settle at 27.7 million tons, driven by the decline (- 7.3%) of the crude oil processed load at refinery level after the shutdown of oil processing operations abroad [2].

I.2.3. Consumption

I.2.3.1. Evolution by form of energy

Total national energy consumption increased (+3.0%) to 66.9 M toe in 2019. It represents nearly 43% of total production.

- Final consumption (per product) : 50.4 M toe
- Other Consumption : 16.5 M toe [2].

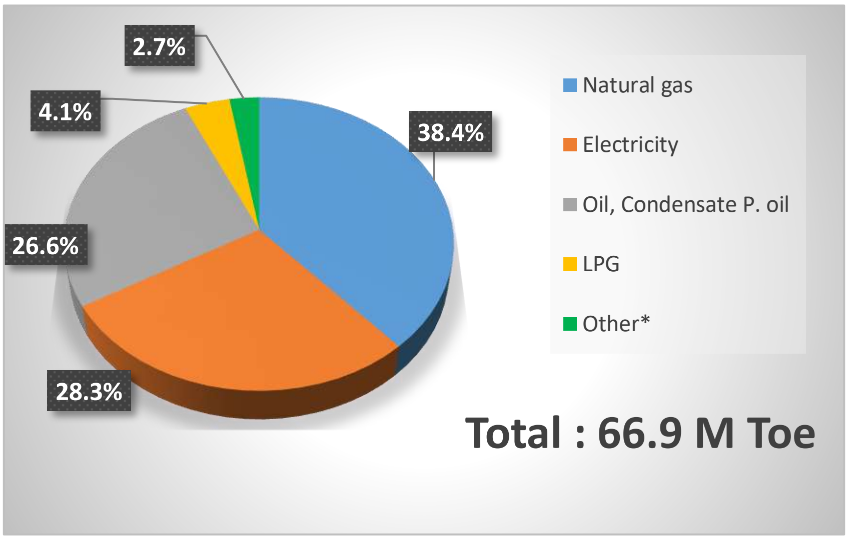


Figure I.3 : National consumption by form of energy [2].

National consumption increased by 3.0% compared to the 2018 level, driven by that of natural gas and petroleum products (3.9% each).

Natural gas (39%), electricity (28%) and liquid products (27%) predominate the structure of national consumption [2].

I.2.3.2. Consumption by sector

The structure of final consumption remains dominated by the "Households & others" sector (46.7%), followed by transport (30.6%) and finally the "industry and construction" sector with a share of 22.7%, as illustrated in the graph below [2] :

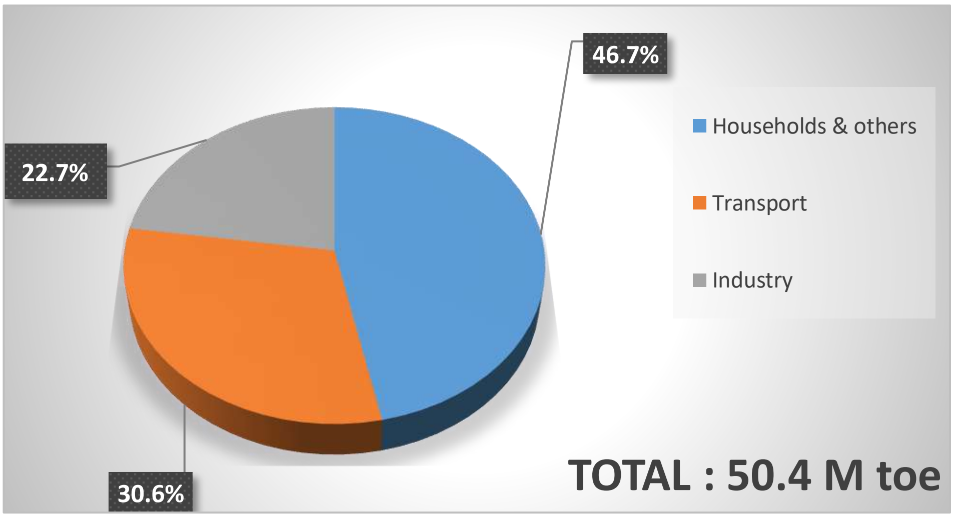


Figure I.4 : Structure of final consumption by sector [2].

By sector of activity, the evolution of final consumption in 2019 highlights the following :

- Increase in consumption by "Households and others" by 5.0% to 23.5 Mtoe, driven by the residential sub-sector (2.9%), thanks to the increase in the number of Sonelgaz customers (in particular BP) and their needs;

- Slight increase (0.8%) in consumption in the “transport” sector to 15.4 M toe in 2019, driven by that of road fuels;

- Increase in consumption in the "Industry and construction" sector by 9.3%, to 11.4 M toe, driven by the sub-sectors of ISMME (41%), construction (84%) and building materials construction (+5%) [2].

I.2.4. Renewable energies

I.2.4.1. Solar energy

Algeria first introduced solar energy, in 1988, into the Southern project. Algeria started preparing larger cities, like Skikda and Oran, with the adequate equipment to improve the potential of solar energy as all.

Solar energy can be generated either through the installation of CSP (Concentrated Solar power Plant) system, or the PV (Photovoltaic) system [3].

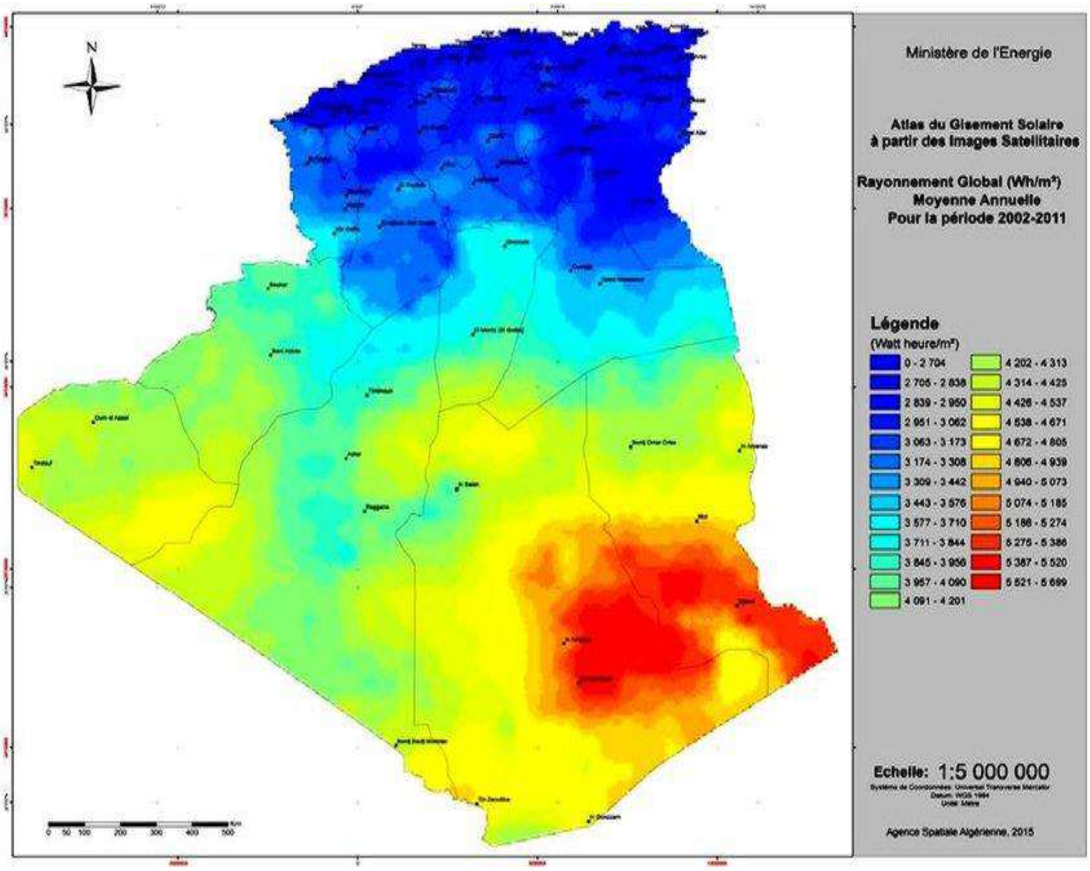


Figure I.5 : Annual solar irradiation (kWh/m^2/year) [4].

View of its geographical location, Algeria has one of the most raised in the world. The duration of insulations on almost the entire national territory exceeds 2000 hours annually and can reach 3900 hours (highlands and Sahara). The energy received annually on a horizontal surface of 1m² is close to 3 kWh/m² at north and exceeds 5.6 kWh/m in the (South TAMENRASSET) [3].

I.2.4.2. Wind power

Usually ranges from a topographic area to another, also it depends on the climate too. Algeria’s climate ranges greatly between the northern and the southern halves of Algeria. Northern half, is unique because it acquires an ideal location on the Mediterranean, it has the Atlas mountains and other high plains. But the northern winds aren’t as strong as the southern ones. The southern winds speeds range from 4m/s - 6m/s, but most southern lands are lower in latitude than the northern region, whereas desert represents more the 70% of the total Algerian surface area. Adrar is considered to be the most suitable place as it’s famous for operating, and providing strong winds. Having strong winds around a high hill or ridge can provide a good power plant [3].

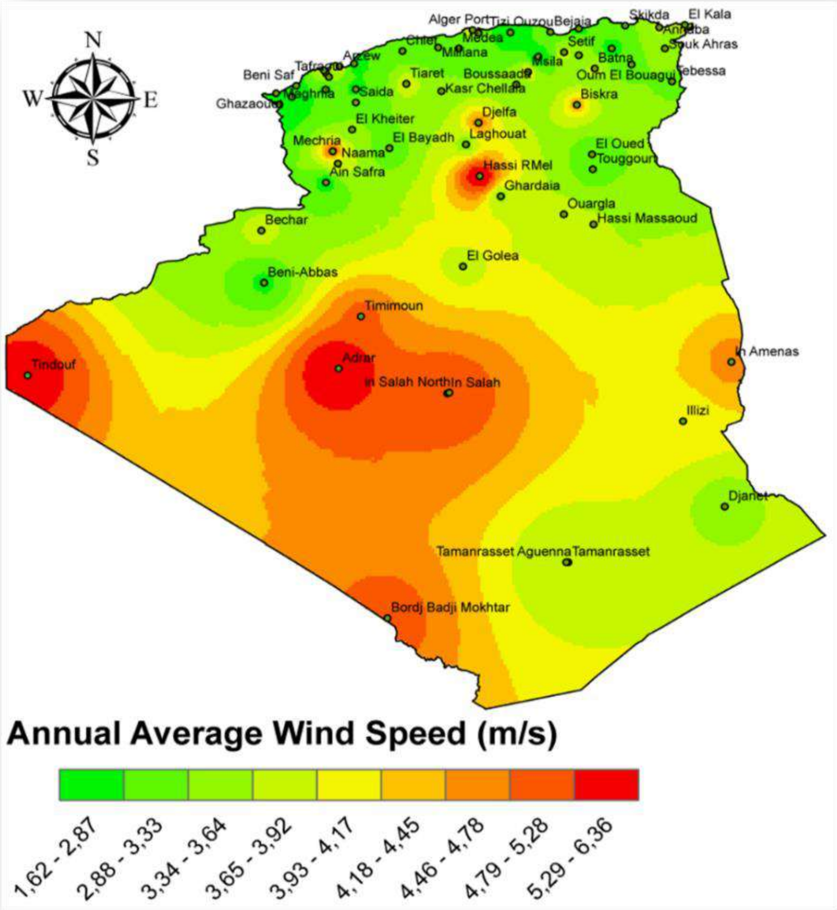


Figure I.6 : Annual Average wind speed (m/s) [4].

Mainly due to a very diverse topography and climate. Indeed, our vast country, subdivides into two major geographical areas. The northern Mediterranean is characterized by a coastline of 1200 km and a mountainous terrain, represented by the two chains of the Tellien Atlas and the Saharan Atlas. Between them are interspersed plains and highlands of continental climate [3].

The South, meanwhile, is characterized by a Saharan climate. The map shown below shows that the South is characterized by higher speeds North, particularly in the Southeast, with speeds above 7 m/s and exceeding the value of 8 m/s in the Tamanrasset region (In Amguel). Regarding the North, it is generally noted that the average speed is low. However, the existence of microclimates on the coastal sites of Oran, Bejaïa and Annaba, on the highlands of Tebessa, Biskra, M'sila and Elbayadh (6 to 7 m/s), and the Great South (> 8 m/s)[3].

I.2.4.3. Geothermal

The compilation of the geological, geochemical and geophysical data contributed to layout a preliminary geothermal chart. More than two hundred (200) hot springs have been recorded in the Northern part of the country [5]. Approximately a third of these hot spring (33%) show temperatures exceeding 45° C. High temperature springs exist in Biskra region reaching 118°C. These natural outflows which are generally leakages from existing reservoirs have a flow of more than 2m^3/sof hot water. This represents only a very small part of the production possibilities of the reservoirs [3].

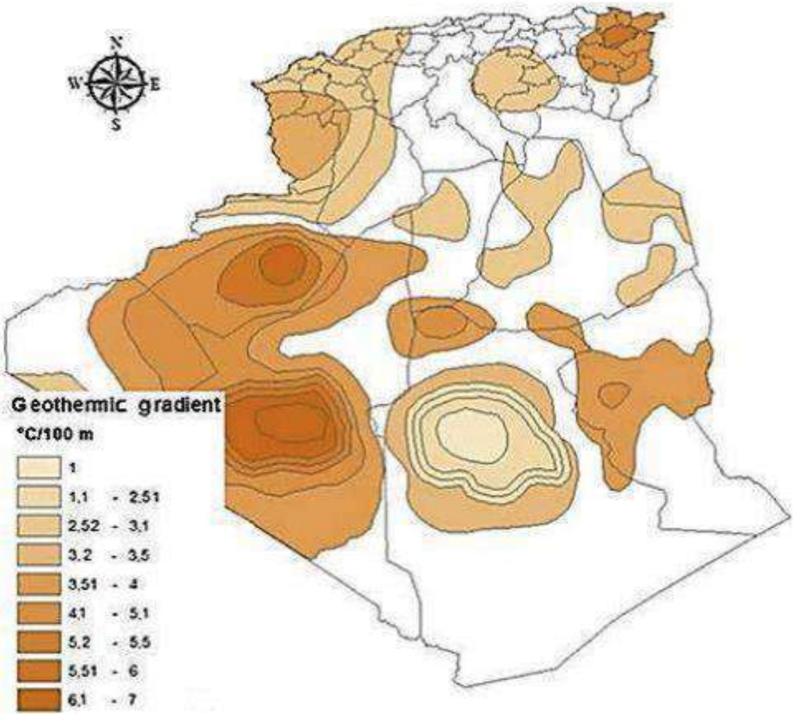


Figure I.7 : Distribution map of geothermic gradient in Algeria [4].

Deeper in the South, the continental rock formation constitutes a great geothermal reservoir extending over several thousand km^2. This reservoir commonly called the ‘‘albian platform’’ is exploited through drilling, at a flow rate of over 4 m^3/s. This water has an average temperature of 57 °C [6]. Studies on the thermal gradient have identified three zones whose gradient exceeds 5 °C/100 m [3] :

- Relizane and Mascara area;

- Area of Ain Boucif and Sidi Aïssa;

- Guelma and Jebel El Onk area.

I.2.4.4. Biomass

To generate fuel through biological processes may require a couple of restrictions. To succeed in generating biofuel, you have to have vast areas of Greenland and not just that, but also to be ready to use them in your generation process. Luckily, Algeria has plenty of agricultural lands and a high quality of unpolluted soil fully rich with minerals, making it a good call to plant soybeans, corn and wheat... for energy purposes. “To each his own biofuel feedstock” - that is what Nakheel, an Algerian biotech company must have thought when it took decision to research and invest in bioethanol production using dates from the abundantly growing palm trees in North Africa and the Near East as a raw material [6].

The biomass potentially offers great promise, with 37 Mtoe (tons oil equivalent), coming from forests, with a rate of recovery around 10%. Moreover 5 million tons of urban and agricultural waste (365 kg of urban waste per Algerian). This potential represents a deposit approximately of 1.33 Mtoe / year; however this potential is not enhanced and consumed yet. In addition, the harnessing of organic wastes, mainly animal wastes, for biogas production could be considered as an economic solution: it is decentralized and ecological since it delivers energy autonomy, and allows sustainable development of rural areas. It is composed of two major types which are the forest and household and similar waste [6].

I.2.4.4.1. Potential of the forest

The current potential is estimated at around 37 Mtoe. The recoverable potential is of the order of 3.7 Mtoes. The current recovery rate is of the order of 10%. The potential of biomass is relatively limited. The wooded area covers about 250 million hectares and represents 10% of the total area of the country where the Sahara covers almost 90% of the territory. Forests occupy an area of about 4.2 million hectares, representing 1.8% of this area, while alfatier zones occupy only about 2.5 million hectares, that is to say a little more than 1% of the extent of the territory. On the other hand, so-called unproductive lands cover more than 188 million hectares, representing 79% of the total area [7].

I.2.4.4.2. Household and similar waste

05 million tons of urban and agricultural waste is not recycled. This potential represents a deposit of the order of 1.33 Mtoe / year [8].

I.2.4.5. Hydraulic Power

The global quantities falling on the Algerian territory are important and estimated at 65 billion m^3, but finally little benefit to the country: reduced number of days of precipitation, concentration on limited spaces, strong evaporation, and fast evacuation towards the sea. Schematically, the surface resources decrease from north to south. Current resources are estimated at 25 billion m^3, of which about 2/3 for surface resources.103 dam areas were identified. More than 50 dam are currently in operation [3].

I.3. Environmental context

I.3.1. Economic indicators and CO_2 emission

Before addressing the Algeria energy profile, it is worth high- lighting the economic aspect and CO_2 emission. According to the Ibrahim Index of African Governance (IIAG) ("GDP.Ibrahim Index of African Governance," 2018), Algeria ranked (in 2017) the fourth country in Gross Domestic Product (GDP) equal to 170 000 million $ after Nigeria (375 771 million $), South Africa (349 419 million $) and Egypt (238.369 million $). Moreover, Algeria is considered as upper-middle income country ("Renewables global status report," 2018). However, it remains plagued by a weak fiscal due to the high dependency to hydrocar- bons revenues and lack of economic reforms (Belaïd and Youssef, 2017). Provide some economic indicators for the period 2013-2018 ("Algeria Economic," 2019; World Bank Algeria Economy, 2019) [9].

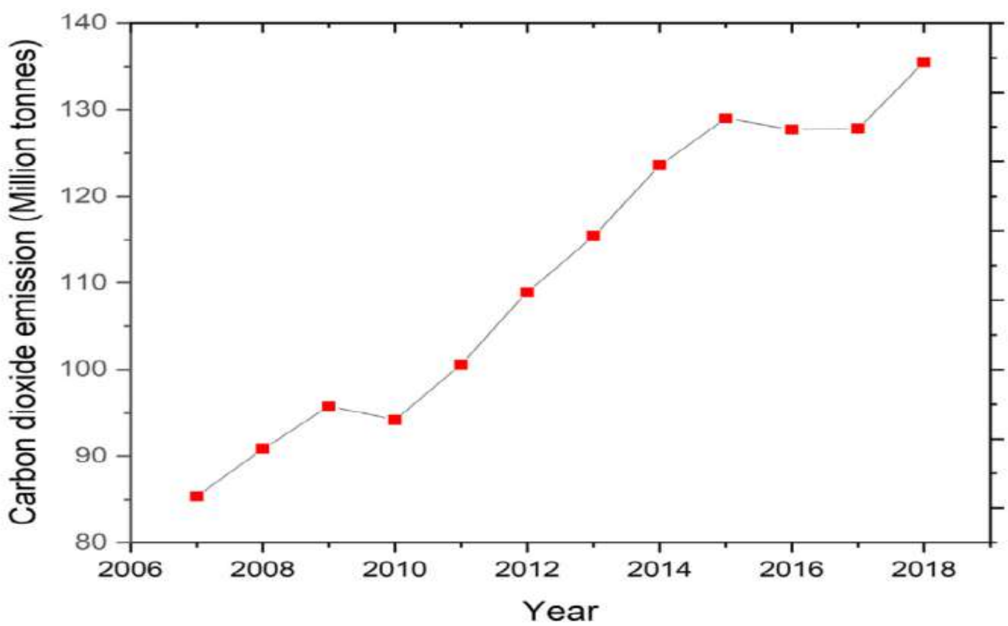


Figure I.8 : Evolution of CO_2 emission in Algeria (2007-2018) [9].

Algeria is considered as one of the most significant emitters of CO_2 among African countries, it ranked third after South Africa and Egypt according to ("Statistical Review of World Energy," 2019) due to economic growth (increase of energy utilization and electricity consumption) (Bouznit and Pablo-Romero, 2016). Figure I.8 provides the evolution of CO_2 emission in Algeria for the period 2007-2018 ("Statistical Review of World Energy," 2019). Algeria has a diverse significant potential of energy resources either conventional such as oil or natural gas, or renewables such as solar and wind. However, hydrocarbons still occupy an important position in the national economy as it is considered among the top 3 producers of oil in Africa (Allegret and Benkhodja, 2015; Amri, 2017; Saheb Koussa and Koussa, 2016). An overview of energy status in Algeria from 2009 to 2018 concerning the primary energy production, energy exchanges and energy consumption is highlighted in order to show that the country is strongly dependent on production and marketing of fossil fuels [9].

I.3.2. National commitment to Climate change

Some global environmental problems such as global warming or thinning of the ozone layer required the application of international measures such as the Kyoto Protocol in 1997 to reduce anthropogenic greenhouse gas emissions [10]. This protocol sets a goal for the 38 most industrialized countries in the world to reduce their global greenhouse gas emissions by 5% from levels observed in 1990 [11].

Algeria has been among the countries to be submitted to the UNFCCC Secretariat (United Nations Framework Convention on Climate Change). It plans to reduce, for 2030, its greenhouse gas emissions between 7% (with its own funds) to 22% (conditioned with international aid). To coordinate the national effort to combat climate change, the government recently adopted a renewable energy development program [12].

I.3.3. National Renewable Energy Program (NREP)

National Renewable Energy Program (NREP) aims to boost Algeria's plans (National Renewable Energy Development Strategy 2015-2030) to untap the high solar energy potential (2,000 kWh/m^2 annual average irradiation), diversify the energy mix and attract private investments in the power sector. Algeria aims to add 13.5 GW of solar energy capacity for 2030. NREP supports Algeria, to deploy this huge utility-scale solar energy generation capacity through a transparent, well-structured and competitive selection of Independent Power Producers (IPPs). NREP's specific objective is to provide technical and financial assistance to complete and roll-out the technical, legal and institutional framework that will allow private IPPs to come and invest in feasible and financially profitable solar energy projects. NREP components are: (i) solar sites identification, prioritization and preparation- solar potential determination, echnical, financial and legal, environmental and social studies/agreements for each selected site; (ii) Capacity building on “Preparation of relevant legal template agreements including Power Purchase Agreements (PPA), Concession Agreements, Direct Agreements, Interconnection Agreements and Land Agreements etc.”, negotiation and related legal and regulatory issues; and (iii) project management and coordination. NREP builds on the Bank’s IPP procurement experience in other countries (Ethiopia, Nigeria and Angola) [13].

I.4. Fuel and transport sector

Energy consumption in the transport sector decreased between 2010 and 2013, dropping from 2.3 Mtoe to 2 Mtoe. This trend obviously emerge from the crisis that has shaken the country since 2011, but could also be explained, in part, by the reduction in gas consumption in the level of pipelines transporting Algerian natural gas to Italy, and by the increasing use of motorists (especially those using the diesel) to the parallel market for the supply of fuel, the quantities of which are not covered by national energy statistics [14].

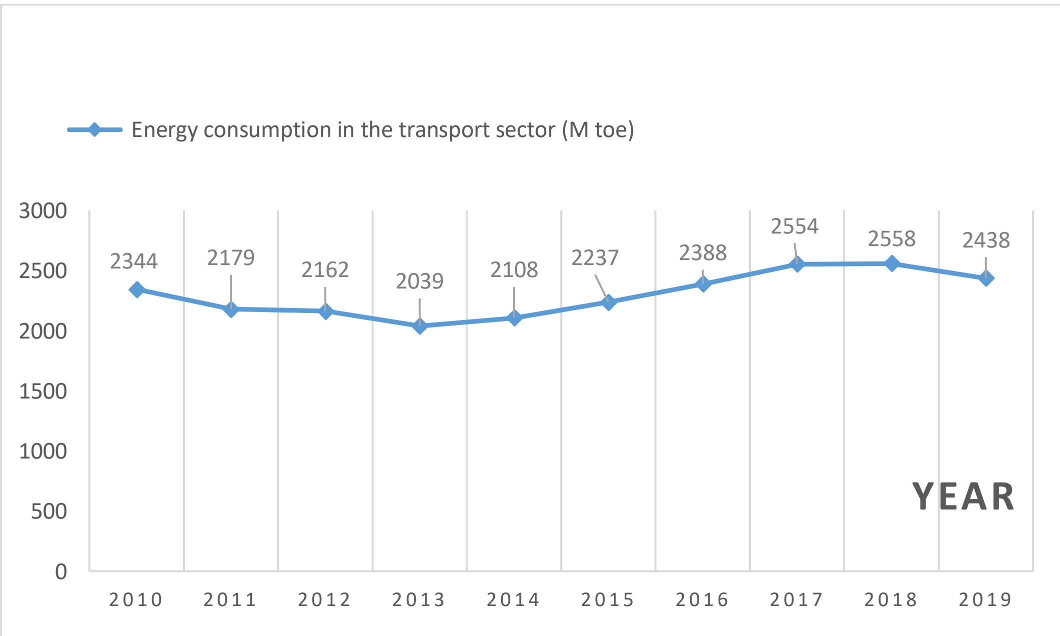


Figure I.9 : Evolution of final consumption in the transport sector between 2010 and 2019 [14].

From 2014, the trend was reversed with an increase in demand from the transport sector, an annual increase of more than 6% was recorded between 2014 and 2017. Although the consumption of the transmediterranean gas pipeline compressor stations has not started to improve that in 2016,The consumption of road fuels increased significantly following the strengthening of border surveillance and consequently a contraction of the parallel market, even if it is still present [14].

In 2018, demand kept the same level of 2018, which hides contradictory orientations between the different forms of energy as shown in the following figure. For the year 2019, the demand decreased due to the contraction in the consumption of compressor stations but also the fall in sales of the diesel announcing the orientation of the new towards the parallel market [14].

It should be noted that in the consumption structure, the share of natural gas has fallen, first between 2010 and 2015 due to the decrease in its consumption in gas pipelines; passing from 15.7% in 2010 to 3.8% in 2015. This drop was made to the benefit of petroleum products, whose share fell from 84% to 95.8%. During the 2nd period 2016-2017, the trend reversed to start a new downward cycle in 2018- 2019 [14].

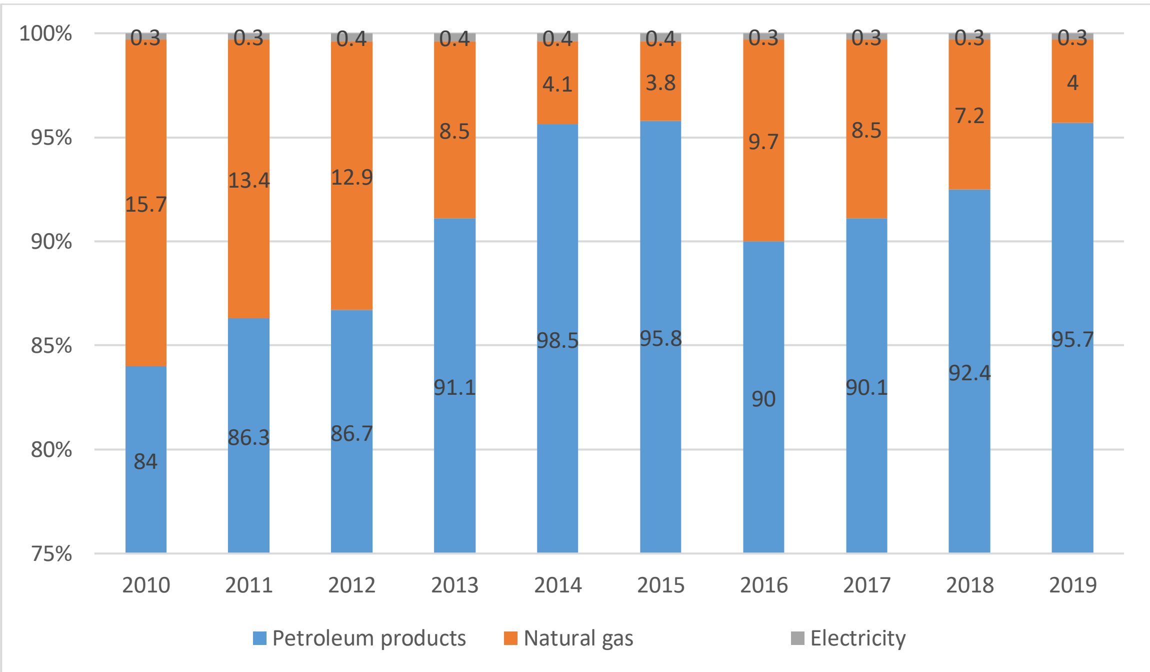


Figure I.10 : Evolution of the consumption structure of the transport sector by form of energy between 2010 and 2019 [14].

Focusing on road transport, we note [14] :

- A decrease in the consumption of LPG fuel by 11% annually on average over the period in question, although in reality, the consumption of LPG as fuel has not decreased; a quantity of domestic LPG is used by individuals and taxis to refuel their cars. This inappropriate use, which spread after the revolution, is prohibited by law and has a negative impact on the state compensation fund.

- A drop in diesel consumption during 2010-2014 then a gradual increase from 2015 and then a further drop in 2019. Ordinary diesel is the product most affected by smuggling. Attempts to approximate the "additional contribution" of smuggled diesel have been made. Nevertheless, the results are very divergent and incomparable with respect to the extrapolation of the existing trend in 2010.

- Very mixed evolutions for gasoline which was affected, of course, by the phenomenon of contraband but to a lesser degree than diesel.

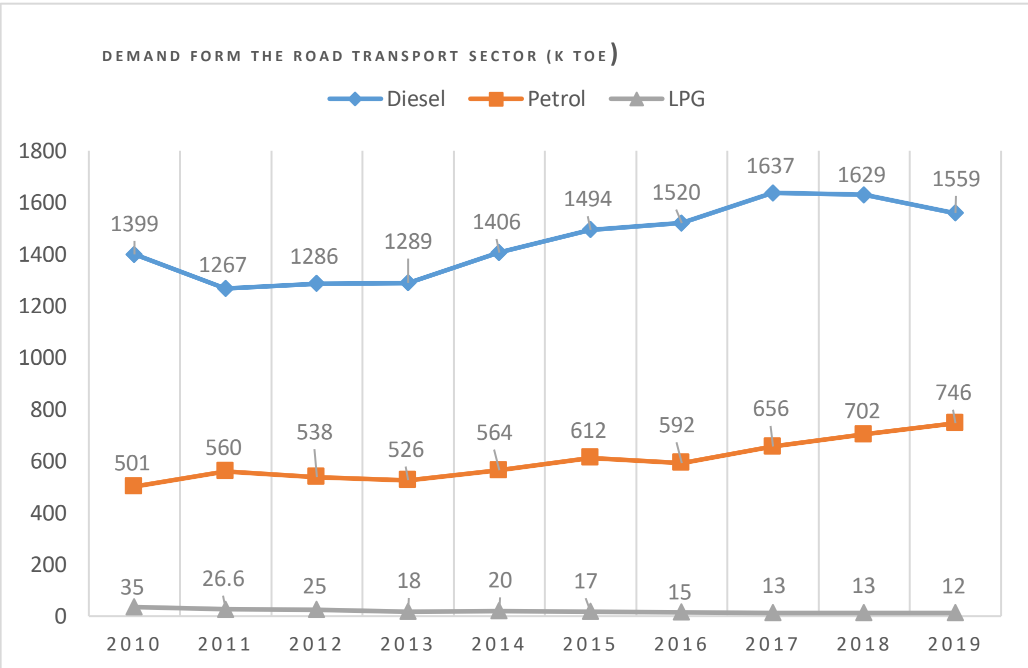


Figure I.11 : Evolution of road transport consumption by product (ktoe) according to the official energy balance [14].

To conclude, it is difficult to determine the additional contribution of smuggling for fuels by extrapolating the same trends from before 2011 because of the multitude of effects that can be taken into consideration (the extension of the rolling stock, the increase in fuel prices, the drop in purchasing power, the actions of energy management, etc.), that on the one hand, on the other hand, the integration of these quantities in the balance sheet as final consumption, requires the introduction also as an import in the national balance sheet and as an export in the balance sheet of the source country, otherwise we risk having an unbalanced balance sheet and/or double counting [14].

I.5. Conclusion

In this chapter, we have a general summary of the energy sector from the resources (reserves, production, energy consumption) and CO_2 emissions and the transport sector in Algeria. After reviewing the realities of energies in Algeria e can notice that the renewable energies are one of the best solutions in the future one of this is biomass which can be produced from organic rubbish and Algeria is one of the best places for this.

CHAPTER II

BIOGAS POTENTIAL IN ALGERIA -OUARGLA

II.1. Introduction

The survival and development of human beings are threatened by environmental pollution and resource exhaustion. At this point, using renewable energy systems to produce the necessary energy has become a need all over the world due to increasing greenhouse gas emissions and environmental pollution. One of the most important sources of renewable energy in the world is biogas. To promote the development of biomass-based biogas systems, it is essential to find suitable locations for such development. This research aims to find the biogas potential from biomass and using the Wilayas of Ouargla as a case study. A variety of constraints, as well as economic, environmental and social factors are integrated in this approach to help determine the most suitable sites for installing such bio-energy systems. As an application of the approach proposed in this work, a land suitability map for locating biogas plants was developed.

The objectif of this chapter discuss the potential of biomass (municipal, animal and palm wastes) and biogas production based on the available potentials, as the biogas produced in this process consists of two components, methane and carbon dioxide with a small amount of other gases. This chapter is a summary of the note " Biofuel plants site selection integrating multi-criteria decision aid methods and GIS techniques in Algeria : A case study of Ouargla ", for students " Maàmri Mohamed Abderrahmane - Drid Mohamed Amine ".

II.2. Biomass potential

II.2.1. Description of study area south eastern (Ouargla)

The city of Ouargla is located in the southeast of Algeria. It is bordered on the north by Oued-Souf and Biskra and Djelfa, on the east by Tunisia, on the south by the states of Illizi and Tamanrasset, and on the west by the state of Ghardaia. Its area is 163,230 km^2 (old administrative division).

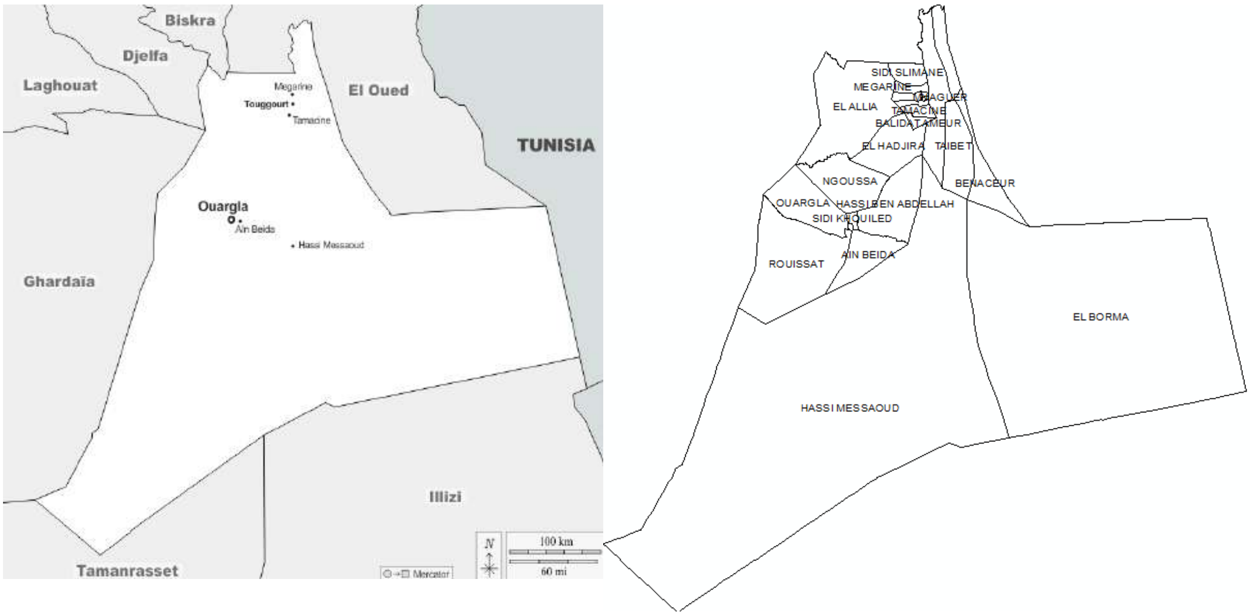


Figure II.1 : Borders and municipalities of the wilaya of Ouargla [16].

The population of the province is estimated to be about 708,463 inhabitants in 2019. It is a desert city characterized by its wide geographical area, and it is one of the largest cities in Algeria [15].

II.2.2. Biomass production in Ouargla

This work focuses on the assessment of the biogas potential from municipal biowaste and agricultural residues, derived from plants (date palms) and livestock (manure) of animals (sheep, cows, camels and goats). The technology used to produce biogas is the anaerobic digestion. Figure II.2 illustrates the biomass classification used in this research work.

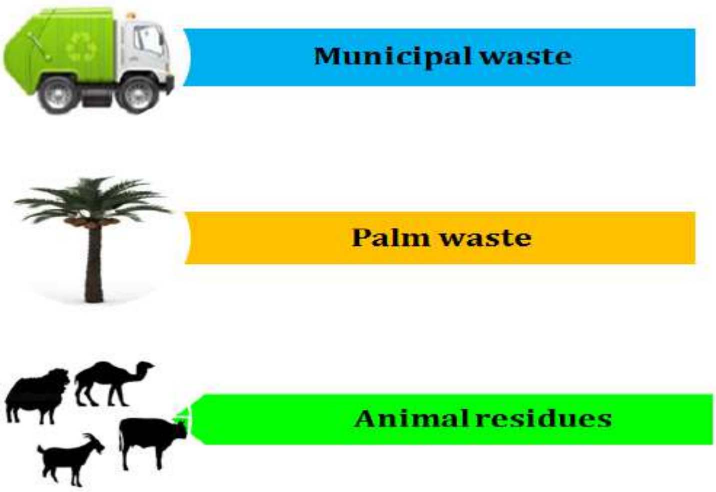


Figure II.2: The classification of biomass used in this work.

The developed method is divided into the following main steps:

• Biomass potential assessment;

• Energy valorisation of potential (biogas);

• GIS mapping.

II.2.2.1. Municipal waste production

According to Law No. 01-19 of 12-12-2001, “household and similar” and “municipal waste” waste is all waste from households (consumer waste), as well as similar waste from industrial activities, commercial, artisanal and other things which by their nature and composition are comparable to household waste [17].

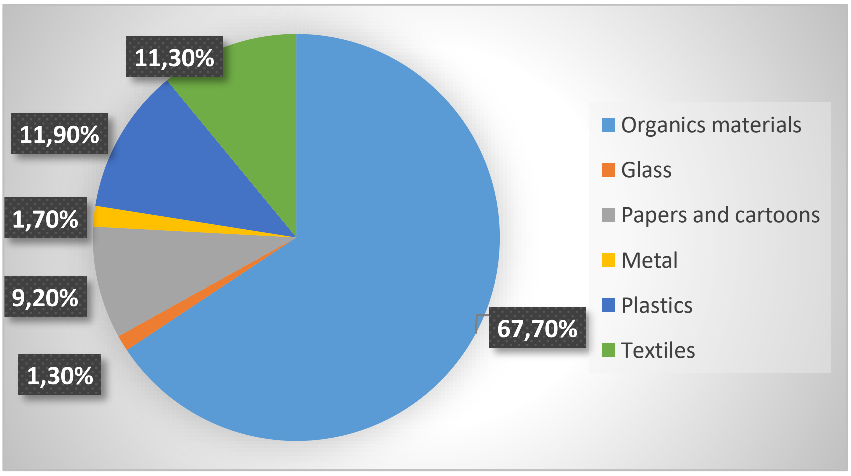


Figure II.3 : Composition of waste in Algeria (2011) [17].

The waste stream is a heterogeneous mixture of products and materials whose composition varies with its sources of generation. The amount of municipal waste generated in homes and public buildings in Ouargla is about 206.8712 kt / year, and it contains 67.7%. biodegradable organic matter. In order to calculate the waste potential, the following data were set :

The amount of waste generated was evaluated at 0.8 kg per inhabitant per day, where 67.7% of waste is organic matter. Data on the amount of municipal waste generated was obtained from the Environment Directorate and National Organization of Statistics and Budget in the Ouargla [18],[19], [15].

The production of waste at the level of a wilaya (QW), during the reference year 2019, is estimated from the specific production ratio per inhabitant and per day estimated for the space in question (RP_M), multiplied by 365 (days) and multiplied by the number of the population (Npop) of that city, based on estimates made for the base year [17].

$$QW_M = Npop.RP_M.365 \qquad (II.1)$$

The total production of organic waste of urban origin (QWO_M) at the level of the city under study, during the reference year is estimated by multiplying the production of city waste (QW_M) and the percentage of average organic matter (OM) in this waste. These steps are summarized in the following equation :

$$QWO_M = QW_M.OM \qquad (II.2)$$

According to the national waste agency [20], the percentage of organic matter OM is estimated at 67.7%. We assume that the composition of the waste is identical everywhere in Algeria. This composition is determined for the year 2011 [17].

II.2.2.2. Animal wastes production

Animal waste is one of the most important sources of biomass for the production of biogas. The province of Ouargla has a large number of animals that produce a significant amount of waste. Where the number of heads of sheep is 145,877 heads, and 213,680 head goats, and 999 head cows, and 41,503 head camels for the year 2019 [19], [18] [15]. Considering these statistics, it can be argued that there is a great potential for utilizing the waste from cattle husbandries to generate biogas in Ouargla. Biogas production from livestock wastes depends on factors such as their animal feed, body weight, and solids in wastes.

Total animal waste production (QW_A) is estimated at the city level under study during the reference year by multiplying the number of livestock heads (N_A) and the rate of production per head (RP_A). These steps are summarized in the following equation :

$$QW_A = N_A . RP_A . 365 \qquad \text{(II.3)}$$

The daily amount of manure as a percentage of the livestock weight is considered to be 9% for large livestock (cows and camels), 4% for small livestock (goats and sheep).

II.2.2.3. Palm waste production

Palm waste is one of the most important sources of biomass for the production of biofuels, as the city of Ouargla has a large potential for palm trees, estimated at 262,8814 palm trees [18], [21], [15].

Theoretical potential of residues from plant production is defined as the annual production of residues generated during agricultural production. The collected waste consists of leaves, leaf stems, and empty fruit clusters. On average, each palm tree produces 6 - 10 empty fruit clusters and 12 - 15 stems, and each stalk has about 120 - 240 leaves. Altogether, represents around 15-35 kg of annual waste per tree. Waste samples were first dried for a few days in an open atmosphere and under direct sunlight with a temperature peak of around 45 ° C, during the day. The dried material was then cut into small pieces before being converted into particles [22].

The total production of palm waste (QW_P) at the province level under study during the reference year is estimated by multiplying the total number of palms (N_P) and the residue to product ratio per palm (PR_P). Total production is estimated according to equation :

$$QWp = N_P . PR_p . 365 \qquad \text{(II.4)}$$

The average production of palm waste ranges from 15 to 35 kg of residues per palm (fruit clusters, stems, stalk, leaves,… etc). According to scientific reports and published reference papers, an average of 25 kg was taken. This approach was used to assess the palm residue potential of 2019 [22] [23].

II.3. Biogas potential

II.3.1. Biogas production from municipal waste

The determination of the volume of biogas VB_M (m^3) estimated from the quantity of organic waste QOW_M (kt/year) and conversion coefficient C_M (m^3/tons) is as follows :

$$VB_M = QOW_M.C_M \qquad (II.5)$$

The conversion factor ranges (C_M) from 100 to 300 m^3 per ton of waste. In our study, we took an average of 200 m^3 / ton. This approach was used to assess biogas recovery from municipal waste [17].

II.3.2. Biogas production from animal waste

The quality and quantity of livestock manure produced varies according to the type of feed and the living conditions of the livestock. There can be differences in the amounts of biogas produced from livestock waste.

The determination of the volume of biogas VB_A (m^3) estimated from the quantity of animal waste QW_A (kt/year) and conversion coefficient C_A (m^3/ tons) is as follows :

$$VB_A = QW_A.\ C_A \qquad (II.6)$$

Therefore, in this study, according to published scientific reports and reference papers, different methods are used to calculate the biogas production factor from biomass (see Table II.1) [26] [24] [25].

II.3.3. Biogas production from palm waste

Based on the great potential of palm waste in the city of Ouargla, which is estimated at 2628814 palm trees which can produce large quantities of biogas, according to published scientific reports and reference papers, the determination of the volume of biogas VB_P (m^3) estimated from the quantity of palm waste QW_P (kt/year) and conversion coefficient C_P (m^3 / tons) is as follows [26] [27] [25] :

$$VB_P = QW_P.\ C_P \qquad (II.7)$$

Table II.1 : Conversion coefficient to biomass and biogas [26], [27], [28].

Resource	Biomass conversion coefficient (kg/head)	Biogas conversion coefficient (m^3/kg)
Cow and calf	**22.5**	**75**
Camels		
Sheep	**1.6**	**13**
Goats		

The conversion coefficient varies from animal to animal. According to published scientific reports and reference papers, the conversion coefficient for each animal has been determined in the Table II.1.

II.4. Total Potential

Biogas is a practical way to recycle organic waste that can be used as fuel for cogeneration of electricity and heat. Livestock-based resources and agriculture have great potential for biofuel generation mainly due to their relatively low cost in Ouargla. This study aims to assess the potential of Ouargla in generating biofuel from both animal and agricultural resources to provide an accurate / realistic estimate of resource availability. Table II.2 shows the calculation of the amount of biogas produced from biomass waste for the year 2019.

Table II.2 : The amount of biogas produced from biomass according to the municipalities of Ouargla province for the year 2019 [16].

	biomass (kt/year)	Biogas (m^3)
animal waste	559.029	**28,908.33**
municipal waste	206.87	**28,010.36**
Palm waste	65.72	**12,167.20**
Total potential	831.621	**69,085.895**

The total palm waste is estimated at 65.720 kt / year, which can be considered as a potential raw material for the production of 12 167.203 m^3 of biogas. In addition, the potential of biogas from 559.029 kt of livestock waste is estimated at 28,908.332 m^3/ year, and the municipal waste is estimated at 206.87 kt / year, which produces 28,010.36 m^3/ year, the results indicated that there is a great potential for generating biofuel.

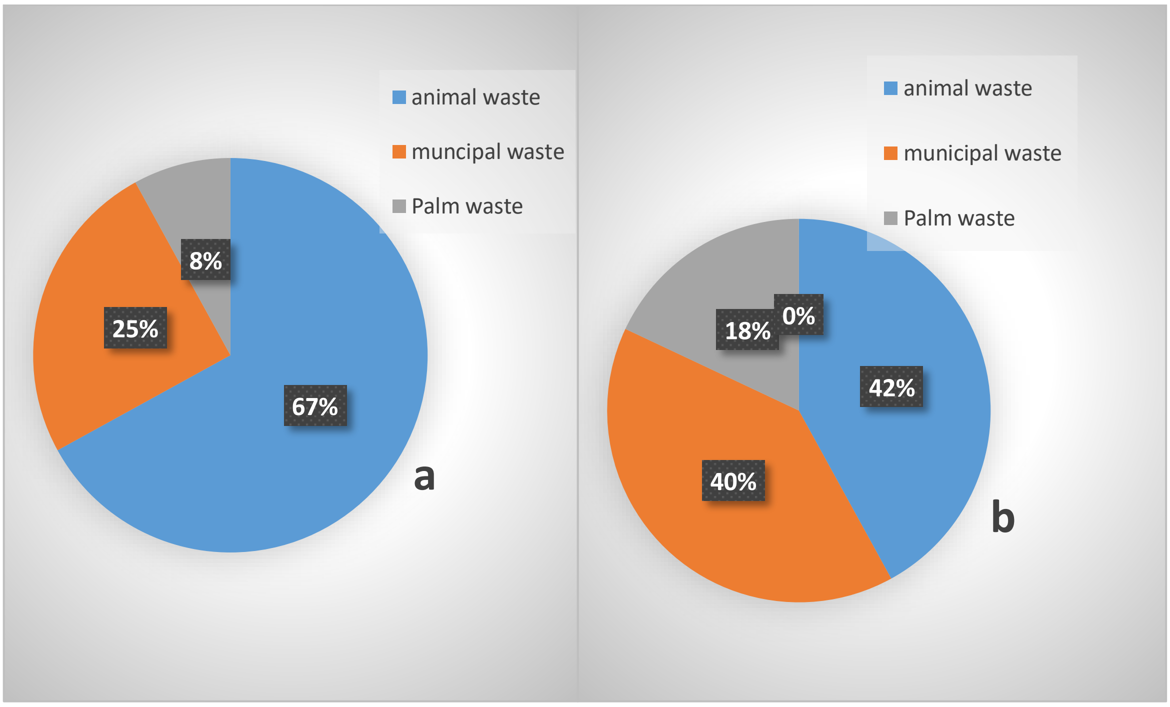


Figure II.4 : percentages of contribution according to source of waste. The total potential of (a) biomass waste and (b) biogas in Ouargla (2019) [16].

Figure II.4 shows the percentages of the biomass waste and biogas potential from livestock manure, municipal and palm waste in 2019 in the wilaya of Ouargla. It was seen that the most of waste production (67%) could be provided by livestock manure compared to municipal waste (25%) and palm waste (8%). the analysis estimated that the total potential to generate biofuel from these organic materials was about 69 085.89 m^3/ year which animal waste present 42% of total followed by municipal waste with 40% and palm waste with 18%. This research provides insights and valuable information for policymakers to formulate a long-term energy policy by making use of this vital waste in Ouargla as a case study.

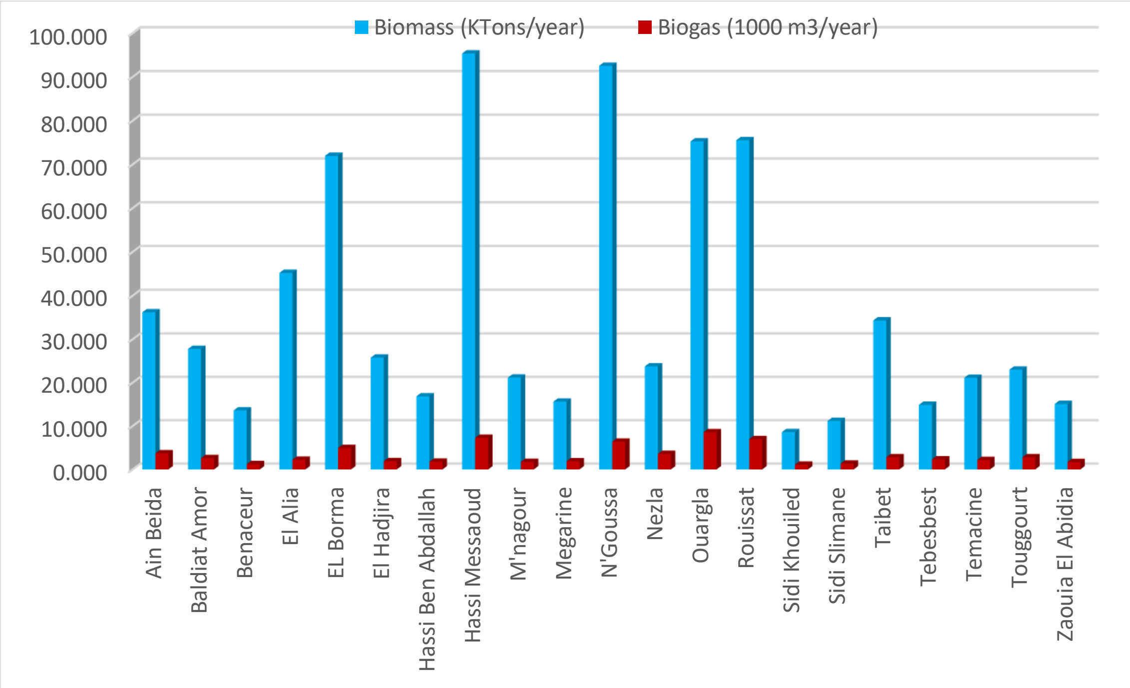


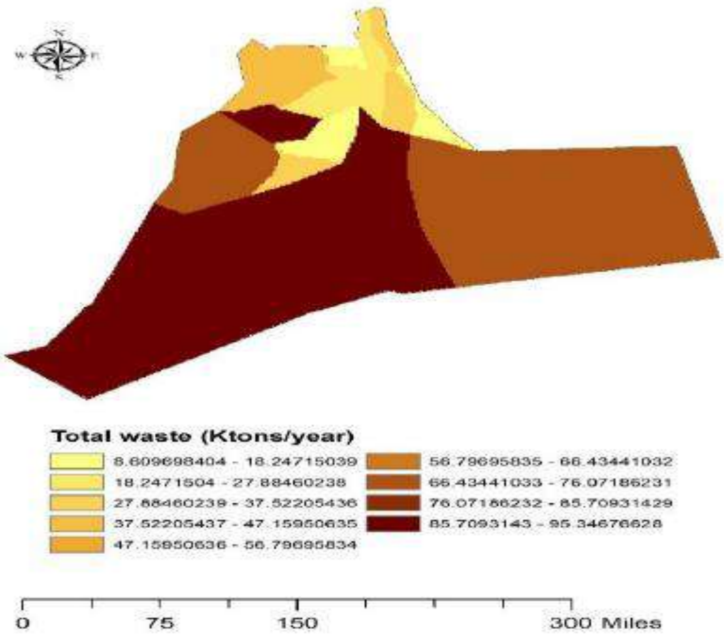
Figure II.5 : The total potential of biomass and biogas in Ouargla (2019) [16].

According to the overall data, the biogas potential from manure was highest in Hassi Messaoud in 2019 at 4,979.8 m^3, which accounted for 17.23% of the total potential value; Hassi Messaoud was followed by N'Goussa, El Borma, Rouissat, and El Alia in potential. The anaerobic digestion potential of livestock in these five municipalities accounted for 66.92% of the total potential value. Tebesbest had the lowest biogas potential with an amount of only 42.79 m^3 (Figure II.5).

II.5. GIS uses

Geographic information systems have emerged in the last decade as an essential tool for urban and resource planning and management. Their ability to store, retrieve, analyze, model, and map large areas with massive amounts of spatial data has resulted in an unprecedented proliferation of applications. Geographic information systems are now used for land use planning, utilities management, ecosystems modelling, landscape assessment and planning, transportation and infrastructure planning, market analysis, visual impact analysis, facilities management, tax assessment, real estate analysis and many other applications.

Biomass is considered a major criterion in determining the suitable area for establishing a biofuel production project, because it is the only source of energy in such projects, and bio-energy is extracted from renewable sources such as agricultural waste, animal dung and municipal waste, and it is the most common source of biomass in the province of Ouargla [29].



II.5.1. Potential of biomass and biogas

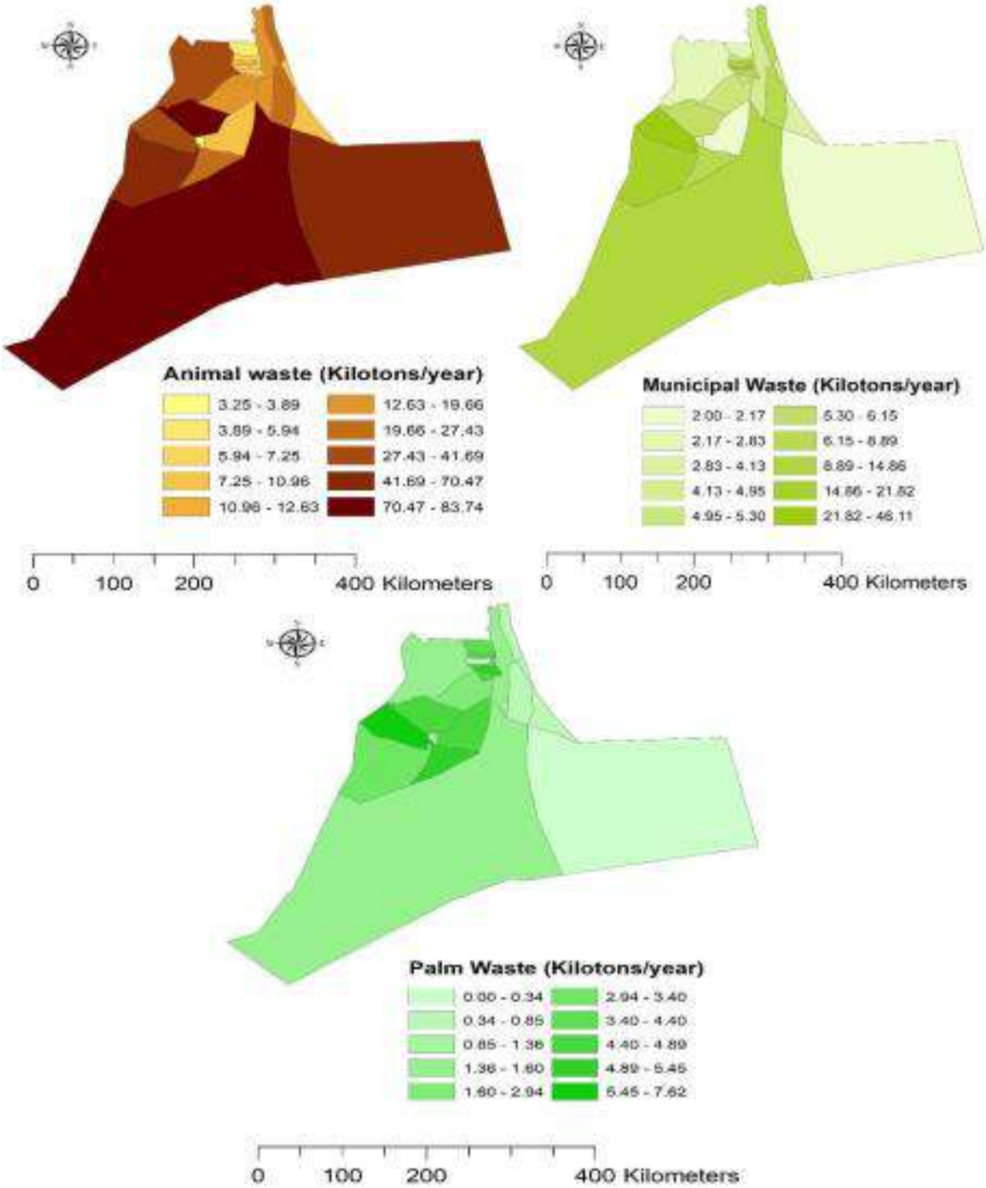


Figure II.6 : Geographical distribution of biomass waste potential in Ouargla (2019) [16].

Figure II.6 shows the biomass waste production potential maps for three types of waste. It was observed that the province of N'Goussa, Hassi Messaoud, Ouargla, and Rouissat could produce the highest waste potentials with the values of 94.51, 90.588, 90.156, and 82.56 kt/year, respectively. potential of livestock in these four municipalities accounted for 43 % of the total potential value. The map presents the potential of the biomass from municipal waste according to all the municipalities of the wilaya of Ouargla, using the GIS program. The total waste of the province of Ouargla is estimated at 206.87 kt / year, with organic matter at 67.7%, estimated at 140.05 kt / year of organic waste in the year (2019).

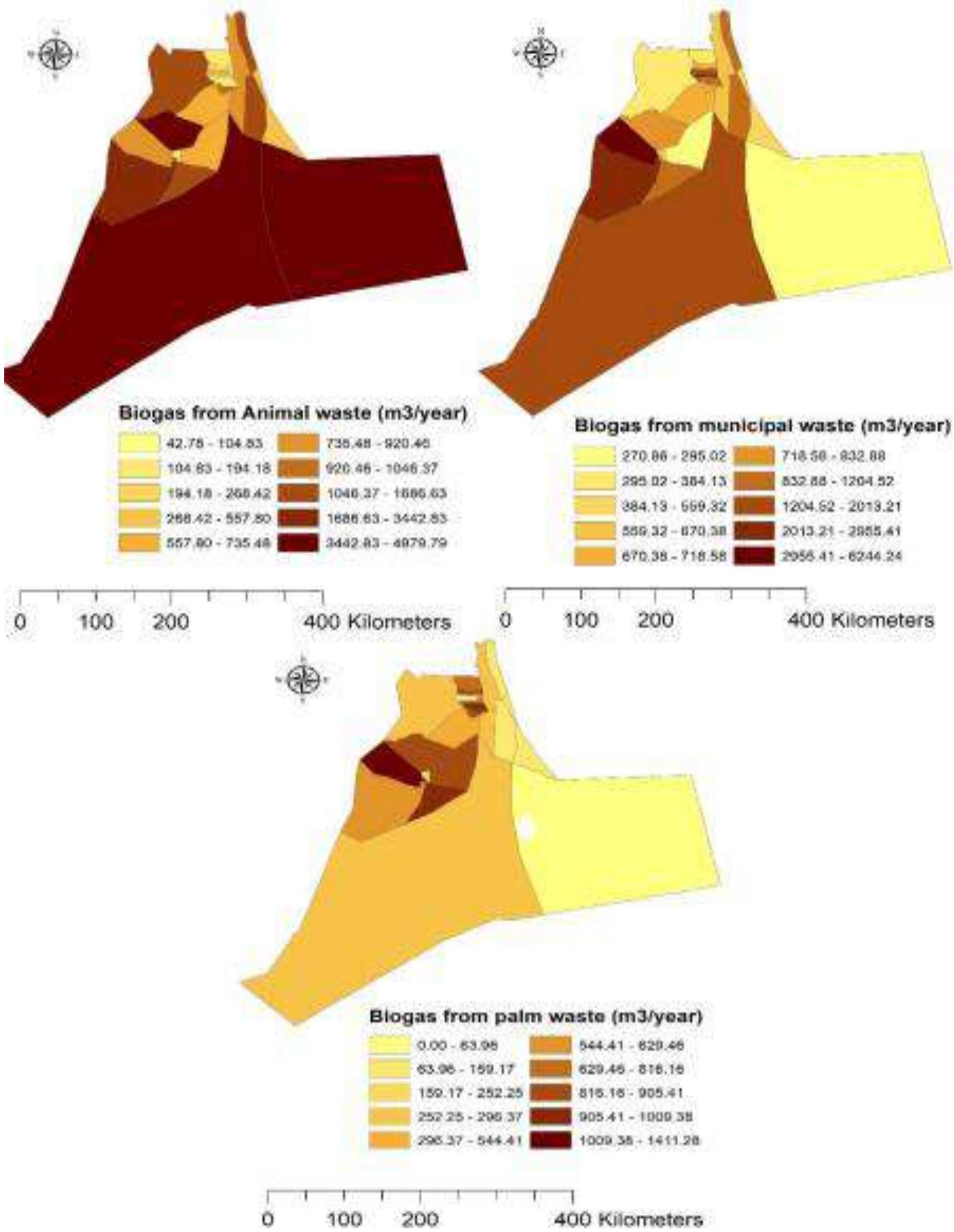


Figure II.7 : Geographical distribution of the biogas potential from biomass waste in Ouargla (2019) [16].

Estimations of palm waste biogas potential and analysis results for its spatial distribution are shown in figure II.6 for 21 municipalities in Ouargla province in 2019. The four municipalities had the highest potentials palm waste biogas with value of 1,411.29 m^3 (Ouargla), 1,009.39 m^3 (Ain Beida), 991.33 m^3 (Temacine), and 905.41 m^3 (Meggarine). The enormous date palm yields in these four municipalities led to an abundance of palm waste, which in turn yielded very high biogas potentials conducive to the development of biogas projects that use this waste.

II.6. Conclusion

For a long time, biomass was the most exploited source of energy by humans. After the industrial revolution came in the nineteenth century. Wood energy has been replaced by fossil fuels: coal, especially hydrocarbons. However, biomass is recovering today. Since the meeting of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in Kyoto, bioenergy has been seen as a distinct way to combat the impact of global warming. In addition to the positive impact on the environment, the increased use of bioenergy makes it possible to reduce dependence on fossil fuels. This chapter presents a study of the potential of biomass and biogas production in the wilaya of Ouargla where the potential of biomass (municipal, animal and palm wastes) is estimated at (831.621 kt/year) and a total amount of biogas was obtained that is approximately (69085.895 m^3/year).

CHAPTER III

INTEGRATION OF BIOGAS IN THE TRANSPORT SECTOR FOR 2050

III.1. Introduction

In this chapter, we first present a bibliographic study on the recovery and valorization of CO_2 (capture and storage or conversion of CO_2), existing techniques and processes and existing industrial demonstrators. Then, a prospective study, we apply a method combines two modules, namely the geographic information system (GIS) and an energy modeling to estimate the potential of the demand for biogas in the Wilaya of Ouargla (Algeria) road transport sector over a period of 2020 to 2050.

The avoided CO_2 emissions for 2050 are estimated for two scenarios, namely a reference scenario CFV (Conventional Fuel Vehicle) which continues in the same way without modification and does not take into account future interventions, and a proactive scenario BV (Biogas Vehicle), in which by introducing new ways of saving and energy efficiency such as the integration of biogas as an alternative fuel.

III.2. Geographic information system (GIS)

III.2.1. Definition

GIS is software that uses the capacity of computers in the field of storage, analysis and representation of data that is associated with the distribution geographic [33]. A geographic information system therefore has the functionality to provide information on a territory by locating the information to arrive at a decision-making process [34].

III.2.2. GIS components

A GIS has five main components: hardware, data, People, software and Methods [35].

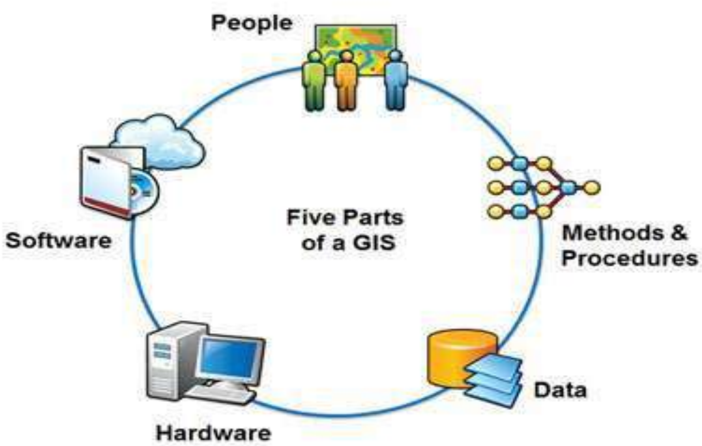


Figure III.1 : GIS components [35].

III.2.2.1. Hardware

The use of a GIS requires the use of one or more computers whether they are stand-alone or networked. In addition, there are now more and more client-server systems that offer card distribution solutions on the web from which the client can directly make requests [17].

III.2.2.2. Data

The data is essential to the GIS. They can be of three types: geographic, attributes or metadata. Geographic data is data localized to which we associate a shape and display parameters (color, thickness line...). They can be raster or vector. Attribute data characterizes geographical data (name of a road, number of inhabitants in a localized building, …) [17].

III.2.2.3. People

GIS are aimed at very different users (town planners, geographers, elected officials, military, commercial, IT...) and today, in particular with the appearance of GIS on the Internet anyone can use a GIS [17].

III.2.2.4. Software

Software is the link between data, hardware and users. From a graphical interface, the user will query a database in order to visualize and to analyze this information [17].

III.2.2.5. Methods

Different technical skills are essential for the implementation and the exploitation of GIS such as knowledge in geodesy, in analysis of data, in graphic semiology or in computer processing [17].

III.2.3. Areas of use

GIS can be used in several fields such as urban planning, transport, energy sector, etc. In the urban planning sector, GIS makes it possible to study everything urban phenomenon, to accompany any urban action and plan the organization territory of a city. It is very useful in the field of energy in a framework of preservation of resources and strengthening of production capacities (the management of gas and electricity networks, planning and management of energy resources). The environment remains one of the main areas of application of the Information System Geographical, with many examples of use (monitoring the quality of water, fire risk forecasting, localization and monitoring of the evolution of species animal and/or plant, the study of the anthropization of an environment or the study of a cover vegetal). In the transport sector (Road, marine, rail, etc.), the GIS makes it possible to manage, analyze and plan network usage. GIS is widely used in the field military or in a security and defense context (Context of operations and of interventions, knowledge of the territory where it is essential or even decisive) [17].

III.2.4. Software used : ArcGIS 10.2

ArcGIS encompasses the full range of GIS tasks from design, management and editing of data, to the production and visualization of maps and the spatial analysis of geographic data. ArcGIS is made up of three applications which are ArcMap (making maps, editing data and visualizing the results of analysis), ArcCatalog (establishing GIS databases and organizing them according to vector type (points, lines, polygons or raster) and the ArcToolbox (The tools which are used for processing, analysis, and conversion of geographic data to develop new databases). The figure below represents the interfaces of these three applications.

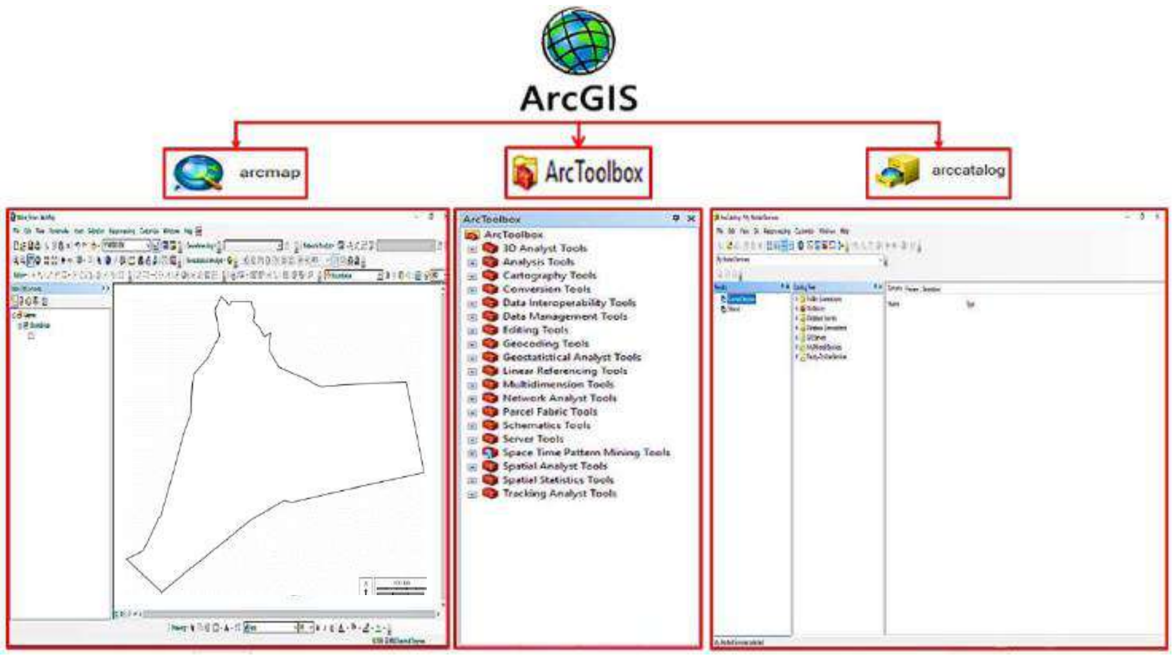


Figure III.2 : Overview of ArcGIS 10.2 applications.

The ArcGIS 10.2 software is the one we used in our study. This allowed us to better present data and visualize maps in the field of energy harvesting.

III.3. Prospective : Notions and generalities

III.3.1. Definition

Foresight is the discipline that deals with the prospective. Foresight is different from planning, which aims to define a set of actions to be carried out in a reasoned and coordinated manner to meet a given political objective [36]. It should be noted that projection and foresight are two extreme modes of forecasting [37].

III.3.2. Prospective models

Boulanger and Bréchet distinguished in their analysis six different classes of models: macro-econometric models, multi-agent models, computable general equilibrium models, Bayesian networks, optimization models, system dynamics [38]. In addition, another distinction relating to their paradigms makes it possible to distinguish three large families: integrated IAM (Integrated Assessment Models) models, economic models and the top-down (TD) approach, and finally technological models. and the bottom-up (BU) approach [39].

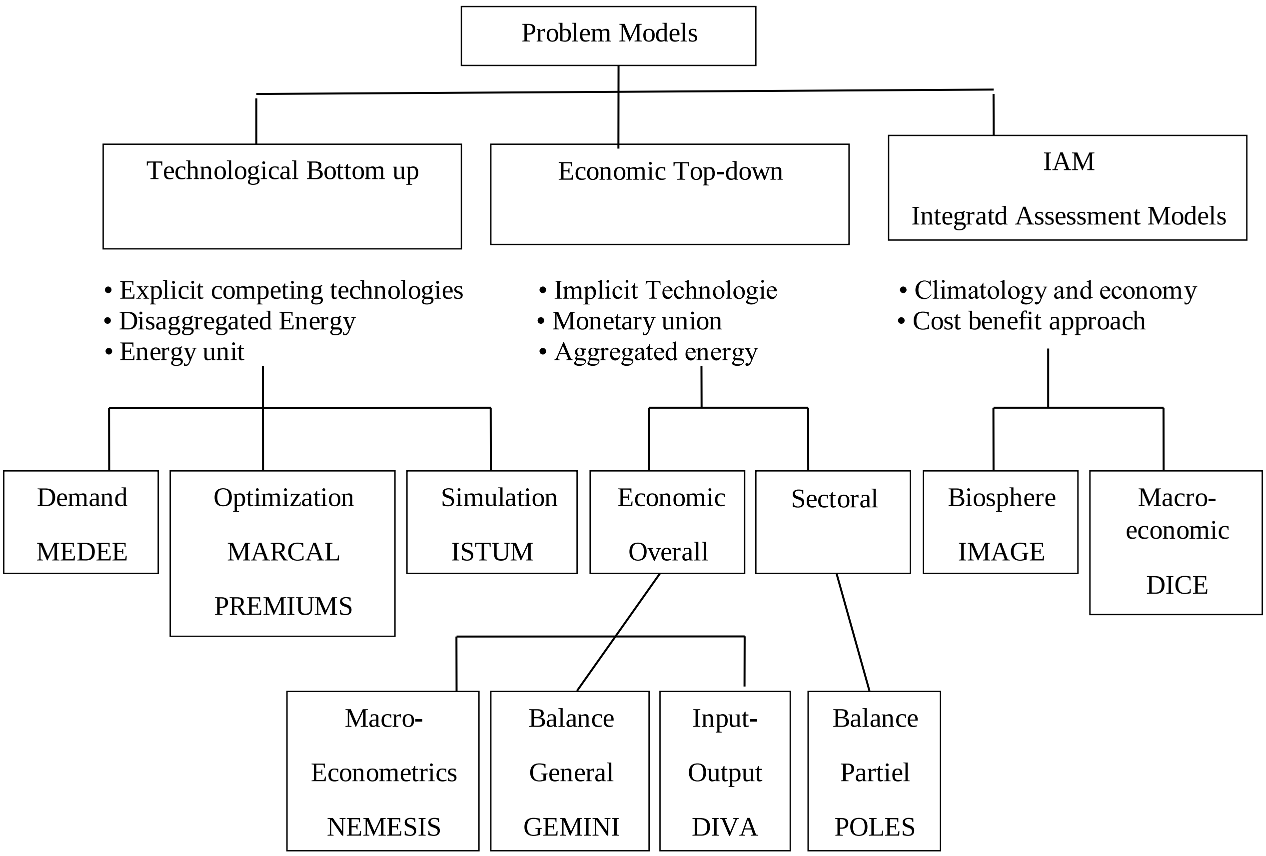


Figure III.3 : Classification of prospective models [40].

Energy forecasting models describe the energy sector by considering all or part of the previous chain. The proposed approaches differ according to the privileged point of view : economic, technological or climatic. In terms of environmental assessment, the first two approaches proceed through cost-effectiveness analyses. The integration of the climate dimension also makes it possible to carry out damage cost analyzes [40].

III.4. Prospective study of the transport sector for 2050

III.4.1. Current context of the Algerian transport sector

III.4.1.1. Road network

Transport in Algeria is diversified given the size of Algeria. Network density road in Algeria reflects the distribution of the population and activities ; the density is very high in the north, quite loose on the high plateaus and very scattered in the south. The network Algerian road is one of the most important in the Maghreb and Africa, with a length of 112,039 km, spread over 29,573 km of national roads, 24,109 km of wilaya paths and 60,420 km of municipal roads [17].

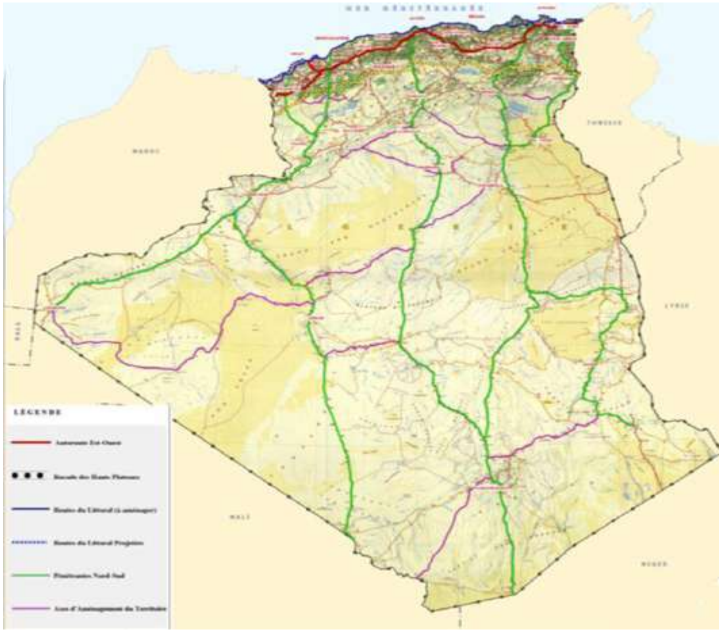
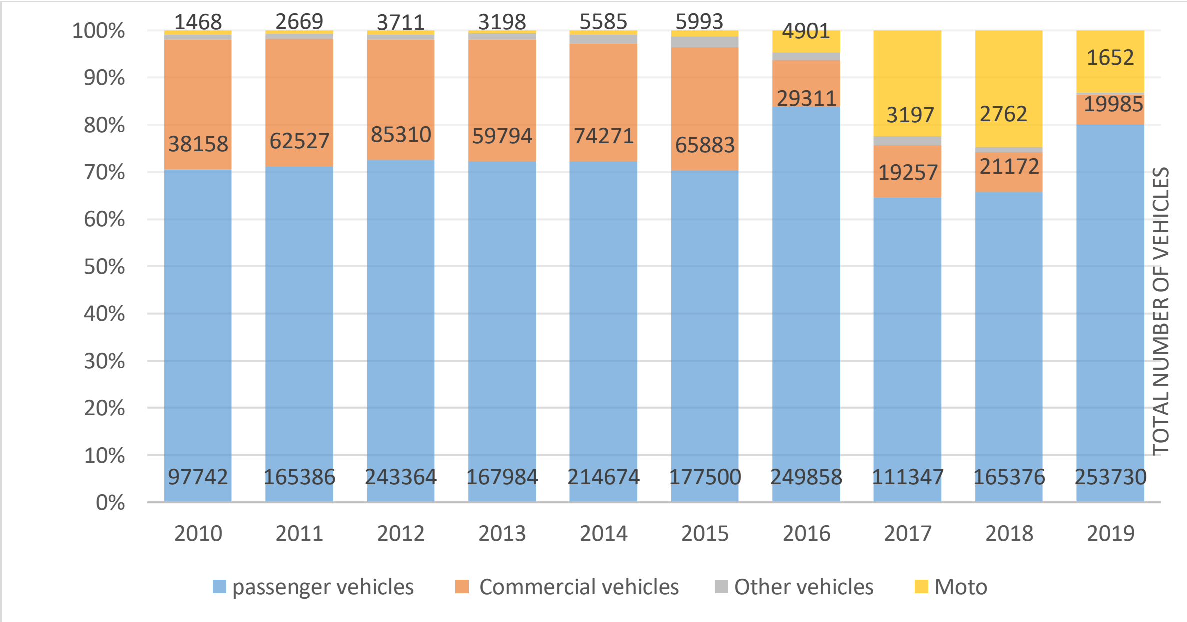


Figure III.4 : Algerian road network [41].

The road network is in full development thanks to the modernization program of road and rail transport which provides for the construction of the East-West motorway of (1.216 km) the high plateau highway (1.330 km) connects the city of Annaba to far east to the city of Tlemcen in the far west, and the completion of 19,000 km of road, thus finishing the trans-Saharan road (north-south) [41].

III.4.1.2. Vehicle fleet

In 2019, road transport represented more than 95% of all traffic. Figure III.5 represents the breakdown of the car fleet in percent by type of vehicle between 2010 and 2019.



Commercial vehicles = Trucks + vans + coaches and buses + road tractors *

**** Other vehicles = Other tractors (Agricultural tractors) + Special vehicles.**

Figure III.5 : Breakdown of vehicle fleet by type of vehicle in Algeria [42] [43] [44] [45].

The main contributors to road transport are light commercial vehicles, light and heavy trucks and tractors (agriculture and road). the average annual kilometers traveled by these categories are 25,000 km, 63,000 km and 78,000 km, [46].

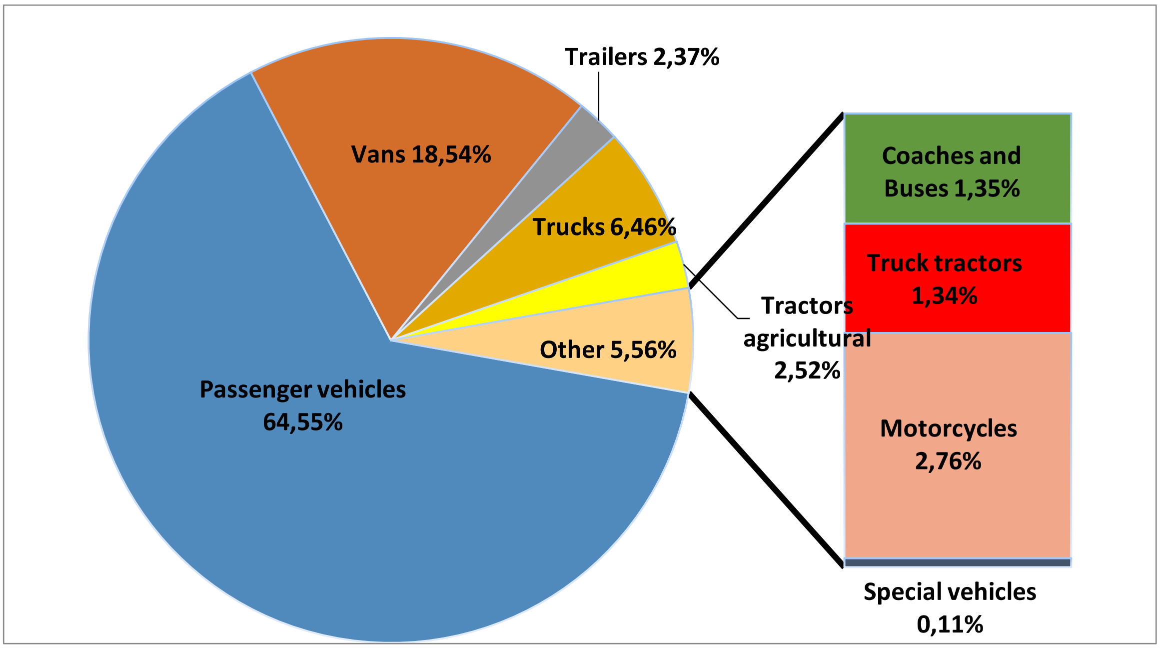


Figure III.6 : Structure of the vehicle fleet by gender in 2019 - Algeria [45].

In 2019, the national automobile fleet reached 6,577,188 vehicles, an increase of 2,420,849 units compared to 2010. By type, passenger vehicles represent 64.55 %, or 4,245,307 units of the entire car fleet, followed by vans with 1,219,476 units (18.54%), trucks with 424,822 units (6.46%), tractors agricultural with 165,968 units (2.52%), trailers with 155,788 units (2.37%), coaches and buses with 88,707 units (1.35%), truck tractors with 88,242 units (1.34%), motorcycles with 181,458 units (2.76%) and special vehicles with 7,420 units i.e. only 0.11% of the total.

III.4.1.3. Energy consumption

The transport sector is an important sector in terms of energy consumption and CO_2 emissions. The transport sector represents the Algerian economic sector the more energy consuming. Its share in total energy consumption reached 30.6% in 2019. In fact, it is the key sector in terms of energy consumption and carbon emissions CO_2.

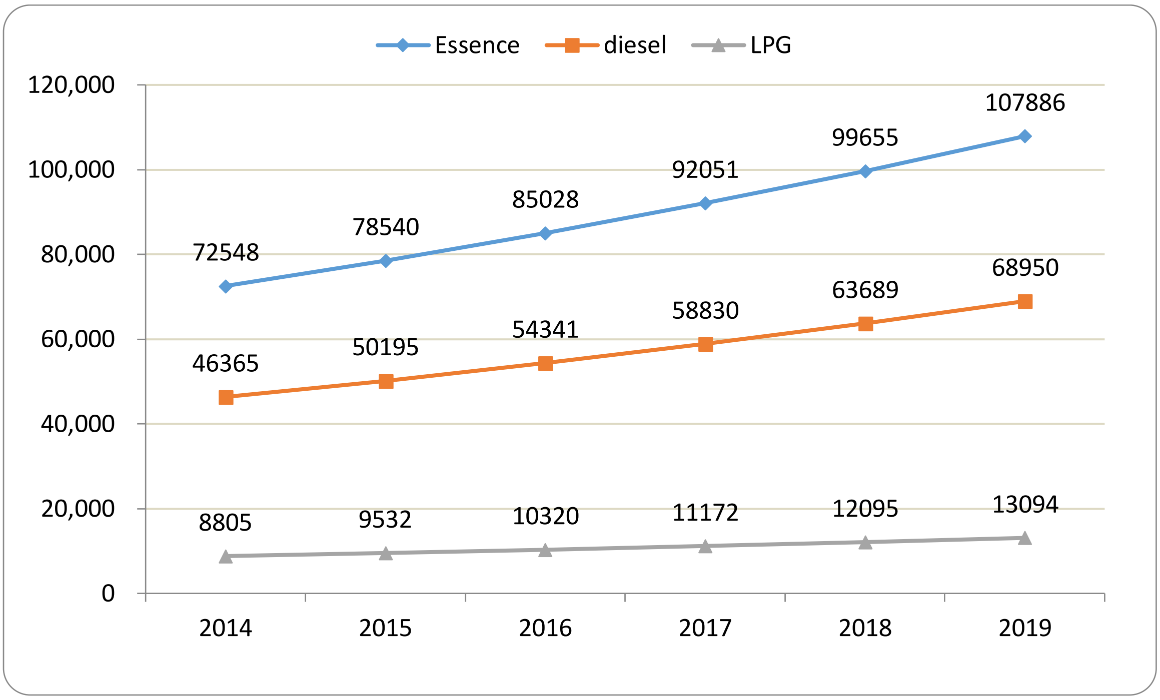


Figure III.7 : Evolution of energy consumption by energy source (ktoe) in Ouargla [47] [48] [49].

Total energy consumption in the transport sector in 2019 reached 15.4 Mtoe and which has increased by around 3.86% over the last year . The majority of this consumption derived from petrol and diesel, with consumption total of 10.556 ktoe and 7.801 ktoe, respectively. LPG "SIRGHAZ" is now cheapest fuel on the Algerian market; but its relative share in the fuel mix is not only 3% and its consumption is stagnating at a low level. Fuel consumption and diesel fuel in the transport sector has continued to increase in recent decades. In 2019, more than 90% of petroleum products were consumed by the sector of transport where 61% of vehicles are powered by gasoline and 39% by diesel fuel [42].

III.4.1.4. CO_2 emissions

Transport has become one of the main sources of pollution. The sector of transport represents one of the main sectors emitting CO_2 in Algeria, 32% of national broadcasts.

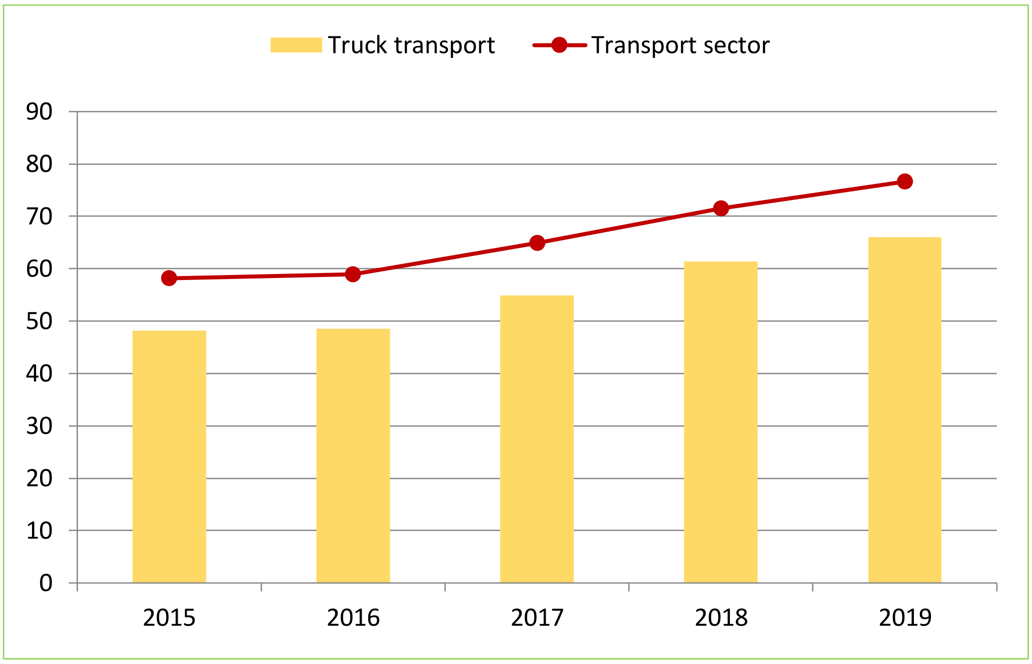


Figure III.8 : Evolution of CO_2 emissions in the transport sector and transport road (Mt) in Algeria [50] [51].

According to the graph above, which illustrates the evolution of CO_2 emissions in the transport sector and road transport during the period 2015-2019. In 2015, emissions in the transport sector were around 58.16 Mt and they are around 76.63 Mt in 2019. CO_2 emissions from road transport have an overall upward trend during this period, representing an overall growth rate of 184%. The growth rate annual average is around 11.1%. Emissions produced by transport are generally large in comparison with other economic sectors. This explained by the 95% dependence of the sector on petroleum products.

III.4.2. Energetic prospective for 2050

III.4.2.1. Description of autonome model

When modeling is used for energy analysis, the question of the choice of model is among the most delicate; there are many of them and we find ourselves easily disoriented by the large dispersion (which can reach several orders of magnitude) of the numerical results to which they lead. Debates about this disparity have sometimes led to distrust of models. Each model indeed offers a formal answer to the (very broad) question of the relevant relationships and implications in the energy system [40]. For our case study, we adapt the autonomous model to project the energy demand in Algeria for 2050. This type of model implements a relationship between the quantity studied and time which is the only explanatory variable. of evolution. The most common formulation is :

$$Et = E0.(1 + \alpha)^t$$

Where Et : represents the observed consumption in year t,

E0 : the calculated consumption of the year of origin t = 0,

α : the average annual growth rate observed over the period studied,

t : the time expressed in year t compared to the original year t= 0.

III.4.2.2. Scenario Construction

To study the impact of biomass valorization in Algeria in the medium and long term, we have developed two scenarios, a trend scenario and a proactive scenario.

a. Trend or reference scenario (Scenario without biomass recovery)

The reference scenario presented and analyzed in this chapter provides a coherent image of the evolution of the energy consumption of the Algerian park for 2050, based on a certain number of argued hypotheses relating to the demographic and economic context (activity sectors, etc.) and on the policies and measures in place concerning energy, assuming the continuation of current trends. In this context, the reference scenario makes it possible to point out the long-term problems concerning energy and the environment and helps to identify the actions to be implemented to provide solutions.

b. Proactive scenario (Scenario with biomass recovery)

Contrary to the trend scenario, the proactive scenario proposes energy management actions in terms of energy recovery, such as the recovery and energy recovery of biomass (vegetable and animal waste and household waste).

III.4.3. Prospective analysis

The problem of energy in transport is also one that foresight must take into consideration. Two scenarios are considered. One trend and the second proactive.

In our study, we used a model developed in ArcGIS to quantify the spatial distribution and biogas demand for each level of market penetration of biogas vehicles. This model is based on spatial characteristics : population density, number of vehicles per inhabitant, daily consumption of biogas per vehicle and the market penetration rate. The Data and parameters used in this study are described as follows :

- Our analysis starts with the data (population, population density) to the year 2015 and the car fleet for the year 2019.

- As biogas demand will occur in the future, a base year of 2050 has was used for the analysis.

- Projected population and vehicle fleet growth factors from 2020 to 2050 were obtained. These were used to project the population and vehicle fleet to short and long term (6 plans) for each region with annual growth rates of 1.6% and 4.4% [52] respectively (see Table III.1).

Table III.1 : Project plans with market penetration rates for each period of weather.

Period	2020-2025	2025-2030	2030-2035	2035-2040	2040-2045	2045-2050
Maps	P1	P2	P3	P4	P5	P6
Rate penetration (%)	5	10	15	20	25	30

- The PD population density (inhab/km^2) was calculated by dividing the population of each of the wilayas by its area (km^2).

- An estimate of the total number of vehicles per km^2 was calculated by multiplying the density of the population by an estimation of the vehicle per inhabitant VH.

- The biogas vehicle density (BV/km^2) was calculated by multiplying the total number of vehicles per km^2 by MPR market penetration rate.

- The BDD biogas demand density "kg of CH_4/(day.km^2)" has been calculated by multiplying the density of the biogas vehicle (BV/km^2), with the estimate of the average fuel consumption of 7.2 kg CH_4/day. vehicle. This estimate is based on the assumption that the vehicle covers an average mileage of 38,000 km/year [46] and consumes 7.2 kg of biogas every 100 km.

- The demand for biogas DB (kg CH_4/day) in the region of interest can be calculated by multiplying the biogas demand density BDD expressed in "kg CH_4/(day. km^2)" by area.

III.4.3.1. Methodology

The data-driven model is used to calculate the demand density in biogas :

DB= PD x VH x MPR x CB

Where DB is the biogas demand (kg CH_4/day), PD is the density of the population (hab/km^2), VH is number of vehicles per inhabitant (vehicle/hab), MPR is the market penetration rate (5%, 10%, 15%, 20%, 25% and 30%) and CB is the average daily consumption of biogas (7.2 kg of CH_4/vehicle. Day).

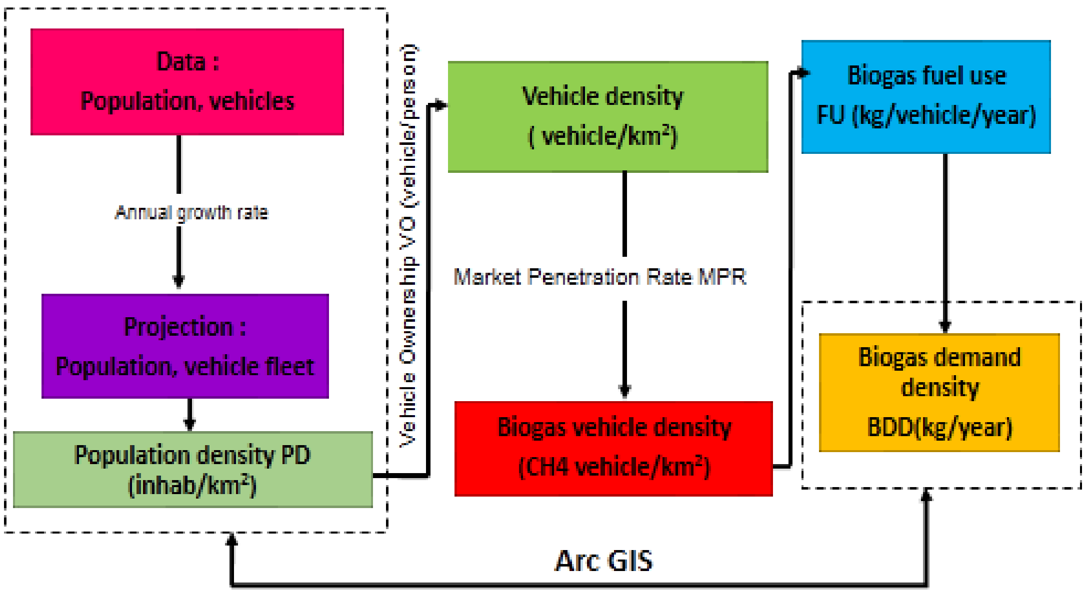


Figure III.9 : Flow chart for estimating annual Biogas demand.

The diagram below summarizes the procedures for calculating biogas demand and the GIS process. The software used during this study is ArcGIS 10.2. What we will make it possible to better present data and visualize maps in the field of transportation.

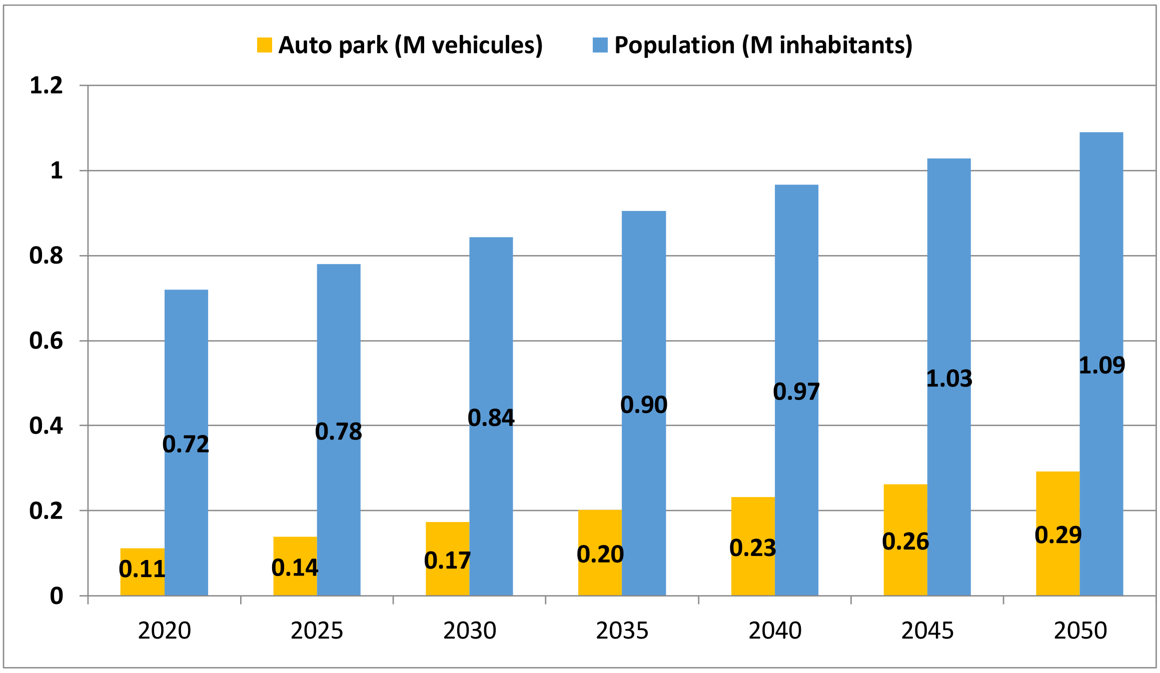


Figure III.10 : Evolution of the population and the car fleet in Ouargla.

Based on Ouargla statistical data and average growth rates of the population and vehicle fleet, the total projected population is approximately 0.84 million inhabitants in 2030 and 1.09 million inhabitants in 2050. The total number of vehicles in Ouargla car fleet is estimated at 0.29 million in 2050, where the number of vehicles in biogas is estimated at 0.14, 0.17, 0.2, 0.23 and 0.26 million vehicles in P1, P2, P3, P4 and P5, respectively.

III.4.3.2. Energy aspect

For the evaluation of annual biogas requests; we consider the request projected biogas in Ouargla for the years 2020, 2025, 2030, 2035, 2040, 2045 and 2050. Figure III.11 represents the annual evolution biogas demand and vehicle fleet.

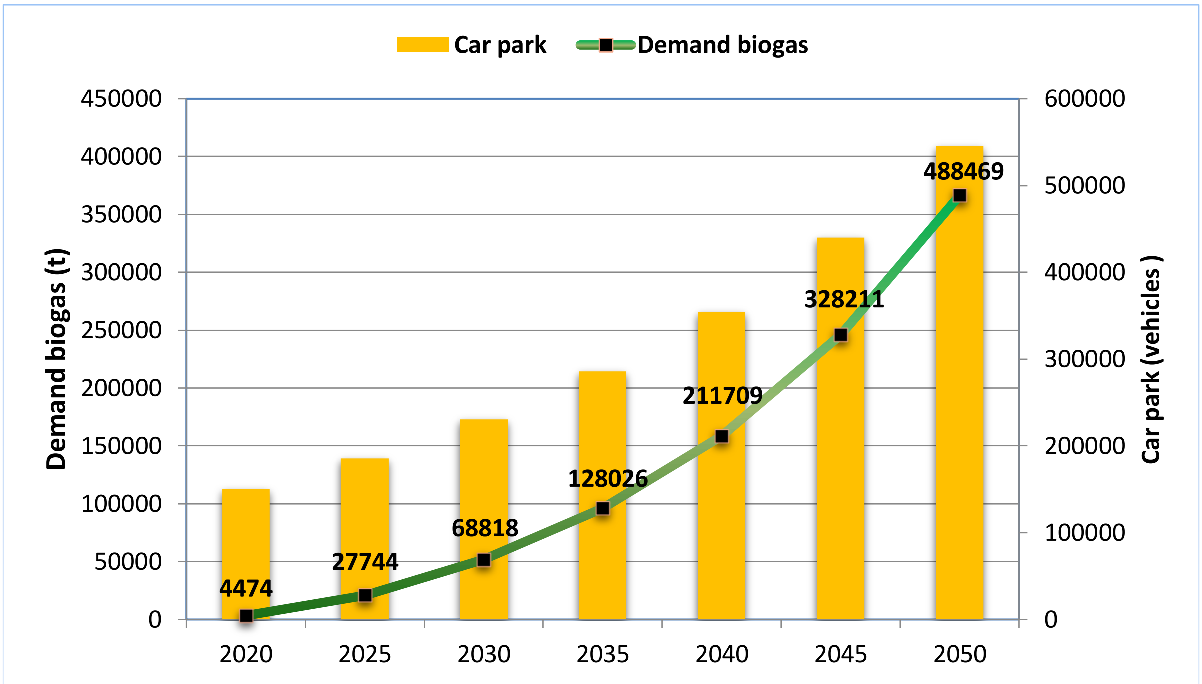


Figure III.11 : Evolution of the demand for biogas and of the vehicle fleet in Ouargla.

In the foreground (P1), at 5% market penetration, biogas demand is 4.47 ktons/year and it is mainly concentrated in the region of Ouargla, which represent 26% of total national demand. Biogas demand varied from 211.7 to 328.2 kt/year between the 20% and 25% Scenario. In the last plan (P6), the demand for biogas reached about 488.46 kt/year.

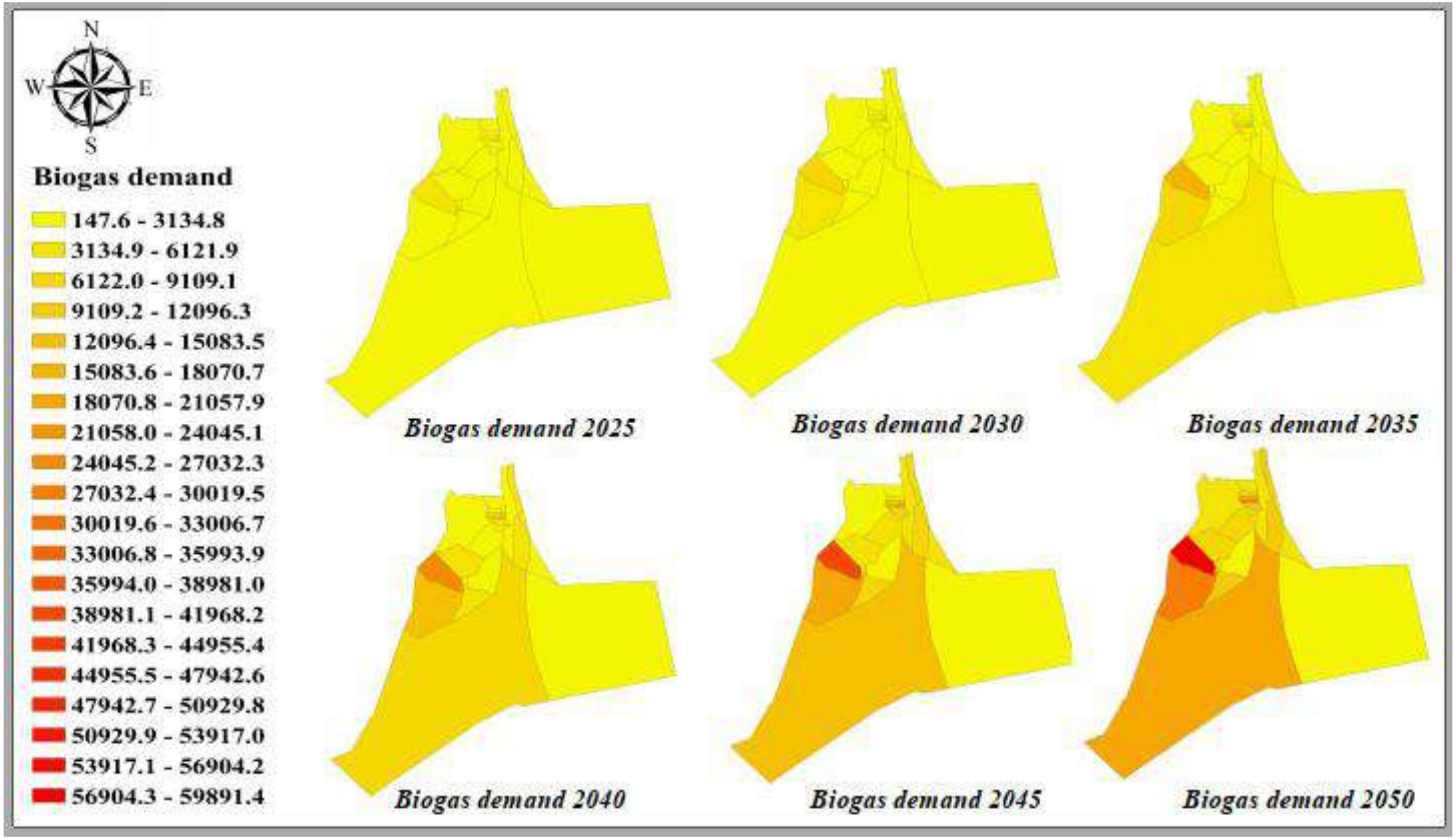


Figure III.12 : Spatial distribution of annual biogas demand by region in Ouargla (m^3).

The above figure shows the distribution of biogas demand from 2020 to 2050 by municipalities. Once the annual biogas demand for each region was calculated, a graphical representation was produced using GIS tools. In the annual review of the geographical distribution, the demand for biogas shows a large gap between the municipalities, as the majority of the demand for biogas remains in the regions especially in the region of Ouargla 59,891.37 m^3 and RouisSat 28346.72 m^3.

III.4.3.3. Environmental aspect

Two categories of scenarios have been developed : a baseline (reference) scenario conventional fuel vehicle "CFV" and voluntarist scenario called vehicle at biogas "BV", which will be compared to the baseline scenario.

• "CFV" scenario assumes that the fleet remains largely composed of gasoline vehicles and diesel.

• The "BV" scenario is characterized by the introduction of biogas in the vehicle fleet in 2020 up to a percentage of 30% for 2050. This fuel is produced by the conversion of CO_2.

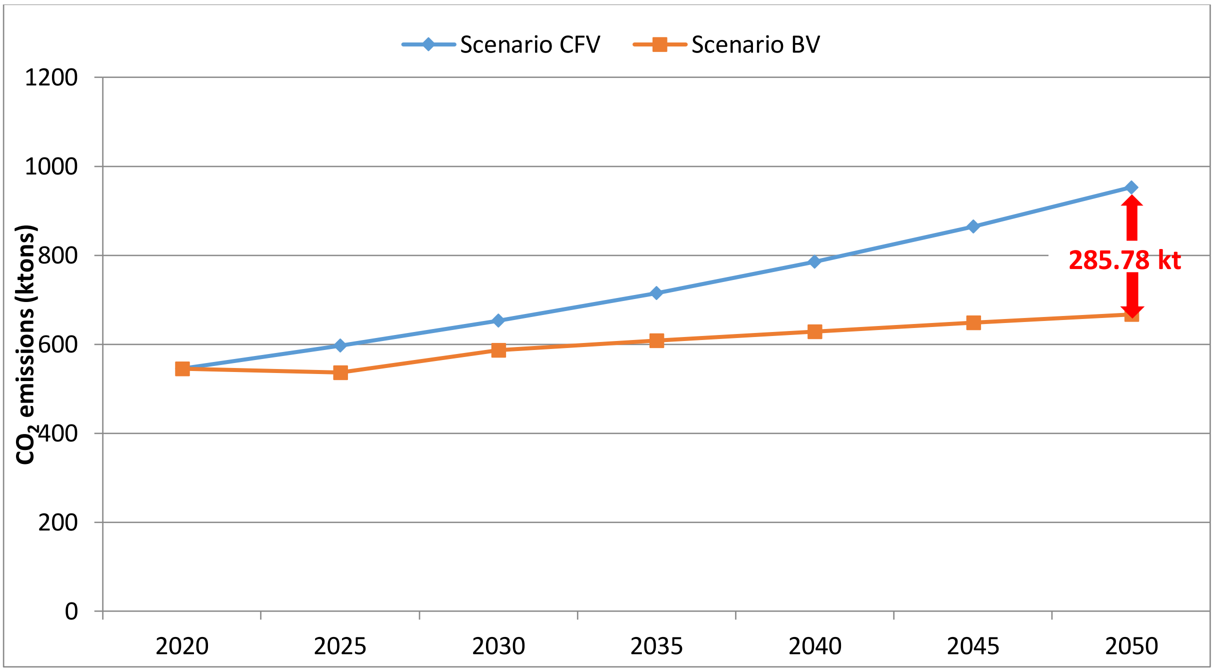


Figure III.13 : Evolution of CO_2 emissions for 2050 in Ouargla.

Figure III.13 presents projected carbon dioxide emissions from the vehicle in Ouargla by fuel type from 2020 to 2050. Only CO_2 emissions are examined since these emissions constitute 93.4% of the GHG emissions produced by the transport sector. of CO_2 emissions from vehicles are determined by the amount of vehicle fuel - consumption and intensity of carbon emissions of the fuel consumed, the mass emission intensity per unit of mass of fuel (tons CO_2/ton of fuel), emissions intensity of biogas, gasoline, diesel and LPG are 0.5625×10^{-3}, 3.172 ,3.2 and 2.85 [53] [54] [55].

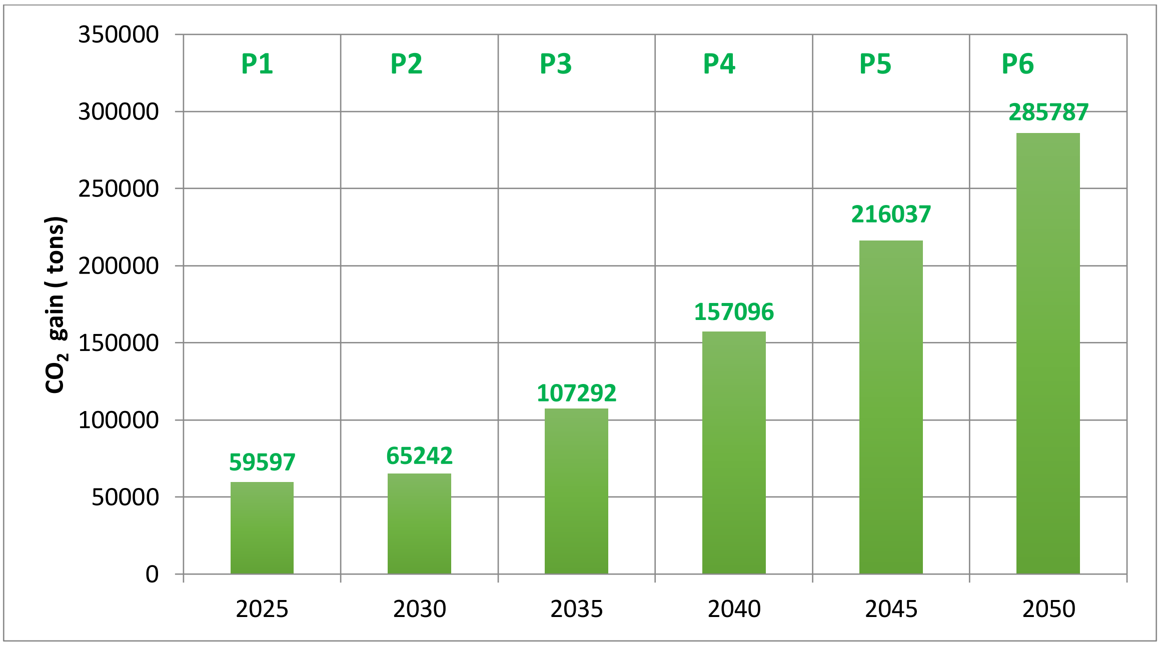


Figure III.14 : Evolution of the CO_2 gain in Ouargla.

In terms of environmental performance, the reduction in carbon dioxide emissions of carbon from the transport sector was remarkable during the year 2050 where the scenario of BV provides the best reduction in CO_2 emissions of 285.78 kt (43%) compared to the CFV baseline scenario.

III.5. Conclusion

In this chapter, an analysis of the development of energy consumption in the road transport sector in Algeria (Wilaya of Ouargla) over the time horizon (2020-2050) has been made. The integration biogas as an alternative fuel with different market penetration rates on the entire horizon studied, makes it possible to reduce energy consumption on the one hand, and make environmental savings in terms of CO_2 emissions, on the other hand. The part biogas vehicles are expected to increase from 5% of total vehicles in 2020 to nearly 10% in 2030, 25% in 2045 and 30% in 2050.

The road transport sector consumes 10.213 ktoe in 2025 and 11.089 ktoe in 2050 fossil fuels; this change is mainly due to the rapid growth of the fleet automobile, which will reach approximately 409,144.14 vehicles in 2050. With the integration of biogas in the Vehicle fleet, its consumption of fossil fuels is reduced to 9.7 ktoe in 2025 and 7.76 ktoe in 2050. Road transport is the source of the emission of 595.971 kt of CO_2 in 2025 and 952.626 kt of CO_2 in 2050 in the case of fossil fuels; it is the sector that experiences the highest “natural” growth without any intervention. Directions listed in the second case (vehicle using biogas) make it possible to reduce emissions from sector in 285.78 kt of CO_2 in 2050. This reduction is obtained mainly by the growth in the penetration rate of biogas vehicles in the national market.

GENERAL CONCLUSION

The integration of biogas as an alternative fuel with different market penetration rates on the entire horizon studied in Ouargla (Algeria), makes it possible to reduce energy consumption on the one hand, and make environmental savings in terms of CO_2 emissions, on the other hand. The part biogas vehicles are expected to increase from 5% of total vehicles in 2020 to nearly 10% in 2030, 25% in 2045 and 30% in 2050.

The energy consumption of road transport sector is 10.213 ktoe in 2025 and will be 11.089 ktoe in 2050. This is mainly due to the rapid growth of the fleet automobile, which will reach approximately 409,144.14 vehicles in 2050. The integration of biogas fuel in the automobile park will reduce the consumption of fossil fuels to 9.7 ktoe in 2025 and 7.76 ktoe in 2050. Road transport is the main source of the emission of sector transport in Algeria, which is 595.971 and 952.626 kt of CO_2 in 2025 and 2050 respectively. Directions listed in the second case (vehicle using biogas) make it possible to reduce emissions from sector in 285.78 kt of CO_2 in 2050. This reduction is obtained mainly by the growth in the penetration rate of biogas vehicles in the national market.

The presented methodology can explain the analysis and results in an easy-to-understand format. In this study, biogas potential was estimated from agricultural waste resources. In the future, the biogas potential can be estimated more accurately by combining various wastes with actual research data.

Recommendations and perspectives

• Determining of accurate statistics for all types of biomass in the Ouargla particularly and Algeria in general.

• Adding an economic feasibility study for this work.

• Calculate the percentage of GHG that will be reduced due to the consumption of biofuels instead of fossil fuels.

• Calculating the amount of energy produced from biomass and giving an estimate of the extent to which, this energy covers the electricity generation and transportation sector, for example, or other sectors, and the extent to which it is substituted for fossil fuels.

• Administrative challenges facing such projects in Algeria.

In the end, hope that such work related to renewable energies will be implemented in reality and exploit the available capabilities, which are considered a huge wealth and a precious treasure if they are optimally exploited.

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Surface (km^2)

Municipal	Surface
Ouargla	2,887
Rouissat	7,331
sidi-khouiled	131
Ain Beida	1,973
hassi ben abdallah	3,060
N'goussa	2,907
El-hadjira	2,429
El-Alia	6,589
Tmacine	300
Blidet Amor	250
Touggourt	216
Nezla	132
Tebesbest	26
Zaouia	30
Meggarine	285
sidi slimane	635
Taibet	4,562
Bennaceur	2,590
M'nagueur	8,399
hassi messaoud	71,237
El-Borma	47,261
TOTAL	163,230

Population (hab)

Municipal	2020	2025	2030	2035	2040	2045	2050
Ouargla	160461,96	173716,325	188065,517	203599,971	220417,591	238624,368	258335,048
Rouissat	75947,016	82220,3374	89011,8432	96364,3362	104324,155	112941,464	122270,575
sidi-khouiled	17227,296	18650,2929	20190,8311	21858,6197	23664,1699	25618,8608	27735,0118
Ain Beida	26209,752	28374,7113	30718,499	33255,8866	36002,8657	38976,7488	42196,2785
hassi ben abdallah	6960,616	7535,57185	8158,0198	8831,88275	9561,40764	10351,1922	11206,2141
N'goussa	21403,056	23170,976	25084,9285	27156,9759	29400,1771	31828,6696	34457,7588
El-hadjira	18465,8	19991,0989	21642,3894	23430,0787	25365,4334	27460,6508	29728,936
El-Alia	9821,672	10632,9548	11511,2505	12462,0947	13491,4797	14605,8934	15812,359
Tmacine	26464,768	28650,7919	31017,3843	33579,4602	36353,1669	39355,9853	42606,8404
Blidet Amor	18170,144	19671,0213	21295,873	23054,9396	24959,3073	27020,9782	29252,9459
Touggourt	51560,984	55819,9877	60430,7906	65422,4518	70826,4307	76676,7851	83010,3864
Nezla	68884,8	74574,7733	80734,7456	87403,5397	94623,1847	102439,182	110900,79
Tebesbest	42382,44	45883,2842	49673,3026	53776,3814	58218,3798	63027,293	68233,4286
Zaouia	27227,784	29476,834	31911,6585	34547,6026	37401,2791	40490,673	43835,2548
Meggarine	17941,544	19423,5387	21027,948	22764,8836	24645,2923	26681,0252	28884,9123
sidi slimane	9871,456	10686,851	11569,5987	12525,2624	13559,8652	14679,9276	15892,5085
Taibet	30953,456	33510,2514	36278,2413	39274,8708	42519,0257	46031,1521	49833,3845
Bennaceur	14373,352	15560,6094	16845,9358	18237,4318	19743,8672	21374,736	23140,3168
M'nagueur	16154,4	17488,7743	18933,3696	20497,2903	22190,3929	24023,3479	26007,7074
hassi messaoud	51734,72	56008,0745	60634,4137	65642,8944	71065,0821	76935,1494	83290,0919
El-Borma	7581,392	8207,62475	8885,58513	9619,54591	10414,1328	11274,3536	12205,6297
TOTAL	719793,328	779249,185	843616,171	913299,954	988739,708	1070410,88	1158828,2

Vehicles

Municipal	2020	2025	2030	2035	2040	2045	2050
Ouargla	25062.38928	31083.14574	38550.273	47811.2338	59296.9622	73541.9156	91208.9448
Rouissat	11862.08669	14711.72462	18245.9332	22629.1673	28065.389	34807.5584	43169.4041
sidi-khouiled	2690.713728	3337.105893	4138.78133	5133.04385	6366.1588	7895.50588	9792.24914
Ain Beida	4093.674336	5077.100773	6296.77648	7809.45578	9685.52717	12012.2886	14898.0096
hassi ben abdallah	1087.171488	1348.343505	1672.25707	2073.98463	2572.21951	3190.14572	3956.5168
N'goussa	3342.921408	4145.99391	5141.98912	6377.253	7909.26524	9809.31392	12165.8127
El-hadjira	2884.1544	3577.016961	4436.32641	5502.06841	6823.83441	8463.12924	10496.2331
El-Alia	1534.036896	1902.559723	2359.61306	2926.46467	3629.49146	4501.4069	5582.78323
Tmacine	4133.505024	5126.500017	6358.04294	7885.44033	9779.76554	12129.1659	15042.9645
Blidet Amor	2837.976192	3519.745328	4365.29637	5413.97477	6714.57797	8327.62604	10328.1778
Touggourt	8053.257312	9987.897319	12387.2973	15363.107	19053.7977	23631.1057	29308.0238
Nezla	10759.0464	13343.70014	16549.2672	20524.91	25455.6244	31570.848	39155.1363
Tebesbest	6619.66992	8209.918159	10182.1929	12628.2687	15661.9671	19424.4532	24090.804
Zaouia	4252.679712	5274.304129	6541.35414	8112.78852	10061.7298	12478.8666	15476.674
Meggarine	2802.271392	3475.463137	4310.37624	5345.86113	6630.10134	8222.85553	10198.2382
sidi slimane	1541.812608	1912.2034	2371.57345	2941.29831	3647.88859	4524.22358	5611.08119
Taibet	4834.588608	5996.005433	7436.43029	9222.88948	11438.5111	14186.3931	17594.4009
Bennaceur	2244.959136	2784.267343	3453.13396	4282.68291	5311.51501	6587.50423	8170.02528
M'nagueur	2523.1392	3129.274811	3881.02283	4813.36384	5969.68182	7403.78294	9182.39923
hassi messaoud	8080.39296	10021.55178	12429.0366	15414.8734	19117.9999	23710.7313	29406.7779
El-Borma	1184.129856	1468.594254	1821.39575	2258.951	2801.62049	3474.65587	4309.37503
TOTAL	112423.7831	139431.4323	172927.149	214469.567	265991.751	329891.148	409141.144

Biomass (tons)

Municipal	2020	2025	2030	2035	2040	2045	2050
Ouargla	702823,3848	760877,5021	823726,9644	891767,8732	965429,0488	1045174,732	1131507,512
Rouissat	332647,9301	360125,0778	389871,8733	422075,7925	456939,7969	494683,613	535545,1169
sidi-khouiled	75455,55648	81688,28269	88435,84011	95740,75447	103649,0642	112210,6105	121479,3515
Ain Beida	114798,7138	124281,2355	134547,0257	145660,7834	157692,5518	170718,1598	184819,6998
hassi ben abdallah	30487,49808	33005,80471	35732,12672	38683,64643	41878,96548	45338,222	49083,21757
N'goussa	93745,38528	101488,8749	109871,9868	118947,5545	128772,7758	139409,573	150924,9834
El-hadjira	80880,204	87561,01308	94793,66561	102623,7445	111100,5981	120277,6507	130212,7396
El-Alia	43018,92336	46572,34187	50419,27733	54583,97461	59092,68126	63973,81288	69258,13227
Tmacine	115915,6838	125490,4687	135856,1431	147078,0357	159226,8709	172379,2157	186617,961
Blidet Amor	79585,23072	86159,07334	93275,92383	100980,6354	109321,766	118351,8847	128127,9029
Touggourt	225837,1099	244491,5462	264686,863	286550,339	310219,7663	335844,3188	363585,4924
Nezla	301715,424	326637,5069	353618,1859	382827,5037	414449,5489	448683,6158	485745,4606
Tebesbest	185635,0872	200968,7846	217569,0652	235540,5504	254996,5034	276059,5432	298862,4173
Zaouia	119257,6939	129108,5331	139773,0644	151318,4996	163817,6027	177349,1478	191998,4159
Meggarine	78583,96272	85075,09931	92102,41216	99710,1901	107946,3803	116862,8904	126515,9158
sidi slimane	43236,97728	46808,40732	50674,84209	54860,64936	59392,20969	64298,08275	69609,18725
Taibet	135576,1373	146774,9009	158898,6969	172023,9341	186233,3327	201616,446	218270,2243
Bennaceur	62955,28176	68155,46917	73785,19875	79879,95126	86478,13818	93621,34384	101354,5875
M'nagueur	70756,272	76600,83125	82928,15863	89778,13141	97193,92076	105222,2639	113913,7585
hassi messaoud	226598,0736	245315,3665	265578,7319	287515,8774	311265,0594	336975,9545	364810,6026
El-Borma	33206,49696	35949,3964	38918,86287	42133,6111	45613,90168	49381,66874	53460,65822
TOTAL	3152694,777	3413111,428	3695038,831	4000253,8	4330679,919	4688399,662	5075667,516

Biogas (m^3)

Municipal	2020	2025	2030	2035	2040	2045	2050
Ouargla	548.564975	3401.73574	8437.8745	15697.3671	25957.8097	40242.0921	59891.3758
Rouissat	259.637069	1610.04938	3993.66548	7429.60007	12285.8912	19046.6751	28346.7264
sidi-khouiled	58.8942775	365.212468	905.895464	1685.27911	2786.84662	4320.41608	6429.97542
Ain Beida	89.6022456	555.637299	1378.23692	2563.99771	4239.93172	6573.1171	9782.61831
hassi ben abdallah	23.7959834	147.562551	366.023226	680.929888	1126.01358	1745.64582	2598.00434
N'goussa	73.1697835	453.737076	1125.47734	2093.77741	3462.35615	5367.65069	7988.5505
El-hadjira	63.1283023	391.468307	971.02206	1806.43712	2987.19848	4631.01924	6892.23893
El-Alia	33.5769628	208.215908	516.471541	960.815826	1588.84444	2463.16715	3665.87476
Tmacine	90.4740588	561.043547	1391.64691	2588.94493	4281.18547	6637.07231	9877.80136
Blidet Amor	62.1175548	385.200506	955.475022	1777.51425	2939.37043	4556.87197	6781.88727
Touggourt	176.269503	1093.07428	2711.32867	5044.00976	8340.98132	12930.9268	19244.7996
Nezla	235.493749	1460.33294	3622.29963	6738.73105	11143.4419	17275.5491	25710.8005
Tebesbest	144.891176	898.492458	2228.67594	4146.10864	6856.17521	10629.0491	15818.9682
Zaouia	93.0825515	577.219211	1431.77002	2663.58781	4404.61799	6828.42831	10162.5921
Meggarine	61.336049	380.354269	943.454116	1755.1512	2902.38998	4499.54161	6696.56381
sidi slimane	33.7471574	209.271311	519.089427	965.686001	1596.89796	2475.65243	3684.45631
Taibet	105.819359	656.202115	1627.68408	3028.05575	5007.31713	7762.78581	11553.1748
Bennaceur	49.1376117	304.709884	755.821133	1406.08891	2325.16626	3604.67836	5364.75951
M'nagueur	55.2264103	342.46746	849.477346	1580.32188	2613.28505	4051.34558	6029.52402
hassi messaoud	176.863447	1096.75742	2720.46456	5061.00568	8369.08646	12974.4979	19309.6455
El-Borma	25.9182059	160.722779	398.666664	741.65798	1226.43604	1901.3296	2829.70492
TOTAL	2460.72907	15259.3592	37850.2529	70414.5711	116440.421	180516.238	268658.146

Emissions CO_2 Biogas (tons)

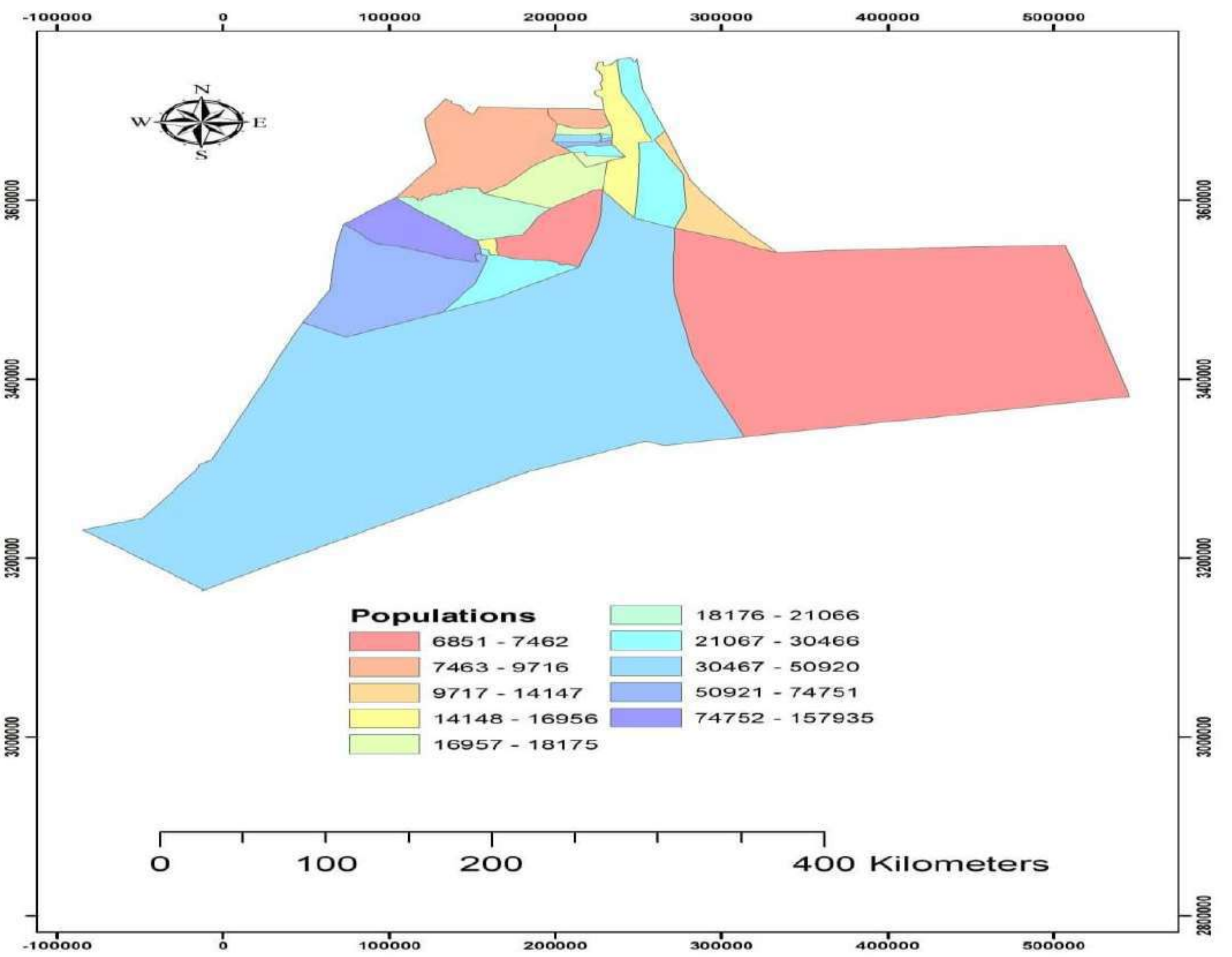
Municipal	2020	2025	2030	2035	2040	2045	2050
Ouargla	308.567798	1913.47635	4746.30441	8829.76898	14601.268	22636.1768	33688.8989
Rouissat	146.045851	905.652774	2246.43683	4179.15004	6910.81382	10713.7547	15945.0336
sidi-khouiled	33.1280311	205.432013	509.566198	947.969499	1567.60122	2430.23404	3616.86118
Ain Beida	50.4012632	312.545981	775.25827	1442.24871	2384.96159	3697.37837	5502.7228
hassi ben abdallah	13.3852407	83.0039352	205.888065	383.023062	633.382637	981.925775	1461.37744
N'goussa	41.1580032	255.227105	633.081006	1177.74979	1947.57534	3019.30351	4493.55966
El-hadjira	35.50967	220.200923	546.199909	1016.12088	1680.29914	2604.94832	3876.8844
El-Alia	18.8870416	117.121448	290.515242	540.458902	893.724996	1385.53152	2062.05455
Tmacine	50.8916581	315.586995	782.801388	1456.28152	2408.16683	3733.35317	5556.26327
Blidet Amor	34.9411246	216.675285	537.4547	999.851765	1653.39587	2563.24048	3814.81159
Touggourt	99.1515953	614.854285	1525.12238	2837.25549	4691.80199	7273.64635	10825.1998
Nezla	132.465234	821.43728	2037.54354	3790.53621	6268.18607	9717.49636	14462.3253
Tebesbest	81.5012867	505.402008	1253.63022	2332.18611	3856.59855	5978.84013	8898.16961
Zaouia	52.3589352	324.685806	805.370639	1498.26814	2477.59762	3840.99093	5716.45805
Meggarine	34.5015275	213.949276	530.69294	987.272552	1632.59436	2530.99216	3766.81715
sidi slimane	18.982776	117.715112	291.987803	543.198375	898.255101	1392.55449	2072.50668
Taibet	59.5233897	369.11369	915.572293	1703.28136	2816.61588	4366.56702	6498.6608
Bennaceur	27.6399066	171.39931	425.149387	790.925012	1307.90602	2027.63158	3017.67723
M'nagueur	31.0648558	192.637946	477.831007	888.931059	1469.97284	2278.88189	3391.60726
hassi messaoud	99.485689	616.926051	1530.26131	2846.81569	4707.61113	7298.15508	10861.6756
El-Borma	14.5789908	90.4065631	224.249998	417.182614	689.870272	1069.4979	1591.70902
TOTAL	1384.1601	8583.38956	21290.7673	39608.1962	65497.737	101540.384	151120.207

Emissions CO_2 carburants conven (tons)

Municipal	2020	2025	2030	2035	2040	2045	2050
Ouargla	121521.789	132858.653	145444.017	159455.978	175105.348	192642.693	212366.975
Rouissat	57516.5432	62882.307	68838.9891	75470.8823	82877.7655	91178.2313	100513.779
sidi-khouiled	13046.655	14263.7877	15614.9603	17119.2931	18799.4193	20682.2396	22799.8507
Ain Beida	19849.2898	21701.0458	23756.731	26045.4355	28601.5935	31466.132	34687.8833
hassi ben abdallah	5271.4457	5763.22303	6309.1586	6916.97789	7595.82576	8356.57132	9212.18315
N'goussa	16209.0607	17721.2168	19399.9029	21268.8741	23356.2495	25695.4505	28326.3538
El-hadjira	13984.6045	15289.2393	16737.5504	18350.0326	20150.9463	22169.1262	24438.9766
El-Alia	7438.19378	8132.10875	8902.44288	9760.09711	10717.9751	11791.4137	12998.7118
Tmacine	20042.4197	21912.1929	23987.8796	26298.8527	28879.8817	31772.2916	35025.39
Blidet Amor	13760.697	15044.4433	16469.5654	18056.2301	19828.3094	21814.1763	24047.684
Touggourt	39048.4014	42691.2576	46735.2926	51237.7333	56266.3205	61901.5674	68239.5391
Nezla	52168.1533	57034.9616	62437.7395	68452.9413	75171.068	82699.6841	91167.1314
Tebesbest	32097.2643	35091.6434	38415.7862	42116.7323	46250.1637	50882.2614	56091.9895
Zaouia	20620.2705	22543.9518	24679.4835	27057.0852	29712.5288	32688.3309	36035.2206
Meggarine	13587.5726	14855.1679	16262.3605	17829.0633	19578.8479	21539.7304	23745.1383
sidi slimane	7475.89643	8173.32871	8947.5675	9809.569	10772.3023	11851.1819	13064.5995
Taibet	23441.8136	25628.7189	28056.4627	30759.3999	33778.197	37161.1884	40966.0446
Bennaceur	10885.293	11900.7906	13028.1224	14283.2413	15685.031	17255.9356	19022.7346
M'nagueur	12234.1245	13375.4556	14642.4787	16053.1234	17628.6133	19394.1737	21379.9025
hassi messaoud	39179.9759	42835.1068	46892.7683	51410.3801	56455.9112	62110.1462	68469.4739
El-Borma	5741.57463	6277.21067	6871.83498	7533.86207	8273.25235	9101.84429	10033.763
TOTAL	545117.191	595971.605	652426.49	715280.736	785480.007	864148.271	952626.602

Emission CO_2 (tons)

Municipal	2020	2025	2030	2035	2040	2045	2050
Ouargla	121521.789	126215.72	130899.616	135537.581	140084.279	144482.02	148656.882
Rouissat	57516.5432	59738.1916	61955.0902	64150.2499	66302.2124	68383.6735	70359.6455
sidi-khouiled	13046.655	13550.5983	14053.4643	14551.3991	15039.5354	15511.6797	15959.8955
Ain Beida	19849.2898	20615.9935	21381.0579	22138.6202	22881.2748	23599.599	24281.5183
hassi ben abdallah	5271.4457	5475.06188	5678.24274	5879.43121	6076.66061	6267.42849	6448.5282
N'goussa	16209.0607	16835.156	17459.9126	18078.543	18684.9996	19271.5879	19828.4477
El-hadjira	13984.6045	14524.7774	15063.7953	15597.5277	16120.7571	16626.8447	17107.2836
El-Alia	7438.19378	7725.50331	8012.19859	8296.08254	8574.38011	8843.56024	9099.09825
Tmacine	20042.4197	20816.5833	21589.0916	22354.0248	23103.9053	23829.2187	24517.773
Blidet Amor	13760.697	14292.2211	14822.6088	15347.7956	15862.6475	16360.6322	16833.3788
Touggourt	39048.4014	40556.6947	42061.7634	43552.0733	45013.0564	46426.1755	47767.6774
Nezla	52168.1533	54183.2135	56193.9655	58185.0001	60136.8544	62024.7631	63816.992
Tebesbest	32097.2643	33337.0612	34574.2075	35799.2224	37000.131	38161.696	39264.3926
Zaouia	20620.2705	21416.7543	22211.5351	22998.5224	23770.023	24516.2482	25224.6544
Meggarine	13587.5726	14112.4095	14636.1244	15154.7038	15663.0783	16154.7978	16621.5968
sidi slimane	7475.89643	7764.66227	8052.81075	8338.13365	8617.84184	8888.3864	9145.21968
Taibet	23441.8136	24347.2829	25250.8164	26145.4899	27022.5576	27870.8913	28676.2312
Bennaceur	10885.293	11305.751	11725.3102	12140.7551	12548.0248	12941.9517	13315.9142
M'nagueur	12234.1245	12706.6828	13178.2309	13645.1549	14102.8906	14545.6303	14965.9317
hassi messaoud	39179.9759	40693.3515	42203.4915	43698.8231	45164.729	46582.6097	47928.6317
El-Borma	5741.57463	5963.35013	6184.65148	6403.78276	6618.60188	6826.38321	7023.63413
TOTAL	545117.191	536374.444	587183.841	607988.626	628384.006	648111.203	666838.621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E
S
Populations
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7463 - 9716
9717 - 14147
14148 - 16956
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100
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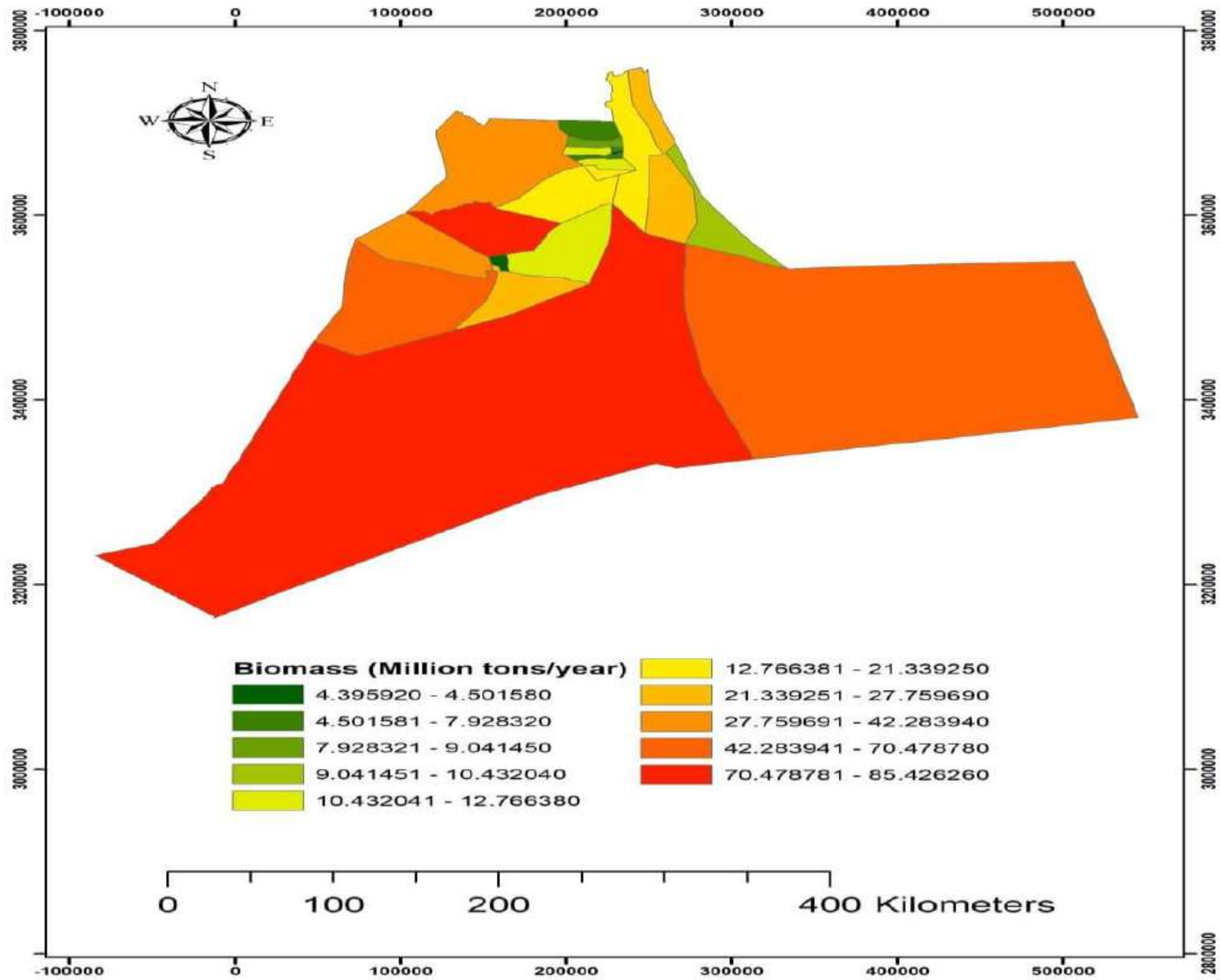
400 Kilometers



N
S
E
W
Biomass (Million tons/year)
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4.501581 - 7.928320
7.928321 - 9.041450
9.041451 - 10.432040
10.432041 - 12.766380
12.766381 - 21.339250
21.339251 - 27.759690
27.759691 - 42.283940
42.283941 - 70.478780
70.478781 - 85.426260
0
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200
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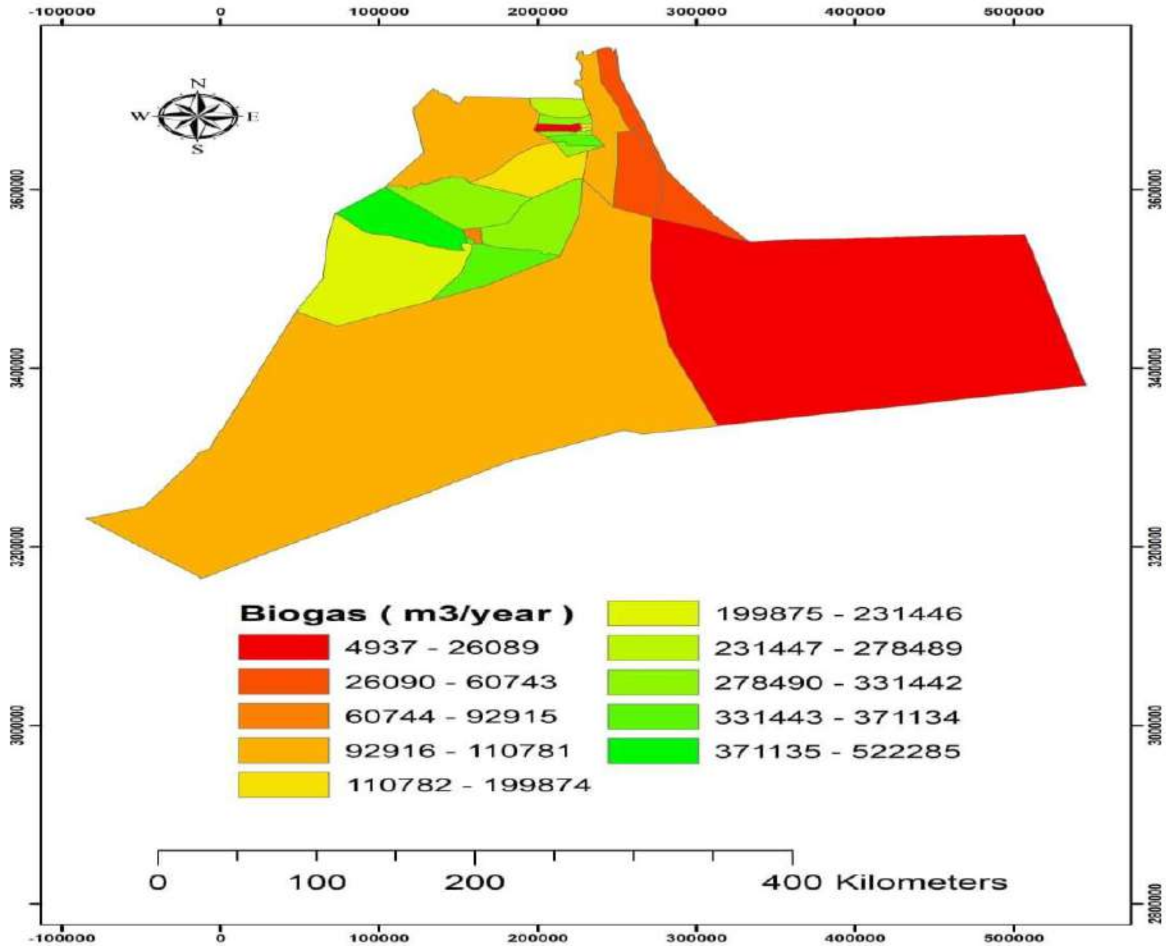

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0
100000
200000
300000
400000
500000
N
W
E
S
3600000
3400000
3200000
3000000
2800000
Biogas (m3/year)
4937 - 26089
26090 - 60743
60744 - 92915
92916 - 110781
110782 - 199874
199875 - 231446
231447 - 278489
278490 - 331442
331443 - 371134
371135 - 522285
0
100
200
400 Kilometers

ABSTRACT

In this study, we address the problem of biogas production from biomass (municipal waste, animal dung, palm waste) as a feedstock in the Ouargla region (Algeria), and the potential of its uses in the transport sector as a renewable fuel in Algeria at the beginning of 2050, to be a magical alternative solution to the current energy and to end Environmental crisis. This may be true to solve all the problems inherent in the energy cycle (production, distribution, storage and use), and to create maps that allow easy presentation of the results. Finally, we developed scenarios to determine the environmental impact before and after the integration of biogas as an alternative fuel in the road transport sector. All stages of work were carried out by a set of technical models with spatial data in a geographic information system (GIS). The results showed that in the case of incorporating biogas as an alternative fuel, it allows us to reduce energy consumption on the one hand, and achieve environmental savings in terms of carbon dioxide emissions.

Key words : Biogas, biomass, geographic information system (GIS), transport sector, environmental impact, Ouargla.

ملخص

نعالج في هذه الدراسة مشكلة انتاج الغاز الحيوي انطلاقا من الكتلة الحيوية (نفايات البلدية، روث الحيوانات، مخلفات النخيل) كمادة وسيطة في منطقة ورقلة (الجزائر)، وامكانات استعمالاته في قطاع النقل كوقود متجدد في الجزائر مطلع 2050، ليكون الحل السحري البديل للطاقة الحالية ولإنهاء الأزمة البيئية. قد يكون هذا صحيحا لحل جميع المشاكل الكامنة في دورة الطاقة (الانتاج والتوزيع، التخزين والاستخدام)، وإنشاء الخرائط التي تسمح بسهولة لعرض النتائج، ولتحقيق هذه النتائج درسنا بأثر رجعي تطوير السيارات واستهلاك الوقود وانبعاثات ثاني أكسيد الكربون لتحديد التوزيع المكاني والزماني لطلب الغاز الحيوي في قطاع النقل البري. وأخيرا فإننا وضعنا سيناريوهات لتحديد الأثر البيئي قبل وبعد دمج الغاز الحيوي كوقود بديل في قطاع النقل البري، تم تنفيذ جميع مراحل العمل من قبل مجموعة من النماذج الفنية مع البيانات المكانية في نظام المعلومات الجغرافية (GIS). وأظهرت النتائج أنه في حالة دمج الغاز الحيوي كوقود بديل يسمح لنا بالحد من استهلاك الطاقة من جهة، وتحقيق وفرات البيئية من حيث انبعاثات ثاني أكسيد الكربون.

الكلمات المفتاحية : الغاز الحيوي، الكتلة الحيوية، نظام المعلومات الجغرافية(GIS)، قطاع النقل، الأثر البيئي، ورقلة.