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# RATIONALIZATION OF ENERGY CONSUMPTION IN PUBLIC BUS TRANSPORTATION - CASE OF THE CENTER OF OUM AL-BOUGHI CITY

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## ABSTRACT

The city of Oum El-Bouaghi has great importance due to its good and strategic location, which has given it a prominent place in the economic movement. It is considered a transit zone between the north and the south via National Road No. 10 and National Road No. 32. All these advantages can help the city to move the wheel of sustainable development forward.

Public urban transportation is a vital artery in the urban system, as it plays a fundamental role in structuring the urban area and circulating daily movement with all its various activities. Accordingly, it is necessary to activate a traffic system that relies on energy conservation techniques to mitigate the problems that negatively affect the activity of individuals and hinder the functional movement of cities, in addition to other problems that are harmful to health due to air pollution. This can be done by encouraging the clean public urban transportation sector within the urban environment.

On this basis, the topic of our research revolves around the rationalization of energy consumption in public transportation in the city of Oum El-Bouaghi by buses. It is a means to confront the many challenges facing the latter, such as the continuous increase in population density and the increase in the rate of daily movements, which results in many traffic problems. The phenomenon of traffic congestion is at the top of these problems, as well as the noise resulting from heavy traffic, and the excessive consumption of fuel. Therefore, it is necessary to work hard to ensure the operation of sustainable public urban transportation.

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## Introduction.

Urban transportation is one of the most important factors that affect cities and make them more competitive, attractive for investment, and provide job opportunities and easy and quick access for their residents. It is also one of the most challenging sectors in terms of combating the clear climate changes that the world is witnessing. It also requires good planning and investment in urban transportation infrastructure to maximize the benefits of these means.

Transportation faces many problems such as traffic congestion, environmental pollution, excessive fuel consumption, traffic accidents, etc. The transportation system also needs many modern

and intelligent technologies in its means such as electric vehicles and the use of clean energy that helps to reduce harmful emissions, save fuel, improve road safety and reduce traffic congestion.

With the increasing demand for energy and ensuring its security, it has become necessary to focus on rationalizing energy use in the transportation sector to achieve sustainable development through the integration of clean and renewable energy in its various forms. Renewable energy technologies such as solar and wind can help provide clean and sustainable energy sources for transportation, reduce fuel consumption and increase vehicle efficiency. Rationalizing energy consumption helps to reduce harmful emissions and save natural resources. In order to achieve this, changes in transportation behavior and technology are needed to improve public health and the environment, and to save fuel and natural resources.

The energy sector in Algeria plays a vital and central role in economic development, acting as the driving force for other branches of the national economy. This is due to the country's abundant hydrocarbon and natural resources. Over the past decade, Algeria's program has focused primarily on rationalizing energy use.

Energy is one of the fundamental pillars of industrial development. The amount of energy consumed per capita in a country has become a measure of economic growth and a reflection of the level of development achieved by that country. It is also the key to the growth of human civilization throughout history and the means by which humans achieve progress and prosperity.

Energy is one of the most important topics that has attracted the attention of researchers due to the diversity of its uses and the increasing global demand for it.

Oum El Bouaghi is one of the Algerian cities witnessing rapid growth in population and economic activity. With the increasing population and demand for vehicles, and in light of the challenges and circumstances facing this city, it has become necessary to focus on rationalizing energy use in the transportation sector to preserve the environment and improve the quality of life.

Rationalizing energy consumption in public transportation is crucial to achieving many benefits, including reducing greenhouse gas emissions, improving air quality, saving natural resources, reducing fuel costs, and mitigating traffic congestion.

The transportation sector is one of the most energy-consuming sectors. It faces challenges related to excessive consumption requirements, especially with the continuous increase in the number of vehicles. At the same time, the surrounding environment experiences high levels of pollution from transportation, which prompts us to think and reconsider rationalizing energy consumption within the framework of sustainable development. The primary goal is to develop the transportation sector, facilitate its operation, eliminate and reduce its problems, and preserve the environment.

Oum El Bouaghi suffers from transportation problems like other Algerian cities due to poor management in this sector, given the freedom enjoyed by private individuals in exploiting the public transportation service. It also suffers from several problems at the level of public bus transportation, which has become a fundamental element in excessive energy consumption due to traffic congestion, especially in congested, narrow roads, and problems with stopping and difficulty in daily commuting for residents.

This has led us to choose the city as a model for rationalizing energy consumption in public bus transportation while providing specific strategies to preserve the environment and move towards sustainable planning in the transportation sector. Based on the above, we have formulated the following main question:

**"How can rationalizing energy consumption in public bus transportation be applied?"**

The research objectives are as follows:

Clarify the meaning of rationalizing energy consumption in transportation.

Reconciling our growing demands for energy and transportation while maintaining a safe environmental system.

Improve energy efficiency in public transportation.

Reduce harmful gas emissions and improve air quality.

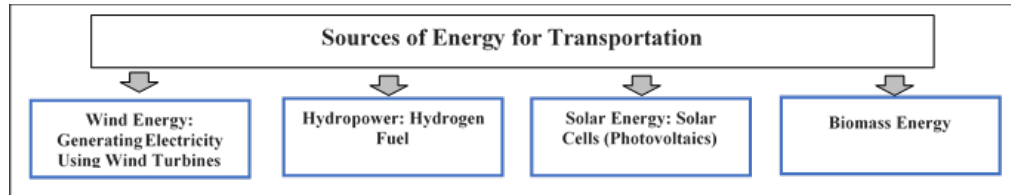
Provide more comfortable and smooth travel for passengers.

Encourage the use of public transportation and reduce traffic congestion.

## Firstly. The Conceptual Framework for Rationalizing Energy Consumption.

### 1. Sources of Energy for Transportation.

Renewable energy sources are expected to play a major role in the future of the transportation sector. The most important renewable energy sources for transportation are: (Laradj, Nassima, and Fatima Zahra Meghair, 2014):



*Figure 1. Sources of Energy for Transportation.*

Source. Laradj, Nassima, and Fatima Zahra Meghair, 2014.

### 2. Definition of Rationalization of Energy Consumption.

Rationalizing energy refers to a set of procedures or techniques that lead to reducing energy consumption without compromising the comfort or productivity of individuals and using energy only when it is truly needed. Improving energy efficiency and rationalizing its consumption does not mean reducing energy consumption as much as it means using this energy in a more efficient way that reduces its waste. It is necessary to raise awareness of this concept among energy users in all sectors. (Ministry of Electricity and Energy, Arab Republic of Egypt).

In the context of energy consumption, does not mean reducing consumption, but rather using energy in the most efficient way possible. This involves adopting wise and prudent methods and measures in the consumption process - regardless of the field - to achieve the best benefits and results from that consumption process. These benefits include stopping waste, avoiding losses, and saving on costs. (Hala Rashed)

According to Article 03 of the Algerian Law 99-09 of July 28, 1999, relating to energy control: "Rational use of energy is the best use of energy consumption at various levels of production, energy conversion and final consumption in the industrial, transport, service and household sectors. (Official Gazette, No. 99-09, 1999)

Rationalization is a fundamental factor for achieving sustainable development. It ensures the rational use of renewable energy sources and reduces the damage and risks facing the environment, especially air pollution, global warming and the dangerous climate changes it causes. (Official Gazette No. 04-09, 2004, p. 11.)

### 3. Importance of Rationalizing Energy Consumption.

Energy plays a vital role in human life. It is the lifeline that cannot be dispensed with. Therefore, it is necessary to use this energy in all its forms wisely, away from waste and in moderation to avoid the effects resulting from its generation or acquisition. Here are some benefits of rationalizing energy consumption in general:

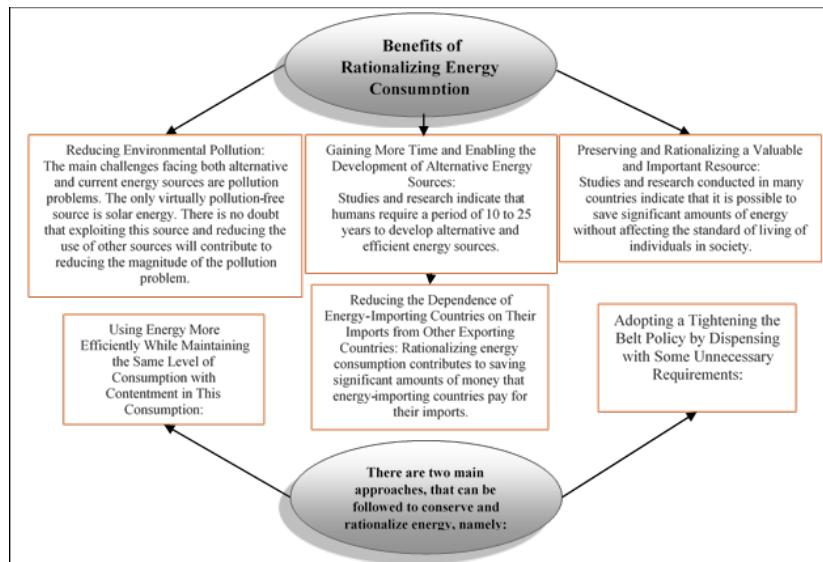
Reducing the electricity bill.

Keeping the environment clean, healthy, and free of greenhouse gases.

Stimulating the ongoing search for new, sustainable, and renewable energy resources.

### 4. Benefits of Rationalizing Energy Consumption.

Rationalizing energy consumption refers to using energy in the most efficient way possible. This can be achieved through a variety of measures, such as using energy-efficient appliances, turning off lights and electronics when they are not in use, and driving less. (Ahmed Madhat Islam, 2008.)



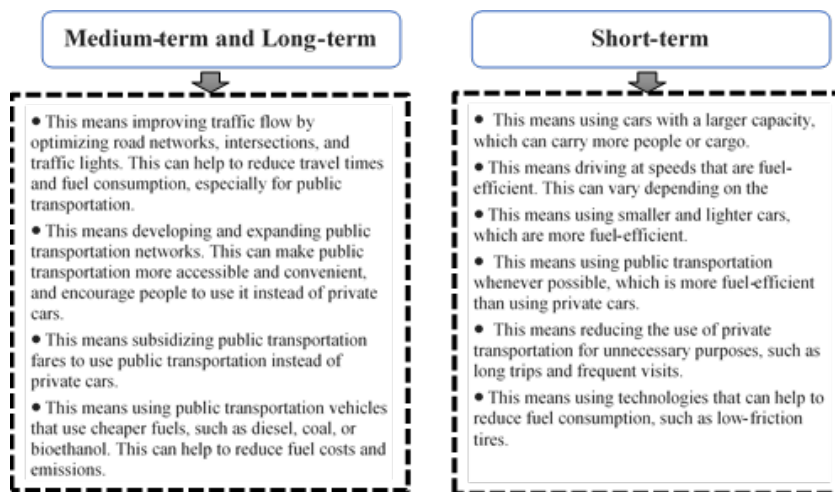
*Figure 2. Benefits of Rationalizing Energy Consumption.*

Source. Ahmed Madhat Islam, 2008.

5. Rationalizing energy consumption in the urban transport sector.

Rationalizing energy consumption in the transport sector is a complex task. It requires changes in the habits, tastes, and aspirations of a large segment of society.

Some important measures that can lead to significant energy savings in this sector include:



*Figure 3. Rationalizing energy consumption in the urban transport sector.*

Source. Prepared by the Researchers.

Secondly. Rationalizing Energy Consumption in Public Bus Transportation in the Study Area.

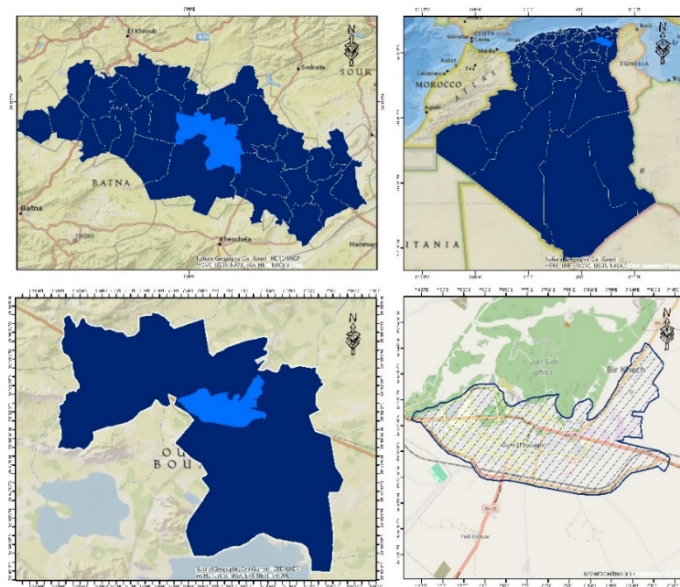
1. Presentation of the study area with respect to the province, municipality, and city:

1.1. Oum El Bouaghi Province and City.

Oum El Bouaghi Province is located in the northeastern part of the High Plateaus of Algeria. It covers an area of 6,187.56 km<sup>2</sup> and has a population of 782,188 (DPSB, 2019) The province consists of 12 districts and 29 municipalities. It is located about 811 km from the capital Algiers and borders 7 other provinces. The city of Oum El Bouaghi is located in the center of the province of the same name. The municipality covers an area of 414 km<sup>2</sup> and represents 6.69% of the area of the province. It includes four secondary clusters: Touziline, Sidi Arghis, Bir Khécha, and Abbas Larbi. The city of Oum El Bouaghi, the capital of the province and the center of the municipality, is considered one of the most important cities in the province. It is the junction of National Highway 10, which connects Tebessa and Constantine, and National Highway 32, which connects Khenchela and Guelma. This makes it

geographically important as a transit area, which has increased its dynamism and attractiveness. It covers an area of 1,358.1 hectares and has a population of 667564, (DPSB, 2022) The city of Oum El Bouaghi occupies an important geographical location and has witnessed remarkable economic development. It has experienced a population increase and significant urban development. This has led to an increase and diversification of individual demands, particularly for transportation.

Given the problems facing the transportation network in the study area, such as traffic congestion caused by excessive fuel consumption and pollution caused by carbon dioxide gas, it is necessary to implement a project to rationalize energy consumption in public bus transportation. This will ensure the provision of its services to all residents at all times and places, which will achieve the development and progress that goes hand in hand with a clean environment, using renewable energy. This strategy can be implemented on the ground to achieve security, comfort, good management, and rationalization.



*Figure 04. Situation of the city of Oum El Bouaghi.*

Source. Administrative divisions of Algeria in 1984.

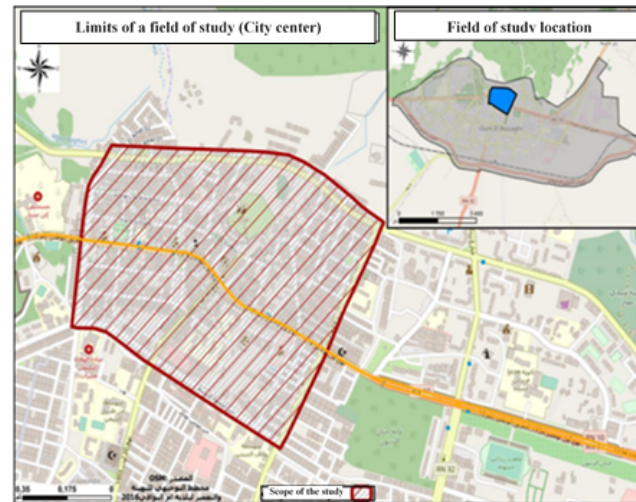
## **2. Analysis of the Study Area (City center of Oum El Bouaghi).**

This part aims to conduct an analytical study of the study area and focus on the important elements that affect the organization of spatial movement. The infrastructure and superstructure of the area will also be studied and the problems facing it will be identified, which can help improve transportation and rationalize energy consumption.

City center of Oum El Bouaghi is located in the northern part of the city at Mount Sidi Arghis. It represents land use plan number 1 of the city center and is bordered by:

- To the north: Mount Sidi Arghis.
- To the south: The railway.
- To the east: Abbad Alawah Street.
- To the west: Youssefi Street.

The study area is located in the city center of Oum El Bouaghi, north of Mount Sidi Arghis. It is divided into two parts by National Highway 10. It has an area of 50 hectares, (PDAU, 2016).



*Figure 05. Situation of City center of Oum El Bouaghi.*

Source. Master Plan for Development and Urban Planning of the Municipality of Oum El Bouaghi 2016.

### **2.1. Climate.**

The climate in the study area is Mediterranean, with hot, dry summers and mild, wet winters. The average annual rainfall is between 200 and 400 mm, and the average annual rainfall is 4.28%. The study area is also prone to flooding due to its location at the foot of Mount Sidi Arghis. As for temperatures, the average ranges from 20 to 40 degrees Celsius in April to September and from 8 to 25 degrees Celsius in October to March. (Meteorological Service-Oum al-Bouaghi, 2023).

### **2.2. Urban Development of the City Center.**

The urban development of the study area in the city of Oum El Bouaghi went through two main stages, which are as follows: (PDAU, 2016).

**Pre-independence period.** This is the urban cluster that today represents the old city center. It was the colonial center at that time, which was completed in 1902. It was equipped with the following facilities: two primary schools, a market, a church, a railway station, and a fountain in the middle. The dominant architectural style at that time was the colonial style specific to the settlers, and the traditional style specific to the native population, whose number reached 650 inhabitants and its total area is estimated at about 34 hectares.

**Post-independence period.** During this period, the center witnessed an expansion along National Highway 10. The post-administrative upgrade period also witnessed a large influx of population, followed by an increase in the number of housing and facilities. The center has become an important point at the city level, as evidenced by:

The development of commercial activities that gave vitality to the center, making it an area of attraction for residents.

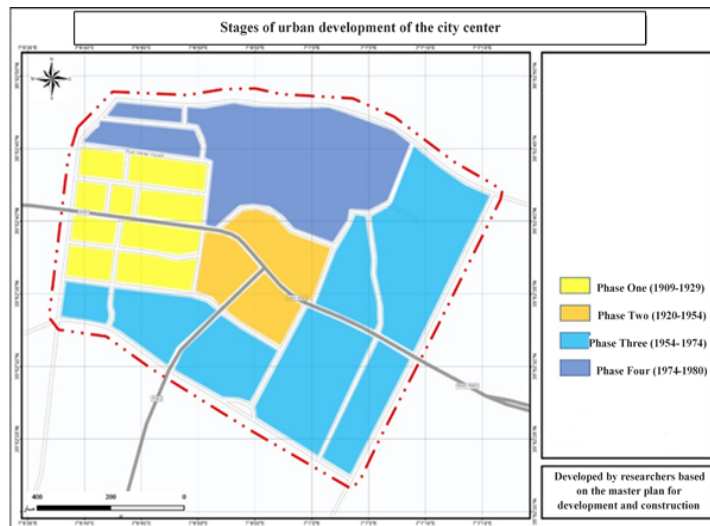
Concentration of population and facilities in the study area.

Demolition of some old buildings and replacement with modern collective housing.

During this period and until 1984, the old city center was the first point with a dense commercial and service activity, but after 1985 and with the rapid expansion of the city, especially in its southern direction, the center gradually lost its importance due to the lack of maintenance operations of the built framework and the focus on expanding towards the south and the absence of urban intervention operations on the old fabric and the absence of development operations.

### **2.3. Plan of the Center.**

We notice that the study area is characterized by a chessboard plan, which gave it vertical and horizontal road sections that form square or rectangular islands. These roads represent the structure of the area, and National Highway 10 represents the main axis of the study area. (PDAU, 2016).



*Figure 6. Stages of urban development.*

Source. Prepared by researchers based on the PDAU and aerial photos.

**2.4. Residential Patterns.**

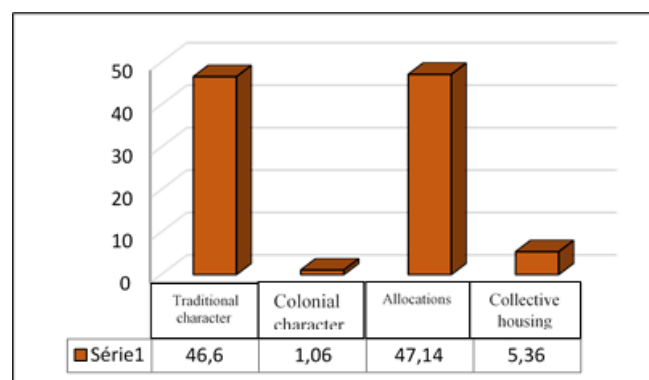
**Single-family housing.** This is the dominant pattern in the city center. Through an analysis of the architectural characteristics of the built framework, three different patterns of single-family housing appear in that area, which are as follows: (PDAU, 2016).

**Colonial style.** This is the style found along National Highway 10 at a rate of 1.06%, which has made it an area of attraction for residents. We note that the existing style still preserves the same old morphological characteristics that date back to the colonial period, represented by the use of stones, the use of tiled roofs with the presence of an internal courtyard.

**Traditional style.** It is concentrated in Abbada Alawah Street at a rate of 46.6%. We note that most of the housing units have a single character with the presence of an internal courtyard and are concentrated in an organized manner and the presence of compactness at the level of the built space. Its physical condition is between average and poor.

**Allocation pattern.** They were completed based on studies of urban interests. Their height ranges from two floors or more, and they are available at a rate of 47.14%. The building materials used are reinforced concrete, as they comply with the building conditions, most of them are in good condition.

**Collective housing** is located in the eastern part of the center in a small proportion compared to single-family housing. It consists of 4 floors in addition to a ground floor intended for commercial use and some other services. Its physical condition is good.

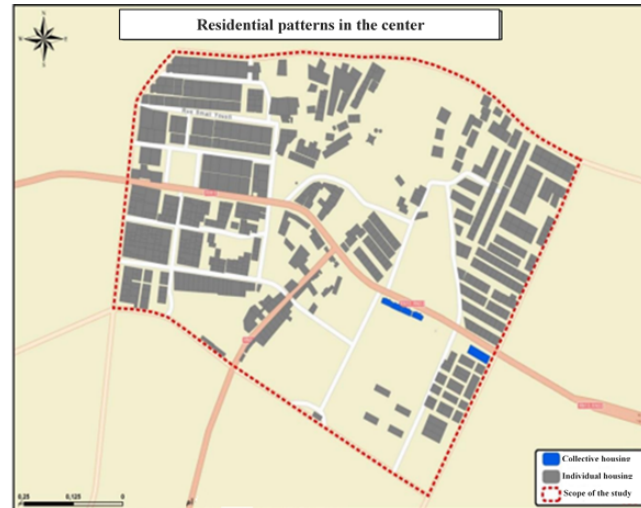


*Figure 07. Distribution of Residential Patterns.*

Source. Land Use Plan + Researchers' Processing 2023.



From the figure, we notice that the largest percentage is represented by the allocation pattern, estimated at 47.14%, and the traditional pattern, estimated at 46%, followed by the colonial pattern at a small percentage estimated at 1.06%. We find that single-family housing is the dominant pattern, as it represents a large percentage of up to 93.57%, or about 1046 housing units, while collective housing represented 5.36%. (Land use plan, OEB).



*Figure 8. Residential patterns.*

Source. Master Plan for Development and Urban Planning 2016.

### **2.5. Equipment.**

Equipment plays a large and effective role in adding dynamism within the center, as it makes it a point of attraction for residents. Since the old city center of Oum al-Bouaghi is centered along National Highway 10, it includes a set of educational, security, administrative, service, commercial and financial, religious, sports and tourism facilities, which are distributed as follows: (PDAU, 2016).

**2.5.1. Educational and training facilities.** The area contains educational and training facilities at various levels, including:

Khansa Elementary School: This school overlooks the road, which has negative effects on the safety and security of students.

- Musa Boubaker Elementary School
- Hamou Bouzid Middle School
- Vocational Training Center

**2.5.2. Security facilities.** These are represented by the security facilities that work to provide protection for citizens and are available at a considerable level in the study area, including:

- National Gendarmerie Headquarters
  - Military Sector
  - Urban Security Headquarters
- The area of these facilities is estimated at 1585 square meters.

**2.5.3. Administrative and service facilities.** These are considered the main factor that highlights the administrative and service function at the level of the center. They are available and strongly concentrated in the study area, especially within the urban fabric along National Highway 10. These facilities include:

- Post and Communications
- Real Estate Agency
- Judicial Council
- Administrative Court
- November 1st Municipal Annex

National Organization of Mujahideen  
Lawyers' Organization  
Purification Center

#### **2.5.4. Commercial facilities.**

These represent the vital function of the urban area, and among these facilities are:

Vegetable Market.  
Shops.  
Cereals and Dry Legumes Cooperative.

#### **2.5.5. Religious, cultural and spiritual facilities.**

These are distributed in a small proportion on the study area, as they are represented by the old mosque, which is located next to National Highway 10. The urban fabric also includes a cemetery dating back to the colonial period, which is located inside the center in the northern part.

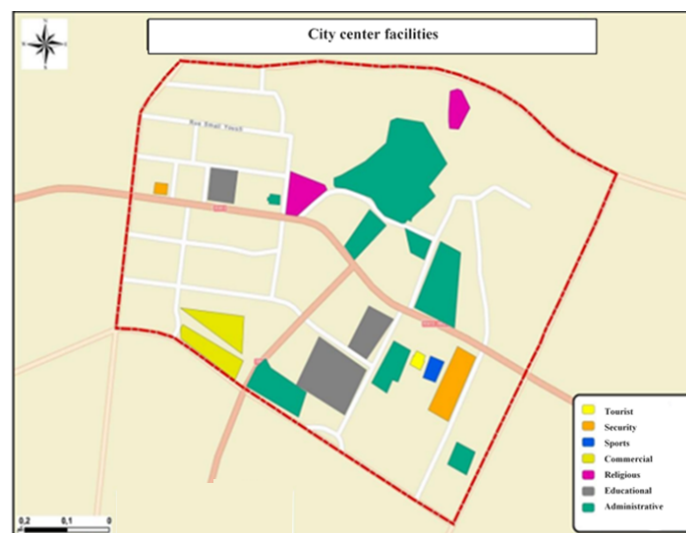
#### **2.5.6. Sports and tourism facilities.**

These are among the most important structuring facilities of the center, and include:

Al-Sharaf Hotel.  
Majid Hotel.

Wilaya League of the Karate Amateur Sports Club.

These facilities are available in a very small proportion at the level of the area.



*Figure 9. Distribution of the various facilities.*

Source. Master Plan for Development and Urban Planning, 2016.

## **2.6. Road Network in the City Center of Oum El-Bouaghi.**

The aim of studying the engineering characteristics of the road network is to determine the relationship between roads and transportation in order to rationalize energy consumption in its means by studying the width of roads and sidewalks, their condition, traffic directions and the transportation used in them.

The city center of Oum El-Bouaghi is characterized by a road network that is considered the arteries for the passage of cars and buses within the urban area and the organization of traffic for bus movements. The types of roads are classified as follows:

**Primary roads.** These are the main roads that represent the main and structuring axes of the center and are represented by: (Traffic and Circulation Plan, 2016)

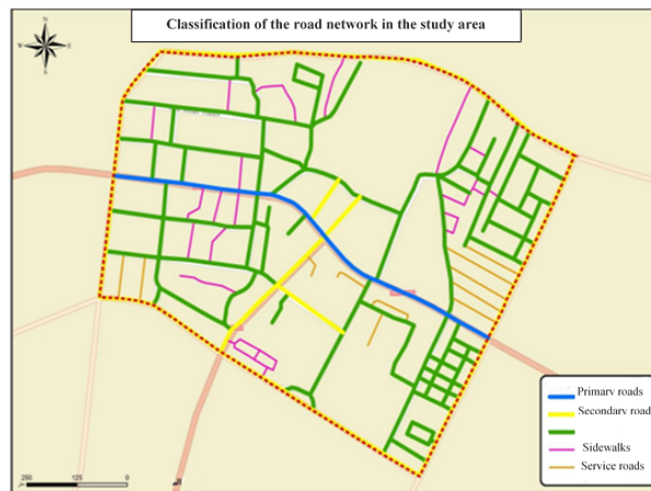
**National Highway 10.** It is a main line that connects the city of Oum El-Bouaghi to its center. Its width ranges between (10-15) meters and divides the study area into two parts. There are a number

of commercial and service activities on its level, and it witnesses heavy traffic that hinders the movement of buses. And the environmental standards are not used in it.

**National Highway 32.** It connects the center to the western side towards the municipality of Ain Zitoun, Khenchela province. It is characterized by heavy traffic as it is the axis that includes the service facilities and the diversity of commercial activities and the presence of shops and the collective market.

**Secondary roads.** Secondary roads are considered a link between the city center and the rest of the neighborhoods. The center includes two secondary roads from the east to the west, and their direction is from north to south. Most of the roads have commercial activities on both sides, especially in the south. They are characterized by less traffic than National Highway 10. Their width ranges from (6-9) meters and they are characterized by an average and poor construction condition.

**Tertiary roads.** These roads allow access to housing and various facilities within the urban fabric and are open on both sides for car traffic.



*Figure 10. Classification of the road network.*

Source. Traffic and Circulation Plan, 2016.

### **Network.**

The study of the engineering characteristics of the road network in the city center of Umm al-Bouaghi is considered one of the important elements. The aim of the study is to determine the width of the roads, sidewalks, and their condition. (Traffic and Circulation Plan, 2016)

**Road width.** The road network identified in the city center is characterized by the following:

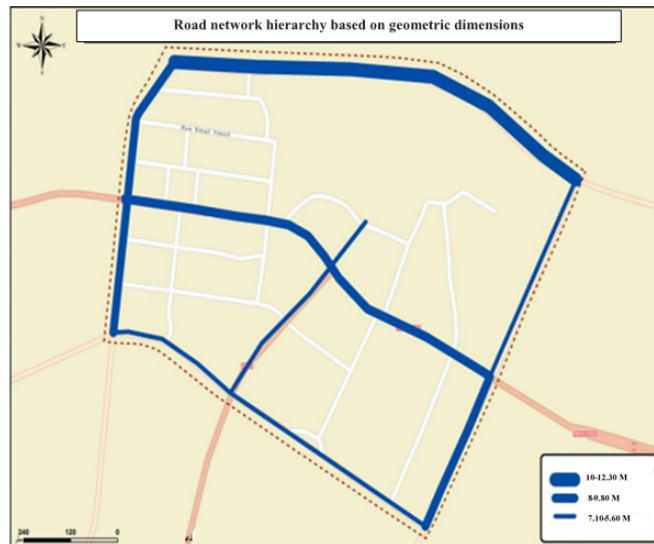
4% of the road network has a width of more than 12.5 meters.

13% represent roads with a width of between (9-10) meters.

30% belong to roads with a width of between (7-8) meters.

26% represent roads with a width of between (5-6) meters.

Roads with a width of less than 4 meters represent 25%, and unpaved roads represent 2%.



*Figure 11. Gradation of the road network according to the geometric dimensions.*  
 Source. Traffic and Circulation Plan, 2016.

**Sidewalks.**

The sidewalks of the main road are in good condition, as the width of the sidewalks of National Highway 10 reaches 7 meters. However, they are used by clothing stores and restaurants, which creates a kind of congestion and affects the general image of the city center.

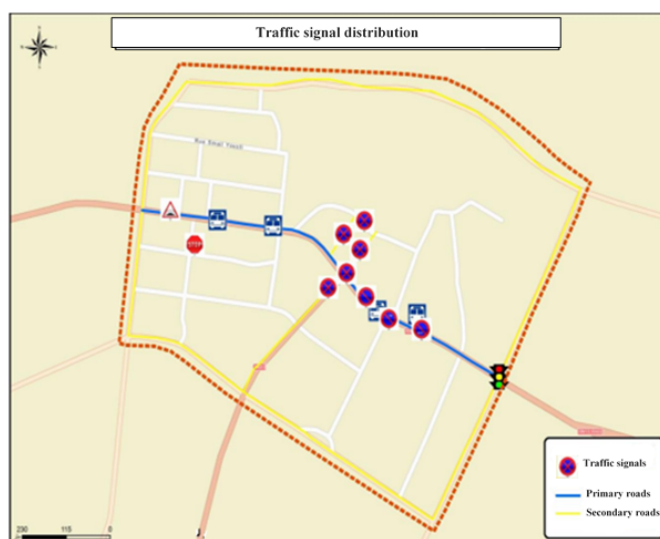
The sidewalks of the secondary and tertiary roads are in poor condition, characterized by narrowness and unevenness in their width.

From this we conclude that the presence of sidewalks in the study area in the city of Oum El-Bouaghi is low, while the absence of sidewalks on both sides of National Highway 10 is an obstacle to the flow of traffic for pedestrians or their use for bicycles.

**Traffic lights and directional signs.** (Traffic and Circulation Plan, 2016).

Traffic lights ensure ease of movement and traffic and maintain the safety of road users. They warn of obstacles and dangers on the road.

Directional signs clarify the main landmarks and points that help individuals reach their destination. We notice that directional signs are almost non-existent in the area.



*Figure 12. Distribution of traffic lights.*  
 Source. Traffic and Circulation Plan, 2016.

### 2.6.2. Traffic Flow Directions.

The most notable feature of the roads in the city center of Oum El-Bouaghi is that they are two-way, accounting for 90%, with the exception of some one-way roads. (Traffic and Circulation Plan, 2016).

### 2.6.3. Stopping on the side of the road.

Stopping on the side of the road is one of the most important factors that lead to congestion in most cities and create noise that disturbs residents.

In the city center of Oum El-Bouaghi, we find a large congestion of cars, especially on National Highway 10. (Traffic and Circulation Plan, 2016)

Through the study of the area, we noticed that there is a lack of parking spaces for cars, which made them stop on the side of the road, which led to traffic congestion.



Figure 13. Locations of licensed and unlicensed parking.

Source. Traffic and Circulation Plan, 2016.

### 2.6.4. Public transport stations: (Traffic and Circulation Plan, 2016).

The study area contains four public transport stops.

These stops operate legally, but they are not well-equipped and lack urban furniture. There are no seats for sitting in the waiting areas for public transport lines.

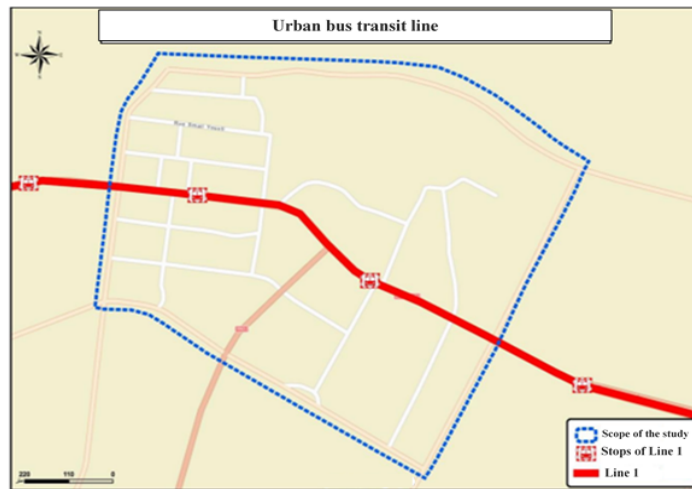


Figure 14. The public transport stops.

Source. By the researchers.

**2.6.5. Public Transport Bus Line in the Study Area.**

Only one public transport bus line passes through the study area, which is the second line according to the line arrangement in the city, and it is number 043023. (Directorate of Transportation, 2023).



*Figure 15. The public transport bus line.*

Source. Directorate of Transportation.

After the analytical study of the natural and urban characteristics and the study of the road network at the level of the study area in the city of Oum El-Bouaghi, we notice that it is characterized by an important location, as National Highway 10 passes through its middle, dividing it into two parts. The latter is considered one of the most important axes that are structured along a set of facilities that make it a point of attraction for residents. Through this study, I concluded many problems that affect mechanical and pedestrian movement.

**3. Problems Identified in the Study Area.**

Through the analytical study of the area, it is possible to extract the current situation of public transport buses, and to extract the most important problems of the infrastructure and superstructure of the study area, which are as follows:

Table 1. Most Important Infrastructure Problems.

Roads	<ul style="list-style-type: none"> <li>• Traffic congestion, especially on main roads.</li> <li>• Random parking of vehicles on the sides of the road.</li> <li>• Lack of parking spaces.</li> <li>• The large number of facilities on the main road of November 1st has led to heavy traffic.</li> <li>• Inability to accommodate traffic flow</li> </ul>
Parking	<ul style="list-style-type: none"> <li>• Shortage of parking spaces.</li> <li>• Insufficient capacity of existing parking spaces.</li> <li>• Concentration of parking on main roads only.</li> </ul>
Sidewalks	<ul style="list-style-type: none"> <li>• Dilapidated sidewalks.</li> <li>• Sidewalks that do not comply with the laws in force.</li> <li>• Exploited by shop owners.</li> <li>• Some of them are difficult to navigate.</li> </ul>
Directional signs	Severe shortage of directional signs
Commerce	<ul style="list-style-type: none"> <li>• Presence of chaotic trade, especially on the main road.</li> <li>• Trade taking over a large part of the sidewalks.</li> </ul>

Source. Field Study 2023.

Table 2. Transportation Line Problems.

Transportation Infrastructure	<ul style="list-style-type: none"><li>- Weak reception and care structures for commuters.</li><li>- Shortage of public transport buses.</li><li>- Public transport buses do not meet the needs of the population.</li><li>- Traffic congestion leads to increased bus arrival times.</li><li>- Long bus waiting times.</li><li>- Non-respect of stopping times and places due to the lack of no-stopping signs and the absence of security guards.</li></ul>
Bus Transportation	<ul style="list-style-type: none"><li>- Buses with excessive fuel consumption.</li><li>- High pollution from bus engines.</li><li>- Noise pollution.</li><li>- Old age of some buses.</li><li>- High production of carbon dioxide leads to air pollution.</li><li>- Lack of cleanliness.</li></ul>
Commuters	<ul style="list-style-type: none"><li>- Overcrowding inside the bus.</li><li>- Weak reception and care structures for commuters.</li><li>- Long waiting times.</li></ul>
Carriers	<ul style="list-style-type: none"><li>- Non-compliance with bus stops.</li><li>- Overloading the bus capacity.</li><li>- Speeding and causing accidents.</li><li>- Disregarding bus cleanliness</li></ul>
Urban Furniture	<ul style="list-style-type: none"><li>- Lack of public seating.</li><li>- Unorganized vegetation.</li><li>- Lack of pedestrian paths.</li><li>- Lack of bicycle paths.</li><li>- Insufficient lighting</li></ul>

Source. Field Study 2023.

All the problems that we have discussed in the study area have been summarized in the form of figure number (16) below:

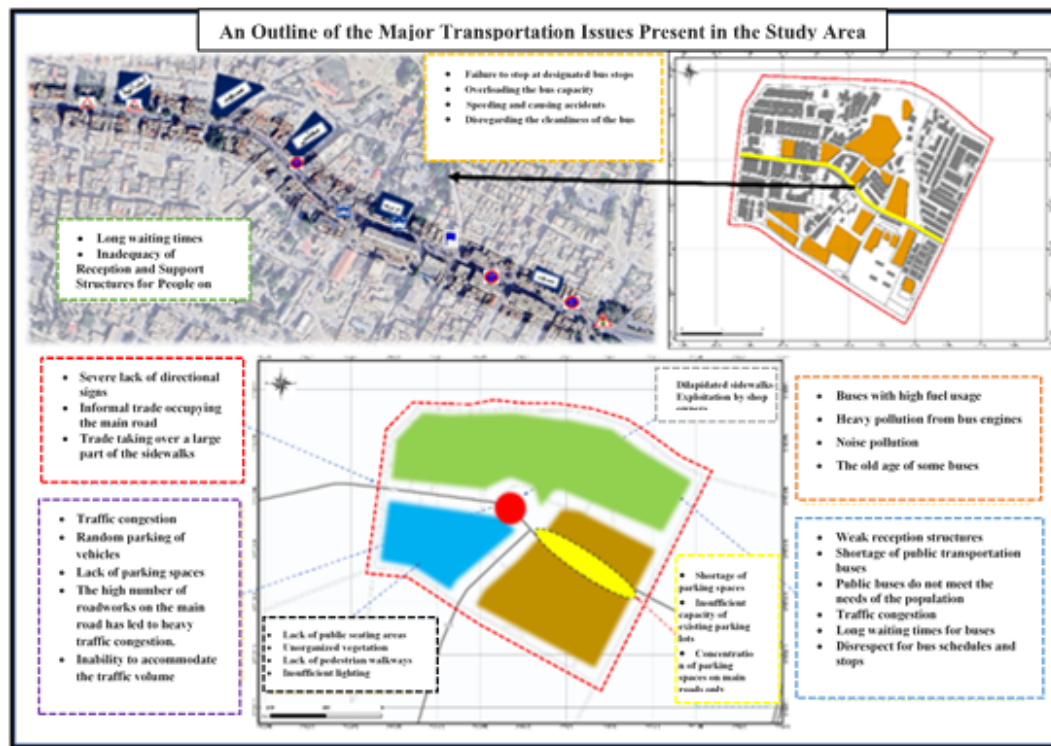


Figure 16. The most important transportation problems in the study area.

Source. By the researchers.

**Transportation problems in the field of study are represented as follows.**

Traffic congestion: Traffic congestion leads to excessive fuel consumption, environmental pollution, and a weak infrastructure for accommodating and supporting passengers. It also causes buses to exceed their capacity.

The study focuses on these problems by proposing solutions to rationalize energy consumption in public transportation.

The study area has many problems, including:

Traffic congestion on the main roads of the area.

Buses that consume excessive fuel.

Sidewalks that do not comply with the regulations in force.

Lack of public seating areas.

A large percentage of sidewalks are occupied by businesses.

Noise pollution.

Lack of parking spaces.

High levels of pollution from harmful gases.

**4. Suggestions.**

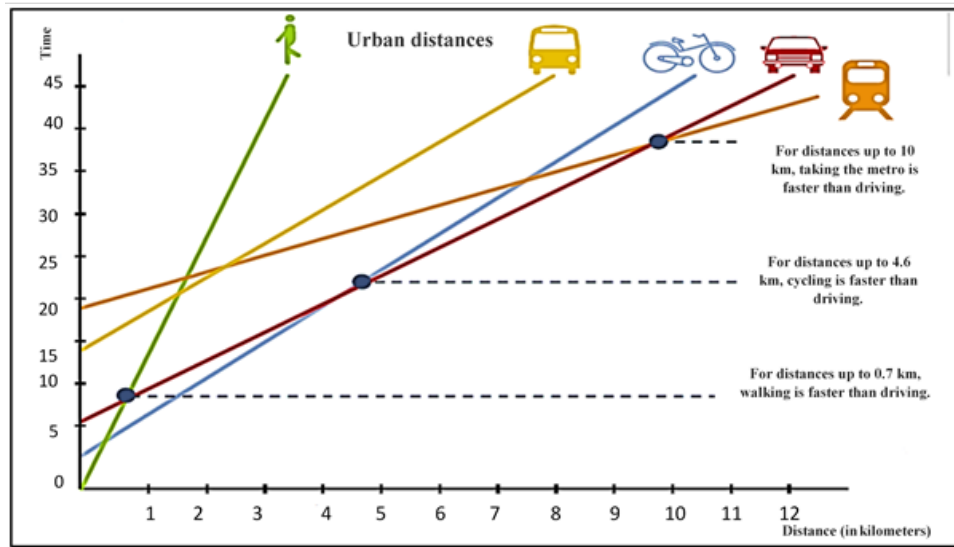
**4.1. Urban Structure.**

**Ease of Movement.**

Transportation is one of the most important factors in facilitating movement and mobility. Through our study of the infrastructure and superstructure, we have proposed several solutions to facilitate the process of mobility and accessibility in order to rationalize energy consumption in public transportation. These include: (Duaa Muhammad al-Sharif, 2018.)

Considering the definition of urban distances.





*Figure 17. Criteria for Defining Urban Distances for Mobility.*

Source. Duaa Muhammad al-Sharif, Institute of Training and Urban Studies, Egypt, 2018.

From Figure (17), we can see that: For distances up to 10 kilometers, the metro can be used because it is the fastest way to get around. For distances of 4 to 6 kilometers, cycling is faster than taking the bus or car. For distances of 0 to 7 kilometers, walking is faster than taking the bus.

We propose the following solutions to rationalize energy consumption in public transportation:  
Use local public transportation apps to find locations near you.

Update public transportation buses to reduce fuel consumption and harmful gas emissions by:

- Limiting the number of passengers on buses, as overloading can increase fuel consumption.
- Installing speed alerts on the driver's phone or a device in the bus that sounds an alarm when the speed limit is exceeded.
- Turning off the engine when waiting.
- Providing a warranty for repairs and free replacement for the first few years of the vehicle's life to improve performance and reduce fuel consumption.
- Choosing the right fuel for buses, such as replacing fossil fuels with biofuels to reduce harmful gas emissions.
- Using energy more efficiently while maintaining the same level of consumption.
- Create spaces for mechanical movement and encourage walking and cycling.
- Use smart cards for payment.
- Create a public database with information about vehicles on the road and their owners.
- Reduce traffic congestion by widening roads and building overpasses.
- Improve road intersections by providing traffic lights and seating areas.

#### **4.2. Zoning.**

Zoning is the process of dividing land into different areas based on specific criteria. The goal of zoning in the study area is to rationalize energy consumption in public transportation.

Figure 22 shows the functional zoning of the city center of Oum El-Bouaghi, which illustrates these criteria:



#### 1. Public Transport Stations.

Proposing a model for smart bus shelters: These shelters are designed in a closed manner and include Wi-Fi networks for wireless internet connection and are equipped with solar panels for lighting and large screens.

Equipping stops with modern technology with advanced features: Bus battery chargers, screens, smart audio, seats, LED lighting, photovoltaic conversion.

#### 2. Public Spaces.

Providing safer and more comfortable pedestrian paths.

Providing bicycle paths and special parking spaces for bicycles.

Planting trees along the bus route to cool the air.

The study recommends a number of specific measures to improve the energy efficiency of outdoor spaces in the study area, including:

Using energy-efficient lighting and appliances.

Installing solar panels to generate electricity.

Planting trees to provide shade and cool the air.

Using sustainable materials in construction.

#### 5. Recommendations.

Reduce fuel consumption.

Optimize the use of alternative and renewable energy sources.

Create and promote a green environment.

Encourage clean transportation within the area.

Reduce harmful emissions.

Provide public spaces for rest and relaxation.

Promote energy efficiency.

Encourage the use of bicycles for easy transportation.

Improve energy efficiency without sacrificing current comfort.

Follow a policy of tightening the belt by eliminating unnecessary requirements.

Through some of the proposals that have been reached in order to rationalize energy consumption in public transportation buses, they have been summarized in Diagram (24), which represents the development of the study area in the city center of Oum El-Bouaghi.



*Figure 20. Proposals for the development of the study area.*

Source. By the researchers.

Figure 20 shows our proposals for the development of the study area in the city center of Oum al-Bouaghi.

These proposals include:

Widening roads and creating dedicated spaces for pedestrians and cyclists.

Improving road intersections and providing them with traffic lights.

Providing parking spaces with advanced features and equipped with solar panels.

Building a solar power plant.

All of these proposals are aimed at rationalizing energy consumption in public transportation.

This section aims to identify the problems existing in the study area and to propose solutions for them. These proposals are implemented in order to meet the needs of the population, provide environmentally friendly means of transportation, facilitate the movement of people, provide a safe and comfortable transportation service, improve the image of the area, and implement a system for rationalizing energy consumption in the study area.

### **Conclusion.**

Rationalizing energy consumption in public transportation is vital for the city of Oum El Bouaghi and other cities in the world. By implementing the mentioned strategies, many environmental, economic and social benefits can be achieved, including: reducing harmful emissions, improving air quality, conserving natural resources, enhancing citizens' comfort.

Achieving rationalization of energy consumption requires cooperation between the local government by promoting the use of sustainable public transportation, improving infrastructure and applying intelligent traffic management technologies. In addition, citizens and drivers should participate in these efforts by adopting economical driving behaviors and supporting the use of public transportation.

The city of Oum El Bouaghi can achieve a positive shift towards a sustainable and environmentally friendly transportation system. By doing so, the city will be able to meet the transportation needs of its residents in an efficient and sustainable manner while preserving the environment and improving the quality of life.

The city should also strive to promote research and innovation in the field of sustainable public transportation technology and develop more efficient public transportation means.

In conclusion, we can say that rationalizing energy consumption in public transportation in the city is essential and vital.

By adopting energy strategies, it can achieve many environmental, economic and social benefits.

The city should focus on: promoting the use of sustainable public transportation, improving fuel efficiency, improving public transportation infrastructure, improving road planning and traffic management and raising awareness and education about the importance of energy rationalization.

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