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# THE IMPACT OF SHIFTING TOWARDS ECO-FRIENDLY TRANSPORTATION AT THE UNIVERSITY OF BAGHDAD, AL-JADRIYA CAMPUS (UBAC)

**Summary**. In recent years, the UBAC has seen severe traffic congestion, resulting in various environmental and traffic problems at the university and its environs. This congestion was due to the significant expansions in buildings andan increase in the number of colleges in addition to the extensive use of private transport modes by students and university employees.

This research was an attempt to find a solution for transportation problems in the UBAC, through studying the current transportation system inside the campus, and then suggesting alternatives to enhance the situation in the Campus and its environs as well. The study solutions focused on replacing the current diesel buses with battery-electric buses and restricting some of the private cars toward the Campus. This study supposes this transformation will reduce the $CO_2$

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emissions by (54%) in the morning peak hours and by (64%) in the afternoon peak hours, enhance the Passenger Car Unit (PCU) by (31%) in the morning peak hours and by (41%) in the afternoon peak hours, and will improve parking capacity by 114% inside the campus.

**Keywords:** University of Baghdad, transportation, eco-friendly transportation, traffic congestion, emission, PCU, diesel and battery-electric buses

## 1. INTRODUCTION

Transportation is essential in our lives. However, the current transportation systems have many problems including global warming, environmental degradation, health problems (physical, mental, emotional, spiritual), and emission of greenhouse gases [1-3]. Given these many problems brought about by the transport sector, many countries sought to shift to different types of transportation modes that are less harmful to the environment [4-8].

### 1.1. Eco-friendly transportation

The priority of eco-friendly transport is shifting towards the use of public transport. The public transport modes offer an efficient way of transport when compared with the usage of a private car. The primary type of public transport are buses, which keeps the space, energy, and emissions efficient. A diesel bus at 20% capacity, for example, produces approximately one-third of the $CO_2$ emissions per passenger kilometre compared to the equivalent number of private vehicles required to transport the same number of people. More so, the same bus at full capacity would have a steep reduction of more than 90% in $CO_2$ emissions. [9]

The advantages of electric buses have been recognised in the policies being implemented in several major cities around the world. The reason for considering electric buses rather than diesel buses is their significant contribution to greenhouse gases (GHG) emissions, which is largely reduced using electric buses. Electric buses are also attractive because they reduce local air pollution, even efficient diesel engines release dangerous substances like nitrogen oxides (NOx) and particulate matter (PM10). Those pollutants are of particular concern in dense urban areas. [9]

Electric vehicles that are powered by electricity do not emit any dangerous gasses, even though plants generating the electricity might produce toxic emissions. Alternative fuels and advanced vehicle technologies are used instead of green vehicles as it puts less pressure on the environment when compared to conventional internal combustion engine vehicles running on petrol or diesel. [10]

The Columbia University, for example, changed its greenhouse gas (GHG) emissions reduction goals by replacing its diesel-powered buses with six new battery-electric buses for its campus shuttle network. Columbia's campus shuttle network operates between many campus locations in Manhattan, New Jersey, and Rockland County. These shuttles make over 1,400 rider trips daily and travel about 180,000 miles per year. By moving to electric buses, a reduction of over 270 metric ton of University shuttle GHG emissions is expected – a 70% reduction from the diesel-powered shuttle buses. [11]

## 2. UBAC

The UBAC established in 1958 on a surface area of 320 hectares, was the first university in Iraq to be built in a campus style including all university facilities (academic, social, residential, and services). [12]

Presently, UBAC has the largest university campus in Baghdad. According to the university administration in 2018, the total number of employees on the campus were 3064, while students and faculty members were 22704 (Table 1). [12]

Tab. 1

Total number of students and faculty members in UBAC in 2018

| College | Students and faculty members in UBAC |
|---|---|
| College of Media | 1166 |
| College of Physical Education | 1319 |
| College of Science for Women | 1512 |
| College of Education for Women | 3962 |
| College of Engineering | 3451 |
| Al-Khwarizmi College of Engineering | 655 |
| College of Agricultural | 4462 |
| College of Political Science | 1175 |
| College of Science | 4396 |
| Institute of Laser for Postgraduate Studies | 72 |
| Institute of Urban and Regional Planning | 117 |
| Institute of Genetic Engineering | 114 |
| Institute of Accounting & Financial Studies | 303 |
| Total | 22704 |

Source: UOB Statistics Department

## 3. TRANSPORTATION, PARKING, AND AUTOMOBILE POLICIES

### 3.1. General overview

General overview:

- The movement within the campus is divided with vehicles (cars and buses) and pedestrians having separate routes.
- The campus was designed under the principle of having a maximum walkable distance of not more than 10 minutes within the academic areas.
- Parking distribution capacity of 2365 parking lots across the university area.
- A campus bus system which comprises of 23 buses operating within the university campus.

### 3.2. A campus for cars

As shown in Table 2, the number of vehicles was more than the designed parking lots, which caused a car-overcrowded campus with a deficiency of 1327 parking lots. [13]

Tab. 2

Number of vehicles and available parking

| Employees vehicles | Faculty vehicles | Students vehicles | Total no. of vehicles | Parking lots |
|---|---|---|---|---|
| 840 | 1337 | 1560 | 3737 | 2365 |

Source: UOB Transportation Department

### 3.3. Campus transportation system

Twenty-three buses were used in transporting students, faculty members, and visitors within the campus with eight bus stops as shown in Figure 1. [13]


Fig. 1. Buses and pedestrian movement inside the campus (source: authors)

Table 3 Shows the type of transportation (trip destination) used by students and employees to the university.

Tab. 3

Type of transportation used to access the campus

| | Private car % | Taxi % | University transport % | Public transport % |
|---|---|---|---|---|
| Students | 42.6 | 23.5 | 22.6 | 11.3 |
| Employees | 30.7 | 7.6 | 58.5 | 3.2 |

Use campus transport

Source: UOB Statistics Department

As shown in Table 3, the campus transportation system is used by approximately 7900 students and employees, and 200 visitors daily.

Each bus contains 45 seats and 20 standing positions, which means each bus makes an estimate of 10 trips per day inside the campus (Table 4).

Tab. 4

Distance covered by buses inside the campus

| No. of buses | Trips for each bus | Trip distance (km) | Distance /bus/day (km) | Total distance covered/day (km) |
|---|---|---|---|---|
| 23 | 10 | 3.5 | 35 | 805 |

Source: UOB Transportation Department

The cost of operation (services and fuel) for each bus per year is estimated at $3,100 – Table 5.

Tab. 5

The operation cost of a diesel bus

| Tank capacity (litre) | Diesel price ($/litre) | Diesel cost ($/year) | Service cost ($/year) | Total operational cost ($/year) |
|---|---|---|---|---|
| 200 | 0.33 | 1600 | 1500 | 3100 |

Source: UOB Transportation Department

The buses operate from 7 am to 2 pm (Table 6). We can see that the peak hours of traffic inside the campus were 7 am - 8 am and 1 pm - 2 pm.

Tab. 6

Traffic inside on campus

| Operation hours | Buses | Employees cars | Faculty cars | Students cars | Total no. of vehicles |
|---|---|---|---|---|---|
| 7-8 | 20 | 672 | 802 | 858 | 2352 |
| 8-9 | 20 | 168 | 534 | 624 | 1346 |
| 9-10 | 11 | 42 | 80 | 31 | 164 |
| 10-11 | 6 | 0 | 66 | 31 | 103 |
| 11-12 | 9 | 42 | 133 | 31 | 215 |
| 12-1 | 10 | 126 | 534 | 546 | 1216 |
| 1-2 | 23 | 630 | 534 | 1092 | 2279 |

Source: field survey

## 4. PASSENGER CAR UNIT (PCU)

The Passenger Car Unit (PCU) is used in transportation engineering to assess the traffic-flow rate. A Passenger Car Equivalent (PCE) is essentially the impact a mode of transport has on traffic variables compared to a single car, for example, typical values of PCE for cars is 1 and 3 for buses. [14]

In Table 7, the PCU during peak hours inside the campus is shown.

Tab. 7

PCU in peak hours

| Peak hours | Type of vehicle | No. of vehicles | PCE | PCU / hour | Total PCU/hour |
|---|---|---|---|---|---|
| 7-8 | Bus | 20 | 3 | 60 | 2392 |
| | Car | 2332 | 1 | 2332 | |
| 1-2 | Bus | 23 | 3 | 69 | 2325 |
| | Car | 2256 | 1 | 2256 | |

Source: field survey

## 5. TRANSPORTATION POLLUTIONS ON CAMPUS

Air pollution is one significant environmental health problem affecting people. Individuals cannot control air pollutants, however, these should be addressed by public authorities, at the national, regional, and even international levels. According to the World Health Organization (WHO), more than 2 million premature deaths each year is caused by urban outdoor air pollution, with fuel combustion being a major contributor [15].

Traffic usually contributes 20-30% of $CO_2$ emissions and other harmful emissions like nitrogen oxides and particulate matter. The hydrocarbon concentrations in diesel exhaust are generally low, but diesel exhaust can contain toxic and smelly components. [16]

Table 8 shows different types of emission for diesel buses and gasoline cars. [17]

Tab. 8

Frequent emissions of diesel buses and gasoline car

| Vehicle type | Fuel type | CO (%) | NO (ppm) | $SO_2$ (ppm) | Smoke opacity (%) | HC (ppm) |
|---|---|---|---|---|---|---|
| Bus | Diesel | 0.1 | 82 | 120 | 51 | 21000 |
| Car | Gasoline | 1.8 | 13 | 31 | 6 | 2800 |

For $CO_2$ emission in a passenger gasoline car, the average emission is about 220 g/km [18], while in diesel bus, the average emission is estimated at 1150 g/km [19].

Tab. 9

$CO_2$ emissions in peak hours

| Peak hours | Type of vehicle | No. of vehicles | $CO_2$ (g/km) | Total distance (km) | Total $CO_2$ (g/hour) |
|---|---|---|---|---|---|
| 7-8 | Bus | 20 | 1150 | 280 | 1091560 |
| | Car | 2332 | 220 | 3498 | |
| 1-2 | Bus | 23 | 1150 | 322 | 1114780 |
| | Car | 2256 | 220 | 3384 | |

Source: field survey

From Table 9, each bus makes about four trips in peak hours, each trip is approximately 3.5 km making the total distance travelled by each bus about 14 km. This number is multiplied by 1150 g/$CO_2$/km and by the number of buses to calculate the total $CO_2$ emission caused by buses operation in peak hours. For cars, each car travels for an average distance of

1.5 km inside the campus in peak hours, multiplied by 220 g/$CO_2$/km and by the number of cars travels to calculate the total $CO_2$ emission caused by cars. Thus, the total $CO_2$ emission is 11091560 g/$CO_2$/h in the morning peak and 114780 g/$CO_2$/h in the afternoon peak.

## 6. MOVING TO ELECTRIC BUS

In the past decade, electric vehicles have become a hot topic. Capturing a small but growing share of the passenger-car market, and an enormous amount of media buzz thanks to Tesla, the Electric Vehicle (EV) industry has its sights on the bus market.

Several companies that manufacture battery-electric buses (BEBs) sell their products to cities interested in zero-emission buses that operate without trolley wire (Figure 2). Our vision is to have a zero-emission campus transport system, which is both eco-friendly and cost-efficient. This idea was first applied in the University of California Irvine (UCI) by transforming their transportation system to electric using 20 electric bus fleet.

The zero-emission campus transport system can be achieved by applying two policies:

1. Reducing passenger cars by preventing the use of personal cars by students and have them use campus transport system instead.
2. Transform the current diesel buses into battery-electric buses.

This transition will result in the reduction of 1560 vehicles (student vehicles) from the campus, which will be compensated by 20 additional buses to the campus fleet.

Effect of this transition was discussed in three primary factors:

1. Availability parking lots.
2. PCU impact.
3. Environmental impact.

### 6.1. Parking lots

The campus parks would not overcrowded with cars, a situation helped by the barring of students' cars on campus. Thus, a total of 188 vacant parking lots would be achieved rather than a deficiency of 1327 (Table 10).

Tab. 10

Number of vehicles and available parking

| Employees vehicles | Faculty vehicles | Students vehicles | Total no. of vehicles | Parking lots |
|---|---|---|---|---|
| 840 | 1337 | 0 | 2177 | 2365 |

Source: authors

### 6.2. PCU Impact

Our suggested policies could lead to a reduction in the total PCU inside the campus from 2392 to 1646 during the morning peak hours and from 2325 to 1356 in the afternoon peak hours (Table 11).

Tab. 11

PCU in peak hours after applying the policies

| Peak hours | Type of vehicle | No. of vehicles | PCE | PCU / hour | Total PCU/hour |
|---|---|---|---|---|---|
| 7-8 | Bus | 43 | 3 | 129 | 1646 |
| | Car | 1517 | 1 | 1517 | |
| 1-2 | Bus | 48 | 3 | 144 | 1356 |
| | Car | 1212 | 1 | 1212 | |

Source: authors

### 6.3. Environmental impact

The main concern of this research was to reduce the negative impact of vehicles especially diesel-operated buses on the campus environment to have a sustainable campus site, and this can be achieved using the battery-electric buses with zero-emission of greenhouse gases (GHG) (Table 12).

Tab. 12

Common emissions of diesel buses and battery-electric bus

| Vehicle type | Fuel type | CO (%) | NO (ppm) | $SO_2$ (ppm) | Smoke opacity (%) | HC (ppm) |
|---|---|---|---|---|---|---|
| Bus | Diesel | 0.1 | 82 | 120 | 51 | 21000 |
| Bus | Battery-electric | 0 | 0 | 0 | 0 | 0 |

Source: authors and [17]

Using BEBs with zero emissions and reducing the number of cars, the $CO_2$ would be significantly reduced (Table 12).

Tab. 13

Estimated $CO_2$ emissions in peak hours

| Peak hours | Type of vehicle | No. of vehicles | $CO_2$ (g/km) | Total distance (km) | Total $CO_2$ (g/hour) |
|---|---|---|---|---|---|
| 7-8 | Battery-electric buses | 43 | 0 | 602 | 500500 |
| | Car | 1517 | 220 | 2275 | |
| 1-2 | Battery-electric buses | 48 | 0 | 672 | 399960 |
| | Car | 1212 | 220 | 1818 | |

Source: authors


Fig. 2. Suggested design of battery-electric bus that will be used inside the campus [20]

## 7. CONCLUSIONS

From the analysis of the current transportation in the University of Baghdad Campus, the research concludes that the problems of deficiency in parking lots, high PCU and high $CO_2$ Emissions can be eliminated by applying the two policies suggested (reduction of vehicles and switching to BEB). Expected benefits are:

1. Reducing vehicles inside the campus from 3737 to 2177 (41%).
2. Decrease in the percentage of parking usage by 114%, from a deficiency of 1327 parking lots to 188 of non-occupied lots.
3. Enhancing the PCU by 31% in the morning peak hours, and by 41% in the afternoon peak hours.
4. Total $CO_2$ emissions were reduced by 54% in the morning rush hours and 64% in the evening rush hours.

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