Green BRT in Tehran

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Abstract**—** Population growth and urban development in recent years, has created many problems in the transport field of major cities. Increased traffic, noise and air pollution in large cities is the phenomenon of negative consequences. Creation Appropriate infrastructure to facilitate the use of the public transport system is the best option for confronting with this problem. With the advent BRT system and dedicated public transport corridor for the public transport system, speed and volume displacement increases and thus reducing private car traffic and pollution levels have declined. This paper presents the design of bus and bus stations equipped with solar cells, with ability isolated and connect power supplies between bus and stations to elimination of fossil fuel in the path of Tehran BRT to increase efficiency and reduce environmental lead contamination. In addition, a brief background of Tehran BRT in section 1 and the electrical bus types are presented in section 2, the methodology employed in section 3 and the idea for improvement described in section 4 and conclusion can be found in section5.

Keywords**—** Tehran BRT, Solar Cells, electrical bus, Battery Replacement.

I. Introduction

Tehran, with a population of 12 million, is the most crowded province of the Iran. The Tehran Bus Company started its operations in June 1956. The first bus Extremist came into operation On 4 May 1975. In September 1992 Tehran transportation fleet was equipped by 30 trolley electrical buses and on 13 March 1997, the second phase of electrical buses opened with 35 units. Already eliminated Corridor bus electric power systems have become the BRT corridor.

Fig. 1 Tehran BRT Corridor

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A Tehran public transport network composed of two layers ,Subway and BRT networks .Subway as the first layer including 5 lines and BRT network including 10 high-speed lines as the second layer are defined in the Tehran integrated public transport [1].

In Iran, the BRT system has been implemented in Tehran. Tehran Bus Rapid Transit has been officially inaugurated by Tehran's mayor in order to facilitate the motor traffic in Tehran on January 14, 2008. Tehran has five BRT lines. The first stretch of Tehran BRT corridor from the Azadi square in Tehran-pars has been operational since Jan (2008) [2].

TABLE I
TEHRAN BRT LINES (TRANSPORT AND TRAFFIC ORGANISATION OF IRAN)

Line number	Start point	End point	Distance (KM)	Stations
One	East Terminal	West Terminal	18.7	24
Two	Khavaran Terminal	Azadi Terminal	18.7	27
Three	Resalat	Khavaran Terminal	14.3	17
Four	Afshar Terminal	South Terminal	21.5	20
Seven	Railway station	Tajrish	18.5	27
Ten	West Terminal	Science and research branch Islamic Azad university	10	17

II. Electrical bus

The main technology used in electric vehicle is a battery pack and it produces the energy to drive an electric motor. The electric motor is then joined with a transmission, and the transmission drives the wheels since they are connected with each other. An electrical bus is a bus powered by electricity. Electrical buses are used one or more electric motors for motive force. Bus Motive force supplied from a variety of sources; there are two main electrical bus categories:

1) On-board stored-electrical bus.
2) Non stored-electrical bus.

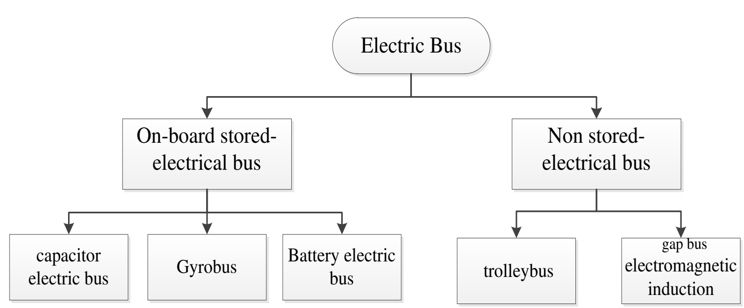

Fig. 2 Electrical bus types

Benefits of electrical buses:

1) Reduces environmental pollution.
2) Low maintenance costs.
3) Generate electricity from the kinetic energy.
4) Produces more torque than the diesel engines.

A. Non stored-electrical bus

1. Trolleybus

A Trolleybus is an electrical bus which draws its power from overhead lines, in a similar way to trams. "Trolley" refers to the trolley poles on the roof of the bus that are used to transmit the electricity from the overhead wires. But unlike a tram, it runs on rubber tires and is steered by the driver. Twin poles mounted on top of the trolleybus run along two parallel overhead wires, drawing current from the first and returning it via the second. The wheels are then powered via electric motors [3].

Fig. 3 Trolleybus

2. Online Electrical bus

The bus gets the power needs from cables under the surface of the road through non-contact magnetic charging .In this technology Electric power strips have been buried 30 cm deep under the road surface and connected to the national grid. Bus collects power through non-contact magnetic induction which is used either to power the vehicle prime-mover or for battery charging.

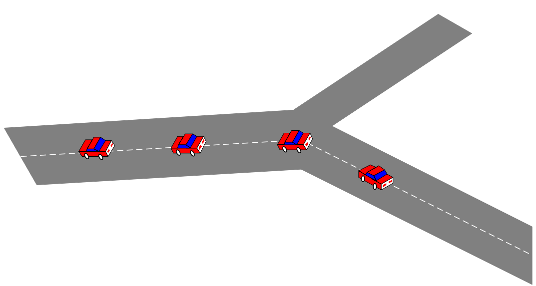

Fig. 4 Electromagnetic induction

B. On-board stored-electrical bus

1. Gyrobus

A Gyrobus is an electrical bus that uses flywheel energy storage, not overhead wires like a Trolleybus [4].

Fig. 5 Gyrobus

2. Battery Electrical bus

Battery electrical buses are an alternative to fossil fuel powered buses, because they produce no local emissions and almost no noise, air quality benefits from application of electrical buses. On Battery Electrical bus, the chemical energy stored in large batteries as the power supply can be installed in buses. This kind of electrical bus used one or more rechargeable battery to supply power to move.

Fig. 6 Battery Electrical bus

3. Super capacitor Electrical bus

Super capacitor is electricity storage devices with quite different from batteries. Super capacitor is charged much faster than batteries and do not suffer rapid wear due to charging and discharging. Usually Supercapacitor used in the recovery of braking energy in numerous vehicles such as bus. Super capacitor electrical bus using the power stored in large on-board super capacitors, which are quickly recharged whenever the electrical bus stops at stations [5].

III. Project under Study

The model presented in this paper based on the first line BRT in Tehran that can also be extended to other lines BRT. The length of this route is 18,700 meters and connects west to East of Tehran. The first line BRT in Tehran has 2 terminals and 26 stations [6]. Approximate travel time is one hour in the corridor. In this model Gasoline and CNG buses will be replaced by rechargeable electrical buses and all stations, terminals and bus will be equipped with solar cells to supply the energy needed for transportation system. Solar cells installed on the buses are used to supply the energy of display panels, cabin lighting, heating and cooling systems. Stations and terminals will be supplying power of the electrical bus system by equipped with solar cell panels. The duty of Terminals at both ends of the path is charging and preparation the electrical bus for the next service.

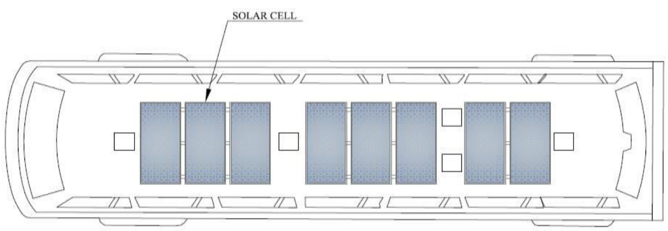

Fig. 7 Electrical bus

There is 11.6 miles distance between eastern and western terminals. Because of this long distance, rapid buses can't finish the route of rapid bus system with one time charging in the terminals. Rapid electrical buses, which are charged one time at the terminals, aren't able to traverse the 11.6 miles distance of the line 1 corridor of rapid buses. All of bus stations are used in order to meet the total energy of the system. Supplied with solar cells, each station can be considered as a small power plant. These green energy producer power plants are used for exchanging and charging the discharged batteries/ super capacitor of buses.

Due to differences in station parameters such as length and location the energy produced with each station not same. Size and place of the stations are affected by several parameters. Therefore, producing clean energy, stations should not only have the characteristics have mentioned in diagram 1 but also the following ones:

1) Station access to sunlight.
2) The geometry and size and dimensions of existing structures around the station to allow sunlight to reach the station.
3) In the construction domain of the stations, there should be dispersal in humidity and downfall rates.

Different factors in designing a system should be considered. Some affect the calculation of capacity and outlet of system or the produced electricity estimation. Others are required to select and design different types of facilities [7]. These factors are as follows:

A. Geographic position

Latitude and longitude and also the height of the setup position of photovoltaic system are factors which are requisite for calculation of radiation power of sunlight.

B. Time position

Construction place and its conditions relating to sun movement and the presence of adjacent heights and structures and even the buildings' shadows should be considered. These obstacles may prevent the panels from direct sun radiation in some hours of the day.

Length of connecting cables is determined by the distance of system to the consumer and cabling route. Electrical resistance and energy losses of the cables are effective in the capacity calculation of a photovoltaic system.

C. Climatic conditions

Number of consecutive cloudy days is an important factor that should be considered in the analysis of climate conditions. For reservation of solar power in cloudy days, this factor should be used in calculations and due to the required power in those days the capacity of photovoltaic system should be computed. Furthermore, wind blow and its velocity for determining the strength of metal and concrete structures, air clearance, sultry and dust rate and their effects on the intensity of sun radiation and thunderbolts are some other factors which should be considered for prospecting appropriate safety equipment. It should be possible to directly obtain passenger welfare requirements through designing the stations by common criteria [8].

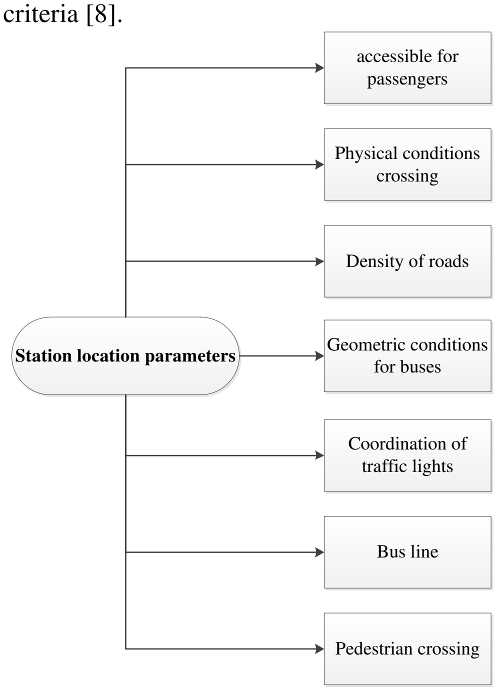

Fig. 8 Parameters of station location

The required energy for heating, cooling, power generation, ventilation and lighting should be obtained by active systems which can be prepared economically by available energies.

For the stations without the mentioned parameters, it is possible to prepare and transmit the required clean power from spaces beyond the stations. While the buses arrive to the corridor of rapid bus system for servicing, the data related to the remaining amount of charge and possible traveling distance are transferred to control center as it travels through the route. Simultaneously, changes to the number of charge battery/super capacitor and the number of batteries which are in charge and the required time for finishing the charging process will be transferred to control center. Having all the information about buses and stations, the control center has the ability to decide appropriately for service mechanism.

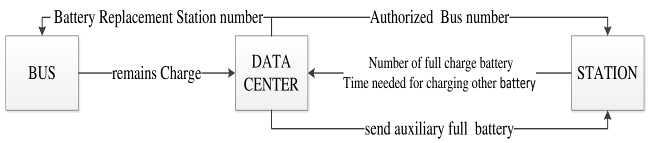

Fig. 9 Mechanism of system

TABLE II
TRANSFERRING DATA FROM STATION

Station name	Battery capacity	Ready charged battery	Generated power	Distance to terminal	Service condition

1) Service condition

Referring to data, sent to the control center, stations which can't generate power or where there are no batteries ready for service will be inactive till the problems are solved.

2) Distance from center

Considering this data, control center calculates distance between two stations and referring to other received data from buses, it reserves battery for each bus in the specified station.

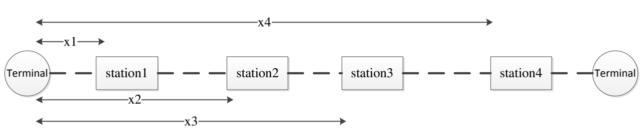

Fig. 10 Calculates distance between two stations

3) Generated power

Regarding the usable area, paneling and the factors, discussed in this section, each station has a specific generative power per hour.

4) Battery capacity

This factor is specified regarding to the number of installed panels and generated power by the station.

IV. Battery replacement mechanism

Limitation of traversal distance of electrical buses due to recharging requirement is a big problem in using them in public transportation. Electrical buses usually are used in short routes and since there is a waste of time to provide energy, they aren't used for long routes. However, the infrastructure capability in rapid bus system corridor makes it possible to use the electrical rapid buses. Here, typical charging procedure is replaced by a new procedure regardless of presence of buses. This procedure prevents the long delay which is caused by the old procedure. In the presented model, 12 meter single cab buses with two replaceable magazines including 20 batteries/super capacitors which provide required energy for movement of rapid electrical buses are used. Considering the fact that all the buses are fully charged before entering the specified corridor of rapid buses, the system can automatically replace the discharged batteries with charged one during arrival and departure of passengers. This procedure is carried out in a station with a prescribe pattern and priority of charging. This procedure will be continued through the route till the bus arrives to the destination terminal .

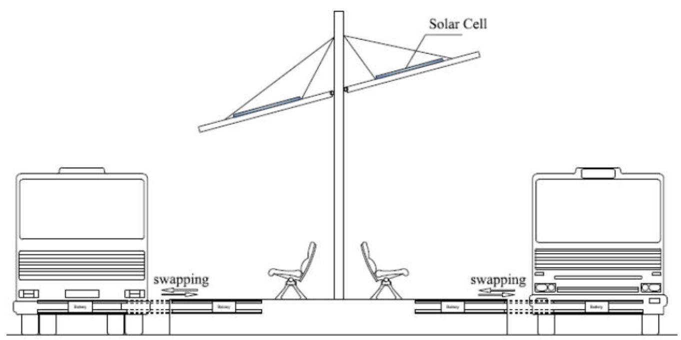

Fig. 11 Battery replacement mechanism

In normal conditions with equipping the stations with required super capacitors and applying an appropriate timing schedule, the system can properly respond the buses requirements. However, adjusting and providing an appropriate service in rush hours is the main problem with this procedure. In these conditions the traversing time of buses decreases and consequently the number of buses increases. Therefore buses have less time to charge the batteries in the stations. Increasing the number of capacitors in each station cannot be considered as a solution due to the following issues:

1) Considerable increase of cost
2) Limitation in generation of required power in each station

Using some special vehicle to transfer a lot of charged batteries to the origin and destination terminals and replacing the batteries which are discharged during the route, is the best and most inexpensive choice for resolving this problem.

V. Conclusion

Replacing the diesel buses with electrical ones not only save gallons of fossil fuel each day, but also considerably decrease air and sound pollutions. For the accomplishment of this pattern all the junctions between the rapid bus corridors and other streets should be eliminated. Buses entering and exiting time should be calculated using the prescribed timing schedule. By increasing the usage of personal electrical vehicles, these stations can provide part of required energy for these vehicles.

REFERENCES

[1] M.Montazeri, S. Hashemi, “Bus Rapid Transit in Tehran,” International Association of Public Transport (UITP), VOLUME 58, 2009, pp. 30-32.
[2] P.Parvizi, S.Mohammadi, “Intelligent BRT in Tehran,” The Journal of Automation, Mobile Robotics & Intelligent Systems, VOLUME 6, No1-2011, pp. 35–38.
[3] L. Brunton, “The trolleybus story,” IEE Review, vol. 38, issue 2, pp. 57 - 61, February 1992.
[4] L.Buzzoni, G.Pede, “New prospects for public transport electrification,” *Power Electronics,*” Conference of *Electrical Systems for Aircraft, Railway and Ship Propulsion (ESARS)*, pp. 1 - 5, Oct. 2012.
[5] J. U. Duncombe, “Infrared navigation—Part I: An assessment of feasibility (Periodical style),” Power Electronics, IEEE Transactions, Vol.26, Issue: 3, pp. 923 - 930, 29 November 2010.
[6] S.Hajeb, P.Parvizi, F.Norouzi Fard, “Safe Lines to Transit in Tehran’s BRT,” International Journal of Science and Engineering Investigations, vol. 1, issue 1, pp. 113-118, February 2012.
[7] “Bus Rapid Transit Stations and Stops,” *American Public Transportation Association,* October, 2010
[8] “Public Transport Infrastructure Manual,” *TransLink Transit Authority,* May 2012