Possible to expand of electric vehicle transportation in Mongolia

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Abstract: There are over 230 thousands of vehicles roaming in the Ulaanbaatar capital, of these over 950 macro-buses, around 300 mini-buses and, 50 trolleybuses are on service now. Around 70% of public transportations working limit is expired so they discharge sufficient amount of exhaust gas in the Ulaanbaatar air. For this reason, we aim to use the electric public transportation extensively that can reduce the air pollution as well as serve at a reasonable price for the passengers.

Keywords: Electric vehicle, air pollution, trolleybus, public transportation, exhaust gas

1. INTRODUCTION

Ulaanbaatar has 1240 thousand people which is 45% of total population and immigration from countryside to Ulaanbaatar has been increasing extensively about 3.8% rise estimated. City population centralization causes a big burden to the public transportation year by year. Trolleybus is one of the economically beneficial transportations that helps to reduce air pollution and improve the service quality. Over 1563 transportation with 131 routes were utilized by passengers of Ulaanbaatar.

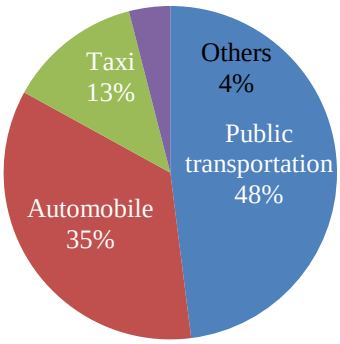

Figure 1. Ratio passenger utilization urban transportation

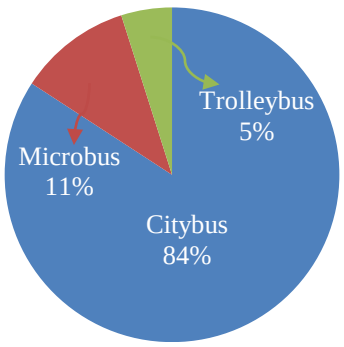

Figure 2. Comparison of public transportation in UB

The first figure shown that about half of population of UB (Ulaanbaatar city) utilized public transportation. The second figure shows that comparison of public transportation in UB then small amount of passengers to serve by trolleybus. Around 80% of the public transportation service is run by state owned public company and takes a constant loss because of the fuel price surge whereas an electric public transportation company gains 3 times more profit.

1.1. Development of electric vehicle transportation (trolleybus) in Mongolia.

In 1987, thanks to the Soviet Republic help 13 sub-station with 250 km long electric distribution overhead line was constructed and 150 trolleybuses started their initial transportation service in Ulaanbaatar city. Urban transportation department received a lot of income loss and worsened the service quality during the transformation period from socialist regime to the democratic society. Currently, number of the trolleybus passengers have reduced up to 8% since the period of Ulaanbaatar residents' number of public transportation usage 20 years ago. The following factors influenced to have a bad service.

- ✓ Cross section decreased of cupper conductor contact overhead line;
- ✓ Depreciation of substation of electric and didn't renovated facility of electric distribution;
- ✓ Outdated trolleybus service and lack of capital re-equipment;
- ✓ Comparing to city bus it has slow speed level because of the low maneuvering junction in road and in making a turn;
- ✓ Uncomfortable environment of passenger so on;

One of the best improvements were made in Mongolia that was constructed a trolleybus manufactory in 2005. Recently in operation total 73 trolleybuses of these, 46 Mongolian made and 27 Russian made trolleybuses are serving on 5 different routes.

Figure 3. JEA-800 type trolleybus

Figure 4. JEA-800F type hybrid trolleybus

Since 2005 year the construction of the first trolleybus, the Mongolian electric transportation company made 3 types of 56 trolleybuses were made with the size of 90 passengers and with the types of JAE-800, JAE-800M, JAE-800T. The Electric transportation company has constructed 8 Duo-buses that were equipped with diesel-electric engine under the type of JAE-800F since 2009. It has a capability of going 10-14 km with internal combustion engine in case of congested road or none constructed road section.

All this undertakings and decisions ecology trolleybus systems. Obviously there is no easy answer what is better–city bus or trolleybus.

- ✓ Zero-emission or low-emission electrical energy is available;
- ✓ The electrical energy is cheap, compared with petrol;
- ✓ This should be considered in long term, so energy price forecasts should be taken into account;
- ✓ Especially noise;
- ✓ The number of passengers are 20% bigger than bus;
- ✓ The lifetime of a Trolleybus is approximately 50 % longer compared to other buses
- ✓ Their strong but smooth acceleration and grade-climbing ability are highly appreciated by passengers.

Due to the importance to increase the number of trolleybus we need to develop the electric transportation industry and study it scientifically. Mongolian made trolleybuses are 25% cheaper than Russian imported vehicles.

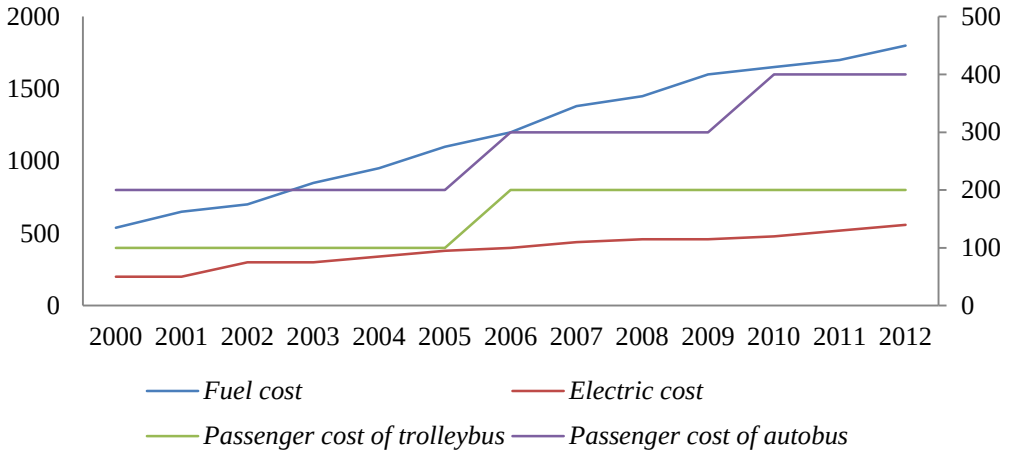

Figure 5. Comparisons of price improvement

The average of multi-year figure indicates that trolleybus serves to passengers constantly in a cheap price using reasonable electricity. Trolleybus has more loading space, electricity cost is 4 times cheaper than fuel cost per 100 km and operational cost is 4 times cheap as well.

1.2. Air pollution and urban transportation current situation in UB

At present, air pollution has become the main problem in many developed and developing countries. Especially, in Ulaanbaatar city of Mongolia, it has become one of the most tackled issues of every citizen living in the capital city. Population growth caused mainly by rural to urban migration has led to major increases in the capital city's air pollution emissions. Much of the population growth has been in the city's low-income Mongolian traditional dwelling districts where coal and wood are burned for heat (60% - air pollution). [1]
Public and private transports also contribute to air pollution of the out capital city UB. From 2005 to 2013, the number of vehicles in Ulaanbaatar increased from 75,000 to 375,100 (25% - air pollution) vehicles registered only in Ulaanbaatar city. Daily, over 180,000 vehicles travels along city roads. It is expected to reach 970,000 vehicles by 2020 in case if municipality doesn't take any of intervention in the sector. [1]
Nowadays 42.6% living in UB city all of Mongolian population, population of UB is rapid increased last 20 years. Also 63 % of vehicles in the country were registered & run in UB city.

Table 1. Current transportation's situation in UB

	General data		Value
1	Total number of own vehicles		375000
2	Public transportation	Bus	1048
3		Trolleybus	66
4		Taxi	885
5		Total	649
6	Road length /paved/		2648
7	Public transportation routes length		427 km
8	Average route length		4414 km
9	Number of bus station		596
10	Public transportation fare	Bus	1 passenger – 500T = 0.28USD

11		Trolleybus	1 passenger – 500T = 0.28USD
12		Taxi	1 passenger – 500T = 0.28USD
13	Passenger per year		1km – 700T = 0.4USD
14	Passenger in a day		262 million passenger /2013/

2. ECOLOGICAL ESTIMATION

The main advantage of electric vehicle is more eco-friendly transportation. The second table shows Rate of not generated exhaust gas in utilization of 1 trolleybus per annual.

Table 2. Rate of not generated exhaust gas in utilization of 1 trolleybus per annual

№	Chemical contents		Ignition of diesel fuel one litter	Ignition of 1600 liter diesel fuel (*per annum*)
			g/liter	*kg*
Exhaust gas				
1	Carbon dioxide	CO_2	20.30	324.80
2	Nitrogen oxide	NO_X	24.75	396.00
3	Carbon monoxide	CO	5.77	92.32
4	Sulphur dioxide	SO_2	165.60	2649.60
Particulate matter				
5	Soot	-	3.30	52.80
6	Benzo-Pyrenees	-	0.26	4.16
7	Aldehyde	-	0.74	11.84
Total Amount			220.72	3531.52

Economic combustion oxygen and clean air estimation. According to the combustion theory, 10000 liter or 14.7 kg oxygen is required in order to exhaust combustion of 1 kilo for an automatic engine cylinder and it was calculated the electric vehicles economized oxygen and non-polluted air measurement that showed the required gas and O_2 rate in ignition of 1liter diesel is on the 3th table. [2]

Table 3. Required gas and O_2 rate in ignition of 1liter diesel

№	Fuel type	Density, g/m^3	Required gas in ignition of 1liter diesel		
			Oxygen	Air	
			weight, *kg*	weight, *kg*	volume, m^3
1	Gasoline	700	2,163	10,3	8,24
2	Diesel	850	2,624	12,5	10,0

In order to burn 1 liter diesel in the automobile engine, it requires 2.624 kg O_2 or 10 cube meter air.

Table 4. Economized fresh air and O_2 rate in not ignited diesel fuel in 1 year

Electric vehicle type	Required gas in ignition of 1liter petrol			Economized diesel rate per annual	Economized gas rate at 13.9 ton diesel		
	Oxygen	Air			Oxygen	Air	
	kg	*kg*	m^3	weight, *kg*	*kg*	*kg*	m^3
Hybrid trolleybus	2.624	12.5	10,0	13900	36.47	173.75	139.0
Trolleybus	2.624	12.5	10,0	16000	41.98	200.0	160.0

Table 5. Greenhouse gas measure that trolleybus operating emission in cooperation of the electric power

Electric vehicle type	Energy source	Average running in one year	Average consumption electric energy	CO_2 emission rate in burned of 1 kg coal	Burned coal rate in generated 1kW electric energy	CO_2 emission rate in generated 1kW electric energy	CO_2 emission rate in running 100km	CO_2 emission rate in per year
		km/year	*kW/year*	*kg*	*kg*	*kg*	*kg*	*ton/year*
JEA-800 trolleybus	Electric-100%	50000	54960	1.370	0.75	1.0	117.2	54.9
JEA-800F hybrid trolleybus	Electric-85%, Diesel Engine–15%	42500	46720	1.370	0.75	1.0	117.2	46.7

Mongolian capital Ulaanbaatar has more centralized with many residents and it causes a lot of traffic congestion and air pollution. The road congestion decreases the automobile speed and its discharge of hazardous smoke has been increasing. Every vehicle's speed limit is 20 km per hour on the congested road and long hour ignited vehicles produce more exhaust.

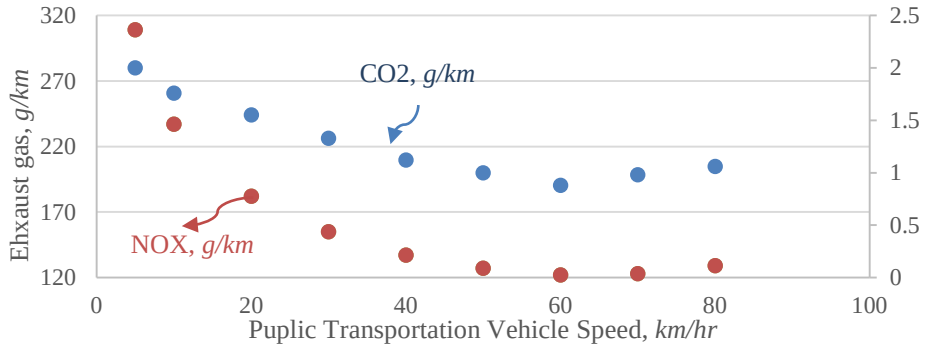

Figure 6. Exhaust gas rate related travel speed of bus internal combustion bus

Average speed decreased in main roads in 1998 it was 30-40 km/h, in 2014 it was 16-20 km/h, during peak hour's center of city nearly 5-8 km/h in capital city of Mongolia.

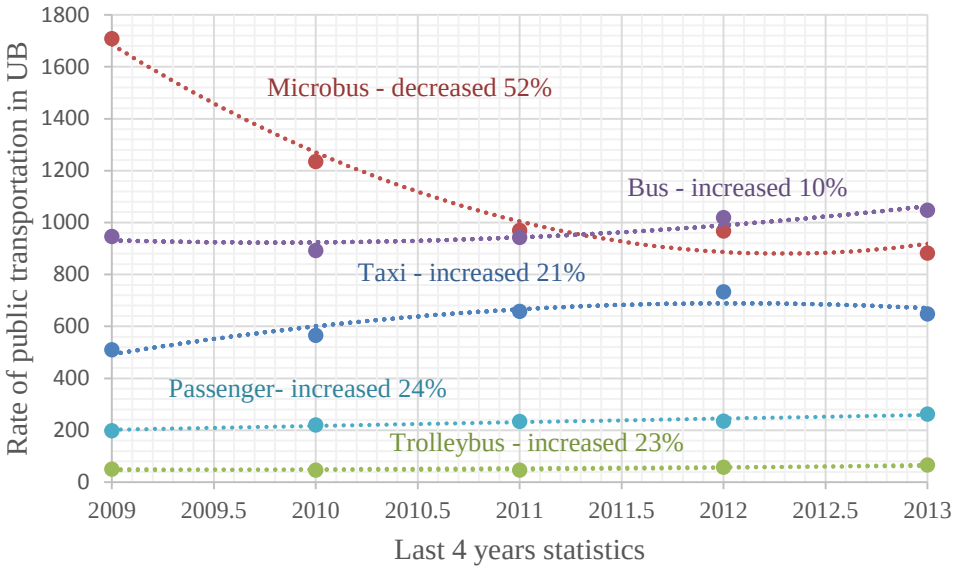

Figure 7. Comparison rate of public transportation

Figure 7 shown comparison statistics public transportation for last 4 years (2009-2013) in UB. Number of microbus decreased 52% and number trolleybus increased 23% for urban

transportation. These two index shown emission of exhaust gas decreased in UB area. However in figure 8 shown number of private vehicle increased rapid. It mean's increasing air pollution urban area. [3]

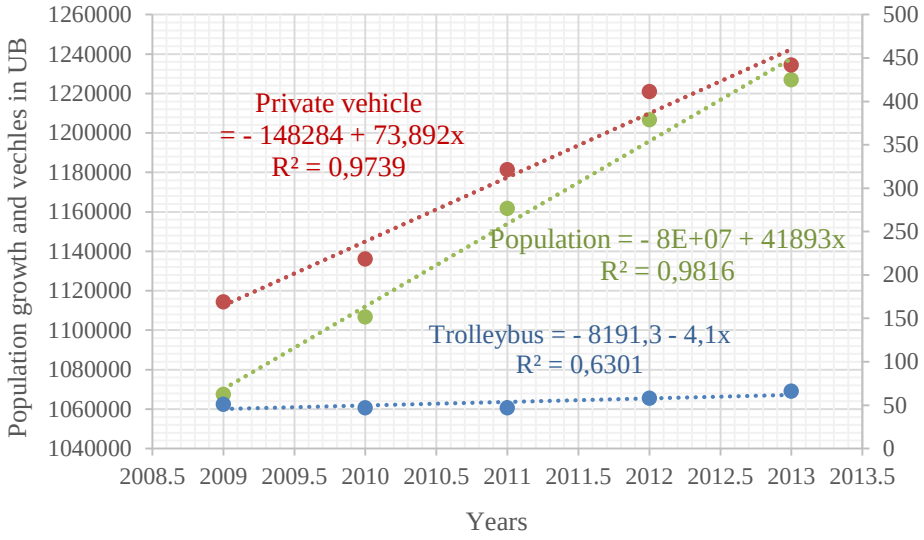

Figure 8. Comparison population growth, private vehicle and trolleybus in UB

The air pollution sources in UB include coal burning in traditional house (ger), industrial boilers and dust emissions of construction, power plants, improved stoves, household heating systems, brick kiln operations, public and private vehicle (Figure 8), road re-suspension, fly ash re-suspension, and garbage burning. Also, the most typical urban pollutants include suspended particulate matter (SPM), sulfur dioxide (SO_2), volatile organic compounds (VOCs), lead (Pb), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NOx) and ozone (O_3). Of these pollutants, the particulate matter (PM) is one of the most critical pollutants responsible for the largest health and economic damages. Because of the importance of the PM pollution for human health, visibility and the environment, many studies are focused primarily on PM pollution as a target pollutant. [7]

3. CONCLUSION

Based on all the above, a conclusion can be reached that an environmentally clean urban public transport system represents one of the main demands for aiding sustainable development of UB in Mongolia. In UB using 66 trolleybuses can be save 133.3 kilo ton oxygen gas, 1056 ton diesel fuel per year in UB. Also 508.2 million meter square area is protected from air pollution. Several facts and arguments are considered in favor of the trolleybus subsystem in this paper. The trolleybus of public transport has the following features:

- ✓ To constitute possibility for raise productivity of trolleybus and extend electric subsystems, route (especially hybrid trolleybus);
- ✓ It is environmentally friendly and acceptable (with no noxious exhaust emissions and the lowest noise levels compared to other modes);
- ✓ It is cost-effective and economically viable, using renewable energy

Finally, the most important advantages of the trolleybus subsystem should be emphasized, that is, the reasons why this subsystem is ranked among the systems which contribute to sustainable development and quality of life especially in UB should be underlined.

An intensive development and operation of the trolleybus subsystem will result in decreasing vehicle prices and operational costs, thereby increasing the quality of component and aggregate production.

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