Abstract: As the biggest industrial center in Vietnam, Hochiminh city (HCMC) is facing various problems from rapid urban development such as traffic congestion, air pollution and high rate of traffic accidents. These problems and solutions to them have been mentioned in many studies which aim is to improve urban traffic management. This paper forwards to propose policy strategies that help to eliminate air pollution of motor vehicles in HCMC. Encouraging public buses in using of CNG to replace the petrol is proposed as one of the most important solutions for environment protection to 2020. At the same time, the paper recommends the using of electric power pilot trolleybus line in HCMC.

Keywords: sustainable transportation, transport energy, trolleybus planning, public transportation

1. INTRODUCTION

HCMC is considered as a big city with high population, economic development in VN nowadays, with a total area of 2,095 square kilometers, including 19 districts and 5 suburban districts; the population is 7.4 millions in year 2010. The Annual average GDP growth rate is increasing year by year as shows in the table 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP Growth Rate</th>
<th>Population Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>11.7</td>
<td>3.4</td>
</tr>
<tr>
<td>2005</td>
<td>12.2</td>
<td>3.7</td>
</tr>
<tr>
<td>2006</td>
<td>12.2</td>
<td>4.0</td>
</tr>
<tr>
<td>2007</td>
<td>12.6</td>
<td>3.7</td>
</tr>
<tr>
<td>2008</td>
<td>10.7</td>
<td>3.3</td>
</tr>
<tr>
<td>2009</td>
<td>8.6</td>
<td>3.2</td>
</tr>
<tr>
<td>2010</td>
<td>11.8</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Source: Statistical Office in HCMC, 2010

HCMC has become a mega-city with multi-functional centers in term of socio-economic development and play a very important role in the development of the entire southern region and to aim at the goal of industrialization and modernization, also the target to build a civilized modern city.

Today, Ho Chi Minh City is facing some problems of the concerning urban development process such as, congestion in the peak hours, smoke and air pollutants, traffic accidents, etc. These happen due to the urban development process and the boom of individual motorized vehicles, especially motorcycles. A number of researches have shown that the CO, NOx concentration in HCMC and Hanoi exceeded the standard limit (by more than 6-10 times).
According to HEPA (Ho Chi Minh City Environment Protection Agency), the emission of motor vehicles is estimated at 116,000 tons of CO; 4,200 tons SO\(_2\); 4,500 tons NO\(_2\); 1,100 tons of dusts, 25 ton of lead; 1.2 megatons CO\(_2\); and 13,200 ton hydrocarbons annually in HCMC.

Air pollution problems along with solutions are mentioned in some studies which aim is to improve urban traffic management; in these, the solutions of using cleaner fuels - natural gas and electricity energy are proposed. Beside these studies, in 2010, HCMC Department of Science and Technology assigned the Center of Environment and Transportation development to conduct a research on "The ability to apply the trolleybus system in HCMC".

The main contents and methodology of the study include some issues, such as: to analyze the emission amount from the motor vehicle and other vehicles in HCMC, to consider and to review the experience from other using clean fuel countries for elimination of air pollution, to evaluate the ability of applying the trolleybus system in some urban roads; to carry out the traffic count, the traffic survey on the road, the state preference survey; to forecast the future demand of traffic etc. Beside that, some policy strategies are being proposed for implementation of trolley bus system in HCMC.

2. AIR POLLUTION CAUSES

2.1 Boom of Private Vehicles
Automobiles and motorcycles are increasing rapidly (10-14% per year). In 2005, there was 275,000 automobiles (cars and trucks), 2.6 million motorcycles. In 2010, there are 442,500 automobiles (cars and trucks), 4.445 million motorcycles. Everyday, nearly 700 thousand motorcycles and 60 thousand automobiles from other provinces join in HCMC. Big number of vehicles contribute negative impacts to environment as well as the people life quality. Following a traffic forecast, the traffic congestion will get worse cause the number of cars will increase faster than motorcycles’ in HCMC in the future. Figure 1 shows the relationship between vehicle ownership and GDP per capital.
The growth curve in figure of car ownership (dark color) & motorcycle (red color) were estimated taking account of the traffic congestion base on experiences of some countries.

2.2 Low Public Transport development

In 2010, there are 148 bus routes, including 112 subsidized bus routes, 36 private bus routes. The total length of bus routes is 3,501 km; the average length of every bus route is 23.7 km.

Because of some buses network’s shortcomings, such as not widespread distribution, unreliability, not much comfort and integration, public passenger transportation plays the little roles in the urban life. In 2010, bus system meets about 6%-7% travel demand in HCMC.

At present, there are 3000 operating diesel engine buses in HCMC. Engines from these buses are not regularly maintained and the emission quality produced is lower than EURO II standards. This makes pollution increase more severely, especially NOx and smoke. These substances affect directly to people’s health. In particular, at traffic lights, where buses stop and depart the amount of smoke NOx get higher.

3. Methodology

3.1 Estimate the car & motorcycle ownership

The total car ownership rate is estimated by the formula below:

\[
HHR = 1 - \frac{1}{\exp(-7.04 + 4.33 \times 10^{-7} \times HHI) + 1}
\]

Where:
- \( HHR \): Rate of households owning cars
- \( HHI \): Household income (VND/month)

Similar to motorcycle ownership rate

3.2 Estimate the travel demand

For forecast of future travel demand, including public transport share, some development scenario were studied.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Estimative travel demand of HCMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>2002</td>
</tr>
<tr>
<td>Population (million)</td>
<td>5,409</td>
</tr>
<tr>
<td>Trips per day (million)</td>
<td>14,0</td>
</tr>
<tr>
<td>Public transport, Medium development scenario (%)</td>
<td>2,2%</td>
</tr>
<tr>
<td>Individual transport: car &amp; motorcycle (%)</td>
<td>97,8%</td>
</tr>
<tr>
<td>Public transport trips per day (million)</td>
<td>0,308</td>
</tr>
</tbody>
</table>

In table 2, the data shows that, the trips per day in 2020 will increase approximately 7 times in comparison with 2010, based on medium development scenario. It means that, when there’s
no change in using clean energy instead of fuel, the pollution emission of buses therefore will increase approximately 7 times.

In some main roads, based on results of traffic surveys, the traffic demand was forecasted by elasticity method.

3.3 Estimating the emissions of motor vehicle

The increasing number of motor vehicles will increase the consumption of fuel. In HCMC, most motor vehicles use fossil fuels such as gasoline/diesel while it is known that fossil fuels are among the highest emission sources.

The estimated emission of motor vehicle is represented as follows:

\[ E = \text{Number of vehicles} \times \text{EF} \times \text{AD} \]  

(2)

Where:

- \( E \): Emission, estimated in kg/hr;
- \( \text{EF} \): Emission factor in kg/km, considering several parameters: vehicle speed, vehicle weight, fuel type for each pollutant (NO\(_x\), CO, PM, SO\(_2\)). The vehicles are classified into four categories (motorcycle, car, bus and truck);
- \( \text{AD} \): Activity data, represented by the travel kilometer of vehicle.

For each type of motor vehicle, estimation of emission amount is calculated with NO\(_x\), CO, PM, and SO\(_2\).

3.4 Data collection

- The research is based on traffic surveys and other surveys. The counting number of motor vehicle in some high traffic road is classified by type of vehicle in peak and peak-off periods
- Scenario of public transport development in research are referred to available studies of Transport Department
- The model of pilot trolleybus line is from some trolleybus system of cities in the world

3. PROPOSAL SOLUTIONS TO MINIMISE AIR POLLUTION IN HCMC

3.1 Using cleaner fuels: Compressed Natural Gas (CNG) and Liquefied Petroleum Gas (LPG)

To mitigate air pollution from vehicles, some countries such as Thailand and Korea have used LPG/CNG for buses and cars. As the results, the pollutants e.g., CO\(_x\), SO\(_x\) and NO\(_x\) are reduced significantly.

For the way to apply this experience, it is suggested that, the supportive policies is needed for investors in the field of fund, tax, technology. Government should keep stably gas consumption price with the level about 50% diesel price.

The Government should support a part of cost of CNG bus, for example, to provide the low interest rate loan to help investors to buy new bus. It is proposed that from now, the big buses projects in urban area should focus only on CNG bus.
From May 2010, a pilot CNG bus line has operated in HCMC, it is bus line No.10. According to examination, CNG buses can save about 40% fuel cost in comparison with diesel bus, and CNG bus can reduce environmental pollution. In table 3, the detail measured data shows the emission of CNG bus and diesel bus from U.S. Based on experiment result, Department of Transport plan to buy some thousands CNG buses in next year. The first CNG stations have been built with capacity of charging 50 vehicles per day.

<table>
<thead>
<tr>
<th></th>
<th>CO</th>
<th>NOx</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>2.4 g/km</td>
<td>21 g/km</td>
<td>0.38 g/km</td>
</tr>
<tr>
<td>CNG</td>
<td>0.4 g/km</td>
<td>9 g/km</td>
<td>0.01 g/km</td>
</tr>
<tr>
<td>% reduction</td>
<td>84</td>
<td>58</td>
<td>97</td>
</tr>
</tbody>
</table>

Source: SAE 2000-01-2822, Medium duty buses in U.S.

### 3.2 Development of electric public vehicles - trolleybuses

In HCMC, two metro lines are being prepared for construction: 19 km line of Ben Thanh – Suoi Tien and 10 km line of Ben Thanh – Tham Luong. The integrated component of metro system will be feeder bus routes of shorter distance to connect metro stations to bus network.

Besides the development of the metro system, it should be the priority development of main bus routes, feeder bus routes. Therefore, the research on application of electric bus – trolleybus is necessary to reduce environmental pollution.

Based on experience from some worldwide cities, in comparison with diesel bus, trolleybus is more efficient on energy, more powerful at commercial speed; it can operate in common urban street/road. Trolleybus does not issue pollutant gases, particulates, water steam. In other side, it is almost noiseless and can meet good service quality: comforts, reliability, fastness, silence, attractiveness for public transport. In table 4, it shows the lower emissions of trolleybus in comparison with diesel bus. But the price of trolleybus is higher than diesel bus.

<table>
<thead>
<tr>
<th></th>
<th>Diesel bus g/vehicle-km</th>
<th>Trolleybus g/vehicle-km</th>
<th>Emissions of trolleybus in comparison with diesel bus (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nox</td>
<td>10.4</td>
<td>0.1</td>
<td>1%</td>
</tr>
<tr>
<td>CO</td>
<td>1.5</td>
<td>0.01</td>
<td>0.7%</td>
</tr>
<tr>
<td>HC</td>
<td>0.85</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>SO2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Particulates (PM)</td>
<td>0.17</td>
<td>0.001</td>
<td>0.6%</td>
</tr>
<tr>
<td>CO2</td>
<td>1600</td>
<td>140</td>
<td>9%</td>
</tr>
</tbody>
</table>

Source: The Electric T Bus group

Based on the research result, for development of trolleybus system in HCMC City, some routes are proposed for trolleybus pilot project, such as the route on Nguyen Van Linh road.

In figure 2 and figure 3, the view Nguyen Van Linh road and cross-section with trolleybus arrangement are showed.
This research result will be the basis to reference for the Department of Transportation to plan the development of bus system in HCMC, including the trolleybus system.

4. CONCLUSION

In the next years, in line with the quick development of the biggest city of Viet Nam, the reorganizing public passenger transport, giving priority to bus development will contribute a key significant role in daily transport of Hochiminh city.

The modernization of bus system and protection of environment can be developed by using cleaner energy (LPG, CNG) and electricity for some main bus routes and feeder bus routes. For project implementation, the PPP (Public Private Partnership) and PSP (Private Sector Participant) are proposed.
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