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PROPOSAL FOR VITALIZATION OF PUBLIC TRANSPORTATION TO IMPROVE AIR POLLUTION IN VIETNAM

- FOCUS ON HANOI

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Abstract

The research that collaborated with FTU (Foreign Trade University) students in Vietnam, was focused on the air pollution problem in Hanoi. This city has one of the worst air quality in the world and by industrialization, it is getting worse. The main causes are old vehicles, conventional stoves and industrial facilities. In Particular, we tried to convert from the private motorbikes which account for a large portion of air pollutant emissions to public transportation. Both poor road conditions due to old and dense urban structures, and inaccessible public transportation system were found to discourage public transportation use and increase private vehicle use. By improving the overall situation, it is necessary to enhance the competitiveness of public transportation and contribute to both its revitalization and solving the problem. We and FTU students brought up the five solutions by comparing the Vietnamese and Korean public transportation system. Replace buses with electric buses to reduce air pollution emissions. Create comfortable bus stops with arrival notification services and CCTV. Adjust flexible bus dispatch interval to meet demand concentrated at certain times. Install STOP signs to ensure the safety of passengers boarding and alighting from buses in complicated traffic situations. Change tickets to reusable electric bus cards for management cost saving and effectively system reform using data. We supposed that these proposals will help to reduce costs, to increase efficiency, and to improve usability. To recognize the severity of the problem and to estimate the possibility of the proposed solution, we conducted field research and interviews in Hanoi. While there was general agreement that it would improve use, the answers included some doubt that it would have a direct impact on improving air quality. Further research is needed to demonstrate the impact of increased ridership on air pollutant emissions. This thesis needs to keep developing and discussing air pollution, a global problem with the

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detailed 11.2 and 11.6 of the 11th of the United Nations Sustainable Development Goals (UN SDGs).

Keywords: Hanoi, Air Pollution, Public Transport, Road Traffic Law, UN SDGs

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I. Introduction

1. Background and Purpose

As concern over air pollution increases worldwide, the World Health Organization (WHO) has raised the annual average recommendation standard for ultrafine dust (PM2.5) from 10㎍/㎥ to 5㎍/㎥. Reflecting this, Vietnam's air quality index (AQI)[3] on January 5, 2023 was 184, exceeding the average concentration standard by 24 times.[4] Such serious air pollution in Vietnam has a direct impact on human health and inconveniences daily life. According to a research report by the world medical journal 'Lancet', about 10% of annual deaths in Vietnam are connected to air pollution.

Vietnam’s air pollution problem began in the 1990s when foreign companies began to invest. Vietnamese government is realizing high economic growth through various economic policies, However, Vietnam's air pollution problem remains unsolved. This stands in contrast to the high economic growth and the government's various economic policy trials. The main causes of air pollution in Vietnam are the population growth rate, urbanization, industrialization, and lack of environmental education and cultural awareness. In particular, the situation in Hanoi is serious. Hanoi ranked as the second most polluted city in Southeast Asia in 2019 by IQAir AirVisual with recorded PM2.5 figures of 40.8 μg/m3 which was an

[3] The US AQI is a standard measurement system used widely to determine the level of airborne pollutants. The figures range from zero to five hundred where the lower the figure, the cleaner the air is. People who are more susceptible to breathing difficulties should avoid long periods of exposure when the number is higher than 150.

[4] www.iqair.com. (n.d.). *Vietnam Air Quality Index (AQI) and Air Pollution information | AirVisual*. [online] Available at: https://www.iqair.com/vietnam.

improvement on the 2017 figure of 45.8 μg/m3.[5] To solve this problem, the government has considered various measures such as revitalizing bicycle use and automobile regulations to reduce air pollution. However, due to the keynote of policy stance based on industrialization and slow movement of environmental policy, the solution is still insufficient to effectively overcome air pollution.

This paper finds practical solutions to air pollution based in Hanoi. Therefore, the study proposes ways to reorganize Vietnam's public transportation using the Korean public transportation system as a model to reduce personal transportation and promote public transportation. To examine the practicality of the solution, we conducted a survey of 40 local college students in Vietnam.[6]

2. Literature Review

Previous studies about Vietnam's air pollution were mainly analyzed at the level of the government's policy and legal system. Previous studies identified the main cause of air pollution as the traffic problem and focused on incomplete legal policies and inefficient air pollution management and monitoring systems. It only mentioned the need for change in transportation, but lacked specific methods. Therefore, this paper proposes ways to revitalize public transportation that is the major cause of air pollution through field research and discussion with students from Foreign Trade University (FTU). We designed a method to improve the convenience and efficiency of public transportation by examining the case of Korea. Through this, we seek to contribute to improving air pollution and saving social costs by promoting demand for public transportation and reducing private transportation.

II. Research Background

1. Air Pollution in Vietnam

1) Definition of Air Pollution

WHO has determined that one or more pollutants are released anthropogenically into the air and that the amount, concentration, and duration of the pollutants cause a nuisance to people in a particular area or pose a public health hazard to that area. Air pollution is defined as a condition that harms the activities of humans, animals and plants and violates the legitimate right to enjoy daily life and property. The causes of air pollution can be divided into anthropogenic factors such as fuel combustion, and natural factors such as volcanic eruptions. Among them, anthropogenic factors cause serious problems today.

Artificial pollutants are emitted from the combustion of fossil fuels, the generation of nuclear energy using nuclear power, physical processes, and the use of public transportation

[5] www.iqair.com. (n.d.). Vietnam Air Quality Index (AQI) and Air Pollution information | AirVisual. [online] Available at: https://www.iqair.com/vietnam/hanoi

[6] The survey period was conducted from January 5th to January 7th, and 40 FTU students participated. It consists of a total of 6 questions. Please refer to the appendices for the questions and results.

such as automobiles and airplanes. Most of all , the biggest impact on air pollution is pollutants generated when burning fossil fuels. Pollutants that cause air pollution include sulfur dioxide (SO2), carbon monoxide (CO), nitrogen dioxide (NO2), fine dust (PM10), ultrafine dust (PM2.5), ozone (O3), lead (Pb), and benzene.

2) Effects of Air Pollution on the Human Body

Air pollution has a direct adverse effect on human health. The main route of air pollution is the respiratory systems. Air pollutants entering the respiratory system cause diseases and affect a wide range of respiratory, nervous, cardiovascular, and reproductive systems. Air pollution due to fine particulate matter has caused diseases—such as heart disease, chronic obstructive pulmonary disease, stroke, lung cancer, and acute respiratory infections in children—that result in 1.8 million premature deaths worldwide each year.[7] According to a paper by a research team from George Washington University and the University of British Columbia, if the concentration of particulate matter pollution in cities around the world achieves the WHO-recommended standard of 5μg/m3, the number of premature deaths would decrease from 1.8 million to 1.21 million.

In addition, it has been confirmed that 9.6 million out of 30.5 million people worldwide who died of complications caused by ultrafine dust between 2000 and 2019 could have avoided early death if they followed the WHO recommendation standards.[8]

3) Air Pollution Status in Vietnam

Air pollution in Vietnam is very serious. At the Vietnam Business Forum (VBF) hosted by Vietnam's National Economic University in 2020, experts estimated that Vietnam's air pollution losses amounted to $108.2 billion to $136.3 billion annually, accounting for 4.45% to 5.64% of Vietnam's GDP. According to the WHO, air pollution killed more than 60,000 people in Vietnam by 2019 , which is three times the number of people killed in traffic accidents. According to the 2022 Environmental Performance Index (EPI), Vietnam's air pollution ranked 130 out of 180 countries and 128th in pollutant emission status.[9]

Table 1. Comparison of Key Indicators Related to Air Quality Between Vietnam and Korea

Division	Global standard (2018)	Vietnam	Korea

[7] World Health Organization (2018). Ambient air pollution: Health impacts. *World Health Organization*. [online] doi:/entity/airpollution/ambient/health-impacts/en/index.html.

[8] 기자강찬수 (2022). *'세계 도시 인구 연간 180만 명 초미세먼지 탓에 조기 사망'*. [online] 중앙일보. Available at: https://www.joongang.co.kr/article/25039445#home. [Accessed 24 Jan. 2023].

[9] Yale Center for Environmental Law & Policy (2020). *Welcome | Environmental Performance Index*. [online] epi.envirocenter.yale.edu. Available at: https://epi.yale.edu/.

Air pollution	44.2	26.5 score (130th)	62.9 score (30th)
PM2.5 exposure (average)	42.7	28.4 score (104th)	47.2 score (45th)
Household solid fuel	46.1	24.9 score (113th)	100 score (1st)
O3 exposure	61.9	41.3 score (106th)	44.4 score (91th)
SO2 exposure	68.2	33.2 score (134th)	100 score (1st)
NO2 exposure	57.6	14.9 score (146th)	100 score (1st)

S**ources:** Environment Performance Index, EPI ,https://epi.yale.edu/

Air quality in Hanoi and Ho Chi Minh is particularly concerning, ranking in the top 15 most polluted cities in Southeast Asia. According to the Department of Trade in Vietnam in 2019, compliance with environmental standards related to fine dust in Hanoi and Ho Chi Minh City was confirmed only on the 8th in Hanoi and 36 days in Ho Chi Minh City. Vietnam's Air Quality Index (AQI)[10] also shows that the air quality in the north and south, where Hanoi is located, is very poor.

Table 2. Vietnam Air Quality Status by Region

Division		Northern	Central	Southern
PM2.5 (μg/m3)	maximum	188	42	137
	minimal	15	13	21
PM10 (μg/m3)	maximum	108	32	71
	minimal	15	3	15
NO2	maximum	5	6	10

[10] www.iqair.com. (n.d.). *Vietnam Air Quality Index (AQI) and Air Pollution information | AirVisual*. [online] Available at: https://www.iqair.com/vietnam.

(ppb)	minimal	1	1	1
SO2 (ppb)	maximum	50	3	3
	minimal	7	2	1
CO (ppm)	maximum	5	7	0
	minimal	1	6	0

Sources: Real-time Air Quality Index, AQI

4) Main Causes of Air Pollution in Vietnam

According to the Vietnam Environment Administration (VEA), old vehicles, conventional stoves and industrial facilities are the main sources of air pollution in Vietnam. According to the Ho Chi Minh University of Transportation, the main cause of CO in Vietnam is aging vehicles, and the main sources of NOx and SOx are industrial and residential facilities. Transportation is responsible for a large portion of air pollutant emissions in Vietnam's urban areas. The main emission substances are sulfur dioxide, nitrogen dioxide, carbon monoxide, and dust (TSP, PM10 and PM2.5), and the largest source of pollution is motorbikes.

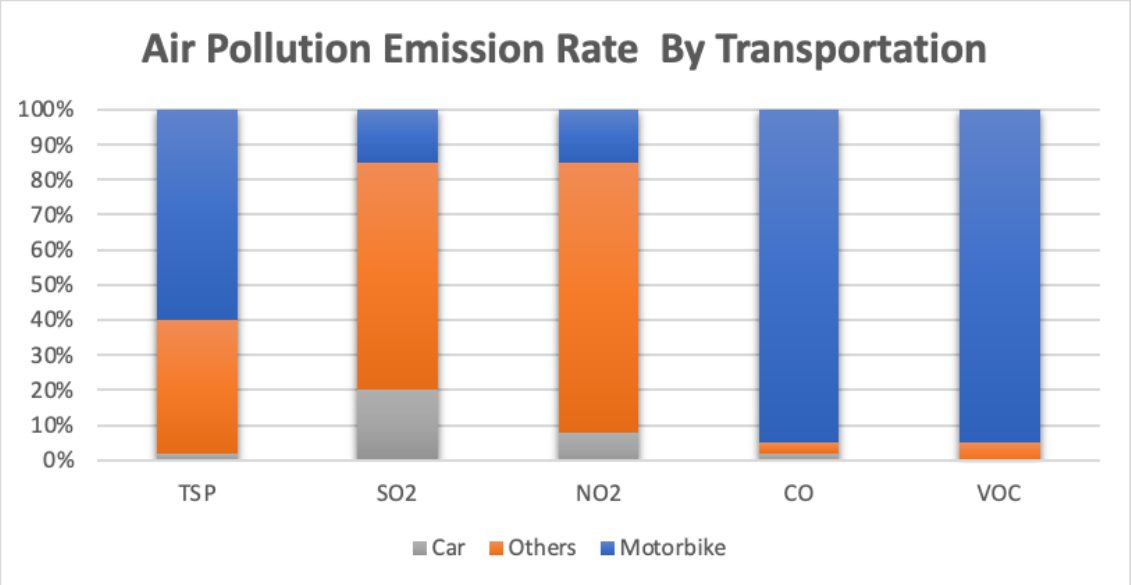


Figure 1. Air Pollution Emission Rate by Transportation

Sources: *Analysis and Evaluation of Air Quality in Urban Areas of Vietnam, Ministry of Environment*

In the case of automobiles, the most popular form of transportation after motorbikes, gasoline and diesel are used as fuel, but toxic gasses such as VOC, benzene, and toluene are

generated through leakage, evaporation, and combustion of fuel. Pollutant emissions from automobiles depend on vehicle quality, fuel, speed, number of drivers, and road conditions. In Vietnam, routine maintenance of motorbikes and automobiles is often neglected, and many types of vehicles and motorbikes have poor fuel efficiency and have high dust emissions. In particular, motorbikes are a main cause of carbon monoxide and VOC emissions. In addition, trucks and buses emit relatively large amounts of nitrogen dioxide and sulfur dioxide.

Buses are the main public transportation in Vietnam. Buses have been improving quantitatively and qualitatively, but they do not meet the needs of citizens and are becoming a major factor in air pollution. The Vietnamese government has subsidized bus fares to encourage bus use, but low bus fares and limited government investment the buses were not replaced and operated, resulting in increased pollutant emissions. In addition, poor road conditions cause traffic congestion, further exacerbating air pollution. According to statistics,[11] up to 70% of air pollution in Hanoi is due to the transportation sector. With more than 4 million buses currently in operation, the transportation sector accounts for 85% of total CO2 emissions and 95% of volatile organic compound emissions.

2. Current State of Public Transportation in Hanoi

1) Traffic Status in Vietnam and Hanoi

Vietnam's transportation plays an important role for balanced national development and industry support. Although 94% of transportation is carried out through roads, However according to advanced socio-economic indicators road infrastructure, and facilities are underdeveloped. . Therefore, road network improvement is underway to convert economic growth concentrated in a specific area into distributed growth across the country. Vietnam is investing about 4% of its GDP for transportation development.[12] Including the resolution to establish a comprehensive infrastructure system in Vietnam, transportation development plans, improvement and modernization projects in the transportation sector, etc. are in progress. In particular, the transportation sector, which is one of the major tasks of the socio-economic development plan, accounts for the largest portion of infrastructure investment.

Nonetheless, Vietnam's national road length is insufficient to meet economic development needs. For example, the Vietnam Expressway Network Master Plan was established in 2015 to expand the length of the expressway from 906.4km to 6,411km by 2030. However, for the 86% unfinished highway network, a lot of economic and time investment is required . As for roads, 40% of Vietnam's national roads are located in mountainous areas, so half of them have insufficient road capacity compared to traffic demand and are vulnerable to natural disasters such as landslides. In addition to road conditions, Vietnam's transportation-related legal and institutional infrastructure is also weak. As for transportation in Vietnam, there are no laws supporting comprehensive transportation investment financing plans, integrated transportation

[11] 한국환경기술원 (2017). *베트남도심지역대기질 분석및평가.*

[12] Ing. Khuat Viet Hung. (2015). TRAFFIC SAFETY STRATEGIES FOR VIETNAM. n.p.: VIETNAM NATIONAL TRAFFIC SAFETY COMMITTEE.

investment coordination, public transportation transfer and connection, means integration, and public transportation and Bus Rapid Transit(BRT) support. As a result, it causes a decrease in profitability and competitiveness of the industry, and it is difficult to expect external investment.[13] Moreover, overcrowding of personal vehicles causes various social costs. For example, the cost of frequent traffic accidents accounts for 2.5% of GDP. This is because the demand for private cars is accelerating due to Vietnam's economic growth, population growth and urbanization. In the case of Hanoi Master Plan 2030, the population is expected to be 99.2m, and private transport is also expected to increase. For now, there are 8 million people and 5.25 million motorcycles, and 480,000 cars registered. Personal car owners are 20 out of 1,000 people, and personal motorcycles are about 487 out of 1,000 people. According to the data, compared to the urban population growth rate of 1%, the number of cars and motorcycles increased by 7% each year from 2011 to 2016.

In particular, Hanoi has several regional specificities that cause traffic problems in addition to the characteristics of road traffic in Vietnam. First of all, the old city center of Hanoi has many intersections within a short distance, so the average traffic speed is about 20 km/h. Second, Hanoi's road area accounts for about 5% of the total city, higher than Ho Chi Minh (1.6%) and Da Nang (0.7%), but Honoi road area is still low because other other developed countries account for 20-25%. Lastly, roads are developed around the downtown area or the old city center in Hanoi, so the road network in some areas is insufficient. As a result, the downtown area is concentrated on traffic with noise and pollution, and the lack of parking space. On the other hand, the out of town is inconvenient in traffic management and social service use, where 42% of Hanoi's population lives.[14]

2) Hanoi Public Transportation Usage Status

Vietnam and Hanoi have policies to ensure access to public transportation for the transportation vulnerable. According to the Vietnam Road Transport Master Plan, in order to expand infrastructure and develop a reasonable public transport system, a plan to increase the use of public transport by 35~45% is being promoted by introducing and improving public transport such as elevated railways and subways in Hanoi and Ho Chi Minh. Also, on the Vietnam Traffic Development Strategy, a road traffic environment improvement plan was established by suppressing the increasing flow of automobiles and motorcycles in large cities and introducing an intelligent signal control system.

[13] Kwon, Y., Ahn, K. and Seo, Y. (2019). 베트남의 교통분야 개발협력 방안 연구 (Korea's Development Cooperation for Transport in Vietnam). *SSRN Electronic Journal*. doi:10.2139/ssrn.3706723.

[14] Nguyen, D.T. and Kajita, Y. (2018). Traffic Congestion and Impact on the Environment in Vietnam: Development of Public Transport System - Experience from Actual Operation of Bus in Hanoi. *Journal of Civil & Environmental Engineering*, [online] 08(03). doi:10.4172/2165-784x.1000317.

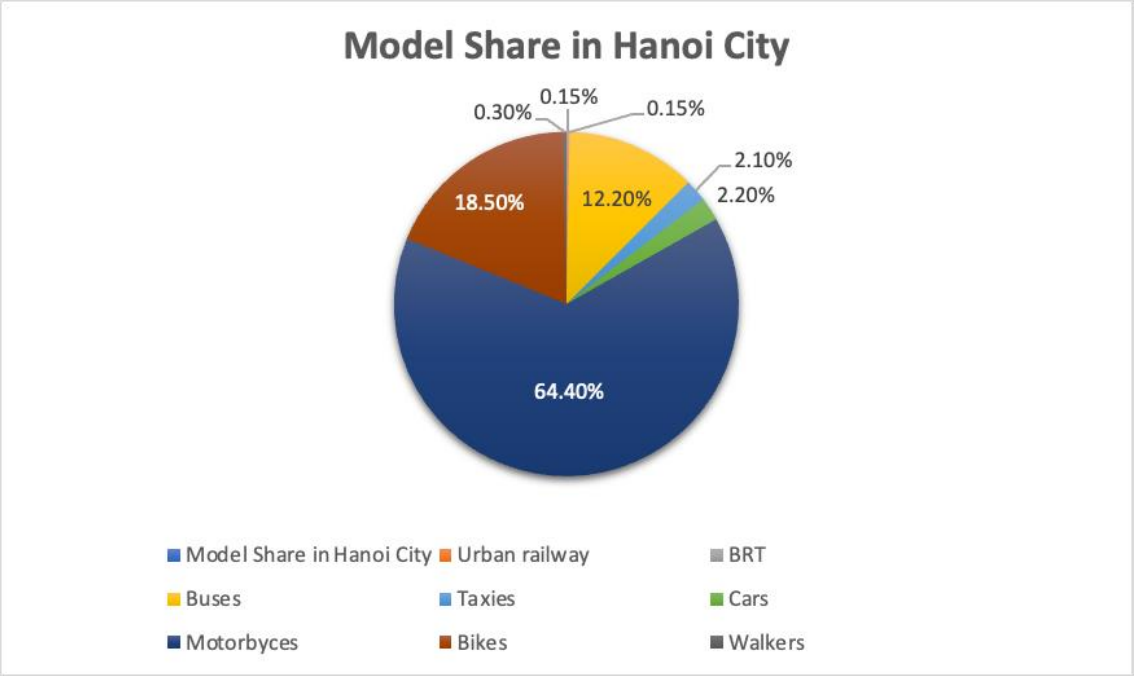


Figure 2. Model Share in Hanoi City

Sources: *TRAMOC, 2015*

Despite these efforts, buses are the majority of public transportation in Hanoi, and the rate of use of the newly introduced BRT and urban railway is low. In 2020, there were more than 100 bus routes, 7 companies, and 8 bus terminals in Hanoi. The proportion of citizens who use public transportation is 14.2%, indicating that the increase in motorcycles and traffic problems cannot be distributed to public transportation.

There are five reasons why the demand for transportation could not be shared through public transportation. The main reason is that they did not feel uncomfortable with personal vehicles and are not familiar with public transportation. Incidentally, lack of access to public transportation, old facilities and safety issues were mentioned. In fact, similar results can be confirmed in a researched survey of FTU students in Hanoi.

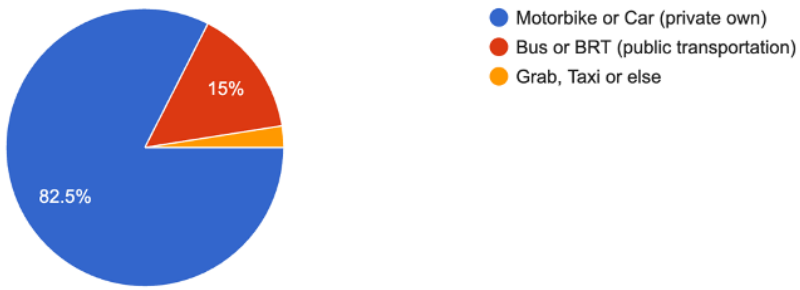


Figure 3. Vehicle

Sources: *Authors's suggestion*

Among the total respondents, 40 people, 33 people own a motorcycle or use private transportation, and 6 people use public transportation such as a bus, so the rate of using public transportation is low. People who use public transportation say convenience and low price are advantages. Conversely, others who own private transportation prefer it because of convenience and time savings. In addition, when they were in middle and high school, they could not drive the motorbike. So, they used public transportation. But the transportation system was not at a reasonable price, far from the bus stop, no stops nearby the house. At the same time, 5 people (15%) responded that there were no other available means of transportation. It shows the lack of functionality of public transportation. - The top four causes of inconvenience in public transportation are already owned private transportation (65.8%), old facilities (55.3%), poor accessibility to bus stops (52.6%), and long intervals (50%). Besides, inconvenience in paying bus fare (26.3%), inaccurate information (21.1%), last bus operation that ended early (15.8%), causing traffic congestion, careless driving, crowded main rush hour, lack of bus routes, taking a long time (2.6%) was mentioned. In addition, the system in Hanoi is impossible to free transfer, and the condition has narrow roads in the densely populated old city center, which hinders regular operation.

Figure 4, 5. Share of Bus Users by Age, Occupation

Figure 6, 7. Income Per Month, Transfer between Different Bus Routes

Sources: *Japan International Cooperation Agency (Preparatory Survey on Hanoi Public Transportation Management and Operation Improvement Project (First Phase) in Socialist Republic of Vietnam Final Report)*

Citizens using public transportation accounted for 14.2%, mostly low-income families, students, and the elderly. Of those, 52% require more than one transfer to get to their

destination. Also, 67% use an annual pass. Through the data, although the number of Public transport users is small, It was confirmed that public transport is the only means for them, So it showed the need for road reorganization and efficiency improvement. To reduce air pollution, it is necessary to increase the use of public transportation, limit the growth of private cars, and continuous improvement solutions for public transportation. In order to solve the problems it is necessary to continuously improve road infrastructure, the efficiency of management and operation of the facilities, and citizens' awareness education on participation.

III. Public Transportation Vitalization Plan

1. Activation Plan for Electric Bus

1) Hanoi Electric Bus Expansion Plan

(1) Electric Bus Definition and Characteristics

As global warming accelerates due to air pollutants and greenhouse gases, many countries are striving to develop and distribute eco-friendly vehicles by expanding investment in electric vehicles as an alternative to vehicles that use fossil fuels. An electric bus, one of the types of eco-friendly vehicles, means a bus using an electric battery and an electric motor, and is classified into various types according to the role of the battery and the motor and the electric charging method.

In the case of an electric bus, a vehicle structure is simpler than a bus using fossil fuel, the vehicle weight is light, and it has excellent characteristics in terms of energy efficiency. In addition, there are fewer mechanical devices, so there is less noise and vibration inside the vehicle, and it has the advantage that no exhaust gas is emitted while driving.

(2) Hanoi Electric Bus Introduction Case

On December 2, 2021, the first electric bus operation was implemented in Hanoi. As of 2022, a total of 9 electric bus routes were operated, operating hours were between 5 am and 9 pm, and dispatch intervals were between 15 and 20 minutes. Ticket prices range from 7,000 to 9,000 VND, and monthly passes range from 55,000 to 200,000 VND, but seniors, people with disabilities and children under 6 can ride for free.[15]

2) Expansion of Hanoi Electric Bus Routes

Most of the regular buses currently operating in Hanoi are diesel buses, and it has been found that there is inconvenience to users due to the continuous lack of maintenance and decrepitude of the buses. As a result of a survey of 40 Vietnamese university students living in Hanoi, 23 students (57.5%) responded that they did not use the bus because the bus was old and inconvenient to use. In the case of the existing regular bus, it was answered that they avoided using the bus due to motion sickness due to the excessive noise inside the vehicle and

[15] 베한타임즈. (2021). *하노이 전기버스 운행 '스타트'*. [online] Available at: http://www.viethantimes.com/news/articleView.html?idxno=15801 [Accessed 24 Jan. 2023].

the body shaking a lot. Due to these problems, Vietnamese students prefer motorcycles rather than buses, and if these problems are not resolved, it is expected that the use of buses by Hanoi citizens will gradually decrease. In addition, 22 students (55%) responded that they did not use the bus due to the small number of bus stops and limited routes. To solve this problem, it is necessary to gradually replace old diesel buses with electric buses to solve the internal noise and vehicle vibration problems, and efforts should be made to revitalize bus use by reorganizing bus routes according to the floating population.

3) Cost Benefit Analysis

(1) Increase in Vehicle Purchase Cost and Charging Infrastructure Installation and Operation Cost

The price per electric bus in Hanoi is about VND7-7.5 billion, which is about three times that of a diesel engine bus. In addition, electric buses are expected to have charging facilities for charging batteries and require a lot of financial resources to maintain and operate them. However, in the case of electric buses, unlike engine buses, the occurrence of fatigue cracks caused by vibrations generated during bus operation is remarkably low, so there is no high cost for replacement of major parts. And the battery's life has been extended due to recent technological advances. In addition, in the case of electric buses, there are benefits in that they can come up with air pollution solutions such as energy saving, air pollutant reduction, and greenhouse gas reduction. Compared to regular diesel buses, electric buses have the effect of reducing 68 tons of carbon dioxide emissions and 344 kg of nitrous oxide per bus. It is possible to provide more convenience to citizens by solving the problem of noise and vibration inside the vehicle, which was a disadvantage of existing diesel buses. This is linked to an increase in bus users. In fact, according to the Hanoi Public Transportation Management Center, the number of electric bus users in the first half of 2022 is steadily increasing to 122 million. The Vietnamese government plans to replace all buses in Hanoi with electric buses by 2050, and it can be confirmed that the above measures are effective. [16]Although it is effective in reducing air pollution, appropriate measures have not been prepared internationally for pollution generated in the process of recycling waste batteries and mining battery raw materials. In this regard, it is necessary to make a complete pollution-free electric bus through continuous research and development.

2. Bus Stop Reorganization

1) Hanoi Bus Station Status

In the case of Hanoi's bus stops, there are signs as shown in Picture 1. Hanoi Bus Stop below. The problem with such a bus stop is that it is difficult to see the bus route without a

[16] www.aseanexpress.co.kr. (n.d.). *베트남 수도 하노이, 2030 년까지 50% 전기버스로 바꾼다.* [online] Available at: https://www.aseanexpress.co.kr/mobile/article.html?no=8166. [Accessed 24 Jan. 2023].

mobile device. And it is impossible to know how many minutes after the next bus will arrive at the bus stop, so bus users must wait endlessly. Even if people have mobile devices, sometimes the app that notifies them of bus arrival is not accurate and dispatch intervals are inconsistent. This intensifies the inconvenience of citizens. According to a survey of university students living in Hanoi, 20% of the students who do not use buses answered that the arrival time of the bus is inaccurate.

Picture 1. Hanoi Bus Stop

Sources: Authors's suggestion

The number of bus stops is also a problem. 55% of students who do not use buses answered that they use motorcycles instead of buses because the distance from their home and university to the bus stop is so long and the small number of bus stops. In order to reduce air pollution emissions by encouraging the use of public transportation, passenger-friendly services must be provided and can be started by reorganizing bus stops.

2) Bus Stop Reorganization Plan

(1) Problems and Solutions of Hanoi Bus Stop

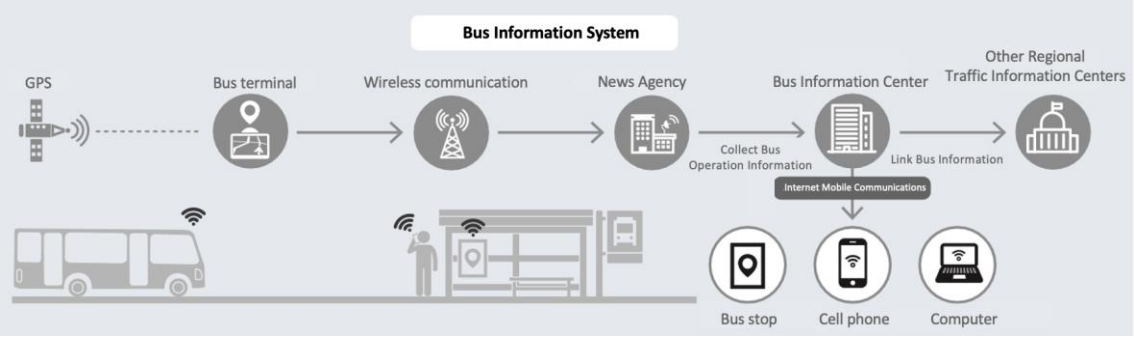
In the case of bus stops in Korea, as shown in Picture 2. Korean Bus Stop below, a "Bus Information System (BIS)" has been established to check the scheduled arrival time of the bus and how many stops are left until the station.

Picture 2. Korean Bus Stop

Sources:
https://m.blog.naver.com/PostView.naver?isHttpsRedirect=true&blogId=travia_blog&logNo=221014430629

The bus information system works based on GPS. It coordinates according to the input to the bus. By using this, when the GPS signal is received from the satellite and passes through a point that matches the coordinates of the bus input in advance, the corresponding data is transmitted to the traffic information center in real time. After that, the estimated arrival time by calculating the location and road conditions of the bus from the collected information, is converted back into visual and auditory data and delivered to passengers at the bus stop. These GPS-based systems can also solve problems with inaccurate bus apps.

Picture 3. Concept of Operation of Bus Information System



Sources: Korea Transport Institute

https://blog.naver.com/PostView.nhn?blogId=koti10&logNo=222316779362

(2) Effect

The above method of reorganizing the bus stop system can solve the inconvenience caused in the process of using public transportation by providing passengers with the bus arrival time

and the current location of the bus in real time. Through this, the 'consumer sovereignty' of consumers who use public transportation can also be restored. Through an interview with a local university student in Vietnam, it was confirmed that there are students who usually use taxis because the exact bus arrival time is unknown. For passengers' consumer sovereignty to be realized, consumers must be able to reasonably choose the means of transportation they will use through sufficient information. If the bus stop system is introduced in Hanoi, the consumer sovereignty of consumers using public transportation can be realized, and the more convenient bus stop service is expected to lead to an increase in the passengers. The increase in bus users is expected to serve as a stepping stone to sustain the public transportation business and ultimately bring about a virtuous cycle. However, the limitation is that the bus services using smartphones distributed intensively among young people is insufficient to revitalize bus use among all age groups. In 2022, Vietnam's adult smartphone prevalence is high at 73.5%, but those who can use this bus service will be limited to only the people who have the mobile phone. In Hanoi as the capital city, people from the countryside will be able to use this service, but the lower the prevalence of smartphones in the countryside.

3) CCTV Installation to Crack down on Illegal Parking at Bus Stops

For the bus to arrive at the bus stop smoothly, CCTVs must be installed in front of the bus stop to strengthen illegal parking crackdowns. If a car or motorcycle is parked or stopped in front of a bus stop, it is difficult for the bus to enter the bus stop, resulting in a delayed arrival time. When walking around Hanoi, people often come across illegally parked or stopped motorcycles. According to the Vietnam Road Traffic Law, fines are imposed on vehicles parked and stopped illegally. It imposes fines of 200,000VND to 300,000VND for illegal parking and stopping motorcycles, 400,000VND to 600,000VND for illegal stopping for cars, and 800,000VND to 1 million VND for illegal parking. However, it is difficult to crack down on illegal parking because illegal parking is mainly cracked down by the traffic police. Local media in Vietnam reported that in large cities such as Hanoi, social and economic problems caused by traffic flow disruption due to illegal parking are serious. To solve these problems, CCTVs should be installed at bus stops to punish illegal parking, and efforts should be made to smoothly use buses. In addition, it is expected that it will be more effective in improving citizens' awareness if the 'illegal parking reporting system' is implemented together to create a system in which citizens can voluntarily report illegal parking. This suggestion is expected to increase the convenience and revitalize public transportation by raising funds for modernization of public transportation facilities and securing punctuality of buses. However, it will be difficult to distinguish illegality through CCTV in Hanoi alleys, which are confusing with colonnades and large amounts of motorcycles.

Picture 4. CCTV Installed at Bus Stops in Korea to Crack down on Illegal Parking

Sources: Yonhap news https://www.yna.co.kr/view/AKR20101214180200004

3. Adjustment of Bus Dispatch Interval

1) Hanoi Bus Dispatch Interval Problem

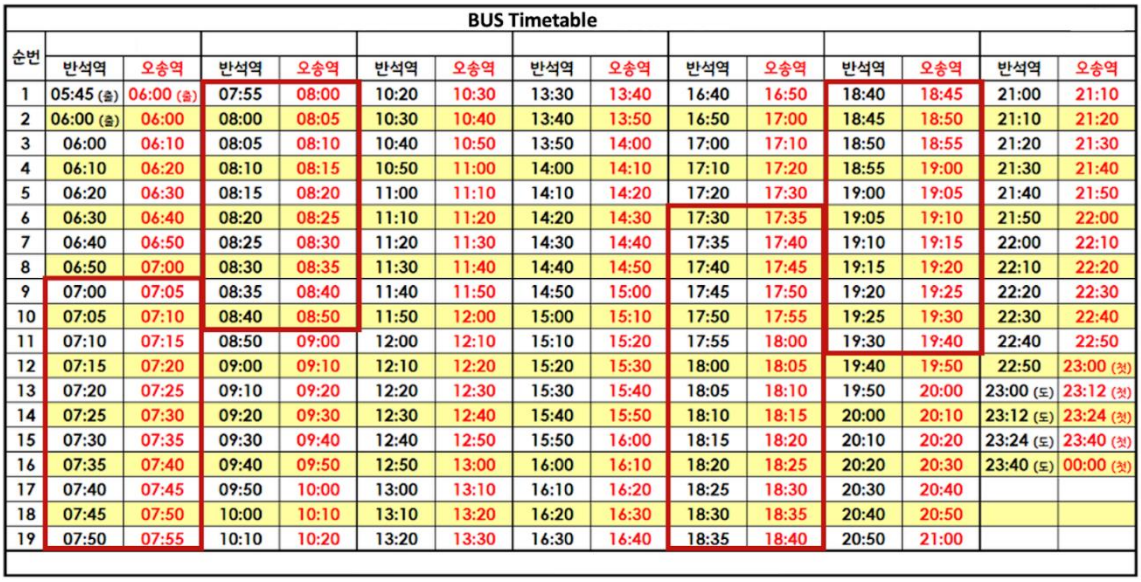
When university students living in Hanoi were asked why they did not use the bus, 20 students (50%) answered that they did not use the bus because the interval between buses was long. In addition, 6 students (15%) responded that they used other means of transportation because it was impossible to use the bus due to the early time of the last bus. Based on a student interview that either the bus dispatch interval is not accurate, and the bus speed is slow during traffic jams, it can be seen that the adjustment of the bus dispatch interval contributes to the increase of citizens' convenience in using the bus. As mentioned earlier, increasing bus convenience is one of the key solutions to reducing air pollution because it strengthens the marketability of public transportation and reduces the advantages of private transportation.

2) Measures to Adjust Bus Dispatch Intervals

Interviews with Hanoi university students showed that the most ideal bus dispatch interval was between 15 and 20 minutes. In addition, it was confirmed that there was a need to adjust the bus dispatch interval through the fact that there were many students who used buses instead of motorcycles when they were in high school. Excluding morning hours (time for students to go to school and office workers to go to work) and evening hours (time for students to leave school and office workers to go home), which are times when people often use the bus, the dispatch interval is adjusted to between 15 and 20 minutes. Also, it is efficient to operate flexibly by reducing the bus dispatch interval to 10 minutes during times of frequent bus use. In the case of Korea, a flexible system for bus dispatch intervals is being implemented, and

citizens' satisfaction with this system has been found to be high. In addition, it is considered desirable to extend the last train time to 10 p.m. on weekdays and 12 p.m.

Picture 5. Sejong BRT Bus Allocation Timetable



BUS Timetable

순번	반석역	오송역	반석역	오송역	반석역	오송역	반석역	오송역	반석역	오송역	반석역	오송역	반석역	오송역
1	05:45 (출)	06:00 (출)	07:55	08:00	10:20	10:30	13:30	13:40	16:40	16:50	18:40	18:45	21:00	21:10
2	06:00 (출)	06:00	08:00	08:05	10:30	10:40	13:40	13:50	16:50	17:00	18:45	18:50	21:10	21:20
3	06:00	06:10	08:05	08:10	10:40	10:50	13:50	14:00	17:00	17:10	18:50	18:55	21:20	21:30
4	06:10	06:20	08:10	08:15	10:50	11:00	14:00	14:10	17:10	17:20	18:55	19:00	21:30	21:40
5	06:20	06:30	08:15	08:20	11:00	11:10	14:10	14:20	17:20	17:30	19:00	19:05	21:40	21:50
6	06:30	06:40	08:20	08:25	11:10	11:20	14:20	14:30	17:30	17:35	19:05	19:10	21:50	22:00
7	06:40	06:50	08:25	08:30	11:20	11:30	14:30	14:40	17:35	17:40	19:10	19:15	22:00	22:10
8	06:50	07:00	08:30	08:35	11:30	11:40	14:40	14:50	17:40	17:45	19:15	19:20	22:10	22:20
9	07:00	07:05	08:35	08:40	11:40	11:50	14:50	15:00	17:45	17:50	19:20	19:25	22:20	22:30
10	07:05	07:10	08:40	08:50	11:50	12:00	15:00	15:10	17:50	17:55	19:25	19:30	22:30	22:40
11	07:10	07:15	08:50	09:00	12:00	12:10	15:10	15:20	17:55	18:00	19:30	19:40	22:40	22:50
12	07:15	07:20	09:00	09:10	12:10	12:20	15:20	15:30	18:00	18:05	19:40	19:50	22:50	23:00 (첫)
13	07:20	07:25	09:10	09:20	12:20	12:30	15:30	15:40	18:05	18:10	19:50	20:00	23:00 (도)	23:12 (첫)
14	07:25	07:30	09:20	09:30	12:30	12:40	15:40	15:50	18:10	18:15	20:00	20:10	23:12 (도)	23:24 (첫)
15	07:30	07:35	09:30	09:40	12:40	12:50	15:50	16:00	18:15	18:20	20:10	20:20	23:24 (도)	23:40 (첫)
16	07:35	07:40	09:40	09:50	12:50	13:00	16:00	16:10	18:20	18:25	20:20	20:30	23:40 (도)	00:00 (첫)
17	07:40	07:45	09:50	10:00	13:00	13:10	16:10	16:20	18:25	18:30	20:30	20:40		
18	07:45	07:50	10:00	10:10	13:10	13:20	16:20	16:30	18:30	18:35	20:40	20:50		
19	07:50	07:55	10:10	10:20	13:20	13:30	16:30	16:40	18:35	18:40	20:50	21:00		

Sources: Sejong City Hall

4. Installation of Bus Stop Signs

Traffic accidents in Vietnam are high enough to account for 2.5% of the total GDP. Buses are no exception. Motorcycles often pass between buses and bus stops when they suddenly overtake buses or passengers get on and off buses. According to the Vietnam Road Traffic Law, driving on the road in a zigzag is strictly illegal, but it is a reality that is not well followed. It is expected that STOP signs should be installed on the right side of the bus for safe use by passengers. In the case of a STOP sign, when the door of the bus is opened, it automatically protrudes and informs the motorcyclist coming from behind that passengers are getting on and off the bus. Considering that Hanoi Road is narrow and there are many side roads such as alleys, STOP signs are expected to protect passengers more effectively. By ensuring safety in bus use in a relatively cheap and simple way, it is effective in enhancing passenger convenience and reducing the frequency of personal public transportation.

Picture 6. Bus Stop Sign

Sources: https://www.shutterstock.com/ko/search/school-bus-stop-sign

5. Introduction of Transportation Card

1) Definition and Types of Transportation Cards

A transportation card is a digital currency used for boarding and using transportation that has the same value as the existing currency. Usually, the types are classified according to payment methods and communication methods. Payment methods are divided into prepayment and deferred payment. Prepayment is inconvenient to charge the card before using it. Deferred payment is a credit card plus a transportation card function. This card is convenient to process, but requires continuous management of risk factors such as overdue. Depending on the communication classification, it is largely divided into contact type and non-contact type. Hybrid type can be used as a contact type and a non-contact type by compromising them, but cannot be mixed, and combination type that can be mixed without distinction between contact type and non-contact type. [17] In Korea, a deferred payment hybrid card issued by a credit card company is generally used. However, students or seniors, foreign travelers mainly use prepaid contactless cards.

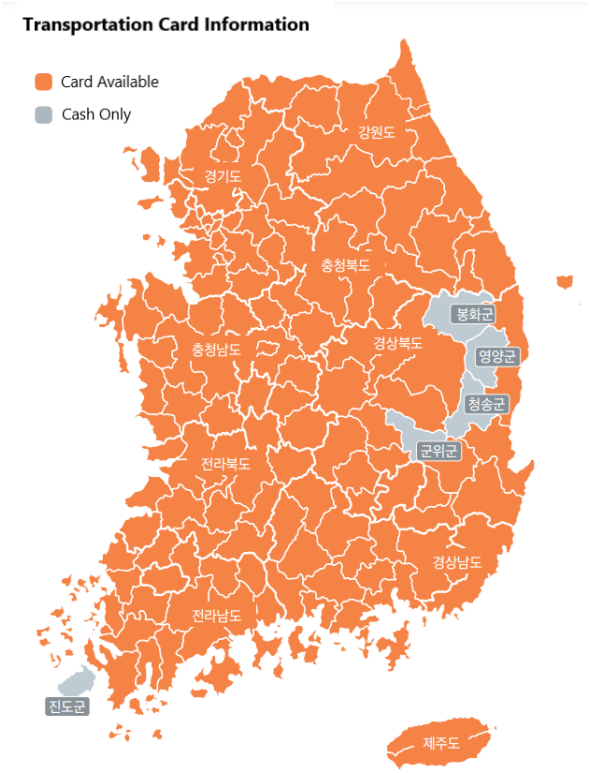
2) Transportation Card in Korea

Nowadays, cash cannot be used to pay for public transportation in most regions, Korea. The majority pay fares through IC cards. According to the announcement of the Seoul Metropolitan Government, in 2004 when the current transportation card system was introduced, the rate of using it was only 74.4%. However, in 2014, 100% of subways, 99.9%

[17] Kdi.re.kr. (2023). *교통카드 이용 현황과 대중교통정책에의 활용방안 | 국내연구자료 | KDI 경제정보센터*. [online] Available at: https://eiec.kdi.re.kr/policy/domesticView.do?ac=0000081843 [Accessed 24 Jan. 2023].

of village buses, and 97.4% of city buses used transportation cards. It was investigated that the reason for the rapid increase was the transfer discount system and the lack of hassle in payment.[18]

Picture 7. Transportation Card Information

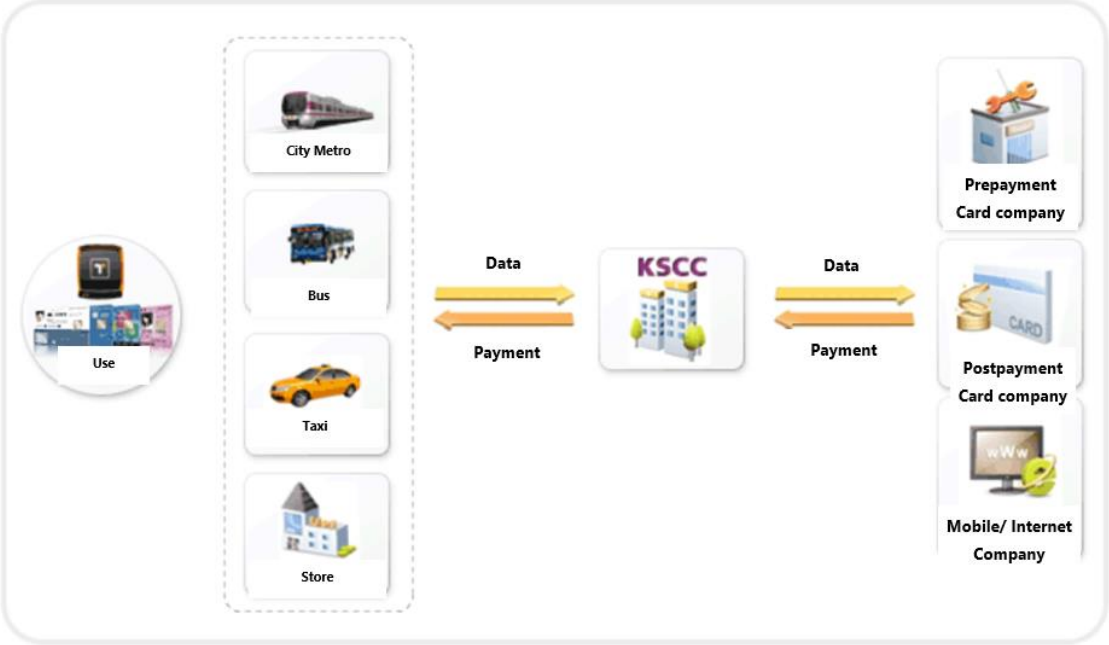


Sources: Minister of Land, Infrastructure and Transport

You can purchase it at convenience stores or subway stations. A deferred payment transportation card is issued by a credit card company. Also, the elderly and youth ages, the disabled can benefit from differential fares by registering their cards. The issued card can be used in all regions with all transportation means such as intercity buses, express buses, subways, high-speed rail, and highways, city buses.

[18] itskorea.kr. (n.d.). *ITS Korea*. [online] Available at: https://itskorea.kr/boardDetail.do?type=8&idx=2693&searchType=&searchText= [Accessed 24 Jan. 2023].

Picture 8. Transportation Card System Configuration



Sources: Seoul Metropolitan Government, https://www.seoulsolution.kr/ko/node/649

When a user pays the fares through the card reader, various information including payment is shared between the card companies, the information center under the government, and the transportation companies. This system could provide benefits for post policies and be used to analyze traffic volume.

3) Introduction Process and Effect

In 1996, starting with Seoul, major cities established transportation card systems that could be used on buses or subways. However, there were system problems such as old facilities, delayed computer processing, and weak security, as well as operational problems such as monopoly and lack of transparency. Crucially, there was a limit that compatibility was impossible as regions or organizations operated individually. To improve this, from 2004 to 2011, through three stages, Seoul established an overall reform plan for the bus route, operating system, and bus-only road as well as the fare and transportation card system. The reform introduced a private management method in the form of a stock company, various welfare cards, and a differential fare system by distance/time. All public transportation fares can be paid with a card. Moreover, by integrating regional systems, all public transportation fares in the whole area can be paid with a transportation card. As a result, the usable range has been expanded and it was reorganized to enable additional services such as a free transfer fare based on the distance proportional system. [19]

[19] Seoulsolution (2014). *교통카드시스템 구축*. [online] 서울정책아카이브 Seoul Solution. Available at: https://www.seoulsolution.kr/ko/node/649 [Accessed 24 Jan. 2023].

Table 3. The Expected Effects for User, Operating Company, and Government by Transportation Card System

	Effects
User	• Eliminate the inconvenience of cash payment • Nationwide use with a single card • Cost reduction with differential rate system • Expansion of transportation card options
Operating Company	• To get the financial support by expanding accounting transparency • Reduce ticket sales and collecting costs • Secured on-time service • Safe driving effect by focusing on the drive, not ticket
Government	• Securing public transportation data • Data base, policy establishment and additional service implementation • Promote market transparency

Sources: Authors's suggestion

The expected effects for user, operating company, and government are as follows. Users can solve the inconvenience of cash payment, and the convenience of use has increased with nationwide compatibility. In addition, cost reduction can be expected due to the distance proportional system and the integrated transfer fare implemented based on it. Public transportation drivers were guaranteed safe operation by relieving the burden of managing toll collection. Due to the digitalized payment method, the operating company can reduce the cost of operating the fare collection system, such as ticket sales and income management, and prevent omission of income by distributing forgery and falsification technology. Accounting transparency expands to benefit from financial support. Simplified fare payment reduces waiting time for rides, enabling on-time operation. These are expected to increase transportation revenue through the expansion of public transportation use. Government can easily obtain data on real-time public transportation by utilizing digitized information. Based on this, it is possible to provide advanced policies and additional services. In addition, it is suitable for financial support and market management by inducing transparent management. As a result, the policy could strengthen equity by increasing public transport utilization, market competitiveness, reducing car use and various different fares.

Costs incurred in implementing the policy were shared by each transportation agency. As for the initial costs, it was necessary to replace ticket vending machines, subway gates, and install additional systems, but the burden was alleviated with government subsidies, a corporation-type operation method, and an increase in users.

4) Possibilities and limitations of Introducing Hanoi

When the policy is applied to public transportation in Hanoi, the expected appearances are as follows. Currently, the credit card penetration rate in Vietnam is high, but most of them are young people, and the elderly are used to using cash. The introduction of this needs to take some time to adapt for students and the elderly, who are the main users. Although it may be a more difficult system for actual users, the fact that the differential fares policy is applied to the elderly and students is a part where the effect of users can be increased. Operating companies can create a favorable environment for Foreign Direct Investment(FDI) in Vietnam through increased transparency. In addition, for the Hanoi government, which needs to be reorganized due to outdated public transportation facilities and inefficient operation, public transportation usage status information by transportation cards will contribute a lot to effective policy establishment. Currently, regarding transportation cards, Hanoi has been piloting a one-off receipt-type transportation card that can be issued on-site for one BRT route since 2018, and a plastic card used for a monthly flat rate. In the case of Ho Chi Minh City, with Visa Card, in September 2020, it was operated on a line and was applied to Metro Line no.1 and 8 bus lines from 2021. The advantages that can be expected from an electronic transportation card are as follows. First, it is possible to save resources compared to disposable cards. Second, it helps to establish an efficient public transportation facility system using data accumulated with electronic cards. Efficient operation can greatly contribute to strengthening consumer use and accessibility and reducing resource consumption of existing diesel buses or electric buses. Therefore, changes by transportation cards can be a solution to reduce air pollution and resource waste along with activation of public transportation.

Picture 9. Hanoi Transportation QR Ticket, Hanoi Transportation IC Card, Ho Chi Minh City Transportation IC Card

Sources: Vietnam community, Vietnam news

VI. Conclusion

This study, together with FTU students, sought ways to activate public transportation to solve the air pollution problem in Vietnam. By comparing the air quality of Hanoi on the WHO standard, the seriousness of air pollution was identified, and the cause was found in many personal vehicles. The reason why there are the large number of private vehicles is a combination of general traffic conditions in Vietnam, such as insufficient road transportation capacity, legal and institutional weakness, and overcrowding of individualvehicles, and Hanoi's states such as many intersections, inefficient transportation network in the old city center, and insufficient parking spaces. Those conditions and states interfere with the use of public transportation and encourage the use of personal transportation. In other words, it is necessary to create an environment where public transportation can be used easily or comfortably for solving the pollution. Once the system changes from low accessibility, inaccurate information, and obsolescence of facilities, the use of public transportation in Hanoi could be increased and the air pollution should be decreased.

The following five solutions were derived to promote public transportation, reduce private vehicles, and resolve air pollution. First, we propose a plan to reduce emissions and expand the use of public transportation through the replacement of electric buses and expansion of bus routes. Although the initial cost is high, it is possible because both the maintenance cost is relatively low, and the government is planning to replace old buses with an electric bus to improve the usage environment. Second, it is necessary to reorganize bus stops and install CCTVs to crack down on illegal parking at bus stops. Reflecting the technology that can check the expected arrival time and location at the bus stop, it provides the predictability to irregular public transportation use and guaranteeing consumer sovereignty through the information. In addition, considering the road traffic states of Hanoi, where the width of the roads in the old city center is narrow and bus traffic is difficult due to traffic congestion, CCTVs check the illegal parking at bus stops and can secure the place of bus way. To overcome the limitations of enforcement by police and to remove the traffic flow obstruction, it is necessary to improve citizens' awareness along with institutional trials. Third, it must adjust the interval between dispatches according to the demand. The flexible spacing system offers the possibility of efficient operation and expanded use. It reduces interval time and extension of the last bus time. Fifth, the safety of users in the complicated road traffic is secured by attaching the STOP sign on the bus. it will relieve users' anxiety and expect a positive change in their perception of public transportation. Lastly, the transportation card is needed to expand the benefits of each subject, and to advance the post policy. The case of Korea showed the positive effects of transportation cards. The survey conducted to figure out the possibility of the solutions received positive responses. Regarding the impact on air pollution, 62.5% expected very positive and positive. However, while the activation of public transportation was mostly positive (47.5%), it was moderate (32.5%) and negative (20%). As a result, these suggested solutions are effective in reducing air pollution, but it needs an additional discussion and improvement for the vitalization of public transportation. Through this study, we can be aware that the vitalization of public transportation is necessary to reduce private vehicles and improve air pollution. Moreover, the majority of people who currently use public transportation are the elderly and students. If those solutions give the possibility for students, who are potential

buyers of motorcycles, to consider public transportation as a new option, the current large number of motorcycles will gradually decrease in the future. Finally, it is expected to contribute to achieving the detailed items 11.2 and 11.6 of the no.11 goal of the United Nations Sustainable Development Goals(SDGs) to address air pollution, which is emerging around the world.

<ACKMOWLEDGEMENT>

This study would not have been possible without the financial support of the UNESCO UNITWIN and Foreign trade University. We are especially indebted to Lê Hà Anh and Đoàn Thị Minh Thủy who have been supportive our study. They informed us in detail about the current state of air pollution in Vietnam and worked hard to find a solution together. Without them, this study could not have been completed.

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Thanks to the 40 FTU students who participated in our survey. Thanks to your participation in the survey, we were able to supplement our solution and understand how confusing public transportation in Vietnam is.

We are grateful to all of those with whom we have had the pleasure to work during this project.

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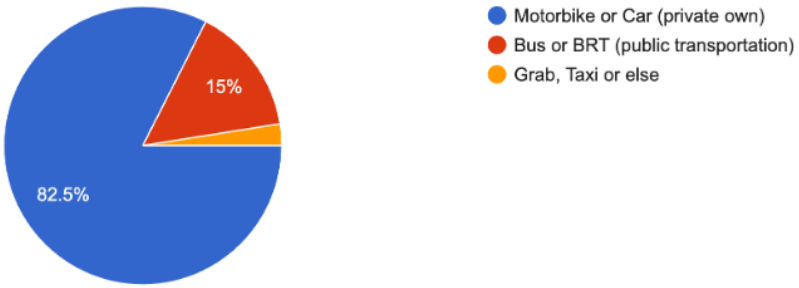
<TABLE LIST>

<FIGURE LIST>

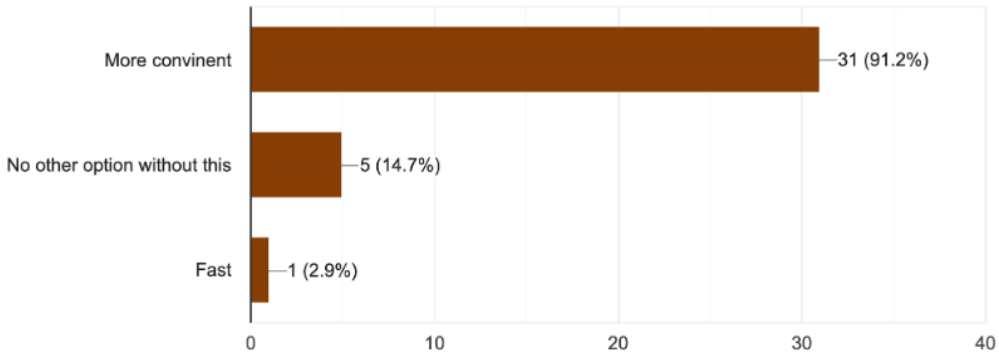
< APPENDICES >

This survey was conducted on 40 FTU students living in Hanoi, Vietnam.

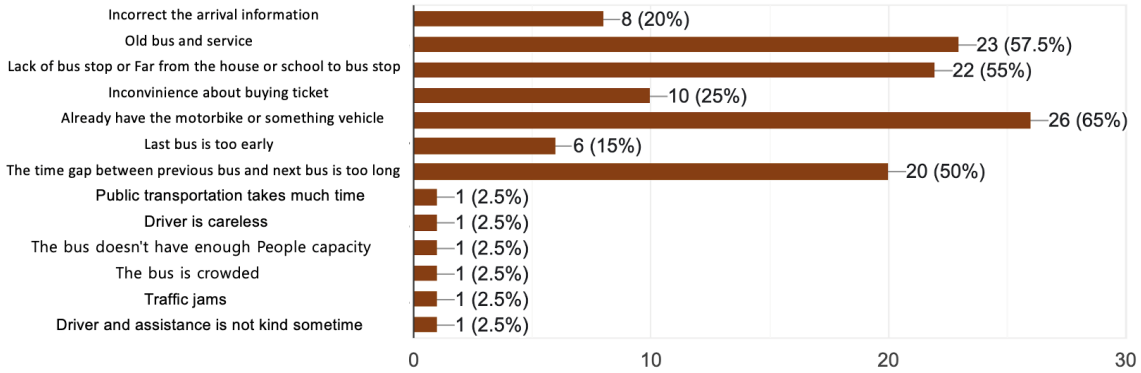
1. **Which one do you mostly use?**



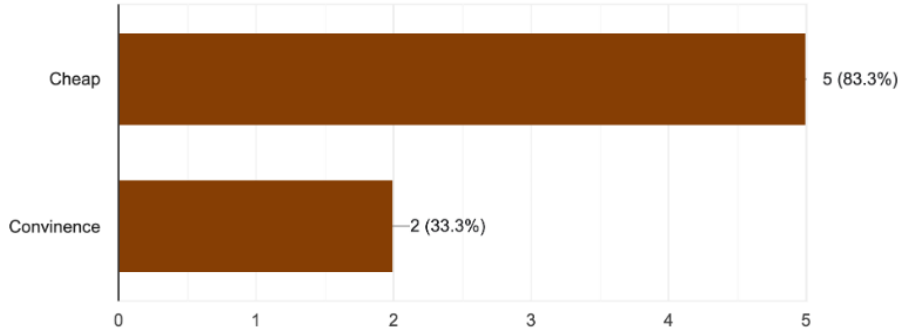
2. **Why did you choose this?**



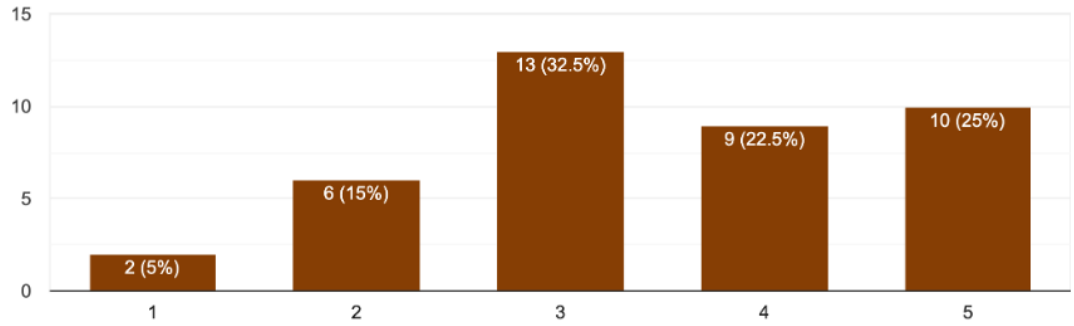
3. **Why don't you use public transportation?**



4. **Why did you choose public transportation?**



5. **In these solutions, will you use public transportation more often?**



6. **Do you think that these solutions can clear the air pollution?**