Chapter 3

Case Study of Da Nang City

September 2017

This chapter should be cited as

ERIA (2017), 'Case Study of Da Nang City', in Kutani, I. (eds.), *Addressing Energy Efficiency in the Transport Sector Through Traffic Improvement*. ERIA Research Project Report 2016-04, Jakarta: ERIA, pp.21-40.

Chapter 3
Case Study of Da Nang City

A comparison of the estimated modal share and the fuel consumption volume (2017) in Da Nang City would reveal that although the truck trips share only 19% (next to 47% of motorcycles), the fuel consumption volume shares 83% of total volume, and that a highway installation mainly for truck trips is quite effective to reduce not only direct fuel consumption volume caused by traffic flow improvement of trips in and outside Da Nang City but also fuel consumption volume caused by alleviating inside trips congestion in the city centre.

For other trips except for truck trip which moves inside the city using the open road, the following scenarios were examined: (i) planned scenario in the Transport Master Plan[4], (ii) its implementation with delay (10 years) scenario, (iii) car-shift scenario as compared with planned scenario (where the most share is taken by motorcycles), and (iv) implementation delay (10 years) of the public transport development plan in the car-shift scenario (Table 3.5).

Based on the results, we could prove that (i) the fuel consumption volume of the car-shift scenario compared with that of the planned scenario is larger by 50%; (ii) the fuel consumption reduction effect, by shifting from motorcycle to public transport in the planned scenario, is limited; and (iii) the car-shift scenario, by shifting from a car trip to a public transportation trip, will directly lead to alleviating traffic congestion and fuel consumption reduction. Therefore, we need to prepare for this car-shift path process and prevent delay in its implementation, as well as an age of 'Car Affluent Society' on the road, by providing the necessary measures.

3.1. Reviews of the Transport Master Plan of Da Nang City

(1) Da Nang Transport Master Plan

The Da Nang Transport Development Master Plan up to 2020 and Vision to 2030 was officially approved on 28 July 2014 (No.5030/QD-UBND) with the following planning viewpoints:

・To fit the Da Nang SEDP (Socio-Economic Development Plan), Land-use Plan, and General Construction Plans up to 2030 and Vision to 2050

・To develop an integrated, sustainable, and modern transport systems and to provide convenient transport services to meet the travel demand

・To formulate a feasible plan on the basis of scientific measures to satisfy both current and long-term demand

[4] Approval of master plan for public passenger transport by bus in Da Nang City for 2013–2020 and vision to 2030.

・To give priority for public transport development, traffic congestion, and accident alleviation in Da Nang City.

The master plan covers the planning period up to 2020 and vision to 2030. The following are the target indicators for key aspects:

(1) Infrastructure

・To develop the transport infrastructure adequately in an integrated manner with other plans, especially the urban construction plan to meet the indicator that the urban transport land should share 20%–26% of urban construction land

・To increase road density to 3 kms/km^2–5 kms/km^2 in 2020 and 5 kms/km^2–6 kms/km^2 in 2030

・To set public transport network density at 2 kms/km^2–2.5 kms/km^2 urban construction land

・Static transport land to account for 3%–4% of urban construction land.

(2) Public Transport Development

・To prioritize development of public transport to increase the public transport share to 15%–20% in 2020 and 25%–35% in 2030

As a result, the master plan is now composed of the following subsectors as illustrated in Figure 3.1 and Figure 3.2:

・Road Infrastructure Development Plan

・Static Transport Plan

・Intersection and Bridge Plan

・Urban Traffic Management and Operation

・Non-motorized Transport and Pedestrian Promotion

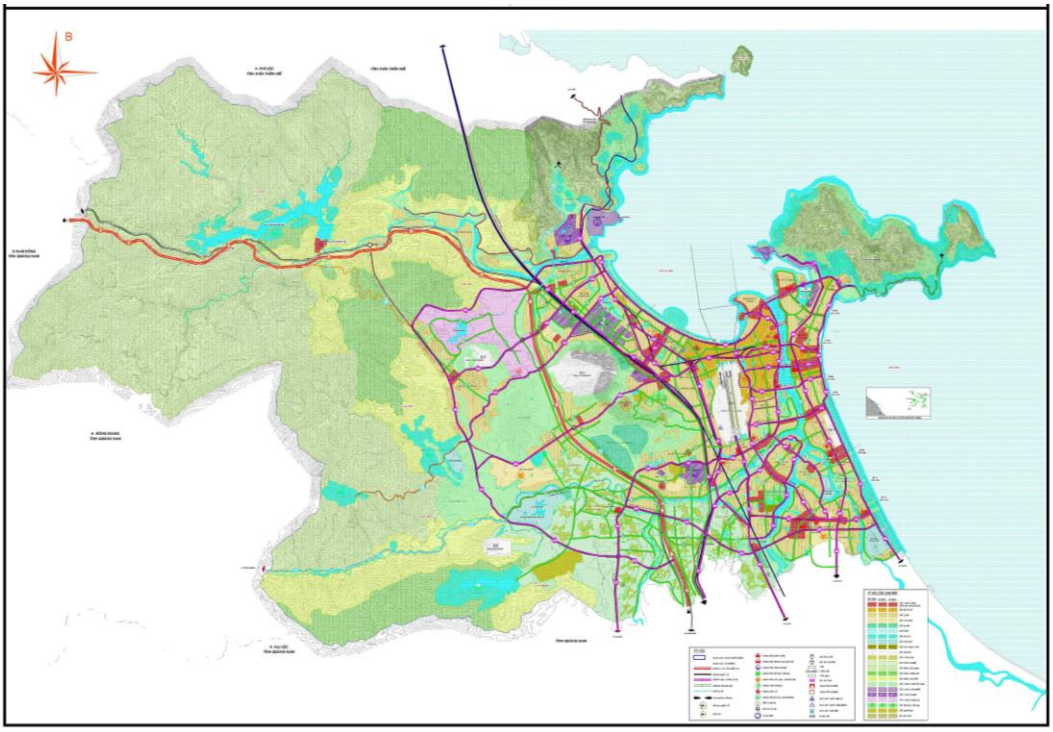
・Public Transport Network Plan

・National Railway Plan

・Waterway Transport Plan

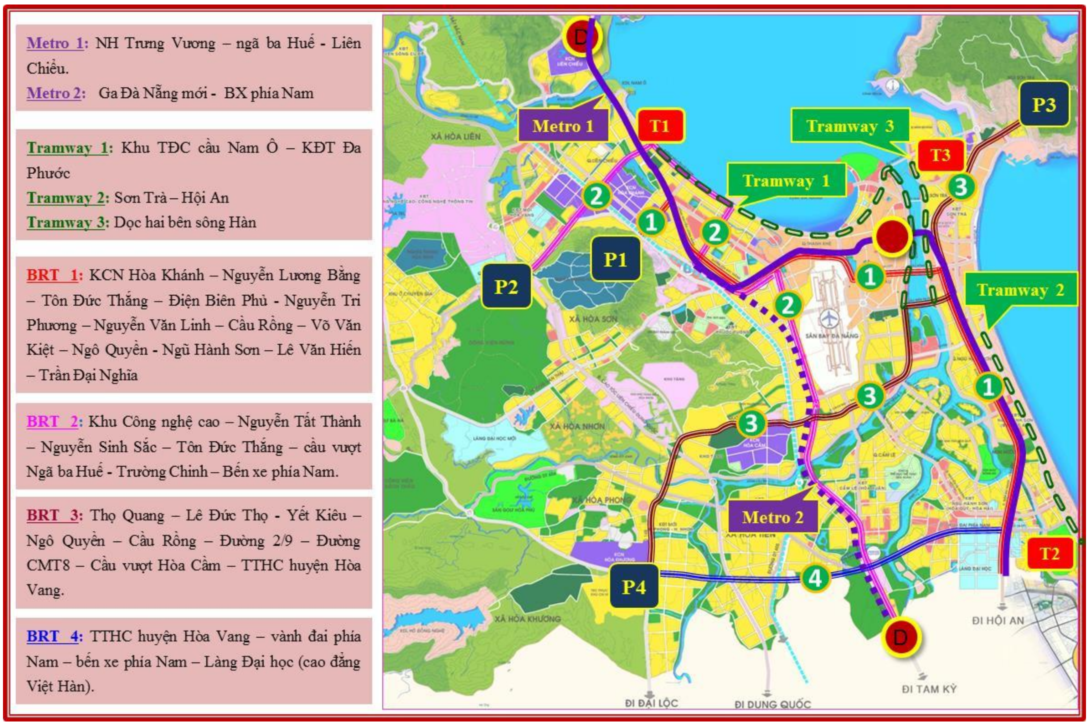
・Air Transport Plan

Figure 3.1: Da Nang Transport Master Plan up to 2020 and Vision to 2030



Source: Da Nang City Government, 2014, Da Nang Transport Development Master Plan up to 2020 and Vision to 2030.

Figure 3.2: Da Nang Public Transport Network Plan up to 2030



Source: Da Nang City Government, 2014, Da Nang Transport Development Master Plan up to 2020 and Vision to 2030.

(2) Implementation Status

The master plan included various plans and projects as summarized in Table 3.1 and 3.2.

Table 3.1: Da Nang Status of Transport Development Plans or Projects

Subsector	Category	Project	Schedule	Status as of May 2017
Road Infrastructure Development Plan	Inter-city Expressway	・ Da Nang–Quang Ngai Expressway: Thuy Loan–Dung Quat Section (6 lanes, 130 kms)	By 2020	On-going (to be completed in 2017)
		・ Da Nang–Quang Ngai Expressway: La Son–Tuy Loan section (2 lanes as initial)	By 2030	On-going
		・ Quang Tri–Da Nang Expressway (4 lanes, 178 kms)	By 2030	Not yet
	National Highways	・ Upgrade of Southern Hai Van Pass Route ・ Upgrade of NH14B: Tien Sa–Tuy Loan (Da Nang)–Thanh May (Quang Nam) ・ Upgrade of NH14G: Tuy Loan (Da Nang)–Dong Giang (Quang Nam)	By 2020/2030 (Not specified)	Partly on-going
	Ring Road	・ Upgrade of Southern, Northern, Western Ring Roads	By 2020/2030 (Not specified)	Partly on-going
	Provincial Road (PR)/District Road (DR)	・ Upgrade of PR601, PR602, PR605, and district roads (DR4, DR8)	By 2020/2030 (Not specified)	Partly on-going
	Urban Road	・ Upgrade and new construction of urban trunk roads (260 kms)	By 2020	Partly on-going
		・ Upgrade and new construction of urban trunk roads (138 kms)	By 2030	Not yet
Static Transport Plan	Terminals and Parking Facilities	・ Northern bus terminal	By 2030	Not yet
		・ Truck terminals ・ Urban bus terminals and parking spaces ・ Parking system	By 2020/2030 (Not specified)	Not yet
Intersections and Bridges Plan	Intersections	・ 9 grade-separated interchanges ・ 38 access-controlled signalized intersections	By 2020/2030 (Not specified)	Partly on-going
	Bridges	・ New Han River Bridges (6) ・ New Cam Le River Bridges (3) ・ Tuy Loan River Bridges (5) ・ Co Co River Bridge (4) ・ Lo Giang River Bridge (1) ・ Vinh Dien Bridge (2) ・ Yen River Bridge (3) ・ Cu De River Bridge (2)	By 2020/2030 (Not specified)	Partly on-going
Urban Traffic Management and Operation	Traffic Control System	・ Traffic signal system, CCTV system, software, ITS, etc.	By 2020/2030 (Not specified)	Partly on-going
Non-motorized Transport (NMT) and Pedestrian Promotion	NMT and Pedestrian	・ Improvement of Nguyen Van Troi Bridge for pedestrian bridge ・ Promotion of NMT/pedestrian street in the CBD and tourist site	By 2020/2030 (Not specified)	Not yet

Source: Da Nang City Government, 2014, Da Nang Transport Development Master Plan up to 2020 and Vision to 2030.

Table 3.2: Da Nang Status of Transport Development Plans or Projects (continued)

Subsector	Category	Project	Schedule	Status as of May 2017
Public Transport Network Plan	Urban Rail	・ Metro Lines ・ Tramways	By 2030	Not yet
	Urban Bus	・ BRT and BRT standard routes ・ Urban bus routes	By 2020/2030	Partly on-going
National Railway Network Plan	National Railway	・ New Da Nang Station ・ New Kim Lien Station ・ Study of New Hai Van Tunnel	By 2020	Partly on-going
		・ Re-route of 20-km railway section ・ Upgrade of Le Trach Station	By 2030	Not yet
Waterway Transport Plan	Da Nang Port	・ Upgrade of Tien Sa and Lien Chieu ports (general cargo and container) ・ Relocation of Han River Port ・ Upgrade of Son Tra Port (general cargo and oil)	By 2020/2030 (Not specified)	Partly on-going
	Inland Waterway	・ New construction material berths ・ New tourist boat berths ・ Upgrading of waterway routes (cargo and tourist)	By 2020/2030 (Not specified)	Partly on-going
Air Transport Plan	Da Nang International Airport	・ New International Passenger Terminal	By 2020	On-going (to be completed in 2017)
		・ Improvement of related facilities	By 2030	Partly ongoing
		・ Expansion of civil aviation land	By 2020	Partly ongoing

Note: Status was indicated by the Study Team.
Source: Da Nang City Government, 2014, Da Nang Transport Development Master Plan up to 2020 and Vision to 2030.

Consistent with the Transport Master Plan, Da Nang City prepared Master Plan for Passenger Transport by Bus for 2013–2020 and Vision to 2030, which was approved on 19 November 2013 (No. 8087/QD-UBND). From this decision, the phased development plan of the urban bus routes is summarized in Table 3.3.

Table 3.3: Status of Urban Bus Route Development Plan

Year Period	Planned No. of Routes			Status (as of May 2017)
	BRT	BRT Standard	Urban Bus	
2013–2015	-	-	11	6 existing routes only
2016–2020	2	3	15	New 5 bus routes started in 2016.
2021–2025	4	3	19	N.A.
2025–2030	4	3	21	N.A.

Note: Status was indicated by the Study Team. BRT = bus rapid transit, N.A. = not applicable.
Source: Da Nang City Government, 2014, Da Nang Master Plan for Public Passenger Transport by Bus for 2013–2020 and Vision to 2030.

(3) Consideration for the Master Plan Implementation

As a result of review of current implementation status of the transport plans and projects, we identified the following considerations for effective implementation of the master plan:

- Urban road network development is progressing relatively smoothly, but improvement of traffic management system, terminal and parking system development, and promotion for non-motorized transport and pedestrians are somewhat falling behind.
- The expected modal shift to public transportation is relatively delayed as BRT development by the World Bank and the expansion of the urban bus route network by the Department of Transport (DOT) are delayed.
- Due to the delay in the development of Lien Chieu Port, port cargoes are concentrated in Tien Sa Port which increases truck traffic and has a negative impact on urban road traffic.
- Da Nang–Quang Ngai Expressway opens soon, but the northern section connecting to Hue is still underdeveloped. As a result, the impact on Da Nang urban transport due to regional traffic moving in the neighbouring areas remains significant.

3.2. Modelling Analysis

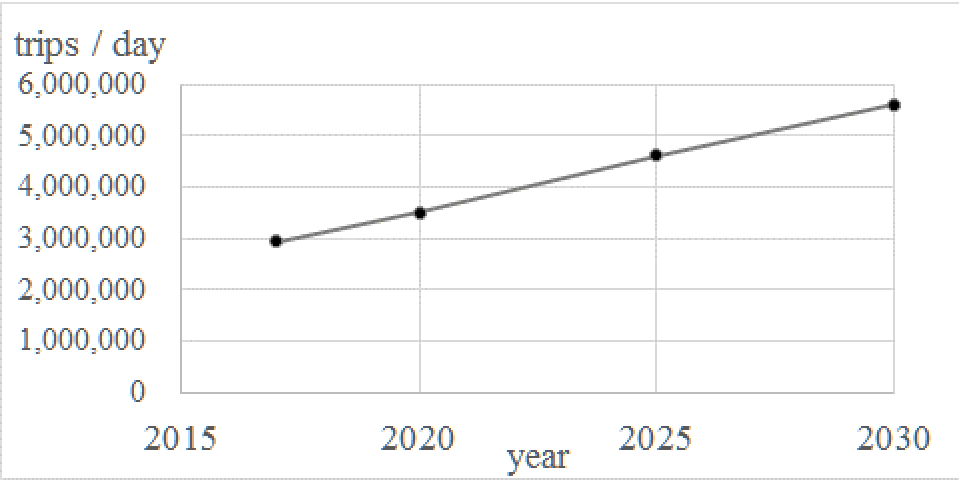
3.2.1. Transport Development and Energy Efficiency in Da Nang City

The first step in handling an energy policy and a traffic policy in an integrated manner is to understand the relation between traffic and fuel consumption. Since traffic congestion is becoming a significant social issue in developing countries in EAS region, the road network and public transportation systems have been designed as the Transport Master Plan by the concerned authority of each country corresponding to the development stage of cities for achieving their sustainable development.

From a transport economy's standpoint, traffic congestion represents a state in which transport demand for roads exceeds the transport supply. Since Da Nang City, like other Asian cities, has been

From a transport economy's standpoint, traffic congestion represents a state in which transport demand for roads exceeds the transport supply. Since Da Nang City, like other Asian cities, has been developing rapidly, transportation demand is expected to grow significantly. The traffic volume in the entire city (trips between zones) is estimated at about 2.9 million trips per day in 2017, which figure is expected to almost double to about 5.6 million trips per day in 2030[5] (Figure 3.3). Therefore, the city intends to cope with the expected sharp increase in traffic volume.

Figure 3.3: Da Nang Transition of Trip Number by Year



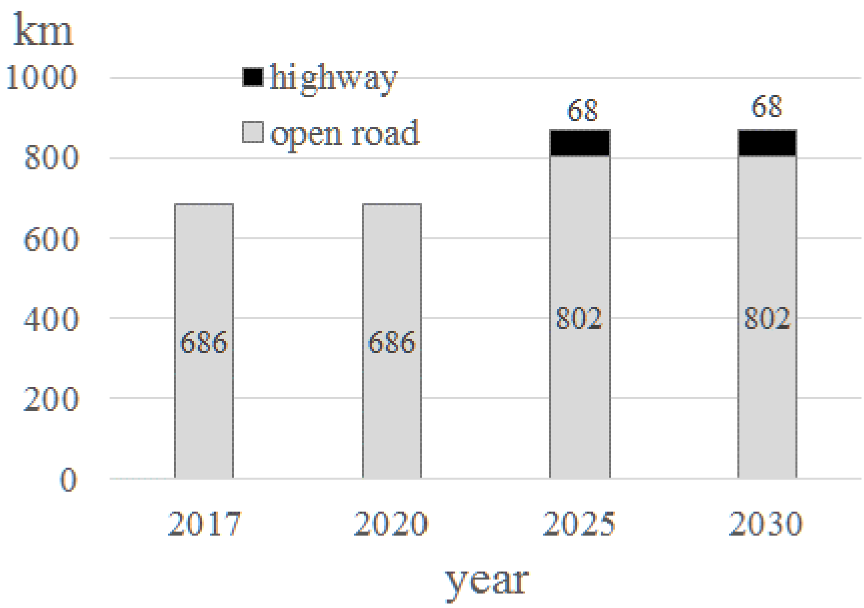
Source: Create from the "Study on the Integrated Development Strategy for Danang City and Its Neighboring Areas in the Socialist Republic of Vietnam"

When congestion occurs in a city, it is usually caused by an increase in transport demand; a significant and sudden fluctuation in supply is unlikely in the case of road-based transport. Methods for improving supply capability to improve traffic flows can be categorized into (i) methods that directly increase supply, such as increasing road capacity or rationalizing road structure (like highway construction) and (ii) methods that improve the supply efficiency by introducing a large-sized road public transport system, such as bus, BRT, or mass rail transit (MRT) system.

For method (i), it is not easy to double the road capacity in accordance with demand increments within such a short period, although the city is planning to expand and improve road transport. According to Transport Master Plan, as shown in Figure 3.4, the 686-km length of open road in 2017 is planned to extend only to 802-km length (an increase of 17% from 2017) in 2030 and 68-km length of highway in 2030.

[5] The numbers in the DaCRISS (Study on the Integrated Development Strategy for Danang City and Its Neighboring Areas in the Socialist Republic of Vietnam) Scenario 3 of 2025 multiplied by the rate of population change are used.

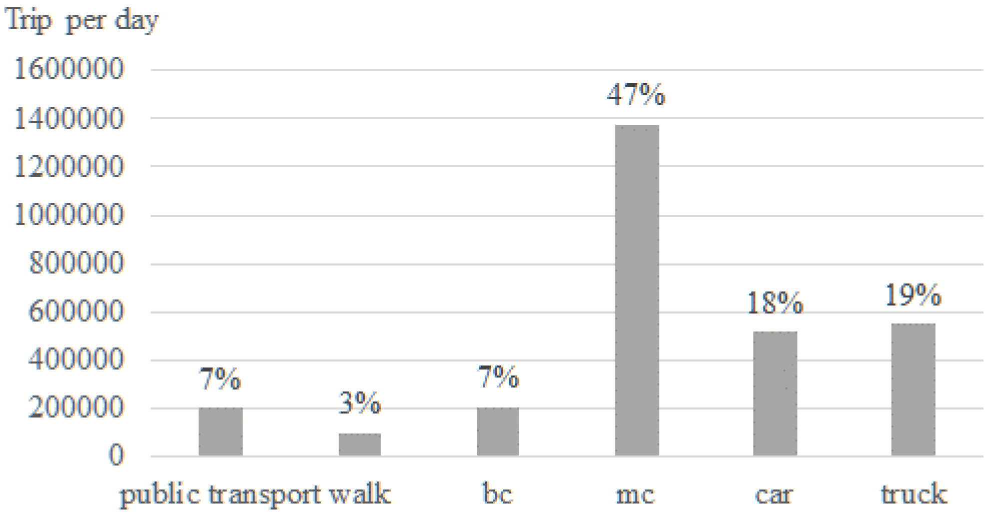
Figure 3.4: Road Lengths Extension (Planned) by Year



km = kilometre.
Source: Create from the "Da Nang Master Plan for Public Passenger Transport by Bus for 2013–2020 and Vision to 2030"

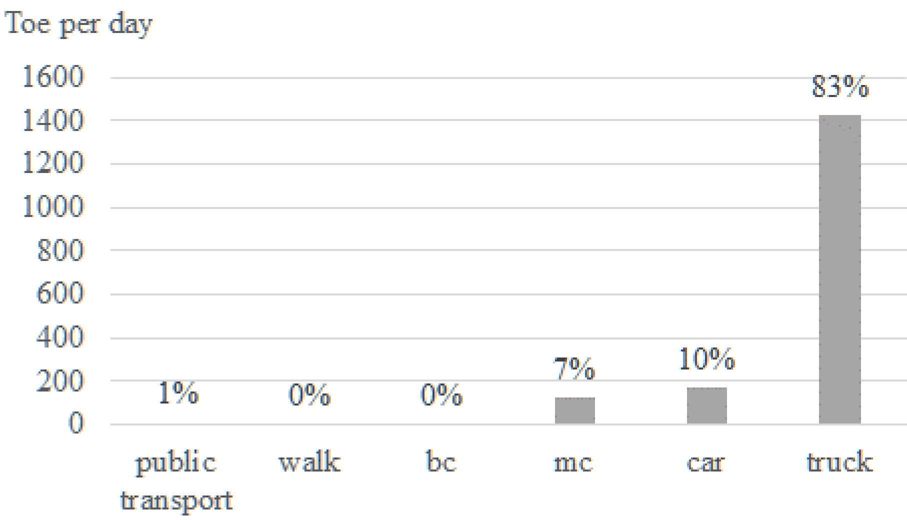
The estimated modal share and fuel consumption volume in 2017 in Da Nang City are summarized in Figures 3.5 and 3.6. The number of truck trips takes only 19% of trip share (548,813 trips per day) in Da Nang City, and the fuel consumption shares 83% of total volume (1,424 tonnes of oil equivalent [toe] per day). On the other hand, the number of car trips takes 18% of trip share (516,074 trips per day), and the fuel consumption shares 10% of total volume (169 toe per day); subsequently, for motorcycles 47% (1,375,669 trips per day) and 7% (124 toe per day), and for other mode 13% and 1%. Thus, the truck trips in Da Nang City is important from the viewpoint of fuel consumption volume since an increase of this trip will have an environmental impact on the society. While truck move in and outside Da Nang City, the other mode trips move mainly inside the city. Thus, we will first examine the effect of the highway construction in the next section.

Figure 3.5: Modal Split Using DaCRISS Model (2017)



bc = bicycle, mc = motorcycle, DaCRISS = Study on the Integrated Development Strategy for Danang City and Its Neighboring Areas in the Socialist Republic of Vietnam.
Source: Study team. (The same 'User preference model' as the FY 2016's report is applied.)

Figure 3.6: Fuel Consumption Volume by Mode (2017)



bc = bicycle, mc = motorcycle. toe = tonne of oil equivalent.
Source: Study team.

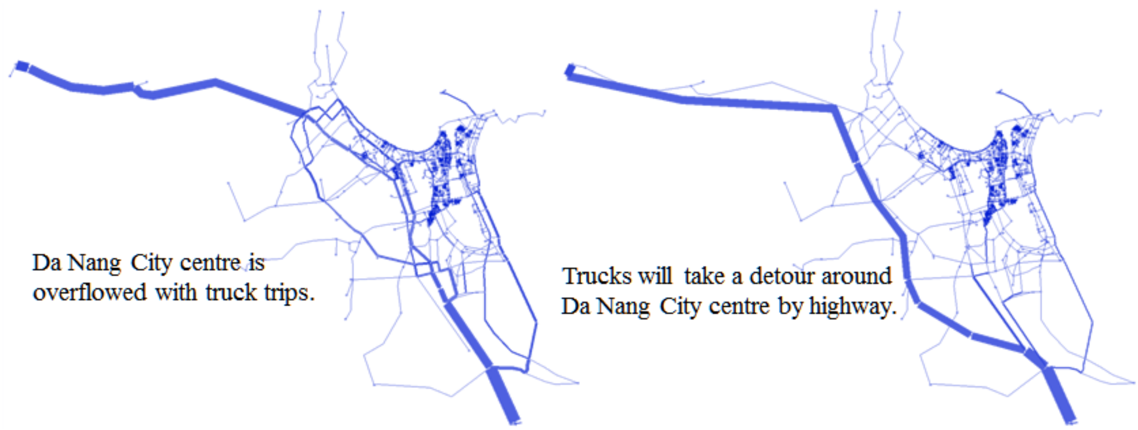
3.2.2. Highway Installation and Energy Efficiency in Da Nang City

The planned highway construction that bypasses Da Nang City centre may achieve not only reducing fuel consumption but also alleviating the traffic congestion in the city, since the currently overflowed truck trips passing through Da Nang City may be taking a detour around the city centre and quite effectively reduce fuel consumption as well.

In fact, according to the website news[6] the Da Nang–Quang Ngai Expressway Project (DQEP), as part of the North–South Expressway, will connect Da Nang and Quang Ngai provinces. Construction started in May 2013 and is expected to complete by 2017 almost as scheduled. This new expressway is expected to shorten the distance and travel time between the provinces of Da Nang (outside Da Nang City), Quang Nam, and Quang Ngai. It is also expected to reduce traffic congestion and increase economic development opportunities in the region.

With this background, we conducted a traffic simulation on how effectively the planned bypass highway construction in the Transport Master Plan around Da Nang City centre will alleviate traffic congestion and reduce fuel consumption volume (Figure 3.7).

Figure 3.7: Traffic Flow with or without Highway (2017)



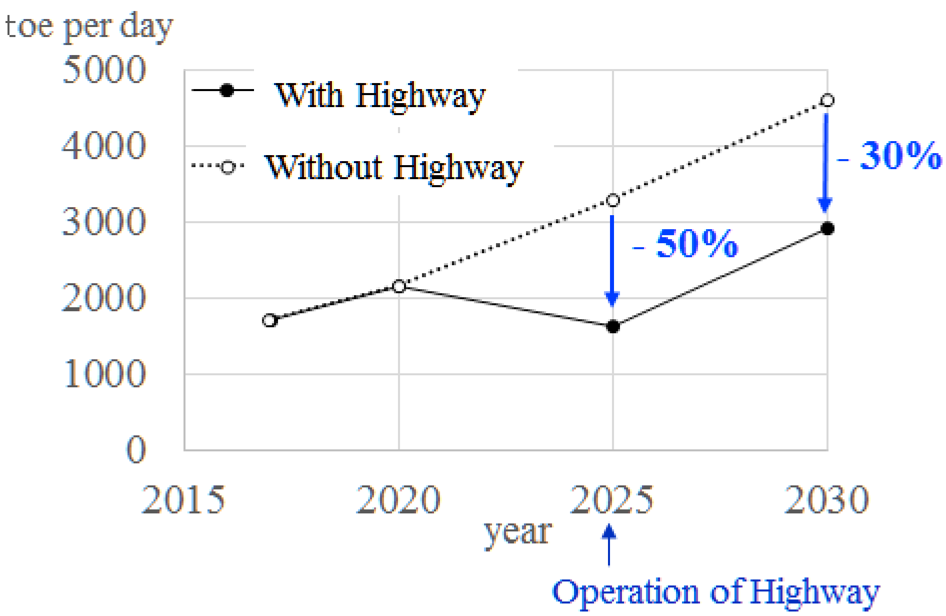
Note: Volume in passenger car unit (PCU).
Source: JICA (2010), Study on Integrated Development Strategy for Danang City and Its Neighboring Areas in the Socialist Republic of Vietnam (DaCRISS).

The results of effect on the fuel consumption with and without highway are shown in Figure 3.8 and Figure 3.9. The highway installation will reduce 50% of the fuel consumption volume in 2025 (equivalent magnitude of the effect of replacing all existing trucks in Da Nang City to fuel-efficient vehicles) and 30% in 2030. If we compare the reduction volume by mode, the truck trips is the largest (39% reduction of fuel consumption from the 'without highway' case), followed by 28% reduction in the car trips, and 12% reduction in motorcycle trips.

This happens because of the traffic flow improvement with highway operation from an average speed of 20 kms/hour (h) in 2020 to 26 kms/h in 2025 (decline to 17kms/h in 2025 without highway). Therefore, the highway operation is a great measure of improving fuel economy and, as a result, curbing oil demand. We could prove that a highway installation is quite effective to reduce not only direct fuel consumption volume caused by traffic flow improvement of trips in and outside Da Nang City but also fuel consumption volume caused by alleviating inside trips congestion in the city centre.

[6] http://www.roadtraffic-technology.com/projects/-da-nang-quang-ngai-expressway-vietnam/

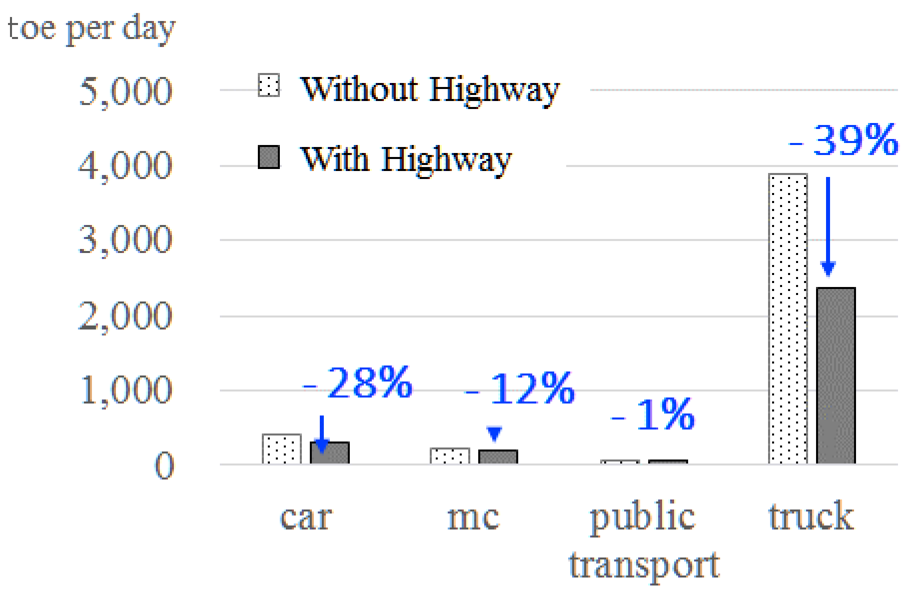
Figure 3.8: Comparison of the Fuel Consumption Effect with or without Highway



toe = tonne of oil equivalent.
Source: Study Team.

Figure 3.9: Comparison of the Fuel Consumption Effect

by Mode with or without Highway (2030)



mc = motorcycle, toe = tonne of oil equivalent.
Source: Study Team.

3.2.3. Public Transport and Energy Efficiency in Da Nang City

Besides the trips moving on the highway, the other mode trips, except truck trips, move mainly inside the city using the open road. On method (ii) described in Section 3.2.1, the lengths of open road are planned to extend only an increase of 17% from 2017 in 2030. Thus, those trips must shift to a larger-sized public transport system through the provision of optimum combination of public transport systems to reduce the fuel consumption.

As shown in Table 3.4, it is clear that bus[7] is the most efficient mode of road-based transportation. Cars require four to nine times bigger road space compared with bus for transporting the same number of passengers. This means that the traffic volume could be alleviated by shifting to the bus mode from cars and motorcycles. Thus, the introduction of a BRT system is one of the key features of public transport system development in Da Nang City.

Table 3.4: Utilization Efficiency of Road Space by Transportation Mode

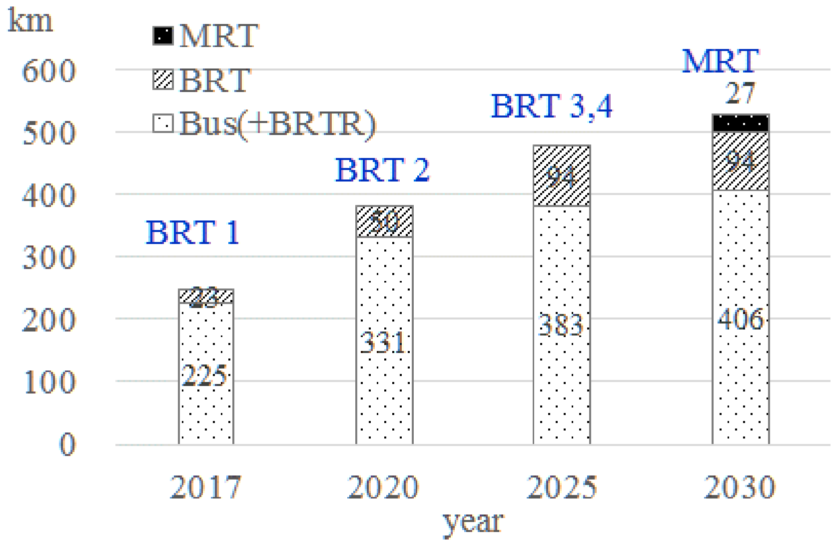
	Car	Motorcycle	Bus
Average Occupancy (pax/vehicle)	2.0	1.3	15–36
PCU (Passenger Car Unit)	1.0	0.4	2
Ave. No. of Passengers per PCU	2.0	3.0	8–16

PCU = passenger car unit.
Note: PCU is a vehicle unit used for expressing highway capacity. One car is considered as a single unit, motorcycle is considered as 0.4 car unit. Bus causes a lot of inconvenience because of its large size and is considered equivalent to two cars or two PCUs.
Source: DaCRISS (2009), The Study on the Integrated Development Strategy for Danang City and Its Neighboring Areas in the Socialist Republic of Vietnam.

According to the Transport Master Plan, four types of public transport are scheduled to be introduced: BRT, BRT standard bus (BRTR[8]), MRT, and bus in the 4 target years, namely 2017, 2020, 2025, and 2030. The first BRT line is planned to be introduced in 2017, and four more in 2025. In addition, the MRT is scheduled to be introduced in 2030. MRT is a track vehicle that is expected to have 10 times the capacity of BRT. MRT, BRT, and BRTR are considered to play the role as the main public transport mode. Table 3.10 shows that the 225 kms route lengths of bus and 23 kms of BRT in 2017 are planned to extend to 406 kms route lengths of bus (an increase of 80% from 2017), 94 kms of BRT (an increase of 400% from 2017), and 27 kms of MRT in 2030.

[7] Average occupancy of bus is 15 passengers at present. It is assumed that it will increase if urban bus service is significantly improved.
[8] BRTR is a type of bus that is specific to Da Nang City. Although it is positioned as a special kind of bus, it is little different from a normal bus given that it does not have dedicated lanes. It is treated here as the main public transport (not the target of optimization) considering its special positioning.

Figure 3.10: Route Length of Public Transport by Year



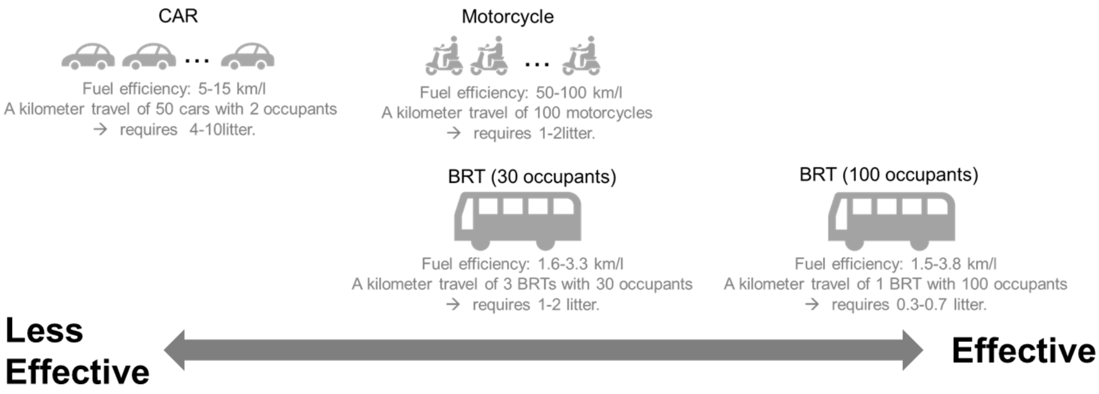
BRT = bus rapid transit, BRTR = bus rapid transit standard bus, MRT = mass rail transit.
Source: Da Nang City Government, 2013, Master Plan for Public Passenger Transport by Bus in Da Nang City for 2013–2020 and Vision to 2030.

In a BRT system, dedicated BRT lanes give the bus system priority over private transport mode, allowing the system to carry a larger number of passengers faster. If used effectively, it could contribute to reducing energy consumption in the transport sector. Alleviating traffic congestion would have a much greater effect on improving fuel efficiency in a shorter period than technological improvements and actual deployments by automobile manufacturers.

As a rough illustration of the energy consumption reduction effect by introducing the BRT system, suppose 100 people travel 1 km along the same road as shown in Figure 3.11. If one person rides on one motorcycle, as is typical in Da Nang City, 100 motorcycles are needed to transport 100 people. Whereas when using the BRT, we can expect a reduction in fuel consumption of about 60% since a bus can accommodate 100 people. Additionally, the BRT, as compared with cars, is expected to reduce fuel consumption by about 90%. Moreover, when the number of passengers per vehicle increases, the BRT system is capable of sudden fluctuation in demand even during doubling trips in a short period, and the energy consumption is reduced.

According to the current transport development situation in Da Nang City described in Section 3.1, the road and highway construction is proceeding almost as scheduled, but the implementation of BRT deployment has been delayed for almost 3 years in its service commencement (from 2016 to 2019). Although some metropolitan areas in the developing world have urban public transit services, such as MRT and BRT, implementation of these projects often tends to take a longer time because of complicated planning and design process, land acquisition procedures, political disputes, and preparation of funding. Therefore, the study examined whether this implementation delay would lead to worsening traffic congestion and, consequently, increase fuel consumption volume due to the increasing trip shares of car and motorcycles modes, to identify the importance of timely deployment of MRT and BRT systems.

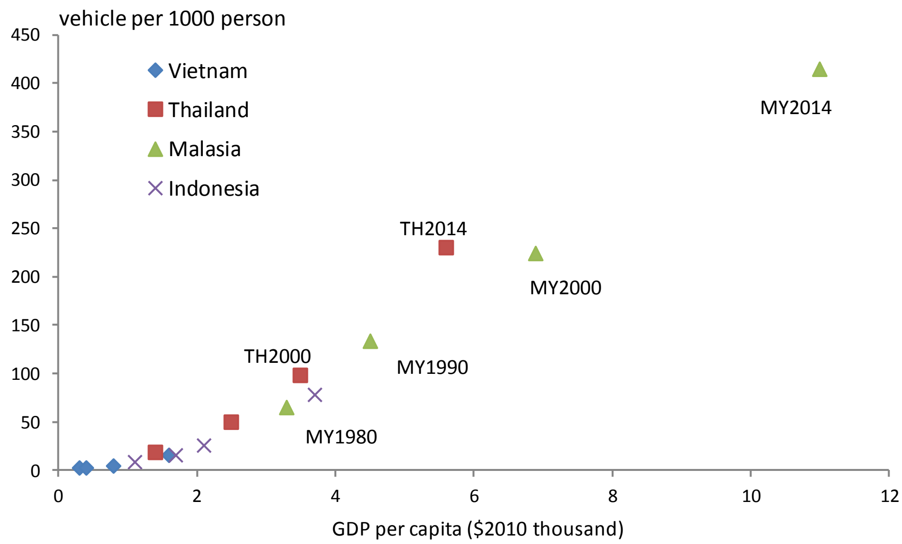
Figure 3.11: Illustration of Fuel Consumption Volume by Transport Mode



BRT = bus rapid transit, km = kilometre, l = litre.
Source: Study team.

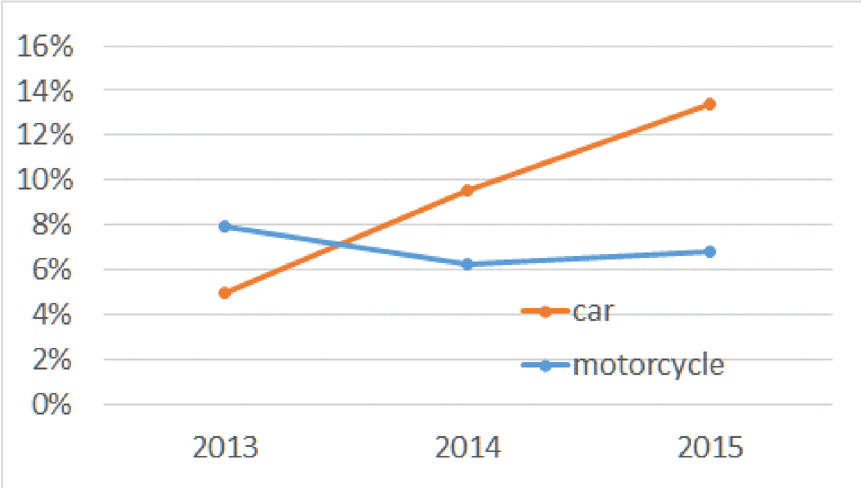
In addition to project delay effect, the study examined the effect of more-than-expected increase of car ownership. History tells an existence of strong correlation between income level of people and number of car ownership. This relationship can be observed in ASEAN countries, such as Indonesia, Malaysia, and Thailand (Figure 3.12). As gross domestic product (GDP) per capita increases, the number of can ownership also increases. Viet Nam seems tracing the same pattern. The balance of GDP per capita and car ownership in Viet Nam in 2014 is similar to that of Indonesia in 1990 and Thailand in 1980. Although there remains a possibility of its going other way, it can be said that car ownership in Viet Nam will increase with high probability. In fact, motorcycles still share the majority of transportation mode in Da Nang City, but, currently, the increment rate of car sales volume is larger than that of motorcycles from 2013 to 2015 (Figure 3.13).

Figure 3.12: Correlation between per Capita Income and Car Ownership in Selected ASEAN Countries



GDP = gross domestic product, TH = Thailand, MY = Malaysia.
Source: The Institute of Energy Economics, Japan (IEEJ) (2016*), Asia/World Energy Outlook 2016*.

Figure 3.13: Recent Growth Rates of Sales Volume for Car and Motorcycle



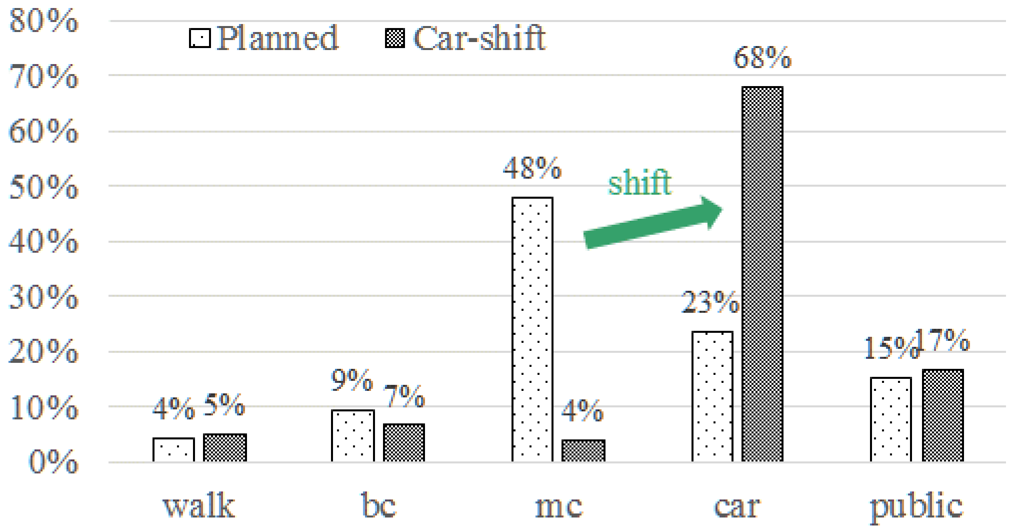
Source: Da Nang Police Department.

Further, in 2018, custom duty on car import and export within the ASEAN region is scheduled to be eliminated, according to the ASEAN Economic Community Blueprint 2025, that may result in an inflow of cheap imported cars to Viet Nam. We expect the worst case of more people shifting from motorcycle to car use than to the planned shares in the Transport Master Plan, which will worsen traffic congestion and increase fuel consumption volume.

As for the passenger car in Viet Nam, the domestic market is immature unlike on the two-wheeled vehicle (motorcycle), and the expansion potential of the market is much larger. The ownership ratio of passenger car in Viet Nam in 2013 was 20 per 1,000 people[9], which is the lowest level among the ASEAN nations. However, the domestic market is in the trend of expansion because of rise in income levels. Global competitiveness of domestic automotive products is remarkably inferior compared with that of other ASEAN nations due to reliance on the import goods for production. Thus, import, for example, from Thailand may increase the import volume if the present high custom duty of 50% is eliminated in 2018. Although the increasing import volume of cars depends on government's future policies of a domestic tax system on cars, we can foresee that a car-dominant society, like in developed cities, is coming to Viet Nam, if the current situation continues. Thus, we have a hypothetical situation where most of motorcycle trips will shift to car trips first (the car-shift scenario, Figure 3.14), and then car trips will shift to public transport trips as Tokyo had experienced (Figure 3.15). This path is different from that of the Transport Master Plan where motorcycle trip will shift directly to public transportation.

[9] ASEAN Automotive Federation, OICA, World Bank.

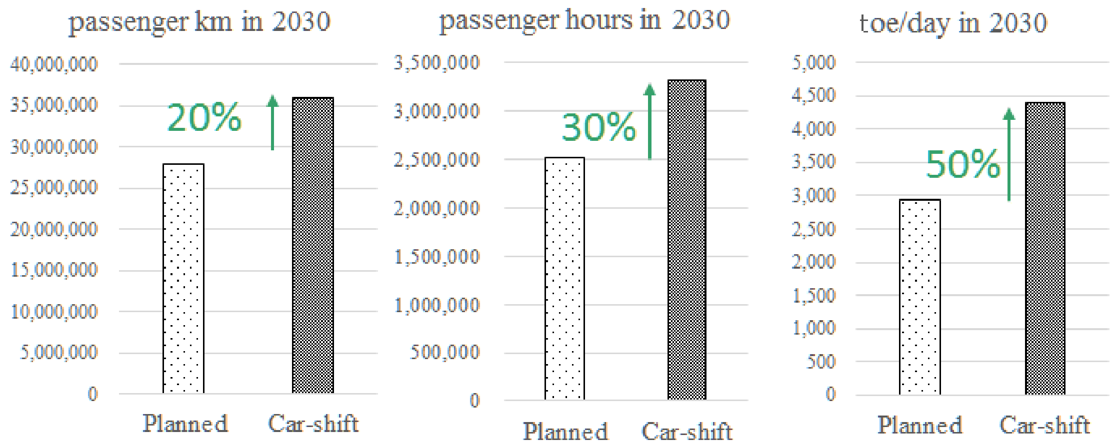
Figure 3.14: Comparison of Modal Share between the Planned Scenario and the Car-shift Scenario in 2030



bc = bicycle, mc = motorcycle, public = public transportation.
Source: Study Team.

We examined whether this car-shift scenario may lead to worsening traffic congestion and increasing fuel consumption volume due to the increasing trip shares of car, with the condition that the number of trips does not change from the Transport Master Plan. The car-shift scenario is compared with the Transport Master Plan (Figure 3.15). The total travelling distance in kilometre will increase by approximately 20% due to the increasing detour traffic in a certain part of roads caused by the larger-sized car influencing other traffic critical than that of a motorcycle. Then, this leads to a 30% increase of passenger hours and a decline in an average speed from 22 kms/h to 20 kms/h in 2030. As a result, the fuel consumption volume for the car-shift scenario increases by 50% than that for the planned scenario. This happens not only because of traffic congestion but also because of the greater fuel consumption rate of cars than motorcycles. The modal shift from motorcycle to car has a significant effect on the increasing fuel consumption volume. Therefore, we need to prepare for this scenario with certain measures in advance before we face an age of 'car-affluent society' on the road.

Figure 3.15: Comparison of the Fuel Consumption Effect between the Planned Scenario and the Car-shift Scenario in 2030



toe = tonne of oil equivalent.
Source: Study Team.

From the above arguments, we examined the following scenarios, i.e. comparison of scenarios with and without the influence of 10 years' implementation delay from the Transport Master Plan, and comparison of scenarios with and without the influence of 10 years' implementation delay from the car-shift scenario, to grasp an effective traffic flow improvement policy.

The following are the four scenarios:

(i) The implementation of the public transport development plan in the Transport Master Plan will proceed as planned (the planned scenario).

(ii) The implementation of the public transport development plan will be behind 10 years as scheduled (the 10 years' delay scenario).

(iii) As more motorization will proceed due to higher economic development with the scheduled implementation of road construction, and the government is adopting a favourable custom duty on car import policy, most motorcycle trips will shift to car trips using the current available trip data (the car-shift scenario).

(iv) The implementation of the public transport development plan in the Transport Master Plan for the car-shift scenario society will be behind 10 years as scheduled (the 10 years' delay car-shift scenario).

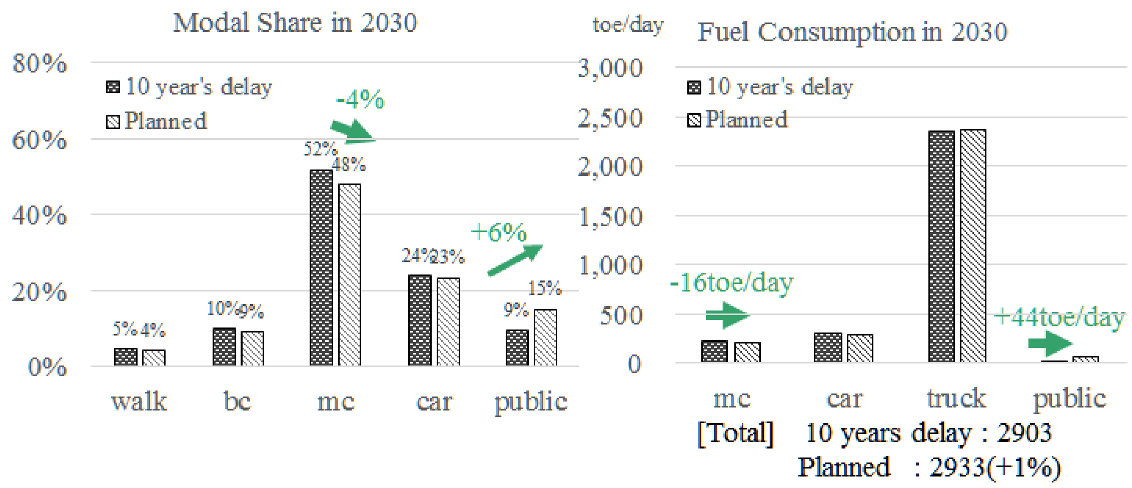
Table 3.5: Scenario Setting

	Name of the Scenario	Progress of the Transport Master Plan	More Car/ Less motorcycle
i	Planned scenario	as scheduled	
ii	10 years' delay scenario	delayed	
iii	Car-shift scenario	as scheduled	✓
iv	10 years' delay car-shift scenario	delayed	✓

Source: Study team.

The results of comparison between the planned scenario and its 10 years' delay scenario are shown in Figure 3.16. The differences are the 6% increase of modal share in the public transportation, and the 4% decrease of modal share in the motorcycle, if there is no delay. These differences do not lead to reduction of the fuel consumption as a whole (in fact, an increase of 1%, i.e. 2,903 toe in the delayed scenario against 2,933 toe in the planned scenario). This happens because motorcycle is very small to alleviate the traffic congestion with the planned public transportation system deployment, and its fuel consumption rate per trip is not that big compared with that of the public transportation use. Thus, we may conclude that this modal-shifting scenario (shift from motorcycle to public transportation) is not effective in terms of fuel consumption reduction.

Figure 3.16: Comparison of the Modal-Shift Effect on the Fuel Consumption between the Planned Scenario and the 10-Year Delay Scenario

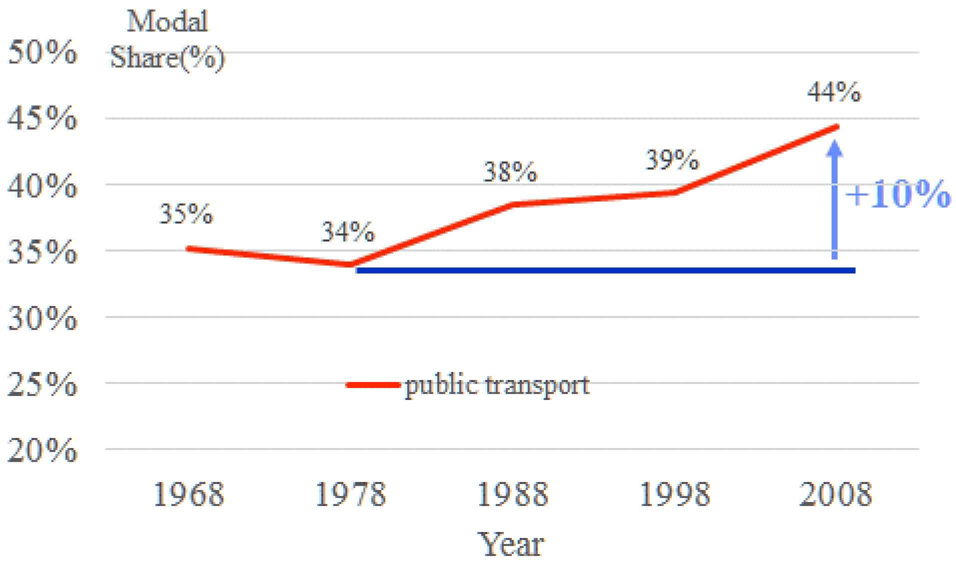


bc = bicycle, mc = motorcycle, public = public transportation, toe = tonne of oil equivalent.
Source: Study Team.

The results of the comparison between the car-shift scenario and its 10 years' delay scenario are shown in Figure 3.18. The differences are the 7% increase of modal share in the public transportation and the 5% decrease of modal share in the car. Tokyo, Japan achieved a 10% increase of modal shift from 1978 to 2008 (Figure 3.17).

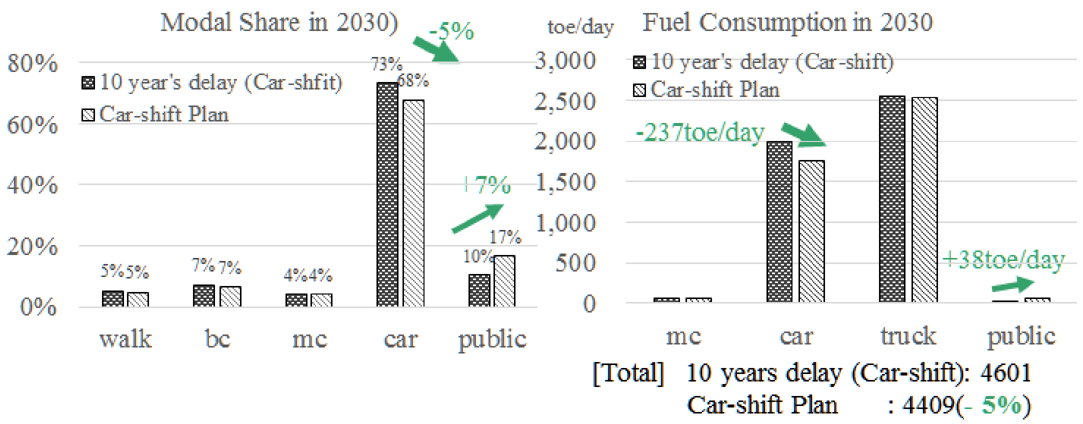
These differences will lead to fuel consumption reduction (a decrease of 5% from 4,601 toe per day in the 10-year delay scenario against 4,409 toe). Thus, if we require reducing a larger amount of fuel consumption as an energy policy (more than 5%), we need to adopt such a traffic policy to decrease the car trip share (more than 5%) and increase the public transportation trip share (more than 7%). This happens because the size of car is large enough to induce traffic congestion compared with that of public transportation, and its fuel consumption rate per trip is a big enough compared with that of public transportation use. Thus, we may conclude that this modal-shifting scenario (shift from car to public transportation) is very much effective in terms of fuel consumption reduction. Therefore, we need to prevent delay in implementation of the public transport development plan with certain measures in advance, before we face an age of 'car-affluent society' on the road.

Figure 3.17: Change of Modal Share of Public Transport in Tokyo, Japan



Source:Tokyo Metropolitan Transport Planning Council (www.tokyo-pt.jp/about/index.html) under Ministry of Land, Infrastructure and Transport of Japan, Tokyo PT Survey in 1968, 1978, 1988, 1998, 2008.

Figure 3.18: Comparison of the Modal-Shift Effect on the Fuel Consumption between the Car-shift Plan and the 10-Year Delay (Car-shift Plan)



bc = bicycle, mc = motorcycle, public = public transportation, toe = tonne of oil equivalent.
Source: Study Team.

3.3. Conclusion

To understand the relation between traffic and fuel consumption, it is noteworthy that the estimated modal share and fuel consumption volume in 2017 in Da Nang City revealed that the number of truck trips shares only 19% (next to 47% of motorcycles), but the fuel consumption volume shares 83% of total volume. Since trucks move mainly in and outside Da Nang City, we examined the effect of the highway installation. The simulation results show that the highway operation will reduce 50% of the total fuel consumption volume (in toe) in 2025 and 30% in 2030. By comparison of various modes, the truck trips shares the largest part of energy consumption of transport sector, i.e. 39%, the car trips shares 28%, and motorcycle trips shares 12%. Therefore, we could prove that a highway installation is quite effective in reducing not only direct fuel consumption volume caused by traffic flow improvement of trips in and outside Da Nang City but also fuel consumption volume caused by alleviating inside trips congestion in the city centre.

Besides trips moving on the highway, the other mode trips, except trucks, move mainly inside the city on the open road. These trips must shift to a larger-sized public transport system through the provision of the optimum combination of transport mode such as bus, BRT, and MRT, to reduce fuel consumption. However, implementations have often been delayed and, hence, an increase in fuel consumption volume due to the increasing trip share of car mode under the car-favourable custom duty policy starting 2018 is expected. Thus, we examined the following scenarios in the traffic congestion and the fuel consumption volume. The scenarios are (i) the planned scenario in the Transport Master Plan, (ii) its implementation delay (10 years) scenario, (iii) the car-shift scenario (car shares the most society) than the planned scenario (motorcycle shares the most society), and (iv) the implementation delay (10 years) of the public transport development plan in the car-shift society.

The modelling analysis indicates that the car-shift scenario will result in a 50% increase of fuel consumption compared with the planned scenario. Further, according to the current transport development situation in Da Nang City described in Section 3.1, the implementation of BRT deployment has been delayed almost 3 years in its service commencement (from 2016 to 2019). In addition to the car-shift scenario analysis, we examined the effect of delay in implementing planned public transportation systems to traffic and fuel consumption volume.

From the above arguments, the four scenarios are set up: (i) the planned scenario in the Transport Master Plan, (ii) its implementation delay (10 years) scenario, (iii) the car-shift scenario, and (iv) the implementation (10 years) delay of the public transport development in the Transport Master Plan scenario.

As a result of comparison between the planned scenario and its 10 years' delay scenario, the increase of modal share in the public transportation, in turn the decrease of modal share in the motorcycle, is not effective in terms of fuel consumption reduction. However, as a result of the comparison between the car-shift scenario and its 10 years' delay scenario, the increase of modal share in the public transportation and the decrease of modal share in the car lead to a meaningful reduction of fuel consumption. Thus, if the policy aims to reduce fuel consumption, government need to adopt such traffic policy to decrease car trips share and increase public transportation trip share. This is because the size of car is large enough to induce traffic congestion and its fuel consumption rate per trip is big enough compared with that of the public transportation.

Thus, we conclude that in the planned scenario, shifting from motorcycle to public transportation, the fuel consumption reduction effect is limited, but shifting from car to public transportation trips in a car-dominated society will directly lead to traffic congestion alleviation and fuel consumption reduction. We therefore need to prepare for this car-shift path process with the necessary measures and prevent implementation delay, before we face an age of 'car-affluent society' on the road.