MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT

**VIET NAM INSTITUTE OF METEROLOGY,
HYDROLOGY AND CLIMATE CHANGE**

TRAN DO BAO TRUNG

RESEARCH ON QUANTIFYING THE CO-BENEFITS OF GREENHOUSE GASES MITIGATION IN THE PUBLIC TRANSPORT SECTOR IN HANOI

Major: Climate Change

Code: 9440221

SUMMARY OF DOCTORAL DISSERTATION

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The dissertation was completed at Viet Nam Institute of Meteorology, Hydrology and Climate Change

Research Advisors:

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Reviewer 1:
Reviewer 2:

The dissertation shall be defended in front of the dissertation Committee at ……………………..
At ………………………………

The dissertation could be found at ……………………..

PREAMBLE

1. The neccessity of the dissertation

Greenhouse gas emissions from human activities are becoming a global problem. Under the impact of climate change, natural disasters tend to change to more extreme nature, threatening human life on Earth. Vietnam is one of the countries that has been early involved in solving the problem of global climate change. In 2020, Vietnam updated the NDC to increase its commitment to mitigate greenhouse gas emissions, with domestic resources reaching 9% of total greenhouse gas emissions compared to the normal economic development scenario, up to 27 % when there is international support through bilateral and multilateral cooperation agreements.

Vietnam's updated NDC has also identified the main measures to mitigate GHG emissions in the public transport sector is measure E16: Modal shifting in passenger transport from personal vehicles to public transport (regular buses, BRT buses and urban rail). It can be seen that the studies on economic evaluation in GHG mitigation are very limited in Vietnam, specifically, there is no research related to the evaluation of co-benefits in the field of public transport. This is one of the research gaps that need to be addressed to create a scientific basis for policymakers and investors to determine the sustainability and effectiveness of mitigation measures in urban public transport sector. Therefore, the dissertation "***Research on quantifying the co-benefits of greenhouse gases mitigation in the public transport sector in Hanoi*** " is necessary, to contribute to providing a more detailed view of economic - social - environmental impacts in the implementation of mitigation measures.

2. Research objectives

- To identify mitigation measures and potential to mitigate GHG emissions in the public transport in Hanoi;

- To quantitatively assess the economic, social and environmental co-benefits of GHG mitigation in public transport in Hanoi and propose measures to mitigate GHG emissions, achieve economic, social and environmental co-benefits.

3. Research subject and scope

- Research subject: The dissertation researched the E16 measure in VietNam's updated NDC for the field of urban public transport, focusing on the modal shifting from personal vehicles (motorbike) to public transport (regular bus, BRT, sky train). The selected personal vehicle for evaluation will be motorbike, because this is currently the main type of personal vehicle used and is also identified as the main cause of traffic congestion, air pollution. The dissertation applies a combination of methods to quantify the potential of GHG mitigation and quantify 4 types of co-benefits: carbon credits, energy savings, travel time savings and health due to air pollution of mitigation measures in urban public transport.

- Spatial scope: Hanoi.

- Time range: from 2020 to 2030.

4. Research Hypodissertation

- What type of public transport cause the majority of GHG emissions in Hanoi?

- Which measures can be applied to mitigate GHG emissions in the public transport sector in Hanoi?

- What is the GHG mitigation potential in the public transport sector in Hanoi?

- Which co-benefits in terms of economic (carbon credits, energy savings), social (travel time savings), and enviromental (health due to air pollution) does GHG mitigation in the public transport sector in Hanoi bring?

5. Research hypodissertation

- It is possible to mitigate GHG in the public transport sector in Hanoi through the application of mitigation measures related to modal shifting.

- Implementing mitigation measures in the public transport sector in Hanoi will achieve economic, social and environmental co-benefits.

6. Research methods

- Methods of collecting, aggregating basic data used as input for calculations;

- Bottom- up method to quantify GHG emissions using ASIF model;

- Co-benefits valuation method using market-based and benefit transfer approach;

- The AERMOD model to simulates the distribution of air pollutant concentrations as a basis for evaluation of health benefits due to air pollution.

7. New contributions of the dissertation

- The dissertation has identified mitigation measures that can be applied to Hanoi and has calculated the potential to mitigate GHG emissions in the public transport sector in Hanoi.

- The dissertation has quantified the co-benefits in terms of economic (carbon credits, energy saving), social (travel time savings) and environmental (reduced air pollution) of GHG mitigation in public transport in Hanoi and proposing measures to mitigate GHG emissions, achieve economic, social and environmental co-benefits.

8. Scientific and practical contributions

a) Scientific contributions

The dissertation has developed a scientific basis to research and select methods to quantify greenhouse gas emissions and co-benefits for the field of public transport. In which, the co-benefits of inter-sectoral factors have been identified and quantified.

b) Practical contributions

The research results of this dissertation can be directly applied in the process of policy making, planning and strategy formulation to mitigate greenhouse gas emissions in the field of public transport, contributing to the implementation of goals in Vietnam's updated NDC, and at the same time ensure sustainable socio-economic development of Hanoi in particular and Vietnam in general.

9. Structure of the dissertation

In addition to the introduction, conclusion and recommendations, the dissertation consists of 3 chapters:

Chapter 1: Overview of studies on quantifying the co-benefits of GHG mitigation in urban public transport sector.

Chapter 2: Research on methods of quantifying GHG emissions and co-benefits in urban public transport.

Chapter 3: Evaluation of co-benefits of GHG mitigation in public transport in Hanoi.

CHAPTER 1: OVERVIEW OF STUDIES ON QUANTIFYING THE CO-BENEFITS OF GHG MITIGATION IN URBAN PUBLIC TRANSPORT SECTOR

1.1. Overview of GHG mitigation in urban public transport

According to the Global Status Report on Transport and Climate Change 2018 [77], GHG emissions from the transport sector are generated during the transport of passengers and goods by road, rail, water and air. The majority of GHG in this sector are CO_2 from burning fossil fuels. During the fuel combustion of vehicles, relatively small amounts of CH_4 and N_2O are emitted.

GHG mitigation measures are types of technologies that allow a reduction in GHG emissions compared to what would happen without the policy or measure (baseline) [52]. According to the 5th Assessment report [60], direct GHG emissions from urban passenger transport can be reduced through the following types of measures:

a) Limiting and reducing travel distances: Regional and urban development policies, spatial planning and optimization of transportation processes.

b) Transitioning to a transport system with low GHG emissions: Encourage investment in public transport, infrastructure for pedestrians and cyclists, encourage other forms of transportation by plane, ship, train.

c) Reducing energy intensity: Enhance vehicle and engine efficiency, use light materials, increase cargo load factor and passenger occupancy rate for vehicle trips; apply new technologies such as electric vehicles.

d) Switching to low emission fuels: Switching from fossil fuels to natural gas, electricity, methane or biofuels.

1.2. Overview of quantifying the co-benefits of GHG mitigation in urban public transport sector

Pearce [71] and Allwood [38] defined that the benefits resulting from the side effects of a policy/measure are called "co-benefits" or "secondary benefits". Similarly, IPCC [58] has defined "co-benefits" as benefits derived from policies implemented for different reasons at the same time including climate change mitigation, recognizing that most policies designed for GHG mitigation have other important roles as well (e.g. related to equitable, sustainable development goals).

Measures to mitigate GHG emissions when deployed often bring about other economic, social and environmental co-benefits [44, 47, 78, 81]. Several studies have been done to identify possible co-benefits including human health, food security, ecology, sustainable development and technological transformation [67]. These studies all agree that GHG mitigation and co-benefits should be considered simultaneously when evaluating GHG mitigation measures because of their close interrelation. In the transport sector, current researches have been carried out on the issue of GHG mitigation; economical and efficient use of energy; affect human health; travel time savings; reduction of traffic congestion; air pollution and noise pollution [56].

The co-benefit quantification methods are relatively new in the world and in Viet Nam. In recent years, these methods have begun to be used to evaluate the effectiveness of GHG mitigation measures to assess in detail the socio-economic-environmental impacts of the implementation process. Commonly used approaches and methods for quantifying co-benefits include: a) Market-based approach; b) Stated preference approach; c) Benefit transfer approach.

1.3. Overview of research area

According to the Transport Planning of Hanoi Capital to 2030, with a vision to 2050, types of passenger transport means of Hanoi in the period after 2020 will include: bicycles, cars machines, cars, regular buses, BRT buses and sky trains.

According to the roadmap for the construction and deployment of public transport in Hanoi, in the period of 2020-2030, regular buses, BRT buses and sky trains will be focused on developing, towards becoming the main form of passenger transport, replacing personal vehicles.

CHAPTER 2. METHODOLOGIES AND INPUTS

2.1. Method to quantify GHG emissions in urban public transport sector using bottom-up approach

On the basis of the ASIF model, the dissertation proposes a quantitative block diagram of GHEG emissions in the field of public transport as follows:

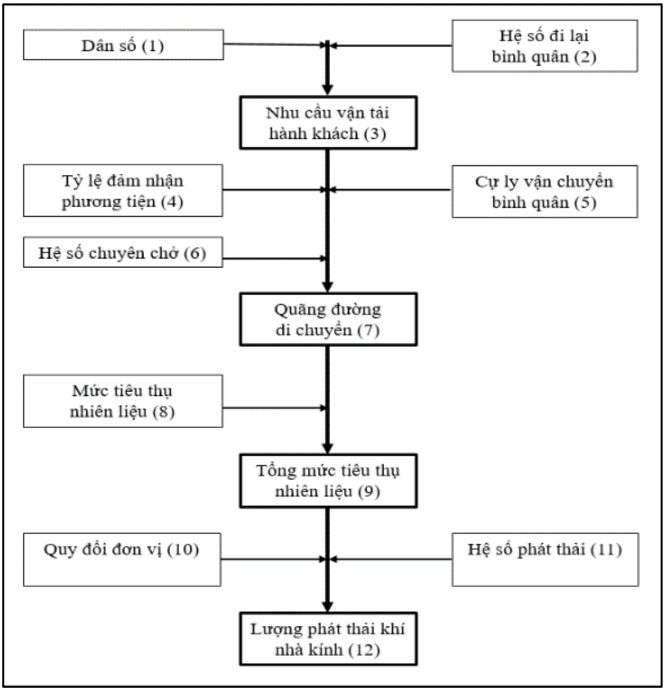

Figure 2.3. Block diagram for the quantification of GHG emissions in the public transport sector

2.2. Methods to quantify co-benefits in urban public transport sector

2.2.1. Co-benefits on carbon credits

Since the value of the carbon credits can be determined through market transactions, a market-based approach will be used to determine the value of this co-benefit. Based on the potential for GHG mitigation compared to the baseline scenario and the forecast of the carbon credit transaction price, the co-benefit on carbon credits can be evaluated according to the following Equation:

$$L_1 = \sum (ER \times p_x) \qquad (2\text{-}11)$$

In which L_1 is co-benefit on carbon credits (VND); RE is the GHG mitigation potential (ton CO_2e); p_x is the transaction price of carbon credits (VND/ton CO_2e).

2.2.2. Co-benefits on energy savings

Values of fuels can be easily obtained through market transactions, so a market-based approach will be used to determine the value of co-benefits on energy savings. Formula to calculate co-benefit on energy savings:

$$L_2 = \sum [(I_e - I_a) \times p_y] = \sum (\Delta I \times p_y) \qquad (2\text{-}12)$$

In which L_2 is the co-benefit on energy savings (VND); I_a is the fuel consumption of the hypothetical scenario (litter or kWh); I_e is the fuel consumption of the baseline scenario (litter or kWh); p_y is the selling price of fuel y (gasoline, diesel, electricity) (VND/litter or VND/kWh).

2.2.3. Co-benefits on health due to air pollution

The AERMOD model will be used to determine the changes in concentrations of air pollutants. After assessing the change in concentrations of pollutants under the scenarios, the widely used health impact function takes the form below to evaluate the health co-benefits [64]:

$$\Delta y = (1 - e^{-\beta \Delta x}) \times y_0 \qquad (2\text{-}16)$$

In which Δy is the change in disease incidence (%); Δx is the change in pollutant concentration; β is the correlation coefficient between the pollutant concentration and disease incidence; y_0 is the mortality rate caused by air pollution.

Once the change in air pollution-related deaths and the corresponding VSL values of Viet Nam are determined, the health co-benefits can be evaluated using the Equation:

$$L_3 = \Delta D \times VSL = (\Delta y \times P) \times VSL$$

In which ΔD is the change in the number of death (number of cases); VSL is the statistical value of a life (VND); P is the population (people).

2.2.4. Co-benefits on travel time savings

Basically, the travel time value is evaluated by multiplying the travel time of the vehicle types by the corresponding time value. The value of time depends on the willingness to pay or the opportunity cost of that time for passengers to use a particular type of vehicle.

$$L_4 = \sum (BT_0 - BT_a) \times t \qquad (2\text{-}19)$$

$$BT = \sum \frac{VKT}{V_{mean}} \qquad (2\text{-}20)$$

In which BT_0 is the total travel time under the baseline scenario; BT_w is the total travel time under the hypothetical scenario; VKT is the total distance traveled by vehicles; V_{mean} is the average moving speed of vehicles; t the travel time value of the user.

2.3. Assumption and data used in the dissertation

A number of assumptions will be applied in the calculation of the dissertation because some data and information are not currently available and may change, fluctuate over calculating period.

In addition, some input data has been collected and aggregated for the calculation. The input data includes vehicle specifications and types of fuel used in urban public transport.

CHAPTER 3. EVALUATION OF CO-BENEFITS OF GHG MITGATION IN PUBLIC TRANSPORT IN HANOI

3.1. Results of GHG emissions of the baseline scenario in public transport in Hanoi from 2020 to 2030

Applying the bottom-up approach and the ASIF model, the GHG emissions of each vehicle type can be determined. According to the baseline scenario, the GHG emissions of each vehicle type as well as the total emissions of this sector will continue to increase steadily over the years from 3.31 million tons of CO_2e in 2020 to 3. 87 million tons of CO_2e by 2030, an increase of about 1.17 times. Total cumulative GHG emissions in the period 2020 to 2030 of the baseline scenario is 39.43 million tons of CO_2e. Although there was no change in the rate of vehicle occupancy during this period, the population of Hanoi continued to grow at 1.58%, leading to an increase in the total demand for transportation, total volume of traffic and GHG emissions.

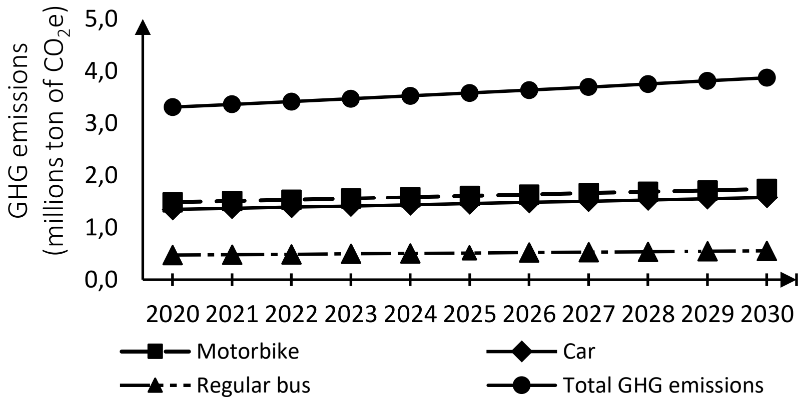

Figure 3.5. Total GHG emissions of passenger transport vehicles in Hanoi from 2020 to 2030 in baseline scenario

3.2. Identifying measures and scenarios for GHG mitigation in public tranport sector in Hanoi

When quantifying the GHG mitigation potential and co-benefits, the dissertation will apply occupancy factors greater than or equal to the minimum occupancy factors of public transport means. Under the assumption that the technology and fuel type do not change in the period of 2020 - 2030, the occupancy factors of public transport means need to be improved to increase the GHG mitigation potential when shifting from using motorbikes to public transport. The selected occupancy factor levels include: (i) O1 level as calculated by the dissertation; (ii) O2 and O3 levels equal to the occupancy factors of European countries with developed public transport systems.

Table 3.3. Occupancy factors of public transport

	O1	O2	O3
Regular bus	38 (63%)	43 (70%)	48 (80%)
BRT	59 (65%)	65 (70%)	72 (80%)
Sky train	339 (38%)	396 (44%)	450 (50%)

Baseline scenario: Normal development of public tranposrt in Hanoi

Under this scenario, the population of Hanoi will continue to grow, the vehicle occupancy factors will be assumed unchanged and no new technologies for GHG mitigation will be applied in the period 2020-2030.

KB01 scenario: Shifting from using motorbike to regular buses

Under this scenario, 48% of mode share from motorbike will shift to regular buses with the conversion rate of 4,8% per year with 3 levels of occupancy factor will be applied. The mode share of other vehicles will remain the same as the baseline scenario.

KB02 scenario: Shifting from using motorbike to BRT

Under this scenario, 48% of mode share from motorbike will shift to BRT with the conversion rate of 4,8% per year with 3 levels of occupancy factor will be applied. The mode share of other vehicles will remain the same as the baseline scenario.

KB03 scenario: Shifting from using motorbike to sky train

Under this scenario, 48% of mode share from motorbike will shift to sky train with the conversion rate of 4,8% per year with 3 levels of occupancy factor will be applied. The mode share of other vehicles will remain the same as the baseline scenario.

3.3. Quantifying the GHG mitigation potential of scenarios of modal shifting from motorbike to public transport in Hanoi from 2020 to 2030

3.3.1. GHG mitgation potential of modal shifting from motorbike to regular bus (KB01)

Total cumulative GHG emissions when shifting to regular bus tends to increase in the period 2020 - 2030 reaching 36.02 to 38.12 million tons of CO_2e. Total GHG emissions in 2030 will reach the lowest level of 3.40 million tons of CO_2e and the highest level of 3.73 million tons of CO_2e in 2030.

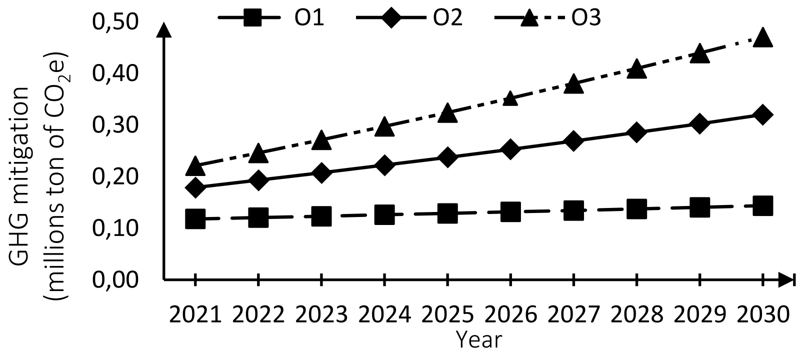

Figure 3.7. GHG mitigation potential of KB01 scenario

3.3.2. GHG mitgation potential of modal shifting from motorbike to BRT (KB02)

The total amount of GHG accumulated when shifting to BRT tends to increase in the period 2020 - 2030 reaching 36.02 to 38.12 million tons of CO_2e. Total GHG emissions in 2030 will reach the lowest level of 3.40 million tons of CO_2e and the highest level of 3.73 million tons of CO_2e in 2030.

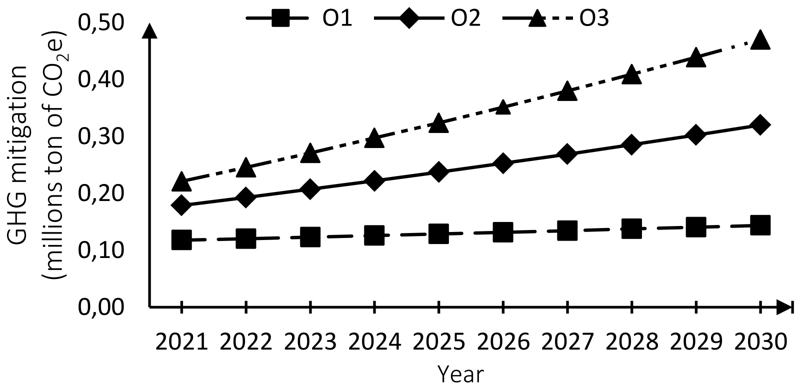

Figure 3.10. GHG mitigation potential of KB02 scenario

3.3.3. GHG mitgation potential of modal shifting from motorbike to sky train (KB03)

Total cumulative GHG emissions when shifting to sky train tends to increase in the period 2020 - 2030, reaching 35.61 to 38.06 million tons of CO_2e. Total GHG emissions in 2030 will reach the lowest level of 3.32 million tons of CO_2e and the highest level of 3.73 million tons of CO_2e in 2030.

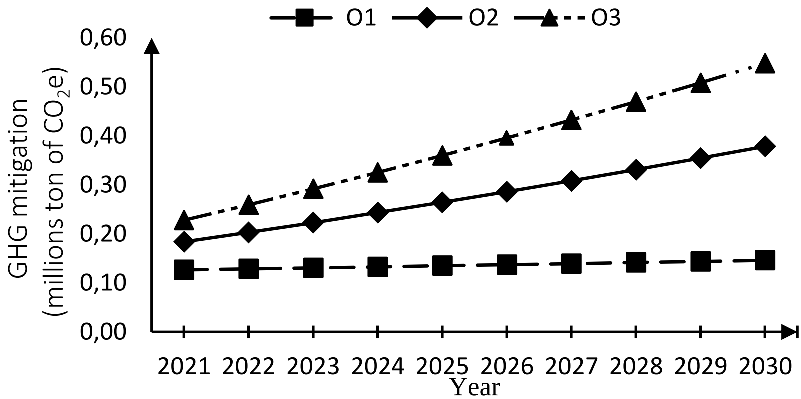

Figure 3.12. GHG mitigation potential of KB03 scenario

3.4. Quantification of co-benefits under scenarios of shifting from motorbike to public transport in Hanoi from 2020 to 2030

3.4.1. Shifting from motorbike to regular bus (KB01)

Co-benefit on energy savings has the highest value among the considered co-benefits, followed by health co-benefit. Co-benefit on carbon credits accounts for a relatively low proportion, however, this is a co-benefit with a lot of potential as the transaction price of carbon credits is likely to increase in the period from 2020 to 2030. The co-benefits in travel time and health are both negative, which reflects some of the disadvantages of regular buses when compared to motorbikes, namely average travel speed and relatively high PM2.5 emissions.

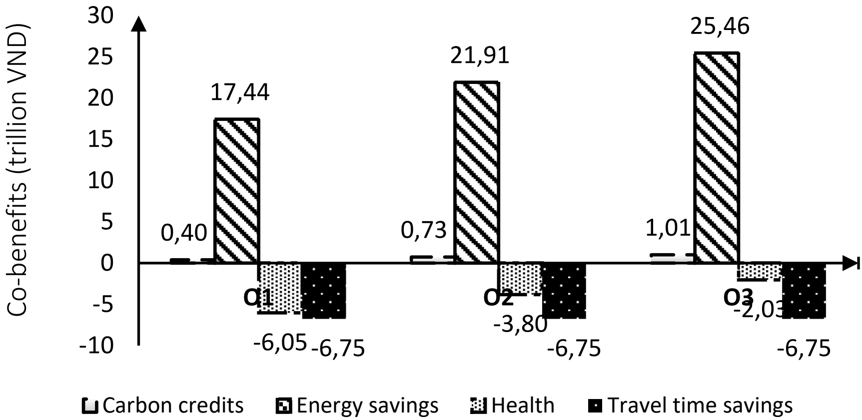

Figure 3.20. Co-benefits of KB01 scenario

3.4.2. Shifting from motorbike to BRT (KB02)

Co-benefits on energy savings continues to be the highest value of co-benefits under consideration. The second is the health co-benefit, then the travel time savings and carbon credits. The co-benefits of travel time and health are both negative, which reflects some of the disadvantages of BRT buses when compared to motorbikes, namely average travel speed and relatively high PM2.5 emissions. BRT could provide co-benefits on health if it could increase the occupancy factor or make engine's improvements. In terms of design, BRT will have dedicated lanes to ensure faster travel and maintain a stable speed due to the absence of mixed traffic congestion. This feature is similar to urban rail systems, making it a more reliable, convenient and faster means of public transport than regular buses. However, in addition to dedicated lanes, BRT also require measures to provide lane priority at intersections. The BRT in Hanoi currently has many shortcomings in implementing this priority, causing the BRT to still share lanes with other vehicles and travel at a relatively low speed, not really effective in the design of this vehicle.

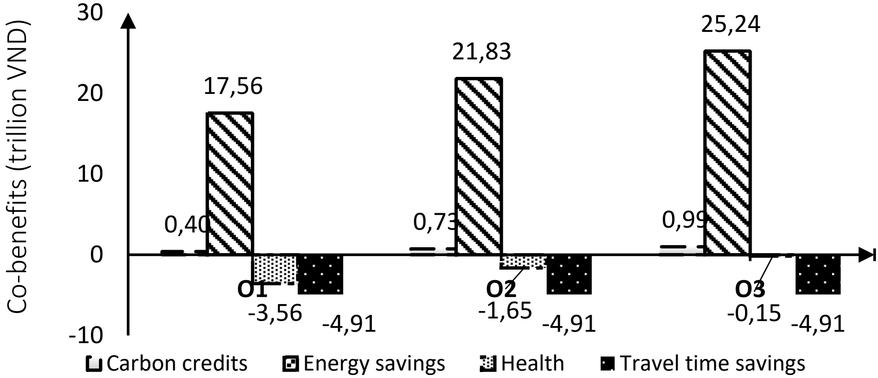

Figure 3.27. Co-benefits of KB02 scenario

3.4.3. Shifting from motorbike to sky train (KB03)

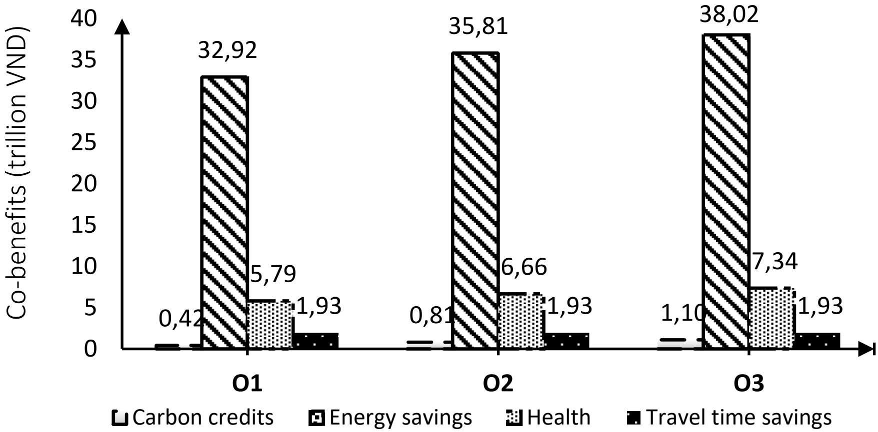

Figure 3.34. Co-benefits of KB03 scenario

The figure above summarizes the present value in 2020 for the 3 levels of occupancy factors of KB03 scenario, in which the co-benefit ratio is similar to the KB01 and KB02 scenarios. Co-benefit on energy savings continues to be the highest share, followed by health and carbon credits making up the smallest share. As for the co-benefit on travel time savings, public transport has a lower travel speed than motorbikes, so this co-benefit is negative for all three types of public transport. Sky train is the only means of public transport where the health co-benefit is positive because there are no dust emissions from fuel combustion as for regular and BRT buses.

3.5. Determining the correlation between GHG potential and economic value of co-benefits according to groups of measures to shift from motorbike to public transport in Hanoi

The dissertation will consider, compare the GHG mitigation potential and value of co-benefits when using a group of public transport means to replace motorbike. Accordingly, the correlation between these values will be determined in order to identify the optimal allocation ratio between different types of public transport means to maximize the co-benefits.

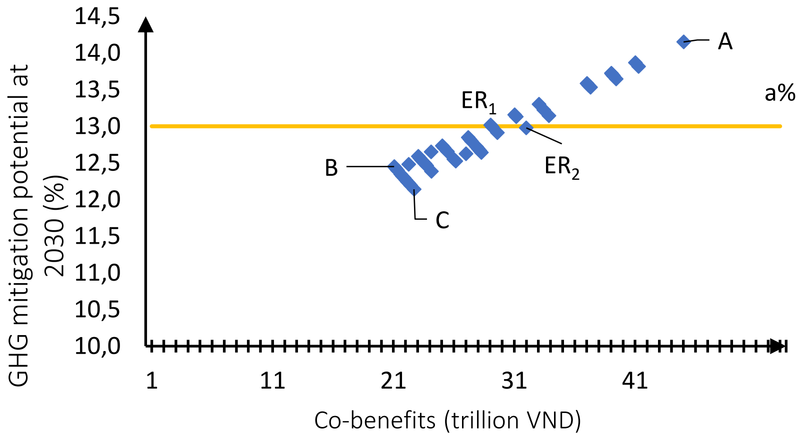

Figure 3.37. GHG mitigation potential and value of co-benefits for level O3 of occupancy factor

Using the graphs depicting the correlation between the GHG mitigation potential in 2030 and value of co-benefits, policy makers can identify an optimal allocation ratio between different types of public transport means. If a horizontal line a% is drawn representing the GHG mitigation to be achieved, this line will intersect the triangle at one or more points ER_1, ER_2, ER_3 … Each of these points represents a combination of ratios that ensure appropriate combination of 3 types of public transport to achieve the desired GHG mitigation.

3.6. Proposing measures to promote modal shifting to mitigate GHG and achieve economic, social, environmental co-benefits

The improvement of the occupancy factor is urgently needed so that public transport means can truly bring about positive economic, social and environmental impacts. When public transport vehicles operate above the minimum occupancy factor, the occupancy factors of public transport means has been shown to be proportional to the value of the co-benefits. Along with increasing the occupancy factors, measures to increase the share of public transport also need to be considered to optimize the value of the co-benefits.

In addition, electric trains show outstanding advantages in terms of GHG mitigation, thereby, bringing about significant co-benefits. Therefore, the use of renewable fuel is also a measure that should be considered for other types of public transport.

The optimization of the value of co-benefits in the deployment of various means of public transport can be applied in the following directions: (i) Increasing the occupancy factor and the share of transport of all types of transport public transport or (ii) Improve the technology of public transport.

The following groups of measures can be considered for implementation in Hanoi:

* Mechanisms and policies

* Technology

* Financial

* Capacity building and marketing

CONCLUSIONS AND SUGGESTIONS

1. Conclusions

On the basis of an overview of domestic and international research, application of approaches, calculation of GHG emission potential in the field of urban public transport combined with economic evaluation methods, the dissertation has interpret and apply these methods to determine the economic values of the co-benefits in terms of carbon credits, energy savings, travel time savings and health from air pollution for mitigation measures in the field of urban public transport in Hanoi.

1. The dissertation has used the ASIF model to determine the minimum level of occupancy factors so that various types of public transport can bring GHG mitigation potential. From there, quantify the potential of the scenarios of modal shifting from motorbike to public transport means in Hanoi. The evaluated scenarios all have the potential to mitigate GHG emissions, if operating at equal to or higher than the minimum occupancy factor. The GHG mitigation potential in 2030 when completely shifting from motorbike to regular buses could reaches 0.48 million tons of CO_2e; to BRT reaches 0.47 million tons of CO_2e and to sky train reaches 0.55 million tons of CO_2e.

2. From data on the current situation and transport planning of Hanoi, the dissertation has evaluated the co-benefits in public transport using market-based and benefit transfer approach. Co-benefits that have been assessed include: carbon credits, energy savings, travel time savings and health from air pollution. Of the assessed co-benefits, the co-benefit on energy savings accounted for the majority of all 3 scenarios considered, while the co-benefit on carbon credits accounted for the smallest proportion. However, the dissertation recognizes that the co-benefits of carbon credits have a lot of potential in the future, when the implementation of commitments under the Paris Agreement will boost the demand for carbon credits exchange. When comparing between scenarios, the sky train is the type of public transport that can provide the highest co-benefits when replacing motorbikes. Regular buses and BRT offer positive co-benefits in terms of carbon credits and energy savings, however, there are downsides in terms of travel time and air pollution when compared with motorbikes. And in general, the co-benefits of all three types of public transport are directly proportional to the level of the occupancy factors.

3. The correlation between the GHG mitigation potential and the total value of co-benefits for groups of measures in the field of public transport has been determined and shown in the form of a chart. This correlation chart is intended to provide an overview, to assist policy makers in estimating the value of co-benefits corresponding to each level of GHG mitigation target. And policy makers can identify appropriate public transport development plans to meet the requirements of GHG mitigation or the socio-economic-environmental goals.

4. The dissertation has successfully developed and applied the method to quantify co-benefits in public transport sector by establishing co-benefit evaluation formulas combined with the application of two models ASIF and AERMOD.

Thus, the objectives of the dissertation have been completed when the proposed combination of processes and methods has been successfully applied to the field of public transport in Hanoi. The research results can be further improved and widely applied in other cities in Vietnam and for the modal shifting of other personal vehicles such as cars to other types of public transport (electric buses) to more accurately assess the economic-social-environmental impacts in the implementation of mitigation measures in the field of urban public transport.

2. Suggestions

Due to many objective and subjective reasons, especially due to budget, data and time constraints, the dissertation still has some limitations such as: using hypothetical data, surveyed values that have been applied in the world but have not been reported in Vietnam. The dissertation has the following recommendations to continue to inherit, improve and supplement the research results that have been achieved:

1. The dissertation has considered 4 representative co-benefits of the urban public transport sector. However, in addition to the co-benefits that have been considered and evaluated in this dissertation, a number of other co-benefits such as noise, traffic congestion reduction, new job creation... can be considered and quantified to clarify the impacts in the process of developing and deploying different types of public transport.

2. The quantification of GHG emissions using the bottom-up approach and the co-benefit evaluation are highly dependent on the completeness and accuracy of the database. In the future, it is necessary to supplement surveys, measurements and complete the database in the public transport sector in general and the greenhouse gas inventory in general, so that the number of assumption can be reduced, increase the accuracy of the calculation results.

3. Research results have demonstrated the advantages of public transport using electric fuel when compared with other types of vehicles using fossil fuels. Therefore, there is a need for further studies to consider and evaluate the effectiveness of vehicles using renewable fuels in order to promote advanced, environmentally friendly technologies and bring potential economic capacity.

4. In order to continue to inherit and complete the results of this study, the dissertation recommends additional cost-benefit calculations of public transport system development plans to determine the optimization plan for co-benefits and GHG mitigation based on investment rate or project size.

LIST OF SCIENTIFIC WORKS OF THE AUTHORS RELATED TO THE DISSERTATION

1. **Tran Do Bao Trung**, Luong Quang Huy, Tran Do Tra My (2020*)*, " Evaluation of greenhouse gases emissions for passenger transport sector based on the transportation planning of Hanoi capital by 2030, with a vision to 2050", *Vietnam Journal of Hydrometeorology*, 8/2020.
2. **Tran Do Bao Trung**, Luong Quang Huy, Tran Do Tra My (2020), " Evaluation of co–benefits for passenger transport sector based on the transportation planning of Ho Chi Minh City by 2020, with a vision after 2020", *Vietnam Journal of Hydrometeorology*, 10/2020.
3. **Tran Do Bao Trung**, Tran Do Tra My (2021), "Calculating GHG mitigation potential and co–benefits of mitigation measures in public transport sector in Ha Noi", *Journal of Climate Change Science*, 12/2021.
4. **Tran Do Bao Trung**, Doan Quang Tri (2022), "Application of the AERMOD Model to Evaluate the Health Benefits Due to Air Pollution from the Public Transport Sector in Ha Noi, Viet Nam", *Journal of Geoscience and Environment Protection,* 2022, 10, 13-33.