RESEARCH REPORT

CARBON TAX SYSTEM FOR VEHICLES USED IN LOGISTIC ACTIVITIES IN THAILAND

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ชื่อโครงการ	การใช้ระบบภาษีคาร์บอนกับยานพาหนะเพื่อการขนส่งในประเทศไทย Carbon Tax System for Vehicles Used in Logistic Activities in Thailand
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ABSTRACT

As climate change issue became one of the most important global problems, carbon dioxide (CO_2) mitigation plan has become an important agenda of many nations around the world. Carbon pricing tools are the real market-based instruments, and they are suggested as an effective incentive for stakeholders to reduce the emission. Specifically, carbon tax is one of the carbon pricing tools. It is an easier mechanism to implement compared to Cap and Trade (CT) system due to administrative cost and procedures. In Thailand, CO_2 from transportation accounts for about a quarter of all CO_2 emissions. Starting from 1 January 2016, new vehicle excise tax has come to be effective for passenger vehicles, while road freight vehicle was still paid less attention on emission reduction. In road transport activities, passenger and road freight vehicles share almost the same proportion in a global view. Hence, this study aims to assess the perspectives of logistics practitioners on diverse topics such as green logistics, electric vehicle (EV), and carbon tax proposal including its possibilities and challenges to implement in order to incentivize the use of EV in road freight activities in Thailand. Qualitative survey was conducted for the perspective assessment. This study employed both descriptive (cross tabulation) and inferential (Chi Square test) statistics to interpret and confirm relationship of the dependent and independent variables of the survey. As a result, the study found that carbon tax proposal can be implemented in Thailand for road freight activities through reforming related taxes and imposing emission fees. However, supports from key players such as logistics practitioners, logistics service users, automakers, and government are the key input for this new proposal to become real.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

In the past decades, climate change problem has become one of the most important global issues. The World finally accepted that climate change really exists (UNFCCC, 2014a). "Climate Change" is defined as the effects from decomposition of atmosphere directly or indirectly of human being actions (Fridahl, 2017). As the alteration of composition, climate change has influenced global through its variability. Determination of climate changes is derived from demographical and economic development, technological advancement, energy usage, and land management. This means development of the society in every sectors including economic, physical infrastructure, new technology adoptions, energy supports as fuel, and land management are factors affecting climate change. Starting from industrial era, development on many aspects has significantly contributed to warning level of climate change (Nakamichi, Hanaoka, & Kawahara, 2016).

One of the major issues in climate change is global warming, which causes the rise of global temperature. As of 2015, global surface temperature has risen by 1.5°C as compared to the level in year 1880. National Aeronautics and Space Administration (NASA) illustrated many figures of earth surface and the color revolution, which showed the change of temperature from 1900 to 2015. The increase of temperature level subsequently resulted in the rise of sea level. Sea level rises about 3.4 millimeters per year, while land ice in Antarctica and Greenland losses at the rate of 287 gigatonnes per year (NASA, 2017). Greenhouse Gases (GHGs) are the major causes of global warming (Häkkinen, Kuittinen, Ruuska, & Jung, 2015). Major GHGs are carbon dioxide,

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methane, nitrous oxide, and fluorinated gases. These gases trap radiation, which is supposed to reflect from earth's surface back to the space, in the earth's atmosphere (EPA, 2016). According to NASA, the amount of carbon dioxide stored in atmosphere hit its record high in May 2016 as it reached 403.26 ppm. The more GHGs exist, the warmer global surface is.

GHGs are produced from fossil fuel used in many economic sectors such as electricity and heating production, transport, buildings, industry, and others, which accounted for 49 gigatonnes in 2010. The major contributors are electricity and heat production, Agriculture, Forestry and Other Land Use (AFOLU), industry and transport; they share 25%, 24%, 21% and 14% respectively (IPCC, 2015).

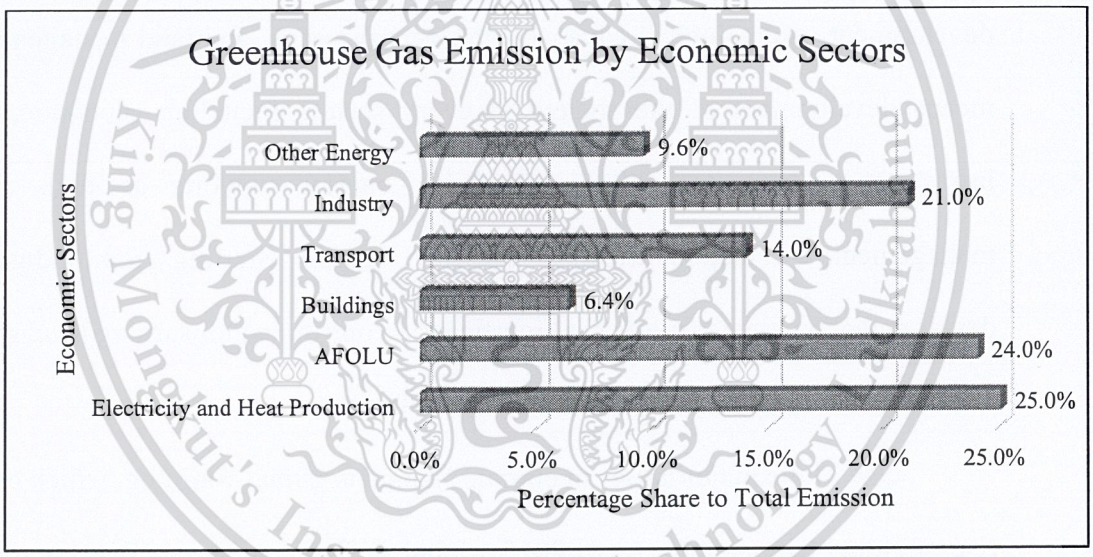

Figure 1.1 Greenhouse gases emitted by sectors in 2015

Source: IPCC, Intergovernmental Panel on Climate Change (2015). Climate Change 2014: Mitigation of Climate Change (Vol. 3): Cambridge University Press.

In December 2015, there was a ground breaking event that the world came to consensus on climate change issue during the Conference of Parties 21 (COP21) event. A total of 195 countries participated the event and accepted a global climate change mitigation deal. The deal was to limit the increasing temperature not over 2°c by 2050. This limitation aimed to reduce emission or maintain the current level on GHGs in all

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sectors. In COP21, Thailand's pledge toward emission was announced to reduce GHGs emissions 25% by 2030 (Patsara, 2015). According to World Bank's Data, in 2012 Thailand emission was contributed 41% by electricity and heat production, 27% from manufacturing industries and construction, and approximate 24% from transport (WB, 2016). Hence, these three main sectors shall be the targets of emission reduction according to 2030' pledge by Thai Prime Minister.

Electricity and heat production, industry and transport sectors are the main contributors of total emission. Furthermore, there are national and international mechanisms, which are currently practicing in order to reduce the emission. For electricity, the trend of renewable and alternative energies have developed and encouraged widely. Those applications of alternative energies are generating electricity and energy from wind, solar, biofuels, biomass, hydro, geothermal, and marine. Investment of these applications of alternative energies was USD 285 billion in 2015, which had 5% growth compare to year 2014 investment and 18% increased for period of year 2004 till 2015 (Joseph et al., 2016).

For industry sector, emission has been concerned and taken action by building real market mechanism as carbon pricing mechanism in order to incentivize the manufacturers to consider on reducing emission from their operations. Carbon pricing mechanism has been implemented since 1990s in Northern European countries such as Norway, Finland, Denmark, etc. Carbon tax is the first carbon pricing tool and later carbon market idea or cap-and-trade was established underlying with The Kyoto Protocol in 1996. These tools have been practiced to levy on mostly energy sectors, and some upstream industries. However, the emission reduction plan for transport sector has not been widely implemented. Policies such as emission standard, fuel Efficiency, and low-sulfur fuel are currently implemented on only the personal vehicle type. The

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heavy-duty vehicles, which are currently utilizing in road freight vehicles, are still remained lack of attention to emission reduction even though it shares almost half of emission from road transport compared to all types of personal vehicles combined (Kodjak, Sharpe, & Delgado, 2015).

A large number of policies related to the encouragement of making low emission vehicle have been implemented. For example, the ECO Car plan, which encourages automotive producers to invest in low emission technology to meet the standards. Also, the Royal Thai Government has recently reformed passenger vehicle excise tax system to be effective from January 1st, 2016. The old system was previously based on engine sizes of vehicles. The new system now taxes vehicles based on their CO_2 emissions. The newly reformed tax structure has directly encouraged the use of hybrid and electric vehicles, which are taxed only 10%, while none hybrid vehicles are taxed between 30-50%. The rate is higher for vehicles, which emit more and lower for more efficient vehicles. The trend of low emission vehicle is currently expanding only in passenger vehicle portion, while road freight transport vehicle is remained lack of attention to mitigate the emission. Hence, a study shall be made to investigate about the situation of emission from road freight activities, as well as the perceptions of practitioners toward emission reduction from this sector.

1.2 Problem Statement

Within the battle era with climate change as a global challenge, environmental policies have been introduced drastically and globally. While carbon pricing, which is one of market based instruments, has already been implemented in many countries around the globe. While transport sector is the third largest contributor, which share the emissions the most in the world, it is yet widely implemented. Upstream policies such

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as Emission Standard, Fuel Efficiency, are currently implementing on only personal vehicle in order to reduce the emission. Less attention to reduce emission has been paid to truck and other vehicles used in road freight activities. The road freight vehicles account for 2.82% of vehicles in Thailand and also contribute significant amount of CO_2 emissions in Thailand. Plus the presence of ASEAN Free Trade Agreement and the goal to be logistics hub in ASEAN of Thailand, the emission from road freight vehicle in Thailand is projected to increase significantly. Therefore, there is a need for study that explore about the possibilities and challenges of carbon pricing system (specifically carbon tax) as a way to incentivize the use of less emission vehicles including electric vehicles in road freight activities in Thailand.

1.3 Objectives of the Study

The study objective is to review carbon pricing system implementation on sectors from around the world and compare advantages and disadvantages after policies implemented. The study also aims to assess the perspective of the practitioners on various issues such as green logistics, feasibility of employing EV in road freight activities, and carbon tax as the incentive for practitioners to choose lower emission vehicles. Finally, this information will be used to explore about possibilities and challenges for the proposal of carbon tax, and utilization of EV in road freight activities in Thailand based on practitioners view.

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CHAPTER 2

LITERATURE REVIEW

2.1 Transport and Externalities

Logistics management is defined by two concepts of management including transportation and storage of products and service. Those management concepts include the activities of inbound and outbound transportation management, designation of fleet planning, and storage. In practical way, it is practiced by including the vertical segments of management such as sourcing, procurement, planning and scheduling of production, assembly, and customer service (CSCMP, 2016). Transportation modes in logistics field are currently available in sea, air, and land. Furthermore, land transport has been divided into two modes as rail and road transport. It has not only produced value of movement of products and services, but also has yielded the negative externalities, which turn out to be the impacts in aspects of social, economic, and environmental factors, especially for land transport activities. Noise pollution, traffic jam, traffic accidents, and air pollution are the major negative externalities caused by land transport (Demir, Huang, Scholts, & Van Woensel, 2015).

Transport sector is one of the major contributor, which is targeted to reduce the emission. Underlying with development trend of powertrain technology, which depend on alternative energies over the fossil fuels. Newly adopted powertrain technologies such as Hybrid Electric Vehicle (HEV), Plug in Hybrid Electric Vehicle (PHEV), Battery Electric Vehicle (BEV), and Fuel Cell Electric Vehicle (FCEV).

By Figure 2.1, it illustrates about the consumptions of petroleum products by sectors in Thailand in 2013 by Office of Transport and Transport Policy and Planning (OTP) of Ministry of Transport. 65% of total petroleum product was consumed by only

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one sector, which is transportation. It combines all transport modes of sea, rail, air, and road transport together. It is also expected that huge emission proportion from this sector had been emitted (OTP, 2013).

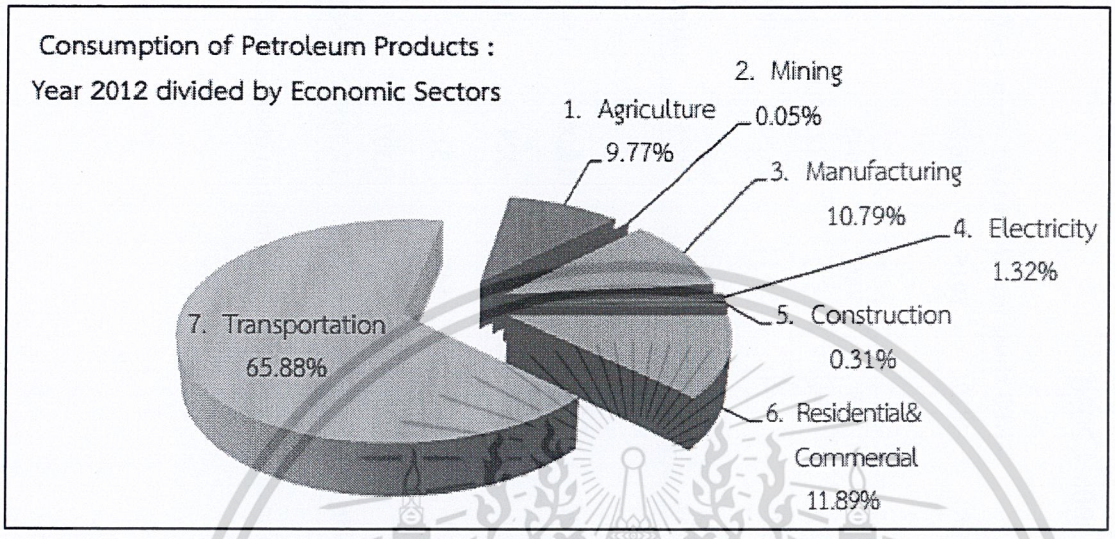

Figure 2.1 Proportion of economic sectors with consumption of petroleum products in 2012, Thailand

Source: OTP, The Office of Transport and Traffic Policy and planning. (2013). Transport and Traffic Statistics and Information

Table 2-1 shows two projections as fuel consumption and GHGs emission from year 2008 till 2030. All transport modes from road, rail, water and air had been illustrated. Pongthanaisawan and Sorapipatana (2013) used historical data of year 1990 till 2007 to develop models and forecast from year 2008 till 2030 based on Business-As-Usual (BAU) scenarios. For road transport, the average percentages growth of GHGs emission is 28% every years and the actual percentage growth of 241% from year 2008 till 2030 (Pongthanaisawan & Sorapipatana, 2013).

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Table 2.1 Projection of fuel consumption and GHG emission as BAU scenarios from 2008 – 2030

	Transport mode Fuel consumptions (ktoe[a])						GHG emissions (Thousand tonnes of CO_2 eq.)					
	2008	**2010**	**2015**	**2020**	**2025**	**2030**	**2008**	**2010**	**2015**	**2020**	**2025**	**2030**
Road transport												
CNG	125	142	196	271	374	516	297	338	466	643	887	1225
LPG	375	427	589	813	1122	1548	989	1125	1552	2142	2956	4080
Gasoline	6190	6815	8806	11,568	15,252	20,080	17,935	19,744	25,511	33,513	44,186	58,175
Bioethanol	189	283	463	534	550	552	–	–	–	–	–	–
Diesel	13,435	14,945	19,534	25,903	34,654	46,410	41,381	46,033	60,168	79,785	106,739	142,950
Biodiesel	58	181	591	874	974	994	–	–	–	–	–	–
Subtotal	20,372	22,793	30,179	39,963	52,926	70,100	60,602	67,240	87,697	116,083	154,768	206,430
Rail Transport	103	104	105	106	108	109	315	316	320	324	328	332
Water Transport	39	31	18	10	6	3	118	94	54	31	18	10
Air transport	301	319	369	427	494	571	921	977	1130	1307	1512	1750
Grand	20,815	23,247	30,671	40,506	53,534	70,783	61,956	68,627	89,201	117,745	156,626	208,522

Source: Pongthanaisawan, J., & Sorapipatana, C. (2013). Greenhouse gas emissions from Thailand's transport sector: Trends and mitigation options. Applied Energy, 101, 288-298.

[a] Tonne of oil equivalent (ktoe)

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In logistics field, land transportation plays significant role to emit emission comparing to warehousing and storage due to fuel combustion in automobile powertrain technology of commercial vehicles.

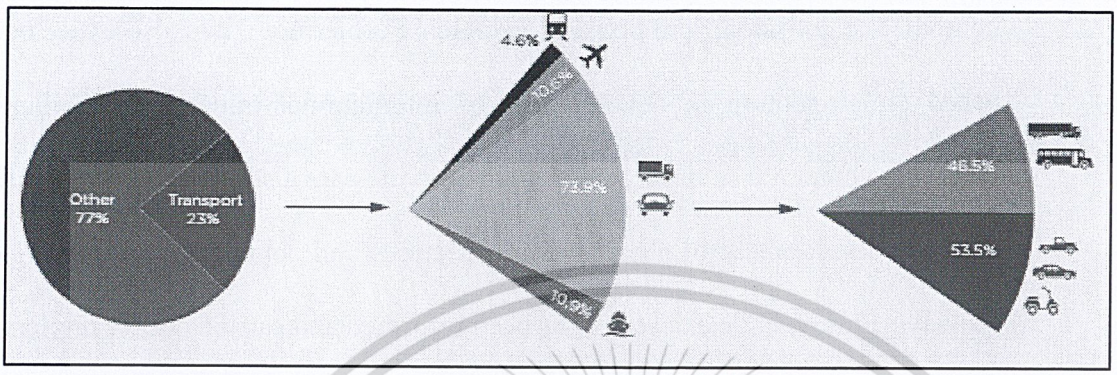

Figure 2.2 Global anthropogenic carbon dioxide emissions from the transport sector in 2010 data (Drew, 2015)

Source: Drew, K. (2015). Policies to Reduce Fuel Consumption, Air Pollution, and Carbon Emission from Vehicles in G20 Nations. 1225 I Street NW, Suite 900

Figure 2.2 showed the proportion of carbon dioxide emission of land transport. It holds significant amount of emission compare to other transport modes as rail, sea and air transport. Approximately 73.9% of emission from transport sector is from land transportation and heavy-duty vehicle shares amount of emission almost equal to passenger vehicle. Driving behavior and loading condition factors are the main contributors to the emission from specific type of vehicle. Globally, heavy-duty vehicle represented only 11% to total number of vehicles in 2015. Each of the countries has proportion of emission from heavy-duty vehicle differently. For example, Japan has 19% of total vehicles as heavy-duty vehicle, and they emitted 43% of CO_2 of road transport emission. In India, 71% of land transport emission was contributed by only 5% of heavy-duty vehicles within the country (Drew, 2015). In Organization for Economic Co–operation and Development (OECD) member countries, 19% of energy was used by transport sector in 2005. 27% of global transport energy were accounted for truck and rail in 2006, while heavy-duty vehicle accounted for 90% of these energy

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consumptions (IEA, 2009). Hence, emission from road freight vehicle is significant and shall be considered for mitigation plans or actions.

Globally, emission from road freight vehicles is also a significant contributor compared to emission from personal vehicles. Furthermore, it is also expected to grow based on circulation of development of international trade. For Thailand, as an emerging economic country, road freight activities are also expected to increase along with the development of physical infrastructures and connectivity from seaports and railways. Plus, vehicle excise tax has been reformed and carried out for implementation since 2016 from engine combust size to emission rate, hence as goal of achieving to be a regional logistics hub and to cut down on emission national plan, heavy-duty vehicles' emission will require to be reduced as well.

2.2 Powertrain Technology in Automobile Industry and Road Freight Vehicles

Powertrain technology in automobile industry today can be seen that it is moving toward the trend of less energy consumption, less fuel consumption and less emission emitted. Less emission can be inferred to environmental friendly, green or sustainable vehicle. It focuses on the development of reducing energy consumption as well as low emission. The trend of sustainable transportation focuses on reduction of CO_2 through advancement technology of combustion engine to adapt on alternative energy rather than the fossil fuel power. The current alternative energy available to use for vehicle currently is only the electricity. In passenger vehicle segment, HEV, PHEV, BEV, and FCEV are the product trend of current automotive industry. HEV is defined technology of combination of fossil-fuel and electric engine. To serve eco purposes, electric engine derives electricity charge from the gasoline engine and shares in total performance to become more efficient of fossil-fuel consumption (Severinsky, 1994).

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PHEV or extended HEV, which consists of plug-in that allows to be charged from external electricity source. It provides more efficiency of fossil fuel consumption and extreme less GHGs emission, while the cons are charging time and investment cost. PHEV is normally more costly than HEV. BEV is referred to vehicle without fossil fuel combustion engine and depends solely on electric as fuel for its overall performance. While FCEV uses hydrogen as fuel to support fuel cell system for total vehicle performance. FCEV is the latest technology of environmental vehicle, which aims to tackle the problem of charging time. However, this technology cost and investment are remained highly expensive (Chan, 2002).

In land freight transport, small, medium, and heavy-duty vehicles are utilizing in varieties ways according to justification between customers' requirements and organizational operation and cost. Vehicles are deployed for land freight purposes in Thailand are pick-up trucks, semi-trailers, box trucks, tank trucks, Hazmat trucks, tow trucks, drag trucks with trailers. Figure 2-3 illustrates the proportion of vehicle types, which are currently use in Thailand in road freight activities. Top three majority of vehicle types are drag, pickup truck, and semi-trailer. They share 21%, 23% and 27% of total number of vehicles used in Thailand in year 2015 respectively (DLT, 2015).

In road freight vehicle proportion, environmental powertrain technology has not been widely utilized as passenger vehicle. Fuel switching is currently well-known within road freight vehicle's technology from fossil to biofuel, diesel, liquid natural gas, compressed natural gas, etc. In terms of powertrain development, commercial vehicle producers also start adopting hybrid electric and hydrogen truck. For example, Hino 300 Series are equipped diesel-electric hybrid power light duty truck, and TTSI Hydrogen Class 8 Truck, which is the first fuel cell truck that had been deployed in 2011 (TTSI, 2016). Last but not least, Tesla as an automotive producer of passenger

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vehicle utilizing alternative energy of electricity, has also come up with master plan to produce electric road freight vehicle such as long haulage truck and high passenger-density urban transport (Howard, 2016). Anyway, these new inventions (HEV, BEV, PHEV, and FCEV) are still questionable on which powertrain technology can be more efficient response to flexibility mileage from urban distribution to thousand kilometer destination, and from light to heavy weight loaded, and the level of cost of investment to adopt those new powertrain systems.

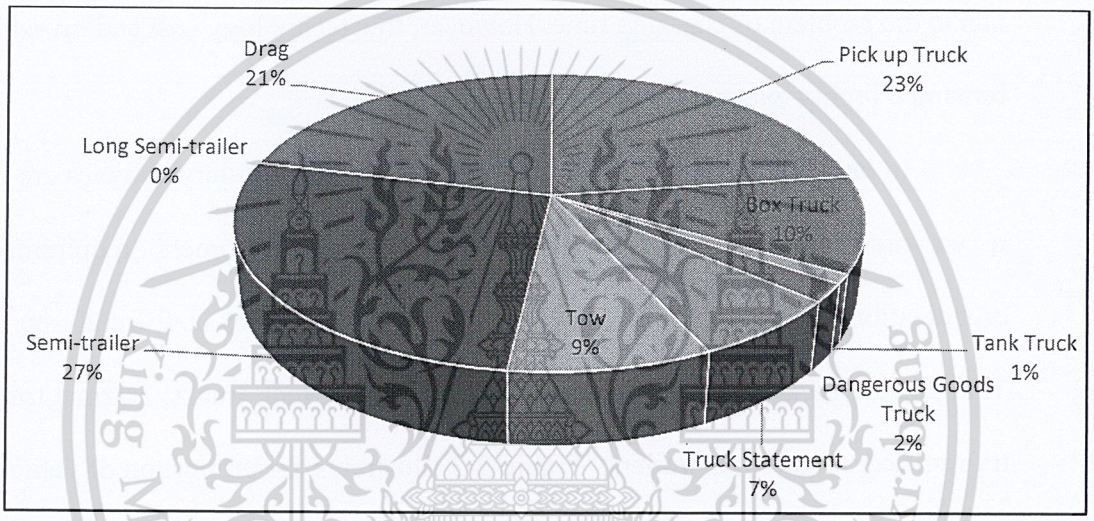

Figure 2.3 Share of types of vehicles deploy in road freight in Thailand 2015

Source: DLT, Department of Land Transport. (2015). Transport Statistics Report: Department of Land Transport, Planning Division, Transport Statistics Group.

2.3 Transport Policy Approaches and Applications

Transport policy has played an important role on creating the incentive for automobile producers or users to consider about the choices of vehicles. Policies can be categorized into two approach as Incentive Based (IB) and Command and Control (CAC) approach. CAC approach is the approach that set standards, regulations, or instructions for the practitioners to follow based on objectives of the policies makers, while IB approach works by building the encouragement of the practitioners to follow the ultimate objectives of the policy makers. CAC can be seen as a top-down approach

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and IB can be seen as a bottom-up approach. The two approaches has been applied for most of situations especially to limit the specific negative externalities from social activities or issues.

Low-sulfur fuel is one of CAC approach policies, which aims to limit the sulfur content emit by burning fossil-fuel activities. The policy has the standard to set the specific amount of chemical contents inside gasoline and diesel for the refineries to follow before distributing to the market as their final products. The low-sulfur fuel standard has been widely implemented globally on gasoline and diesel. Standards have been implemented differently from the regions around the world. For instance, low-sulfur diesel standards currently practice are from China, European Union (EU), Environmental Protection Agency (EPA), India, and California Air Resource Board (CARB), while there are four low-sulfur gasoline standards of China, EU, India, and EPA. Each of standard has different level for example EU III, IV and V. Each of upgraded level shows the lower trend standards of specific parameter contents in diesel or gasoline. For Thailand, both diesel and gasoline low-sulfur standards are following EU V standards, and from 2016 both gasoline and diesel low-sulfur standards are limited to 10 parts per million (ppm) of sulfur substance (Josh, 2016). Recently, Peru's Government has decided to upgrade low-sulfur standard on diesel to EU IV in 2016, and gasoline in 2017. With cooperation of government and private sectors, the budget plan for implementing the upgrading is up to USD 4 billion, and it is expected to create the cleaner fuel products, and raise the air quality in Peru (Sebastian & Chris, 2016).

Emission standard is a policy, which aims to set standard of emission on vehicles based on specific gases released by vehicle. Emission standard indicators are Carbon Monoxides (CO), Hydrocarbon (HC) and Nitrogen Dioxides (NO_x). In Thailand, both light and heavy-duty vehicle have been applied the EU IV emission

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standard. There are four main standards, which are from EU, US, China, and Japan (Josh, 2016).

Fuel efficiency is one of the policy, which aims to limit the fuel consumption of vehicle. The main indicator can be used as amount of fuel consumption of the vehicle per kilometer (l/km) and amount of CO_2 emit by vehicle per kilometer (g/km). This policy aims to limit the amount of fuel consume by vehicle for automotive producers. Both passenger vehicles and heavy-duty vehicle are in the scope of fuel efficiency implementation. Passenger vehicle fuel efficiency has been implemented widely, while for heavy-duty vehicle has been targeted to implement the fuel efficiency standard by only four countries such as Japan, the US, China and Canada. The US and Canada implemented this policy on heavy-duty vehicle on the same time frame as from 2014 till 2018, and to achieve 14% average CO_2 compare to year 2010 model. For other heavy-duty vehicle markets such as Russia, and South Korea are still considering. But for EU, mitigation plan of emission from heavy-duty vehicle are set and fuel efficiency on heavy-duty vehicle is one of the policy to be implemented (Drew, 2015).

For Thailand, ECO Car and Sticker are currently practicing on passenger car for automotive producers to follow. Thailand ECO Car plan had been carried out for two phases since 2008. The mechanism of Thailand ECO Car is about setting the specification of the car to be produced by automobile producers with the criteria of investment specifications such as capital, production rate, etc. In the return, manufacturers who can successfully apply for ECO Car specification will be able to receive attractive incentives such as 30% of excise tax lower compare to the conventional vehicles, corporate tax exemption for eight years, and exemption on the import duty of machineries and equipment up to 90% for first two years. Thailand ECO Car is one of the successful policy in Thailand.

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Table 2.2 Thailand excise tax reform from engine sized base to CO_2 emission rate base

Type	Previous Scheme (Before 1 Jan 2016)						New Scheme (Effective from 1 Jan 2016)					
	Engine Size (< 220HP)	Gasoline Gasohol (E10)	E20	E85	NGV	HEV , PHEV, BEV, FCEV	Engine Size	CO_2	E0 - E20	E85, NGV	HEV	PHEV, BEV, FCEV
Passenger Cars	< 2000cc	30%	25%	22%	20%	10%	< 3000 cc	< 100 g/km	30%	25%	10%	10%
	2001 - 2500 cc	35%	30%	27%	20%			101 - 150 g/km			20%	
	2501 - 3000 cc	40%	35%	32%	20%			151 - 200 g/km	35%	30%	25%	
								> 200 g/km	40%	35%	30%	
	> 3000 cc or 220 HP	50%	50%	50%	50%		> 3000 cc		50%	50%	50%	
Eco - Car	Gasoline < 1300 cc	17%					Gasoline < 1300 cc	< 100 g/km	14% or 12% for E85			
	Diesel < 1400 cc	17%					Diesel < 1400 cc	101 - 120 g/km	17%			

Source: Mary, S. (2012). Thailand Restructures Vehicle Taxes, Tax-News. Retrieved from http://www.tax-news.com/news/Thailand_Restructures_Vehicle_Taxes___58922.html

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The lessons learn from Eco Car plan is competitiveness of industries can be increased by the strict environmental standard policy. As Thailand is the only country in ASEAN who is considered as automobile hub, and it can be inferred that, once the strict environmental policy impose with attractive incentives, the firms in industry tend promote their Research and Development (R&D) in order to build their own competitiveness to optimize operational cost and well as to obtain the incentives. But without the involvement from automobile, this policy would not be able to be successful (Tanawat, 2014). On 1 January 2016, Thailand new excise tax has come to be effective, which the reform is about reforming the base state from engine size to emission rate of CO_2 per kilometer (g/km). The new excise tax aims to encourage the production and usage of lower emission vehicles than the conventional vehicle. This new excise tax can minimize the price gap between low emission vehicles with the conventional vehicles (Mary, 2012). The automotive producers shall invest in low emission cutting-edge technology in order to produce the vehicles that meet to the standard, which has lowest excise tax, in order to reduce vehicle cost, and in return of maintaining the sale volume of the companies. From customer side, there will the closer gap between low and normal emission rate vehicle, so purchasing and using lower emission rate vehicle tend to have higher probability. Anyway, this reform did with only passenger vehicles, while road freight vehicle type is still complied with non-reform import duty and excise tax.

2.4 Carbon Pricing Mechanism

Climate change is one of global issue, which requires the participation of all nations to deal with. Rising of sea level, severer drought, strong typhoon, global warming are consequences of climate change, which initiates by the presence of

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overwhelm amount of GHGs in the earth atmosphere.

Since 1979, World Climate Conference had held to raise the issue about changes of climate and firstly presented proofs of climate changes. It was held in Geneva, Switzerland by World Meteorological Organization (UNFCCC, 2014a). Moreover, significant climate change mitigation context was made in Kyoto, Japan, on 11 December 1997 and two important key feathers of this protocol were emission binding with commitment of developed countries and flexible market of carbon emission trading. Anyway, these mechanism had entered to force on 16 February 2005 (UNFCCC, 2014b). Later, this Kyoto Protocol had been amended and named as "Doha Amendment to the Kyoto Protocol" in Doha, Qatar, on 8 December 2012. Key feathers to be amended were the second commitment period from 1 January 2013 to 31 December 2020, list of greenhouse gases for second commitment. In summary, there are three mechanisms introduced in Kyoto Protocol such as International Emission Trading, which refers Carbon Market; it requires the participation of parties in commitment to trade emission units. Second mechanism is Clean Development Mechanism (CDM). It allows commitment parties in Annex B to invest in the projects to reduce emission in developing countries and yield as the earned unit of emission reduction of the invested parties. The last mechanism is defined in Article 6 known as Join Implementation (JI), which responses to CDM project from side of host parties. They will also receive CDM project to earn the credit on emission reduction as well (UNFCCC, 2014c). In December 2015, another significant agreement of climate change mitigation was made in Paris so called "Parties of Conference (COP21)". It has shown another context from commitment (of Kyoto Protocol) to "nationally determined contributions". This aims to let parties solely share up to date about progress and own mandates implementation and further steps information (UNFCCC, 2014d).

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Carbon pricing term has been introduced due to its cost. Carbon dioxide as a main contributor to climate change imposes many consequences through illusion as natural disasters, animal species wipe out, agricultural yield reduction, etc. It is predicted that global income will be reduced by 23% as it would be without presence of climate change in 2100 (Worland, 2015). Transport Sector contributes not only the significant portion of CO_2 emissions, but it also creates huge losses of welfare economically and socially. Hence, CO_2 emission is considered as another negative externality that should be mitigated by economic instruments (G. Santos, Behrendt, Maconi, Shirvani, & Teytelboym, 2010). Such economic instruments include Carbon Tax and Cap and Trade system, are the mechanisms to set price on carbon, which is emitted to the environment. Carbon tax is defined as tax based on greenhouse gases generated from fossil-fuel burning activities. The tax aims to discourage and lower CO_2 emissions and promote less emission practices (Antimiani, Costantini, Martini, Salvatici, & Tommasino, 2013). Cap and Trade system is a regulatory measure that is used to limit certain amount of emissions and allow the excessive emissions to be traded in a designated market (Antimiani, Costantini, Kuik, & Paglialunga, 2016). Economically, carbon emission is holding a certain cost, which response to loss. As known to stimulate and tackle the emission externalities, two main market-based instruments have been introduced as carbon tax and cap and trade system.

Academically, mechanisms of carbon mitigation are Carbon Tax (CT), Conventional Cap and Trade (CCT), and Hybrid Cap and Trade system (HCT). CCT is the system, which come up after The Kyoto Protocol in 1996. It allows all practitioners to trade the carbon units between each other in order to get the neutral status. For those who are able to achieve lower emission units than the standard, they are be able to trade those excess of the units to others and can get financial benefits in return. Moreover, it

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is based on real market supply and demand of emission units, hence price volatility can be unpredictable. On the other hand, HCT is based on CCT system, which allow the emission units to be tradable, but in order to tackle the price volatility, price floor and ceiling have been set. Finally, CT is system does not involve with trading emission units, but it is in form of tax, fees, charge based on carbon emission, which is contributed by fossil fuel burning activities on specific sectors. It is under the controlled of government, and amount of tax may increase as government policy on emission mitigation plan.

Goulder and Schein (2013) examined reviews and characteristics of these CCT, HCT, and CT on 13 different dimensions. The review method was applied in this study in order to point out the equal and difference dimensions caused by the three different mechanisms of carbon pricing. Four dimensions such as incentive of reduce emission, distribution of burden across industries and household groups, international competiveness, and connection with offsets are considered as the equal dimensions. All of mechanisms are be able to create incentives for the target groups to reduce emission in different way, and the scope can be justified for different targets (industries or household) in order to maintain the international competitiveness. For the other nine dimensions, three of them results in different ways. Those three dimensions are the administrative cost, volatility of emission price, and addressing the uncertainty. For administrative cost, CT is marked as best fit due to the complexity of carbon market, trader creation and real time carbon price trend are main cost factors for CCT and HCT. For CT, cost to implementation is low as it is in the form of regulation and imposing the fees or charge. Government will be the only party to involve in mechanism preparation. Volatility of emission price is a major problem CCT. As this system is not be able to control the price volatile of emission unit, hence price can rise and drop in

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unpredictable way. Finally, the addressing uncertainty, CT and HCT are better than CCT on this dimension. Because the predictable price of emission can cause the firms to setup the operations to limit the emission accordingly predicted price, while in CCT system, the firms cannot project optimized investment or setup as price of emission is highly volatile (Goulder & Schein, 2013).

Currently, there are 40 nations and 20 sub-nation jurisdictions that implement the carbon pricing mechanism, and it has accounted around 12% of global emissions in 2015. The pricing are varying from 130 to less than 1 USD per tonnes of CO_2, as Sweden sets highest and Mexico and Poland sets the lowest rate (Kossoy et al., 2015). Experiences of each nations toward carbon pricing tools are varying due to different contexts and choices of carbon tax or cap and trade system.

According to Interagency Work Group on Social Cost of Carbon in 2010, carbon shall be taxed equal to the marginal benefits of emission reduction to achieve effectiveness and efficiency, and it shall be covered every sectors, which emit the emission (Aldy & Stavins, 2011). So, not only down or upstream of sectors utilize the fossil combustion, it is required all sectors to be involved to carbon tax and its rate shall be responded to benefits without the presence of the emission as it is supposed to be.

In real practice, carbon tax has been levied on energy sector or the upstream sector such as refineries, coal mines and natural gas companies. While tax is set, they normally will push responsibility to the end users via product price, hence it will create the incentive for conventional automobile users to look for choice of more efficient vehicles on petroleum product consumption. As the example of Northern Europe as Norway, Sweden, Finland, Denmark, and Netherland have experienced with carbon tax since 1990s. In 1991, Norway started to impose carbon tax on energy sectors such gasoline, coal and diesel (while diesel has been taxed the lowest rate). Norway reached

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to cover emission about 55% of all sectors in 2009. For Sweden has similar mechanism, but Swedish government allows the exemption of carbon tax on sectors, which are covered already by EU Emission Trading Scheme (EU ETS) to avoid double responsibility and also metal related sectors are also in exemption list. Till 2015, price of carbon in Sweden costs USD 130 per tonnes (Aldy & Stavins, 2011). For Denmark with experiences, carbon tax was introduced in fossil fuel tax with energy tax in May 1992. As a result, Denmark emission per capita was reduced 15% from 1990 to 2005. In Netherland, carbon tax started in 1990 on energy sector. The revenue has been using on environmental program and incentive schemes for corporate benefits. As tax rate keeps increasing, annual CO_2 is expected to cut down about 4.6 to 5.1 million tonnes in 2020. Specifically, Finland as a first country to adapt the carbon tax, it was added on fossil fuel tax while fossil fuel using in commercial vessels and aviation were exempt. In 2000, the government announced 7% of emission was reduced due to the presence of carbon tax (Sumner, Bird, & Dobos, 2011).

Starts from 2000s, carbon tax has been adopted in other nations such as United Kingdom, Quebec of Canada, Boulder of Colorado, France, etc. The trend has been following due to the tension of climate change issues, environmental agreements, which bound by international protocols such as Kyoto Protocol and COP. The consequences of carbon tax is mainly to reduce the emission within the country, but for Norway, emission were increased by 15%, while GDP increased by 70% from 1991 to 2008. Even though, emission was not reduced in Norway, but gaining 70% of GDP is a major success story.

To understand and see the position of countries with or without implementation of carbon pricing tools, scatter plot has been utilized. Figure 2.4 shows the position of Thailand compared to other nations who already adopted the carbon pricing policy

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(carbon tax or emission trading system) by total annual emission. Because China, Japan and EU are the most contributor on CO_2, the level of emission from these countries are too high compared to others. Hence, they are removed from the plot.

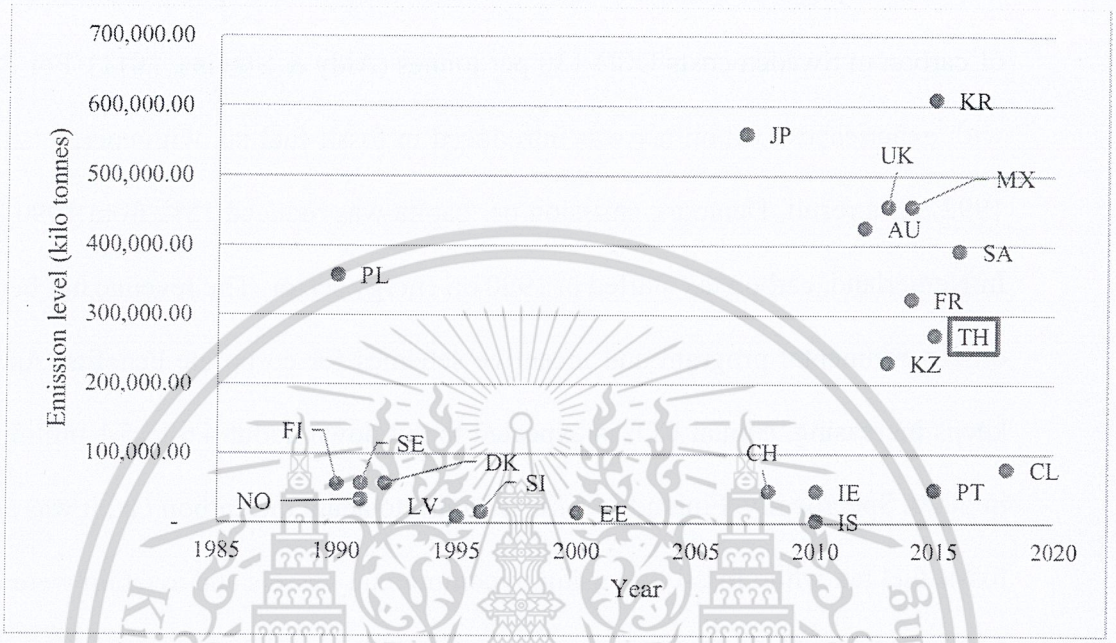

Figure 2.4 Plot of total emission and year implemented of carbon pricing

Note: AU = Australia, CA= Canada, CL = Chile, CN = China, DK = Denmark, EE = Estonia, EU = European Union, FI = Finland, IS = Iceland, IE, Ireland, JP = Japan, KZ = Kazakhstan, LV = Latvia, MX = Mexico, NO = Norway, PL = Portugal, SI = Slovenia, SA = South Africa, KR = South Korea, SE = Sweden, CH = Switzerland, TH = Thailand, UK = United Kingdom

As mentioned above, the northern European countries are the first mover of carbon tax since 1990s, and this can be seen that Poland has the greatest total amount emission compared to the other first movers such as Finland, Denmark, and Norway. Thailand positions in the middle of the groups of countries who implemented carbon pricing tools from 2005.

However, comparing amount of total annual emission level can be misleading due to the difference level of macro-economic factors of the countries. Those factors are emission per capita and GDP to total emission level. They can be used to illustrate the accurate position of Thailand compared to other countries who already implemented

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carbon pricing tools.

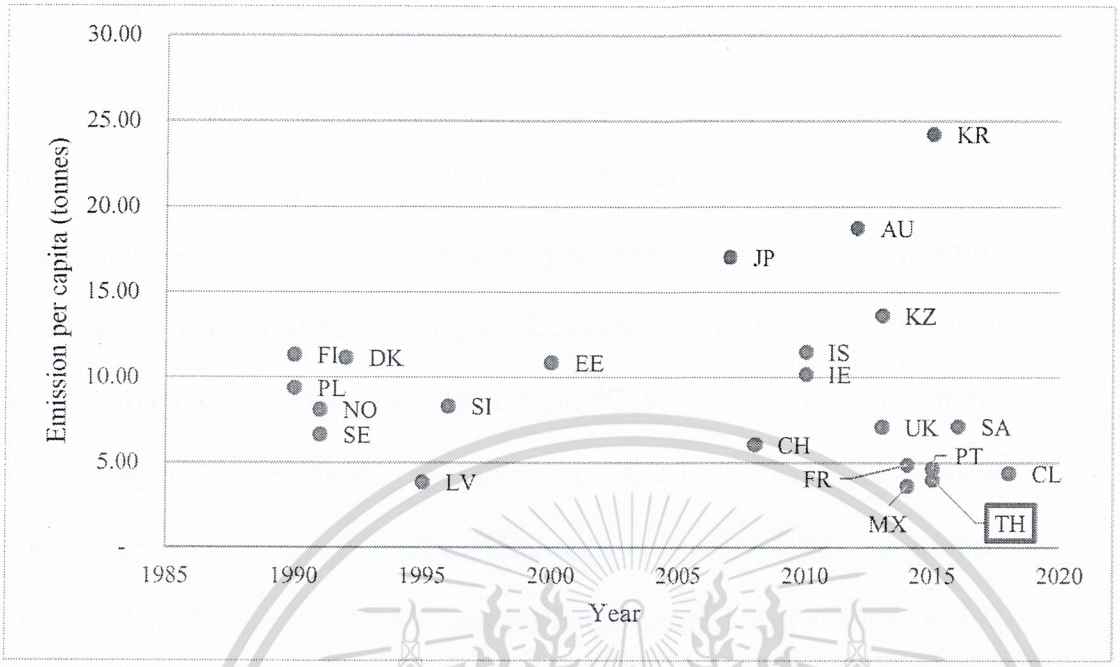

Figure 2.5 Plot of emission per capita to year implemented carbon pricing mechanism

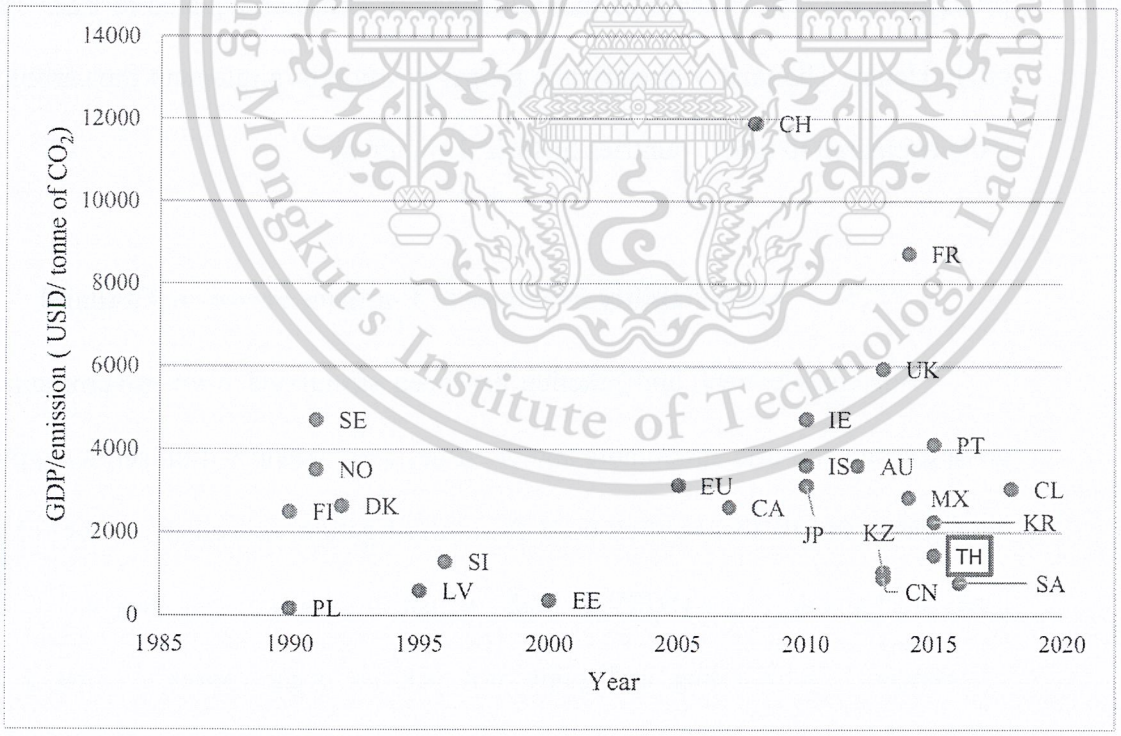

Figure 2.6 Plot of GDP to emission level to year implemented carbon pricing mechanism

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Figure 2.5 illustrates the emission per capita versus the year implemented carbon pricing tools. South Korea has the highest level of emission per capita (24.25 tonnes/capita), and Mexico has the lowest level (3.64 tonnes/capita). For Thailand, emission per capita by year 2015 was 4 tonnes per capita, which is considered as low compared to other countries in the plot; however, the low level of emission per capita countries such as France, Mexico, Portugal, and Chile already implemented carbon pricing tools. In Figure 2.5, GDP per emission is introduced. Switzerland is the country who has highest level of GDP per emission. In Switzerland, one tonne of emission equaled to USD 11,895.57 of total GDP in 2008 (as the year of carbon pricing tools implemented in this country). For Thailand, one of emission equaled to USD 1,453.35 of total GDP in 2015. By the figure, Thailand position locates closely to Kazakhstan, South Korea, Chile, and South Africa. However, Poland has implemented carbon pricing since 1990, by the time that one tonne of emission equaled to USD 180.89 of GDP. Hence, Thailand is already in a proper position to implement the carbon pricing tools compared to other countries historical situations.

2.5 Sustainability Practices in Logistics Sector in Thailand

Sustainable trend and practice has been stimulated from government side to private sector to build sustainable and environmental friendly mindset to support legal mechanism and national policy on emission mitigation as well the global plan. Dow Jones Sustainable Index (DJSI) is body investing in sustainable practice by creating assessment, benchmarking, and guide took part the organizations toward sustainable practice and especially raising stock performance in market. Carbon Disclosure Project (CDP) is also a project, which aims to make transparency on organizations' priority to reduce emission through benchmarking emission level according to CDP's guideline.

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In Thailand, Siam Cement Group (SCG) and PTT are well-known for sustainable practitioners as these two companies has been listed in DJSI and annually participate in CDP. Even though solid legal instrument has not been rolled for private sectors to participate and practice business in sustainable framework, the trend in market has been lined up. Specifically, to logistics sector, SCG Logistics Management is one of the companies, which raise up the sustainable or green logistics by their strategies on three pillars, which are multimodal management, deadhead deduction management, and consolidation management. The multimodal management refers to the arrangement of the shipments to various modes of transportation under specific condition to save cost and meet customer expectation. For example, SCG tends to use rail, road and sea mode for their multimodal management strategy. The deadhead deduction management is all about optimize the decoupling period. SCG applies this strategy to ensure trucks shall be not traveled with empty trailer. This strategy can boost company performance financially, and environmentally. The last strategy is consolidation management, which refers to the use full-loading truck rather than partial.

2.6 Previous Studies Related to Carbon Pricing Mechanism Effects and Applications of Electric Vehicle in Logistics Activities

To logistics practitioners, cost is the main contributor for the decision makers to select transport mode and require the practitioners to optimize with service level in order to gain the competitive advantages. As carbon mechanism studies for road freight vehicle are limited and it is not yet implemented, hence impact, insight, overview, challenges and methodologies of carbon mechanism on passengers will also be discussed.

To achieve reduction of emission in Japan, Oshiro and Masui (2015) used AIM/Enduse model to assess the impact of low efficient vehicles in 10 regions in Japan.

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The study was done by completing the assessment of model frameworks focusing on the impact of low emission vehicles in transport sector. All types of vehicles regardless the size of heavy, medium, and light duty vehicles were in the scope of this study. As low emission vehicles also refer to the vehicles, which consume electricity as the fuel. Hence, the assessed framework was revised based on current and estimated situation of power generation in Japan until year 2050. Scenarios are made regarding to the factors such as socio-economic indicators, power generating (without nuclear power plant), carbon price presence, and technological assumptions. The results showed that significant emission would be reduced and the share of low emission vehicle would increase by 90% and 60%, respectively for passenger and freight vehicles, once carbon tax was introduced.

AIM/Enduse model was used by Selvakkumaran and Limmeechokchai (2015) to modelled Thailand's land transport sector with under three low carbon society scenarios and four assumed of emission taxes. Low carbon society scenarios are Low-Low Carbon Society (L-LCS), Medium-Low Carbon Society (M-LCS), and High-Low Carbon Society (H-LCS). Emission tax scenarios were USD50, USD100, USD200, and USD500 per tonne of CO_2. An assessment was also carried out to be subjected to the marginal abatement cost and the co-benefits, as an example, the energy security. Conclusion was drawn that emission tax 100 USD per tonne would be the average abatement cost to fit in H-LCS.

Liu et al. (2015) used the integrated model approach to build projection of emission from truck and rail in United State until 2050. Models were integrated with macroeconomic activities, freight demand by commodities, networks of transportation, and technology emission in order to assess the future of freight emission. The study indicated that shift between road to rail would be existed. Moreover, this would lead to

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reduce emission and energy consumption for 10-28% and 30% respectively by 2050 once carbon tax implemented, as the existence of carbon tax would affect to fuel cost and over all transportation cost.

Hennessy and Tol (2011) assessed the impact of the new emission based reform tax and GHGs level. Within three layers of reform taxes to fuel, purchase and ownership taxes, the study was based on model of car stocks and car purchase preference model in Ireland. This study aimed to seek for the distribution of mileage, total cost of ownership, and the behaviors of end users. Huge shift behavior to greener fleets, and the drop tax revenue from passenger vehicle were found after model was simulated. Car users would choose low emission vehicle, and this led to the lower annual tax revenue come from purchase tax, and especially the vehicle registration fees.

A simplified dynamics model was established by Cheng, Chang, and Lu (2015) to oversee the impact of urban transportation policy regarding to the emission mitigation and fuel consumption reduction. Study was based in Kaohsiung city with three examined policies of fuel tax, motorcycle parking management, and free bus service for 30 years timeframe. Only fuel tax and motorcycle parking management were effective to mitigate emission and reduce energy consumption.

Carbon policies study for supply chain and logistics design was studied by Jin, Granda-Marulanda, and Down (2014) in United States in the case study of the biggest retailer, Walmart. This study assumed the retailed business consists of three layers, which are suppliers, distribution centers (DCs), and retailers. Cost optimization was employed under three assumed carbon policies. Four models were generated: (1) cost-only model, (2) carbon tax model, (3) carbon cap model, and (4) carbon market model. The Cost-only model is the model without presence of carbon policy. The carbon tax model was a model, which the carbon tax was presented; tax rate as USD per kg of CO_2

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was existed in this model. The carbon cap model was a model, which specific amount of CO_2 was in the constraint of the retailers' operations. Similarly, the carbon market model refered to model with carbon cap policy, but it allowed the firms to trade CO_2 units. By optimization, simulation, and sensitivity analysis test of each model, the study showed that redesign of supply chain and logistics flow could be conducted through extreme, or very strict policies of carbon tax, inflexible cap, and carbon market. This study also exemplified that reaching the consensus of accepting carbon policy between policy makers and practitioners was extremely difficult.

Vehicle to Grid (V2G) opportunities was studied by Zhao, Noori, and Tatari (2016) to assess its benefit in terms of net present value and emission mitigation of future electric commercial truck. Assumed by two types of electric truck in future as BEVs and Extended Range Electric Vehicles (EREVs); cost analysis and emission of BEVs and EREVs were benchmarked with conventional diesel trucks. After V2G framework developed, this service could annual yield $20K - $50K with 300 tonnes of CO_2 after BEV and EREV were adopted.

Seitz, Beuttenmüller, and Terzidis (2015) conducted a study on structure of preference that influence on the willingness of logistics practitioners to choose emission efficient powertrain for medium to heavy-duty vehicles. Buying condition and decision frameworks were constructed based on organizational, technological and environmental frameworks. By using multiple linear regression and coefficient determination, influenced factors, which were corporate social responsibility, and market stage (environmental mature, and be oriented), found to be significant. This finding was found only in the large companies, while in the small and medium companies, the conclusion could not be drawn.

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Davis and Figliozzi (2013) compared the competitiveness of EV. The samples of study were one brand of diesel truck and two brands of electric trucks. The study conducted by optimizing a model, which was integrated by four different models. The four models were: (a) a vehicle ownership cost minimization model, (b) a continuous approximate model to estimate traveled distance, fleet size, plus ensuring that constraints of practical routing are satisfied with the model, (c) a power assumption model of electric trucks to estimate power consumption, and maximum potential range with the factor of vehicle velocity and weight, (d) an adjustment for real-world velocity profiles. The study found that 85% of scenarios were fallen into diesel truck category. Therefore, diesel truck was more competitive than electric trucks. However, through elasticity analysis, purchase cost found to be the most influencing factor for companies to choose the diesel truck over the electric trucks.

Macharis, Van Mierlo, and Van Den Bossche (2007) developed a model to estimate the ownership cost of light commercial EV in Brussels by comparing eight BEVs, five diesel, and two petrol models of vehicles. Based on the sensitivity test, EV were more competitive for weight load lower than 1,000 kg, while conventional vehicles were more competitive for weight load more than 1,000 kg. This result implied that EV are suitable for urban distribution and last-mile delivery practices. Similarly, the adoption of EV distribution was studied by Saenz-Esteruelas, Figliozzi, Serrano, and Faulin (2016) to improve quality of life by reduction of GHGs. The study was conducted in Portland and used real data of one logistic company to evaluate the carbon footprint. The use of electric tricycles for last-mile delivery delivered a huge reduction of GHGs due to the nature of urban distribution itself. Hence, it could be inferred that once carbon policy implemented in the urban areas for logistics activities along with the use of electric tricycle distribution mode by logistic companies, emission of GHGs

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will reduce, and quality of life in the urban areas will also be improved.

Kleiner et al. (2015) assessed a techno-economic assessment based on Transport Application based on Cost Model (TAMCO) on powertrain technology advancement of freight vehicles with gross weight lower than 3.5 tonnes. The comparison and assessment were taken in different countries such as Germany, Austria, the United Kingdom, Turkey, and South Korea. The result showed that BEV was more competitive in terms of cost comparing to FCEV. Furthermore, the main indicators of decision-making were purchase tax, resale value and energy price.

Logistic distribution routing model was determined and followed with simulation test of the total operational cost by Zhou, Wang, and Tao (2015) under the carbon policies. As carbon policies implemented, fossil fuel burning activities, specifically, the transportation would be incurred more cost. So, routing of logistic business would need to be re-modified in order to reduce the emission. This study showed that in order to reduce emission along each carbon policies, logistic routing decision must re-modified. However, the study also suggested that financial incentive schemes should also be implemented along with carbon policies.

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CHAPTER 3

RESEARCH METHODOLOGY

3.1 Study Setting and Sample Size

In logistics operation, there are four layers of practitioners divided by scope of services and responsibilities. There are 1st Party Logistics (1PL), 2nd Party Logistics (2PL), 3rd Party Logistics (3PL), and 4th Party Logistics (4PL). 1PL refers to the real consignees or shippers, who own the products, and they perform logistic activities by themselves. 2PL refers to the logistic companies, who own assets for their operation such as vehicles and warehouse for transportation and warehousing services. 3PL refers to the logistic companies, who do not own the assets, but they play the role as a party to control the shipment arrangement on behalf of the real consignees or shippers. Finally, 4PL is company, who control the over all of supply chain of product or service to ensure all key performance indicators are met with standards of the clients.

The study is set to assess the perspectives of logistics practitioners on the mechanism of carbon tax and implementation of electric vehicle for road freight transport in Thailand. As the ultimate impact party will be the Logistics Service Provider (LSP), who own the vehicles, then 2PL is the primary focus group of the study. Based on Thailand Truck Center website, there are 36,746 trucking companies by 10 January 2017.

In order to determine the sample size of the study, Yamane Taro's formula for sample size is followed to calculate the specific required number of the samples (Yamane, 1967). The confidence level of the study in 95% or with sampling error of 5%. The formula and notation are as below:

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$$n=\frac{N}{1+Ne^2} \tag{3.1}$$

Where n = sample size to be surveyed

N = total number of population

e = level of precision or sampling of error (0.05)

As total number of population is 36,746 companies, and the confidence level is 95% (e = 0.05), hence number of sample size for this study is 395.7 or approximately 396 companies.

3.2 Questionnaire Design

Data collection method of this study is primary data collection through the survey. In the survey, the questionnaire is the tool to obtain the data. The designed questionnaire consists of four types of questions such as categorical, ordinal, continuous and open-ended question types. It is structured as six sections as below:

a. Demographic and company information: in this section, four questions are set in order to get information of respondent as type of business, number of employees, types of transport service provided in company, and the annual revenue in year 2015.

b. Vehicle and usage: information of total number of vehicles categorized by Gross Vehicle Weight (GVW), monthly average distance of each type of vehicle, and fuel types are gathered.

c. Decision framework toward vehicle selection: two scenarios were built in order to understand the perceptions of practitioners on vehicle selection decision framework. First scenario is to discover the pre-and post-sale vehicle-related factors impact on the vehicle selection, and second scenarios is to investigate the pre and post-sale vehicle-related

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factors impact on the total operational cost of trucking service.

d. Perspectives on green logistics: nine questions were placed in order to assess the information related to the practice of "Green logistics", appropriate strategies to reduce carbon footprint, benefits after reducing carbon footprint for the business, and factors impact on the consideration to apply carbon footprint reduction in their organizations.

e. Perspectives about implementation of electric vehicle: in this section, perspectives related to situations, and applications of electric vehicle are collected.

f. Perspective of carbon tax proposal in Thailand: six questions are assessed in this section in order to collect the perceptions of practitioners on carbon tax, and how carbon tax should be implemented in logistics sector.

The questionnaire was built in English, then it was converted into Thai with the supports of native Thai people. Because the targets of population are Thai companies, hence to be convenient, and to reduce the misunderstanding at respondent side, questionnaire was translated from English into Thai.

3.3 Survey Procedures and Data Collection

As this research data is obtained from conducting the survey, validity and reliability of the survey data are crucial for the study setting. To confirm the validity of questionnaire for the survey, questionnaire pre-test was conducted. Draft of questionnaire was firstly sent to 10 companies for pre-testing the questionnaire. After getting feedbacks, questionnaire was revised on terminologies, and the flow of the questions.

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Survey questionnaire of this research are in online and hard-copy forms. For online form, questionnaire was uploaded into Google Form[a] and QR[b] code for convenience of the respondents to access the survey. The link of questionnaire was sent to respondents via email. For hard-copy questionnaires, they were sent via Thai Post Mail service to respondents' addresses.

Responses of respondents were collected from both channels, and coded into Microsoft Excel. Data collected from the survey is confidential and served for this research purpose only.

Number of respondent contacts are relied on different sources in order to full the standard sample size of 396 samples.

a) Website of Thai Truck Center
b) Companies are in the scope of project of Regional Truck Terminal of Thailand
c) Participants of Market Sounding, which is a part of Thailand Regional Truck Terminal project

The total of 585 questionnaires were sent to the above sources by mail services, hard copy forms, and online form in Google Form. Furthermore, this study also got supports from associations as below to help to distribute the questionnaires to their internal members:

a. Thai Land Transport Association
b. Thai Transportation and Logistics Association (TTLA)
c. Thai International Freight Forwarders Association (TTFA)

More than 586 companies have received the access to the survey from all

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[a] The link of survey questionnaire in Google Form is in Appendix
[b] The QR code is attached in Appendix

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sources. Eventually, this study received 24 respondents. The low response rate was received due to the sensitivity of this topic related to new proposal of tax, which is the conflict of interest between government and private sector.

This study reliability test and analysis employed the Cronbach's alpha or coefficient alpha to confirm level of reliability toward the Likert scale question type. By Table 3, the Cronbach's alpha of the study equals to 0.916 (> 0.75), hence the results of Likert scale questions from respondents are confirmed to be consistent and reliable.

Table 3.1 Analysis of reliability or consistency level

Reliability Statistics	
Cronbach's Alpha	N of Items
0.916	24

3.4 Data Analysis

Data was recorded into Microsoft Excel 2013 for data preparation. Then, it was imported into SPSS Statistics Application Version 22 for the analysis. Reliability test and both descriptive and inferential methods were used to analyze this data.

a) Reliability Test: in order to confirm the consistency level of the study, Cronbach's alpha or coefficient alpha test was utilized. The coefficient results in percentage or value from 0 to 1. It interprets the consistency of respondents to the survey questions, and the acceptable level is 0.75 or 75% (J. R. A. Santos, 1999).

b) For descriptive method, cross tabulation was employed to illustrate percentages and frequencies between two different variables in the study. The target variables were visualized by cross tabulation in order to see the joint frequency of the target parameters.

c) For inferential method, Chi Square test was used in order to confirm

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possible relationship between two categorical variables (Norušis, 2006).

The hypothesis test of Chi Square test are:

a. H_o : No evidence of possible relationship between the variables

b. H_1 : There is significant possible relationship between the variables, reject H_o if p-value < 0.05

As the questionnaire is formed mixed four types of questions, the categorical, ordinal, and Likert-scale types are both analyzed with the cross tabulation and Chi Square methods, while open-ended question response will be categorized and represented in Cross tabulation table.

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CHAPTER 4

RESULTS AND DISCUSSION

4.1 Demographical and Operational Information of the Observations

After distributing the 585 questionnaires to total population through post mail service and e-mail, there were a total 24 respondents responded to the survey in total. Demographical information about the respondents mostly are questions in section 1 and 2. Specifically, demographical information in the study includes company business type, types of transport service, share of inter and intra city total shipments, current fuel types use for vehicle, number of employees, number of vehicles, and the company revenue. The frequencies of the demographical factors of respondents are illustrated in Table 4.1.

Approximately, 75% of the respondents were sole proprietorship, while another 25% were corporation. Intra city shipment refers to boundaries of transportation inside the city, while intercity refers to the boundaries of transportation, which is between the cities. All of respondents were operating both inter and intra city shipment; however, they had different proportions between these two types of shipments. Five scenarios were built in order to investigate how much each type of shipments weight to total shipments handling in normal operating period or season. If there will be impacts on intra or intercity transport in terms of policies or regulations, respondents will concern about that issue the most.

Most of the respondents have both intra and intercity transport shipments. It consisted of 83.3% of the total respondents. Approximately, 29.2% of respondents had same proportion between inter and intra city shipment. Approximately, 4.2% of the respondents had intra city shipment, which was relatively higher than having intercity

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shipment. Another 25% of the respondents had majority shipment as intercity shipment, and the rest of 41.7% of the respondents had majority shipment as intra city shipment. Number of employees from the respondents was varied from 6 to 500 employees. There were 54.2% of the respondents have the number of employees up to 50 people, 12.5% had employees between 50 to 100 people, and 33.3% of them had more than 100 employees. For revenue side, it ranged widely from 2 million baht till 400 million baht in year 2015. This range of revenue was quite huge. There were 29.2% of the respondents had revenue up to 50 million baht, 16.7% of them had revenue between 50 to 100 million baht, and another 54.2% of them had revenue between 100 to 200 million baht. The most used fuel type, which majority used for transport operation in respondent companies, 75% is diesel. For the number of vehicles, 58.3% of the respondents owned up to 50 vehicles, 4.2% of them owned 51 to 100 vehicles, and another 37.5% owned more than 100 vehicles. The detailed demographical information of the respondents of the study is in below Table 4.1.

Table 4.1 Frequency and descriptive table of demographical factors of the respondents

Demography Factors	Frequency	Percent	Valid Percent
Company business types			
Sole proprietorship	18	75	92.3
Corporation	6	25	7.7
Total	24	100.0	100.0
Types of transport service			
Intra city transport	3	12.5	12.5
Intercity transport	1	4.2	4.2
Both intra and inter city transport	20	83.3	83.3
Total	24	100	100
Share of inter and intra city shipments			
Intercity 50% intra City 50%	7	29.2	29.2

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Demography Factors	Frequency	Percent	Valid Percent
Intercity 35% intra city 65%	1	4.2	4.2
More than 85% is intercity	6	25	25
More than 85% is intra city	10	41.7	41.7
Total	24	100.0	100.0
Majority type of fuel use			
Diesel	18	75	85.7
NGV	1	4.2	4.8
Others	2	8.3	9.5
Missing	3	12.5	
Total	24	100	
Number of Employees			
Up to 50 people	13	54.2	54.2
51 – 100 people	3	12.5	12.5
More than 100 people	8	33.3	33.3
Total	24	100	100.0
Revenue in 2015 (millions baht)			
Up to 50 million baht	7	29.2	29.2
Between 50 to 100 million baht	4	16.7	16.7
More than 100 million baht	13	54.2	54.2
Total	24	92.3	100.0
Number of vehicles (units)			
Up to 50 vehicles	14	58.3	58.3
From 51 – 100 vehicles	1	4.2	4.2
More than 100 vehicles	9	37.5	37.5
Total	24	100	100.0

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4.2 Perspectives of the Practitioners on "Green logistics" and Carbon Footprint or Emission

In this part, assessment of perspectives of Thai logistics practitioners on "Green logistics" and carbon footprint or emission was made. Descriptive results are shown in Table 4.2.

Four related questions were assessed. Most of the practitioners knew that CO_2 is the most important GHGs. It is the largest contributor toward currently climate change issue. Methane (CH_4) is also of important GHGs, but it ranks lower than CO_2 in terms of contribution level. On the topic of concerning carbon footprint in operation, only 20.8% of the respondents responded "No", while 79.2% responded that they are concerning. The respondents, who responded that they were concerning about carbon footprint, provided additional reasons that emission is the main cause of climate change issue, so it shall be reduced. Additionally, they indicated that emission shall be mitigated because the impacts of environmental problem is a global issue. For respondents who answered "No" in this question, they raised the reason that they are just the Small and Medium Enterprise (SME), so their business impacts could not be significant compared to the other huge industrial businesses.

In part of understanding "Green logistics", 58.3% of the respondents chose the correct definition, which indicate that "Green logistics" is the conceptual practice that concern about all three bottom lines (society, economy, and environment). The other 37.5% of the respondents thought that "Green logistics" was about the environmental concerned approach, and the rest 4.2% of the respondents thought that it was about society concerned approach. There were 62.5% of the respondents, who were following the "Green logistics" in their business, while the rest are not. The respondents, who were following the "Green logistics", provided the examples about their approaches such as the regular internal vehicle inspection, utilization of the cleaner energy, making

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the engine idle during the traffic jam or the long breaks, and reduction the deadhead trucks. For the respondents who were not following "Green logistics", they raised up that there were lacking of initiatives, policies, and specific practices in general from both public and private sectors.

Table 4.2 Perspectives on green logistics and climate change issues

Factors	Frequency	Percent	Valid Percent
Response on the most important GHGs			
CO_2	19	79.2	79.2
CH_4	1	4.2	4.2
I don't know	4	16.7	16.7
Total	24	100.0	100.0
If the company strategies concerning about carbon footprint?			
Yes	19	79.2	79.2
No	5	20.8	20.8
Total	24	100.0	100.0
Response on meaning of "Green logistics"			
Society concerned approach	1	4.2	4.2
Environment concerned approach	9	37.5	37.5
All the above	14	58.3	58.3
Total	13	100.0	100.0
If the company operating under "Green logistics Approach"?			
Yes, we are following	15	62.5	62.5
No, we are not following	9	37.5	37.5
Total	24	100.0	100.0

4.3 Perspectives of the Practitioners on Factors Impact on the Vehicle Selection Decision Framework

Vehicle selection decision framework in the study assumed to be affected by factors such as vehicle price, fuel types, fuel consumption rate, fuel emission rate, ease

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level of legal process, and customer requirements. The Likert scale questions with five impact ranges were employed. In Table 4.3, there are the factors, which impact on the vehicle selection framework. The standard deviation (SD) of all factors were in the range of 1.007-1.274. As a result, the most impact factor on vehicle selection framework was fuel consumption rate (mean = 4.166), and the least impact factor was the emission rate (mean = 3.083). Three factors such as vehicle price, fuel type, and customer requirements were in the condition as these got exactly the same mean equal to 3.75. The mean of legal process was 3.166.

As mentioned earlier, vehicle emission rate policies in Thailand has just been effective from 1 Jan 2016, and it is the policy for passenger vehicles. Hence, it is can be expected that vehicle emission rate is not an impact factor for the vehicle selection framework for freight vehicle yet. Interestingly, the mean of 3.08 was still in the positive area (mean < 3.0), so this result can be in line with the above result of perspectives of "Green logistics" and carbon footprint that the respondents have awareness on the area of green logistics and carbon footprint issue. From this, it can be predictable that once there are regulations supporting the green logistics or capping the carbon footprint, the practitioners will also consider to choose low emission vehicles.

Table 4.3 Factors affecting on vehicle selection decision framework

Factors	N	Mean	Std. Error	Std. Deviation	Variance
Vehicle price	24	3.875	0.227	1.115	1.245
Vehicle's fuel type	24	3.750	0.227	1.113	1.239
Vehicle's fuel consumption rate	24	4.166	0.205	1.007	1.014
Vehicle's emission rate	24	3.083	0.240	1.176	1.384
Legal processes	24	3.166	0.260	1.274	1.623
Customers' requirement	24	3.750	0.235	1.151	1.326

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4.4 Perspectives of the Practitioners on Factors Impact on Operational Cost in Transportation

In this part, the scenarios were built to question that if the cost of five factors are fluctuating, how they will impact on the operational cost in transportation. The Likert scale question type was again employed in this part. The assumed factors are vehicle depreciation, fuel price, maintenance cost, additional transport fees (road or toll fees), and vehicle registration and license fees. By calculating the mean, the results illustrates as in below Table 4.4. All factors had SD in the range from 0.991 - 1.160. Fuel price was the strongest impact factor on operational cost in transportation with the mean of 4.3, followed by vehicle maintenance cost (mean = 4.125), and vehicle depreciation cost (mean = 4.083). The additional transport fees (road or toll fees) and vehicle registration and license fees had less impact to the operational cost in transport as they got the mean of 3.583 and 3.291, respectively.

Interestingly, the vehicle registration and license was considered to be the least impact factor on operational cost, and the ease level of legal process was not considered as an impact factor on vehicle selection decision framework for the business. This indicated that initiatives from government on registration or licensing road freight vehicle will also be able to impact on business vehicle selection decision framework.

Table 4.4 Descriptive statistics of factors impact on operation cost in transportation

Factors	N	Mean	Std. Error	Std. Deviation	Variance
Vehicle's depreciation cost	24	4.083	0.207	1.017	1.036
Fuel cost	24	4.375	0.206	1.013	1.027
Vehicle maintenance cost	24	4.125	0.202	0.991	0.984
Road or toll fees	24	3.583	0.207	1.017	1.036
Vehicle registration and licensing procedures	24	3.291	0.236	1.160	1.346

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4.5 Perspectives of the Practitioners on Emission Reduction Strategies, Benefits and Initiatives

In this section, three different perspectives of the practitioners will be discussed such as applicable emission reduction strategies, the benefits from emission reduction, and the initiatives of emission reduction in the business of the practitioners. Result found out that using low CO_2 emission per energy content fuel, and route optimization were ranking as highest level of applicability in the perspective of the respondents with the mean of 4.416 and 4.333 respectively. The vehicle upgrade had lower rank in terms of applicability compare to the others as show in Table 4.5. In overall result, all below three strategies were applicable to reduce the emission from road freight activities, but employing new vehicles seemed not to be a priority option for the respondents.

Table 4.5 Applicable emission reduction strategies

Strategies	N	Mean	Std. Error	Std. Deviation	Variance
Choosing fuel with lower CO_2 emission per energy content	24	4.416	0.169	0.829	0.688
Vehicle upgrade	24	4.291	0.175	0.858	0.737
Optimize route of transportation	24	4.333	0.155	0.761	0.580

The results of assessment the perspectives of practitioners on the benefits from emission reduction are shown in Table 4.6. There were three assumed benefits given. As a result, by reducing the emission in the business, the respondents thought that environmental performance would be increase the most, followed by public relation and CSR value and finally the business benefits. In this part, it can be seen that the perspectives of Thai logistics practitioners on emission reduction will result more on the environmental perform and CSR value instead of business benefits or opportunities. This indicates about the less practice of green business in business environment in

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Thailand. However, the mean of business benefits was not quite low compared to other two benefits, this can be inferred that once green business practice is promoted, the practitioners will increase the awareness of the importance of emission reduction in their businesses as well.

Table 4.6 Benefits from emission reduction for business

Benefits	N	Mean	Std. Error	Std. Deviation	Variance
Business benefits	24	3.9167	0.198	0.974	0.949
Environmental performance	24	4.2917	0.140	0.690	0.476
CSR and PR	24	4.0417	0.164	0.806	0.650

Table 4.7 illustrates the central tendency analysis of the initiations to emission reduction in the business from respondents' perspective. All of the provided initiatives were confirmed to be the impact factors for the business to consider on emission reduction in the business operations. The most impact factor was top management direction (mean = 4.375), followed by company CSR (mean = 4.250), customer pressure (mean = 4.208), business benefits (mean = 4.083), availability of alternative technology (mean = 4.041), and the least impact on the initiative of emission reduction from the perspectives of the practitioners was the government incentives. By the SD value, it was confirmed that top management direction (SD = 0.575) was the most important factor for the firms to consider to reduce the emission.

Table 4.7 Initiatives toward emission reduction

Initiatives	N	Mean	Std. Error	Std. Deviation	Variance
Customer pressure	24	4.208	0.159	0.779	0.607
CSR value	24	4.250	0.150	0.737	0.543
Alternative technology availability	24	4.041	0.140	0.690	0.476
Business benefits	24	4.083	0.224	1.100	1.210

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Government incentives	24	3.916	0.189	0.928	0.862
Top management direction	24	4.375	0.117	0.575	0.332

4.6 Perspectives of the Practitioners on Barriers, Decision, and Implementation of Electric Vehicle for Road Freight Transport in Thailand

In this section, perspectives of the practitioners on barriers, decision, and implementation of EV in road freight transport were discussed. Table 4.8 indicated about three questions about decision, and implementation of EV in the business of respondents. There were 54.2% of the respondents thought that, EV is suitable for the last mile delivery or urban distribution and lead to be more competitive than conventional vehicle. All of the respondents agreed that, implementing EV would lead to emission reduction from their logistics activities. Moreover, there were 45.8% of the respondent rejected to consider on adopting the EV in their business.

Table 4.8 Descriptive statistics of practitioner on implementation of EV

Factor	Frequency	Percentage	Valid Percentage
Do you know that "Electric fleet is suitable for last mile delivery or urban distribution and lead to be more competitive than conventional vehicle"?			
Yes	13	54.2	54.2
No	11	45.8	45.8
Total	24	100	100
Do you think that using EV for intra city shipments will lead to reduce the emission?			
Yes, I think so.	18	75	75
No, I don't think so.	2	8.3	8.3
I don't know.	4	16.7	16.7
Total	24	100	100
Will you consider adopting electric fleet for logistics activities of your business?			

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Factor	Frequency	Percentage	Valid Percentage
Yes	13	54.2	54.2
No	11	45.8	45.8
Total	24	100	100

For the barriers to implementation of EV in road freight activities in Thailand, the central tendency (mean) was employed. According to Table 4.9, all provided barriers were confirmed to be highly impact on the implementation of EV in road freight activities, because all of the barriers below were considered to be important from the respondents' perspectives. The most impact barriers was being lack of supporting infrastructure (mean = 4.625), and followed by the lack of supply of EV in the market (mean = 4.541).

As known, the EV trend is only expanding for personal vehicle, while in road freight vehicles, the EV is not developed widely at all. The core problem can be because of the battery performance. In freight activities, vehicles are used in different patterns from personal vehicle, hence road freight vehicle EV development will also require more efficient performance battery. Additionally, the other barriers were also found as the strong impact barriers toward the use of EV in Thailand as well, since the overall mean of the barriers are more than 4. From this result, it can be inferred that government and automakers are the main key players in terms of initiation of implementation of EV for road freight vehicles and the establishment of supporting infrastructure for EV.

Table 4.9 Barriers to the implementation of EV in road freight activities in Thailand

Barriers or Factors	N	Mean	Std. Error	Std. Deviation	Variance
High cost of EV	24	4.291	0.140	0.690	0.476
Lack of support infrastructure	24	4.625	0.117	0.575	0.332

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Barriers or Factors	N	Mean	Std. Error	Std. Deviation	Variance
Capacity and performance of EV	24	4.416	0.158	0.775	0.601
Uncommon practice of EV	24	4.166	0.196	0.963	0.928
Lacking of the supporting regulations	24	4.416	0.189	0.928	0.862
Lacking of the supply EV	24	4.541	0.120	0.588	0.346

4.7 Perspectives of the Practitioners on Carbon Tax and Its Implementation

In this part, the perspectives of the practitioners on carbon tax and its implementation was assessed. Awareness of carbon tax, the ways to implementation, and possibility of road freight vehicle tax reforming were questioned in this part. For the definition of carbon tax, 62.5% of the respondents answered correctly. As new passenger vehicle excise tax has been already effective in Thailand from 1 Jan 2016, the similar mechanism as reforming excise and import tax for road freight vehicle was questioned. As a result, approximately 62.5% of the respondents responded that road freight vehicle excise and import tax should be reformed based on the level of emission.

Table 4.10 Descriptive statistics on the perspectives of carbon tax and its implementation

Opinions	Frequency	Percent	Valid Percent
What is carbon tax?			
Emitters have to pay for emission.	6	25	25
Tax which is based on emission level.	9	37.5	37.5
I don't know	9	37.5	37.5
Total	24	100	100
Should road freight vehicle tax be reformed based on emission rate?			
Yes, it should.	15	62.5	62.5

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Opinions	Frequency	Percent	Valid Percent
No, it should not	9	37.5	37.5
Total	24	92.3	100

In Table 4.11, the perspectives of carbon tax implementation was assessed. As a result, "Emission shall be taxed equal to its negative impact" had the mean of 3.458, and "Carbon tax is an incentive to reduce emission from logistics activities" had the mean of 3.333. For the perspectives on "Emission shall be taxed equal to its negative impact", 54% of the respondents are in positive side, and 16.7% of them opposed this idea. For the perspectives on "Carbon tax is an incentive to reduce emission from logistics activities", 58.3% of the respondents were positive with the given statement, while 25% of them disagreed.

Both perspectives were slightly in between the moderate and positive amplitude to agree with those perspectives. By seeing the SD value of each factors, the conclusion could not be drawn that "Emission shall be taxed equal to its negative impacts" and "Carbon tax is an incentive to reduce emission from logistics activities" are agreed or disagreed by the respondents at all.

Table 4.11 Perspectives on taxing the carbon

Scales of Reponses	Frequency	Percent	Valid Percent	Mean	Std. Deviation
"Emission shall be taxed equal to its negative impacts"					
Strongly disagree	1	4.2	4.2		
Disagree	3	12.5	12.5		
Moderate	7	29.2	29.2	3.458	1.020
Agree	10	41.7	41.7		
Strongly agree	3	12.5	12.5		

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Scales of Reponses	Frequency	Percent	Valid Percent	Mean	Std. Deviation
"Carbon tax in an incentive to reduce emission from logistics activities"					
Strongly disagree	3	12.5	12.5		
Disagree	3	12.5	12.5		
Moderate	4	16.7	16.7	3.3333	1.239
Agree	11	45.8	45.8		
Strongly agree	3	12.5	12.5		

In part of carbon tax implementation, four mechanisms were proposed as the options. Most of the respondents chose that carbon tax in logistics activities should be implemented with combination mechanisms such as reforming energy tax, legal process fees, and proposing the emission fees. Almost 80% of the respondents think that carbon tax should be implemented by reforming the energy tax. There were 75% of them chose that it should be implemented by reforming legal process of vehicle registration and licensing. Finally, 70.8% of them chose that it should be implemented in the form of emission fees, which is based on the amount of total emission emitted by the businesses.

4.8 Exploration of the Association between Variables

In this part, cross tabulation and Chi Square test were employed to explore the joint percentage between two variables and their possible relationship. The analysis focus on three main questions as the dependent variables:

A. Do you concern about emission in transport operation in your company?

B. Will you consider adopting EV in your transport operation?

C. Should road freight transport vehicle's tax reform to base on emission level as the personal vehicle?

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The above questions were set as the main parameters in the Chi Square test to test with other parameters in the contexts of operation, demography, perspectives of green logistics, carbon footprint, vehicle selection framework, and the perspective of carbon tax and its implementation.

Table 4.12 illustrates the p-value derived from Chi Square test in SPSS. Only variables, which had significant p-value, are shown. The complete table is separately placed in Appendix B.

Table 4.12 P-value of Chi Square test between dependent and independent variables

Independent variables	Dependent variables		
	Concerning about carbon footprint	EV adaptation perspectives	Reforming freight vehicle tax
	Sig.	Sig.	Sig.
Opinion about "Climate change"	0.858	0.008***	0.380
"Emission shall be taxed equal to its negative impacts"	0.810	0.524	0.040 ***
"Carbon tax is an incentive to reduce emission from logistics activities"	0.340	0.035 ***	0.027***

As mentioned in Chapter 3, if p-value is less than 0.05, the null hypothesis (H_o) indicates no relationship between the variables, shall be rejected, and the alternative hypothesis (H_1) indicates that there is relationship between the variables, or otherwise. Above table illustrates the result as p-value of chi-square test between the dependent and independent variables, which were explained below:

a. Dependent variable, which was concerning about carbon footprint in transport operation, had no relationship with all independent variables.

b. Dependent variable, which was about consideration about using EV in the transport operation, had relationship with independent variables, which were the opinion regarding the climate change issues and the

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assessment of the agreement on carbon tax is considered as an incentive to reduce emission in the practitioners' operations. Based on the cross tabulation below in Table 4.13, the respondents, who had broader awareness on climate change, tend not to consider on the implementation of EV in their operations. These two variables showed about the negative association between each other. Similarly, for the 2nd case, respondents, who were in negative attitude on "Carbon tax is an incentive to reduce emission from logistics activities", tend to consider to use the EV rather than the respondents, who were on the positive side of the perspectives.

c. Dependent variable, which assess about the idea that the road freight vehicle shall or not shall reform the excise or import duty, tended to have relationship with two independent variables. The first independent variable was about the emission shall be taxed equally to its impacts, and the second independent variable, which related to if carbon tax is considered or not to be a proper incentive tools to reduce the emission in road freight activities. According to the cross tabulation Table 4.14, a positive association was found. The respondents, who thought that emission shall be tax equally to its impact, tended to agree on the reform of road freight vehicle tax. Similarly, a positive association can found between respondents' opinion on "carbon tax in an incentive to reduce emission from logistics activities" and the reform of road freight vehicle related taxes.

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Table 4.13 Cross tabulation of consideration to use EV in operation versus independent variables

Crosstab		Will you consider to use EV? Yes	No	Total
What is the most contributor to currently climate change issue?	CO_2	9	10	19
	CH_4	0	1	1
	I don't know	4	0	4
Total		13	11	24
"Carbon tax is an incentive to reduce emission from logistics activities" how you agree with this?	Strongly Disagree	3	0	3
	Disagree	3	0	3
	Moderately agree	0	4	4
	Agree	5	6	11
	Strongly agree	2	1	3
Total		13	11	24

Table 4.14 Cross tabulation of perspective to reform the tax versus independent variables

Crosstab		Should road freight vehicle tax be reformed based on emission rate? Yes	No	Total
"Emission shall be taxed equal to its negative impacts", how you agree with this?	Strongly Disagree	0	1	1
	Disagree	0	3	3
	Moderately agree	4	3	7
	Agree	9	1	10
	Strongly agree	2	1	3
Total		15	9	24
"Carbon tax is an incentive to reduce emission from logistics activities" how you agree with this?	Strongly Disagree	0	3	3
	Disagree	2	1	3
	Moderately agree	1	3	4
	Agree	9	2	11

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Crosstab		Should road freight vehicle tax be reformed based on emission rate?		Total
		Yes	No	
	Strongly agree	3	0	3
Total		15	9	24

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CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Objectives of the study are to assess the perspectives of Thai logistics practitioners on various context as green logistics, feasibilities and barriers of implementation of EV in road freight activities, and carbon tax implementation for road freight activities in Thailand. The key findings for this study are:

a) Thailand position is properly to implement the carbon pricing tool mechanism based on macro-economic factors such as total emission level, total emission per capita, and total GDP to total emission level.

b) In the vehicle decision framework, emission rate of vehicle and vehicle ownership legal process were the least impact factors, while vehicle price, fuel consumption rate, and customer requirement were the most impact factors. Furthermore, the study found out that the practitioners agreed that implementing EV can lead to emission reduction in their operations.

c) As in cost fluctuation period, fuel cost, maintenance cost, and vehicle depreciation cost were highly impact on the operational cost in the portion of transportation. Legal process fees and additional transport fees (road fees and toll fees) were the least impact factors on the operational cost.

d) In terms of emission reduction, the respondents thought that switching to low CO_2 per energy content, vehicle upgrading and transport route optimization were applicable strategies to reduce emission from their

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operations. However, vehicle upgrading was the least applicable strategies among all.

e) In terms of benefits and initiatives to implement emission reduction in business, the study found out that all initiatives were highly impact to emission reduction initiations. For business stakeholders, especially top management, customers, and company CSR value were the biggest impact groups, while government incentives and availability of alternative technologies were considered as second highly impact initiatives.

f) For the barriers to implement EV in logistics activities in Thailand, the study found out that the lack of EV supply in the market and the lack of supporting regulations were the main barriers in the perspectives of practitioners.

g) The road freight vehicle import and excise could be reformed to be based on emission level similar to the tax reform on passenger vehicle.

h) Carbon tax shall be implemented in all possible ways as reforming vehicle import and excise tax, vehicle registration and annual license fees, energy tax, and the emission fees.

i) Finally, in the perspective of the study respondents, proposing carbon tax was not considered as a proper incentive for firms to reduce the emission in their operations.

In conclusion, implementing carbon tax is possible to be implemented for road freight vehicles and it can be implemented by the combination of reforming vehicle and energy tax and proposing the fees of emission for the firms. Awareness of green logistics and carbon mechanism are main factors on the implementation of the proposal

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of carbon tax. Even though most of the respondents have awareness on carbon footprint issue, and green logistics, but emission reduction does not benefit the business in terms of business opportunities yet in the perspectives of the practitioners. This can be inferred that in the market of road freight industry, other parties are not concerning about emission in their operations yet. For initiatives, government incentives, policies, customer pressure and management direct are the drivers in order to start the practice the emission reduction strategies in road freight activities. Finally yet importantly, in order to incentivize the logistics practitioners in Thailand to start thinking about adopting EV and reducing the emission, carbon tax alone is not sufficient to build a proper state of incentives for firms. The key actions below shall be considered to implement along:

a) Promote the emission reduction in across industries to create fair competition state for emission reduction focused firms
b) Invest more on physical infrastructure of EV especially, the charging stations
c) Promote EV markets for road freight vehicles to automakers
d) Non-financial scheme incentives, such as awards and assessments shall be practiced.

5.2 Recommendations and Future Studies

Because the study aimed to explore the perspectives of Thai logistics practitioner on green logistics, application of EV, and proposal of carbon tax, it was heavily relied on the qualitative approach, which cause the study is more conceptual and not practical confirm a solid success expectation of carbon tax implementation. Furthermore, the study focused only one group (2PL), while 3PL, 4PL and ultimate

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customer's perspectives are remained unexplored. Hence, recommendation for further studies are illustrates as below:

a) Scope of new studies shall be widening with related parties such 3PL and 4PL, and ultimate customers or the key buyers of products and services

b) Update the projection the emission of road freight transport activities in Thailand

c) Quantitative study on modelling the price of carbon based on macro-economic factors and market readiness factors of Thailand toward implementation of carbon pricing mechanism shall be made

d) Simulation of the practitioners' behavior in dynamic market constraints toward new proposal of carbon tax shall be studied.

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APPENDIX A: FORM OF QUESTIONNAIRE

The questionnaires are available in google form below links:

- Thai version: https://goo.gl/forms/51be2HBhHoXuIzB13
- English version: https://goo.gl/forms/XSSBgVSbDJxVkE2T2

Section 1: General Information

V1. Name of Correspondent: .....

V2. Gender: (1). Male (2). Female

V3. Position: .....

V4. Name of Company: .....

V5. Phone Number: .....

V6. Email Address: .....

Section 1: Demographic Information of Your Organization

V1.1. Business type:

(1). Sole Proprietorship (2). Partnership

(3). Corporation (4). Other:

V1.2. Number of employee:

V1.3. Types of logistic services provided by your business

(1). Intra City (2). Inter City

(3). Both

V1.4. Approximate percentage share of Inter City and Intra City shipments to all shipments on average:

(1). Inter City 50% Intra City 50% (2). Inter City 35 % Intra City 65%

(3). Inter City 65% Intra City 35% (4). More than 85% is Inter City

(5). More than 85% is Intra City

V1.5. Revenue in fiscal year 2015 of company (in millions baht): (.....)

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Section 2: Vehicles and Usage

Please identify the amount of vehicle or your business.

V2.1. Number of total vehicles: (……)

V2.2. Number of Four Wheels Truck: (……)

V2.3. Number of Six Wheels Truck (LDV): (……)

V2.4. Number of Eight Wheels Truck (MDV): (……)

V2.5. Number of Ten Wheels Truck (HDV): (……)

V2.6. For a full operating month, what is the average total distance travelled by Four Wheels Truck of your business? (Please advise in kilometer): (……)

V2.7. For a full operating month, what is the average total distance travelled by Six Wheels Truck of your business? (Please advise in kilometers): (……)

V2.8. For a full operating month, what is the average total distance travelled by Eight Wheels Truck of your business? (Please advise in kilometers): (……)

V2.9. For a full operating month, what is the average total distance travelled by Ten Wheels Truck of your business? (Please advise in kilometers): (……)

V2.10. What is the most used fuel type for logistics vehicles of your business?

(1). Diesel (2). Natural Gas Vehicle (NGV)

(3). Other: (……)

Section 3: Decision Framework toward Vehicle Selection

V3.1. How do the following factors affect your decision on vehicle purchasing?

General Factors	1	2	3	4	5
a. Vehicle Price	○	○	○	○	○
b. Vehicle Fuel Types	○	○	○	○	○
c. Fuel Consumption Rate	○	○	○	○	○
d. Emission Rate	○	○	○	○	○
e. Ease of Legal Process for License and Registration	○	○	○	○	○

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General Factors	1	2	3	4	5
f. Specific Requirement From Customers	○	○	○	○	○

V3.2. How is operating cost of logistics vehicles of your business affected when the following costs change?

Cost Factors	1	2	3	4	5
a. Depreciation of vehicle price	○	○	○	○	○
b. Fuel Price	○	○	○	○	○
c. Maintenance cost	○	○	○	○	○
d. Road fees or Toll fees	○	○	○	○	○
e. Vehicle license and registration	○	○	○	○	○

Section 4. Perspectives on Green logistics

V4.1. In your opinion, among below greenhouse gases (GHGs), what is the most important contributor to the current global climate change?

(1). Carbon Dioxide (CO_2) (2). Methane (CH_4)

(3). Nitrous Oxide (N_2O) (4). I do not know.

V4.2. Do you concern about carbon footprint in your business?

(1). Yes, we do concern.

(2). No, we do not concern.

V4.2.1. Please provide the reasons for the above responses: .....

V4.3. How of often have you ever been asked by your customers whether your fleet is environmentally friendly?

(1). Always (2). Sometimes

(3). Rarely (4). Never

V4.4. what do you think about when you hear about "Green logistics"?

(1). Economy Concerned Approach

(2). Society Concerned Approach

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(3). Environment Concerned Approach

(4). All of the Above

V4.5. Is your company operating underlying "Green logistics Approach"?

(1). Yes, we are following.

(2). No, we are not following.

V4.5.1. Please explain: .....

V4.6. "To implement Green logistics, we shall consider about reducing emission in operation", how you agree with this statement?

(1). Strongly Disagree

(2). Disagree

(3). Moderate

(4). Agree

(5). Strongly Agree

V4.7. If your business decides to reduce emission from logistics vehicle operation, how are the following measures applicable to your business?

Factors	1	2	3	4	5
a. Choose fuel with low CO_2 emission per energy content (e.g., using more environmentally friendly fuel, etc.)	○	○	○	○	○
b. Vehicle upgrade (e.g., renew the fleet, use more environmentally friendly vehicles, etc.)	○	○	○	○	○
c. Optimize route of transportation (e.g., avoid empty backhaul truck head, increase full loaded shipment by consolidation)	○	○	○	○	○

V4.8. How do you agree with the following benefits when your business' carbon footprint is lower than your competitors?

Benefits or Gains	1	2	3	4	5
a. Business benefits (e.g., green marketing)	○	○	○	○	○

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b. Environmental performance	○	○	○	○	○
c. Public relation and Corporate Social Responsibility (CSR) performance	○	○	○	○	○

V4.9. How do the following factors impact your consideration about emission reduction?

Factors	1	2	3	4	5
a. Customer pressure	○	○	○	○	○
b. Company's Corporate Social Responsibility (CSR) value	○	○	○	○	○
c. Availability of alternatives technology	○	○	○	○	○
d. Business benefits	○	○	○	○	○
e. Incentives from government	○	○	○	○	○
f. Top Management Direction	○	○	○	○	○

Section 5. Perspectives about Implementation of Electric Vehicle Fleet

V5.1. How do you agree with "Implementing electric fleet will lead to emission reduction in logistics activities"?

(1). Strongly disagree

(2). Disagree

(3). Moderate

(4). Agree

(5). Strongly Agree

V5.2. Do you know that "Electric fleet is suitable for last mile delivery or urban distribution and lead to be more competitive than conventional vehicle"?

(1). Yes

(2). No

V5.3. Do you think using electric vehicle for intra city shipments will lead to emission reduction?

(1). Yes, I think so.

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(2). No, I don't think so.

(3). I don't know.

V5.4. Will you consider adopting electric fleet for logistics activities of your business?

(1). Yes

(2). No

V5.4.1. Please specify your reasons: .....

V5.5. How do below factors impact on implementing electric vehicles for logistics activities in Thailand?

Barriers	1	2	3	4	5
a. High Cost of Technology	○	○	○	○	○
b. Lack of Supporting Infrastructure	○	○	○	○	○
c. Capacity and Performance of EV	○	○	○	○	○
d. Not widely used	○	○	○	○	○
e. Lack of Supporting Regulations by Government	○	○	○	○	○
f. Lack of supply of Electric Vehicle	○	○	○	○	○
e. Other: (Please specify)	○	○	○	○	○

Section 6. Perspectives on Carbon Tax in Thailand

V6.1. What do you think about when you hear about "Carbon Tax"?

(1). Emitters have to pay for emission.

(2). Carbon Market.

(3). Tax which is based on emission level.

(4). No idea.

V6.2. How do you agree that "Emission shall be taxed equal to its the negative impacts"?

(1). Strongly disagree

(2). Disagree

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(3). Moderate

(4). Agree

(5). Strongly Agree

V6.3. How do you agree that "Carbon Tax is an incentive to reduce emission from logistics activities"?

(1). Strongly disagree

(2). Disagree

(3). Moderate

(4). Agree

(5). Strongly Agree

V6.4. As passenger vehicle excise tax has reformed based on emission level starting from Jan 2016, do you think tax structure of commercial vehicles in transport and logistics sector should be reformed based on emission level as well?

(1). Yes, it should.

(2). No, it should not.

V6.4.1. Please advise your reasons for choosing the above choice: .....

V6.5. How should carbon tax be implemented in logistics sector? (Available to choose multiple choices

(1). Reform vehicle import tax or vehicle excise tax based on emission level

(2). Reform energy tax on each type of fuel based on emission level

(3). Reform vehicle regulation and annual license fees to be based on emission level of the vehicle

(4). Emission fees based on the amount of total emission of the organization

(5). All of the Above.

(6). Other: .....

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V6.6. Base on your opinion, what are the steps that the government should do in order to encourage the use of electric vehicle for freight activities in Thailand?

.....

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APPENDIX B: ANALYSIS TABLES

Table apx1 Descriptive statistic on Likert scale questions

Descriptive Statistics	N	Range	Minimum	Maximum	Sum	Mean		Std.	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
How vehicle price impacts on vehicle selection decision framework	24	4.00	1.00	5.00	93.00	3.8750	0.22772	1.11560	1.245
How vehicle fuel type impacts on vehicle selection decision framework	24	4.00	1.00	5.00	90.00	3.7500	0.22722	1.11316	1.239
How vehicle fuel consumption rate impacts on vehicle selection decision framework	24	4.00	1.00	5.00	100.00	4.1667	0.20560	1.00722	1.014
How vehicle emission rate impacts on vehicle selection decision framework	24	5.00	0.00	5.00	74.00	3.0833	0.24014	1.17646	1.384
How legal process impacts on vehicle selection decision framework	24	4.00	1.00	5.00	76.00	3.1667	0.26006	1.27404	1.623
How customer requirements impacts on vehicle selection decision framework	24	4.000	1.000	5.000	90.000	3.75000	0.235061	1.151558	1.326
How the change of vehicle depreciation cost impacts on transport operation cost	24	3.00	2.00	5.00	98.00	4.0833	0.20779	1.01795	1.036
How the change of fuel cost impacts on transport operation cost	24	4.00	1.00	5.00	105.00	4.3750	0.20688	1.01350	1.027
How the change of vehicle maintenance cost impacts on transport operation cost	24	3.00	2.00	5.00	99.00	4.1250	0.20245	.99181	.984
How the change of road or toll fees cost impacts on transport operation cost	24	3.00	2.00	5.00	86.00	3.5833	0.20779	1.01795	1.036
How the change of vehicle registration and license procedure and cost impacts on transport operation cost	24	4.00	1.00	5.00	79.00	3.2917	0.23682	1.16018	1.346
How do you agree "To implement Green logistics, we shall consider about reducing emission in operation"?	24	3.00	2.00	5.00	100.00	4.1667	0.15542	0.76139	0.580

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Descriptive Statistics	N	Range	Minimum	Maximum	Sum	Mean		Std.	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Choosing fuel with lower CO_2 emission per energy content in order to reduce emission in logistics operation	24	3.00	2.00	5.00	106.00	4.4167	0.16936	0.82970	0.688
Vehicle upgrade in order to reduce emission in logistics activities	24	3.00	2.00	5.00	103.00	4.2917	0.17528	0.85867	0.737
Optimize route of transportation in order to reduce emission in logistics activities	24	2.00	3.00	5.00	104.00	4.3333	0.15542	0.76139	0.580
Business benefits gained when carbon footprint is lower	24	3.00	2.00	5.00	94.00	3.9167	0.19888	0.97431	0.949
Environmental performance gained when carbon footprint is lower	24	2.00	3.00	5.00	103.00	4.2917	0.14090	0.69025	0.476
CSR and PR gained when carbon footprint is lower	24	2.00	3.00	5.00	97.00	4.0417	0.16462	0.80645	0.650
Customer pressure as an impact factor for the consideration to reduce emission	24	2.00	3.00	5.00	101.00	4.2083	0.15902	0.77903	0.607
CSR value as an impact factor for the consideration to reduce emission	24	3.00	2.00	5.00	102.00	4.2500	0.15048	0.73721	0.543
Alternative tech availability as impact factor for the consideration to reduce emission	24	2.00	3.00	5.00	97.00	4.0417	0.14090	0.69025	0.476
Business benefits as an impact factor for the consideration to reduce emission	24	4.00	1.00	5.00	98.00	4.0833	0.22455	1.10007	1.210
Government incentive as an impact for the consideration to reduce emission	24	3.00	2.00	5.00	94.00	3.9167	0.18955	0.92861	0.862
Top management direction as an impact factor the consideration to reduce emission	24	2.00	3.00	5.00	105.00	4.3750	0.11753	0.57578	0.332
"Implementing electric fleet will lead to emission reduction in logistics activities"	24	3.00	2.00	5.00	87.00	3.6250	0.18855	0.92372	0.853
Lacking of the supply electric vehicle as an impact factor on EV implementation in logistics sector in Thailand	24	2.00	3.00	5.00	109.00	4.5417	0.12007	0.58823	0.346
"Emission shall be taxed equal to its negative impacts", how you agree with this?	24	4.00	1.00	5.00	83.00	3.4583	0.20833	1.02062	1.042
"Carbon tax is an incentive to reduce emission from logistics activities" how you agree with this?	24	4.00	1.00	5.00	80.00	3.3333	0.25300	1.23945	1.536
Valid N (list wise)	24								

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Table apx2 Pearson chi square value and p-value of chi square test

Independent variables	Dependent variables					
	Concerning about carbon footprint		Will you consider to adopt EV in your transport operation?		Should freight vehicle tax be reformed in road freight transport activities?	
	$\chi 2$	Sig.	$\chi 2$	Sig.	$\chi 2$	Sig.
Company business types	0.084	0.772	0.503	0.478	0.533	0.465
Types of logistics services	0.556	0.757	1.175	0.556	0.676	0.713
Share of intercity and intra city shipment in the business	5.637	0.131	4.071	0.254	1.326	0.723
Number of employees	0.661	0.719	3.434	0.18	2.776	0.25
Revenue	2.479	0.29	1.06	0.588	4.015	0.134
Number of vehicles	1.48	0.477	0.951	0.622	2.328	0.312
Opinion about "Climate change"	0.306	0.858	4.92	0.085	1.937	0.38
Customers' behaviors toward green business practice	5.474	0.14	3.659	0.301	1.576	0.665
Opinion about "Green logistics"	0.277	0.871	2.134	0.344	5.41	0.067
How do you agree with "To implement Green logistics, we shall consider about reducing emission in operation"	7.21	0.066	3.55	0.314	5.785	0.123
"Implementing electric fleet will lead to emission reduction in logistics activities", how do you agree?	2.678	0.444	3.074	0.38	1.62	0.655
Have you ever know "Electric fleet is suitable for last mile delivery or urban distribution and lead to be more competitive than conventional vehicles	2.97	0.085	0.001	0.973	0.548	0.459
Opinion on using EV for intra city shipment	1.263	0.532	0.056	0.972	0.533	0.766
"Emission shall be taxed equal to its negative impacts", how you agree with this?	1.595	0.81	3.208	0.524	10.001	0.04 ***
"Carbon tax is an incentive to reduce emission from logistics activities" how you agree with this?	4.524	0.34	10.329	0.035 ***	10.974	0.027***
Consideration to reduce emission	N/A	N/A	0.511	0.475	0.017	0.897
Consideration to use EV	0.511	0.475	N/A	N/A	0.011	0.916

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Independent variables	Dependent variables					
	Concerning about carbon footprint		Will you consider to adopt EV in your transport operation?		Should freight vehicle tax be reformed in road freight transport activities?	
	χ2	Sig.	χ2	Sig.	χ2	Sig.
Should road freight vehicle related tax be reformed?	0.17	0.897	0.011	0.916	N/A	N/A

Table apx3 Cross tabulation of independent variables against the concerning about carbon footprint

Cross tabulation		Do you concern about carbon footprint?		Total
		Yes	No	
Company Business Type	Sole Proprietorship	14	4	18
	Corporation	5	1	6
Total		19	5	24
Type of logistics service	Intra city	2	1	3
	Inter city	1	0	1
	Both	16	4	20
Total		19	5	24
Share of Intercity and Intra City	Intercity 50% intra city 50%	5	2	7
	Inter City 35% intra city	0	1	1
	More than 85% is inter city	6	0	6
	More than 85% is intra city	8	2	10
Total		19	5	24
Number of employee cat	Up to 50 employees	10	3	13
	Between 50 - 100 employees	2	1	3
	More than 100 employees	7	1	8
Total		19	5	24
Revenue 2015 cat	Up to 50 million baht	6	1	7

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Cross tabulation		Do you concern about carbon footprint?		Total
		Yes	No	
	Between 50 - 100 million baht	2	2	4
	Between 100 - 200 million baht	11	2	13
Total		19	5	24
Number of vehicles cat	Up to 50 vehicles	12	2	14
	From 51 - 100 vehicles	1	0	1
	More than 100 vehicles	6	3	9
Total		19	5	24
What is the most contributor to currently climate change issue?	CO_2	15	4	19
	CH_4	1	0	1
	I don't know	3	1	4
Total		19	5	24
How often do your customer ask about environmental friendly fleet?	Always	5	0	5
	Sometimes	7	2	9
	Rarely	4	0	4
	Never	3	3	6
Total		19	5	24
What do you about "Green logistics"?	Society concerned approach	1	0	1
	Environment concerned approach	7	2	9
	All the above	11	3	14
Total		19	5	24
How do you agree "To implement Green logistics, we shall consider about reducing emission in operation"?	Disagree	0	1	1
	Moderately agree	2	0	2
	Agree	9	4	13
	Strongly agree	8	0	8
Total		19	5	24

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Cross tabulation		Do you concern about carbon footprint?		Total
		Yes	No	
"Implementing electric fleet will lead to emission reduction in logistics activities"	Disagree	2	1	3
	Moderately agree	7	0	7
	Agree	7	3	10
	Strongly agree	3	1	4
Total		19	5	24
Have you ever know "Electric fleet is suitable for last mile delivery or urban distribution and lead to be more competitive than conventional vehicles"?	Yes	12	1	13
	No	7	4	11
Total		19	5	24
Do you think using electric vehicle for intra city shipments will lead to emission reduction?	Yes, I think so.	15	3	18
	No, I don't think so.	1	1	2
	I do not know.	3	1	4
Total		19	5	24
"Emission shall be taxed equal to its negative impacts", how you agree with this?	Strongly Disagree	1	0	1
	Disagree	2	1	3
	Moderately agree	5	2	7
	Agree	8	2	10
	Strongly agree	3	0	3
Total		19	5	24
"Carbon tax is an incentive to reduce emission from logistics activities" how you agree with this?	Strongly Disagree	3	0	3
	Disagree	2	1	3
	Moderately agree	4	0	4
	Agree	7	4	11
	Strongly agree	3	0	3
Total		19	5	24
Will you consider to use EV?	Yes	11	2	13

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Cross tabulation		Do you concern about carbon footprint?		Total
		Yes	No	
	No	8	3	11
Total		19	5	24
Should road vehicle tax be reformed based on emission rate?	Yes, it should.	12	3	15
	No, it should not	7	2	9
Total		19	5	24

Table apx4 Cross tabulation of independent variables against the consideration to use EV

Cross tabulation		Will you consider to use EV?		Total
		Yes	No	
Company Business Type	Sole Proprietorship	9	9	18
	Corporation	4	2	6
Total		13	11	24
Company Business Type	Sole Proprietorship	9	9	18
	Corporation	4	2	6
Total		13	11	24
Share of Intercity and Intra City	Intercity 50% intra city 50%	4	3	7
	Inter City 35% intra city	0	1	1
	More than 85% is inter city	5	1	6
	More than 85% is intra city	4	6	10
Total		13	11	24
Number of employee cat	Up to 50 employees	7	6	13
	Between 50 - 100 employees	3	0	3
	More than 100 employees	3	5	8

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Cross tabulation		Will you consider to use EV? Yes	No	Total
Total		13	11	24
Revenue 2015 cat	Up to 50 million baht	4	3	7
	Between 50 - 100 million baht	3	1	4
	Between 100 - 200 million baht	6	7	13
Total		13	11	24
Number of vehicles cat	Up to 50 vehicles	7	7	14
	From 51 - 100 vehicles	1	0	1
	More than 100 vehicles	5	4	9
Total		13	11	24
What is the most contributor to currently climate change issue?	CO_2	9	10	19
	CH_4	0	1	1
	I don't know	4	0	4
Total		13	11	24
How often do your customer ask about environmental friendly fleet?	Always	4	1	5
	Sometimes	3	6	9
	Rarely	3	1	4
	Never	3	3	6
Total		13	11	24
What do you about "Green logistics"?	Society concerned approach	1	0	1
	Environment concerned approach	6	3	9
	All the above	6	8	14
Total		13	11	24
How do you agree "To implement Green logistics, we shall consider about reducing emission in operation"?	Disagree	1	0	1
	Moderately agree	0	2	2
	Agree	8	5	13

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Cross tabulation		Will you consider to use EV? Yes	Will you consider to use EV? No	Total
	Strongly agree	4	4	8
Total		13	11	24
"Implementing electric fleet will lead to emission reduction in logistics activities"	Disagree	2	1	3
	Moderately agree	2	5	7
	Agree	7	3	10
	Strongly agree	2	2	4
Total		13	11	24
Have you ever know "Electric fleet is suitable for last mile delivery or urban distribution and lead to be more competitive than conventional vehicles"	Yes	7	6	13
	No	6	5	11
Total		13	11	24
Do you think using electric vehicle for intra city shipments will lead to emission reduction?	Yes, I think so.	10	8	18
	No, I don't think so.	1	1	2
	I do not know.	2	2	4
Total		13	11	24
"Emission shall be taxed equal to its negative impacts", how you agree with this?	Strongly disagree	1	0	1
	Disagree	2	1	3
	Moderately agree	2	5	7
	Agree	6	4	10
	Strongly agree	2	1	3
Total		13	11	24
"Carbon tax is an incentive to reduce emission from logistics activities" how you agree with this?	Strongly disagree	3	0	3
	Disagree	3	0	3
	Moderately agree	0	4	4
	Agree	5	6	11
	Strongly agree	2	1	3

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Cross tabulation		Will you consider to use EV? Yes	No	Total
Total		13	11	24
Do you concern about carbon footprint?	Yes	11	8	19
	No	2	3	5
Total		13	11	24
Should road vehicle tax be reformed based on emission rate?	Yes, it should.	8	7	15
	No, it should not	5	4	9
Total		13	11	24

Table apx5 Cross tabulation of independent variables against the reforming tax on fright vehicles

Cross tabulation		Should road vehicle tax be reformed based on emission rate? Yes, it should.	No, it should not	Total
Company Business Type	Sole Proprietorship	12	6	18
	Corporation	3	3	6
Total		15	9	24
Type of logistics service	Intra city	2	1	3
	Inter city	1	0	1
	Both	12	8	20
Total		15	9	24
Share of Intercity and Intra City	Intercity 50% intra city 50%	4	3	7
	Inter City 35% intra city	1	0	1
	More than 85% is inter city	3	3	6

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Cross tabulation		Should road vehicle tax be reformed based on emission rate?		Total
		Yes, it should.	No, it should not	
	More than 85% is intra city	7	3	10
Total		15	9	24
Number of employee	Up to 50 employees	10	3	13
	Between 50 - 100 employees	1	2	3
	More than 100 employees	4	4	8
Total		15	9	24
Revenue 2015	Up to 50 million baht	6	1	7
	Between 50 - 100 million baht	1	3	4
	Between 100 - 200 million baht	8	5	13
Total		15	9	24
Number of vehicles	Up to 50 vehicles	10	4	14
	From 51 - 100 vehicles	0	1	1
	More than 100 vehicles	5	4	9
Total		15	9	24
What is the most contributor to currently climate change issue?	CO_2	12	7	19
	CH_4	0	1	1
	I don't know	3	1	4
Total		15	9	24
How often do your customer ask about environmental friendly fleet?	Always	3	2	5
	Sometimes	5	4	9
	Rarely	2	2	4
	Never	5	1	6

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Cross tabulation		Should road vehicle tax be reformed based on emission rate?		Total
		Yes, it should.	No, it should not	
Total		15	9	24
What do you about "Green logistics"?	Society concerned approach	1	0	1
	Environment concerned approach	3	6	9
	All the above	11	3	14
Total		15	9	24
How do you agree "To implement Green logistics, we shall consider about reducing emission in operation"?	Disagree	0	1	1
	Moderately agree	0	2	2
	Agree	9	4	13
	Strongly agree	6	2	8
Total		15	9	24
"Implementing electric fleet will lead to emission reduction in logistics activities"	Disagree	1	2	3
	Moderately agree	5	2	7
	Agree	6	4	10
	Strongly agree	3	1	4
Total		15	9	24
Have you ever know "Electric fleet is suitable for last mile delivery or urban distribution and lead to be more competitive than conventional vehicles"	Yes	9	4	13
	No	6	5	11
Total		15	9	24
Do you think using electric vehicle for intra city shipments will lead to emission reduction?	Yes, I think so.	12	6	18
	No, I don't think so.	1	1	2
	I do not know.	2	2	4
Total		15	9	24
"Emission shall be taxed equal to its negative impacts", how you agree with this?	Strongly disagree	0	1	1
	Disagree	0	3	3

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Cross tabulation		Should road vehicle tax be reformed based on emission rate?		Total
		Yes, it should.	No, it should not	
	Moderately agree	4	3	7
	Agree	9	1	10
	Strongly agree	2	1	3
Total		15	9	24
"Carbon tax is an incentive to reduce emission from logistics activities" how you agree with this?	Strongly Disagree	0	3	3
	Disagree	2	1	3
	Moderately agree	1	3	4
	Agree	9	2	11
	Strongly agree	3	0	3
Total		15	9	24
Do you concern about carbon footprint?	Yes	12	7	19
	No	3	2	5
Total		15	9	24
Will you consider to use EV?	Yes	8	5	13
	No	7	4	11
Total		15	9	24

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CARBON PRICING SYSTEM FOR VEHICLES USED IN FREIGHT TRANSPORT

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ABSTRACT

Carbon dioxide (CO_2), as one of the most important Greenhouse Gases (GHGs), is the major contributor to global climate change problem. In Thailand, CO_2 from transportation accounts for about a quarter of all CO_2 emissions. In 2016, Thailand started implementing the reform of excise tax rates based on CO_2 emissions of different types of vehicles. The new system was primarily applied to passenger vehicles. This is in line with what has been implemented in 40 other countries and 20 cities throughout the world. The system does not only force people to move towards less emission vehicles, it also works as an indirect incentive for people to start looking at electric vehicles (EV) as more preferable alternatives. Freight transport vehicle including trucks and other commercial vehicles consumes a significant amount of global fossil fuels. It accounts for 19% of global energy use and 23% of energy-related CO_2 emission in transport sector in 2009. As a result, a large amount of CO_2 emission is produced from this sector. Therefore, policymakers should start considering the ways to incentivize the uses of less emission vehicles in this area. This paper discusses about the possibilities and challenges of carbon pricing system as a way to incentivize the use of less emission vehicles including EV for logistic sector in Thailand.

Keywords: Carbon pricing, electric vehicles (EV), carbon tax system, climate change

1. INTRODUCTION

In the past decades, climate change problem has become one of the most important global issues. The problem is an important consequence of the rise of Greenhouse Gases (GHGs) in the earth atmosphere. These gases trap radiations (e.g., UV) in the earth's atmosphere. These radiations should have reflected from the earth's surface back to the space without the presence of GHGs (EPA, 2016). According to National Aeronautics and Space Administration (NASA), the amount of carbon dioxide (CO_2) in the earth atmosphere hit its record high in May 2016 as it reached 403.26 ppm. The more GHGs exist, the warmer that global surface is. Additionally, there are many other evidences illustrating that the impacts of climate change are real. The mean of global temperature increased by 0.85°c from 1880 to 2015. Sea level rose by 6.7 inches in the last century. In 2009, the top 700 meters of the oceans absorbed heat and warmed itself up by 0.302 °F compared to the temperature in 1969 (Levitus et al., 2009).

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To tackle this problem, the United Nations Framework Convention on Climate Change (UNFCCC), through its 21st Conference of the Parties (COP21), successfully had its nation parties agree on GHGs reduction through the Nationally Determined Contributions (NDCs) and the Nationally Appropriate Mitigation Action (NAMA). Large emission contributors like the United States, Japan, China, Russia, and European Union have adopted these policies to reduce emissions from transport sector as one of their main targets (UNFCCC, 2014).

For Thailand, its NAMA proposes to take action in the energy and transport sectors to reduce emissions between 7 to 20 percent below projection by 2020 (UNFCCC, 2015). The NAMA measures are including the switch to renewable and alternative energy sources, improvement of energy efficiency, and utilization of sustainable transit system. Therefore, in 2016, Thailand first implemented the reform on automotive excise tax for passenger vehicles based on the levels of CO_2 emission. This new excise tax system favors low emission, hybrid, and EV to the conventional internal combustion engine (ICE) vehicles (Swire, 2012).

Vehicles used in freight transport such as pickup trucks, trailers and semi-trailers consumed approximately 19% of global energy in 2009. In 2010, 23% of anthropogenic emissions were from transportation. Road transport vehicles contributed 73.9% of this amount. Within emissions contributed by road transport, heavy-duty vehicles are employed only 11% of total global vehicles in transport sector, but they accounted for 46.5% of the emissions (Kodjak, 2015). Unfortunately, many CO_2 emission reduction efforts have focused mostly on passenger vehicles, while heavy-duty vehicles received much less attention including what has happened in Thailand.

Thailand should be prepared for potentially increased emissions due to the nation's mission to be logistic hub in Southeast Asia for land transport and freight services. This paper discusses about possibilities and challenges of carbon pricing mechanism and the electric-powered vehicle fleets for freight transport in Thailand underlying with the trend of global environmental policies and lessons learned.

2. GLOBAL TREND AND POLICIES

Since 1979, when the first World Climate Conference took place in Geneva, Switzerland, climate change has become a global problem and led to other agreements such as Kyoto Protocol, The Doha Amendment to Kyoto Protocol, and the Paris Agreement or COP 21. The Kyoto Protocol held on 11 December 1997 had two important key features including 1) binding commitment of developed countries to reduce emission with average of 5% compared to 1990 level over five years period (i.e., from 2008 to 2012) and 2) creation of flexible market of carbon emission trading which was effective from 2005. In 2012, The Doha Amendment to Kyoto Protocol established second commitment of emission reduction for the period of 2013 to 2020 and revised the list of GHGs. For COP 21, which was held in Paris 2015, set new goal to limit the temperature increase not more than 1.5 °C compared to the current level and keep global temperature rise below 2 °C above pre-history level (UFCCC, 2016).

Incentive Based (IB) and Command and Control (CAC) policies are the two main transport policy types for negative externality reduction. IB policies can be further categorized into price and quantity controls. Price IB policy can be in the forms of taxes, charges, and fees on activities, which causes negative externalities. Carbon tax is one of the important Price IB policies, which has been widely used as an emission mitigation measure. Quantity IB policy sets allowable levels of negative externalities. The cap-and-trade system is a good example of Quantity IB policy. This system aims to put a cap on emission level, while allowing the trade of emission units in the market (Santos, Behrendt, Maconi, Shirvani, & Teytelboym, 2010).

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CAC refers to a form of regulation from government towards negative externalities such as placing a control on sulfur substances. For example, low-sulfur fuel regulation requires all refineries to apply a standard level of sulfur substances in their final products. Table 1 illustrates a summary of global trend and development of CAC type policies in transport sector in various countries.

Table 1. Summary of Potential CAC Policies for Transport Sector

Policy	Characteristics/Initiatives	Adopted countries
Low-sulfur fuel	It is an upstream policy, which aims to lower sulfur contents in gasoline and diesel. Since sulfur from fossil fuel burning is considered to be a harmful substance to the environment, this policy provides standards for refineries to develop their petroleum products per the requirements set.	Brazil, China, EU27, India, Japan, Russian, Thailand, United States, South Africa.
Emission standard	This policy requires automotive producers to invest in research and development to meet emission standards. Globally, there are three dominant emission standards, which each of the standards belonged to the US, European Union, and Japan. Many other countries tend to adopt at least some parts of these aforementioned standards in their regulations.	Brazil, China, EU27, India, Japan, Russia, Thailand, United States, Argentina, Australia, California, Canada, Chile, Indonesia, Mexico, Peru, South Korea.
Fuel-efficient economy	This policy sets standards of fuel consumption per particular distance for new vehicles to be produced by manufacturers. Policy parameters include lighter vehicle weight, less emission, and more efficient fuel consumption. Light-duty vehicle such as passengers and motorcycles are main types of vehicles for fuel-efficient economy policy, while heavy-duty vehicle fuel economy remained implemented in only four main economies including Canada, Japan, China, and United States.	China, EU27, India, Japan, United States, Canada, Mexico, Thailand and South Korea.

Source: (Kodjak, 2015) and Miller (2016)

Table 1 shows the summary of current trend of transport policies towards emission reduction. They are designed to tackle on different targets for emission reduction. Lower-sulfur fuel policy targets emission reduction at the fuels. Emission standard policy aims to set the limits of emissions emitted from vehicles. Fuel-efficient economy policy intends to force manufacturers to improve fuel economy of their fleets and, as a result, would decrease emissions emitted from fossil fuel burning. All of the above three policies are enforced on upstream stakeholders such as energy and automobile producers.

For passenger vehicles, fuel-efficient economy policy has been implemented widely among G20 countries. Canada, as one of the G20 members, set the highest standard of emission reduction in the forms of average CO_2 rate (gram/vehicle-km) up to 35% reduction for model year 2025 compared to baseline model year 2017. Followed by EU, Germany, France and Italy set fuel-efficiency standard to be 27% improvement from vehicles in model years 2020 and 2021 compared to model year 2015. The US set higher goal to be 50% improvement from the period of 2012 to 2025. However, this goal was compared to the fuel efficiency in 2010 (Kodjak, 2015).

Apart from passenger vehicles, fuel-efficient economy for heavy-duty vehicles is still in the early-age of development with only four countries implementing it including China, United States, Japan, and Canada. It was first initiated by Japan in 2005 due to Kyoto Protocol, but it has come to enforcement just in 2015 along with the other three nations. Fuel economy standard for

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heavy-duty vehicle was improved by 11 – 14% from model year 2014 as compared to vehicles model year 2006 to 2012 as the baseline. This new standards are effective until model year 2018 (Kodjak, 2015).

Thailand as one of the leading automotive industry hubs in Southeast Asia, has also implemented policy in transport sector to achieve emission reduction. Emission standards has been implemented in Thailand since 1998 primarily based on European emission standards, and currently emission standard implemented in Thailand reaches Euro 5 and Euro 3 standard level for light-duty and heavy-duty vehicles, respectively (Wagner, 2012). In 2015, ECO sticker was first implemented for new passenger vehicle producers and importers in Thailand. Implementation of ECO sticker was part of the promotion of ECO Car in Thailand. ECO Cars refer to passenger vehicles, which meet environmental and fuel-efficiency standards issued by Thai government. These vehicles are qualified to receive some incentives such as tax breaks and other investment incentives. So far, Thailand is now approaching its Phase II of ECO Car program. As shown in Table 2, qualified vehicles in this phase are required to emit less than 100 g/km of CO_2 and have fuel economy better than 4.3 L/100 km (Boonpradith, 2014).

Table 2. Summary of Thailand ECO Car Specification

Engineering Specifications	ECO Car Phase I	ECO Car Phase II
Emission Standard	Euro 4	Euro 5
Carbon Dioxide (CO_2)	Less than 120 g/km	Less than 100 g/km
Fuel Consumption	Less than 5 L/100 km	Less than 4.3 L/100 km
Impact Standard	UN ECE R94, UN ECE R95	UN ECE R94, UN ECE R95
Breaking Standard	None	UN ECE R13H
Capacity of Benzene Engine	Less than 1300cc	Less than 1300 cc
Capacity of Diesel Engine	Less than 1400cc	Less than 1500 cc

Source: (Boonpradith, 2014)

Furthermore, starting from 1 January 2016, the new excise tax system was implemented. While the old system taxed vehicles based on their engine sizes, the new system set tax levels based on CO_2 emission. The more CO_2 emitted, the higher tax level is charged. This new excise tax system further encourages the use of greener and more fuel-efficient vehicles. For example, under the old excise tax, vehicles with engine size less than 2000 cc using E20 gasoline were subjected to a fix excise tax rate of 25% regardless of their CO_2 emission levels. Under the new system, vehicles with the same engine size are now subject to excise tax rates in range of 30 - 50% depending on their CO_2 emission levels. Another example, Hybrid Electric Vehicle (HEV) enjoyed the flat tax rate of 10% under the old system regardless of its emission level. Under the new system, HEV is taxed in range of 10 – 50% depending on its emission level (Swire, 2012).

3. CARBON PRICING INSTRUMENTS

CO_2, as a main contributor to climate change, is the cause of many environmental problems such as natural disasters, animal species extinction, agricultural yield reduction, etc. It is predicted that, in 2100, global income will be reduced by 23% compared to the projected level with the presence of climate change (Worland, 2015). Economically, carbon emission holds a certain cost corresponding to the loss it may cause. In response to this problem, two main market-based instruments were introduced including Carbon Tax (CT) and Conventional Cap and Trade (CCT) systems.

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CT system charges certain rates of fee depending on the amount of CO_2 emitted by each activity. CCT system refers to a system that limits the amount of GHG emissions and allows the polluters (e.g., industries) that cannot control their emissions under the limits set to purchase carbon credits from others. A party can gain carbon credits by some carbon saving efforts such as energy saving projects. Goulder and Schein (2013) examined characteristics of these instruments including a Hybrid Cap and Trade (HCT) system, which is a form of CCT but it consists of floor and ceiling prices. The creation of floor and ceiling prices is to avoid existence of free allowance or price per unit of carbon credit to turn into zero due to real market mechanism as experienced by the European Union Emission Trading System (EU ETS) in 2007 (EU, 2016). The study of characteristics of three carbon pricing tools was based on 12 dimensions. Out of these 12 dimensions, the three aforementioned carbon pricing tools have only 4 dimensions in common as presented in Table 3.

Table 3. Summary of Carbon Pricing Tool Characteristics

Dimensions of Carbon Pricing Systems	CT	CCT	HCT	Remark
Equal Dimension Effects Caused Between Carbon Pricing Tools				
Incentives to Reduce Emissions	√	√	√	All systems are capable of creating incentives.
Distribution of Burden across Industries and across Household Groups	√	√	√	Scope of implementation of all systems can be justified and allocated.
International Competiveness	√	√	√	It can be maintained depending on the subsidizing mechanism and border adjustment of policy (down or upstream). However, normally, implementation of all systems will cause reduction of competitive advantages especially to carbon-intensive or trade-exposed industries.
Connection with Offsets	√	√	√	Offset refers to the additional emission reduction gained by entities outside of the scope of system implementation. All systems can generate and exclude the offset
Difference Dimension Effects Caused Between Carbon Pricing Tools				
Administrative Case	√	N/A	N/A	CT has potential due to fewer cost requirements of administrative work compared to HCT and CCT.
Avoid Volatility of Emission Price	√	N/A	√	CCT has fewer comparative advantages than other systems to avoid price fluctuation since there are no floor and ceiling prices set.
Addressing Uncertainty	√	N/A	√	CT and HCT have fewer uncertainties due to provision of cost per unit of emission reduction, which is favorable for entities to setup investment cost.
Interaction with other Climate Policies	√	N/A	N/A	If additional of GHGs reduction policy is introduced in HCT and CCT, overall emission under current system will not be changed due to the fall of emission allowance. In contrast, overall emission will fall in CT system in this case.

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Dimensions of Carbon Pricing Systems	CT	CCT	HCT	Remark
Wealth Transfers to Oil Exporting Countries	√	N/A	N/A	CT has a potential advantage for not allowing wealth transfer due to exogenous price of emission. With higher tax implemented, consumes tend to reduce oil consumption.
Budget Discipline and Tax Reform	√	N/A	N/A	CT offers more stable revenue, while revenues generated from CCT and HCT relies on transactions among emitting parties.
Potential for Linkage across Jurisdictions	N/A	N/A	N/A	There is no clear cut of advantages among three systems because each nation normally chooses to set regulation individually.
Potential for Greater Cost-Effectiveness from Broad Sectoral Coverage	N/A	N/A	N/A	In CT system, more sectors to be covered can lead to cost ineffectiveness as some sectors will be able to justify itself not to be covered by the tax system. However, in CCT and HCT, broaden sectorial coverage can lead to high administrative cost.
Perceptions and Political Feasibility	N/A	N/A	N/A	Implementation of the systems solely depends on government's aim to increase revenue or emission reduction regardless of political feasibility.

Source: Goulder and Schein (2013)
Note: N/A: Not applicable

Based on Table 3, CT and HCT have more competitive advantages over CCT on avoiding price volatility and expected policies errors. Currently, there are 40 nations and 20 sub-nation jurisdictions implementing the carbon pricing mechanisms. Overall, carbon pricing implementation in these countries accounted for approximately 12% of global emissions in 2015. The prices vary from 130 to less than one USD per ton of CO_2. Sweden set the highest price, while Mexico and Poland set the lowest rates (Kossoy, 2015). Experiences of each nation toward carbon pricing tools vary due to different contexts and choices of carbon pricing mechanisms.

CCT system or emission trading is another market-based tool for emission mitigation. Similar to the CT system, CCT was accelerated by environmental treaties such as Kyoto Protocol and its amendment. EU ETS was implemented for European Union members, plus Iceland, Norway, and Liechtenstein in 2008. EU ETS was divided into four phases of implementation with targets of emission reduction of 20% by 2020, and 80% to 95% compared to 1990 level. EU ETS covered three main GHGs including CO2, nitrous oxide (N_2O), and perflourocarbon (PFCs) (European Commission, 2013).

According to the Interagency Work Group on Social Cost of Carbon, it was reported in 2010 that carbon should be taxed equal to the marginal benefits of emission reduction to achieve good effectiveness and efficiency. The mechanism should cover all sectors, both upstream and downstream (Aldy & Stavins, 2011). In real practice, CT mechanisms have normally been implemented on energy sector deemed as upstream businesses such as refineries, coalmines and natural gas companies. While the tax was charged upstream, the increased cost was eventually pushed to the end users via product price. As a result, this mechanism indirectly forces conventional automobile users to look for vehicles that are more efficient.

For example, in Northern Europe such as Norway, Sweden, Finland, Denmark, and Netherland, they have experienced with CT since 1990s. In 1991, Norway started to impose CT on energy sectors by charging CT on gasoline, coal and diesel products. Norway successfully

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implemented CT on 55% of their emissions in 2009. Swedish government also used similar mechanism. However, the government allowed the exempts of CT on sectors already covered by EU ETS to avoid double tax charging and redundant costs to the producers. In 2015, carbon was priced at $130 per ton in Sweden (Aldy & Stavins, 2011).

In Denmark, CT was introduced in the forms of energy tax in May 1992. As a result, Denmark emission per capita was reduced 15% from 1990 to 2005. In Netherlands, CT was first implemented in 1990 on energy sector. The revenue gained from the tax was used for national environmental programs and incentive schemes for corporate benefits to avoid losing national competitiveness. As the tax rate kept increasing, the annual amount of CO_2 is expected to be reduced about 4.6 to 5.1 million tons in 2020.

Finland, as the first country to adopt CT system, the tax was charged in the forms of fossil fuel tax, while fossil fuel used in commercial vessels and aviation were exempt. In 2000, the government announced that 7% of the emissions were reduced due to the presence of CT (Sumner, Bird, & Dobos, 2011). Starting from 2000s, CT was also adopted in other countries such as United Kingdom, Quebec of Canada, Boulder of Colorado, France, etc. The trend was accelerated by the tension of climate change issue and environmental agreement bound by international protocols such as Kyoto Protocol and COP 21.

Figures 1 and 2 show the position of Thailand in terms of CO_2 emission level and the year of carbon pricing implementation compared to other nations. As of 2015, Thailand also produced approximately 4 tons per capita per year and 271.9 million tons of CO_2 as a whole. Thailand's emission per capita level is similar to France, Portugal, Mexico and Chile, which have emission per capita around 5 tons of CO_2 per year. In 2016, Thailand first implemented carbon-based excise tax, which is the reform on automobile industry for passenger vehicles. Based on the data, Thailand may not produce too much CO_2 compared to other nations, which already implemented carbon pricing mechanism. However, as a nation, Thailand produced relatively high CO_2 emission. Therefore, Thailand likely stands in an obligatory position to consider carbon pricing system compared to the early practitioners of carbon pricing system.

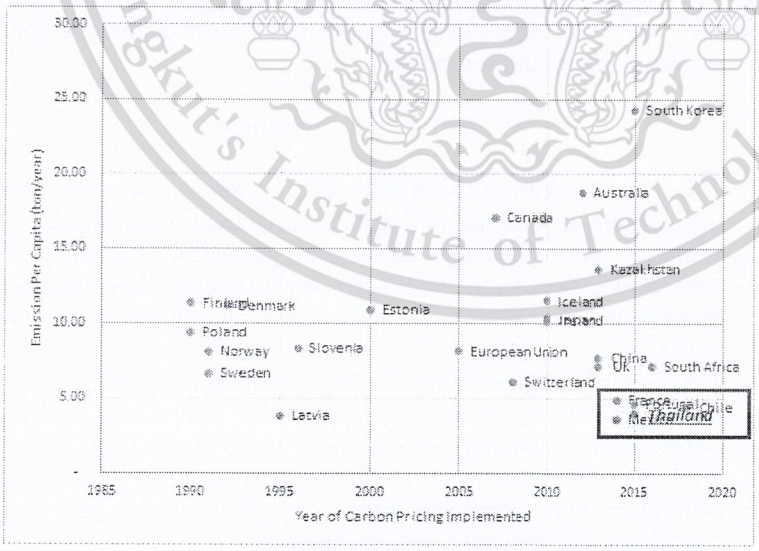

Figure 1. Plot of Emission Per Capita and Year Implemented of Carbon Pricing (United Nations Population Division, 2016) and (Olivier, Janssens-Maenhout, Muntean, & Peters, 2015)

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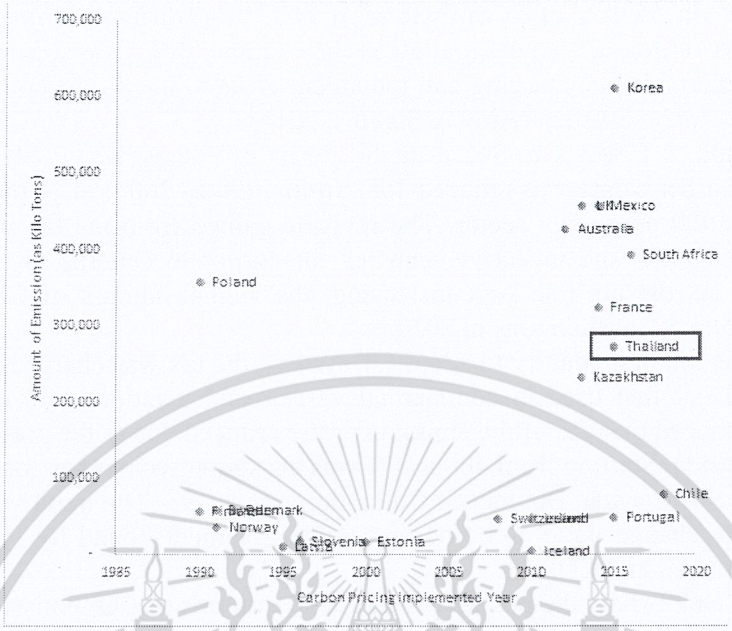

Figure 2. Plot of Total Emission and Year Implemented of Carbon Pricing (Olivier et al., 2015)

4. SUSTAINABLE TRANSPORTATION IN LOGISTIC PRACTICE

In logistic activities, transportation is a major contributor of emission. Vehicle powertrain technology and fuel option are the important factors that influences the level of emission. Besides Hybrid Electric Vehicle (HEV), other three electric vehicle technologies including Plug-in Hybrid Electric Vehicle (PHEV), Battery Electric Vehicle (BEV), and Fuel Cell Electric Vehicle (FCEV) require supporting infrastructures such as charging stations. Therefore, EV is not widely used for logistic activities, yet especially for long routes. As the result, EV for commercial purpose remains questionable. Potential and challenges of using electric vehicles for commercial purposes were discussed in many studies as summarized below.

Author	Findings
Davis and Figliozzi (2013)	The study carried out to compare the competiveness of EV. The samples are one brand of diesel truck and two brands of electric trucks. The study found that 85% of scenarios were fallen into diesel truck category. Therefore, diesel truck is more competitive than electric trucks. However through elasticity analysis, purchase cost found to be the most influencing factor to choose the diesel truck over the electric trucks.
Macharis, Lebeau, Van Mierlo, and Lebeau (2014)	The authors developed a model for estimating ownership cost of light commercial EV in Brussels by comparing eight BEVs, five diesel, and two petrol vehicles. Based on the sensitivity test, electric vehicles are more competitive for weight load lower than 1,000 kg, while conventional vehicles are more competitive for weight load more than 1,000 kg. This result implied that EV are suited for urban distribution and last-mile delivery practices.
Saenz-Esteruelas, Figliozzi, Serrano, and	The adoption of EV distribution was studied to improve quality of life by reduction of GHGs. The study was conducted in Portland and utilized real-world data of one logistic company to evaluate carbon footprints. The utilization of electric tricycles for last-mile delivery delivered huge reduction of GHGs due to nature of urban

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Faulin (2016)	distribution.
Kleiner et al. (2015)	The authors assessed a techno-economic assessment based on Transport Application based on Cost Model (TAMCO) on powertrain technology advancement of freight vehicles with gross weight lower than 3.5 tones. The comparison and assessment were taken in different countries such as Germany, Austria, the United Kingdom, Turkey, and South Korea. The result showed that BEV is more competitive in terms of cost comparing to FCEV. Furthermore, main indicators of decision-making are purchase tax, resale value and energy price.
Selvakkumaran and Limmeechokchai (2015)	AIM/Enduse model was used to model Thailand's land transport sector under three low carbon society scenarios and four assumed emission taxes. An assessment carried out with each of marginal abatement costs in relation with benefits gained including energy security, energy productivity, and emission mitigation. They concluded that average abatement cost to fit in the high level of low carbon society equaled to emission tax of 100 USD per ton.
Seitz, Beuttenmüller, and Terzidis (2015)	The authors conducted a study on structure of preference influencing willingness of the logistic practitioners to choose efficient emission powertrain from medium to heavy-duty vehicles. Buying condition and decision framework were constructed based on organizational, technological and environmental aspects. Relationship can be drawn within large companies that Corporate Social Responsibility (CSR) and market stages are two influencing factors. However, no conclusion about the relationship can be drawn from the small companies.
Liu et al. (2015)	Integrated model approach (macroeconomic activities, freight demand by commodity, network of transportation, and powertrain emission to estimate emissions from the future freight activities) was employed to estimate emissions from freight activities by truck and rail in the US by 2050. The study indicated that, assuming CT is implemented, the shift between roads to rail will reduce emissions by 10% to 28% and reduce energy consumption by 30% by 2050.
Oshiro and Masui (2015)	AIM/Enduse model was used to assess the impacts of low efficient vehicles in 10 regions of Japan by revising power generation sector and categorizing transport demands. The results showed that emissions were significantly reduced. Shares of low emission vehicles for passenger and freight vehicles also increased by 90% and 60%, respectively, once CT was introduced.

Based on Australia's experience, initiation of carbon tax was debated due to its consequences may cause the increase cost of trucking (Pierce, 2011). Since logistic is one of an energy-intensive sector, countries implementing CT and ETS provide some exempts for this sector to avoid the increase cost of transportation which can affect the nation competitive advantage comparing the other nations (CT Center, 2010). However, emission mitigation across the sectors shall be done equally due to the trend of global plan response to climate change, which can be proved by implementation of fuel economy on heavy-duty vehicles in countries such as, Japan, United States, China, and Canada. In Denmark, to avoid public intolerance to extra tax, CT was set partly to substitute the current taxes in energy in form of environment tax to create the awareness of emission cost firstly. Then, the percentage of environment tax was set to be increasing according to preference of tax designer to incentivize users to use renewable energy. Nel and Nienaber (2012) studied on carbon tax design on passenger vehicles in South Africa and suggested that the combination of purchase, usage, and ownership tax are effective for emission reduction and usage of lower emission vehicles. For Thailand, carbon tax substitution in current purchase, usage, and ownership tax of road freight vehicles shall be a considerable option for the initiation. Because all combination of carbon tax introduction to each tax stage of road freight vehicle tax's structure will be able to create awareness and to incentivize the practitioners in this

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field to look for low-emission vehicle and EV.

5. CONCLUSIONS AND IMPLICATION OF CARBON TAX

Due to the global trend on emission mitigation responding to climate change problems, many policies have been adopted so far to reduce and control emissions. While road freight transport (e.g., heavy-duty vehicles) is also a major contributor to total emissions from transport sector, its mitigation plans and policies have not been implemented widely compared to passenger vehicles. Many environmental policies that have widely been implemented such as emission standard, fuel economy, and low-sulfur fuel are upstream policies to encourage and force vehicle and energy producers to comply. On the other hand, CT, which is one of market-based instruments, shall be a considered to apply for commercial vehicles users to create the demand for low emission fleets for commercial activities. According to the reviews, light commercial EV is the most suitable alternative for low emission practice in logistic sector. Additionally, CT is a suitable incentive tool to balance competitiveness due to the high purchase cost of EV compared to conventional vehicle. Furthermore, light EV can be more competitive for the case of urban distribution. Due to the battery technological advancement, EV for commercial purpose can only support in short routes . So in order to incentivize for the use of light commercial EV, there should be more supporting regulations, particularly on urban distribution as the example of heavy-duty vehicle ban in the urban area, the assessment of carbon footprint for last-mile delivery, or highly emitted vehicle prohibited area, etc.

Hence, to successfully adopt the CT for logistic vehicles in Thailand, the next areas of study should be the projection of road freight transport emission in Thailand based on new approach for commercial vehicle driving pattern. Not only vehicle technology and fuel types are matter to the level of emission, but the driving pattern of those vehicles an also important factor toward the increase of emission. This can been seen through the fact that the almost half of road transport emission comes from heavy-duty vehicle which is employed only 11% of total vehicles globally. Secondly, perspective assessment of logistic practitioners toward new proposal of CT should gather because practitioners are the direct stakeholders. Their inputs and acceptance are the crucial factors for a new policy to be successfully implemented. Finally yet important, mathematical modeling on price of carbon shall be carried out by approaches such as Marginal Abatement Cost Tool (MACT), Energy Forecasting and Emission Consensus, and Tool for Rapid Assessment of City Energy Approach. The result could project the real cost of emission under the development scenarios of each nation. These approaches are suggested by Partnership for Market Readiness (PMR), which is an innovative forum to build climate change mitigation, specifically focus on building market readiness components of nations toward climate change mitigation and setup the carbon pricing tools. Participants of PMR are categorized by three types, and currently there are 17 implementing partners, 13 contributing partners, and 4 technical partners.

As the initial stage of CT implementation, substitution of the existing tax by CT with no significantly added tax amount can be a strategy to convey the awareness as well as to avoid public intolerance. It should be noted, however, that unwell-designed CT can affect country's competitive advantage. This is especially important for Thailand as the country is a member of ASEAN Economic Community (AEC). If the CT unfairly results in an increase of logistic cost in Thailand, the country may further lose cost competitiveness. The subsequent impact would be the outflow of Foreign Direct Investment (FDI) from Thailand to other neighboring countries. Hence, to ensure fair play of trade and climate change mitigation throughout the region, a consensus of regional agreement including CT and other emission mitigation issues shall be achieved before implementation of CT.

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