

Carbon Credit Estimation: A Case Study of Shifting Freight Mode to Railway from ICD Lat Krabang, Bangkok to Laem Chabang Port, Chonburi

Nantarat Tangvitoontham and Papusson Chaiwat

Abstract—This study aims to investigate the estimation of greenhouse gas emissions and simply analyzing the value of carbon credits of the government's project, Rail Transfer Terminal Center at Inland Container Depot (ICD) Lat Krabang, Bangkok and Laem Chabang Port, Chonburi. The results reveal that the reduction of greenhouse gases (GHG) is at high rate and increases every year. As you can see, the emission of carbon dioxide equivalent reduces averagely 201,256.60 tCO₂e per year. Additionally, government can gain from carbon credit approximately 90.84 million baht per year.

Index Terms—Carbon credit estimation, carbon dioxide emission estimation, environmental valuation, environmental economics.

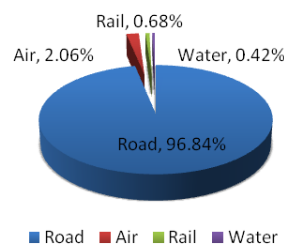
I. INTRODUCTION

Nowadays, the world is facing a climate change. Economic activities are the major cause of greenhouse gases (GHG) emission to the atmosphere, which leads to a global warming. From these reasons, many countries have reached an agreement on climate change and trading greenhouse gases, which is called "carbon credit". Both government and the private sector can trade through the Clean Development Mechanism (CDM) under the Kyoto Protocol. Carbon credit is the amount of greenhouse gases that reduce from human and economic activities. There are several types of gases such as carbon dioxide, methane, nitrous oxide hydro fluorocarbon, perfluorocarbons and sulphur hexafluoride [1]. Carbon credits are an important tool in reducing greenhouse gas emissions through the mechanism as well as an new source of government revenue [2]. Thailand is also a member and obligates to perform under the clean development mechanism as well. Additionally, Thailand may be forced to reduce the amount of greenhouse gases in the next 10 years as well. Therefore, it should reduce the usage of energy consumption simultaneously. The government should also encourage reducing emissions by investing in the infrastructure of the country to contribute to environmental preservation and create a sustainable development.

II. CASE STUDY BACKGROUND

Thailand's government creates a master plan for reducing

GHGs emission since 2012. Regarding to the statistics from National Statistical Office, we found that the highest energy consumption is in industry sector which accounts for 35.9 percent following by transportation sector which accounts for 35.4 percent of all energy consumptions [3]. As you can see the transportation sector consumes approximately one third of the country's energy consumption and tends to increase year by year. Regarding to the Kyoto Protocol and Thailand's government obligation to reduce GHGs emission, the Office of Transportation and Traffic Policy and Planning (OTP) announces the development master plan for a sustainable transportation and logistics system.



Source: Thailand greenhouse gas management organization

Fig. 1. CO₂ emissions from the transportation sector in Thailand

Fig. 1 shows that CO₂ emission from road transportation is 96.84 percent followed by the emission from air transportation (2.06 percent), railway transportation (0.68 percent) and water transportation (0.42%) [4]. Since the energy consumption in the road transportation sector is very high, it is necessary to create the project in order to support changing transportation mode for reducing air pollution and greenhouse gas emissions. OTP plans to invest in green transportation system and encourage business sector to use transportation mode which have lower emission rates instead. One of the main projects of the government which defined in the master plan is "Rail Transfer Terminal Center" at Inland Container Depot (ICD) Lat Krabang, Bangkok and Laem Chabang Port, Chonburi. This project objects to reduce the truck freighting and encourage railway freighting from ICD Lat Krabang to Laem Chabang Port. Therefore, this study aims to investigate the estimation of greenhouse gas emissions and simply analyzing the value of carbon credits in this government's project.

III. METHODOLOGY

The benefits from CO₂ emission reduction will occur only if the project is established. Therefore, the benefit from

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changing mode of transportation will be determined around where the organization is located. The carbon credit reflects the net benefit of the project. Thus, the results are the different of CO₂ emission from train and truck between with and without the project.

Also, the study assumes that the lifetime of the project is 30 years, so the estimation will be start from year 2014 to year 2043. According to the project feasibility report of OTP, the demand for freighting from ICD Lat Krabang to Laem Chabang Port was already estimated by using econometric model. The econometric models for freighting demand are as follows [5]:

$$LCP = -3726727 + 1.9528 \text{ RGDP} \quad (1)$$

$$(R^2 = 0.9674)$$

$$LICD = 121406.2 + 0.3097 \text{ LCP} \quad (2)$$

$$(R^2 = 0.9817)$$

where

LCP = Containers in Laem Chabang Port (TEU)

RGDP = Real Gross Domestic Product (Million Baht)

LICD = Containers which deliver from ICD Lat Krabang to Laem Chabang Port (TEU)

There are two scenarios in this study as follows:

A. Without the Project

Since there is no project, the proportion of freighting by truck and railway remain unchanged. The proportion is 74:26. Therefore, the container deliveries by railway are limited at 500,000 TEU per year and will be increased to 1,000,000 TEU in 2015 because there is a plan to increase the trips from 10 to 20 trips per day.

B. With the Project

If the project is established, the potential of railway freighting will be raised. The freighting by railway is faster and more convenience. The proportion of freighting by truck and railway will be changed to 60:40. Therefore, the capacity of container deliveries by railway is 2,000,000 TEU per year.

Moreover, in order to calculate carbon credit of the project, there are several variables to explore such as Conventional Factor [6] and Emission Factors [7]. OTP's study in 2011 revealed that the different vehicles at various speeds consume fuels such as gasoline, diesel, gas, LPG and NGV differently. It can create different multiplier emissions which are called "Emission Factors (EF)" These EFs are used to estimate the air pollution emission in transportation sector which are shown in Table I.

TABLE I: POLLUTION EMISSION IN TRANSPORTATION SECTOR

Pollution Emission in Transportation Sector	Nation level (million tons)	Bangkok (million tons)
Hydrocarbon (HC)	0.04	0.03
Carbon monoxide (CO)	0.62	0.15
Nitrogen oxides (NO _x)	0.24	0.11
carbon dioxide (CO ₂)	39.21	18.21

Source: Office of transportation and traffic policy and planning

Additionally, IPCC Second Assessment (1995) reported

that different types of pollutants have potential to warm the climate differently. Consequently, its research determines the potential of various gases to heat the globe which is called "Global Warming Potential (GWP)" which shows in Table II. This study is considered three types of greenhouse gases which are carbon dioxide (CO₂), nitrous oxide (N₂O) and methane (CH₄) [8].

TABLE II: GHGS CONTROLLED UNDER THE KYOTO PROTOCOL AND GLOBAL WARMING POTENTIAL

Greenhouse Gas	GWP (Carbon Dioxide Equivalent:
1. Carbon dioxide (CO ₂)	1
2. Methane (CH ₄)	21
3. Nitrous oxide (N ₂ O)	310
4. Hydrofluorocarbon (HFCs)	140 - 11,700
5. Perfluorocarbons (PFCs)	6,500 - 9,200
6. Sulphur hexafluoride (SF ₆)	23,900

Source: Climate change 1995, IPCC second assessment report

However, emissions from each type of vehicle are not equal, so this study will use the Emission Factor (EF) to explain and clarify the estimation of GHGs emission from different type of vehicles as well. Table III shows the EF index of land transportation including truck and train [9].

TABLE III: INDEX OF VEHICLE'S GHGS EMISSION (LAND TRANSPORTATION)

Type of Vehicles	CO ₂ (g/km)	N ₂ O (g/km)	CH ₄ (g/km)
Light Duty Petrol (<3.5 tonnes)	297.5	0.0055	0.075
Light Duty Diesel (<3.5 tonnes)	280	0.0200	0.005
Light Duty LPG/CNG (<3.5 tonnes)	180	0.0050	0.180
Heavy Duty Petrol (>3.5 tonnes)	535	0.0060	0.100
Heavy Duty Diesel (>3.5 tonnes)	770	0.0300	0.060
Heavy Duty LPG/CNG (>3.5 tonnes)	550	N/A	N/A
Motorcycles Petrol	95	0.0020	0.175
Diesel electric emissions	3,188	0.08	0.215
Range of Diesel Engines (Train)	3,000-3,500	N/A	0.18-0.25

Source: New Zealand transport agency research report 497

In this study, trucks transportation bases on Heavy Duty Diesel (> 3.5 Tons) in EF index. Railway transportation will be assumed the weight of fuel 1 liter equals to 0.8 kg, and the

oil is approximately 4 liters per kilometer. Both transportation modes is calculated by using the same distance which is from the ICD Lat Krabang, Bangkok to Laem Chabang Port, Chonburi (115 kilometers).

Also, the OTP's research found that the emissions of the pollutants tend to decrease if the average speed of the vehicle is increasing. For example, the Heavy Duty Diesel emits CO₂ 821 g./km. at the speed of 30 km./ hour while the emission rate decreases to 577 g./km. at the speed of 60 km./ hour. The Light Duty Diesel emits CO₂ 203 g./km. at the speed of 30 km./ hour while the emission rate decreases to 154 g./km. at the speed of 60 km./ hour.

The rates of air pollution emission from road transportation are show in Table IV.

TABLE IV: AIR POLLUTION EMISSION RATE IN ROAD TRANSPORTATION

Pollutants	Rate of Air Pollution Emission (kg. per ton - 1000 km.)
HC	0.273
N ₂ O	0.273
CO ₂	0.134

Source: Office of transportation and traffic policy and planning

Amount of carbon dioxide equivalent emission in truck and railway freighting is calculated by using a ton of emission in one year (tCO₂e/year). The calculation of the carbon dioxide emission from truck freighting and railway freighting are according to the following formula.

- Carbon dioxide equivalent emission from truck freighting in one year

$$= \{ [\text{Number of trips which use trucks within a year} * \text{distance (km)} * \text{rate of fuel consumption by truck (liter / km)} * \text{EF index for carbon dioxide emission (g / km)} * \text{GWP of carbon dioxide}] \\ + [(\text{Number of trips which use trucks within a year} * \text{distance (km)} * \text{rate of fuel consumption by truck (liter / km)} * \text{EF index for nitrous oxide (g / km)}) * \text{GWP of nitrous oxide}] \\ + [(\text{Number of trips which use trucks within a year} * \text{distance (km)} * \text{rate of fuel consumption by truck (liter / km)} * \text{EF index for methane (g / km)}) * \text{GWP of methane}] \}$$

- Carbon dioxide equivalent emission from railway freighting in one year

$$= \{ [\text{Number of trips which use trains within a year} * \text{distance (km)} * \text{rate of fuel consumption by train (liter / km)} * \text{the weight of 1 liter of fule (kg)} * \text{EF index for carbon dioxide emission (g / km)} * \text{GWP of carbon dioxide}] \\ + [\text{Number of trips which use trains within a year} * \text{distance (km)} * \text{rate of fuel consumption by train (liter / km)} * \text{the weight of 1 liter of fule (kg)} * \text{EF index for nitrous oxide emission (g / km)} * \text{GWP of nitrous oxide}] \\ + [\text{Number of trips which use trains within a year} * \text{distance (km)} * \text{rate of fuel consumption by train (liter / km)} * \text{the weight of 1 liter of fule (kg)} * \text{EF index for methane emission (g / km)} * \text{GWP of methane}] \}$$

IV. RESULTS

OTP has the development plan for shifting freighting mode from trucks to railway. OTP will establish Rail

Transfer Terminal Center in ICD Lat Krabang and delivers all containers to Laem Chabang Port by railway. This project promotes reduction of GHGs emission and adopts the Clean Development Mechanism. First of all, the volume of containers which will be delivered from ICD Lat Krabang to Laem Chabang Port has to be estimated. According to the econometric model which is presented in the previous section, the amount of containers that transport by truck and railway in both scenarios are estimated in Table V.

TABLE V: CONTAINER VOLUMES THAT DELIVER FROM ICD LAT KRABANG TO LEAM CHABANG PORT BY TRUCK AND RAILWAY (TEU)

Year	Without Project		With Project	
	Truck	Railway	Truck	Railway
2014	1,438,477	505,411	1,166,333	777,555
2015	1,485,990	522,105	1,204,857	803,238
2016	1,534,918	539,295	1,244,528	829,685
2017	1,584,944	556,872	1,285,090	856,726
2018	1,635,793	574,738	1,326,319	884,213
2019	1,687,240	592,814	1,368,033	912,022
2020	1,739,110	611,039	1,410,089	940,059
2021	1,791,270	629,365	1,452,381	968,254
2022	1,843,625	647,760	1,494,831	996,554
2023	1,896,106	666,200	1,537,384	1,024,922
2024	1,948,667	684,667	1,580,001	1,053,334
2025	2,001,277	703,151	1,622,657	1,081,771
2026	2,053,914	721,645	1,665,336	1,110,224
2027	2,106,566	740,145	1,708,026	1,138,684
2028	2,159,224	758,646	1,750,722	1,167,148
2029	2,211,885	777,149	1,793,420	1,195,613
2030	2,264,546	795,651	1,836,118	1,224,079
2031	2,317,205	814,153	1,878,815	1,252,543
2032	2,369,862	832,654	1,921,510	1,281,007
2033	2,422,518	851,155	1,964,204	1,309,469
2034	2,475,173	869,655	2,006,897	1,337,931
2035	2,527,826	888,155	2,049,588	1,366,392
2036	2,580,478	906,654	2,092,279	1,394,853
2037	2,633,129	925,153	2,134,969	1,423,313
2038	2,685,780	943,652	2,177,659	1,451,773
2039	2,738,430	962,151	2,220,349	1,480,233
2040	2,791,080	980,650	2,263,038	1,508,692
2041	2,843,730	999,148	2,305,727	1,537,151
2042	2,914,027	1,000,000	2,348,416	1,565,611
2043	2,985,175	1,000,000	2,391,105	1,594,070

Source: authors' calculation

The calculation of GHGs reductions in case of successful establishment of the project during the years 2014 – 2043 according to the formula in the previous section is shown in Table VI to calculate carbon credits; this study also uses the

valuation of travel time savings concept [10]. The carbon credits of the project regarding to the Certified Emission Reductions (CERS) that can be traded in the carbon market was valued on April 1, 2010 is 1 ton of carbon dioxide equivalent emission per year equal € 11.70. The exchange rate which is used in this study is from 5 July 2013 was € 1 equals 39.58 baht. The estimation results are shown in Table VI and Table VII.

TABLE VI: COMPARISON OF GHGs RELEASED INTO ATMOSPHERE BETWEEN WITH AND WITHOUT PROJECT FROM YEAR 2014 TO YEAR 2043

Year	GHGs Emission without the Project (tCO ₂ e/year)	GHGs Emission with the Project (tCO ₂ e/year)
2014	734,686.22	660,500.47
2015	758,952.81	682,316.72
2016	783,942.10	704,782.68
2017	809,492.49	727,753.09
2018	835,463.18	751,101.36
2019	861,739.22	743,647.34
2020	888,231.01	766,508.72
2021	914,871.24	789,498.20
2022	941,610.88	812,573.47
2023	968,415.19	835,704.54
2024	995,260.20	822,978.78
2025	1,022,129.85	845,197.24
2026	1,049,013.63	867,427.38
2027	1,075,904.91	889,663.73
2028	1,102,799.67	911,902.96
2029	1,129,695.59	893,403.05
2030	1,156,591.42	914,673.22
2031	1,183,486.57	935,942.85
2032	1,210,380.84	957,211.79
2033	1,237,274.23	978,480.02
2034	1,264,166.83	956,038.15
2035	1,291,058.80	987,973.08
2036	1,317,950.25	1,019,907.41
2037	1,344,841.33	1,051,841.29
2038	1,371,732.12	1,083,774.83
2039	1,398,622.71	1,115,708.14
2040	1,425,513.16	1,147,641.28
2041	1,452,403.52	1,179,574.30
2042	1,484,104.34	1,211,507.26
2043	1,516,037.25	1,243,440.17

Source: authors' calculation

The results showed that the project (Rail Transfer Terminal Center) can reduce GHGs emission year by year whenever the project is established. As the railway freighting has lower GHGs emission rate per unit compared to truck freighting because it can deliver more containers in one trip and consumes less energy. If we compare between the GHGs emission when the project is established and without the

project, the reduction of GHGs emissions is at high rate and increases every year.

As you can see, the emission of carbon dioxide equivalent reduces 74,185.75 tCO₂e per year in year 2014 and reduces up to 272,597.08 tCO₂e per year in year 2043. The value of carbon credit is 33.486 million baht in year 2014 and increases year by year to 123.047 million baht in year 2043.

TABLE VII: CARBON CREDITS THAT OCCURS WHEN THE PROJECT IS ESTABLISHED FROM YEAR 2014 TO YEAR 2043

Year	GHGs Reduction (tCO ₂ e/year)	Carbon Credit (Million Baht)
2014	74,185.75	33.486
2015	76,636.09	34.592
2016	79,159.42	35.731
2017	81,739.40	36.896
2018	84,361.82	38.08
2019	118,091.88	53.305
2020	121,722.29	54.944
2021	125,373.04	56.592
2022	129,037.41	58.246
2023	132,710.65	59.904
2024	172,281.42	77.765
2025	176,932.61	79.865
2026	181,586.25	81.965
2027	186,241.18	84.067
2028	190,896.71	86.168
2029	236,292.54	106.659
2030	241,918.20	109.198
2031	247,543.72	111.738
2032	253,169.05	114.277
2033	258,794.21	116.816
2034	308,128.68	139.085
2035	303,085.72	136.809
2036	298,042.84	134.532
2037	293,000.04	132.256
2038	287,957.29	129.98
2039	282,914.57	127.704
2040	277,871.88	125.427
2041	272,829.22	123.151
2042	272,597.08	123.047
2043	272,597.08	123.047

Source: authors' calculation

The carbon dioxide equivalent emission is approximately 201,256.60 tCO₂e per year and the total amount of the reduction in 30 years is 6,037,698.04 tCO₂e. Additionally, carbon credit that Thailand's government will be gain is averagely 90.84 million baht per year or total values is around 2,725.33 million baht.

From these reason, the project is a powerful policy due to CO₂ equivalent emission reduction and generates

environmental friendly logistics system. Indeed, this project creates greatly sustainable economic values. Moreover, it creates a sustainable transportation system and has a positive impact on society in the long term as well.

V. CONCLUSION

The project has a positive impact and support the development of the clean development mechanism. The carbon dioxide equivalent emission is reduced if the Rail Transfer Terminal Center can be successfully established. Thailand's government can gain the carbon credit which created from this project as well.

Therefore, encouragement of investment in transportation and logistics infrastructure, which reduce social and environmental damages in addition to efficiently use of energy, is very important for future improvements. The policy also supports sustainable development in transportation sector.

VI. LIMITATION

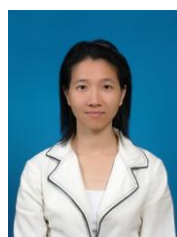
This study does not perform the sensitivity analysis. Thus, the estimation of the container volumes, which will be delivered from ICD Lat Krabang to Laem Chabang Port, is under the normal circumstance. The model assumes there is no economic crisis and other variables remain unchanged.

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