A Study of Carbon Dioxide Emissions in Import-Export Activities to be Approach for the Carbon Tax Structure for Sustainable Port Development

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***Abstract*— The future ports must be environmentally friendly. The World Maritime Organization faces the challenge of reducing carbon dioxide emissions by 2030, in which CO_2 emissions from container ships are a significant matter and impact the environment. However, container terminals' carbon dioxide activities comprise both onshore and offshore activities. The CO_2 emission assessment does not consider the actual cargo load, which does not reflect reality. Therefore, it is necessary to assess the CO_2 emissions based on the actual cargo weight in all activities. This paper is to present the import-export of containers analysis forecast for 2015–2030 using a linear regression method. The results were analyzed and assessed the amount of CO_2 emissions. The import assessment started from the ship entering the anchorage area or entrance buoy until the container left the port. For the exports, the evaluation started from the trailer entry at the gate to the ship leaving the port, through the entrance buoy, as well as considering evaluating the loading and unloading activities that occur throughout the process. Then calculate the amount of CO_2 emissions per 1 TEU to be used as the basis for calculating or determining the future carbon tax by studying the carbon tax structures of countries around the world and comparing them with the carbon tax structures in Southeast Asia and Thailand. Finally, the result is used as a basis for calculating and determining measures for supporting environmental policy in the future.**

Keywords*— *Greenhouse gas (GHG), Container ship, Port operation, Sustainable development, Carbon tax.

I. INTRODUCTION

Ocean freight accounts for 80–90% of all trade worldwide. It is a mode of transportation that is currently quite well-liked. There are 10 trillion tons of import and export containers that are sent via containers [1]. Onshore and offshore activities are two linked activities. These two activities both involve the use of fuel oil. Import and export are measured in 1 liter of transportation oil. Carbon monoxide (CO) and carbon dioxide (CO_2), hydrocarbons (hydrocarbons), nitric oxide (NO_2), nitrogen oxides (NO_x), aldehyde (aldehyde), and sulfur dioxide (SO_2) [2] are all constituents of combustion exhaust (sulfur dioxide). Its release will have an impact on Port Said's sustainability in a variety of aspects (social, environmental, and economic) [3] and lessen its contribution to world problems. By 2030, the International Maritime Organization (IMO) [4] aims to have addressed this issue. Another solution to the issue is the collection of CO_2 emissions taxes [5] [6].

Fig. 1 On shore and off shore

The study forecasts CO_2 emissions, then presents the results of a study on the method used to calculate CO_2 emissions at ports, followed by CO_2 emissions forecasts, advantages, and growth potential in 2030. Finally, the tax structure and CO_2 emissions model for container ships for sustainable development ports. The scope of activities as shown in Fig 1

II. LITERATURE REVIEW

The ecosystem will be impacted by global warming brought on by CO_2 emissions from port operations [7]. The literature review led to the calculation of the port's CO_2 emissions tax.

A.CO₂ emission

The examination towards the sustainability of CO_2 emissions in relation to policy and trends in marine CO_2 emissions was emerged [8] [9] [10]. Studies show that CO_2 emissions are mostly emerged. The study was completed autonomously using a ship or a vehicle. Studies that included research on vehicles, ships, and port activities were extremely rare.

B. CO_2 Emission Process

A suitable taxation model based on welfare economics was offered [11]. These external factors must be taxed, which demands external government contributions. This point of view is based on the welfare theory [12], often known as the prosperity theory, which attempts to offer an accurate assessment of the resources used by society. The person must evaluate all the consequences of their economic activities. Regardless of any external factors, the analysis concluded that the majority of studies and collections fit measures emissions of CO_2 in tons. No taxes are levied in the form of a per-TEU (twenty-foot equivalent unit) container fee that could be used as a benchmark for calculating the tax rate [13] that would apply to each shipment of goods. Future society and all economic sectors should be made aware of environmental responsibility.

III. METHODS

The operational activities [14] of a container port are used to calculate the CO_2 emissions from land and sea transportation to and from that port. The activities accounted for both the direct and indirect CO_2 emissions [15]. The scope of the assessment is divided into two parts: This CO_2 emission assessment applies to both onshore and offshore activities, as shown in Fig 2.

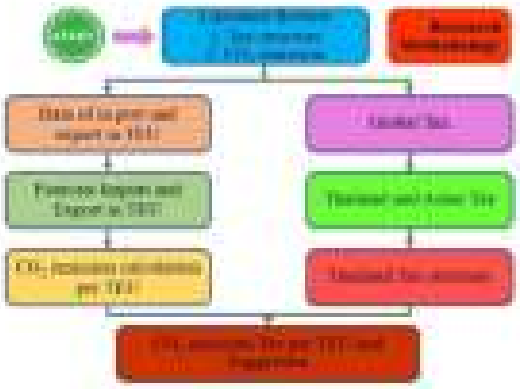


Fig. 2.Research Methodology

This analysis uses a container ship to import and export containers to examine the structure of the upcoming carbon tax as well as the onshore and offshore container port activities that result from goods entering and leaving the port. A second forecast covering the period from 2015 to 2021 was made, along with a forecast of the container in and out for 2050 using the program to linear in the future. The initial forecast was made between 2015 and 2019 and its accuracy was evaluated using 2020 [16] findings. The classification of ships was subsequently developed container to determine how much CO_2 is emitted during a single ship voyage; the counting begins when the ship enters the anchorage or passes the entrance buoy and continues until the container departs the port. This was done in relation to exports, which began as soon as the vehicle arrived at the port. The formula for calculating CO_2 emissions per TEU container is calculated prior to the ship leaving the port through the entrance buoy to be used as a basis for calculating or determining carbon tax in the future by comparing the carbon tax structures of various countries with Thailand's variables and the Southeast Asian carbon tax scheme. This foundation will be used to determine the amount of future revenue due to the treasury tax. Describe the scope of the activities occurring in the port as shown in Fig 3.

Fig 3 Marine port limited LCB

In addition to Thailand's factors, the study of the global tax structure compares it to the tax structures in Southeast Asia and Thailand, bringing the tax per container (TEU) to be used as a basis for estimating or enacting a carbon tax in the future. Then use it as a foundation to calculate how much future treasury taxable income will actually be, comparing it to Thailand's components and Southeast Asia's carbon tax scheme.

The different sizes of container ships necessitate categorizing them according to the size of the load and the ship's name, as shown in Fig 4.

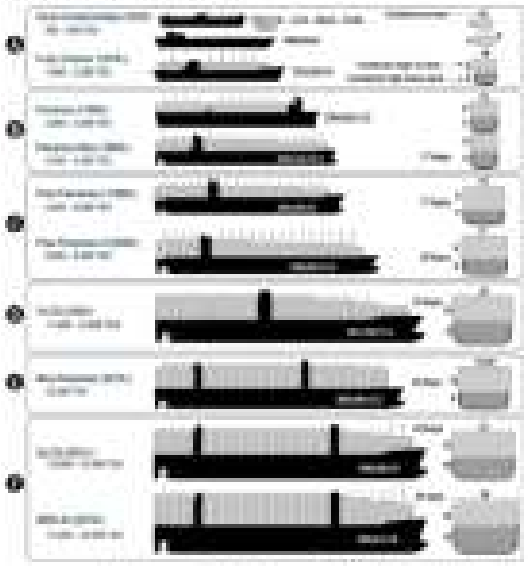


Fig. 4. Evolution of Containerships

The total CO_2 emissions, which must be distinguished from the source of the Emission Factor (EF) [19] with marine fuel, are calculated using Equation 1. Additionally, despite having the same name, automotive fuels behave

differently in mixtures of fuels, causing them to eventually separate and then come back together. The different names for the fuel used in ships are marine gas oil (MGO) and high-speed diesel oil (HSDO).

$$TotalCO_2Em = SeaCO_2Em + LandCO_2Em \quad (1)$$

Researchers will segregate the CO_2 emissions by land and sea after obtaining an overview of the emissions according to formula 1. Where 'Em' denotes Emission.
Sea scope

CO_2 emissions by ships can be calculated according to formula 2.

$$Emission = \sum_{a=a}^{f}(Consump\ x\ N\ x\ EF) \quad (2)$$

Where 'a-f' denotes the type of container vessels, N denotes the number of container vessels. EF denotes the Type a Early Container- Fully Cellular (Picture 4)
Type b Panamax- Panamax Max
Type c Post Panamax I- Post Panamax II
Type d VLCS
Type e New Panamax
Type f ULCS- MGX 24
Emission Factor of fuel used in water transportation.

Table 1 Emission Factor for Vessel In case a ship is using a type of fuel for which no default value is provided (such as bio-fuels, alternative non-fossil fuels or any other fuels), specific emission factors shall be applied as Type A Marine and Type B Land.

TABLE 1 EMISSION FACTOR

Type A Marine

Type of Fuel	Emission factor (tCO_2 /t fuel)
Heavy Fuel oil	3.114
Light Fuel oil	3.151
Diesel/Gas oil	3.206
LPG(Propane)	3.000
Methanol	1.375
LNG	2.750
Ethanol	1.913

(Emission factor of Marine fuel type [20])

Type B Land

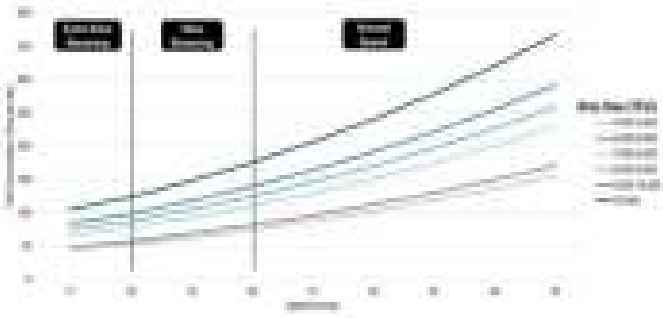
Emission source	Emission factor
Electricity	0.85kg CO_2 per KWh
Diesel (a liter)	2.653kg CO_2 per liter

(Emission factor of Diesel fuel type [21])

$$EF = Vessel\ x\ (Consumption/Hours) \quad (3)$$

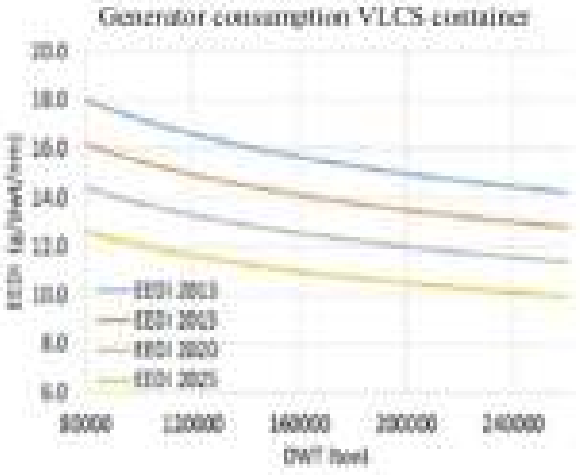
Where 'Vessel' denotes the number of container vessels according to formula 3.

Fuel consumption of container ships according to the size and speed of the ship used is shown in Fig 4.



Fuel consumption by containership size and speed [22]

Fig 5 Fuel consumption by containership



Engine selection Manual [23]

Fig 6 Engine selection for very large container vessels

Depending on the size and color of electric machines for workplace safety and navigation in constrained spaces, container ship fuel consumption varies. While the ship is in the trench and while docking for work, two electrical machines must be running at all times. Boilers are required to power the machines. The fuel usage of the Table 2 container ship radiator is displayed in the table below.

TABLE 2 BOILER CONSUMPTION

Emission source	Consumption
Boiler	2.5 t/h

(Container boiler consumption [24])

CO2 emissions by car can be calculated according to formula 4.

$$Emission = Consumption\ x\ \frac{Q}{2}\ x\ distance\ x\ EF \quad (4)$$

Where 'Q' denotes the type of container truck (2 TEU)
Emission Factor of fuel used in land transportation

Rail Crane 5 kW capacity of LCB port 35 TEU per Hrs.

$$Emission = kW\ x\ EF \quad (5)$$

A sizable number of nations, regions, and cities declared a "climate emergency" in 2019. The 10-year

average was 1.1°C higher than pre-industrial levels. Alarming sea level rise is occurring. For the development of the nation, it is urgent to collect CO_2 emissions. And it is the idea that CO_2 emissions can be decreased by using the tax system as a check. The world's top priority for implementing policy at the moment is addressing the urgent problems of global warming and climate change. Thailand has acknowledged the significance of these issues. On December 28, 1994 it became a party to the United Nations Framework Convention on Climate Change., Thailand approved a Kyoto Protocol ratification [24] on August 28, 2002. According to Table 1, Thailand is a developing nation with no requirements to lower greenhouse gas emissions.

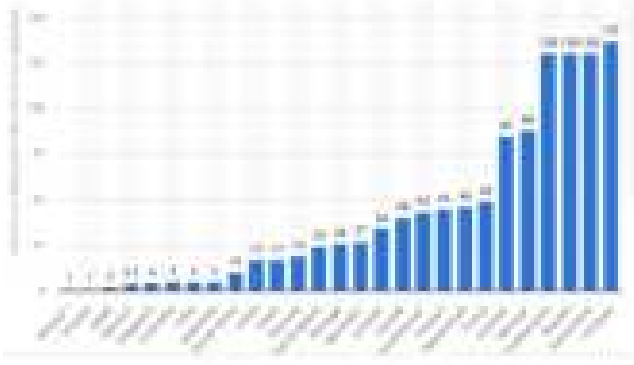
TABLE 2 THAILAND APPROVED KYOTO PROTOCOL

Annex I Development	Annex II Non Development country
1. GHG reduce 5.2 %	1. Plan reduce
2. Report and audit	2. Report and audit
	3. Support climate change

(Compare Kyoto Protocol of Thailand [24])

An emissions framework for developed nations serves as the foundation for the idea of universal taxation. It includes a carbon tax, also known as a tax or fee on the production, use, or sale of fossil fuels like coal, natural gas, or oil. When these fuels are burned, carbon dioxide is produced and released into the atmosphere of the Earth. The gas tax rate is the foundation for this tax or fee. A carbon tax is a fee or levy levied by the federal government on people who consume fossil fuels, which include natural gas and oil.

The national tax rates for each nation will take effect on April 1, 2022, and they will be calculated based on the price per cubic ton of CO_2 emissions shown in Fig 7 in US dollars.



(Different tax rates worldwide as of April 1, 2022 by country [27])

Fig 7 Carbon tax rates worldwide

In Asia, China, Japan, and Singapore have announced policies to collect taxes on CO_2 emissions as shown in TABLE 4.

TABLE 4 CARBON TAX

County	Carbon Tax $/t $CO2e
Singapore	5.00
Taiwan	3.26
China	8.52
Indonesia	2.10
Japan	2.00

(Singapore [28] Taiwan [27] China [29] Indonesia [29] Japan [30])

Countries that enforce carbon emissions taxes are shown by the blue carbon trade price. Countries that development carbon emissions taxes are shown by the blue carbon trade price, shown in Fig 8.

(Carbon pricing rising interest in Asia and the Pacific [31])

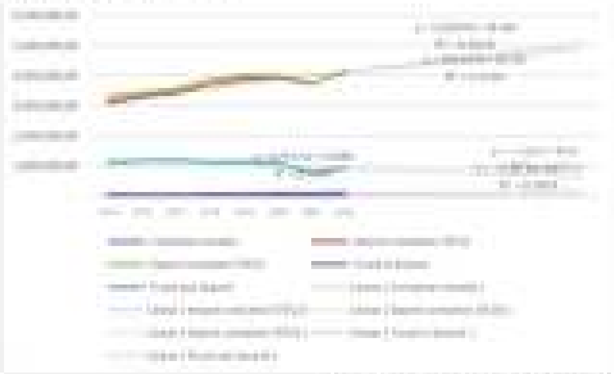
Fig 8 Carbon pricing

As of January 1, 2016, the Commission's tax structure and the structure for the automobile excise tax were both approved on December 18, 2012, and they are as follows: 1. To identify luxury, taxes should be calculated based on engine size. 2.Determining the tax rate for vehicles that promote energy efficiency and renewable sources. 3. Select tax rates to promote competition. 2019 saw the publication of the announcement of the pickup, green vehicle, and product champions as well as the rules and regulations for the race. The tax collection table lends credence to the idea that an empty car is unaffected by the actual loading conditions, which can result in significant CO_2 emissions depending on the payload.

IV. RESULTS

Analysis of container volumes based on on-shore and off-shore activities started in 2015 based on the forecast, with 3.1 million and 3.2 million containers produced annually, and 4.2 million containers produced annually in 2021. Assuming that there are 10 million containers coming in and going out in 2030, the results show that the curve is rising for exports of 3.2 million containers per year, which are forecast based on the data above. Using this information and a container ship to import and export containers, the carbon emissions will be assessed. A second forecast covering the period from 2015 to 2021 and a forecast of the box in and out for 2030 were made after the initial forecast, which was created between 2015 and 2019, was used in 2020 observations to evaluate its accuracy. To determine how much CO_2 is emitted during a container ship voyage, start counting when the ship enters the anchorage or passes the entrance buoy and stop counting until the container leaves the port, with regard to exports getting underway as soon as the container pulled up to the port. This was done using a program that is linear in the future classification of

ships. The CO_2 emission formula is computed for each TEU container from 2015 to 2021. It is evident that the number of containers tends to increase from 2015 to 3.4 million containers until 2030, when it is predicted that there will be 5.7 million containers.



(Forecast Container in 2030: [illegible])

Fig 9 Forecast Container in 2030

Consideration should be given to how CO_2 emissions originated with ships and entered the city's loading and unloading port during the already-conducted activities in the port. To unload the van, a truck was heading that way. The process is finished when container trucks arrive at the port, board the boat, and depart. In this case study, the 214,286-gross tonnage of the Manila Maersk ship is utilized. The CO_2 emissions from loading into the Lam Chabang port average 1,800 TEU. Emissions of CO2 from cargo terminal operations used as vehicles in this investigation are ships and trucks. The ship made its approach from the entrance buoy, bring the ship to the port's entrance, dock, and then depart from the port for the entrance buoy. The machines used are the main engine, generators , and a boiler. Containers are lifted by a gantry crane at the port. There are two categories of trucks: those are used to import products (getting into with empty vehicles and exiting with heavy trucks) and those are used to export goods. (Getting into with the heavy truck, getting out of with the empty one.)as shown in Table 5.

TABLE 5 SUMMARY CO2 EMISSION IN ONE VOYAGE CARGO OPERATION

Activity	Import TEU/Voy	Export TEU/Voy	Hrs	Sea CO_2e Kg	Land CO_2e Kg	Total CO_2e Kg
Main engine inbound			1	15,557		15,557
Main engine outbound			1	15,557		15,557
Generator x 2 in-out			2	1,650		1,650
Generator x 2 in-out			76	40,000		40,000
Boiler			2	8,000		8,000
Gantry crane*Bolt			36	-	21,992	21,992
Truck import 8.5 km**						
Truck in (Full)	600				1,400	1,400
Truck out (Empty)		600			1,069	1,069
Truck export 8.5 km**						
Truck in (Empty)		1,200			2,138	2,138
Truck out (Full)	1,200				2,802	2,802
Total						105,910

(*Gantry crane capacity [illegible] Import and Export [illegible])

**Truck [illegible]

Table 5 provides information on the CO_2 emissions produced by a single ship voyage. Based on these figures and the number of containers that were unloaded during this trip, the CO_2 emissions were estimated to be 105,910 Kg/1,800 TEU. 1,800 containers have been unloaded throughout this trip (including 600 inbound containers and 1,200 outbound containers). To estimate CO_2 emissions and tax revenue, the Marine Department's data in a single window system converts CO_2 emissions per TEU container to 58.84 kg per cabinet. It is shown in Fig 6 based on Japan's \$2.00/t CO_2e carbon tax collection.

TABLE 6 REVENUE FROM CARBON EMISSION TAX

Year	Container TEU (forecast)	CO_2 emission (Tons CO_2e)	Revenue (approx) USD
2022	[illegible]	[illegible]	[illegible]
2023	[illegible]	[illegible]	[illegible]
2024	[illegible]	[illegible]	[illegible]
2025	[illegible]	[illegible]	[illegible]
2026	[illegible]	[illegible]	[illegible]
2027	[illegible]	[illegible]	[illegible]
2028	[illegible]	[illegible]	[illegible]
2029	[illegible]	[illegible]	[illegible]
2030	[illegible]	[illegible]	[illegible]

Table 6, it can be seen that if a carbon emission tax is applied, the government can collect an average income of 1,088,725 USD/year.

V. CONCLUSION

This paper presents the prediction and assessment of CO_2 emissions per TEU in all activities of cargo import-export both onshore and offshore using a case study. The MANILA MAERSK cargo ship, with a size of 214,286 gross tons, is loaded and unloaded at Lam Chabang Port, an average of 1,800 TEU per ship. The CO_2 emission value is 58.84 kg CO_2e per TEU. The government may have to plan on collecting taxes, which means future income can be collected from CO_2 emissions. In many countries, CO_2 emissions are estimated based on fuel consumption, but in Thailand it is considered by engine size. However, in both cases, the product's weight is not included. As a result, the weight of the shipment should be used to determine the CO_2 emissions tax because the fuel consumption rate is not the same. If the government implements the carbon emission tax scale, it can collect an average income of 1,088,725 USD annually (based on Japan's carbon tax collection of \$2.00/t CO_2e). If the government imposes a tax on carbon emissions, it might bring in an average of \$1,088,725 USD (based on Japan's carbon tax collection rate of \$2.00/t CO_2e). These proceeds are used to formulate environmental policies, such as the policy to assist in using alternative energy, the approaches to support electric vehicle use, etc. In addition, entrepreneurs and businesses must realize the adoption of energy-saving and environmentally friendly technology.

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