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The Carbon Emissions Assessment from Road Transport with Topography Varying and Consideration of Health Safety Effect

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Abstract. In current business operation, apart from the products we also have to consider the logistics system which is regarded as the heart of the operation. So that, the costs of logistics are the core of the production process and goods distribution. In Thailand, the transportation of goods in the logistics system uses road transport most because of its physical features. Rivers are not connected, and the infrastructure of rail transport throughout the country is not linked yet. As a result, road transport is most popular because it can deliver the goods door-to-door. However, the result of this kind of transport is air pollution. Most of air pollution emitted from combustion is carbon dioxide, which causes the greenhouse effect and has a long-term impact on the health of the people in the district. Research results found that in the traffic-congested area, the steep area and the densely-inhabited area, the impact on health is high (impact level 4). These areas include Bangkok, Chiang Mai, Khonkaen, Nakhon Ratchasima, Chonburi, Rayong and Songkhla. The study discovered that these areas released a high amount of carbon dioxide. In the abbreviated period of 2-3 years, people may not suffer any health impact or it cannot be clearly seen. This can be a disease that is not harmful and does not affect other parts of the body except the respiratory system. Nevertheless, in the long run, inhaling a large amount of carbon dioxide will affect the nervous and circulatory systems, consequently this may lead to the brain problem caused by air pollution.

Introduction

Talking about transportation, most of the people who work in the transportation and logistics system will think about the calculation of costs or seek for the highest profits, but they may overlook the environmental impact that will follow. At present, the government began to place importance on the impact of road transport on the environment in order to prevent long-term problems and impacts on the local people such as the nervous system problem, the respiratory system problem and the circulatory system problem. They studied the number of the journey of private cars and the journey for delivering goods via road transport and calculated the density of the traffic. Then, they used the data from the fieldwork to estimate the amount of carbon dioxide emitted from the combustion of the engines. The estimation was summarized in the form of the levels that affect the people who live in those areas. The conclusion of this research can be further developed for the government to set a policy that can be adjusted for goods transportation or giving assistance to the people who suffer the impact of goods delivery by road transport.

Literature Review

From the study of the academic article and research related to the emission of carbon dioxide from road transport of N. Wong Chawalitkul [1] and research related to indicated the traffic volume and traffic conditions of W. Rattanawong [2], the estimation of carbon dioxide is divided into three models: Tier 1, using the standard emission factor of each fuel oil; Tier 2, setting the emission factor of their own fuel oil; and Tier 3, used in this research, is the estimation of the carbon emission according to the ASIF model. The ASIF sets 4 scores for calculation as follows: A-Activity, S-Structure, I-Intensity and F-Factor as displayed in Fig 1.

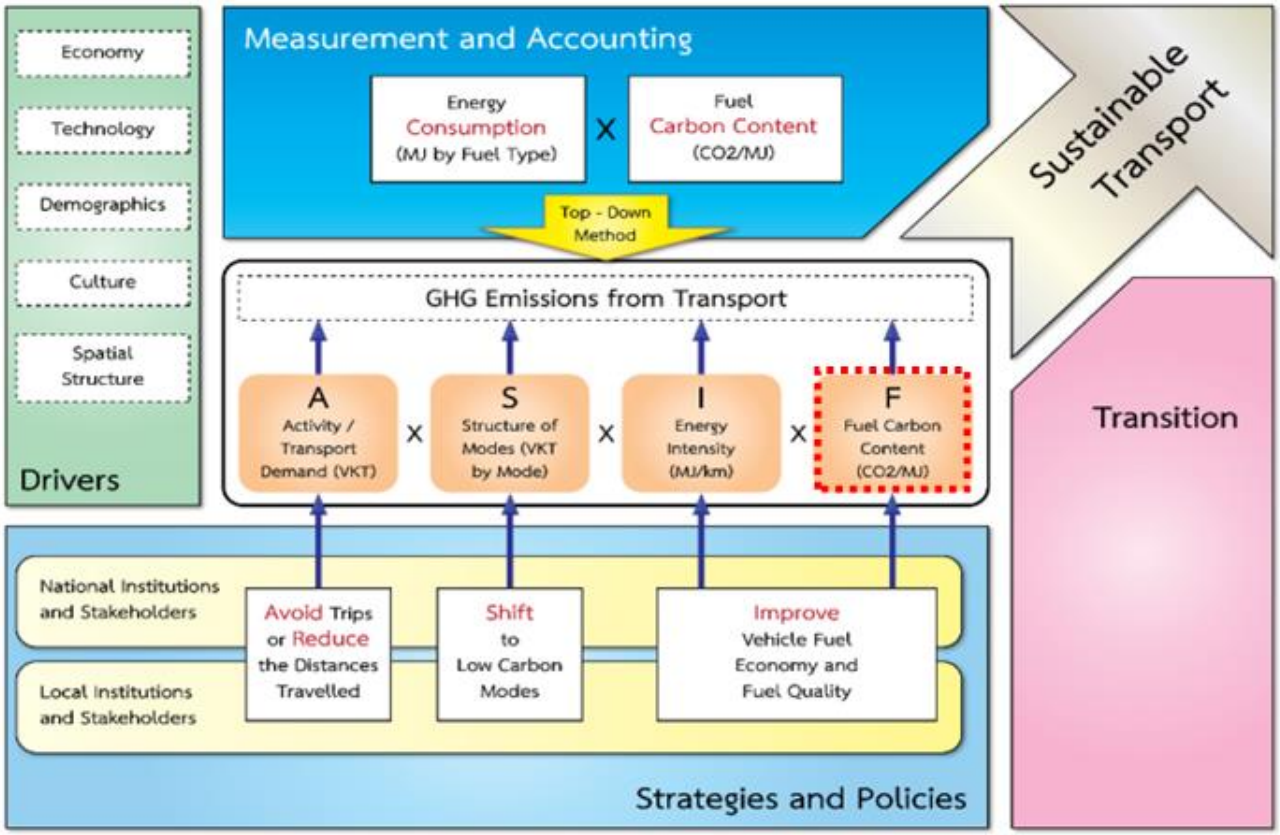

Fig. 1. Calculation of carbon emissions in the ASIF model
Intergovernmental Panel on Climate Change, 2016

When we estimate carbon emissions from road transport, the researcher further studied the impact on the health of the people inhabiting in those areas. According to the article of C L Townsend [3] and DG Penney [4], in each breath of 5-8 liters, carbon dioxide binds hemoglobin in the red blood cell more vigorously than oxygen. Cellular hypoxia from CO toxicity is caused by impedance of oxygen delivery. CO reversibly binds hemoglobin, resulting in relative functional anemia. Because it binds hemoglobin 230-270 times more avidly than oxygen, even small concentrations can result in significant levels of carboxyhemoglobin (HbCO). An ambient CO level of 100 ppm produces an HbCO of 16% at equilibration, which is enough to produce clinical symptoms. The level of 180 ppm of CO in blood will affect other systems and equally cause depression, anxiety, headache, and nausea.

Methodology

This research began with the fieldwork to study and collect data on the main roads of the country such as the Asia Highway and the main roads of each region. Traffic data were divided into various kinds of vehicles such as motor cycle, sedan, four-wheel van/ pick up, public bus, six-wheel truck, 10-wheel truck, 18-wheel trailer and 22-wheel trailer. Then, we used all kinds of vehicles for the calculation of PCU (Passenger Car Unit is a metric used in Transportation Engineering, to assess traffic-flow rate on a highway. After converting them into PCU, the density of each area was calculated to set the road condition factors (RC). Then the RC will be further used for calculating the amount of CO emissions. The collected data of all kinds of vehicles are calculated to find out the CO emissions of each kind of vehicle by using the factors of CO emissions of EPPO (Energy Policy and Planning Office) Ministry of Energy, Thailand. The result of the estimation of CO emissions will be calculated to gain the ratio of the emissions to the area space and the number of the population in order to calculate the level of risk of each area. The population's rate of respiration is set at 7 liters per breath (normally we consume 5-8 liters per breath). After having the conclusion, the data were displayed in the form of Carbon Emissions Map.

Research Framework

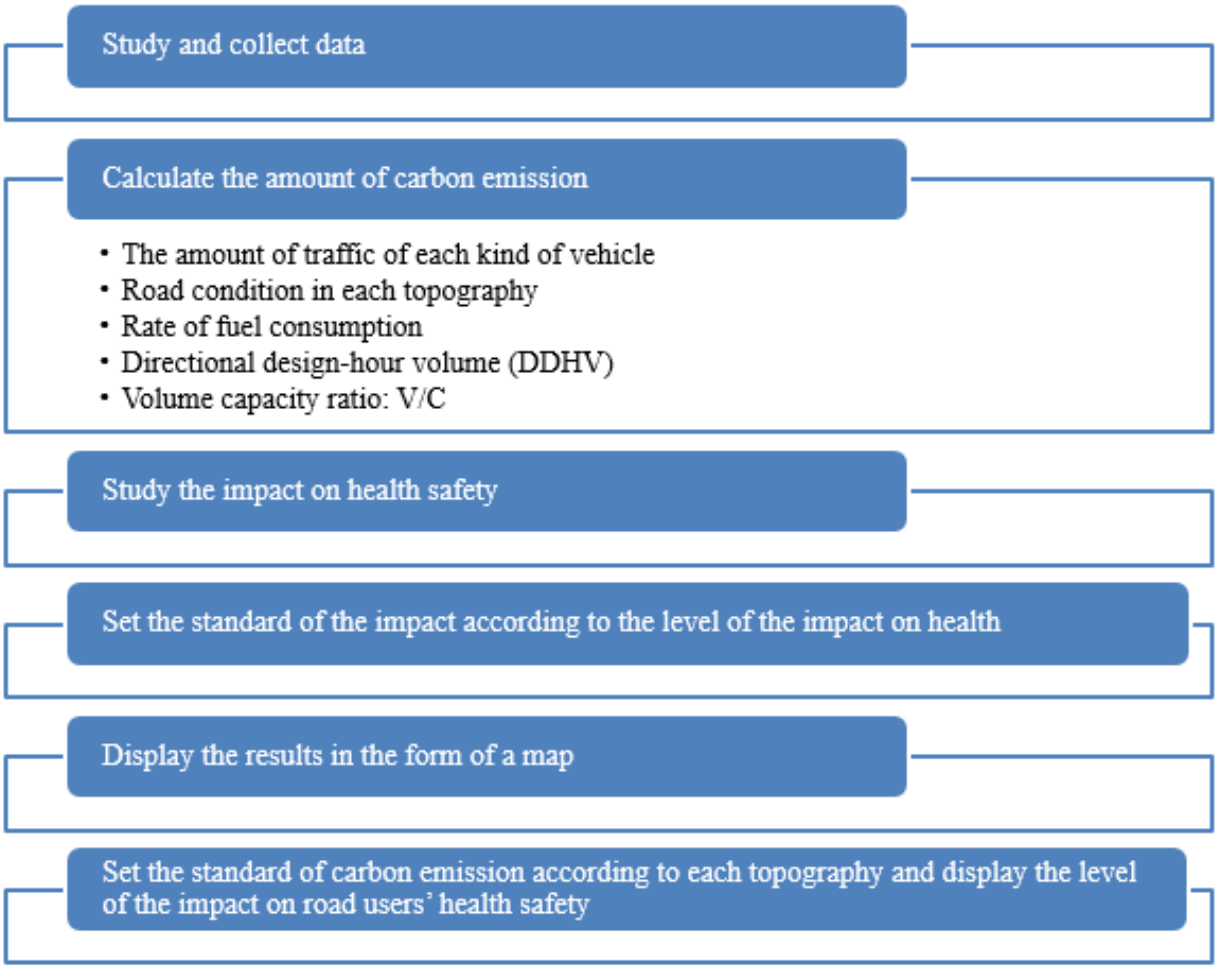

Fig. 2. Research Framework

Equation

Total Emissions = Transport Demand (Passenger KM) X Energy Intensity [Liter per KM] X CO2 Intensity [CO2 per KM]

$$Em_{j,k}(t) = \sum_{l}\sum_{m} FC_{k,l,m}(t)\left[\sum_{n} EF_{j,k,l,m,n}\, R_{k,l,m,n}(t)\right]$$

Where

j,k,l,m,n: Subscripts representing vehicle type, volume, sector, distance, fuel type and fuel/technology combination;

Em(t): Emissions of vehicle type j from Volume k;

FC: Fuel consumption (km/liter)

EF: Emission factor specific to each fuel/technology, including the effects of post combustion controls;

R: Road condition factor specific to angle of road and Volume Capacity Ratio

Result

Survey Results and Data Collection classified by road type, vehicle type and vehicle volume used on the road. When data from the survey and collected data as example. Therefore, the obtained data to calculate the carbon dioxide content. When the carbon dioxide is released into the street area. It then leads to the average value that residents in that area receive carbon dioxide. Calculated from the amount of carbon dioxide per population. The experiment was based on an average of 7 liters per breath (Normal breathing is around 5-8 liters).

ROAD_NO	ROAD_NAME	No. of Traffic lan	Province	KM1	Road length (KM)	VEH1_T	VEH2_T	VEH3_T	VEH4_T	VEH5_T	VEH6_T	VEH7_T	VEH8_T	VEH9_T	VEH10_T	VEH11_T	VEH12_T	VEH_T	CAP_RD	SPEED	PEAK_HV	VC_RATIO
11	โชยสถาน - Chiangmai	4	Chiangmai	551+500	13.389	7	2,065	18,885	3,575	543	669	1,421	32,250	2,136	3,555	2,615	375	68,094	8400	90	4200	0.50
11	อุโมงค์ -โชยสถาน	2	Chiangmai	543+850	9.463	37	3,808	16,261	6,829	829	1,421	2,070	54,228	8,658	6,270	3,505	2,105	106,021	3800	70	6363	1.67
4	ทังลา - จุดผ่านแดนถาวรสะ	4	Songkhla	1300+84	12.759	10	1,077	4,798	3,219	211	132	191	2,085	928	815	668	2,370	16,503	8400	90	1110	0.13
4	ทังลา - จุดผ่านแดนถาวรสะ	6	Songkhla	1280+04	21.845	9	1,504	5,828	1,540	282	513	260	18,310	1,029	1,175	4,308	383	35,139	13200	100	2257	0.17
2	มวกเหล็ก - บ่อทอง	6	Nakhon Ratchasim	45+600	22.178	2	305	10,573	5,433	1,472	974	2,660	42,403	6,462	9,833	8,758	7,825	96,698	13200	100	5837	0.44
2	บ้านไผ่ - ทางพระ	4	Khonkaen	310+578	30.103	3	424	6,535	6,784	378	171	609	2,360	2,459	3,125	4,600	5,813	33,261	8400	90	2143	0.26
12	ห้วยยำมะคาว - ขุมแฟ	8	Khonkaen	469+996	12.647	3	1,256	5,749	1,198	156	215	333	23,806	1,539	1,130	2,560	1,083	39,027	17600	100	2490	0.14
12	ขุมแฟ - แยกไปภูเวียง	4	Khonkaen	472+549	33.570	6	1,145	3,843	504	142	197	200	24,488	1,250	1,085	2,053	1,053	35,964	8400	90	2306	0.27
12	แยกไปภูเวียง - บ้านเก่ง	4	Khonkaen	508+049	18.837	16	1,256	4,522	714	77	66	383	23,388	1,214	735	1,530	988	34,888	8400	90	2242	0.27
12	บ้านเก่ง - Khonkaen	8	Khonkaen	545+249	19.997	93	4,713	22,267	14,352	3,035	4,299	4,205	48,915	4,981	6,133	5,035	3,363	121,390	17600	100	7226	0.41
24	สี่แยกโชคชัย - หนองบัน	4	Nakhon Ratchasim	70+097	24.550	364	1,218	6,675	7,678	2,070	3,269	2,865	5,956	5,563	6,188	5,383	5,368	52,595	8400	90	3295	0.39
2	โรโลกสูง - โคกกรวด	8	Nakhon Ratchasim	117+262	14.875	1	325	8,011	3,478	668	384	1,814	26,792	3,249	3,215	3,113	3,955	55,003	17600	100	3437	0.20
2	มวกเหล็ก - บ่อทอง	6	Nakhon Ratchasim	58+015	17.116	5	228	5,921	5,254	531	564	1,875	29,495	3,616	6,138	5,793	4,043	63,461	13200	100	3931	0.30
24	สี่แยกปักธงชัย - สี่แยกโชค	4	Nakhon Ratchasim	50+000	14.199	51	668	5,863	4,604	605	633	780	11,078	3,373	3,550	3,003	3,310	37,517	8400	90	2400	0.29
23	บ้านไผ่ - ไทศาล	4	Khonkaen	5+185	16.487	20	864	2,971	1,474	434	266	539	11,764	2,392	1,628	1,220	1,245	24,816	8400	90	1628	0.19
12	Khonkaen - พรหมนิมิตร	4	Khonkaen	562+054	31.264	3	2,068	4,759	4,686	262	221	1,056	16,376	813	1,245	820	760	33,068	8400	90	2132	0.25
2	หินลาด - โนนสะอาด	4	Khonkaen	374+669	18.393	173	618	4,936	4,576	702	987	1,005	13,929	3,921	5,093	5,308	5,078	46,324	8400	90	2925	0.35
2	หินลาด - โนนสะอาด	4	Khonkaen	365+007	9.410	35	625	9,446	6,755	859	875	2,258	10,981	5,267	6,475	4,805	5,043	53,422	8400	90	3344	0.40
12	ห้วยยำมะคาว - ขุมแฟ	2	Khonkaen	436+385	7.891	9	356	886	2,102	22	41	95	2,554	714	393	1,453	420	9,043	3800	70	631	0.17
2	ตอนหวาย - บ้านวัด	4	Nakhon Ratchasim	204+357	18.591	3	197	10,084	3,187	39	119	818	25,811	2,854	3,055	2,075	5,098	53,339	8400	90	3339	0.40
2	ตอนหวาย - บ้านวัด	4	Nakhon Ratchasim	204+357	11.745	3	197	10,084	3,187	39	119	818	25,811	2,854	3,055	2,075	5,098	53,339	8400	90	3339	0.40
12	ห้วยยำมะคาว - ขุมแฟ	8	Khonkaen	469+996	22.690	3	1,256	5,749	1,198	156	215	333	23,806	1,539	1,130	2,560	1,083	39,027	17600	100	2490	0.14
2	Khonkaen - หินลาด	0	Khonkaen	344+331	23.259	97	5,728	27,701	13,690	2,607	3,543	4,271	48,672	5,265	4,675	3,200	2,100	121,549	3800	70	7235	1.90

Fig. 3. Data Collection

The results of the research found that in areas with heavy traffic and with a high slope, there is a lot of carbon dioxide emissions. However, this may have less health impact if the area in that area is less populated. As shown in Fig. 4. Demonstrate the level of health impact of the population living on

the transport route. (Based on the calculation of carbon dioxide emissions, Carbon level 1 measured below 30ppm or 30 mg/m3, Carbon level 2 between 31-60ppm or 60 mg/m3, Carbon level 3 between 61-90ppm or 90 mg/m3, and Carbon level 4 measured over 91 ppm or over 90 mg/m3)

Fig. 4. THAILAND CARBON MAP

Conclusion

From the research results and the data collection it was found that the traffic- congested area and the steep area are the areas that emit a lot of pollution. However, the impact on the health of the people living in the precipitous area is less than the impact on those who live in the traffic-congested area. The reason for this that most steep areas are in provinces with a vast open space with less population density, so nature effectively absorbs carbon dioxide. When we consider the traffic-congested areas, most of them are community areas and economic zones, so the inhabitants are affected by the emission of carbon dioxide from road transport. Superficially, we will not see the impact of the pollution because

we think that we inhale the smoke only for a moment and it will soon disappear, but we cannot move from the present habitation to another, so we have to endure this living condition.

Therefore, if we want to solve air pollution in the area that risks the emission of toxic carbon dioxide, the government and the private sector must cooperate in solving the problems as follows:

Government

- Should have a policy on protecting and developing a plan against the pollution from the delivery of goods by road transport
- Should assist in healing the inhabitants of the area with a high amount of carbon dioxide
- Should charge more tax on trucks that go through the areas that have a high amount of carbon dioxide so that truck users will use other routes that charge lower tax (Carbon Tax for Road Transport)
- Should especially reduce tax for the agencies that help to lessen the emission of carbon dioxide in transportation
- Should issue a law to help the people who suffer the long-term impact to prevent air pollution
- Should provide special routes that can help to reduce the traffic density and avoid the precipitous areas

Private Sector

- Should improve transport vehicles to reduce carbon emissions
- Should adjust transport routes to avoid traffic-congested routes and precipitous areas
- Should set the back-hauling system to lessen the amount of carbon emissions
- Should use the reduction of carbon emissions for the publicity of Green Logistics in order to create a good image of the organization and stimulate other entrepreneurs to make a development for carbon emissions reduction too.

Health effects of medical advice: The Health and Safety Executive recommend a limit of 30 ppm, which can cause COHb levels to rise above 2.5% in less than one hour.

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