Developing the City-Level Climate Change Master Plan: The Case of Energy Sector in Bangkok

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Abstract. This study focuses in the developing energy sector plan of city-level climate change master plan in Bangkok, the capital city of Thailand. The energy consumption, which consists of electricity and fossil fuels, are investigated and forecasted to be Business-as-Usual (BaU) scenario covering year 2013 to 2023 by using trend analysis. The Greenhouse Gas (GHG) emission mitigation scenario was then analyzed by applying the energy reduction from the national energy efficiency development plan as well as the own reduction activities by Bangkok Metropolitan Administration (BMA). We can conclude that if the national energy efficiency plan can fully implemented, the GHG reduction potential of the city from energy sector would be at around 18% from BAU in 2023 from all energy conservation and renewable energy measures.

1 Introduction

Climate change is one of the largest challenges to the current and future development of human society. The Intergovernmental Panel on Climate Change (IPCC) issued its 5th Assessment Report [1] and warned that warming of the climate system is unequivocal, and it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century. Hence, the long-term climate change policies and plans which focus mainly in mega-city level are very important to each country due to the very high impact to overall GHG emission of the country.

The World Bank Study[2] pointed out that Bangkok Metropolitan Region (consists of Bangkok, Nonthaburi province, Samut Prakarn province, and Pathum Thani province) might face a serious challenge by climate-induced large scale flooding within the next 50 years and urged actions to increase the readiness to cope with such extreme events [3], [4]. Bangkok area was hit by a large scale flooding in 2011 with huge economics and social loss were recorded.

BMA also implemented the Bangkok Action Plan on Global Warming Mitigation 2007-2012 [5], aiming at the GHG reduction of 15% by undertaking five initiatives as follows: (i) expansion of mass transit and improvement of traffic system, (ii) promotion of the use of renewable energy, (iii) improvement of building electricity consumption efficiency, (iv) improvement of solid waste management and wastewater treatment efficiency, and (v) expansion of park areas. After ending of the plan on 2012, BMA policymakers had efforts to develop the next ten-year climate change master plan covering 2013 to 2023, by related sectors. This new master plan would support to the national climate change policy which Thailand will put her efforts to reduce the GHG in the range of 7 to 20% below the BaU in energy and transport sectors in 2020 through her NAMAs [6]-[8].

2 Scope of this study

2.1 Economic sector classification

BMA develops the Bangkok Master Plan on Climate Change 2013-2023, which is the city level long-term climate change plan. It consists of five main sectors; i.e. (i) energy efficiency and renewable energy, (ii) environmental sustainable transport, (iii) efficient solid waste management and wastewater treatment, (iv) green urban planning, and (v) adaptation planning.

This paper focuses only on the development of the energy sector, the biggest emission source of Bangkok, which includes the mitigation actions in energy efficiency and renewable development activities in Bangkok and exclude the energy consumption in transport and waste sectors. The energy sector in this study then consists of BMA governmental category and other civil category (industry, commercial, and residential parts). It should be noted here that there are only few activities of agriculture sector in Bangkok, hence we neglected the agricultural sector of this city in this study.

2.2 Greenhouse gas emission type

The energy sector covers only CO_2 emissions from energy utilization.

2.3 Level of this study

In this study, we focus mainly in the entire Bangkok area. This level (hereafter, Bkk) would focus all energy consumption and reduction potential which occur in Bangkok city, as a whole area and focus all government and non-government categories.

2.4 Energy sector data collection

We investigated and developed our energy data structure into two main types; (i) electricity, and (ii) thermal energy. All data are covering the year 2009-2012.

In Bangkok area, secondary data is main source of collecting energy data which is divided into the data from all sectors responsible to Bangkok entire area. All of collected data can be divided into 4 energy types which are electricity, oil, natural gas and coal as followings:

2.4.1 Electricity

Electricity consumption data in Bangkok is collected in secondary data from Metropolitan Electricity Authority directly requested data, not publish) in the year 2009-2012, covering residential, small and large general service, specific business service, government institute, non-profit organization, and temporary user and public lighting.

2.4.2 Fuel and petroleum products

Oil consumption data in Bangkok is collected in secondary data from Department of Energy Business (DOEB) [9]and classified in gasohol (all types), gasoline, diesel, fuel oil, LPG and other types of oil.

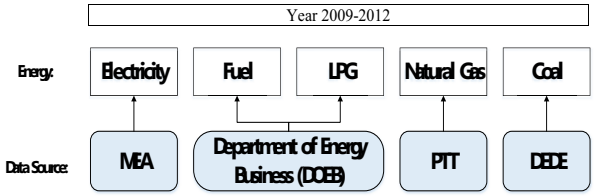
2.4.3 Natural gas

NG data is collected in secondary data from PTT Plc. (directly requested data, not published).

2.4.4 Coal

Coal data is collected from Department of Alternative Energy Development and Efficiency (DEDE).

Figure 1 illustrates the Structure and sources of energy data in this study.



Note: Fuel means oil based petroleum products

Figure 1. Structure and sources of energy data.

3 The BAU scenario

Like other climate change and energy plans, it is important to see GHG emission amount by comparing cases without mitigation actions (business-as-usual or BAU) and with actions. In other words, how much GHG is reduced in quantity is one crucial approach to assessing the degree of success in mitigation actions in an objective way. In this Master Plan, GHG emissions have also been quantified for the two emission scenarios, namely the case of BAU and the case with emission reduction by taking mitigation actions.

Figure 2 illustrates the concept of how to develop our BAU of Bangkok climate change model in this study.

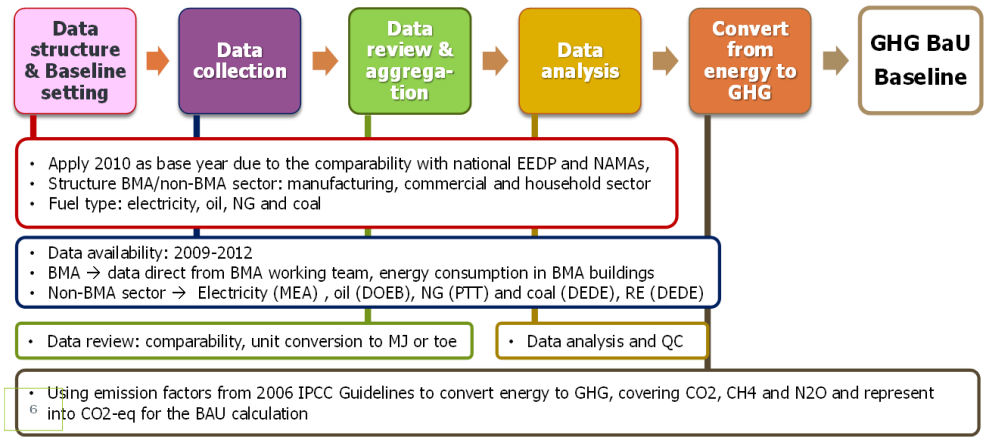


Figure 2. Flow of BAU greenhouse gas emission calculation.

By using the trend analysis from equation (1), the energy consumption in Bangkok area was then forecasted separately by each fuel type.

$$y_t = \sum_{i=1}^{t-1} \frac{y_i}{t-1} \qquad (1)$$

while y = forecast of y, in energy unit

t = time, annually

The results of the forecasted energy consumption in BAU, presented in Table 1, would then calculate into GHG value by using equation (2). Finally, BAU in Bangkok from the year 2013 to 2023 presents in Table 2.

Table 1. Energy consumption in BAU in Bangkok.

Type (Million MJ)	2013	2018	2023
Electricity	111,960.00	131,040.00	150,120.00
Thermal energy	85,057.11	91,665.53	102,699.59
Total	197,017.11	222,705.53	252,819.59

Table 2. GHG emission in BAU in Bangkok.

Energy type	BAU emissions (Million tCO_2-eq/year)							
	2009	2010	2011	2012	2013	2014	2015	2016
Electricity	15.76	16.70	16.76	17.83	18.55	19.19	19.82	20.45
Thermal	7.83	6.81	7.09	7.20	7.05	7.11	7.17	7.23
Total	23.59	23.58	23.86	25.02	25.60	26.29	26.99	27.68

Energy type	BAU emissions (Million tCO_2-eq/year)						
	2017	2018	2019	2020	2021	2022	2023
Electricity	21.08	21.71	22.35	22.98	23.61	24.24	24.88
Thermal	7.41	7.60	7.78	7.96	8.14	8.33	8.51
Total	28.49	29.31	30.12	30.94	31.75	32.57	33.38

$$\textit{Emissions estimate} = AD_t \times EF \quad (2)$$

while AD = Activity data, in energy unit per year

EF = Emission factor of each fuel type

In this study, we applied the emission factor from Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories [9] in each thermal energy in BAU.

4 The GHG mitigation scenario

In GHG mitigation scenario, we focus to the GHG reduction potential from the energy efficiency and renewable energy in Bangkok, exclude transport and waste sector, covering the year 2013-2023. All steps present in figure 3.

In this Master Plan, possible mitigation actions are divided into two major categories; (a) actions which BMA can implement by themselves, and (b) actions which are implemented by other stakeholders within Bangkok area. It should be noted that the GHG emission from activities by BMA itself is less than 1% of the total emission from whole Bangkok area. Therefore, it is important to consider the effect of mitigation actions of category (b). In addition, because it is difficult for BMA to monitor and control the mitigation actions of category (b), we have selected related national plans to calculate GHG mitigation potential in entire Bangkok area.

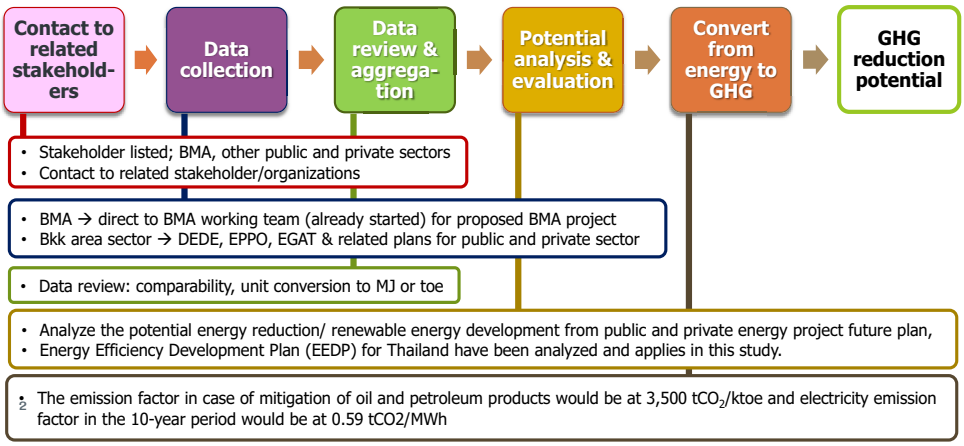


Figure 3. Flow of GHG emission mitigation scenario.

By using the national energy efficiency development plan (EEP) [10] and alternative energy development plan, we assume that the energy reduction potential in Bangkok, in percentage, is as same as the energy reduction of the country. This means that all calculation are based on the national plan but focus in city level.

In case of energy conservation, we can conclude the annual energy reduction which exclude transport and waste sector, in Bangkok as follows;

For electricity conservation, based on EEP

- Residential sector would be at 0.25% per year,
- Commercial building would be at 1.5% per year,
- Industry sector would be at 0.81 % per year

For thermal energy conservation, based on EEP

- Commercial building would be at 0.3% per year,
- Industry sector would be at 0.5 % per year

For emission actor, due to this study focus in the long-term period, hence the future energy consumption proportion would be very flexible. We then applied one universal figure of emission factor, average from various fuel types in Thai energy market. The emission factor in case of mitigation of oil and petroleum products would be at 3,500 tCO_2/ktoe and electricity emission factor in the 10-year period would be at 0.59 tCO_2/MWh (or 7,000 tCO_2/ktoe). The results in this scenario in Bangkok illustrate in figure 4 and table 3 and the amount of GHG mitigation in Bangkok presents in Table 4.

Table 3. Energy consumption in GHG mitigation scenario.

Type (Million MJ)	2013	2018	2023
Electricity	985.79	13,940.89	29,209.39
Thermal energy	106.93	5,869.96	15,869.22
Total	1,092.72	19,810.85	45,078.61

Table 4. GHG emission in GHG mitigation scenario.

Type (Thousand t-CO2eq)	2013	2018	2023
Electricity	152.17	2,236.24	4,692.47
Thermal energy	8.86	486.34	1,314.80
Total	161.02	2,722.58	6,007.27

Table 5. Selected countermeasures in GHG mitigation scenario of Bangkok master plan.

Sector	Measure		Possible mitigation actions	2013		2018		2023	
				Energy reduction (Million MJ)	GHG mitigation (Thousand tCO2-eq)	Energy reduction (Million MJ)	GHG mitigation (Thousand tCO2-eq)	Energy reduction (Million MJ)	GHG mitigation (Thousand tCO2-eq)
Residential	Promotion of energy saving house	a	Promotion of low-carbon/energy saving detached house (Publicity of cost benefit from the viewpoint of LCC, backup exhibition)	13.50	2.23	16.20	2.67	18.90	3.12
		b	Facility equipment introduction promotion of energy saving house (LED, energy saving air conditioning, etc.)						
	Promotion of energy saving repair work	a	Publicity of cost benefit by repair work for energy saving	9.00	1.49	10.80	1.79	12.60	2.09
		b	Promotion of repair work for energy saving (heat barrier film, renew air conditioning device, etc.)						
	Promotion of energy saving home appliances	a	Purchase promotion of energy saving home electric appliances (air conditioning, fridge, TV etc.)	9.00	1.49	10.80	1.79	12.60	2.09
	Promotion of energy saving action	a	Promote better understanding of air conditioner maintenance	27.00	4.47	32.40	5.37	37.80	6.26
	Others	a	Promote solar panel installation （subsidy system or mediating installable roof）	9.00	1.49	10.80	1.79	12.60	2.09
Commercial	Promotion of energy saving building	a	Incentive for constructing/repairing saving energy factory (tax reduction, subsidy, zero-interest finance etc.)	55.94	9.23	66.53	10.97	77.11	12.72
	Promotion of energy saving repair work for existing building	a	Conduct energy saving inspection of public buildings	55.94	9.23	66.53	10.97	77.11	12.72
		b	Promotion of ESCO business for existing buildings						
			(Educate ESCO business, advertisement promotion support, subsidy system for energy saving diagnostic)						
		c	Promotion of repair work for energy saving: insulation upgrade by double glazing, heat barrier film, renew air conditioning device (subsidy system etc.)						
		d	Publicity of cost benefit by Electricity Peak-Cut (automatic control facility of Electricity Peak-Cut, etc.)						
	Promotion of energy saving action	a	Promote saving energy activity (publicity of cost benefit etc)	167.83	27.68	199.58	32.92	231.34	38.16
		b	Raise preset cooling temperature at public buildings						
			Turn off lightings during lunch break						
		c	Thorough power saving setting on PC or OA equipment						
		d	Commendation for saving energy activity						
	Others	a	Promote solar panel installation （subsidy system or mediating installable roof）	167.83	27.68	199.58	32.92	224.99	37.11
Industry	Promotion of energy saving factory	a	Incentive for constructing/retrofitting saving energy factory (tax reduction, subsidy, etc.)	145.08	23.93	160.56	26.48	176.04	29.04
	Promotion of energy saving repair work for existing factory	a	Conduct energy saving inspection of public factories	145.08	23.93	160.56	26.48	176.04	29.04
		b	Promotion of repair work for energy saving (subsidy system etc.)						
		c	Publicity of cost benefit by Electricity Peak-Cut						
	Promotion of energy saving action	a	Promotion activity for factory's energy saving technique (for SMEs)	377.21	62.22	417.46	68.85	457.70	75.49
		b	Commendation for saving energy activity						
	Others	a	Promote Solar Energy （subsidy system or mediating installable roof）	33.18	2.75	430.63	35.68	1199.11	99.35
		b	Promote beneficial use of factory exhaust heat						

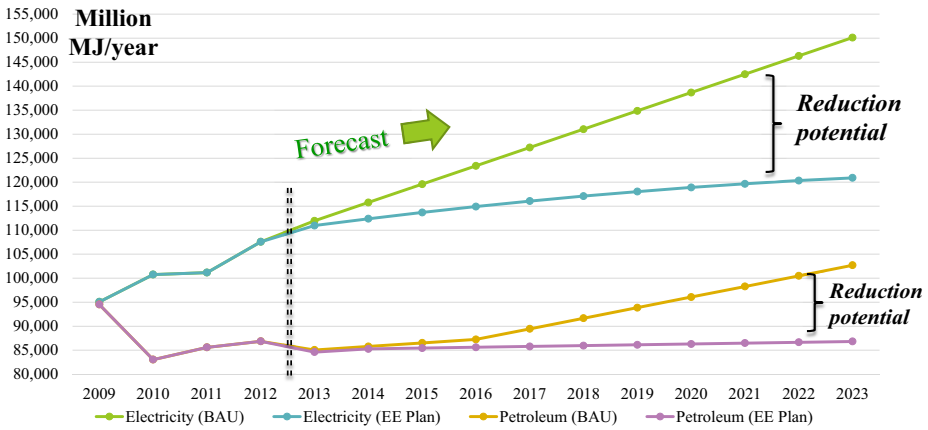


Figure 4. Flow of GHG emission mitigation scenario from 2009 to 2023.

From this scenario, we can conclude that if the EEP can fully implemented, it would reduce the energy by 17.83% while there is also potential of GHG emission reduction at around 18.00% from the BAU in the year 2023. However, it must be noticed that it is a potential but not the emission reduction target of the Master Plan.

Selected energy countermeasures including the GHG mitigation is presented in table 5. Most energy measures cover in three economic sectors while there is small potential of renewable energy in Bangkok except the solar roof top. Wind and biomass power plant are not easy to construct. On-ground solar farm is not economic-feasible because of the very expensive land. The energy conservation measures consist of the housekeeping, process improvement, major change equipment, and public awareness concept. The potential of energy conservation and renewable energy measures are adjusted from the national energy conservation potential.

5 Conclusions

This study focuses in the developing of city-level GHG mitigation master plan from energy sector in Bangkok. The energy consumption in all economic sectors except transport and waste sector are also investigated and forecasted to be BAU scenario covering year 2013 to 2023 by using trend analysis.

The GHG emission mitigation scenario was then analyzed by applying the energy reduction from the national energy efficiency plan. We can conclude that the energy reduction potential from energy sector would be at 17.83% while the potential of GHG emission reduction of the city from energy sector would be at around 18.0% from BAU in 2023 from all energy measures.

Acknowledgement

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