Initiative for Climate Action Transparency (ICAT):

Improving Thailand's MRV System for Climate Change Mitigation

Final Report on MRV for the Building Sector

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Initiative for Climate Action Transparency - ICAT -

Improving Thailand's MRV System for Climate Change Mitigation

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DISCLAIMER

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ABBREVIATIONS

ACMV	Air-Conditioning and Mechanical Ventilation
AEDP	Alternative Energy Development Plan
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BAU	Business-as-Usual
BEBR	Building Energy Benchmarking Report
BEC	Building Energy Code
BESS	Building Energy Submission System
BMA	Bangkok Metropolitan Administration
BREEF	Building Retrofit Energy Efficiency Financing
BTR	Biennial Transparency Report
BUR	Biennial Update Report
CBECS	Commercial Building Energy Consumption Survey
CEPA	Committee on Energy Policy Administration
CHP	Combined Heat and Power
ChP	Chiller Performance
CH4	Methane
COE	Crude Oil Equivalent
COP	Coefficient of Performance
DEDE	Department of Alternate Energy Development and Efficiency
DOE	Department of Energy
DOEB	Department of Energy Business
DPT	Department of Public Works and Town & Country Planning
EEM	Energy Efficiency Measure
EEP	Energy Efficiency Plan
EER	Energy Efficiency Ratio
EERS	Energy Efficiency Resource Standards
EGAT	Electricity Generating Authority of Thailand
EIA	Energy Information Administration
ENCON	Energy Conservation
EPA	Environmental Protection Agency
EPPO	Energy Policy and Planning Office
ERCETS	Emission Trading Scheme
EU	European Union
EUI	Energy Use Intensity
ft	Foot
FTI	The Federation of Thai Industries
GDP	Gross Domestic Product
GFA	Gross Floor Area
GGGI	Global Green Growth Institute
GHG	Greenhouse Gases
GJ	Gigajoule

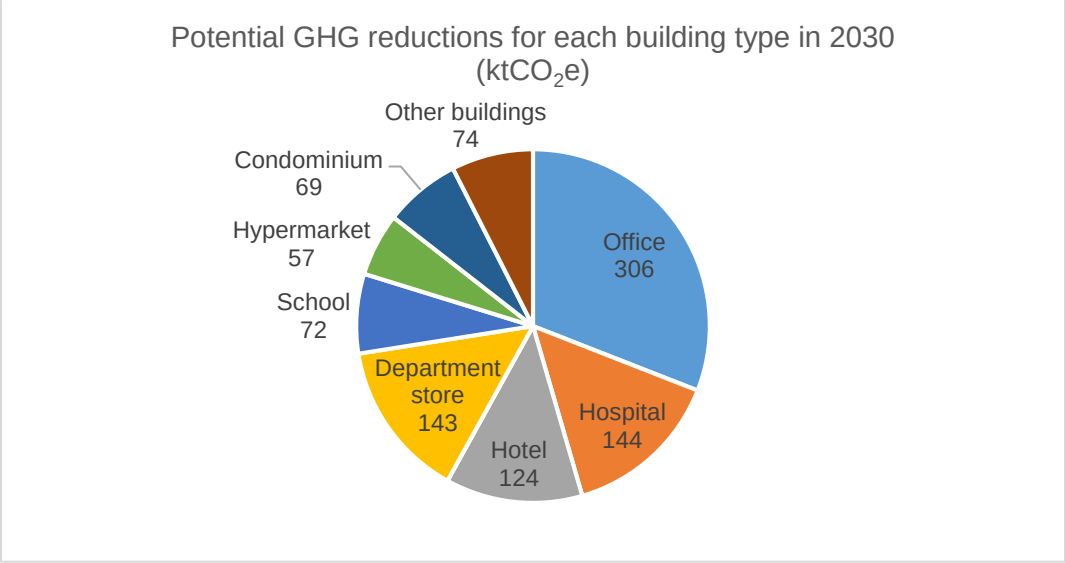
GMFM	Green Mark Facility Managers
GM-GFA	Green Mark Incentives Scheme for Gross Floor Area
GMIS-EB	Green Mark Incentives Scheme for Existing Buildings
GMIS-NB	Green Mark Incentives Scheme for New Buildings
GMIS-DP	Green Mark Incentives Scheme for Design Prototype
GMIS-EBP	Green Mark Incentives Scheme for Existing Building and Premises
GMM	Green Mark Managers
GMP	Green Mark Professionals
GPR	Gross Plot Ratio
GWh	Gigawatt hour
HFC	Hydrofluorocarbon
ICAT	Initiative for Climate Action Transparency
IEAT	Industrial Estate Authority of Thailand
INDC	Intended Nationally Determined Contribution
JPY	Japanese Yen
kBTU	kilo - British Thermal Units
kVA	kilovolt Ampere
kWh	kilowatt hour
LAO	Local Administration Organization
LDCs	Least Developed Countries
LP	Licensed Professional
LPD	Lighting Power Density
LULUCF	Land Use, Land-Use Change and Forestry
MEA	Metropolitan Electricity Authority
MER	Monthly Energy Review
MJ	Megajoule
MOT	Ministry of Transport
MRV	Measurement, Reporting and Verification
NAMA	Nationally Appropriate Mitigation Actions
NC	National Communication
NCCC	National Committee on Climate Change Policy
NEA	National Environment Agency
NEPC	National Energy Policy Council
NESDP	National Economic and Social Development Plan
NDC	Nationally Determined Contribution
OAE	Office of Agricultural Economics
OERC	Office of Energy Regulatory Commission
ONEP	Office of Natural Resources and Environmental Policy and Planning
OTP	Office of Transport and Traffic Policy and Planning
OTTV	Overall Thermal Transfer Value
PCD	Pollution Control Department
PDP	Power Development Plan
PE	Professional Mechanical Engineer
PEA	Provincial Electricity Authority

PFC	Perfluorocarbon
REC	Renewable Energy Certificate
RTS	Rapid Transit System
RTTV	Roof Thermal Transfer Value
SDG	Singaporean Dollar
SEC	Specific Energy Consumption
SF_6	Sulphur hexafluoride
SMF	Small and Medium Facility
tCO_2	Tons of Carbon dioxide
TGBI	Thai Green Building Institute
TGO	Thailand Greenhouse Gas Management Organization (Public Organization)
TREES	Thai's Rating of Energy and Environmental Sustainability
TMG	Tokyo Metropolitan Government
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar

EXECUTIVE SUMMARY

Regarding the GHG emission mitigation measures, Thailand has made significant efforts as a signatory Party under the United Nations Framework Convention on Climate Change (UNFCCC) according to its capabilities. It pledged its first Nationally Appropriate Mitigation Actions (NAMAs) to the UNFCCC on 29 December 2014. The NAMA proposed that Thailand has put the efforts, along with given international supports, to reduce GHG emission in the range of 7-20% below the business-as-usual (BAU) level particularly in the energy and transportation sector by 2020. In addition, Intended Nationally Determined Contributions (INDCs) and relevant information was submitted to UNFCCC on 1 October 2015 to restate that GHG emissions would be reduced by 20% (111 $MtCO_2e$) from BAU level by 2030, and up to 25% with international support. As of now, there is no common methodological framework to measure, report and verify the progress made through the GHG mitigation measures that suitable for all sectors and countries. Thus, this report is prepared to study the current situation/baseline of current measurement, reporting and verification (MRV) practice/gaps/barriers and opportunities for an effective MRV. Further the report provides recommendations to strengthen MRV in the building sector especially for office building, department store and hospital as they are the top three highest potential GHG reductions in NDC period.

As per the Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021-2030 (NDC Roadmap), building sector is classified as a sub-sector under the energy and transportation sector and it targets commercial and public buildings. It is expected that the GHG emission reductions through energy efficiency measures (EEMs) from these commercial and public buildings would contribute to around one million tCO_2. Its target of GHG reductions are divided into eight building types 1) Office 2) Hospital 3) Hotel 4) Department store 5) School 6) Hypermarket 7) Condominium and 8) Other buildings, with four measures for energy efficiency improvement 1) Lighting system 2) Air conditioning system 3) Office equipment and 4) Other systems.



Potential GHG reductions for each building type in 2030

Referring to the above potential GHG reductions, the highest potential GHG reductions is in office buildings (306 $ktCO_2e$), followed by hospital (144 $ktCO_2e$) and department store (143 $ktCO_2e$) respectively. Total potential GHG reductions of these three building types are 593 $ktCO_2e$ or 59.3% of total potential GHG reductions in building sector.

The report observes that the NAMA does not indicate specific GHG mitigation measures for the building sector and there is no existing MRV in this sector. Based on the study, analysis and discussion with the stakeholders, the report proposes a MRV practice developed based on the current institutional arrangement and the existing reporting practice followed by the designated buildings in Thailand.

The recommendations are provided as below;

(1) At present, the designated buildings are mandated to submit an energy management report on an annual basis. This report contains almost data required for the GHG calculation, but it is not generally reported in term of GHG inventory or emission reduction data. It needs to be further calculated as the GHG inventory or emission reduction data. Thus, the GHG report is required to be developed on annual basis (calendar year) for the best MRV practice.
(2) Unlike the designated building, BEC and non-designated buildings have no process or reporting system for the report submission on an annual basis. Therefore, it is required to create a reporting system for the BEC building and non-designated buildings participating in the DEDE's promotion/mitigation measures to submit the report on annual basis until 2030 (end of NDC period).
(3) Quantification and monetization of (positive and negative) externalities over the building life cycle should be well-integrated into decision-making processes.
(4) Continuous monitoring and constant modification of performance and dynamics of building codes would allow implementation to catch up with the potential for efficiency improvements and co-benefits. This would also provide better feedback to the policymaking process, creating awareness, capacity building and training. For the designated building, there is a well-designed data collection and reporting system. In order to improve this existing practice to be an appropriate MRV for GHG emissions, the determination of quality indicator for the responsible organizations should be measurable as per institutional arrangement policy and design of domestic MRV system should be conformed to an existing practice.
(5) As per the BEC building measure in the Energy Efficiency Plan (EEP2015) that aims to reduce energy demand by 36% (1,166 ktoe) of the total energy demand in new buildings to achieve international green building standard such as Leadership in Energy and Environment Design (LEED) or Thai's Rating of Energy and Environmental Sustainability (TREEs) standards by Thai Green Building Institute (TGBI). If these plans could combine or link to GHG emission term, then it would be a clear understanding.
(6) The data of Label no.5[1] should be separately identified in the energy management report for avoiding on double counting issue.
(7) The recommendation on the GHG emission methodology is provided in Chapter 7.

[1] An energy efficiency labelling scheme

(8) Generally, the GHG emission inventory and the GHG emission mitigation measure are reported on annual basis. Since the GHG reporting format has not been created so far, therefore it should be created by all relevant agencies e.g. TGO, DEDE, ONEP and Energy Working Group. The GHG report could be reported via online submission for ease of convenience to the related agencies.

(9) Verification is the periodic independent review of reported data. It is the process of confirming the GHG inventory as well as the GHG emission mitigation actions achieved by the implemented measures. Thus, based on the domestic MRV system and institutional arrangement proposed in the second BUR, the GHG data should be verified by the Energy Working Group and the Climate Change Knowledge and Database Sub-Committee respectively. The verification guideline should be determined by all relevant agencies e.g. TGO, DEDE, ONEP and Energy Working Group as appropriate for the building sector.

1. INTRODUCTION

Thailand is located in Southeast Asia and covers an area of 513,115 km^2. The country is bordered on the north by Myanmar and Laos; on the east by Laos, Cambodia, and the Gulf of Thailand; on the south by Malaysia; and on the west by Myanmar and the Andaman Sea. The topographic relief of Thailand includes hills in the north and flatland in the central part of the country. The southern part of Thailand features a long peninsula between the western Andaman Sea and the eastern South China Sea. The country is divided into five parts: Northern, Northeastern, Central, Eastern, and Southern region. The population of Thailand was around 66.4 million based on the registration records in December 2018[2].

For the past decade, Thailand's total final energy consumption[3] has been steadily increasing at an average rate of 2.3% per year as illustrated in Figure 1-1. The transportation and industrial sectors consumed around three-quarters of the total final energy consumption. The average energy consumption transportation and industrial sector is 35.5% and 35.3% of the total final energy consumption respectively.

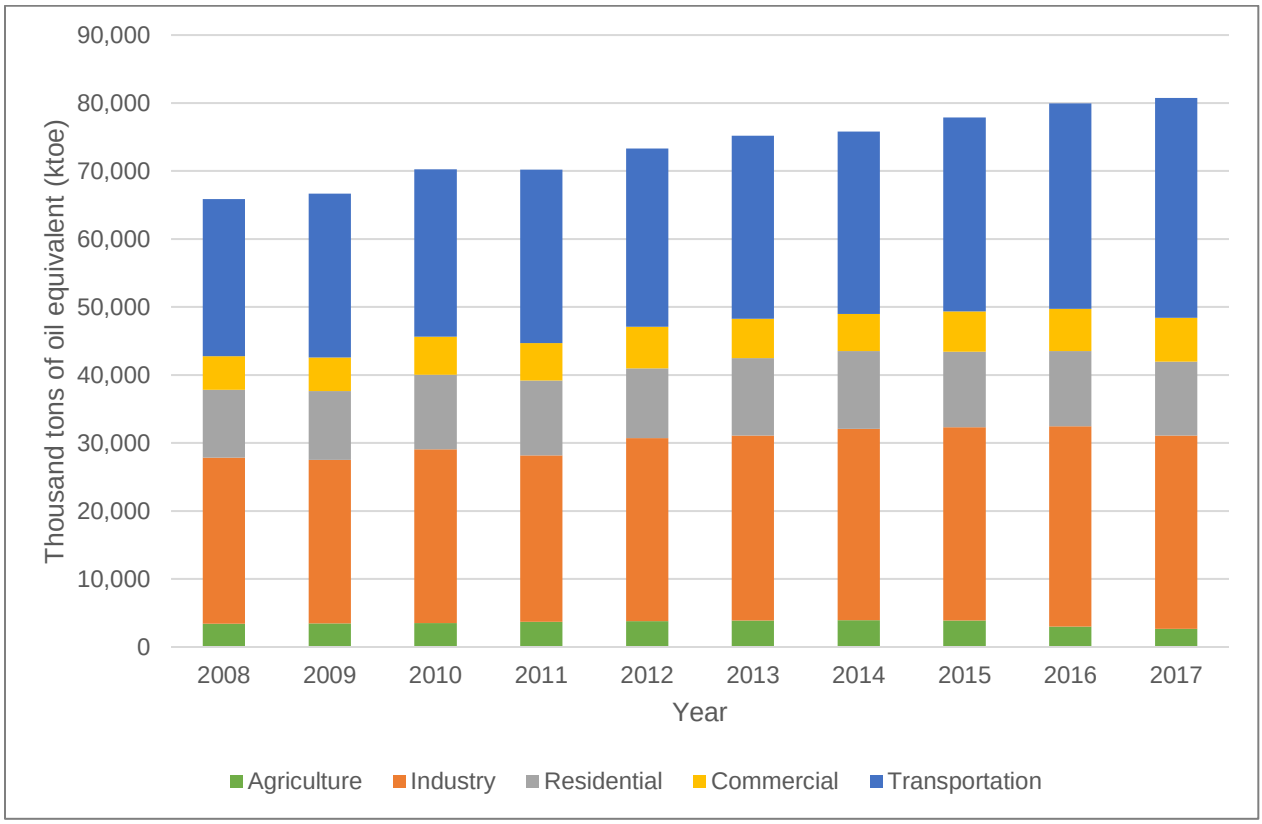


Figure 1- 1. Historic energy consumption trend in Thailand

As per the national greenhouse gases (GHG) inventory, during 2000–2013, the total emissions (excluding those from the Land use, land-use change, and forestry (LULUCF) sector) increased

[2] Department of Provincial Administration
[3] Department of Alternative Energy Development and Efficiency

from 226,086 $GgCO_2e$ in 2000 to 318,662 $GgCO_2e$ in 2013. The net removal of CO_2 increased from 11,995 $GgCO_2e$ in 2000 to 86,102 $GgCO_2e$ in 2013. Therefore, the net GHG emission increased from 214,091 $GgCO_2e$ in 2000 to 232,560 $GgCO_2e$ in 2013, with annual increase of 0.6%. With the inclusion of the LULUCF sector, the net emission in 2013 increased by 8.6% when compared with the net emission in 2000 (refer Figure 1-2). The major source of GHG emissions was the energy sector, which increased from 161,005 $GgCO_2e$ in 2000 to 236,936 $GgCO_2e$ in 2013, an increase of 47.2%.

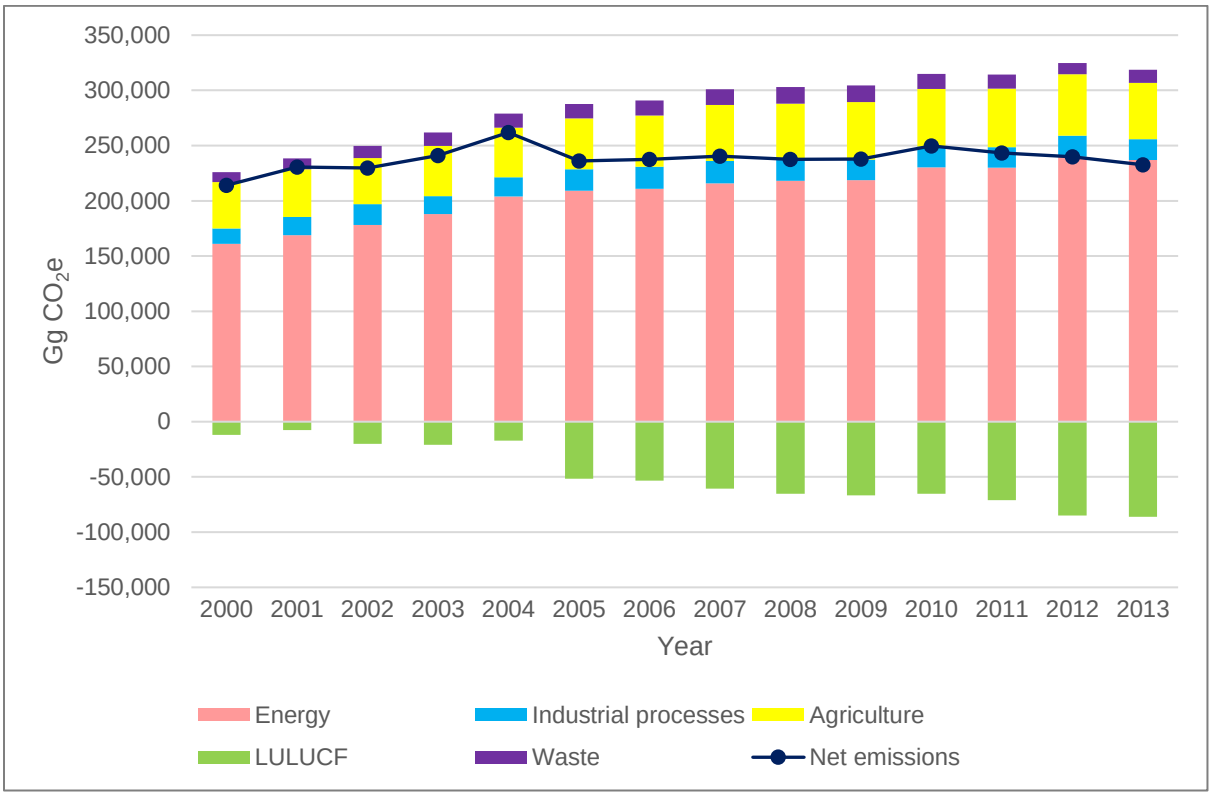


Figure 1- 2 Historic GHG emissions/removal[4]

Regarding the GHG emission reduction target, Thailand has made significant efforts as a signatory Party under the United Nations Framework Convention on Climate Change (UNFCCC) according to its capabilities. Thailand pledged its first Nationally Appropriate Mitigation Actions (NAMAs) to the UNFCCC on 29 December 2014. The NAMA proposed that Thailand has put the efforts, along with given international supports, to reduce GHG emission in the range of 7-20% below the business-as-usual (BAU) level particularly in the energy and transportation sector by 2020. In addition, Intended Nationally Determined Contributions (INDCs) and relevant information was submitted to UNFCCC on 1 October 2015 to restate that GHG emissions would be reduced by 20% (111 $MtCO_2e$) from BAU level by 2030 (refer Figure 1-3), and up to 25% with international support.

[4] Second Biennial Update Report of Thailand

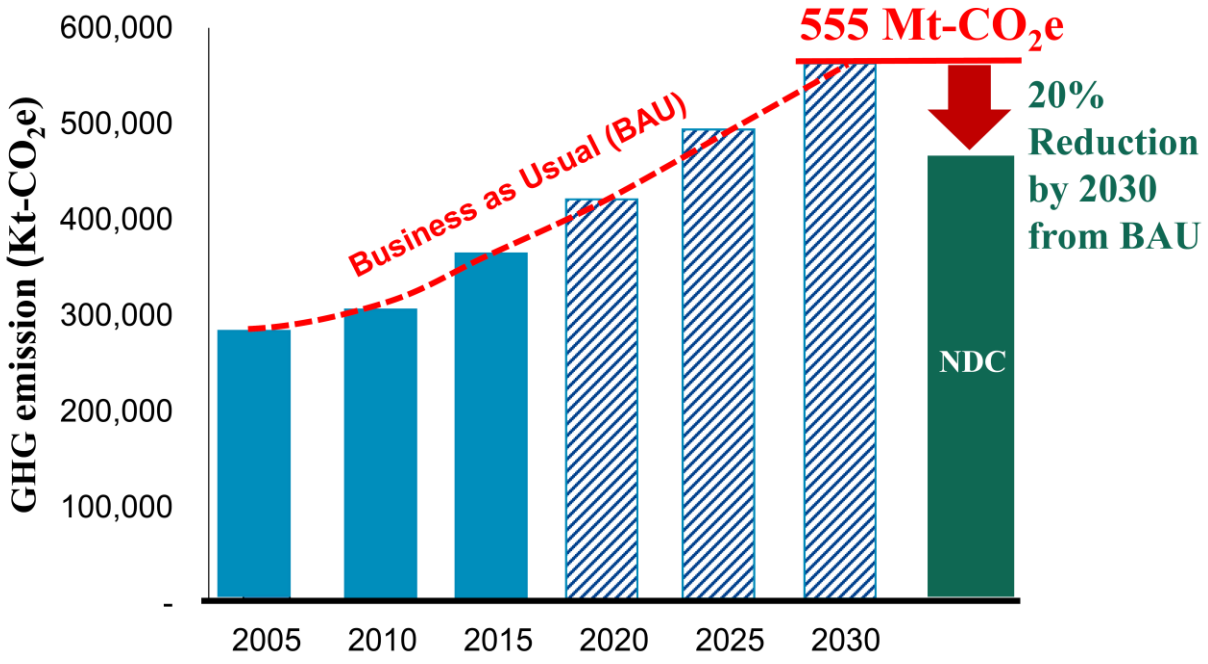


Figure 1- 3 Thailand's NDC Targets[5]

Since the submission of its NAMAs, several climate-change mitigation policies and measures have been put in place at the national level to fulfill Thailand's drive toward a resilient, low-carbon society, as stated in the 12th National Economic and Social Development Plan (NESDP), 2017-2021. The 12th NESDP supports Thailand's NAMAs and sustains efforts towards reduction of GHGs by 7–20 % in 2020. According to the Second Biennial Update Report of Thailand, the country had achieved GHG reductions of 40.14 $MtCO_2e$ thus meeting its NAMA target of 7% (24.9 $MtCO_2e$) reduction in GHG emissions over the BAU level by 2020.

For NDC[6], in order to meet its target (111 $MtCO_2e$ or 20% from BAU level by 2030), the Cabinet approved Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021-2030 on 23 May 2017. The roadmap is based on the relevant national plans already approved or in the pipeline for approval by the Cabinet. The total potential GHG reductions in this roadmap is 115.6 $MtCO_2e$ or 20.8% from the BAU level by 2030 which is conformed to the NDC's target. The roadmap considers five sectors according to Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories; 1) energy and transport, 2) industrial processes, 3) agriculture, 4) LULUCF, and 5) waste. The major mitigation measures in this roadmap are focused on the energy and transport, industrial processes and waste sectors, while agriculture and LULUCF sectors are in study process of potential GHG reductions. The potential GHG reductions in each sector and the summary information on Thailand's NDC mitigation measures are shown in Figure 1-4 and Table 1-1 respectively.

[5] Office of Natural Resources and Environmental Policy and Planning
[6] Nationally Determined Contribution (NDC) was used instead of Intended Nationally Determined Contributions (INDCs) after the Paris Agreement entered into force on 4 November 2016

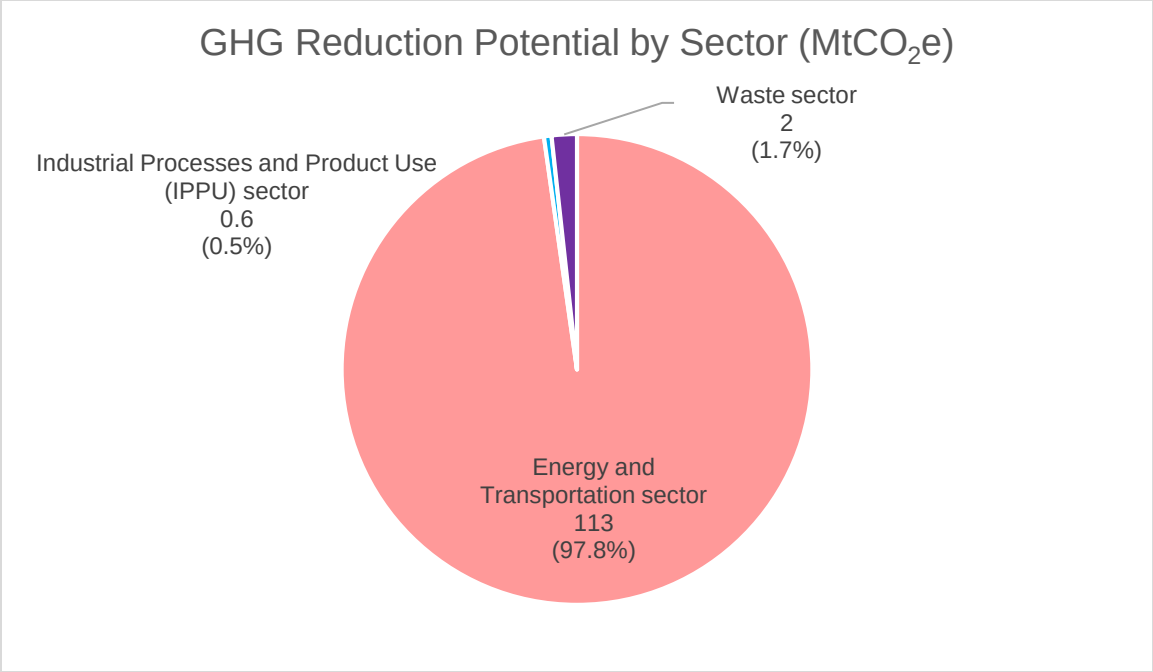


Figure 1- 4 GHG Reduction by Sector

Table 1- 1 Summary information on Thailand's NDC mitigation measures[7]

No.	Measure	Potential GHG reductions ($MtCO_2e$)	Target group
1	**Energy and Transportation (Total potential GHG reductions 113.0 $MtCO_2e$ or 20.4% from BAU level by 2030)**		
1.1	**Power generation**	**24**	
	1) Energy efficiency improvement	6	Power producers
	2) Substitution of renewable energy	18	
1.2	**Residential**	**4**	
	1) Energy efficiency improvement	4	Residential
	2) Substitution of renewable energy		
1.3	**Building**	**1**	
	1) Energy efficiency improvement	1	Building
1.4	**Industry**	**43**	
	1) Energy efficiency improvement	11	Private entrepreneur
	2) Substitution of renewable energy	32	
1.5	**Transportation**	**41**	
	1) Energy efficiency improvement	31	Producers/ travelers/ land, water, air transport system/ people

[7] Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021-2030

No.	Measure	Potential GHG reductions ($MtCO_2e$)	Target group
	2) Substitution of renewable energy	10	Car producers / users
2	**Industrial Processes and Product Use (IPPU) (Total potential GHG reductions 0.6 $MtCO_2e$ or 0.1% from BAU level by 2030)**		
2.1	**Process change**	**0.6**	
	1) Substitution of clinker substance	0.3	Cement factories/ construction materials
	2) Substitution of refrigerant substance	0.3	Refrigerant producers/ users
3	**Waste (Total potential GHG reductions 2.0 $MtCO_2e$ or 0.3% from BAU level by 2030)**		
3.1	**Waste**	**1.3**	
	1) Waste management	1.3	Households /communities
3.2	**Wastewater**	**0.7**	
	1) Methane recovery from industrial wastewater	0.7	Industrial factories
	2) Clean technology		Industrial factories
	3) Municipal wastewater management		Households /communities
	Total	**115.6**	

For the Measurement, Reporting and Verification (MRV) on GHG inventories and emission reductions according to the NAMAs Roadmap, Thailand has developed MRV system as follows:

- Measurement is carried out according to specific GHG emission reduction measures by responsible installations/sources (e.g., power plants and liquid fuel production plants);

- Reporting is carried out by responsible installations to corresponding authorities (e.g., Energy Regulatory Commission, Department of Energy Business, and Electricity Generating Authority of Thailand (EGAT); and

- Verification is undertaken by authorized agencies such as the Department of Alternative Energy Development and Efficiency (DEDE)

1.1. Project background

To pursue sustainable development and reduce national GHG emissions, Thailand is still lack effective tools and well-designed institutional arrangements to comprehensively assess the impacts of national climate policies and actions. There is no common methodological framework to measure, report and verify the progress made by a country through its GHG mitigation measures.

To respond to the above challenge, Initiative for Climate Action Transparency (ICAT), a global initiative assisting policy makers around the world with tools and support to measure and assess the impacts of their climate actions, in partnership with the Natural Resources and Environmental

Policy and Planning (ONEP), join force in executing the *Improving Thailand's MRV System for Climate Change Mitigation project* ('the project'). The project aims to strengthen MRV system for Thailand's climate change mitigation; especially in the areas of industry and buildings.

Based on rigorous consultations with ONEP, Ministry of Natural Resources and Environment, who is the project counterpart, it was agreed that the initiative in Thailand will focus on strengthening MRV systems in buildings, that is this report (in addition to the industrial sector). Also, these two activities should be aligned with, and contribute to, the implementation of Thailand's NDC Roadmap.

With this, the project has three major components:

1. MRV in the industrial sector;
2. MRV in the building sector (*this component is covered in this report*); and
3. Contribution to Thailand's NDC Roadmap - Presenting sector findings to the relevant stakeholders.

1.2. Objective and scope

In line with the project background discussed above, the objectives and scopes for the building sector are listed as follows:

1. Review of international best practice/case studies on MRV in the building sector;
2. Identification of current situation/baseline of current MRV practice for the building sector in Thailand for three building types (office, department store and hospital);
3. Identification of gaps, barriers and opportunities for effective MRV in the building sector; and
4. Formulation of recommendations to strengthen MRV in the building sector.

2. OVERVIEW OF THAILAND's BUILDING SECTOR

The building sector is considered as one of the critical GHG emitters and GHG reduction contributor. Under the NDC Roadmap, it is expected that GHG from the sector could be reduced by 1 MtCO2e. It is, however, found that there is currently no MRV system for Thailand's building sector. The closest system that could effectively apply for is the energy reporting system under the Energy Conservation Promotion Act B.E.2535 (1992).

The act has been effective since 3 April 1992. Since then, the energy conservation in Thailand has been substantialized. This Act aims to:

- Identify the measure to supervise, promote, and assist the energy usage through energy conservation policies, energy conservation goals and plans, audit and analysis of energy conservation, procedures in energy conservation;
- Identify the level of energy usage in machinery and equipment;
- Establish energy conservation promotion fund to support and assist the energy conservation;
- Protecting and solve the environmental problems from energy usage and the research on energy; and
- Identifying the measures to support the energy conservation or to produce highly efficient machinery and equipment or materials for energy conservation.

The amended Energy Conservation Promotion Act (No.2) B.E.2550 (2007) has been effective since 1 June 2008.

The Energy Conservation Promotion Act B.E.2535 (1992) and its amendment in B.E.2550 (2007) has the following three main objectives:

1. To supervise, promote, and support the persons who need energy conservation according to the law to conserve energy from the efficient and economical energy production and usage.
2. To promote and support the production and the usage of highly efficient machinery and equipment, and the materials used in the energy conservation within the country.
3. To promote and support the energy conservation by establishing "Energy Conservation Promotion Fund" to provide financial assistance to persons who must implement energy conservation according to the law.

According to this Act, many regulations have been launched for prescribing details on energy conservation as shown in Table 2-1 and Figure 2-1.

Table 2- 1 Main regulations related to energy conservation in building sector

Type of Regulation	Name of Regulation
Act	Energy Conservation Promotion Act B.E.2535 (1992)
	Energy Conservation Promotion Act (No.2) B.E.2550 (2007)
Royal Decree	Royal Decree on Designated Building B.E.2538 (1995)
Ministerial Regulation	Ministerial Regulation Prescribing Standards, Criteria and Energy Management Procedures in the Designated Factory and Building B.E.2552 (2009).
	Ministerial Regulation Prescribing Qualifications, Duties and Number of Person Responsible for Energy B.E.2552 (2009)
	Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedure in Designing Building for Energy Conservation B.E.2552 (2009)
	Ministerial Regulation Prescribing Qualifications, Criteria, Procedures and Conditions for Auditing and Certification of Energy Management for Energy Auditor B.E.2555 (2012)
	Ministerial Regulations related to energy efficiency standards for machines and equipment (e.g. chiller, refrigerator, air-conditioner)

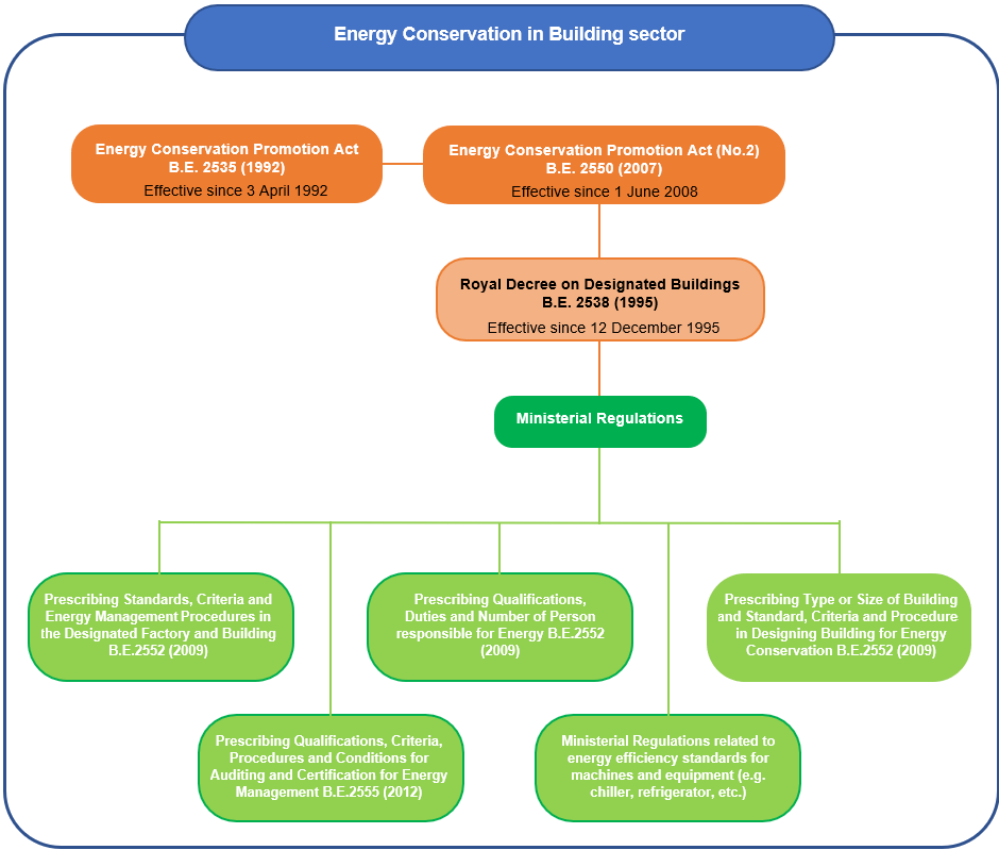


Figure 2- 1 Regulations for energy conservation in building sector[8]

[8] The original diagram is from www.dede.go.th and modified by the author

As per the above regulations, energy conservation in building sector can be divided into two groups;

1. Energy conservation for new / modified building
2. Energy conservation for existing building

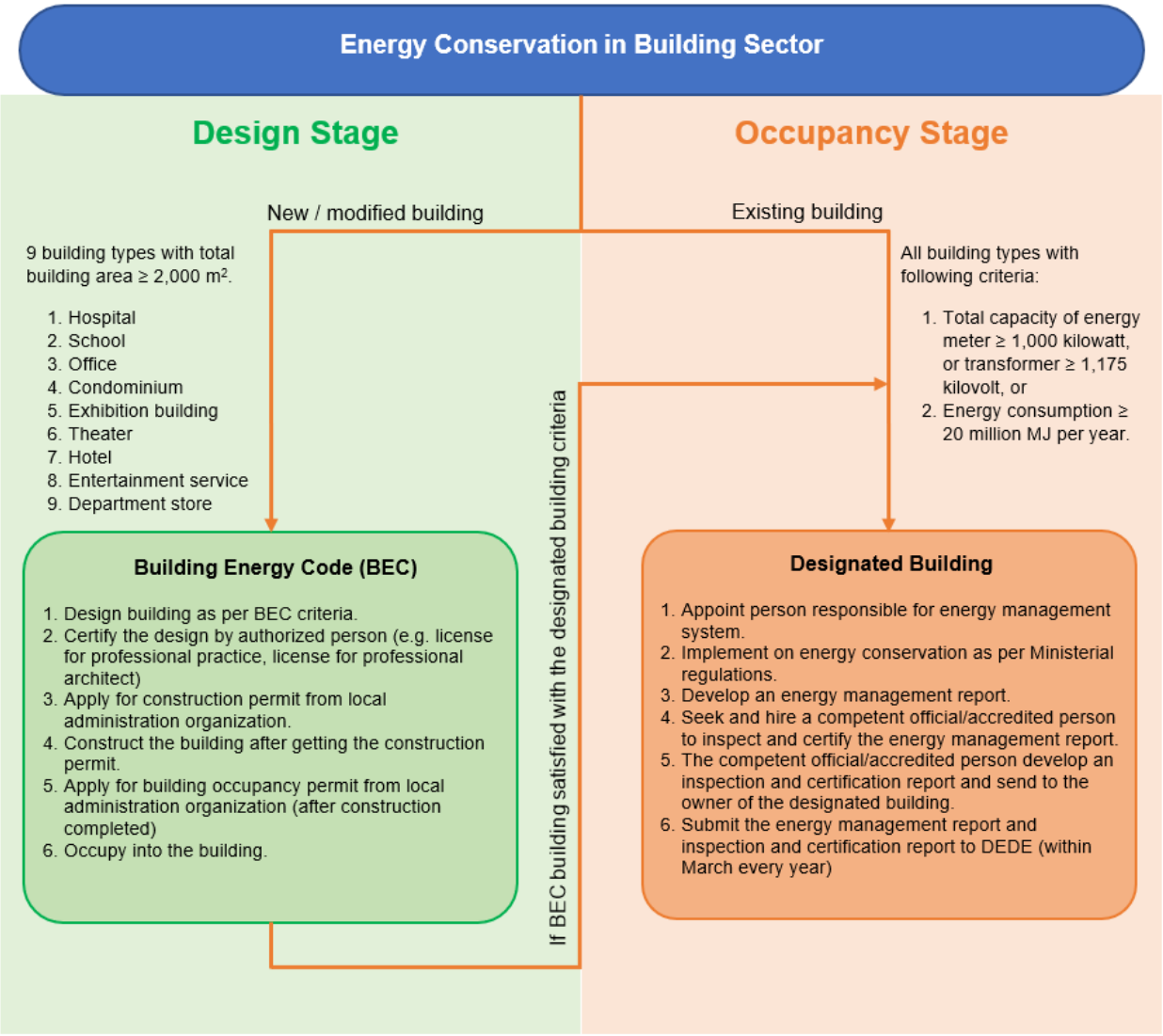


Figure 2- 2 Energy conservation in building sector[9]

1. Energy conservation for new / modified building

The new building or modified building - with a total area of 2,000 square meters or above must be designed to comply with Building Energy Code (BEC) standard. The building design must be approved by authorized person holding relevant license (e.g. license for professional practice, license for professional architect) before submitting to local administration organization for building construction / modification permit. There are nine types of targeted building for BEC as listed below.

[9] The diagram is developed by the author

1) Hospital
2) School
3) Office
4) Condominium
5) Exhibition building
6) Theater
7) Hotel
8) Entertainment service
9) Department store

BEC standard comprises of six components and, the design for each component must be complied to its standard as follows;

1) Building envelope (wall and roof)
The Overall Thermal Transfer Value (OTTV) and Roof Thermal Transfer Value (RTTV) of the building envelope shall comply to the following standard value.

Table 2- 2 Standards of OTTV and RTTV for building envelope[10]

Type of targeted building	OTTV (watt/m^2)	RTTV (watt/m^2)
a) School, Office	≤ 50	≤ 15
b) Exhibition building, Theater, Entertainment service, Department store	≤ 40	≤ 12
c) Hotel, Hospital, Condominium	≤ 30	≤ 10

2) Lighting system
Power consumption rate for lighting system shall comply to the following standard value.

Table 2- 3 Standard of power consumption rate for lighting system[11]

Type of targeted building	Power consumption rate (watt/m^2)
a) School, Office	≤ 14
b) Exhibition building, Theater, Entertainment service, Department store	≤ 18
c) Hotel, Hospital, Condominium	≤ 12

3) Air-conditioning system
Coefficient of Performance (CoP) and Energy Efficient Ratio (EER) standards for small air-conditioning system (split type), and Chiller Performance (ChP) standard for large air-conditioning system (chiller) are shown in Table 2-4 and 2-5 respectively.

[10] The standard values are based on the Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedure in Designing Building for Energy Conservation B.E.2552 (2009)

[11] The standard values are based on the Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedure in Designing Building for Energy Conservation B.E.2552 (2009)

Table 2- 4 COP and EER standards for small air-conditioning system (split type) [12]

Size of split type (watt)	COP (watt/watt)	EER (Btu/hr/watt)
≤ 12,000	≥ 3.22	≥ 11

Table 2- 5 ChP standard for large air-conditioning system (chiller) [13]

Type of chiller		Refrigeration capacity (full load) (ton of refrigeration)	ChP (kilowatt/ton of refrigeration)
Type of condenser	Type of compressor		
Air-cooled	All types	≤ 300 > 300	≤ 1.33 ≤ 1.31
Water-cooled	Reciprocating	All capacities	≤ 1.24
	Rotary, Screw and Scroll	≤ 150 > 150	≤ 0.89 ≤ 0.78
	Centrifugal	≤ 500 > 500	≤ 0.76 ≤ 0.62

4) Hot water generating system

Hot water generating system is divided into two systems: (1) boiler and (2) air-source heat pump water heater. Standards for these two systems are shown in Table 2-6 and 2-7.

(1) Boiler

Table 2- 6 Standard of boiler efficiency[14]

Type of boiler	Boiler efficiency (%)
a) Oil fired steam boiler	≥ 85
b) Oil fired hot water boiler	≥ 80
c) Gas fired steam boiler	≥ 80
d) Gas fire hot water boiler	≥ 80

(2) Air-source heat pump water heater

[12] The standard values are based on the Ministry of Energy Notification Prescribing Minimum standard of COP, EER and ChP for air-conditioning system installed in Building B.E.2552 (2009)

[13] The standard values are based on the Ministry of Energy Notification Prescribing Minimum standard of COP, EER and ChP for air-conditioning system installed in Building B.E.2552 (2009)

[14] The standard values are based on the Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedure in Designing Building for Energy Conservation B.E.2552 (2009)

Table 2- 7 COP standard of air-source heat pump water heater[15]

Type of design	Temperature of water inflow (ºC)	Temperature of water outflow (ºC)	Temperature of ambient (ºC)	COP
a) Type 1 b) Type 2	30.0 30.0	50.0 60.0	30.0 30.0	≥ 3.5 ≥ 3.0

5) Whole building energy performance

If the design for new / modified building does not satisfy on the standard in building envelope, lighting system or air-conditioning system, then the whole building energy performance must be lower than that of its reference building

6) Renewable energy utilization

In case the building consumes energy from the renewable source, then it will not be taken into account in the total energy consumption.

There are two options for designing building to be qualified in BEC standard

1) Qualified by passing in four components (building envelope, lighting system, air-conditioning system and, hot water generating system)
2) Qualified by passing in whole building energy performance and hot water generating system.

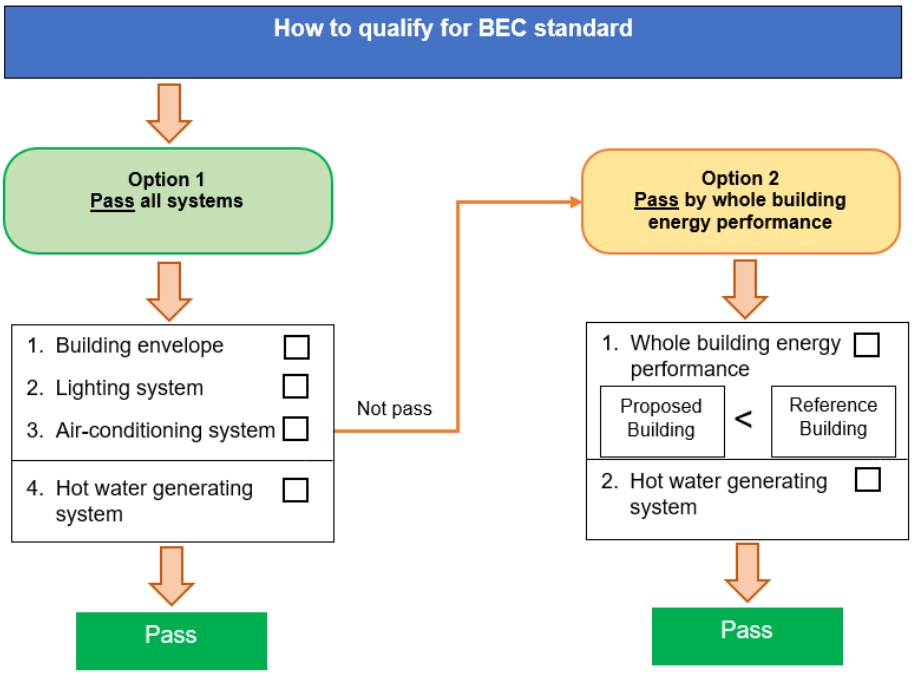


Figure 2- 3 Options for designing building to be qualified BEC standard[16]

[15] The standard values are based on the Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedure in Designing Building for Energy Conservation B.E.2552 (2009)

[16] Source: A guidebook on evaluation of BEC standard

As of June 2019, there are total 1,895 buildings qualified as per BEC standard. The building types such as condominium, office and hotel are largely certified. Figure 2-4 provides the total number of BEC certified buildings in Thailand.

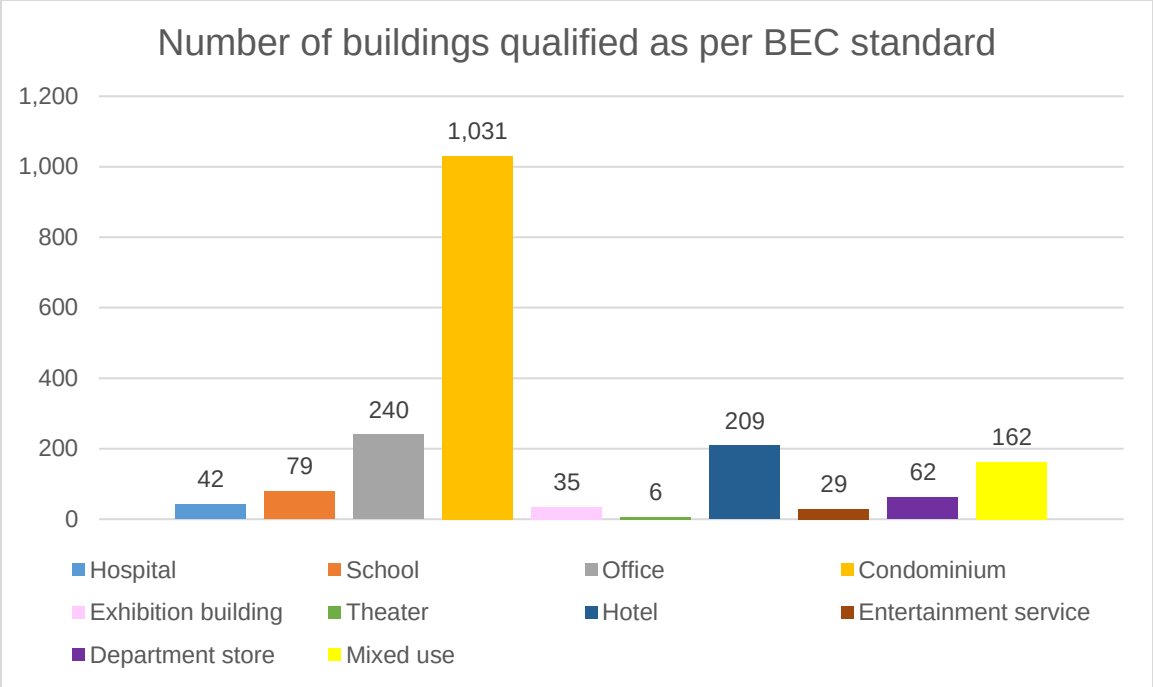


Figure 2- 4 Number of building qualified as per BEC standard[17]

Currently, BEC standard is based on voluntary basis for new building or modified building - with a total area of 2,000 square meters or above. However, it is on the legal process for mandatory basis which is expected to be finalized within 2019.

2. Energy conservation for existing building

According to the Royal Decree on Designated Building B.E. 2538 (1995), the building that satisfies the following criteria is defined as the “designated building”:

1) A single building or more registered in the same address which has one energy meter or more with total capacity 1,000 kilowatt or above, or has one transformer or more with total capacity 1,175 kilovolt ampere (kVA) or above.

2) A single building or more registered in the same address, using grid electricity or heat from the district steam or non-renewable sources, with total annual energy consumption of 20 million Megajoule (MJ) or above (during calendar year).

The duties of owner of the designated building are listed as follows;

[17] Source: Coordinating Center for Energy Conservation Building Design

1) Assigning the responsible persons for energy management in each designated building is based on the criteria given in Table 2-8.

Table 2- 8 Number of responsible persons for energy management[18]

Item	Designated building	
Capacity of energy meter (kilowatt)	< 3,000	≥ 3,000
Capacity of transformer (kVA)	< 3,530	≥ 3,530
Total energy consumption (million MJ/year)	< 60	≥ 60
Number of person responsible for energy	1	2

2) Developing and implementing the energy management and energy conservation activities There are eight steps in energy management guideline as given in Figure 2-5:

(1) Establishing a structure, committee/working group for energy management
(2) Evaluating the existing energy management situation
(3) Determining policy for energy conservation and public relation
(4) Evaluating on energy conservation potential
(5) Determining targeted energy conservation measure
(6) Developing energy conservation plan
(7) Implementing activities according to the energy conservation plan
(8) Reviewing, analyzing, revising on weak points of the energy management system

[18] The standard values are based on the Ministerial Regulation Prescribing Qualifications, Duties and Number of Person Responsible for Energy B.E.2552 (2009)

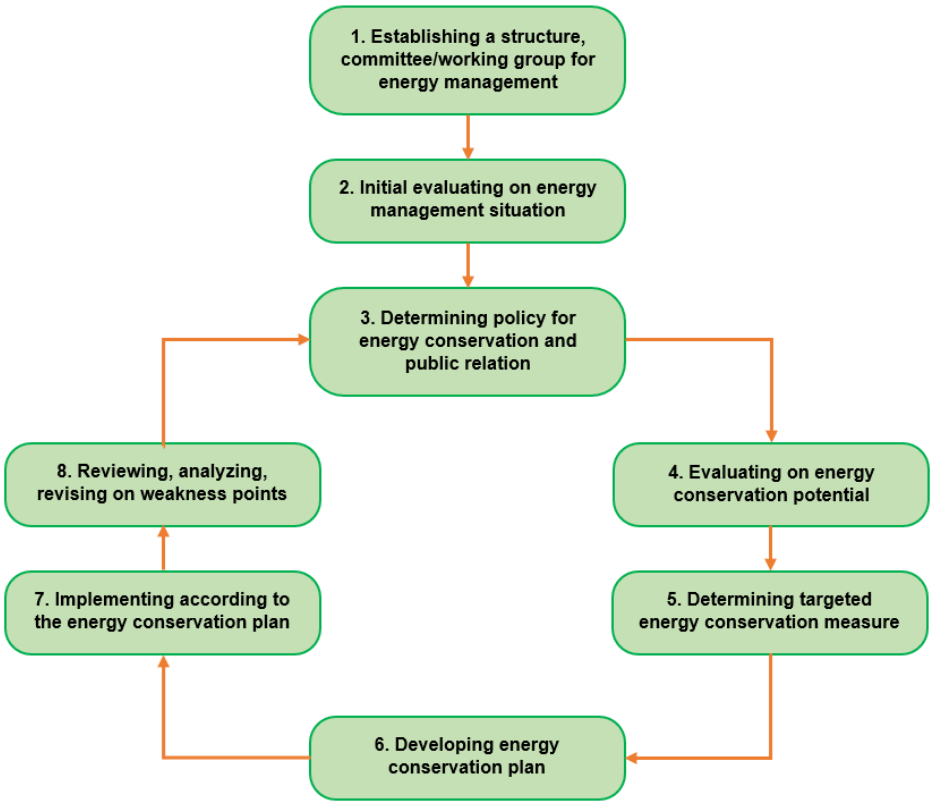


Figure 2- 5 Energy management guideline[19]

3) Submitting the energy management report and the auditing & certification energy report to Department of Alternative Energy Development and Efficiency (DEDE) within March every year.

   Owner of the designated building must develop an energy management report and then send to the competent official / accredited person for approval. After getting approval and receiving the auditing and certification energy report from the competent official/accredited person, the owner of designated building must submit the energy management report and auditing and certification energy report to DEDE within March every year. Figure 2-6 shows the flow chart of steps involved in submission of the energy management report to the DEDE.

[19] Source: Manual for explanation on the Energy Conservation Promotion Act B.E.2535 (1992) for designated factory and designated building

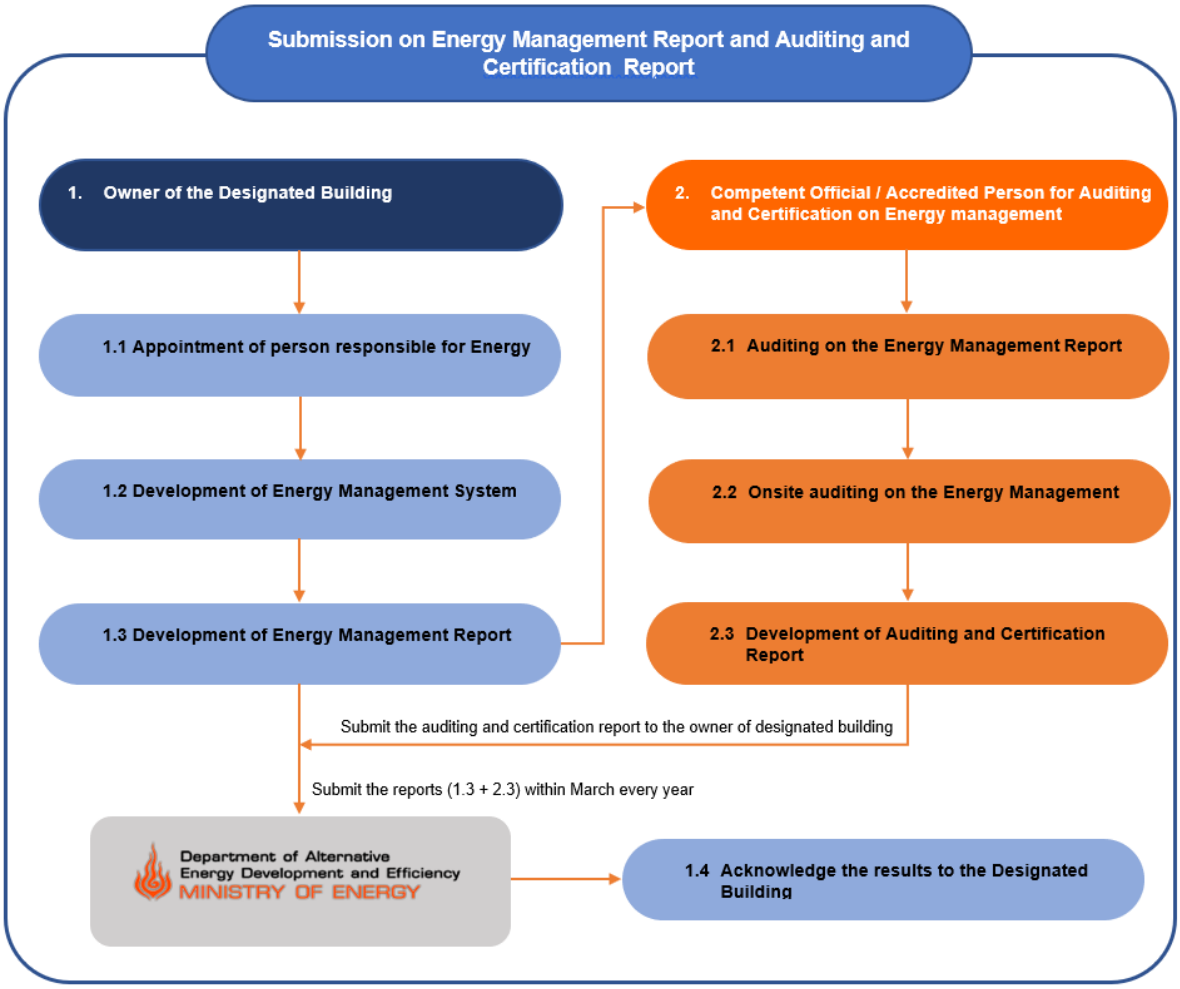


Figure 2- 6 Submission on energy management report[20]

According to DEDE's database, there are 3,104 designated buildings in 2018. The number of designated buildings has increased since 2015. The department store has highest number of designated buildings (762), followed by office buildings (734) and hotel buildings (551) respectively as shown in Table 2-9.

Table 2- 9 Number of designated buildings in Thailand[21]

Type of building \ Year	2015	2016	2017	2018
Water supply	3	3	3	3
Electricity	7	7	7	8
Livestock farm	97	95	99	95

[20] Source: The energy conservation center of Thailand
[21] Source: Department of Alternate Energy Development and Efficiency, May 2019

Hospital	268	271	271	279
Hotel	522	535	544	551
Department store	669	712	735	762
School	282	283	286	286
Office	701	710	729	734
Other buildings	356	366	374	386
Total	**2,905**	**2,982**	**3,048**	**3,104**
Increase/decrease	**-**	**2.65%**	**2.21%**	**1.84%**

As per the energy consumption data for each type of building from DEDE's database, the major energy intensive building types are department stores, office and hotels. Figure 2-7 and Table 2-10 provided the energy consumption data for each building types.

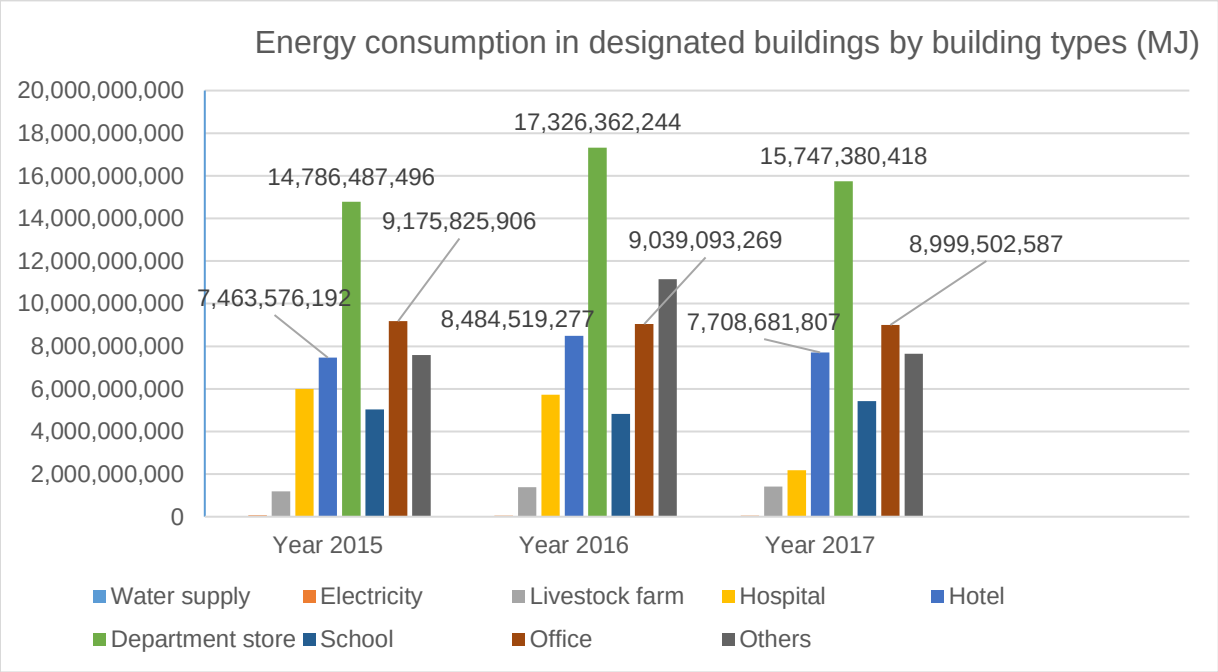


Figure 2- 7 Energy consumption in designated building by building types

Table 2- 10 Energy consumption in designated building

Type of building	2015			2016			2017		
	Electricity (kWh)	Thermal (MJ)	Total (MJ)	Electricity (kWh)	Thermal (MJ)	Total (MJ)	Electricity (kWh)	Thermal (MJ)	Total (MJ)
Water supply	7,859,538	0	28,294,338	6,040,519	0	21,745,868	7,549,205	0	27,177,137
Electricity	15,927,316	0	57,338,338	12,603,400	0	45,372,240	12,691,842	0	45,690,631
Livestock farm	296,130,468	124,835,840	1,190,905,523	343,729,001	151,791,800	1,389,216,204	326,606,582	238,583,089	1,414,366,783
Hospital	1,495,789,927	614,385,712	5,999,229,449	1,430,215,108	580,853,869	5,729,628,258	576,939,739	107,053,427	2,184,036,487
Hotel	1,645,051,616	1,541,390,376	7,463,576,192	1,871,118,561	1,748,492,456	8,484,519,277	1,673,808,137	1,682,972,513	7,708,681,807
Department store	4,066,392,279	147,475,290	14,786,487,496	4,792,256,778	74,237,843	17,326,362,244	4,368,603,693	20,407,124	15,747,380,418
School	1,371,237,155	104,857,451	5,041,311,208	1,327,194,035	46,588,643	4,824,487,170	1,489,871,452	63,831,281	5,427,368,509
Office	2,535,906,703	46,561,777	9,175,825,906	2,497,625,222	47,642,469	9,039,093,269	2,491,613,379	29,694,422	8,999,502,587
Other buildings	1,941,270,703	606,103,739	7,594,678,271	2,093,744,092	3,605,388,102	11,142,866,831	2,020,918,023	373,242,898	7,648,547,780
Total	**13,375,565,704**	**3,185,610,184**	**51,337,646,720**	**14,374,526,717**	**6,254,995,182**	**58,003,291,362**	**12,968,602,051**	**2,515,784,754**	**49,202,752,139**
Increase/decrease	**-**	**-**	**-**	**7.47%**	**96.35%**	**12.98%**	**-9.78%**	**-59.78%**	**-15.17%**

3. KEY STAKEHOLDERS

Some of the key bodies identified from the building sector energy efficiency in relation to MRV practices in Thailand are provided below and Figure 3-1:

1) National Committee on Climate Change Policy (NCCC)

The Government has established the National Committee on Climate Change Policy (NCCC), chaired by the Prime Minister. The NCCC is responsible for

(1) national climate change policy and strategy;
(2) determination of national positions the international negotiations under UNFCCC and any relevant international agreements; and
(3) monitoring and evaluating implementation results of government agencies as stated in national policy and strategy.

2) Subcommittee on Climate Change Knowledge and Database

The Subcommittee on Climate Change Knowledge and Database, chaired by the Permanent Secretary of Ministry of Natural Resources and Environment, is to verify GHG estimation methodology and amount of GHG emission reduction.

3) Working Group on GHG Inventory and Mitigation Measure

The Working Group on GHG Inventory and Mitigation Measure is to verify GHG estimation methodology and amount of GHG emission reduction. There are five sectoral working groups under the Working Group on GHG Inventory and Mitigation Measure; namely energy, industrial processes, agriculture, LULUCF, and waste, are to determine evaluation criteria for GHG emission reductions including:

1. Selection GHG emission reduction policies and measure to be monitored
2. MRV process and structure
3. Appropriate GHG emission reduction methodologies
4. Emission factors

4) Office of Natural Resources and Environmental Policy and Planning (ONEP)

The ONEP is a government agency under the Ministry of Natural Resources and Environment. According to the Ministerial Notification on the Organization Chart of the Office of Natural Resources and Environmental Policy and Planning, the Ministry of Natural Resources and Environment, B.E. 2560 (2017), the ONEP performs the following roles and responsibilities:

- Establishing policies and plans for the natural resources and environment conservation and managing the natural resources and environment.
- Coordinating and establishing management plans for the natural resources and environment and performing other functions according to the laws of Promotion and Conservation of National Environmental Quality and other related laws, including coordinating management to lead concrete practice.
- Studying, analyzing, coordinating and processing to announce the areas and measures for natural resources and environment.
- Following-up, monitoring, evaluating the results of operations according to policies, plans and measures and preparing environmental quality reports.

- Proceeding on the environmental impact assessment that may occur from projects or activities proposed by the government or private and tend to cause damage to the environment quality.
- Efficiently managing the environmental fund for supporting the policies, plans and measures, and management of the natural resources and environment in all dimensions,
- Proposing opinions for the consideration on establishment of policies and guidelines for land management and soil resources, land owning plans, land conservation and development for the public and conservation or prohibition of state land.
- Cooperating with the international and national organizations on development of draft policies and plans for the natural resources and environment conservation and management.
- Proposing opinions for consideration on establishment of policies and strategies for prevention and problem solving on climate change, GHG inventories and emissions, including studying, researching and developing related to climate change.
- Proposing opinions for consideration on establishment of policies and plans for sustainable conservation and utilization biodiversity, including implementing on obligations of international agreements related to biodiversity and wetlands.
- Performing other functions as required by law, the Ministry of Natural Resources and Environment or the Cabinet.

Regarding the MRV practices, ONEP is the secretariat of the NCCC. In addition, the ONEP takes a leading role in the development and oversight of national climate policies and strategies, while providing the needed support to implementation of the strategies and policies at the sectoral and subnational levels. The ONEP also acts as a focal point in coordinating potential and received international support related to climate change.

5) Energy Policy and Planning Office (EPPO):

The EPPO is a government agency under the Ministry of Energy whose mandate is to devise related national policies, strategies and measures on energy. The EPPO plays a key role in the administration of national energy affairs and is responsible for the energy administration plans, promotion of energy conservation and alternative energy as well as prevention of fuel shortages over short and long terms. It also monitors and assesses the efficiency and success of national energy policies and plans, as well as strategies and measures. In order to efficiently and successfully drive energy policies, strategies and measures, the EPPO has been working through various committees' mechanism as follows:

1. National Energy Policy Council (NEPC)

The NEPC is chaired by the Prime Minister, with the EPPO serving as its secretariat. With senior ministers and heads of various government agencies being its members, the NEPC is the central supreme body for energy policy formulation, which enables itself to efficiently make recommendations on the national energy policies and plans for the Cabinet. The NEPC is tasked with

- Making recommendations for the Cabinet on the national policies and plans concerning energy administration and development.
- Developing rules and terms for energy pricing in harmony with such national policies and plans.
- Monitoring, overseeing, coordinating, supporting and accelerating tasks performed by all empowered committees.
- Assessing the compliance of these tasks with the national policies and plans.

2. Committee on Energy Policy Administration (CEPA)

To ensure efficient operation, resolve dispute of problem-solving and make recommendations on the formulation of national energy administration and energy development policies, the NEPC established the Committee on Energy Policy Administration (CEPA), chaired by the Minister of Energy, with the EPPO serving as its secretariat. The CEPA is tasked with

- Advocating energy policies, plans and measures involving energy administration and energy development.
- Making recommendations on and ranking plans/projects involving energy affairs.
- Setting energy prices and rates of contribution to the Oil Fund as instructed by the NEPC.
- Recommending energy pricing policies and measures.
- Giving recommendations to the NEPC on decrees, ministerial regulations and other measures to be in line with the regulations of the promoting energy conservation.
- Requesting ministries, departments and other local government agencies, state enterprises, and individuals to submit academic data, financial information, statistics, and other essential facts and figures for the national energy policies and plans on energy administration and development.
- Appointing subcommittees to support its work as necessary.

3. Energy Conservation Promotion Fund (ENCON Fund) Committee

To support the promotion of energy conservation and the administration of the Energy Conservation Promotion Fund (ENCON Fund), the NEPC is also bound by the Energy Conservation Promotion Act B.E. 2535 (1992) and its second amendment B.E. 2550 (2007) to make recommendations to the Cabinet on policies, goals and measures for energy conservation, and set monetary contribution to the above-mentioned fund by different fuel type. To this end, the ENCON Fund committee was set up, chaired by a deputy Prime Minister assigned by the Prime Minister, with the EPPO serving as its secretariat. The committee is tasked with

- Recommending criteria, terms and priorities for fund-spending to ensure conformity to Article 25 to the NEPC.
- Allocating the fund as intended by Article 25 in line with the criteria, terms and priorities set by the NEPC under Article 4(4).
- Setting rules and procedures to file requests for assistance or support by the fund.
- Proposing on the rate of contribution to the fund from fuel sales.
- Proposing to the types of fuel exempted from contribution to the fund.
- Setting the NEPC-endorsed special tariffs
- Granting special tariffs exemption.
- Approving requests for support and assistance under Article 40 (2) in line with the NEPC's criteria and terms under Article 4 (8).
- Devising criteria and procedures for filing requests for support and assistance under Article 41.

Regarding the MRV practices, EPPO is responsible for developing the Thailand's NDC Action Plan for the Energy Sector 2021-2030 (NDC Action Plan), compiling all required activity data for GHG emission calculation from the Department of Alternative Energy Development and Efficiency (DEDE) and other government agencies under the energy sector.

6) Department of Alternate Energy Development and Efficiency (DEDE)

The DEDE is a government agency under the Ministry of Energy. The roles and responsibilities of the DEDE are as below.

a) As announced by the Ministerial Notification on the Organization Chart of the DEDE under the Ministry of Energy, B.E. 2551 (2008).

The DEDE performs the functions to promote and regulate energy efficiency and conservation, including the identification of the energy resources, development of different options for alternative energy mix as well as systematically disseminate the energy technology to respond sufficiently to all sectors requirement with reasonable cost effectiveness for the country's development and better quality of life of the people. Accordingly, the DEDE is tasked with;

- Promoting, supporting and regulating the energy conservation.
- Conducting research, development and promotion of the alternative energy.
- Establishing regulations and standards, provide technology transfer and dissemination on the energy production, transformation, transmission, consumption and conservation development.
- Following-up and evaluating the result of alternative energy and energy conservation development initiatives.
- Managing all data and information about alternative energy and energy conservation.
- Performing other functions as required by law, the Ministry of Energy or the Cabinet.

b) As prescribed by the Energy Conservation and Promotion Act B.E. 2535 (1992) and its Additional Amendment B.E. 2550 (2007).

The DEDE is authorized to regulate, oversee and facilitate large designed factories/building to ensure that they can appropriately and efficiently implement their roles as prescribed in the Royal Decree, the Energy Conservation Promotion Act, Ministerial Regulations and Orders.

c) As prescribed by the Energy Development and Promotion Act B.E. 2535 (1992).

The DEDE has responsibilities to look for the energy resources, production and construction and to consider energy production license and expansion of controlled energy set in the Royal Decree, taking into account the impact on the environment, economy, security of the country, any harm that may arise from energy production/expansion and the technical use of the raw materials and the natural resources.

Regarding the MRV practices, DEDE is responsible for collecting and verifying all required activity data for GHG emission calculation for building sector before submitting to the EPPO.

7) Thailand Greenhouse Gas Management Organization (TGO)

The Thai Cabinet's resolution approved the establishment of the Greenhouse Gas Management Organization as a public organization in accordance with the law on public organization on May 15 B.E. 2550 (2007). While the autonomous public organization has an administrative independence, it also acts as the center for collaboration among government, private sector and international organizations. As published in Government Gazette in July 6 B.E. 2550 (2007), the TGO is established with the following objectives;

- Analyzing, scrutinizing and collecting views and opinions on approval and appraisal of authorized projects to further project advancements and the market of greenhouse gas quantity trading as approved.

- Being an information center for circumstances on GHG operations.
- Making a database about the authorized projects and the approved trading of GHG reduction quantity
- Enhancing the efficiency and provide instructions to public agency and private body in the management of GHG emissions
- Disseminating and conducting public relations campaign on the GHG management.
- Promoting and supporting relevant climate change operations.

Regarding the MRV practices, TGO is responsible for developing GHG methodologies, designing on the MRV system, supporting in capacity building in collecting data and quality control, supporting as GHG data center, and technical support related to GHG.

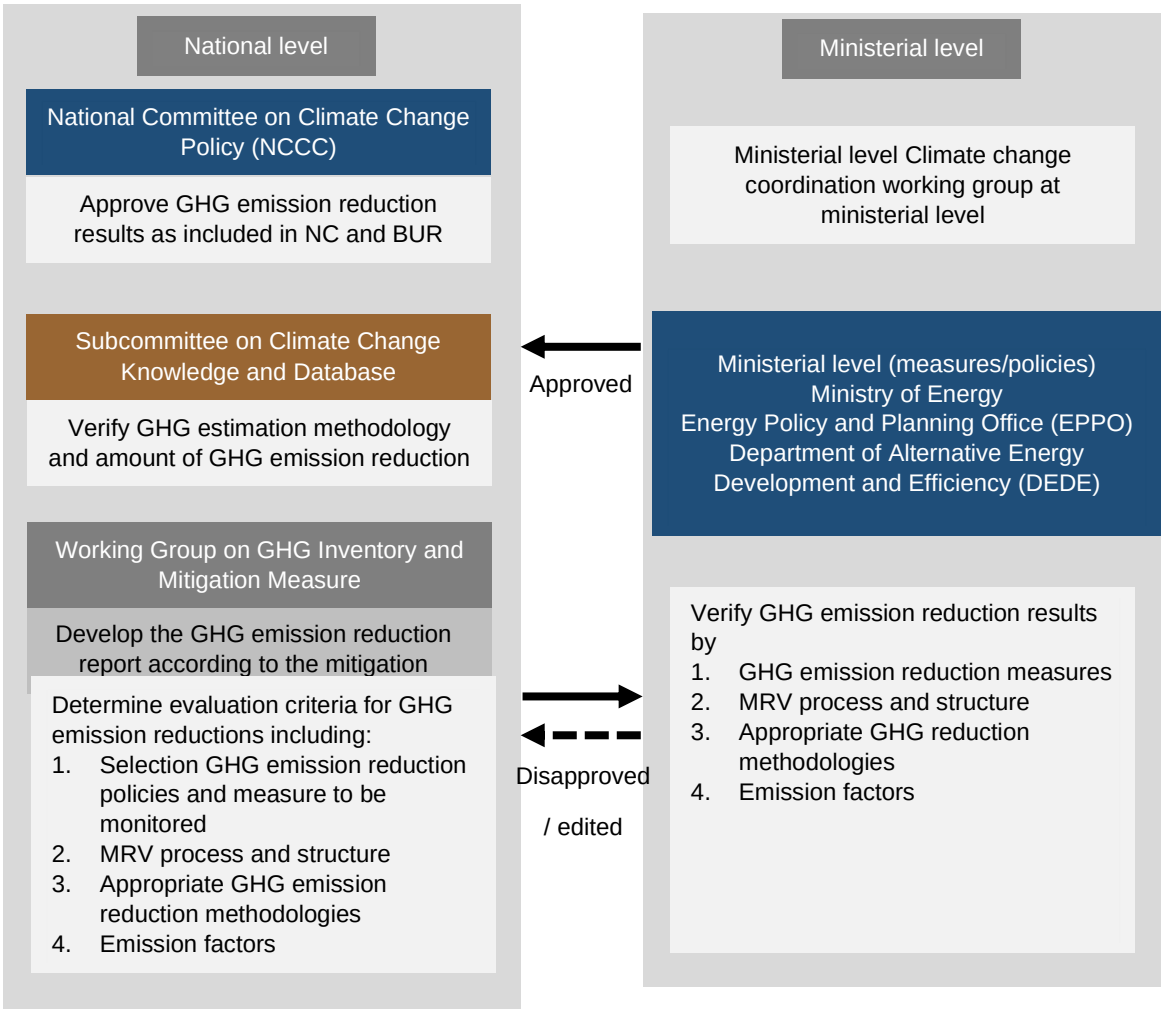


Figure 3- 1 Institutional structure in relation to MRV practices

4. CURRENT MRV PRACTICES IN THE BUILDING SECTOR

4.1. Review of NDC and related policies

As per the Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021-2030, building sector is classified as a sub-sector under the energy and transportation sector and it mainly targets commercial and public buildings. It is expected that the GHG emission reductions through energy efficiency measures (EEMs) from these commercial and public buildings would contribute to around 1 million tCO_2. The buildings are classified into eight types with four important EEMs.

The eight targeted building types for GHG reductions in building sector are as follows:

1) Office
2) Hospital
3) Hotel
4) Department store
5) School
6) Hypermarket
7) Condominium
8) Other buildings

There are four measures for energy efficiency improvement in building sector;

1) Lighting system (e.g. T5 and LED)
2) Air conditioning system (e.g. efficient air conditioning (COP5 and COP8))
3) Office equipment (e.g. efficient office equipment)
4) Other systems (e.g. efficient heater)

Potential GHG reductions for each measure and in each building type is shown in Table 4-1 and Table 4-2 respectively.

Table 4- 1 Potential GHG reductions for each measure in building sector[22]

Measure	Potential GHG reductions ($ktCO_2e$)			
	Year 2015	Year 2020	Year 2025	Year 2030
Lighting system	16	34	100	180
Air conditioning system	44	93	275	490
Office equipment	20	42	124	225
Other systems	10	20	58	105
Total	**90**	**189**	**557**	**1,000**

Figure 4-1 provides the potential GHG emission reductions in each building type in 2030.

[22] Source: Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021-2030

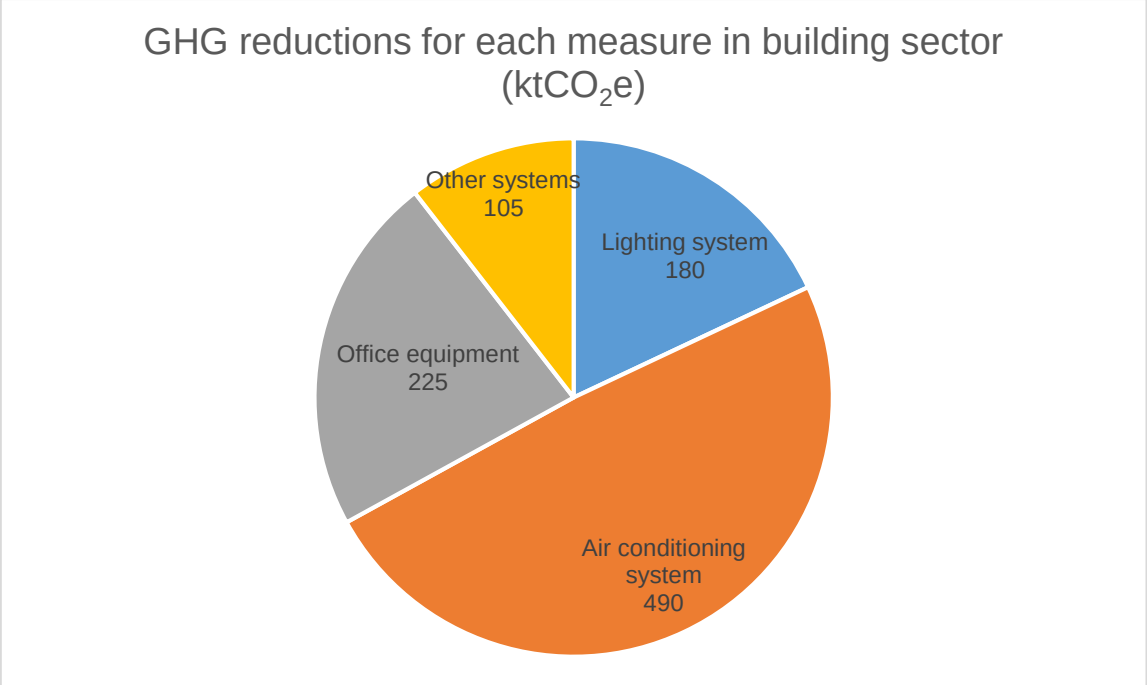


Figure 4- 1 Potential GHG reductions for each measure in building sector in year 2030

Table 4- 2 Potential GHG reductions for each building type[23]

Type of building	Potential GHG reductions ($ktCO_2e$)		
	2010	2020	2030
Office	**0**	**64**	**306**
- Lighting system	0	12	62
- Air conditioning system	0	35	155
- Office equipment	0	14	76
- Other systems	0	2	13
Hospital	**0**	**28**	**144**
- Lighting system	0	4	22
- Air conditioning system	0	12	58
- Office equipment	0	4	26
- Other systems	0	7	38
Hotel	**0**	**24**	**124**
- Lighting system	0	2	10
- Air conditioning system	0	14	68
- Office equipment	0	2	16
- Other systems	0	6	30
Department store	**0**	**24**	**143**
- Lighting system	0	5	25
- Air conditioning system	0	12	80
- Office equipment	0	4	23
- Other systems	0	3	14
School	**0**	**12**	**72**
- Lighting system	0	2	13
- Air conditioning system	0	4	28
- Office equipment	0	5	27
- Other systems	0	1	4

[23] Source: Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021-2030

Type of building	Potential GHG reductions ($ktCO_2e$)		
	2010	2020	2030
Hypermarket	**0**	**12**	**57**
- Lighting system	0	2	11
- Air conditioning system	0	4	19
- Office equipment	0	5	24
- Other systems	0	1	3
Condominium	**0**	**12**	**69**
- Lighting system	0	2	9
- Air conditioning system	0	7	50
- Office equipment	0	3	8
- Other systems	0	0	2
Other buildings	**0**	**13**	**74**
- Lighting system	0	3	16
- Air conditioning system	0	5	32
- Office equipment	0	5	25
- Other systems	0	0	1
Total	**0**	**189**	**1,000**

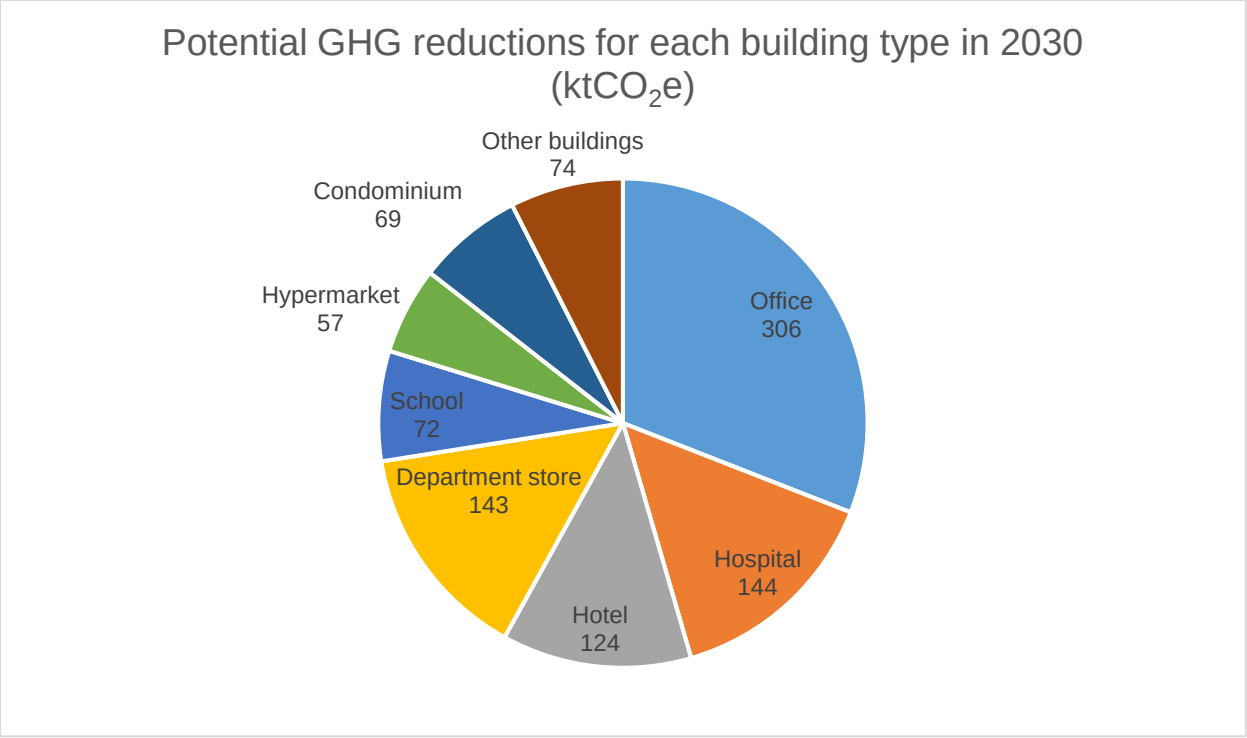


Figure 4- 2 Potential GHG reductions for each building type in 2030

As per the potential GHG reductions for each building type, the office buildings have highest potential GHG reductions (306 $ktCO_2e$), followed by hospital (144 $ktCO_2e$) and department store (143 $ktCO_2e$) respectively. The total potential GHG reductions of these three building types are 593 $ktCO_2e$ or 59.3% of total potential GHG reductions in the building sector.

As the Energy Efficiency Plan (year 2015-2036) (EEP2015) is the master plan for energy efficiency development and GHG reductions on energy efficiency improvement (including building sector), therefore DEDE as the main responsible government agency for energy efficiency development has developed the 5-year energy efficiency action plan (year 2017-

2021) in synergy with the EEP2015. In this action plan, there are three strategies to be applied for energy efficiency development in building sector as follows:

1) Compulsory Program
   1.1) Enforcement measures on energy conservation standards according to the Energy Conservation Promotion Act B.E. 2535 and its amended B.E. 2550 on the energy conservation management system in designated building.
   1.2) Enforcement measures on BEC standard for new building.
   1.3) Measures to determine standards and labeling equipment, machinery and materials for energy conservation.
   1.4) Enforcement measures on Energy Efficiency Resource Standards (EERS) for energy producer and distributor.
2) Voluntary Program
   2.1) Support/subsidy measures on energy conservation implementation.
   2.2) Promotion measures on the use of lighting for energy conservation.
3) Complementary Program
   3.1) Capacity building measures to energy conservation personnel.
   3.2) Public relation measures to raise energy conservation consciousness

4.2. Review of the existing MRV practices for the sector

Currently, there is no existing MRV practice in the building sector. However, the designated buildings have to report their energy consumption through an energy management report on annual basis. The owner of designated building is required by law to assign energy manager to be responsible for energy management as indicated in the Table 2-8. The steps in the existing reporting practice are listed below:

1. The designated building implements the energy conservation measure;
2. The designated building measure and record data as required by the energy management report;
3. Owner of the designated building develop the energy management report;
4. Owner of the designated building seek and send the energy management report to a competent official / accredited person for approval;
5. The competent official / accredited person verifies the energy management report and develop an auditing and certification energy report and send to the designated building; and
6. The designated building submits the energy management report and auditing and certification energy report to DEDE within March every year.

4.3. Review of current institutional arrangement

To effectively capture GHG reduction and transparently report the results, Thailand has developed the domestic MRV system by which duties and responsibilities are based on institutional arrangement which is shown in Figure 4-3 below. This institutional arrangement is set primarily for consolidating energy and GHG data, evaluating the emissions and summarizing the findings for inclusion in the National Communication (NC) and Biennial Update Report (BUR)/ Biennial Transparency Report (BTR).

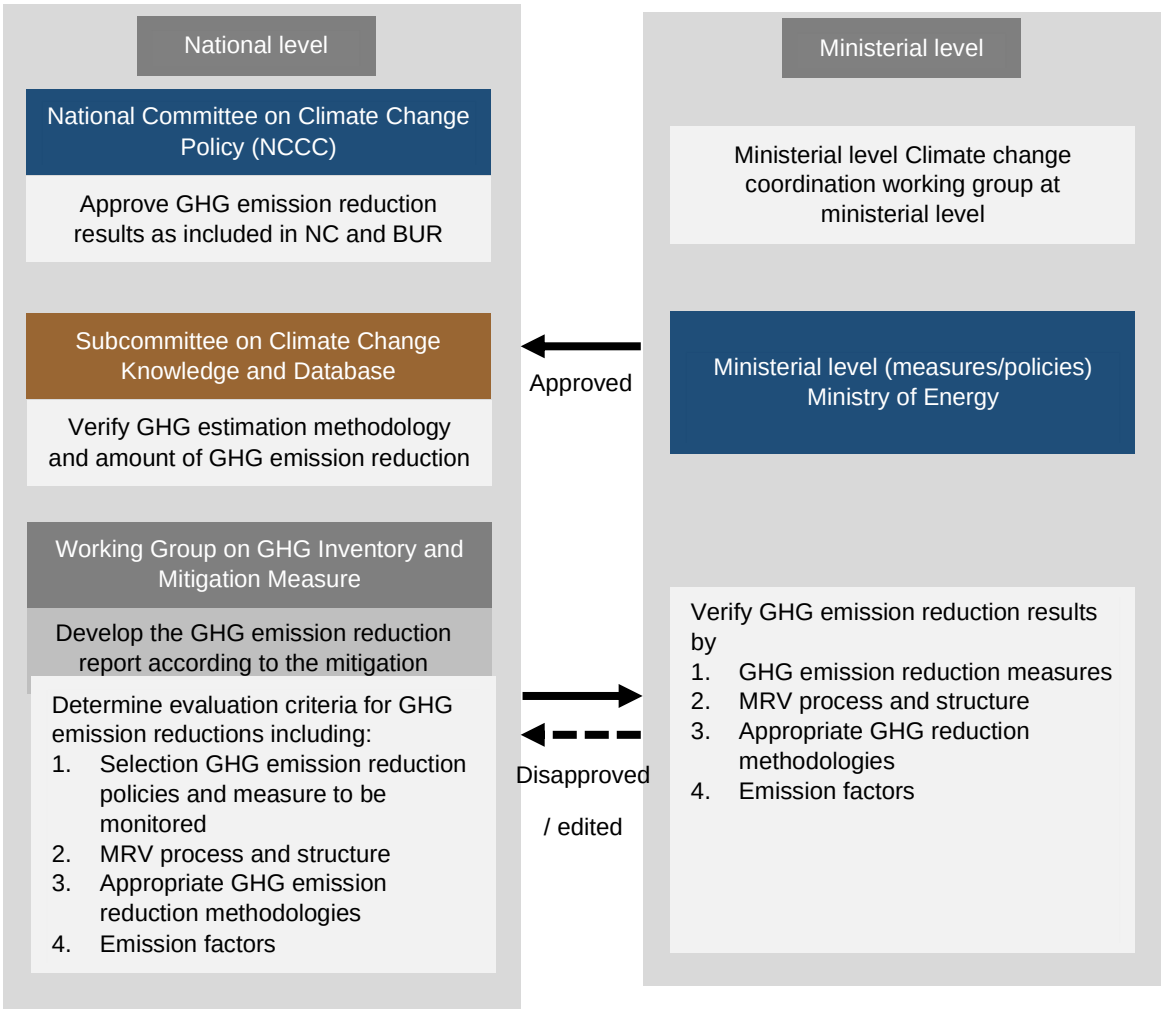


Figure 4- 3 Current institutional arrangement

The descriptions of current institutional arrangement for GHG emission is provided as below;

1) Working Group on GHG Inventory and Mitigation Measure

The Working Group on GHG Inventory and Mitigation Measure has main responsibilities as follows:

1.1) Estimate GHG emissions and develop the GHG emission report

1.2) Determine evaluation criteria for GHG emission reduction including;

- Selection of the GHG emission reduction policy and measure to be monitored
- MRV process and structure
- Appropriate GHG emission reduction methodologies
- Emission factors

2) Ministry of Energy

Once the Working Group on GHG Inventory and Mitigation Measure develops the mitigation plan as described above, then all information will be sent to the Ministry of Energy for approval in following topics:

2.1) Appropriate measures/policies for MRV process

2.2) GHG emission reduction methodologies

2.3) MRV structure for activity data

2.4) Mitigation result according to the measures/policies

The Ministry of Energy has established a working group of energy sector to review and assess above aspects. After the detailed review and analysis, the Ministry of Energy approves them and then informs the Working Group on GHG Inventory and Mitigation Measure (via ONEP as the secretariat of the working group).

3) Subcommittee on Climate Change Knowledge and Database

After the Ministry of Energy approves on all aspects of GHG mitigation plan as above, all information will be sent to the Subcommittee on Climate Change Knowledge and Database (via ONEP as the secretariat of the Subcommittee on Climate Change Knowledge and Database) for approval.

4) National Committee on Climate Change Policy

After the Subcommittee on Climate Change Knowledge and Database approves it, then it will be sent to the National Committee on Climate Change Policy for approval as inclusion in the National Communication (NC) and Biennial Update Report (BUR)/ Biennial Transparency Report (BTR).

From the review, the project found that Thailand successfully established key foundations for effective MRV systems. All institutional mandates are clarified and roles for each relevant agency is identified. Reporting and approval workflow is well developed. This provides a vital steppingstone for the country to develop effective MRV system.

With these all necessary components in place, it would help the country save a lot of time and effort in moving forward with clear and transparent MRV systems for key mitigation sectors; i.e. building and industry. It is highly recommended that MRV systems for mitigation sectors should be developed under this framework.

5. INTERNATIONAL MRV BEST PRACTICES IN THE BUILDING SECTOR

With raising global consensus on the need for strong measures against the climate change, the greenhouse gas (GHG) measurement, reporting and verification (MRV) plays a significant role in mitigating the emissions from the economic and development activities of any country. The key function of MRV is to enhance transparency through the tracking of national GHG emission levels, the impact of mitigation actions, climate funds, etc. The MRV facilitates sharing information and creates transparency and shows the continuity of a country's actions against climate change. The transparent MRV approaches can improve comparability at national and international levels thus supporting coherence between domestic and international MRV systems. The MRV system will be also helpful for the countries in reporting the GHG emission compliances under the Paris Agreement during the NDC period.

5.1 Development of international MRV guidelines

The guidance and tools for implementing the MRV system were developed by several international organizations such as the Greenhouse gas (GHG) Protocol, International Organization for Standardization (ISO), Intergovernmental Panel on Climate Change (IPCC), , Initiative for Climate Action Transparency (ICAT), and etc. These international standards and tools are helpful for the countries to report their direct and indirect GHG emissions at the national level and at sector level.

a) The GHG Protocol[24]

The GHG Protocol was formed in 1988 through coordination of businesses, non-governmental organizations (NGOs), governments, academic institutions and others convened by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). This international standard is widely followed by business entities in developed and developing countries to report their emissions. In 2016, 92% of Fortune 500 companies reported their carbon emissions using GHG Protocol directly or indirectly.

b) ISO standards

Similarly, the ISO published in 2006 the ISO 14064 (Greenhouse Gas Emissions and Removals Quantification and Reporting) standard[25] in addition to the ISO 14000 environmental management series to address the climate change effects. This standard gives the guidance for quantifying, reporting and verification of GHG emissions at the organizational level.

c) IPCC[26]

The IPCC was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) to assess the climate change. It provides scientific information at all levels to the governments so that they can use them develop climate policies. It also conducts a comprehensive assessment on climate change and reports the findings to the United Nations Climate Change Conference (UNFCCC). In 2006, the IPCC has published its guidelines for the national GHG inventories which is currently followed by most of the countries to report their emission levels. The Clean Development Mechanism framework under UNFCCC uses the IPCC standards for its projects. The IPCC suggests three

[24] http://ghgprotocol.org/
[25] https://www.iso.org/standard/66453.html
[26] https://www.ipcc.ch/

different tier levels (Tier 1, 2 and 3) for the GHG emission reporting based on the quantity of data required and the degree of analytical complexity of data.

- Tier 1 - Uses the default emission factors and other assumptions provided by the IPCC
- Tier 2 - Uses emission factors and other parameters which are specific to the country
- Tier 3 - Uses most complex and equipment & activity specific data and emission factors

Progressing from Tier 1 to Tier 3 generally represents a reduction in the uncertainty of GHG estimates, though at a cost of an increase in the complexity of measurement processes and analyses. Most of the countries report their emission levels to UNFCCC using Tier 1 approach as defined by the IPCC. However, the countries should consider Tier 2 approach as defined by the IPCC for orientation, when developing their initial MRV systems. The Tier 2 approach requires a proper coordination of relevant institutions and implementation of robust MRV system at domestic and national level for GHG emissions, which will result in estimation of accurate emission levels of the country.

d) Initiative for Climate Action Transparency (ICAT)

ICAT developed series of guidance for assessing the impacts of policies and actions addressing GHG emissions. It is intended to be used in combination with any other. The series of guidance is intended to enable users that choose to assess GHG impacts, sustainable development impacts and transformational impacts of a policy to do so in an integrated and consistent way within a single impact assessment process.

One of the series is the Building Efficiency Guidance. The guidance provides methods for assessing the GHG impacts of energy efficiency policies in the buildings sector. The guidance targets residential, commercial and public buildings. Also, it is applicable to three building stock types: new buildings, existing buildings with retrofit, and existing buildings without retrofit.

5.2 General approaches in national/sector level MRV

In general, the data collection for the MRV of primary energy consumption or GHG emissions at the national level follow two significant approaches:

Top-down approach: Figure 5-1 represents the tentative top-down approach in implementing a nation-wide energy efficiency labeling program.

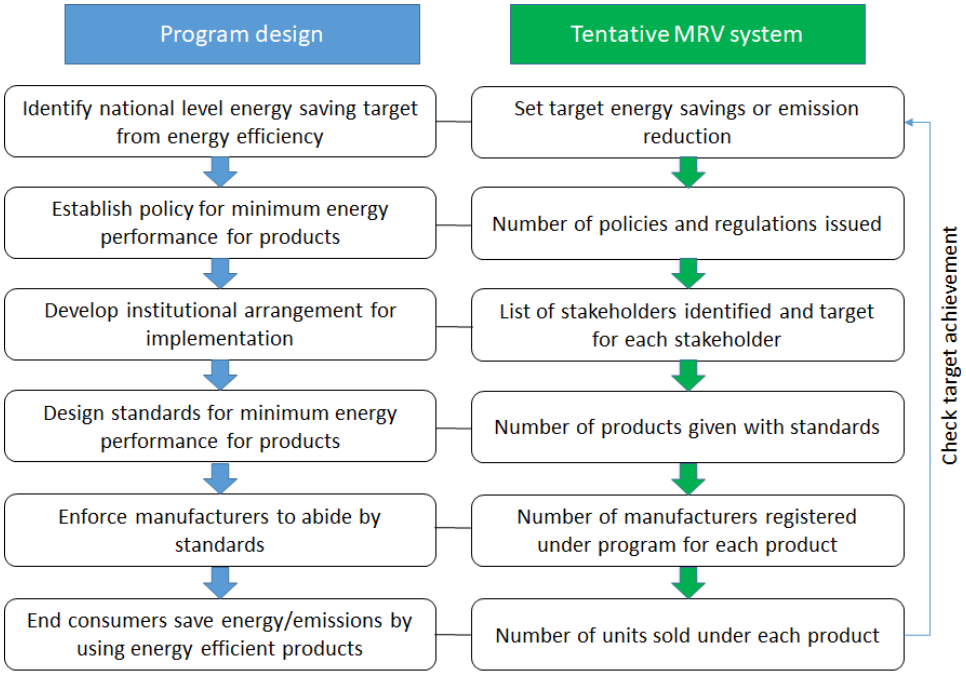


Figure 5. 1 Program with top-down MRV system

The data are aggregated from the sector level or regional or ministerial records and/or registries and then the contribution of different sectors or buildings are proportioned based on the available economic or development statistics. A top-down approach to an MRV system design has the advantage of direct linkage to the goals defined in an NDC and other national level planning. This approach allows for a broader overview of MRV governance. However, this approach requires a well-established institutional set-up and coordination of stakeholder groups involved at the various levels for MRV. Since the data are taken from the market registries or records, the accuracy of results achieved could be low. However, this approach is cost-effective as it requires relatively low administrative effort. This is the approach followed by most of the developing countries and least developed countries (LDCs) in reporting their energy consumption and GHG emissions.

Bottom-up approach: Figure 5-2 represents the tentative bottom-up approach in implementing the GHG emission reduction program in different sectors.

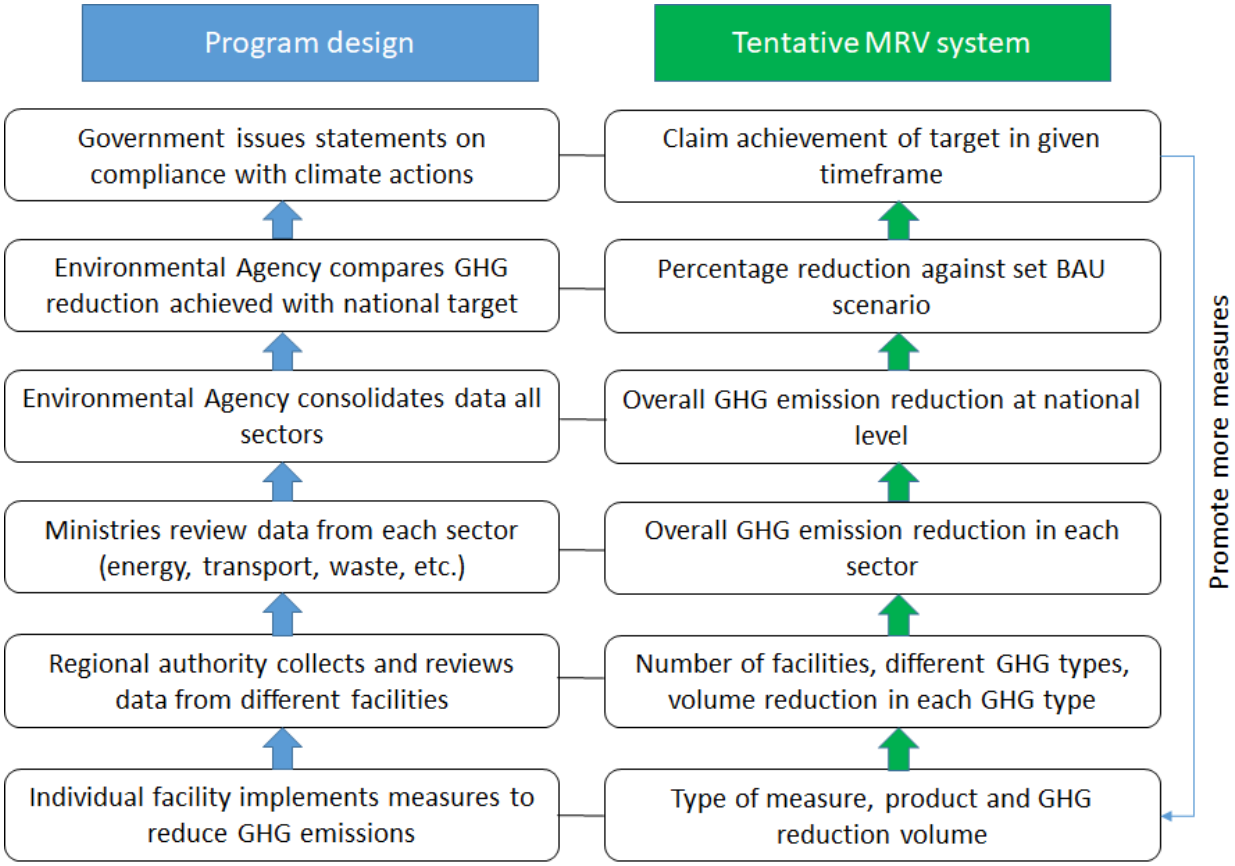


Figure 5. 2 Program with bottom-up MRV approach

The data are collected at the point of energy consumption or GHG emission at the consumer end (for example at individual buildings). The data are then consolidated at sector level or regional level and then up to the national level. Since the data are monitored and reported at the energy consumption or emission point itself, the accuracy of the results achieved tend to be high. However, this approach requires (i) an extensive effort from a number of stakeholders and ministries, (ii) very high investments and (iii) sufficient capacity at all stakeholder levels. It also consumes more time. This bottom-up approach can lead to completely different MRV designs for different mitigation actions, even within the same sector and especially between different sectors. However, the bottom-up approach offers the advantage of direct linking the MRV system to specific actions at the consumer or facility level. This approach is followed by the developed countries those who have a well-established national level monitoring and reporting systems connected to every individual energy consumer or GHG emitter.

Both the top-down and bottom-up approaches to MRV system design have a risk of information being misaligned with national targets. Risks exists in a top-down approach, when a stakeholder cannot deliver a defined parameter. Similarly, risks exist under a bottom-up approach when the information delivered by the stakeholder cannot be used within the national level MRV system. The most appropriate MRV system (even with synergies between the two approaches) can be selected based on the existing conditions at national level and sector level.

5.3 Best practice case studies in building sector MRV

Several countries such as EU, India, Indonesia, Japan, Singapore, US, etc., have launched the building sector MRV under varied context of energy efficiency initiatives and GHG mitigation programs with varied level of enforcements. The Paris Agreement requires all

Parties to put forward their best efforts through “nationally determined contributions” (NDCs) and to strengthen these efforts in the years ahead. This includes requirements that all Parties must report regularly on their emissions and on their implementation efforts[27]. Therefore, other countries are now working on developing appropriate national level or sector level MRV mechanism to fulfil their emission reporting compliance under the Paris Agreement.

The general practices of MRV design in terms of legal framework, institutional arrangement, boundary setting, robust database management, etc., that are applicable for any national level industrial or power sector program are applicable to the building sector MRV as well. The assessment metrics (mainly energy consumption) for different building types in the building sector do not vary significantly when compared to the wide range of assessment metrics needed for different type of processes (product types, process emissions, waste treatment, etc.) as in the industrial sectors. However, the building sector is diverse, disaggregated and dispersed in nature which makes the collection of data and database management complicated for different building types. Therefore, for review of best practices in this report, few other aspects that are specific to the building sector are considered in this section with references from the international best practices. There are three reference case studies related to building sector; 1) Green Mark Program, Singapore 2) Energy Star Program, United State and 3) Tokyo Emission Trading System, Japan. The overview of reference case studies considered in this report are provided below.

a) Green Mark Program, Singapore:

The Green Mark program is the main initiative under its Clean Energy Strategy, which features a national target of greening at least 80 percent of its buildings by 2030. The scheme involves a rating system to evaluate the environmental impact and the buildings performance based on the internationally-recognized best practices. As of July 2018, more than 3,300 buildings or 36% of the building stocks by ground floor area, Singapore have achieved Green Mark standards. This scheme has been adopted outside of Singapore with certified projects in Indonesia, Malaysia, Thailand and China. To date, close to 50 Singapore-based firms are involved in over 300 overseas Green Mark projects in 14 countries.

The MRV of the building performance are set within the certification process of the program. The three key elements in the Green Mark certification;

(1) Minimum Green Mark standard for building with GFA of at least 15,000 m^2
(2) Three-yearly energy audit (by accredited auditor) on the building with GFA of at least 15,000 m^2
(3) Annual mandatory submission of the building information and energy consumption data via online portal. The government agency can directly draw electricity data from utility companies.

Measurement: The building measures and records all relevant data (building information, energy consumption data, etc.)

Reporting: Annual mandatory submission of the building information and energy consumption data via online portal. The government agency (Building and Construction Authority: BCA) can directly draw electricity data from utility companies.

Verification: All data is verified by third party (professional mechanical engineer registered with the BCA)

b) Energy Star Program, United States:

The Energy Star is a voluntary program which was initiated by the United States Environmental Protection Agency (EPA) in 1992 to drive the economy towards an energy

[27] https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement

efficient and cost -effective path. Initially, the program started with star labelling of energy efficient products and over the years was expanded to include all major appliances, office equipment, lighting, home electronics and the energy performance assessment of the residential buildings and commercial & industrial buildings and manufacturing plants. More than 9,500 buildings in US and Canada had earned the Energy Star certification in 2017, bringing the total to more than 32,000 buildings certified so far. On an average, the Energy Star certified buildings are found to use 35% less energy than the typical buildings nationwide. The energy star program is helpful in reporting the GHG emissions in the National Communications and Biennial Update Report (BUR) to the UNFCCC from the US building sector[28].

The MRV of this program are set within the certification process of the program. The Energy Star certification is valid for 12 months. To qualify for the Energy Star certification, a building should be benchmarked in the Portfolio Manager tool. The verification process will be done by the accredited verifier. Once the verification process is complete, the owner has to upload the signed application form in the Portfolio Manager tool and submit it to the EPA. The EPA reviews the application and provides the Energy Star certification to the building.

Measurement: The building measure and record all relevant data
Reporting: The owner of the building upload the application form signed by the licensed professional and submit to the United States Environmental Protection Agency (EPA)
Verification: All data is verified by third party (licensed professional accredited by EPA)

c) Tokyo Emission Trading System (ETS), Japan:

The Tokyo Emission Trading Scheme (ETS) was launched in 2010 by the Tokyo Metropolitan Government (TMG) as an initiative enforcing the mandatory GHG emission reduction by the large facilities located within the limits of Tokyo city. This program is not only the first cap-and-trade scheme in Japan, but also the world's first urban cap-and-trade scheme which specifically targets large facilities of the commercial sector. The first compliance period of the Tokyo ETS came to an end in December 2014 and achieved an emissions reduction of 23% compared to the base year emissions during the four years. In 2017, the emissions from covered facilities amounted to 12.04 million tCO_2, achieving a 27% reduction from base emission as a result of continuous energy efficiency efforts.

The MRV of this program, the covered facilities are required to submit an annual report on the previous year's emissions and their emission reduction plans by the end of November of the following year. The report must cover GHG emission of all types (CO_2, CH_4, N_2O, PFC, HFC and SF_6). The verification process will be done by a registered independent verification agency. Once the verification process is complete, a verification report issued by a registered independent verification agency must be attached to the emission data report. The verification is mandatory at the following stages:

- Reporting of compliance for the period
- Applying for a top-level facility certification
- Applying for offset credits

Then, the owner has to submit the verified application to TMG for certification and for credit issuance respectively.

Measurement: The covered facilities (buildings) measures and records all relevant data as per their monitoring plans

[28] United States Climate Action Report, 2014

Reporting: The covered facilities (buildings) are required to submit an annual report on the previous year's emissions and their emission reductions plans. The report must cover GHG emission of all types (CO_2. CH_4, N_2O, PFC, HFC and SF_6)
Verification: All data is verified by third party (verifier registered with the TMG)

More details on each of the referred case study are provided as separate annexes (Annex 1, 2 and 3) to this report.

5.3.1. Extracting energy use data directly from the energy supply utilities

The electricity is the major source of energy in any type of buildings. The energy used for the heating and cooling, backup electricity generation, etc., are subject to the country and regional conditions. Since the buildings (commercial, residential, institutional, etc.) consume electricity from the grid supply utilities and payment is made for the metered consumer account, it is possible to collect the energy consumption of any consumer directly from the database of the grid utilities. The same concept is also applicable for natural gas supply or steam use from the district heating systems, if it is done through the registered utilities with established pipeline networks. This approach is more reliable and at the same time less resource consuming.

The consideration of the same in selected case study programs is presented below.

a) Green Mark Program, Singapore: The Building Energy Submission System (BESS), an online database under the program, facilitates seamless data collection by drawing electricity data directly from the power supply utilities. The building owners are only required to update any changes to the building information as they arise and review the energy consumption data prior to the submission. Other fuel consumption such as diesel or natural gas is very minor in Singapore and they can be reported by building owners separately through the BESS.

b) Energy Star Program, United States: The Portfolio Manager, an online tool facilitates the electricity data collection directly from the power supply utilities. Apart from electricity, the natural gas consumption and steam consumption from the district heating systems are also significant in the United States. Thus, the Portfolio Manager tool also includes data collection from these energy supply utilities.

Since the data is extracted from the utilities database, it would be easier to track and compare the reduction in energy consumption achieved through top-down approach as well.

5.3.2. Identification of source of energy use and related emissions

The buildings can source their electricity from different available power distribution companies in the region or diesel or natural gas-powered generators or through renewable sources. Further, there will be transmission and distribution losses in electricity supply. Thus, it is important to capture the sources of electricity when there are several grid utilities supplying electricity from different sources and also when electricity is transmitted over very long distances. The same approach can be considered for other energy sources such as natural gas, diesel, steam, etc., as applicable. Depending on these sources, the GHG emissions for the energy use will also vary.

a) Green Mark Program, Singapore: Given that Singapore is a small country with single grid network, only the site energy consumption is taken into consideration.

b) Energy Star Program, United States: The program objective is to evaluate individual building performance, it considers source energy intensity (i.e., site energy consumption + losses occurred in supply network for that energy consumption amount) and uses source-site

ratio parameter to convert site energy consumptions. Because the Portfolio Manager tool is available in both the United States and Canada the country-specific source-site ratios are used. The energy sources include grid electricity, petroleum products, district heating system, etc. For each country, there is only one national source-site ratio for each of the primary and secondary fuels in the Portfolio Manager. The source-site ratios computed and applied in the Portfolio Manager tool depend on several characteristics including the quality of the fuels, the average efficiency of conversion from primary to secondary energy and the distribution efficiency. The ratios are expected to change in due course of time as the national infrastructure and fuel mix evolve. Therefore, the ratios for all fuels are reviewed every three to five years and updated accordingly. Additionally, the specific ratios may be updated as needed to reflect new information, methodologies or policies.

c) Tokyo Emission Trading System (ETS), Japan: Since the program boundary is limited to the authority of Tokyo city, the energy consumption is considered only at the site level (no consideration of transmission and distribution losses of energy from the source).

Thus, identification of energy sources can be helpful in the analysis losses associated with different sources and also in understanding their emission intensity.

5.3.3. Compliance reporting based on building's energy use intensity (EUI)[29]

Different type of buildings such as commercial offices, hotels & restaurants, hospitals, educational institutions, residential buildings, malls & supermarkets, public infrastructure such as parks, etc., have different energy consumption patterns. Therefore, it is necessary to define the EUI for each of these building types separately for more accurate planning, benchmarking, reporting of energy use and evaluation of performance. The level of energy conservation and MRV procedures to be followed may vary based on the baseline EUI level of any building. The building owners must ensure that the energy consumption within the buildings are in compliance with any set limits of EUI and the parameters for such evaluation are monitored, documented and reported during the compliance period.

The consideration of the same in selected case study programs is presented below.

a) Green Mark Program, Singapore: Since its launch in 2005, the scheme has evolved to 17 different categories covering all building infrastructure like parks, data centers, retail outlets, supermarkets, homes and offices. The scheme also distinguishes new buildings from the existing buildings in its compliance requirements.

b) Energy Star Program, United States: The performance of a building is compared to performance of similar other buildings nationwide that have the same primary use. Every four years, the U.S. Department of Energy's Energy Information Administration conducts a national survey to gather data on the building characteristics and energy use from thousands of buildings across the country. As of now, the energy performance scores are available for 15 different types of buildings which represents over 50% of the commercial building space in US.

c) Tokyo ETS, Japan: The legal obligations of the scheme applie to the large-scale facilities, which are defined as the individual buildings or facilities that annually consumes above 1,500 kl of crude oil equivalent (COE). The medium/small-scale energy intensive facilities must submit an annual energy efficiency report if they belong to a corporation that annually consumes above 3,000 kl of COE. However, reductions are not mandatory for such facilities.

[29] Energy use intensity is the amount of energy consumed per unit area of the building. It may vary based type of building such as hotels, schools, hospitals, etc.

Given that there are several options in grouping the building types and their energy performance as discussed above, initially the program MRV can cover only the major energy intensive building types and it can be gradually expanded over time to include other building types as well.

5.3.4. Clubbing with concepts of the green buildings and/or sustainable buildings

More often the energy efficiency improvement initiatives for the buildings are related with the concepts of the green buildings and/or sustainable buildings. Therefore, along with energy consumption, other aspects such as water use, indoor air quality, environmental protection, innovative green building design, use of energy efficient equipment and air-conditioning systems, etc., can also be included in the assessment of building performance. This approach ensures that the overall living environment of the building is improved. For the reporting of energy savings or emission reduction from the building sector, only that relevant information can be extracted from the MRV reporting for calculation of the GHG reduction benefits.

The consideration of the same in selected case study programs is discussed below.

a) Green Mark Program, Singapore: The scheme rates the buildings according to five key criteria which are (i) energy efficiency, (ii) water efficiency, (iii) environmental protection, (iv) indoor environmental quality and (v) other green and innovative features that contribute to the better building performance. Based on the overall assessment, a building will be awarded the Green Mark ratings (ranging from 75 to 190). The certified buildings are required to be re-assessed every three years to maintain the Green Mark status.

b) Energy Star Program, United States: This program does not evaluate performance of environmental or sustainability aspects, except for the energy performance and water consumption of a building. Though the Energy Star program is voluntary, many building owners actively participated in the program since studies found that the Energy Star certified buildings command a higher premium of up to 16 percent for the sales prices and rental rates. Also, the federal agencies may not lease space in any building that has not earned the Energy Star label in the most recent year.

c) Tokyo ETS, Japan: The program regulates only the GHG emissions at the building level. However, the facilities are allowed to sell their emission allowances that are left over once a facility's annual emissions are accounted for, thus providing opportunity to generate additional revenue.

In summary, clubbing of other sustainability concepts can encourage the building developer and/or building owners to effectively implement the MRV in order to achieve potential additional benefits from the increased rentals rates or revenue. This would lead to increased participation under the MRV program.

5.3.5. Digitalization of MRV

The digitalization of MRV would facilitate the program management, handles large volumes of information, allow access to multiple users and as well as integrate with other data management systems. A diligent design and standard format is essential for an efficient and effective MRV system. The data collection template can take up considerable part of the overall MRV efforts. The MRV system also needs to be able to accommodate changes in data sources and data structure. A traceable of data/ data sources and systematic of data flow helps ensure that the quality of the MRV system is maintained.

The consideration of the same in selected case study programs is discussed below.

a) Green Mark Program, Singapore: The program uses central electronic systems called as BCA Green Mark Online. It is a one stop platform for documentary evidence submission and Green Mark assessment. The platform offers multiple support tools such as e-score calculator, e-filing portal, building energy assessment system and technical support courses to stakeholders. The system directly collects the electricity consumption details of the building directly from the power utilities database.

b) Energy Star Program, United States: The electronic tool of the program is called as Portfolio Manager. It is an online tool that the industries can use to measure and track their energy and water consumption, as well as the GHG emissions. It can be used to benchmark the performance of one building or a whole portfolio of buildings and share reports with others, all in a secure online environment. Forty percent of commercial building space in the U.S., including 35% of the Fortune 500 are already assessing their performance using the Portfolio Manager[30].

c) Tokyo ETS, Japan: The program uses the Tokyo Registry System to manage the compliance reporting, assessment and crediting of allowances and trading of credits. The details of covered facilities are made publicly available on-line through the database.

Thus, a reliable database management is important for the accurate estimation of energy savings or emission reductions benefits from a program and assure that the emission reductions achieved are real and tradable under international climate/carbon markets standards.

As of July 2018, more than 3,300 buildings or 36% of the building stocks by ground floor area I Singapore have achieved Green Mark standards. This scheme has been adopted outside of Singapore with certified projects in Indonesia, Malaysia, Thailand and China. To date, close to 50 Singapore-based firms are involved in over 300 overseas Green Mark projects in 14 countries.

More than 9,500 buildings in US and Canada had earned the Energy Star certification in 2017, bringing the total to more than 32,000 buildings certified so far. On an average, the Energy Star certified buildings are found to use 35% less energy than the typical buildings nationwide.

The first compliance period of the Tokyo ETS came to an end in December 2014 and achieved an emissions reduction of 23% compared to the base year emissions during the four years. In 2017, the emissions from covered facilities amounted to 12.04 million tCO_2, achieving a 27% reduction from base emission as a result of continuous energy efficiency efforts.

The review of international best practices above provides valuable key lessons learned for Thailand as well as other countries to leapfrog their MRV system development. As part of this project, the key lessons learned have been integrated into the recommendations provided in the chapter below.

[30] Overview of EPA's ENERGY STAR Portfolio Manager®: A tool to measure and track energy consumption and greenhouse gas emissions

6. BARRIERS, GAPS AND OPPORTUNITIES

Ideally, effective MRV systems will allow policymakers to determine which policies are contributing most effectively to the climate mitigation goals, and to measure whether policies are achieving their goals cost-effectively. As demonstrated by some systems described in this project, tracking systems are well-equipped to serve this role when they involve an impartial review process, present information in a timely manner, and have a strong institutional connection to the policy development process. A strong, dynamic MRV system can allow policymakers to continually readjust to find the most efficient and effective policies and make the best use of available resources.

The barriers, gaps and opportunities are provided as follows:

(i) Barriers and gaps

(1) Lack of action, information linkage and guidelines between the energy and GHG emission reduction policies. e.g. the Alternative Energy Development Plan (AEDP2015) and the Energy Efficiency Plan (EEP2015) are presented in energy term (megawatt / ton of oil equivalent). However, there are not linkage to the GHG emission reductions (tCO_2); especially the GHG reduction targets under the Paris Agreement.
(2) MRV at the sector level and policy level need to use data from many government agencies in various ministries, and this data is not always easily accessible. Thus, there is a barrier in data access.
(3) For the BEC building/designated building measures, GHG emission reductions in building sector can be calculated from the energy efficiency improvement data in the energy management report. However, this energy efficiency improvement data might also include the energy efficiency data from the Label No.5 measure which could lead to double counting issue.
(4) There is limitation of data to determine the baseline, building energy use and building stock types. Without this data, it is challenging to develop reliable and practical baselines.
(5) Regarding the NDC Roadmap and NDC Action Plan (Energy sector), there are some mitigation measures that will promote/apply to non-designated building. They are not clear on how to engage the non-designated building to submit the required data on annual basis until 2030 (end of NDC period).
(6) Regarding the BEC building measure in the NDC Roadmap and NDC Action Plan (Energy sector), it is not clear on how to engage condominium and non-designated building to submit a report/energy management report on annual basis until 2030 (end of NDC period). Note that these types of building consume rather significant amount of energy and emit GHG emissions. However, in the current energy management system, these types are not covered.
(7) Comparing to the Green Mark Program (Singapore) reviewed in the previous chapter, the project found that there is a strong similarity with Thailand's BEC. From the analysis, it is found that there are gaps for Thailand's program. The Green Mark Certificate has 3-year validity with annual mandatory submission of the building information and energy consumption data, while the BEC standard is not clear on the validity period of the certificate as well as it has no annual mandatory submission of the building information and energy consumption data yet.

(8) Based on the comparison with the Energy Star program for building (USA) reviewed in the previous chapter, it is found that it is fairly resemble to BEC building in Thailand, but there are gaps. The Energy Star Certificate has 12-month validity, while the BEC standard is not clear on the validity period of the certificate.
(9) Based on the comparison with the Tokyo Emission Trading Scheme (Japan reviewed in the previous chapter). The scheme is a cap and trade the emission allowance. Thailand has not set the target group or cap of emission allowance for each building yet.

(ii) Opportunities

(1) As the building sector will be implemented in NDC period (year 2021-2030), so there is a period of time and opportunity to collect data from related government agencies and then establish a data center for relevant government agencies to access the data required for GHG emission.
(2) Since the existing energy management reporting system only covers designated buildings, there is an opportunity to expand the reporting requirement to capture energy consumption and GHG reductions from other types of buildings; especially buildings in the BEC scheme, condominiums, and other non-designated buildings.
(3) Currently, BEC standard is based on voluntary basis for new building or modified building. It is on the legal process for mandatory basis which is expected to be finalized within 2019. So, it is an opportunity to add a mandatory report submission on annual basis into this legal notification or following regulations.
(4) Given the fact that awareness on environmental conservation and sustainable development has increased significantly over the past few years, there are currently several private companies, real estate developers, building owners, and other relevant stakeholders developing their own GHG reporting systems and green building initiatives. Some of the leading companies are even listed on Dow Jones Sustainability Indices (DJSI). This provides a great opportunity for the government to engage these building owners to take parts in newly developed MRV system for building.
(5) With the experiences from international best practices reviewed in the previous chapter, it is found that there is a large opportunity to digitize the MRV system for buildings. This will enable building owners to easily input necessary data, process data efficiently, and extract and utilize the data effectively. This is also in line with the Thai Government's vision on Thailand 4.0 and Smart Cities.
(6) Although baseline is strongly needed for effective MRV system for buildings, there is currently a limitation of necessary data for baseline establishment. This is in fact another opportunity for Thailand MRV system development. Effective data collection, including energy use intensity (EUI), should be set up.

7. RECOMMENDATIONS TO STRENGTHEN MRV SYSTEM

7.1 Recommendation for the MRV practice

The proposed MRV practice for the building sector for both GHG inventory and mitigation measures is based on the current institutional arrangement and the existing reporting practice of designated building. The steps in the proposed MRV practice is as follows:

1. Owner of BEC building/designated building implements the BEC standard/energy conservation measure
2. The activity data of BEC building and the designated building is verified and compiled by the Department of Alternate Energy Development and Efficiency (DEDE)
3. The DEDE submits the activity data to the Energy Policy and Planning Office (EPPO)
4. The EPPO compiles the activity data from the DEDE and other government agencies (other subsectors in energy sector)
5. Relevant government agencies estimate GHG emissions
6. Working Groups (with support from TGO) review the estimation
7. The GHG emission estimation is submitted to the Climate Change Knowledge and Database Sub-Committee
8. The Climate Change Knowledge and Database Sub-Committee verifies the reported GHG emissions
9. The National Committee on Climate Change Policy (NCCC) approve the GHG emissions as included in the National Communication (NC) and Biennial Update Report (BUR)/ Biennial Transparency Report (BTR)

The proposed MRV practice in building sector is shown in Figure 7.1

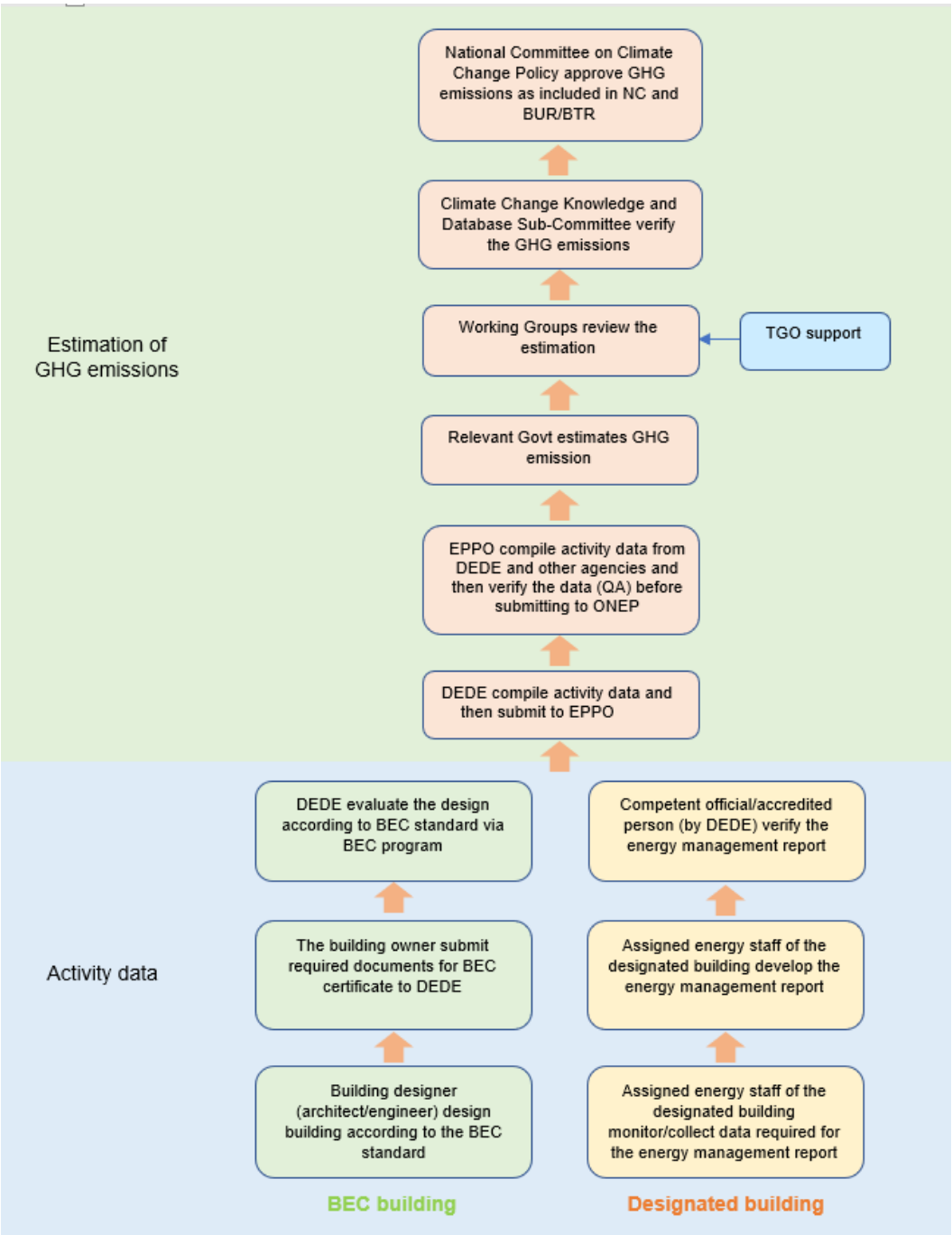


Figure 7- 1 Proposed MRV practice in building sector[31]

The relevant agencies involved in the GHG emissions in the building sector and their roles and responsibilities are shown in the Table 7-1.

[31] The proposed MRV diagram is developed by the author

Table 7- 1 List of relevant agencies and their roles and responsibilities

Agency name	Roles and responsibilities
Owner of BEC/designated building	- Support the national policy on energy efficiency/GHG emission reductions - Collect energy consumption data and prepare the energy management report in the required template - Submit to the competent authority/accredited person to review and approve the data by providing the energy audit and certification report - In case of BEC buildings, the owner submits the design of BEC building and other documents to the DEDE
Department of Alternative Energy Development and Efficiency (DEDE)	- Collect activity data from BEC building and designated building - Verify the required activity data for GHG emission estimation
Thailand Greenhouse Gas Management Organization (Public Organization) (TGO)	- Develop GHG methodologies - Design on the MRV system - Support in capacity building in collecting data and quality control - Support as GHG data center - Technical support related to GHG
Energy Policy and Planning Office (EPPO)	- Develop the NDC Action Plan in Energy Sector - Compile all activity data in energy sector
Office of Natural Resources and Environmental Policy and Planning (ONEP)	- Submit the GHG emission estimation to the Climate Change Knowledge and Database Sub-Committee
Working Group (Energy sector)	- Review the methodology of the GHG emission estimation as part of quality control to ensure that the GHG emission estimation is valid, accurate and compete
Climate Change Knowledge and Database Sub-Committee	- Verify the GHG emissions
National Committee on Climate Change Policy	- Approve the GHG emissions as included in the National Communication (NC) and Biennial Update Report (BUR)/ Biennial Transparency Report (BTR)

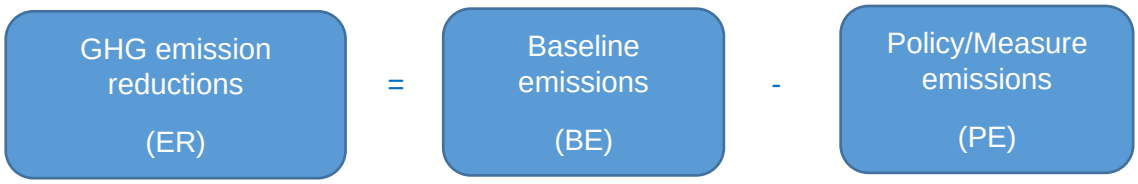
7.2 General recommendations for the building sector

(1) At present, the designated buildings are mandated to submit an energy management report on an annual basis. This report contains almost data required for the GHG calculation, but it is not generally reported in term of GHG inventory or emission reduction data. It needs to be further calculated as the GHG inventory or emission reduction data. Thus, the GHG report is required to be developed on annual basis (calendar year) for the best MRV practice.

(2) Unlike the designated building, BEC and non-designated buildings have no process or reporting system for the report submission on an annual basis. Therefore, it is required to create a reporting system for the BEC building and non-designated buildings participating in the DEDE's promotion/mitigation measures to submit the report on annual basis until 2030 (end of NDC period).

(3) Quantification and monetization of (positive and negative) externalities over the building life cycle should be well-integrated into decision-making processes.
(4) Continuous monitoring and constant modification of performance and dynamics of building codes would allow implementation to catch up with the potential for efficiency improvements and co-benefits. This would also provide better feedback to the policymaking process, creating awareness, capacity building and training. For the designated building, there is a well-designed data collection and reporting system. In order to improve this existing practice to be an appropriate MRV for GHG emissions, the determination of quality indicator for the responsible organizations should be measurable as per institutional arrangement policy and design of domestic MRV system should be conformed to an existing practice.
(5) As per the BEC building measure in the Energy Efficiency Plan (EEP2015) that aims to reduce energy demand by 36% (1,166 ktoe) of the total energy demand in new buildings to achieve international green building standard such as Leadership in Energy and Environment Design (LEED) or Thai's Rating of Energy and Environmental Sustainability (TREEs) standards by Thai Green Building Institute (TGBI). If these plans could combine or link to GHG emission term, then it would be a clear understanding.
(6) The data of Label no.5 should be separately identified in the energy management report for avoiding on double counting issue.
(7) The recommendation on the GHG emission methodology is provided below;

The general equations to calculate the GHG emissions are given below.



GHG emission = Activity Data (AD) x Emission Factor (EF)

Where:

BE_y = Baseline emission in year y (tCO_2/year)
PE_y = Policy/Measure/Project/Activity emission in year y (tCO_2/year)
ER_y = Emission reduction in year y (tCO_2/year)
AD = Activity data (unit/year)
EF = CO_2 emission factor (tCO_2/MWh)

The activity data is the measure of energy consumption in a facility/unit. In buildings, electricity is the major source and hence any savings in the electricity would result in reduction of GHG emissions.

1) Fixed baseline year (energy saving multiply by grid emission factor)

$$ER_y = \Delta EC_y \times EF_{EC,y} \times 10^{-3}$$

Where:

$$\Delta EC_y = BE_{EC,y} - PE_{EC,y}$$

Where:

ER_y = Emission reductions in year y (tCO_2/year)
ΔEC_y = Electricity saving in year y (kWh/year)
$EF_{EC,y}$ = Grid emission factor in year y (tCO_2/MWh)
$BE_{EC,y}$ = Baseline electricity consumption in year y (kWh/year)
$PE_{EC,y}$ = Policy/Measure/Project/Activity electricity consumption in year y (kWh/year)

2) Specific Energy Consumption

The emission reduction calculation based on the specific energy consumption formulae is

$$BE_y = SEC_{BL,y} \times Area_{PJ,y} \times EF_{EC,y} \times 10^{-3}$$
$$PE_y = SEC_{PJ,y} \times Area_{PJ,y} \times EF_{EC,y} \times 10^{-3}$$
$$ER_y = (SEC_{BL,y} - SEC_{PJ,y}) \times Area_{PJ,y} \times EF_{EC,y} \times 10^{-3}$$

Where:

$$SEC_{PJ,y} = EC_{PJ,y} / Area_{PJ,y}$$

Where:

BE_y = Baseline emission in year y (tCO_2e/year)
PE_y = Policy/Measure/Project/Activity emission in year y (tCO_2e/year)
ER_y = Emission reductions in year y (tCO_2e/year)
$SEC_{BL,y}$ = Baseline specific energy consumption saving in year y (kWh/m^2)
$SEC_{PJ,y}$ = Policy/Measure/Project/Activity specific energy consumption saving in year y (kWh/m^2)
$EF_{EC,y}$ = CO_2 emission factor of the grid electricity in year y (tCO_2e/kWh)
$EC_{PJ,y}$ = Policy/Measure/Project/Activity electricity consumption in year y (kWh/year)
$Area_{PJ,y}$ = Policy/Measure/Project/Activity covered area in year y (m^2)

(8) Generally, the GHG emission inventory and the GHG emission mitigation measure are reported on annual basis. Since the GHG reporting format has not been created so far, therefore it should be created by all relevant agencies e.g. TGO, DEDE, ONEP and Energy Working Group. The GHG report could be reported via online submission for ease of convenience to the related agencies.

(9) Verification is the periodic independent review of reported data. It is the process of confirming the GHG inventory as well as the GHG emission mitigation actions achieved by the implemented measures. Thus, based on the domestic MRV system and institutional arrangement proposed in the second BUR, the GHG data should be verified by the Energy Working Group and the Climate Change Knowledge and Database Sub-Committee respectively. The verification guideline should be determined by all relevant agencies e.g. TGO, DEDE, ONEP and Energy Working Group as appropriate for the building sector.

Initiative for Climate Action Transparency (ICAT):

Improving Thailand's MRV System for Climate Change Mitigation

Final Report on MRV for the Building Sector - Annexes

Photo by Andreas Brücker on Unsplash

Initiative for Climate Action Transparency - ICAT -

Improving Thailand's MRV System for Climate Change Mitigation

Deliverable #1

AUTHORS

The Global Green Growth Institute

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DISCLAIMER

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Annex 1. Green Mark Scheme for Buildings, Singapore

1. Introduction

As a resource constrained country, Singapore depends on the imported fuel for all of its energy needs. It has limited access to the renewable energy sources. Therefore, the energy efficiency forms a core part of its Clean Energy Strategy, which features a national target of greening at least 80 percent of its buildings by 2030. The main initiative under this building energy efficiency strategy is the Green Mark Scheme, a rating system to evaluate the environmental impact and the buildings performance based on the internationally-recognized best practices.

2. Key program features

Scope	All residential, commercial and industrial buildings
Mechanism	Issuance of certification based on the level of energy efficiency of a building in comparison with the benchmarked performance
Participation	Mandatory and supported with incentives
Performance benchmarking	Standards are updated and revised at regular intervals by the Building and Construction Authority (BCA) of Singapore
Certification validity	3 years
Monitoring, Reporting and Verification	Monitoring and annual reporting is done at facility level. The building performance must be verified by the third-party verification agency before issuance of certification

3. Legal framework

The building sector is well-regulated in Singapore. The Code for Environmental Sustainability of Buildings was first published in 2008 and adopted as the compliance standard under the Building Control (Environmental Sustainability) Regulations. It sets out the mandatory environmental sustainability standard providing a baseline to drive and integrate green building design into the mainstream building practices. The Code covers various key sustainability aspects delineated by the established Green Mark criteria framework including the energy efficiency, water efficiency, use of sustainable materials, waste reduction, sustainable construction, indoor environmental quality and use of other green features, practices and technologies. From 2008, all the new buildings and the existing buildings with the gross floor area (GFA) above 2000 m^2 that undergo major retrofitting works must meet the Green Mark Certification standard.

Under the Building Control Act 2012 Amendment, the annual submission of energy consumption data is also required via the Building Energy Submission System (BESS) online portal. These requirements were implemented in stages starting with the hotels, retail buildings and office buildings.

There is also an Energy Conservation Act enacted in 2013 which mandates the companies consuming more than 15 GWh of energy per year to:

- Appoint a trained Energy Manager

- Monitor and report energy use within the company
- Submit the energy efficiency improvement plans

In 2014, it became mandatory for the building owners to conduct periodic energy audits and achieve the minimum Green Mark certification when updating or retrofitting their cooling system.

4. Scheme design

The Singapore Green Mark Scheme was developed in January 2005 by the Building and Construction Authority (BCA) of Singapore and supported by the National Environment Agency (NEA) to build more environment-friendly buildings. It intends to promote sustainability in the building environment and raise environmental awareness among the developers, designers and builders to eventually deliver ‘‘healthier’’ products to end-users. It uses a benchmarking approach to achieve a sustainable building environment by incorporating the best practices in the environmental design & construction and the adoption of the green building technologies. Incentives (monetary and grant of additional floor area above Gross Plot Ratio (GPR)) are given to the developers/projects that meet the requirements of the Green Mark certification.

The scheme comprises a number of distinct rating tools which comprehensively rate a building for its environmental performance. The rating tool covers the following buildings types:
- New buildings: non-residential, residential, data centers and landed housing
- Existing buildings: non-residential, residential, data centers and schools
- User centric: office interior, retail, supermarket, restaurant and laboratories
- Beyond buildings: districts, parks and infrastructure

Figure A.1.1 provides the simple process flow of Green Mark scheme.

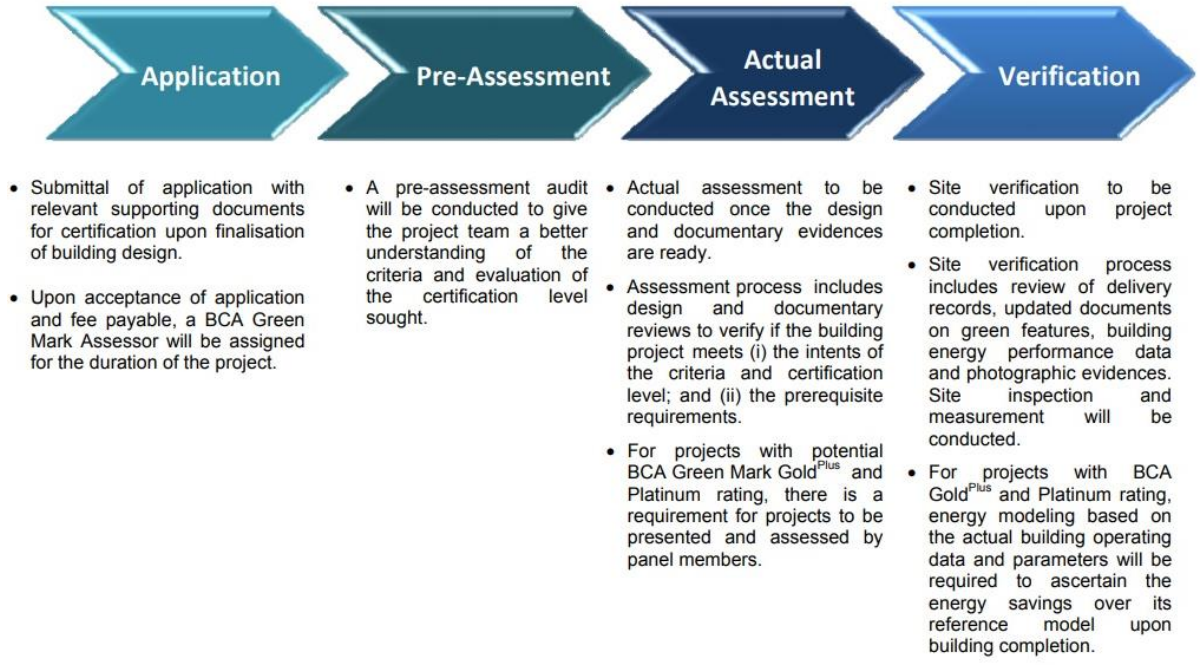

Figure A.1.1. Process flow of Green Mark scheme

The scheme rates the buildings according to five key criteria:
- Energy efficiency

- Water efficiency
- Environmental protection
- Indoor environmental quality
- Other green and innovative features that contribute to the better building performance

Based on the overall assessment, a building is awarded one of the following Green Mark certification based on the ratings:

- Green Mark Certificate (for rating from 50 to 74)
- Green Mark Gold (for rating from 75 to 84)
- Green Mark Gold Plus (for rating from 85 to 89)
- Green Mark Platinum (for rating from 90 and above)

The buildings are awarded a maximum of 140 points for the residential category and 190 points for the non-residential category. The scheme sets parameters and establishes indicators to guide the design, construction and operation of the buildings towards increased energy efficiency and enhanced environmental performance. Figure 2 represents the general schematic of green mark certification process.

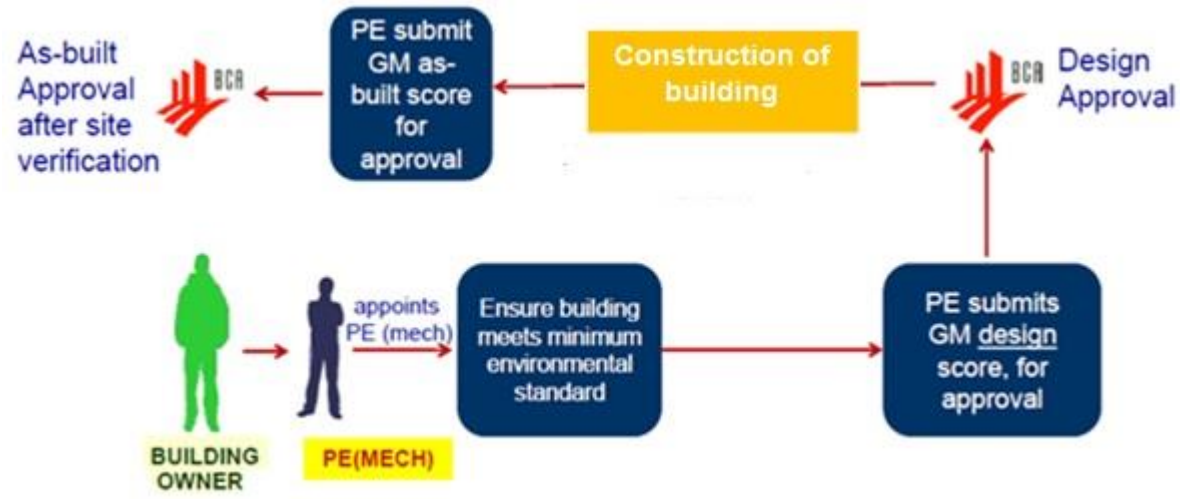

Figure A.1.2. Schematic of Green Mark certification process for buildings

Initially, the participation in the scheme was voluntary for the existing buildings in the private sector. However, a 2008 regulation requires all new buildings and all existing buildings undergoing major retrofitting to meet at least the minimum Green Mark standards. The public sector is held to higher requirements. All new public buildings must achieve Platinum rating and all existing public buildings must achieve Gold Plus rating by 2020. The achievement of higher Green Mark ratings is also a land-sales condition in key growth areas.

The certified Green Mark buildings are required to be re-assessed every three years to maintain the certification status. The new buildings certified are subsequently be re-assessed under the existing buildings criteria. Before the beginning of the assessment process, a project developer must submit an application form to the BCA. After that, the BCA team conducts a meeting with the project team to specify the criteria and request for the documentary proofs to substantiate the submissions. The actual assessment includes the design and the documentary reviews as well as the site verification. The documentary evidences should be submitted at the end of the assessment. When the assessment is fully completed, a letter of award (Certification) is sent to the project developer.

5. Incentive schemes

Several incentive schemes have been introduced particularly to encourage the private sectors to actively involve and support the green vision of Singapore. The SGD 20 million Green Mark Incentives Scheme for New Buildings (GMIS-NB) was initially introduced by the BCA in 2006, followed by a SGD 100 million Green Mark Incentives Scheme for Existing Building (GMIS-EB) as well as the Green Mark Incentives Scheme for Gross Floor Area (GM GFA) in 2009.

To encourage innovation in the green building development, the Green Mark Incentives Scheme for Design Prototype (GMIS-DP) worth SGD 5 million (≈ 3.65 million USD) was introduced in 2010. In 2011, the BCA implemented the Pilot Building Retrofit Energy Efficiency Financing (BREEF) Scheme. Another incentive scheme was then applied in 2014 for Existing Building and Premises (GMIS-EBP). These incentive schemes were one of the success factors of the green building implementation in Singapore encouraging the private sectors to participate and succeed in the green vision of the country.

6. Methodology

Under the Green Mark scheme, the building owners are required to provide basic building information such as the GFA, building activity and building systems. The electrical energy consumption data is obtained directly from the utility companies. The other data such as the fuel consumption, building information, etc., are submitted by the building owners. The following information are required under the mandatory submission of building information:

- Ownership and activity type (ownership, occupancy type, activity type, etc.)
- Building data (GFA, air-conditioning floor area, renovation/retrofitting works, etc.)
- Service information (lifts, air conditioning and mechanical ventilation (ACMV), lightings and hot water systems)
- Energy consumption (electricity, diesel, etc.)

The Building Energy Submission System (BESS) facilitates seamless data collection by drawing electricity data directly from the utilities. The building owners are only required to update any changes to the building information as they arise and review the energy consumption data prior to completing the submission. The building owners have to submit their energy consumption details every year through this online portal.

The electricity is the main source of energy used in Singapore buildings and the other energy sources were excluded in the computation of EUI. The EUI is measured by the total electricity used within a building in a year, expressed as kilowatt hour (kWh) per gross floor area (m^2).

$$Energy\ use\ intensity\ (EUI) = \frac{Total\ energy\ consumption\ (kWh)\ in\ a\ year\ y}{Gross\ floor\ area\ (m^2)}$$

Where,

Total energy consumption in a year y	=	Energy consumed by the building (excluding energy generated by the renewable energy sources)
Gross floor area	=	All covered floor areas of a building, except otherwise exempted and uncovered areas for commercial uses, are deemed the gross floor area

of the building. Generally, car parks are excluded from gross floor area computation.

The EUI is used as an index by the building owners and the facility managers to compare their building's annual energy performance against the similar building types. The total number of energy intensive buildings trended each year are updated to reflect the newly added buildings and the existing buildings that have completed major renovation. A study was conducted to compare the Green Mark certified building energy savings with the non-green mark buildings by the BCA. It found that the Green Mark buildings has less energy use intensity (EUI) than the non-Green Mark buildings and during 2008 to 2017, the annual electricity consumption of buildings has increased at a slower rate by 25%, compared with the growth of the GFA at 40%. However, the EUI of energy intensive buildings have improved to 11% over these period.

7. Measurement, reporting and verification (MRV)

The MRV of the building performance are set within the certification process of the program. The three key elements in the Green Mark certification of the existing buildings and the MRV involved are detailed as below.

7.1. Minimum Green Mark Certification standard for the buildings with GFA of at least 15,000m^2

Figure 5 provides the schematic of certification process for the existing buildings that renovates the chiller unit.

Figure A.1.3. Schematic of Green Mark certification process for existing building that renovates the chiller unit

The building owners are required to meet the minimum environmental sustainability standard at the time of construction or installation of chiller units. They must engage a Professional Mechanical Engineer (PE) registered with the BCA to carry out an evaluation of their building design in accordance with the prescribed code and submit the necessary documents to the BCA. The BCA will provide a design approval to continue with the construction or installation. Once the works are complete, the application must be submitted with the PE assessment of final building to the BCA for review and issuance of the Green Mark certification.

7.2. Three-yearly energy audit on the building cooling system for the buildings with GFA of at least 15,000 m^2

Figure 6 shows the schematic of three yearly energy audit process.

The building owners must engage a PE or an Energy Auditor registered with the BCA to carry out an energy audit on their premises in accordance with the prescribed code and submit the necessary documents to the BCA. This is to ensure that a building cooling system continues to operate efficiently and comply with the minimum standards throughout its lifetime.

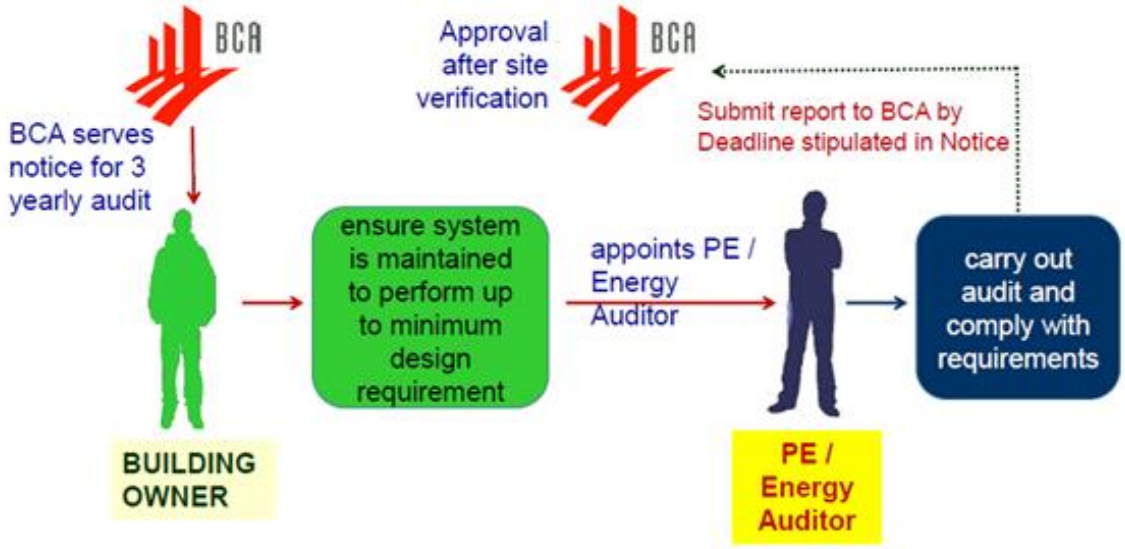

Figure A.1.4. Schematic of three yearly audit process

7.3. Annual mandatory submission of the building information and energy consumption data

The building owners must submit the building information and energy consumption data annually through an online submission portal. The submitted data forms the basis of the national building energy benchmarks, which is shared with the building owners to encourage them to improve the energy performance of their buildings. The Building Energy Submission System (BESS) facilitates data collection by drawing electricity consumption data directly from the power supplying units. The building owners are only required to update any changes to the building information as they arise and review the energy consumption data prior to completing the submission. The BESS also includes access to downloadable self-help tools such as a user submission manual, technical guides and training and demonstration videos.

At the close of the submission period, the data collected through the BESS is checked for any inconsistencies or data entry errors. Once all the data has been verified, the national energy benchmarks for the commercial buildings are carried out and the findings are shared with the building owners via the BESS and the BCA Building Energy Benchmarking Report (BEBR).

It must be noted that a security deposit of 50% of the market value of the allowable GFA is retained by the BCA upon application of the GFA incentive and there are significant financial penalties for failing to achieve the agreed level of compliance, which may exceed the security deposit value.

The BCA has focused training programs aimed at equipping professionals with new skills, to deepen their professional skills and expertise in the area of environmental sustainability. These include the Certification courses for the Green Mark Managers (GMM), the Green Mark Facility Managers (GMFM) and the Green Mark Professionals (GMP).

8. Implementation status

The Green Mark scheme was launched in 2005 to rate the environmental sustainability of buildings. Since then, it has evolved to cover 17 different types of buildings such as data centers, retail outlets, supermarkets, parks, homes and offices. Table 3 provides the list of different building types considered for Green Mark certification.

Table A.1.1. Green Mark categories

Building type	Categories
New buildings	• New non-residential Buildings • New residential Buildings • Landed houses
Existing buildings	• Existing non-residential Buildings • Existing residential buildings • Existing schools
Within buildings	• Office Interior • Restaurants • Retail Outlets • Supermarket • Data Centers
Beyond buildings	• Existing parks • New parks • Infrastructures e.g. barrages, bridges, road construction etc. • Rapid Transit Systems (RTS) • Districts e.g. improving energy efficiency in district cooling, heating, waste management etc.

As of July 2018, more than 3,300 buildings or 36% of the buildings by gross floor area have achieved Green Mark standards[1]. This scheme has also been adopted outside of Singapore with certified projects in Indonesia, Malaysia, Thailand and China. To date, close to 50

[1] Super low energy technology road map, BCA, 2018

Singapore-based firms are involved in over 300 overseas Green Mark projects in 14 countries[2].

9. Lessons learnt

Starting with a strong commitment from the policy maker to set and achieve the green vision, the BCA has been endorsed and fully supported by the NEA to develop and manage the Green Mark scheme.

- Public sector leading the change: The public sector took the lead and provided good examples in greening both the new and existing public sector buildings. The government is very active in trying to forge interaction among the various stakeholders. In the process of refreshing its master plan and legislation, BCA calls upon an international panel of experts to provide their feedback and engages stakeholders through consultation sessions to review their plans and standards.

- Strong incentive schemes for the private sector: The Government provides incentive schemes to encourage the private sectors to green their new and existing buildings. The government also provides adequate support for the green building research and trainings in raising 'green' awareness among the public and the industry.

- Green building features are still expensive: The high cost of a green building is related to provisions of green materials and technology which typically cost more than the conventional ones. The tenants of a green building are seen to have more benefits compared to the builder who have to fork out the premium costs. The lack of information of green products, system and technologies put the builders in difficult position to execute a green building.

- Difficulty in coping up with the rapid technology changes: As the codes and regulations of the green buildings are getting more complex, the builders find difficulties in estimating the costs to comply with the codes and regulation. The use of materials which are not environmentally friendly by local contractors is still found in practice. The public awareness of the latest technologies and benefits of green buildings is also found insufficient.

Applicability for Thailand

The certificate has validity 3-year period with annual mandatory submission of the building information and energy consumption data. Thus, the validity period could apply for BEC building in Thailand as well as mandatory submission on building information.

[2] https://www.bca.gov.sg/newsroom/others/PR_GMA2018.pdf

Annex 2. Energy Star Program for Buildings, United States of America (USA)

1. Introduction

The Energy Star is a voluntary program which was initiated by the United States Environmental Protection Agency (EPA) in 1992 to drive the economy towards an energy efficient and cost -effective path. Initially, the program started with star labelling of energy efficient products and over the years was expanded to include all major appliances, office equipment, lighting, home electronics, new homes and commercial & industrial buildings and manufacturing plants. Through its Energy Star label, the program provides a simple, credible and unbiased product information to the end users for decision making.

2. Key program features

Scope	All major appliances, office equipment, lighting, home electronics, new homes and commercial & industrial buildings and manufacturing plants
Mechanism	Issuance of certification based on the level of energy efficiency of a product or building in comparison with the benchmarked performance
Participation	Voluntary
Performance benchmarking	Revised every four years with the latest data to compare the product or buildings energy performance
Certification validity	12 months
Monitoring, Reporting and Verification	Monitoring and reporting is done at the facility level. The product or building performance must be verified by the third-party verification agency before issuance of certification

3. Legal framework

The Energy Star program was established by the EPA under the Clean Air Act, 1963 which was amended in 1977. In 1993, the EPA piloted the Energy Star Buildings program with 23 building owners to showcase an approach. Later in 2005, the Energy Policy Act directed the EPA and the Department of Energy (DoE) to implement a voluntary program to identify and promote energy efficient products and buildings in order to reduce the energy consumption, improve energy security and reduce pollution.

The regulation mandates use of Energy Star labelled products such as the lighting fixtures and the bulbs in all the federal buildings and the procurement of energy efficient appliances for installations in the public housing. All federally owned buildings are required to track and report their energy use under the Energy Star program. Also, the federal agencies may not lease space in any building that has not earned the Energy Star label in the most recent year.

Countries like Canada, Japan, Iceland, Liechtenstein, Norway, Switzerland and Taiwan have included the Energy Star standards in their own policies through the formal agreements with the EPA.

4. Scheme design

Figure A.2.1 shows the simple schematic of the Energy star certification.

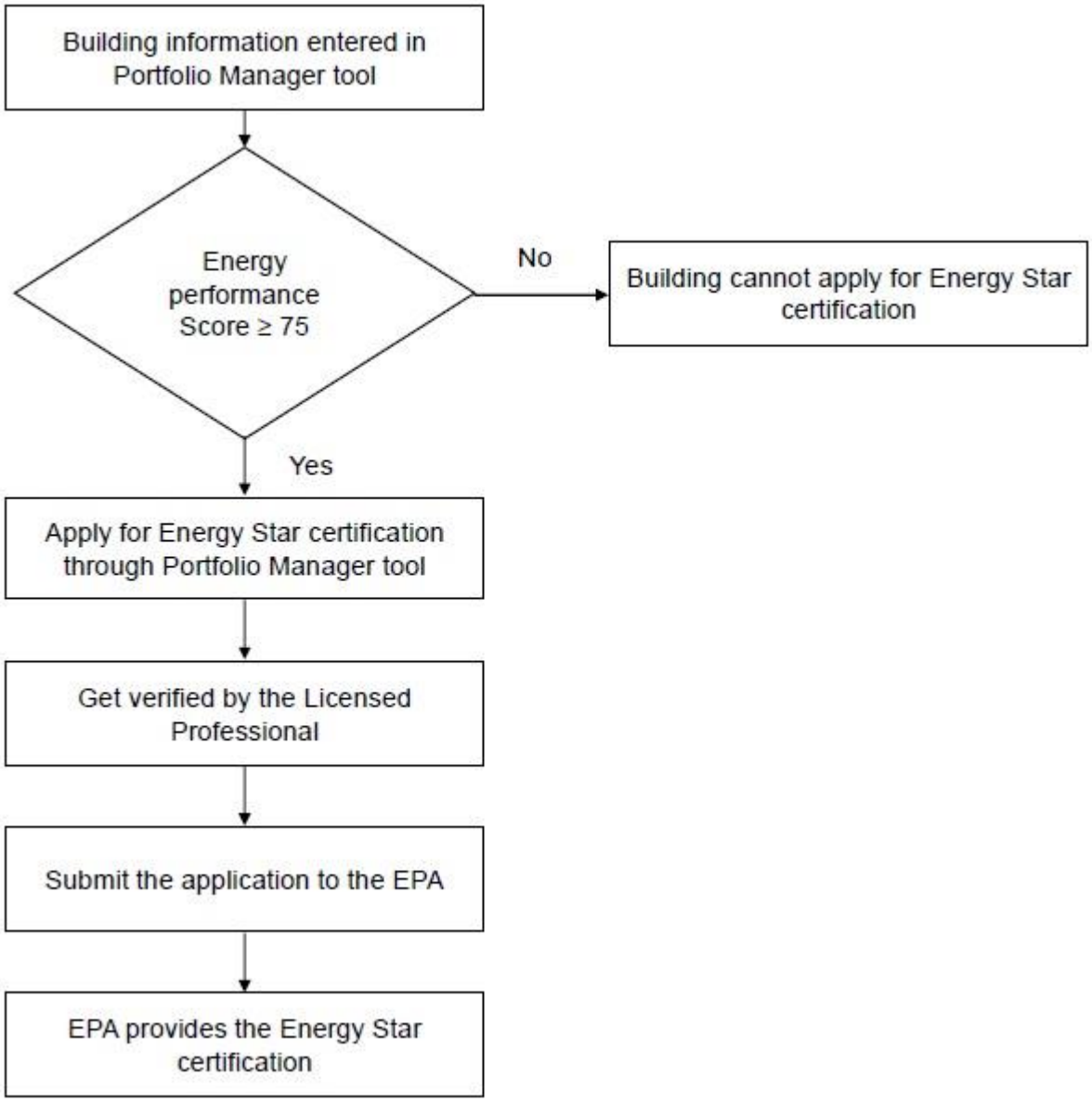

Figure A.2.1. Schematic of Energy Star certification

The Energy Star program is intended to promote sustainability in the building environment and raise environmental awareness among the developers, designers and builders and eventually deliver ‘‘healthier’’ products to the end-users.

The energy performance score system of the program provides the building managers a standardized, comparable metric for improving the building energy efficiency. The building managers need to enter the building operating characteristics and a year of utility bills into the EPA’s online benchmarking tool - Portfolio Manager, to receive a 1-to-100 score indicating

how the building compares to similar buildings nationwide. A score of 75 or higher is eligible to earn the Energy Star certification.

The Portfolio Manager tool obtains the energy consumption data of the buildings from the energy service providers over the web services directly. It helps to measure and track the energy use, water use and GHG emissions of the buildings through online. It can also be used to identify under-performing buildings, set investment priorities, verify efficiency improvements and receive the Energy Star certification.

The Energy Information Administration (EIA) under the Department of Energy conducts a nationwide survey to gather data on the building characteristics and the energy use from thousands of buildings for every four years. This Commercial Building Energy Consumption Survey (CBECS) is the only national-level source of data on the characteristics and energy use of the commercial buildings. The Portfolio Manager tool compares the individual building performance against this building survey performance benchmarks and provides the score for that respective building.

The energy performance scores are available for 15 different types of buildings a listed below representing over 50% of the commercial building space in the US.

- Bank/Financial institution
- Courthouse
- Data centers
- Hospital
- Hotel
- House of worship
- School
- Medical office
- Municipal wastewater treatment plant
- Office
- Residence hall/Dormitory
- Retail store
- Senior care
- Supermarket
- Warehouse

Once the building is registered in the Portfolio Manager tool, the following steps are used to compute the score for a building:

i. Computation of actual source EUI
ii. Computation of the predicted source EUI
iii. Computation of the efficiency ratio comparing the actual EUI with the predicted EUI
iv. Assigning the score based on how the ratio compares with the national performance benchmarks

5. Incentive schemes

A tax deduction of up to USD 1.80 per square foot is available to the owners or designers of the commercial buildings or systems that save at least 50% of the heating and cooling energy

as compared to that of the ASHRAE Standard 90.1-2007[3]. The deduction is available for the buildings or systems placed in service before December 31, 2017.

The Federal Energy Policy Act of 2005 established tax credits of up to USD 2,000 for the builders of new energy-efficient residential buildings. However, this tax credit was stopped in December 2017.

6. Methodology

The commercial buildings consume energy from different sources such as electricity, natural gas, fuel oil, district steam and many others. The energy consumption at the site is the net energy use which does not include the generation efficiency and transmission/distribution losses occurred during the conversion from the primary source energy. To evaluate energy performance for these buildings, the source energy is the most equitable unit of evaluation and enables a complete assessment of the energy efficiency. The Energy Star program considers only the primary energy (source energy) of the buildings for the performance evaluation.

The main aim of the Energy Star program is to provide comparisons of the building EE relative to a national peer group and therefore it is more appropriate to employ the national-level source-site ratios. As the Portfolio Manager tool is available in both the United States and Canada, country-specific source-site ratios are used. For each country, there is only one national source-site ratio for each of the primary and secondary fuels in the Portfolio Manager tool, including the grid purchases of electricity.

The source-site ratios computed and applied in the Portfolio Manager tool depends on several characteristics including the quality of the fuels, the average efficiency of conversion from primary to secondary energy and the distribution efficiency. Therefore, the ratios are expected to change in due course of time as the national infrastructure and fuel mix evolve. The characteristics that impact the ratios do not change drastically from one year to the next ,but may be expected to change over time. Therefore, the ratios for all fuels are reviewed every three to five years and updated accordingly. Additionally, the specific ratios may be updated as needed to reflect new information, methodologies or policies.

6.1. Source-site ratio for different primary and secondary energy use

Electricity from grid

The source-site ratio for the grid electricity is calculated from the Energy Information Administration's (EIA) Monthly Energy Review (MER). The MER report includes the information about the electricity generation in the US from the fossil fuels, nuclear and the renewable energy systems. The source-site ratio for the grid electricity is calculated as follows:

$$Source - site\ ratio = \frac{Total\ energy\ consumed\ in\ the\ electricity\ generation}{Net\ electricity\ generation - Transmission\ and\ distribution\ lossses}$$

The source-site ratio can be calculated separately for any given year and the average of past five years of source-site ratio is considered for the estimation.

Electricity from the renewable sources

[3] The American Society of Heating, Refrigerating and Air-Conditioning Engineers

The electricity generated from the renewable energy sources such as solar photovoltaic panels, wind turbines, etc., at the building site are considered as a secondary form of energy. There is no conversion loss from these renewable energy sources, because electricity is derived from the sun or the wind directly. In addition, as the electricity is converted on-site, there are no transmission or distribution losses too. Hence, the source-site ratio for the on-site solar or wind electricity is considered as 1.0.

Wood

Wood is a type of primary energy that is combusted on site to produce heat and/or electricity. There is no transmission or distribution losses associated with the delivery of wood to a site. Therefore, the source-site ratio for wood is considered as 1.0.

Coal

Coal is a type of primary energy that is burned on-site to produce heat and/or electricity. There is no direct quantifiable loss of coal that occurs when it is stored, transported or delivered to a building. Therefore, the source-site ratio for coal is taken as 1.0.

Natural gas

The EIA publishes an annual report on the natural gas energy generation and consumption, losses occurred in the pipeline, etc. The source-site ratio is calculated from the data published in the annual report. The source-site ratio accounts the losses incurred in pipeline transmission and distribution of natural gas from the provider to the customer. This source-site ratio indicates the total amount of gas that is used at the distribution plant or lost in transmission for each unit of gas that is delivered to a consumer. The source-site ratio for the natural gas is calculated as follows:

$$Source - site\ ratio = \frac{\binom{Gas\ delivered\ to}{the\ customer} + \binom{Gas\ consumed\ at\ the\ plant}{and\ at\ pipeline\ distribution}}{Gas\ delivered\ to\ the\ customer}$$

Petroleum products

The petroleum products include the fuel oil, diesel and kerosene. The source-site ratio takes into account the losses incurred in fuel distribution, storage and dispensing. The EIA does not produce an annual report that quantifies the losses associated with the fuel oil distribution, storage and dispensing. A Lifecycle Emissions Study (LEM) conducted by the University of California is considered for the source-site ratio calculation.

The LEM study identified that for every 100 units of oil use by end consumer, the distribution and storage losses is around 0.8 units and losses in the fuel dispensing is around 0.2 units. Thus, the source-site ratio for petroleum products is considered as 1.01 (i.e., (100+0.8+0.2) /100)

District steam

The district steam is a type of secondary energy that is generated off-site and delivered to a building. The district steam is generated using both the conventional boiler technology and the combined heat and power (CHP) technology. Both systems are incorporated into the source-site ratio to accurately reflect the steam market. Properties of district systems, including ranges

for the production and distribution efficiencies are taken from “District Energy Services: Commercial Data Analysis for EIA’s National Energy Modelling System” report.

In the case of conventional boiler steam generation, the source-site ratio is calculated as follows.

The boiler efficiency at full load condition is calculated as,

$$Boiler\ efficiency_{\ full\ load\ condition} = \begin{pmatrix} Average\ of\ the\ typical\ boiler\ efficiency \\ range\ taken\ from\ the\ EIA\ report \end{pmatrix}$$

The boiler efficiency at part load condition is calculated as,

$$Boiler\ efficiency_{\ part\ load\ condition} = \begin{pmatrix} Maximum\ boiler\ efficiency\ at\ part\ load \\ condition\ taken\ from\ EIA\ report \end{pmatrix}$$

Based on the boiler efficiency at full load and part load condition, the production efficiency is calculated as,

$$\begin{pmatrix} Production \\ efficiency \\ (\%) \end{pmatrix} = \\ \left(Boiler\ efficiency_{\ full\ load\ condition}\right) X \left(Boiler\ efficiency_{\ part\ load\ condition}\right)$$

The heat losses from the boiler are taken from the EIA report.

$$\begin{pmatrix} Heat\ losses \\ from\ the\ boiler\ (\%) \end{pmatrix} = \begin{pmatrix} Average\ of\ the\ typical\ boiler\ losses \\ range\ taken\ from\ the\ EIA\ report \end{pmatrix}$$

Accordingly, the overall efficiency of boiler system is calculated as,

$$\begin{pmatrix} Efficiency\ after\ heat\ losses \\ from\ the\ boiler\ (\%) \end{pmatrix} = \begin{pmatrix} Production \\ efficiency\ (\%) \end{pmatrix} - \begin{pmatrix} Heat\ losses\ from\ the\ boiler\ (\%) \\ \times \\ Production\ efficiency\ (\%) \end{pmatrix}$$

From above parameter, the source-site ratio is calculated as,

$$Source - site\ ratio = \frac{1}{Efficiency\ after\ heat\ losses\ from\ the\ boiler\ (\%)}$$

In the case of the CHP steam generation, a separate nation-wide study was conducted by the EIA. It is found that the average CHP district system produces 33.2 units of steam and 25.6 units of electricity for every 100 units of input energy. This is equivalent to a system-wide conversion efficiency of 59%.

$$Conversion\ efficiency = \frac{Steam\ and\ electricity\ output}{Total\ input\ energy}$$

The input for the steam in CHP technology is compared with the conventional boiler system to produce the same amount of steam. The ratio of the steam input to the total input for the traditional systems is multiplied by the total CHP input energy of 100 units to get the input energy associated with steam generation for the CHP system.

For example, assuming a conversion efficiency of 82.5% for traditional steam and 32% for traditional electricity, 40.2 units of input energy would be needed to produce the same amount of steam and 80.0 units of input energy would be needed to produce the same amount of electricity in the CHP system. Then, the total input energy for the traditional systems would be 120.2. The percent breakdown in the input energy for the traditional systems can be used to equitably divide CHP input energy between the steam and electricity. The ratio of the steam input to total input for the traditional systems (40.2 units / 120.2 units = 33.5%) can be multiplied by the total CHP input energy of 100 units to get the input energy associated with steam generation for the CHP system of 33.5.

The production efficiency is calculated as,

$$\begin{pmatrix} Production \\ efficiency \end{pmatrix} = \frac{Steam\ output\ from\ the\ CHP}{Input\ energy\ for\ steam\ generation\ in\ CHP} = \frac{33.2}{33.5} = 99.2\%$$

Accordingly, the overall efficiency of boiler system is calculated as,

$$\begin{pmatrix} Efficiency\ after\ heat\ losses \\ from\ the\ boiler\ (\%) \end{pmatrix} = \begin{pmatrix} Production \\ efficiency \\ (\%) \end{pmatrix} - \begin{pmatrix} Heat\ losses\ from\ the\ boiler\ (\%) \\ \times \\ Production\ efficiency\ (\%) \end{pmatrix}$$

The source-site ratio for the CHP system from the production efficiency is calculated from the formulae similar to the conventional boiler system as mentioned below.

$$Source - site\ ratio = \frac{1}{Efficiency\ after\ heat\ losses\ from\ the\ boiler}$$

At the national level, the district steam source-site ratio is calculated by the weighted average of the CHP and non-CHP ratios found using the above mentioned formulae.

Other fuels/energy sources

The Portfolio Manager tool includes the source-site ratio for many types of fuels, each of which falls into one of the preceding categories. In the event that a building using a different fuel on-site (e.g., waste biomass), then a user may select the “Other” category. In these situations, because the primary fuel source is not reported, it is not possible to quantify losses associated with conversion, transportation or distribution. Hence, the source-site ratio is considered as 1.0.

6.2. Energy Use Intensity (EUI)

The building energy consumption is estimated using the source-site ratio in the Portfolio Manager tool. The building owners enter the secondary energy consumption data which is converted into the primary energy form in the Portfolio Manager tool. The Portfolio manager tool presents the total primary energy consumption of the building to the owners which makes them aware and encourages them to further improve the building energy efficiency.

The total primary energy consumption in the building is given as,

$$\begin{pmatrix} Total\ primary\ energy \\ consumption\ in \\ the\ building \end{pmatrix} = \left(\begin{array}{l} \left(\begin{pmatrix} Energy\ consumed \\ from\ the\ fuel\ type\ 1 \\ in\ the\ building \end{pmatrix} \times \begin{pmatrix} Source - site\ ratio \\ of\ fuel\ type\ 1 \end{pmatrix} \right) \\ + \\ \left(\begin{pmatrix} Energy\ consumed \\ from\ the\ fuel\ type\ 2 \\ in\ the\ building \end{pmatrix} \times \begin{pmatrix} Source - site\ ratio \\ of\ fuel\ type\ 2 \end{pmatrix} \right) \\ + \\ \ldots \end{array} \right)$$

The performance of the buildings is presented in terms of Energy Use Intensity (EUI). The EUI is measured by the total energy consumed within a building in a year (measured in kBtu or GJ) per gross floor area (ft^2). For the purpose of benchmarking, the EUI is used as an index for the building owners and the facility managers to compare their building's annual energy performance against similar building types.

The EUI is calculated as,

$$Energy\ use\ intensity\ (EUI) = \frac{Total\ energy\ consumption\ (kBtu\ or\ GJ)\ in\ a\ year\ y}{Gross\ floor\ area\ (ft^2)}$$

Where,

Total energy consumption in a year y	=	Sum of all source energy consumed by the building, kBtu or GJ
Gross floor area	=	All covered floor space, ft^2 (whether within or outside a building and whether or not enclosed) measured between party walls including the thickness of external walls (excluding the areas such as exterior spaces, balconies, decks, terrace, exterior loading docks, driveways covered walkways, outdoor courts and parking)

7. Measurement, Reporting and Verification (MRV)

To qualify for the Energy Star certification, a building should be benchmarked in the Portfolio Manager tool and achieve a score of 75 or higher accounting for all its energy use. If the building achieves the score of 75 or higher, the owner can apply for the Energy Star certification through the Portfolio Manager tool.

The owner must engage a Licensed Professional (LP) who is accredited by the EPA. The LP makes a site visit and verifies the information provided in the application. Once the verification process is complete, the owner has to upload the LP signed application form in the Portfolio Manager tool and submit it to the EPA. The EPA reviews the application and provides the Energy Star certification to the building.

The Energy Star certification is valid for 12 months and the buildings will be notified before the certification gets expired. The buildings must undergo the same procedure as mentioned above whenever it has to get the certification.

The following documents can be generated from the Portfolio Manager tool which summarizes the important energy information and building characteristics. These documents will provide transparency and accountability to demonstrate strategic use of funding and the energy savings for an individual building.

- Statement of energy performance
- Energy Star scorecard
- Progress & goals report
- Data verification checklist
- Statement of energy design intent

8. Implementation status[4]

Since 1992, the Energy Star program (including Energy Star products, Energy Star for commercial, residential buildings and industrial plants) helped US to save more than USD 450 billion and over 3.5 trillion kilowatt-hours of electricity while also achieving broad emission reductions through this voluntary action.

For commercial buildings

The Energy Star program for the commercial buildings helped the businesses and organizations save nearly USD 10 billion in energy costs in 2016, contributing to cumulative energy cost savings of over USD 150 billion since 1992. Most of the commercial buildings use EPA's Energy Star Portfolio Manager tool to measure, track, assess and report on their energy and water consumption.

More than 9,500 buildings earned the Energy Star certification in 2017, bringing the total to more than 32,000. On an average, the Energy Star certified buildings use 35% less energy than typical buildings nationwide.

Studies found that Energy Star certified buildings command a premium of up to 16 percent for the sales prices and rental rates. At the end of 2018, 29 local governments, three states and one Canadian province rely on the EPA's Energy Star Portfolio Manager tool as the foundation for their energy benchmarking and transparent policies.

For new and existing residential buildings

The Energy Star certified new residential buildings program helped homeowners save USD 360 million in energy costs in 2016, contributing to the cumulative energy cost savings of USD 3.1 billion since 1995. More than 100,000 Energy Star certified single-family and multifamily residential buildings were built in 2017 alone with for a total of nearly 1.9 million houses certified since 1995.

As of 2017, nearly 90% of the US top homebuilders build Energy Star certified homes. One out of every 10 single-family residential buildings in 2017 was Energy Star certified. The Energy Star certified buildings are at least 10% more energy efficient than the buildings built to code and achieve a 20% improvement on average, while providing homeowners with better quality, performance, and comfort. The Home Performance program which was managed by the corporate sponsors/organizations with Energy Star program completed 91,000 energy efficiency improvement projects on the existing buildings in 2017.

[4] https://www.energystar.gov/about/origins_mission/energy_star_numbers

9. Lessons learnt

The key lessons learnt from the program implementation are:

- Interactive support in data reporting and analysis: The Portfolio Manager tool is one the key success factor for the US Energy Star program. It provides a direct user interface for the building owners to input and analyze the energy performances. The tool can be used to compare one building against itself over time, compare one building against a national sample of similar buildings. It can be also used to set priorities and targets for the use of limited resources or investment capital. Over the period, the tool has evolved as the industry standard for analysis of energy performance. Importantly, all of the EPA's tools and resources under the program, including Portfolio Manager, are free to use.

- Revision of benchmarks in line with the rapid technology changes: The revision of benchmark standards once in every three to five years through national level survey is another a success factor since it provides greater flexibility for revisions to occur quickly without waiting for the minimum standards to be revised. This flexibility to revise benchmark performance ensures that the program adapts and accurately reflects the quickly changing markets and increasing penetration of energy efficient technologies.

- Rigorous accreditation procedures for the third party verifiers: The use of third-party verification partners help the EPA guarantee the integrity of compliance reports without needing to dedicate significant government resources to support implementation and enforcement. The program has very stringent accreditation requirements which ensure the quality and capabilities of third-party verification partners.

- Increasing participation by building awareness and market confidence: Though the participation is voluntary, more and more buildings have opted for the Energy Star certification due to the awareness created and the market competition for the energy efficient buildings. A study conducted by the EPA confirms that the Energy Star certified buildings are at least 20% more energy efficient than the ordinary buildings. The purchasers of Energy Star certified buildings are more likely to recognize and pay the increased building value resulting from the decreased energy use and increased net operating income.

Applicability for Thailand

The certificate has validity 12-month period, meaning that the building must submit all required information and energy consumption every year for renew the certificate. Thus, the validity period could apply for BEC building in Thailand as it has not been clear yet.

Annex 3. Tokyo Emission Trading Scheme, Japan

1. Introduction

The Tokyo Metropolitan Government (TMG) launched the Tokyo Emission Trading Scheme (ETS) in 2010 as an initiative to reduce the GHG emissions and mitigate the risks of climate change. This program is not only the first cap-and-trade scheme in Japan, but also the world's first urban cap-and-trade scheme which specifically targets large facilities of the commercial sector. The commercial and residential buildings in Tokyo city accounted for more than 72% of the energy-induced CO_2 emissions in 2013[5].

2. Key program features

Scope	All the energy intensive commercial and industrial facilities within the jurisdiction of Tokyo city
Mechanism	Cap and trade the emission allowances similar to the European Union Emission Trading Scheme (EU ETS)
Participation	Mandatory for commercial and industrial facilities with the annual energy consumption above a set threshold limit
Target setting	Each participating facility is provided with a GHG reduction target (allowance) - in fixed percentage unit from its baseline emission 1st compliance period: 8% or 6% reduction below base-year emissions 2nd compliance period: 17% or 15% reduction below base-year emissions 3rd compliance period: 27% or 25% reduction below base-year emissions 4th compliance period: 35% (tentative) reduction below base-year emissions
Target period	5 years, with the progress reported at the end of each financial year 1st compliance period: Year 2010 to 2014 2nd compliance period: Year 2015 to 2019 3rd compliance period: Year 2020 to 2024 4th compliance period: Year 2025 to 2029
Measurement, Reporting and Verification	Measurement and reporting is done at the facility level. Emission reduction must be verified by a third party verification agency before issuance of credits
Penalties	Any non-compliance of targets or misconducts in reporting will lead to imposition of penalties

3. Legal framework

[5] Urban Efficiency II, Seven Innovative City Programmes for Existing Building Energy Efficiency, C40 cities and TMG

In 2002, the TMG launched the “Tokyo Carbon reduction reporting program for the large-scale buildings and businesses in the industrial and commercial sectors”. Under this program, the large facilities have to mandatorily report their emissions and potential emission reduction plans to the TMG. However, the implementation of emission reduction plan was kept voluntary.

In 2006, the TMG set a target to reduce emissions to 25% below 2000 levels by 2020[6]. The Tokyo Climate Change Strategy and Tokyo Metropolitan Environment Master Plan were passed in 2007 to set a framework for achieving this target. Based on the framework, the cap-and-trade (or emission trading scheme) system was launched in 2010 enforcing the mandatory GHG emission reduction by the large facilities.

In parallel, the “Tokyo’s carbon reduction reporting program for the small and medium facilities” was launched in 2010, which mandates the commercial buildings and other facilities to report their emissions (but the emission reduction is voluntary).

4. Scheme design

Figure A.3.1 shows the schematic for the issuance of credits in this program.

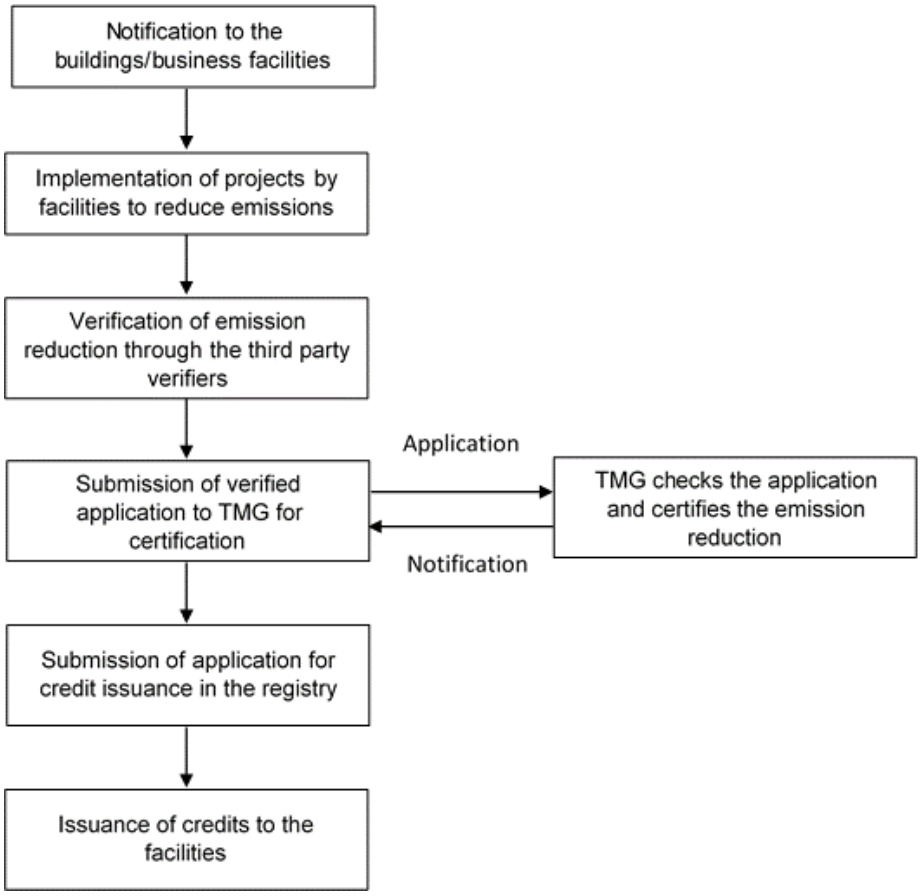

Figure A.3.1. Schematic of Tokyo Emission Trading Scheme

Based on the energy usage data submitted by the facilities covered under the “Tokyo carbon reduction reporting program for the large facilities” at the end of March 2010, a total of 1,332 facilities were designated and subjected to the mandatory emission reduction under the ETS.

[6] Tokyo Cap and Trade Program, Bureau of Environment, TMG

The scheme envisages to cap emissions at 10.44 million tCO_2 in 2020 out of which 9.7 million tCO_2 is expected from the existing facilities and the remaining is assigned for the new entrants.

The scheme is based on absolute cap set at the facility-level. It is composed of two five-year compliance periods, with first compliance period spanning from 2010 to 2014 and the second compliance period from 2015 to 2019. The base year emission is the average CO_2 emissions from any three consecutive years between 2002 and 2007 that a covered facility selects.
First compliance period (2010-14): The scheme set two different emission reduction targets (compliance factors) among the covered facilities. A target of 8% GHG reduction is set for the office buildings, district heating and cooling plants. A target of 6% GHG reduction is set for facilities that use at least 20% of their energy from the district heating and cooling plants, factories, water and sewage facilities and waste processing facilities.

Second compliance period (2015-19): In this compliance period, a target of 17% GHG reduction is set for the commercial buildings, district heating and cooling plants and 15% is set for the facilities that consume at least 20% of their energy from the district heating and cooling plants.

The TMG plans to roll out the third compliance period from 2020 – 2022. The target for this compliance period is yet to be determined.

The business facilities/buildings are notified by the TMG to participate in the ETS. Upon notification, the facilities calculate the baseline emissions from any of the three consecutive financial years from 2002 to 2007. The facilities must implement projects to reduce the emissions from the baseline. The emission reduction are estimated for each financial year and verified by engaging a third party verification agency. The verified application is submitted to the TMG for approval through the registry. Once the TMG checks and approves the application, credits will be issued to the facilities.

Threshold limit

The large-scale facilities such as the commercial buildings, industrial facilities, waste processing units, etc., that consume ≥ 1,500 kl of crude oil equivalent (COE) annually, must submit five-year emission reduction plans and annual progress reports.

The medium/small-scale energy intensive facilities must submit an annual energy efficiency report if they belong to a corporation that annually consumes over 3,000 kl of COE. However, the emission reductions are not mandatory for such facilities.

A facility may leave the ETS if its energy consumption from the previous year is below 1,000 kl of COE or if the energy consumption from the three prior years is below 1,500 kl of COE or if the installation is shut down or suspended. More than 100 facilities have left the program after reducing emissions below the threshold. As of January 2015, 1,232 facilities had obligations to report their emission reductions under the ETS.

For large facilities

The ETS covers 40% of the industrial and commercial sectors' CO_2 emissions, which equates to 20% of all of Tokyo's CO_2 emissions[7]. The ETS covers both indirect and direct CO_2 emissions from the energy use (electricity, heavy oil, heat and other fuel). The ETS regulates at the facility level which includes office buildings, commercial buildings, educational facilities,

[7] Tokyo Cap and Trade Program, Bureau of Environment, TMG

medical facilities, art facilities, public facilities (such as gymnasiums, public bath, jails, funeral halls, social welfare facilities), district cooling/heating plants, factories, water and sewage facilities and waste processing facilities.

In case of buildings with more than 5,000 m^2 of rented/leased space or with more than 6 million kWh per year consumption, the tenants must create their own emission reduction plan and submitted it through the building owner. Each tenant is not specifically required to cap their emissions. If no individual tenant exceeds these energy consumption limits but a single building as a whole does, the tenants are required by law to cooperate with the building owner in reporting of emissions although the final report is submitted by the building owner.

For small and medium facilities (SMFs)

The SMFs that spread across the Tokyo city may have a number of buildings, factories, etc. If the cumulative energy consumption per annum of all the buildings within the facility is over 3,000 kl of COE but no single building or facility consumes over 1,500 kl of COE per annum, then the company must submit an energy efficiency plan every year. Although these SMF companies are not required to cap their emissions, the TMG aims to help the companies understand their (i) energy consumption profile and (ii) methods to lower their emissions.

If the consumption of an entire company is less than 30 kl of COE per annum, then there is no obligation to submit a report for their facility, but the TMG welcomes such micro facilities with interest in lowering the emissions to submit plans for energy efficiency on a voluntary basis.

There are also monetary incentives within the residential sector for the heat pump water heaters and solar power, as well as for appliance with the energy efficient labelling. For the small and medium scale emitters, free energy audits are available and the energy efficiency investments are 50% tax deductible[8].

Top-level facility

The ETS legislation provides an extra incentive to reduce the emission target by defining the concept of "*top-level facility*", by certifying those businesses and facilities that make significant progress to reduce their emissions and meet the ETS requirements. Such facilities can apply for a "*top-level facility*" certification at the end of September each year. There are two categories of certification and benefits:

- Outstanding progress: a facility's compliance factor is reduced to half
- Excellent progress: a facility's compliance factor is reduced to three-quarters

These certified facilities receive a lower compliance factors in accordance with their rates of progress. The reduced compliance factor is applicable from the consecutive financial year and will be effective for the duration of that entire compliance period. If the progress of a certified facility declines, its certification will be cancelled or downgraded.

5. Methodology

[8] The World's Carbon Markets: A Case Study Guide to Emissions Trading, Environment Defense Fund and International Emission Trading Association

In Tokyo ETS, the boundary is decided according to the area of the building or facility. Multiple facilities or buildings are also considered as a single building/facility if the following conditions are satisfied:

- All those facilities are provided with one single integrated energy management system
- Facilities are located adjacent to each other and owned by a common owner

5.1. Base year emissions

The scheme freely distributes allowances at the beginning of each compliance period. The allowances are allocated to the covered facilities based on their historical emissions. The base year emissions are calculated as the average of actual emissions of three consecutive years between the financial years of 2002-2007, as chosen by each facility.

A certain quantity of allowances are set-aside for new entrants. The new entrant in the scheme can select the baseline emissions as the average of three consecutive years between the financial years 2002-2007 if they had data of the past emissions of the facility or based on the emission intensity standards given by the TMG.

The baseline emissions for a facility is calculated as,

$$Base\ year\ emissions = Average\ of\ consecutive\ three\ years'\ total\ emissions$$

The total emissions for any year from the facility is calculated as,

$$\begin{pmatrix} Total\ emissions \\ from\ the\ year\ i \end{pmatrix} = \begin{pmatrix} Electricial\ energy \\ (kWh) \end{pmatrix} \times \begin{matrix} Emission \\ factor \end{matrix} \left(\frac{tCO_2}{kWh}\right) + \left(\begin{pmatrix} Energy\ consumed \\ from\ the \\ fossil\ fuel\ (TJ) \end{pmatrix} \times \begin{pmatrix} Emission\ factor \\ of\ that\ fuel \\ \left(\frac{tCO_2}{TJ}\right) \end{pmatrix} \right)$$

Recalculation of base year emissions

The scheme provides flexibility to recalculate the baseline emissions of the facility in the second compliance period. This is due to the fact that the emission factor used in the first compliance period for the electricity and the fuel used may not have a significant impact on the emission reduction in the second compliance period. Hence, in the second compliance period, the following methods can be considered for calculating the base year emissions of the facility.

i) Primary method A: Recalculating using the latest emission factor values

In this method, the latest emission factor for the electricity and the fuel consumed are used to recalculate the baseline emissions of the facility.

$$\begin{pmatrix} Baseline\ emissions \\ of\ the\ facility \end{pmatrix} = \begin{pmatrix} Electricial\ energy \\ (kWh) \end{pmatrix} \times \begin{matrix} Emission\ factor\ estimated\ in \\ the\ second\ compliance\ period \end{matrix} \left(\frac{tCO_2}{kWh}\right)$$

$$+\left(\begin{pmatrix}Energy\ consumed\\ from\ the\\ fossil\ fuel\ (TJ)\end{pmatrix}\times\begin{pmatrix}Emission\ factor\ of\ that\ fuel\\ in\ the\ second\ compliance\ period\\ \left(\frac{tCO_2}{TJ}\right)\end{pmatrix}\right)$$

ii) Primary method B: Recalculating the baseline emissions using the factor set by the TMG

The factor is provided by the TMG based on average of the rate of increase of base-year emissions of all facilities due to the revision of the CO_2 emission factor.

$$\begin{pmatrix}Baseline\ emissions\\ of\ the\ facility\end{pmatrix}=\begin{pmatrix}Baseline\ emissions\\ considered\ in\ the\ first\\ compliance\ period\ (tCO_2)\end{pmatrix}\times Factor\ given\ by\ the\ TMG$$

iii) Method C: Recalculating the baseline emissions using the factor based on power and heat consumption (exceptional)

The facilities are also allowed to choose exceptional method C, if the recalculated baseline emission value is more favorable to them.

$$\begin{pmatrix}Baseline\ emissions\\ of\ the\ facility\end{pmatrix}=\begin{pmatrix}Baseline\ emissions\\ considered\ in\ the\ first\\ compliance\ period\\ (tCO_2)\end{pmatrix}\times\begin{pmatrix}Emissions\ calculated\ with\\ compliance\ factor\ for\ the\\ second\ compliance\ period\\ \hline Emissions\ calculated\ with\\ compliance\ factor\ for\ the\\ first\ compliance\ period\end{pmatrix}$$

5.2. Compliance factor

The cap is set on the total emission reduction as a percentage of total GHG emissions (noted as compliance factors) among the covered facilities. Table A.3.1 gives the compliance factor for the facilities/business entities that are covered under the ETS. Each compliance period of the ETS is for 5 years. During the compliance period, the facilities must report their annual GHG emissions every financial year to the TMG. These reports should be verified by the registered verification agency designated by the TMG.

As a special provision for the second compliance period to establish and promote more significant CO_2 reduction, the TMG has set the compliance factor of first compliance period for the facilities that are newly included into the scope of reduction obligations in the second compliance period.

Table A.3.1. Compliance factor for the different group of buildings

No.	Group	Compliance factor	
		1st compliance period (FY 2010 – FY 2014)	**2nd compliance period (FY 2015 – FY 2019)**
1	**Group I -1**	8%	17%

No.	Group	Compliance factor	
		1st compliance period (FY 2010 – FY 2014)	2nd compliance period (FY 2015 – FY 2019)
	Office buildings, government buildings, department stores, restaurants, hotels, schools, hospitals, museums and libraries, district heating and cooling plants (except covered under Group I-2) etc.		
2	**Group I -2** Facilities that receive 20% or more of their total energy consumption from the district heating and cooling plants	6%	15%
3	**Group II** Business facilities other than stated in Group I-1 and I-2.	6%	15%

5.3. Allocated allowances for each building

The base year emissions of a building is multiplied by the compliance factor (set by the TMG) and then by the length of the compliance period to obtained the allowances for the GHG emissions for the respective compliance period.
The allocated allowances for a facility is calculated as,

$$Allocated\ allowances = \left(\begin{matrix}Base\ year\\ emissions\end{matrix}\right) \times (1 - Compliance\ factor) \times \left(\begin{matrix}length\ of\\ compliance\ period\end{matrix}\right)$$

5.4. Compliance assessment

At the end of each compliance period, the total GHG emissions are calculated. The emissions must be within the allocated allowances. Figure 2 represents the approach of Tokyo's ETS.

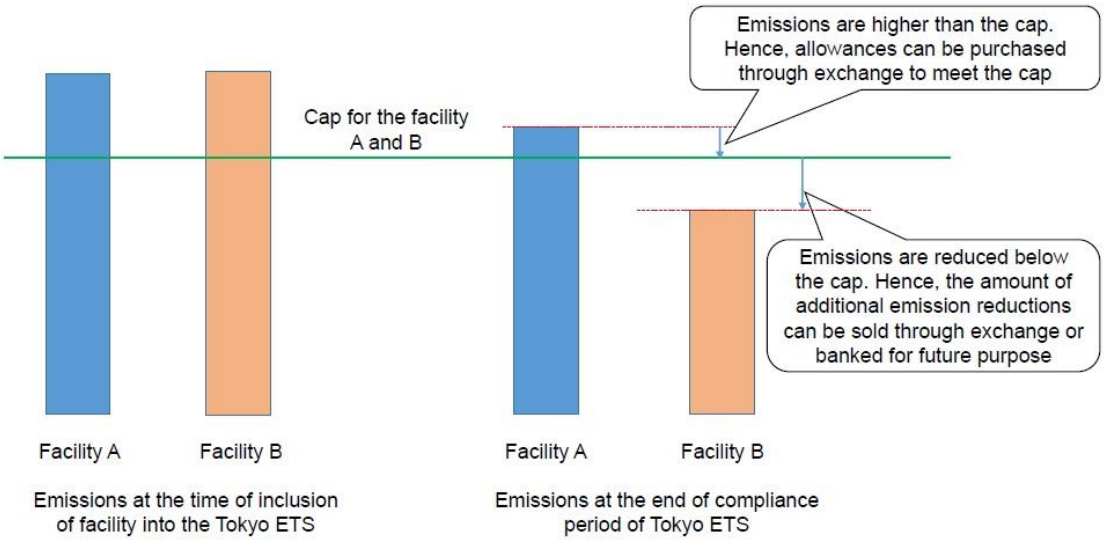

Figure A.3.2. Schematic representation of Tokyo ETS approach

The compliance assessment is conducted at the end of each compliance period. The covered facilities under the ETS are only allowed to sell their emission allowances that are remaining after a facility's annual emissions are accounted for. The Japan Climate Exchange and the Tokyo Stock Exchange are the platforms used for trading credits within the Tokyo ETS.

6. Measurement, Reporting and Verification (MRV)

The covered facilities are required to submit an annual report on the previous year's emissions and their emission reduction plans by the end of November of the following year. The report must cover GHG emission of all types (CO_2, CH_4, N_2O, PFC, HFC and SF_6).

A verification report issued by a registered independent verification agency must be attached to the emission data report. The verification is mandatory at the following stages:

- Reporting of compliance for the period
- Applying for a top-level facility certification
- Applying for offset credits

Table A.3.2 provides the different verification segments and its respective contents. The auditing and verification of emissions is required under the Tokyo ETS and the cost of auditing is borne by the facility. The verification is carried out on a segmented basis. There are several different private auditing companies within Tokyo that are licensed to verify the emission reduction. Each auditing firm is registered to verify different segments.

Table A.3.2. Different verification segments and their contents

No.	Verification segments	Verification contents
1	GHG/baseline emissions	• Annual GHG emission verification

No.	Verification segments	Verification contents
		• Verification of baseline for achievement of the emission reduction goals
2	Emission reductions inside and outside the city	• Small and medium sized facility credit verification inside the city • Credit verification outside the city
3	Verification of environmental value retention through electricity consumption changes	Verification of renewable energy mix in the electricity consumption, etc.
4	Category 1-A: Office buildings, public facilities, commercial buildings, lodging, educational facilities, medical facilities, etc.	Certification of baselines and emissions
5	Category 1-B: Buildings in which air conditioning/heating from district cooling/heating plants make up more than 20% of energy consumption	Certification of baselines and emissions

The TMG is responsible for the maintenance and data management of the electronic registry. The registry includes three types of accounts: compliance accounts (to track emission reduction status of the covered facilities), trading accounts (to transfer credits) and surrender accounts (record credits surrendered for compliance). The registry is used to manage and record the trading of credits for each capped facility, as well as the brokers and entities that wish to participate (but are uncapped) within the system.

Annual emissions and actual reductions are disclosed every year on the TMG website. At the end of each compliance period, the Governor of Tokyo checks the final status of the compliance obligation. If the total emission reduction exceeds the obligation, the excess reductions may be carried over to the next compliance period as banked credit.

A facility will be accused of market misconduct if it submits a fraudulent application, receives credits in the registry account through illegal actions or engages in actions that obstruct the TMG's investigations into submitted applications. If any market misconduct is suspected, the TMG will first provide guidance to the participant and later apply penalties if necessary.

In the case of non-compliance, the facility will receive an order to reduce their emissions by the amount of the shortfall multiplied by 1.3. If facilities fail to meet this order, the violation will be published for public viewing and the facility will have to pay a fine of up to JPY 500,000[9] (≈4,500 USD). In this specific case of failing to comply with the order, the TMG purchases the reduction shortage, records them and registers that the reduction target has been fulfilled. Thereafter, the cost of TMG's purchase is billed to the facility. Once the fines are settled by the facilities, they must reduce their future emissions as previously mandated.

7. Offset credits

[9] The World's Carbon Markets: A Case Study Guide to Emissions Trading, Environment Defense Fund and International Emission Trading Association

To comply with the targets, the facilities can choose to reduce the emissions at their facility or reduce emissions by purchasing offset credits. There are five types of offset credits:

a) Excess emission reduction credits
b) Small and midsize facility credits
c) Renewable energy credits
d) Outside Tokyo credits and
e) Saitama credits

The facilities which generate emission reductions to sell offset credits are required to apply for certification to the TMG before such credits can be issued.

a) Excess credits

When a covered facility reduces emissions by more than its compliance obligation, it can apply for credit issuance within a given period after the emissions are determined. In this instance, the facility can sell its excess credits amounting up to one-half of its base year emissions. The credits obtained during the first compliance period could be banked until the end of the second compliance period (but not to the third period). The CO_2 emission reductions are only considered as the carbon credits in the ETS.

b) Small and midsize facility credits

When small and midsize facilities reduce their emissions through energy-saving measures below their base-year emissions, they can apply for the emission reduction credits. The base year emission has to be one financial year out of the most recent three consecutive financial years before the measures are implemented. There is no limit on the use of these credits. The credits can be issued for up to five years from when emission reduction measures were undertaken. The eligible measures are limited to measures completed in or after the financial year 2005. In principle, the applications are submitted according to an entire building's energy consumption. However, if the energy use can be monitored separately, individual tenants could apply separately for the credits.

c) Renewable energy credits

The local and national renewable energy programs which generate renewable energy and reduce emissions are eligible. Depending on the source of renewable energy, the quantity of renewable energy certificates (REC) will vary. For electricity from wind, solar, geothermal and small-scale hydropower, one ton of CO_2 reduction receives one-and-a-half (1.5) times the certificates as the emission reductions from other sources of renewable energy such as biomass, etc. The use of RECs is unlimited. The REC is only eligible if the issued certificates indicate that their purpose is to be used in compliance with the Tokyo ETS.

d) Outside Tokyo credits

The emission reduction from the energy-saving measures by large facilities outside the Tokyo city are eligible only if they do not negatively impact the reduction effort within Tokyo. The covered facilities can use these credits for up to one-third of their compliance obligation if they meet the following two requirements:

- The emission reductions come from a large facility outside Tokyo with a minimum energy consumption of 1,500 kl of COE in a base-year and with base-year emissions of 150,000 tCO_2.

- The estimated total reduction rate must be at least 6% at the initial application and when applying for the emission reduction certification.

e) Saitama credits

Saitama is a city in Japan which established its own ETS in April 2011 as part of the Saitama Prefecture Global Warming Strategy Promotion Ordinance. The Saitama ETS is bilaterally linked to the Tokyo ETS. If the Saitama ETS confirms that the reduction target has been achieved, then these credits can be used in the Tokyo ETS. The use of credits is unlimited as long as they are derived from the facilities with base year emissions of at least 150,000 tCO_2.

8. Implementation status

The first compliance period of the Tokyo ETS came to an end in December 2014 and achieved an emissions reduction of 23% compared to the base year emissions during the five years. In 2013, the accumulated CO_2 emission reductions were 880,000 tCO_2, just below the planned accumulated emission reductions of 1.08 million tCO_2. By February 2015, over 90% of the covered facilities had surpassed their reduction targets for the first compliance period and 69% of facilities had already exceeded their second compliance period targets of 15-17% reductions[10].

During the first compliance period, the majority of the participants purchased excess credits and RECs to comply. According to a TMG survey released in November 2014, the estimated excess credit supply was 420,000 (73.7% of overall supply) and the REC supply was 140,000 (24.6% of overall supply). According to another survey carried out by the TMG in October 2014, the price ranges for these credits were (i) JPY 5,000 - 6,000 per tCO_2 for RECs and (ii) JPY 4,000 - 5,000 per tCO_2 for excess credits[11].

In 2017, the emissions from the covered facilities amounted to 12.04 million tones, achieving a 27% reduction from the base emission as a result of continuous energy efficiency efforts[12].

9. Lessons learnt

The experience of the Tokyo ETS since 2010 clearly demonstrates how it has been very effective as an instrument to promote reductions in GHG emissions among the largest facilities in the city. A number of lessons can be drawn that would be of relevance to any city considering an ETS of its own:

- Mandatory reporting: The availability of data for Tokyo ETS began with the mandatory reporting program in the years prior to the design and implementation of the ETS. Such data is essential to design an ETS and to ensure robust monitoring, reporting and verification (MRV) throughout. In addition, these reports gave the TMG a large database of information concerning not only the overall GHG emissions of a company, but also the detailed breakdown of each individual energy consuming source at each facility. This had a positive effect in stakeholder consultations as the TMG was able to respond to the stakeholders who thought it is difficult to achieve energy efficiency targets.

[10] The World's Carbon Markets: A Case Study Guide to Emissions Trading, Environment Defense Fund and International Emission Trading Association

[11] Tokyo: An emission trading case study, Environmental Defense Fund, CDC climate research, International Emission Trading Association

[12] Results of Tokyo Cap-and-Trade Program in the 8th Fiscal Year for the covered Facilities Continue Reducing Emissions in Second Compliance Period, TMG

- Simple reporting system: Many companies had complained that they do not have the technical capacity to develop an emissions report each year. The development of a simple reporting system that relied on the existing data from electricity, gas, and fuel bills and equipment inventory lists was one of the most important elements for gaining acceptance for the ETS while also obtaining reliable data. This was considered appropriate, since the dominant emitter of GHGs is the commercial building sector in Tokyo.

- Development of incentive mechanism: The Tokyo CO_2 voluntary emission reduction program provides the TMG an opportunity to learn about creating incentives for the facilities. This voluntary program initially shows only minimum achievements of emission targets. Hence, the TMG undertook measures to strengthen the program by introducing guidelines for target setting and reduction measures, evaluation and public announcement of results of mitigation efforts and submission of progress reports. The development of incentive mechanisms for the emission reduction program rose the participating facilities to 4.8% among 1,255 facilities and almost 98.5% of the facilities obtained ratings with the implementation of basic measures requested by the TMG within their facilities.

- Flexibility on selection of base year: The Tokyo ETS provided covered facilities with some degree of flexibility, such as with the selection of the base year for emissions. The special provisions for calculating emissions following the earthquake also provided facilities the opportunity to avoid being penalized by the consequences of that unexpected natural disaster. Such flexibility is important for ensuring stakeholder buy-in for continued smooth implementation of the ETS.

- Predictable rules and frameworks: The Tokyo ETS operates within a clear and predictable rules based framework. The TMG has provided a framework for long-term goal setting by indicating the estimated emissions reductions that would be required in the second compliance period. This in turn enables participating facilities to plan and execute their emissions reduction activities well in advance, taking the long-term view and planning for investment as necessary.

Applicability for Thailand

This cap and trade scheme could be a scheme that help Thailand to meet the GHG emission reductions target. Thus, this scheme would be one mechanism indicated in the Thailand Climate Change Act that being developed.