Initiative for Climate Action Transparency (ICAT):

Improving Thailand's MRV System for Climate Change Mitigation

Contribution to Thailand's NDC Roadmap Report

Photo by Karsten Würth (@karsten.wuerth) on Unsplash

Initiative for Climate Action Transparency - ICAT -

Improving Thailand's MRV System for Climate Change Mitigation

Deliverable #3

AUTHORS

The Global Green Growth Institute (GGGI)

Date of the deliverable 11 December 2019

PUBLISHED BY

Office of Natural Resources and Environmental Policy and Planning (ONEP), Thailand's Ministry of Natural Resources and Environment

PREPARED UNDER

Initiative for Climate Action Transparency (ICAT) project supported by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the Children's Investment Fund Foundation (CIFF), the Italian Ministry of Ecological Transition (IMET) and ClimateWorks.

The ICAT project is managed by the United Nations Office for Project Services (UNOPS)

ACKNOWLEDGEMENT

We would like to acknowledge and express gratitude to the Royal Thai Government, especially the Office of Natural Resources and Environmental Policy and Planning (ONEP), Thailand Greenhouse Gas Management Organization (TGO), Department of Alternative Energy Development and Efficiency (DEDE), and other relevant agencies, for their strong commitment towards assisting the global communities address climate emergency and provide strong support to the project. Also, we would like to thank other relevant stakeholders for their constructive and useful contributions to the project.

The project is under guidance of Emmanuel K. Ackom, Susanne Konrad, and Denis Desgain from UNEP DTU Partnership, and made possible with support from the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, Children´s Investment Fund Foundation (CIFF), the Italian Ministry for Environment, Land and Sea Protection, and ClimateWorks.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

BAU	Business-as-Usual
BEC	Building Energy Code
BMA	Bangkok Metropolitan Administration
BTR	Biennial Transparency Report
BUR	Biennial Update Report
ChP	Chiller Performance
COP	Coefficient of Performance
DEDE	Department of Alternate Energy Development and Efficiency
DIW	Department of Industrial Works
DPT	Department of Public Works and Town & Country Planning
EEP	Energy Efficiency Plan
EER	Energy Efficiency Ratio
EERS	Energy Efficiency Resource Standards
EGAT	Electricity Generating Authority of Thailand
EPPO	Energy Policy and Planning Office
ESCO	Energy Service Company
EUI	Energy Use Intensity
GGGI	Global Green Growth Institute
GHG	Greenhouse Gases
GJ	Gigajoule
ICAT	Initiative for Climate Action Transparency
IEAT	Industrial Estate Authority of Thailand
INDC	Intended Nationally Determined Contribution
kVA	kilovolt Ampere
kWh	kilowatt hour
LAO	Local Administration Organization
LULUCF	Land Use, Land-Use Change and Forestry
MEA	Metropolitan Electricity Authority
MJ	Megajoule
MOAC	Ministry of Agriculture and Cooperatives
MRV	Measurement, Reporting and Verification
NAMA	Nationally Appropriate Mitigation Actions
NC	National Communication
NCCC	National Committee on Climate Change Policy
OERC	Office of Energy Regulatory Commission
ONEP	Office of Natural Resources and Environmental Policy and Planning
OTTV	Overall Thermal Transfer Value
PEA	Provincial Electricity Authority
RTTV	Roof Thermal Transfer Value
SEC	Specific Energy Consumption
tCO_2	Tons of Carbon dioxide
TGO	Thailand Greenhouse Gas Management Organization (Public Organization)
TISI	Thai Industrial Standards Institute
UNFCCC	United Nations Framework Convention on Climate Change

1. EXECUTIVE SUMMARY

Thailand, as a signatory Party under the United Nations Framework Convention on Climate Change (UNFCCC), has made significant efforts in mitigating the country's GHG emissions with available resources and capabilities. It pledged its first Nationally Appropriate Mitigation Actions (NAMAs) to the UNFCCC on 29 December 2014. The NAMA proposed that Thailand would reduce its GHG emission in the range of 7-20% (20% with international support) 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 were 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 is 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 in Thailand and identify the gaps, barriers and opportunities for an effective MRV. Further, the report provides recommendations to strengthen MRV in the building and industrial sectors.

As per Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021-2030 (NDC Roadmap), the building sector is classified as a sub-sector under the energy and transportation sector and it covers the 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 by 2030 (Refer figure 1-1). Its target groups for GHG reductions are categorized under eight building types namely: 1) Office, 2) Hospital, 3) Hotel, 4) Department store, 5) School, 6) Hypermarket, 7) Condominium and 8) Other buildings. The measures for energy efficiency improvement in building sector mainly include: 1) Lighting system, 2) Air conditioning system, 3) Office equipment and 4) Other systems.

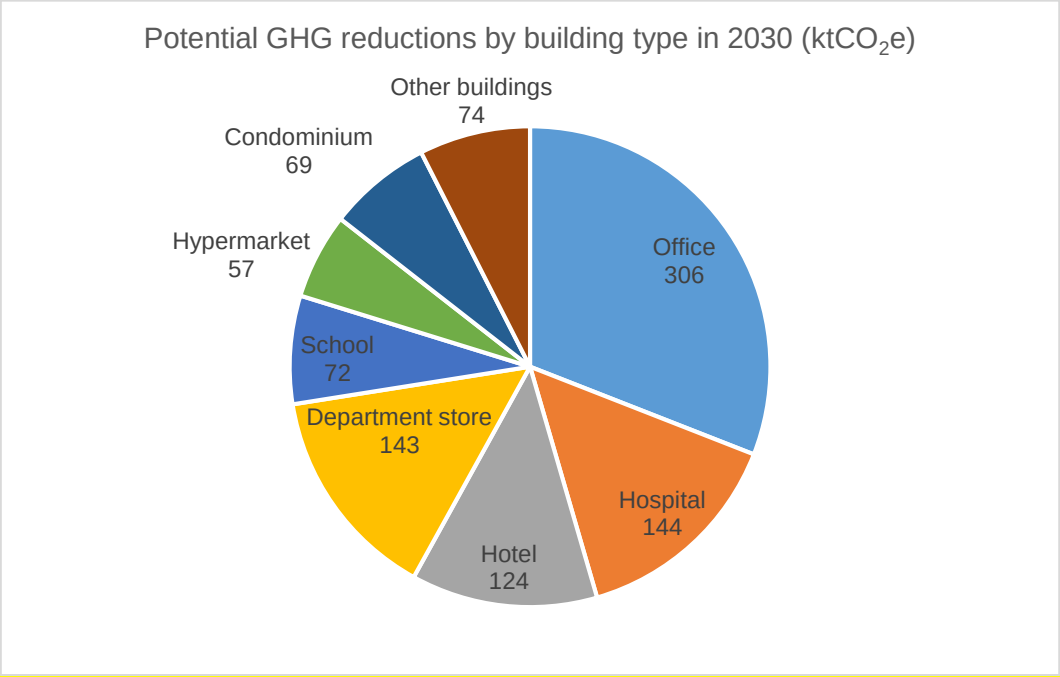


Figure 1- 1 Potential GHG reductions by building type in 2030

Referring to the above potential GHG reductions, the highest potential GHG reductions is in office buildings (306 $ktCO_2e$), followed by hospitals (144 $ktCO_2e$) and department stores (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.

As per the Thailand's NDC Roadmap, the industrial sector is classified as a sub-sector under the energy and transportation sector and its main target measures are 1) energy efficiency improvement and 2) substitution of renewable energy – with total potential GHG reductions of 43 million tCO_2e (Refer figure 1-2).

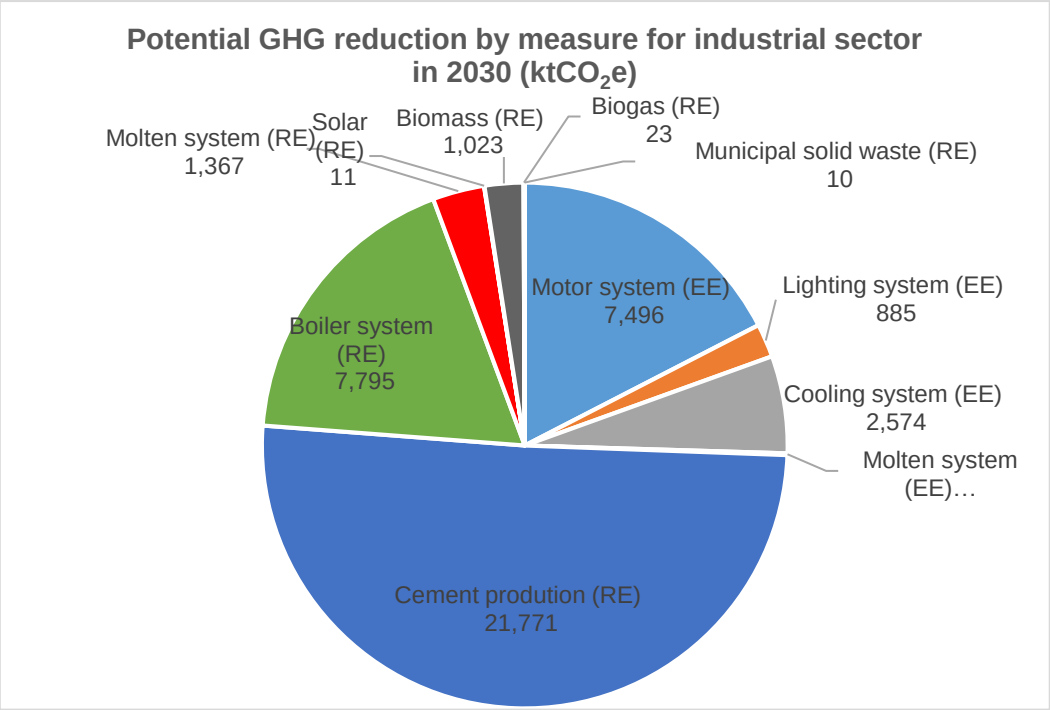


Figure 1- 2 Potential GHG reduction by measure for industrial sector in 2030

The report observes that the existing NAMA does not indicate specific GHG mitigation measures for the building and industrial sectors and there is no existing MRV in these sectors.

Based on the study, analyses, and discussion with the stakeholders, the report proposes a MRV practice developed based on the existing reporting framework, followed by the designated building/factory in Thailand. The designated building/factory has to submit an energy management report to the Department of Alternative Energy Development and Efficiency (DEDE) on an annual basis. The data in this report could be further used for the GHG emission calculation. For those buildings covered under the Building Energy Code (BEC) and non-designated buildings/factories that are included in the mitigation measures in the NDC Roadmap and NDC Action Plan for Energy sector, there is no clear approach available as of now, to engage them in the GHG reporting on annual basis until the end of the NDC period (year 2030). Also, the NDC Action Plan for Energy sector does not propose any clear guideline or plan to engage them to submit the energy report on an annual basis during the NDC period. According to that Action Plan, the potential mitigation measures in the building and industrial sectors are: 1) Enforcement of the energy efficiency standards in the designated building / factory, 2) Enforcement of Building Energy Code (BEC) for new building, 3) Determination of standards and labeling on efficient machine/equipment (including label no.5) and 4) Mitigation measures in non-designated building/factory, etc. Therefore, when reporting in terms of GHG emissions achieved by each of the mitigation measures, due care must be

taken to avoid double counting issue, since different mitigation measures could be implemented in the same building/factory and at the same period.

Based on the results from the Report on MRV for the Industrial Sector and Building Sector which are the key inputs for this report, the recommendations are provided below;

(1) At present, the designated building/factory is mandated to submit an energy management report on an annual basis. This report contains most of the data required for the GHG calculation, but it is not generally reported in terms of GHG inventory or emission reduction data. It needs to be further calculated for the GHG inventory or emission reduction data. Thus, the GHG report is required to be developed on an annual basis (calendar year).

(2) Unlike the designated building/factory, the BEC building and non-designated building/factory 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 building/factory participating in the DEDE's promotion/mitigation measures to submit the report on an 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/factory, 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] (an energy efficiency labelling scheme) should be separately identified in the energy management report for avoiding double counting issue.

(7) The recommendation on the GHG emission methodology is provided in Chapter 4.

(8) Generally, the GHG emission inventory and the GHG emission mitigation measures are reported on an annual basis. Since the GHG reporting format has not been created so far, 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 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

[1] 2019. Thailand's NDC Action Plan for the Energy Sector 2021-2030. Energy Policy and Planning Office. Ministry of Energy. 42pp.

agencies e.g. TGO, DEDE, ONEP and Energy Working Group as appropriate for the building and industrial sectors.

2. 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 areas 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 is around 66.4 million based on the registration records in December 2018[2].

In the past decade, Thailand's total final energy consumption has been steadily increasing at an average rate of 2.3% per year as illustrated in Figure 2-1. The transportation and industrial sectors consume around three-quarters of the total final energy consumption. The average energy consumption in the transportation and industrial sector is 35.52% and 35.25% of the total final energy consumption respectively.

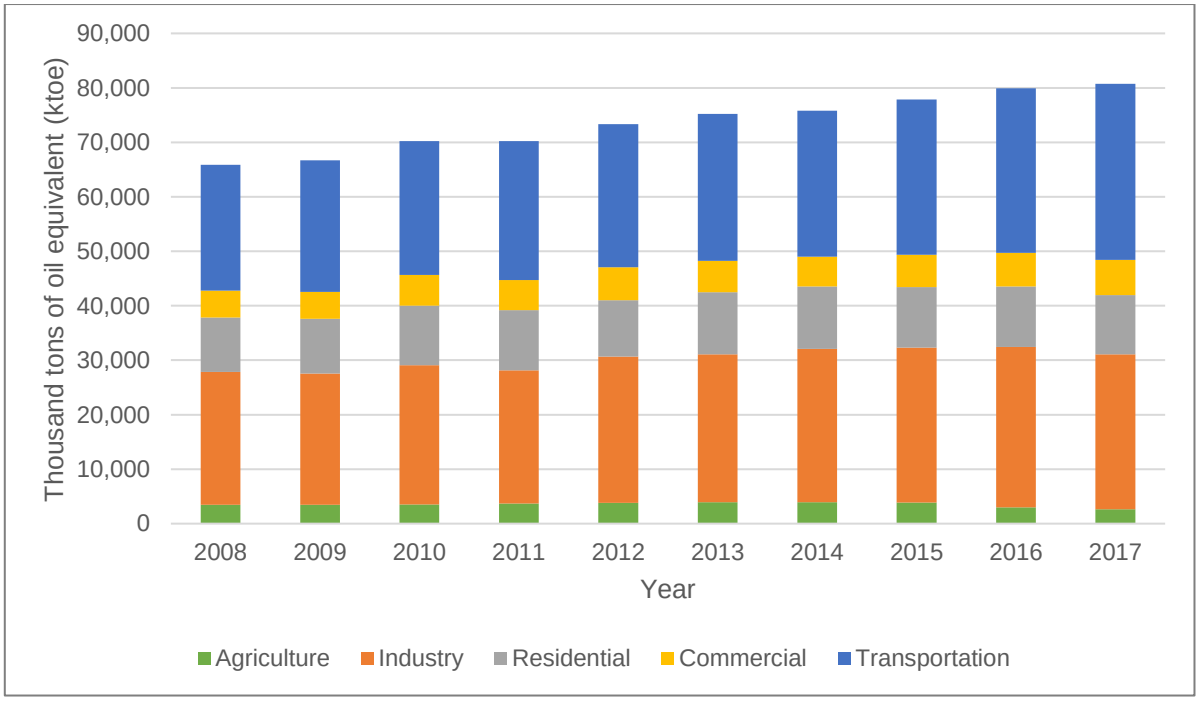


Figure 2- 1 Historic energy consumption trend in Thailand[3]

According to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, there are four sectors/sources emitting GHGs. These are: 1) energy; 2) industrial process and product use (IPPU); 3) agriculture, forestry, and other land uses (AFOLU); and 4) waste. Since the focus of this report is on the industrial sector, the relevant GHG emitting sources are: 1) energy; 2) IPPU; and 3) waste.

According to 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 from 226 $MtCO_2e$ in 2000 to 318 $MtCO_2e$ in 2013. The net removal of CO_2

[2] Department of Provincial Administration, 2018, Accessed on 8 November 2019: http://stat.bora.dopa.go.th/stat/statnew/statTDD/views/showProvinceData.php.
[3] Department of Alternate Energy Development, 2018, Accessed on 8 November 2019: https://www.dede.go.th/ewt_news.php?nid=47349.

increased from 11 $MtCO_2e$ in 2000 to 86 $MtCO_2e$ in 2013. Therefore, the net GHG emission increased from 214 $MtCO_2e$ in 2000 to 232 $MtCO_2e$ 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 2-2). The major source of GHG emissions was the energy sector, which increased from 161 $MtCO_2e$ in 2000 to 236 $MtCO_2e$ in 2013, which is an increase of 47.2%. This is in line with energy consumption trend during the same period.

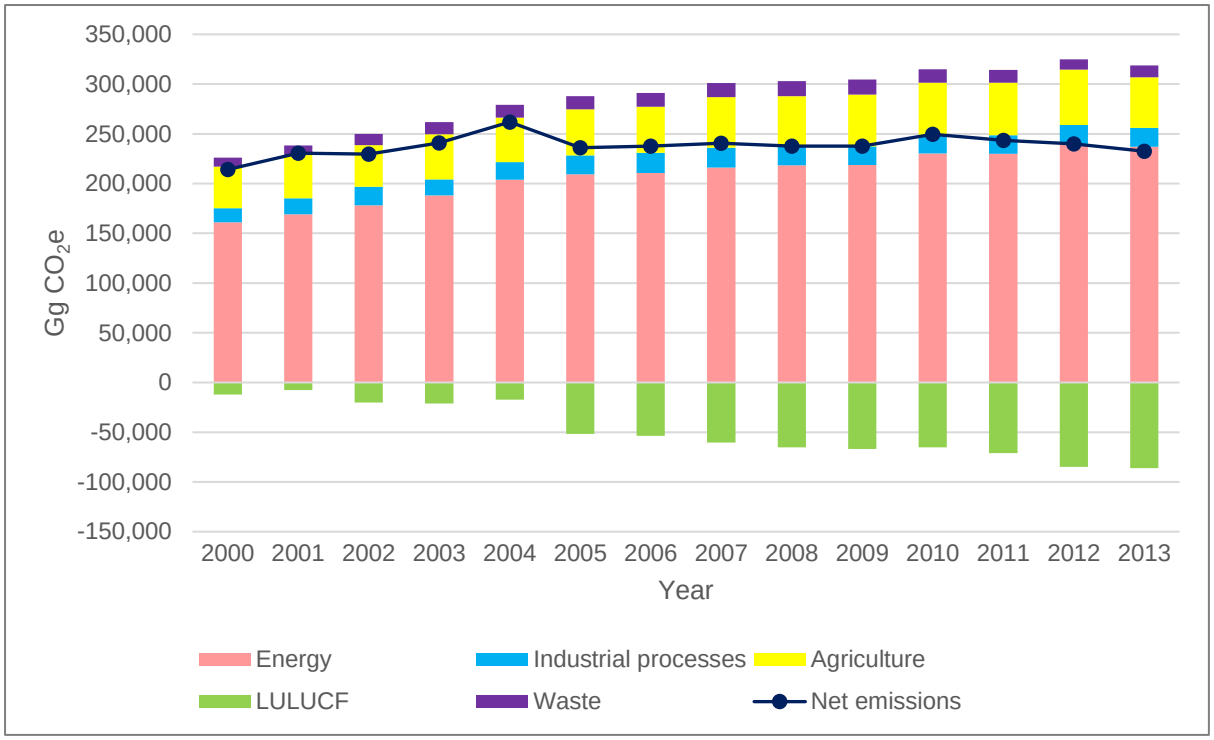


Figure 2- 2 Historic GHG emissions/removal[4]

Energy is the key emission source for the industrial sector as energy is one of the major inputs for all manufacturing process. This leads to GHG emissions both directly emitted at factory sites (e.g. fuel oil, LPG, diesel) and indirectly generated (e.g. GHG emission from grid electricity). However, GHG emissions from IPPU and waste from the sector are considered much more limited and less relevant. With this, Thailand's GHG reduction policies and measures described below give much less priority to these emission sources. Consequently, this report will focus mainly on GHG emissions from the energy rather than the other two emission sources.

To address climate emergency, Thailand has made significant efforts, as a signatory Party under the United Nations Framework Convention on Climate Change (UNFCCC), in mitigating the country's GHG emissions with available resources and capabilities 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 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

[4]2019. Second Biennial Update Report of Thailand. Office of Natural Resources and Environmental Policy and Planning. 108pp.

by 20% (111 $MtCO_2e$) from BAU level by 2030 (refer Figure 2-3), and up to 25% with international support.

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 40.1 $MtCO_2e$ thus meeting its NAMA target of 7% (24.9 $MtCO_2e$) reduction in GHG emissions over the BAU level by 2020.

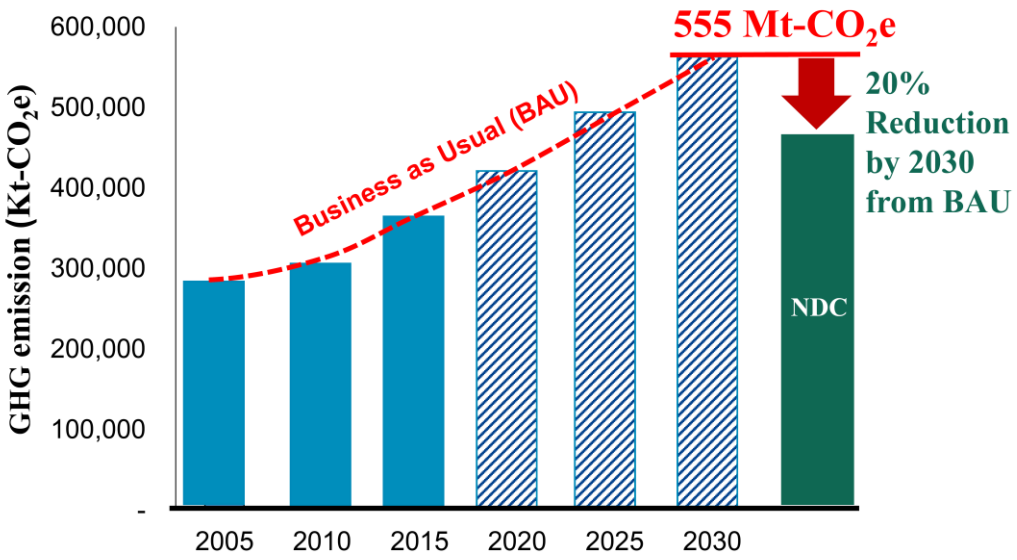


Figure 2- 3 Thailand's NDC Targets[5]

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 (NDC Roadmap) 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 NDC Roadmap is 115.6 $MtCO_2e$ or 20.8% from the BAU level by 2030 which is conformed to the NDC's target. The NDC Roadmap considers five sectors according to Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories namely; 1) energy and transportation, 2) industrial processes, 3) agriculture, 4) LULUCF, and 5) waste. The major mitigation measures in this NDC Roadmap are focused on the energy and transport (113.0 $MtCO_2e$), industrial processes (0.6 $MtCO_2e$) and waste (2.0 $MtCO_2e$), 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 2-4 and Table 2-1 respectively.

[5] 2019. MRV workshop presentation. Office of Natural Resources and Environmental Policy and Planning. 20pp.
[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.

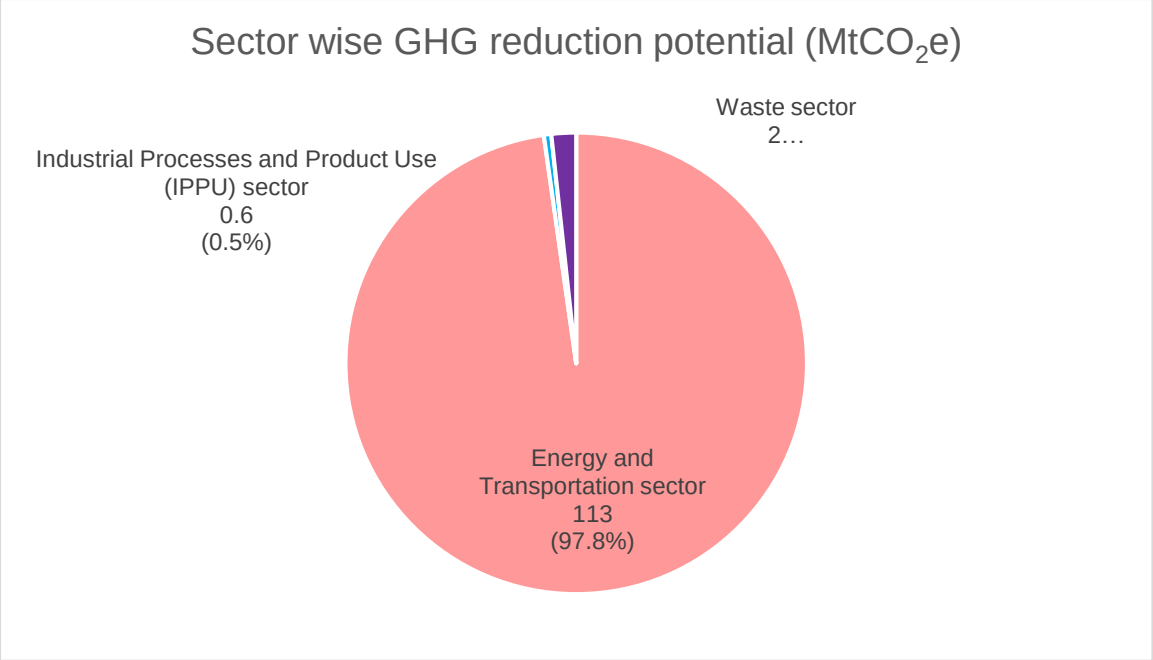


Figure 2- 4 GHG reduction potential by sector

Table 2- 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 (sector of focus for this project)**	**1**	
	1) Energy efficiency improvement	1	Private and public buildings
1.4	**Industry (sector of focus for this project)**	**43**	
	1) Energy efficiency improvement	11	Private entrepreneur

[7] 2018. Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021-2030. Office of Natural Resources and Environmental Policy and Planning. 98pp.

No.	Measure	Potential GHG reductions ($MtCO_2e$)	Target group
	2) Substitution of renewable energy	32	
1.5	**Transportation**	**41**	
	1) Energy efficiency improvement	31	Producers/ travelers/ land, water, air transport system/ people
	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**	

As described above, it is worth noting that this project mainly focuses on the building and industrial sectors (no.1.3 and 1.4 in energy and transportation sector).

2.1 Project background

To pursue sustainable development and reduce national GHG emissions, Thailand lacks 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 the 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), have joined 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. Ultimately, the focus of the two areas will lead to effective contribution to Thailand's NDC implementation.

With this, the project has three major components:

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

It is worth noting that, while the results of the first two components on MRV in the industrial sector and MRV in the building sector are available separately, the two reports provide critical inputs for this report, the Contribution to Thailand's NDC Roadmap, and should be viewed as a key foundation for this document. Since several parts of this report refer or make references to the two previous documents, the three reports under this project were not designed to be stand-alone documents and should instead be viewed as a set of documents.

2.2 Objective and scope

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

1. Review of international best practice/case studies on MRV;
2. Identification of current situation/baseline of current MRV practice in Thailand;
3. Identification of gaps, barriers and opportunities for effective MRV; and
4. Formulation of recommendations to strengthen MRV.

3. REVIEW OF NDC ROADMAP AND NDC ACTION PLAN

In 2017, the National Committee on Climate Change Policy (NCCC) assigned the Energy Policy and Planning Office (EPPO), Ministry of Energy, as the responsible agency for developing an action plan in energy sector, in order to achieve goals laid down in the NDC Roadmap. The EPPO completed the Thailand's NDC Action Plan for the Energy Sector 2021-2030 (NDC Action Plan) in November 2018. The review of activities proposed under both the NDC Roadmap and the NDC Action Plan for building and industrial sectors are reviewed below.

3.1 Review of NDC Roadmap

Building sector

As per the NDC Roadmap, the 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_2e. The buildings are classified into eight types with four important EEMs.

Based on the NDC Roadmap, 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; and
8. Other buildings.

The four key measures for energy efficiency improvement in the building sector are:

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)

The potential GHG reductions from each measure is provided in table 3-1 and figure 3-1.

Table 3- 1 Potential GHG reductions for each measure in building sector[8]

Measure	(Accumulated) 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**

As per the NDC Action Plan, the lighting system is implemented under the Promotion in Energy Efficiency Lighting Usage which is to support in Light Emitting Diode (LED) replacement in public building (both designated and non-designated buildings).

Figure 3-1 provides the potential GHG emission reductions in each building type in 2030.

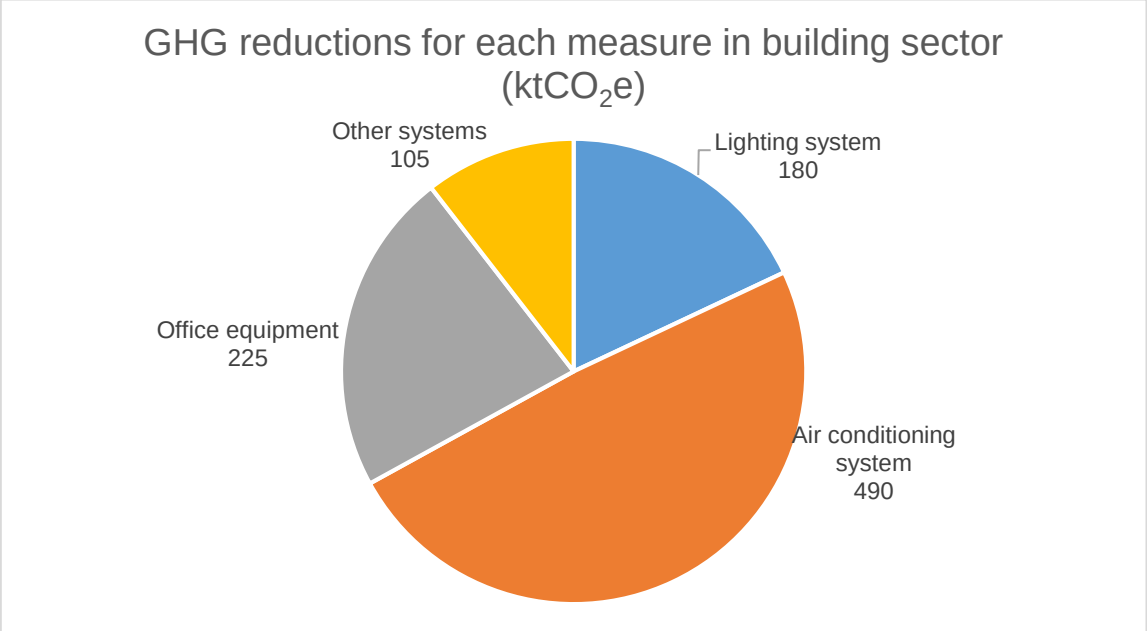


Figure 3- 1 Potential GHG reductions for each measure in building sector in 2030[9]

For the air-conditioning system, office equipment and other systems, these energy efficiency improvements are implemented in many activity plans such as the Project to Intensively Improve Energy Efficiency in SMEs' Factory and Building and Project to Support Energy Efficiency Usage in Commercial Buildings, etc.

[8] 2018. Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021-2030. Office of Natural Resources and Environmental Policy and Planning. 98pp.

[9] 2018. Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021-2030. Office of Natural Resources and Environmental Policy and Planning. 98pp.

The potential GHG reductions under different building type are shown in table 3-2 and figure 3-2.

Table 3- 2 Potential GHG reductions for each building type[10]

Type of building	(Accumulated) 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
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

[10] 2018. Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021-2030. Office of Natural Resources and Environmental Policy and Planning. 98pp.

Type of building	(Accumulated) Potential GHG reductions ($ktCO_2e$)		
	2010	2020	2030
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**

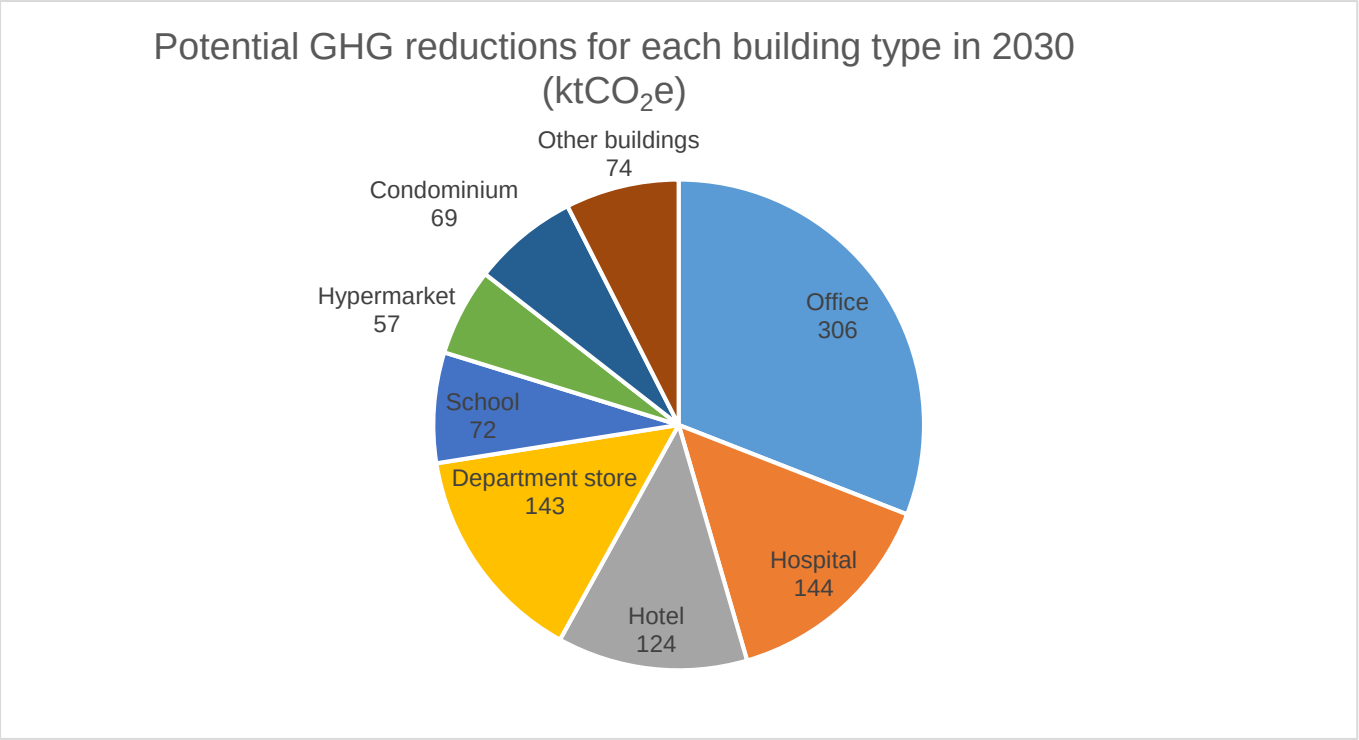


Figure 3- 2 Potential GHG reductions for each building type in 2030[11]

As per the potential GHG reductions for each building type, the office buildings have highest potential GHG reductions (306 $ktCO_2e$), followed by hospitals (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.

[11] 2018. Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021-2030. Office of Natural Resources and Environmental Policy and Planning. 98pp.

Industrial sector

As per the NDC Roadmap, the industrial sector is classified as a sub-sector under the energy and transportation sector and its main target measures are a) energy efficiency improvement and b) substitution of renewable energy – with total potential GHG reductions of 43 million tCO_2e. The details of each measure are as follows.

a) Energy efficiency improvement

This measure is divided into four systems namely:

(1) Motor system
(2) Lighting system
(3) Cooling system
(4) Molten system

b) Substitution of renewable energy

This measure is divided into two components namely:

(1) Thermal energy consumption improvement which targets at,
- Cement production
  - Efficient kiln
  - Efficient kiln with combined heat and power
- Boiler system
  - Efficient boiler
  - Advanced boiler
- Molten system
  - Efficient furnace

(2) Substitution of renewable energy which targets at,
- Solar
- Biomass
- Biogas
- Municipal solid waste

Table 3-3 provides the GHG reduction potential through each of above measures.

Table 3- 3 Potential GHG reductions for each measure in industrial sector[12]

Measure	(Accumulated) Potential GHG reductions ($ktCO_2e$)			
	2015	2020	2025	2030
1) Energy efficiency improvement	**44**	**2,375**	**8,268**	**11,000**
(1) Motor system	43	1,618	5,634	7,496
(2) Lighting system	0	191	665	885
(3) Cooling system	1	556	1,935	2,574
(4) Molten system	0	9	34	46

[12] 2018. Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021-2030. Office of Natural Resources and Environmental Policy and Planning. 98pp.

Measure	(Accumulated) Potential GHG reductions ($ktCO_2e$)			
	2015	2020	2025	2030
2) Substitution of renewable energy	**1,735**	**11,446**	**19,653**	**32,000**
(1) Thermal energy consumption improvement				
- Cement production	1,072	7,853	13,414	21,771
- Boiler system	242	2,456	4,573	7,795
- Molten system	79	454	791	1,367
(2) Substitution of renewable energy				
- Solar	3	7	9	11
- Biomass	327	654	839	1,023
- Biogas	7	15	19	23
- Municipal solid waste	3	6	8	10
Total	**1,779**	**13,821**	**27,921**	**43,000**

As per the NDC Action Plan, the energy efficiency improvement (motor, lighting, cooling and molten systems) is implemented in many activity plans such as Project to Intensively Improve Energy Efficiency at SMEs' Factory and Building and Project to Promote Energy Efficiency in SMEs Factories and etc.

For the substitution of renewable energy, this measure is implemented in many activity plans such as the Development of Solar Power, Development of Biomass, Development of Biogas and Development of Waste to Energy projects.

Figure 3-3 shows the contribution of GHG reduction potential from different measures.

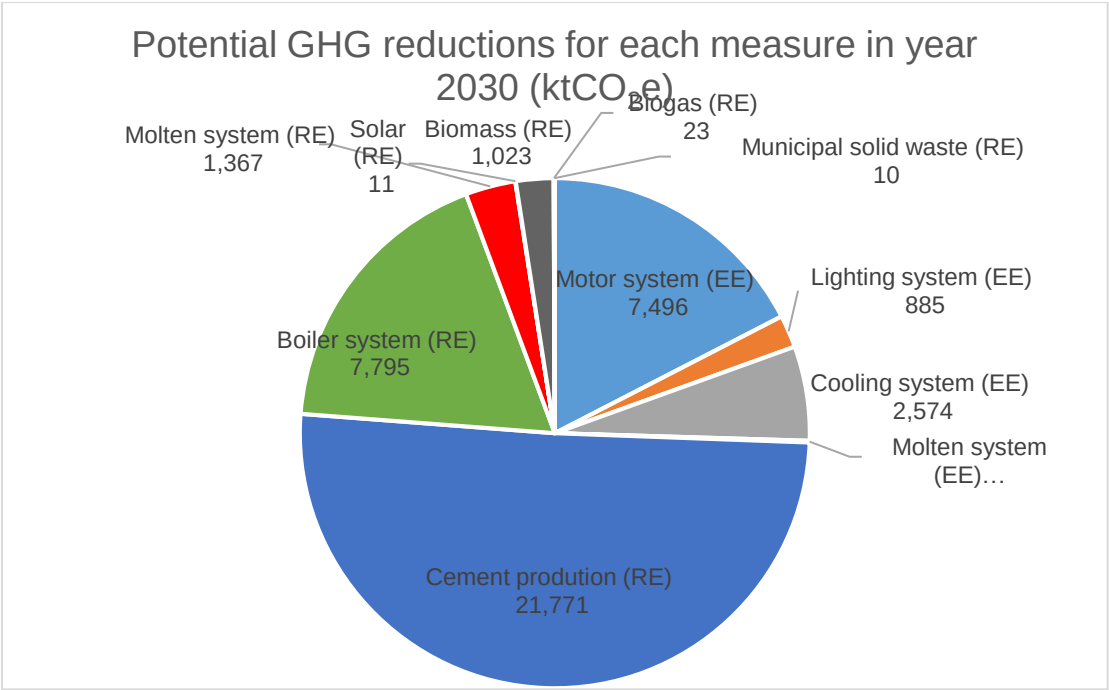


Figure 3- 3 Potential GHG reductions for each measure in industrial sector in year 2030[13]

3.2 Review of NDC Action Plan

As per the Strategy No.1.1 "Integrating policies and plans with related parties for driving GHG reductions in energy efficiency improvement" of the NDC Action Plan, there are many measures to be implemented to achieve the GHG emission reduction target as follows:

1) Enforcement of energy efficiency standards in the designated building / factory
2) Enforcement of Building Energy Code (BEC) for new building
3) Determination on standards and labelling on efficient machine/equipment
4) Enforcement of Energy Efficiency Resources Standards
5) Support/subsidy in energy efficiency implementation
6) Promotion in energy efficiency lighting usage
7) Efficiency improvement in power production

The responsible agency and its support agencies for each of the measures above are provided in Table 3-4.

Table 3- 4 Responsible agency and its support agencies for each of measures (building sector)[14]

Measures	Responsible agency/ies	Support agencies
1) Enforcement of the energy efficiency standards in the designated building / factory		
Supervision and promotion of energy conservation under the law for designated factory	DEDE	DIW / IEAT / ONEP / TGO

[13] 2018. Thailand's Nationally Determined Contribution Roadmap on Mitigation 2021-2030. Office of Natural Resources and Environmental Policy and Planning. 98pp.
[14] 2018. Thailand's NDC Action Plan for the Energy Sector 2021-2030. Energy Policy and Planning Office. Ministry of Energy. 42pp.

Measures	Responsible agency/ies	Support agencies
Supervision and promotion of energy conservation under the law for designated building (private building)	DEDE	DIW / IEAT / ONEP / TGO
Supervision and promotion of energy conservation under the law for designated building (public building)	DEDE	DPT / ONEP / TGO
Project to promote energy efficiency in production and use of steam system in designated factory	DEDE	DIW / IEAT / ONEP / TGO
Project to promote energy efficiency in compressed air system in designated factory	DEDE	DIW / IEAT / ONEP / TGO
Project to promote energy efficiency in chiller in designated building	DEDE	DPT / ONEP / TGO
2) Enforcement of Building Energy Code (BEC) for new building		
Coordinating center for energy conservation building design	DEDE	DPT / ONEP / TGO
3) Determination on standards and labeling on efficient machine/equipment		
Standard and labeling on energy label no.5	EGAT	TISI / ONEP / TGO
Project to promote highly efficient machine & equipment and material by labeling	DEDE	TISI / ONEP / TGO
4) Enforcement of Energy Efficiency Resources Standards (EERS)		
Enforcement of Energy Efficiency Resources Standards (EERS)	EGAT/MEA/ PEA	EPPO / DEDE / OERC / ONEP/ TGO
5) Support/subsidy in energy efficiency implementation		
Project to study and pilot support SOP to small and medium scale enterprises (SMEs) and/or residential	DEDE	EPPO / ONEP / TGO
Project to support SOP to SMEs and/or residential	DEDE	EPPO / ONEP / TGO
Project to intensively improve energy efficiency at SMEs' factory and building	DEDE	EPPO / ONEP / TGO
Demonstration project of using energy-saving equipment in public building (non-designated building)	DEDE	EPPO / ONEP / TGO
Project to improve energy efficiency by soft loan	DEDE	EPPO / ONEP / TGO
Project to promote business and market stimulate in energy efficiency by Energy Service Company (ESCO)	DEDE	EPPO / ONEP / TGO
Project to promote investment in energy efficiency and alternative energy by ESCO Revolving Fund	DEDE	EPPO / ONEP / TGO
In-depth technology demonstration project for energy efficiency	DEDE	EPPO / ONEP / TGO

Measures	Responsible agency/ies	Support agencies
Tax incentives for energy efficiency	DEDE	EPPO / ONEP / TGO
Project to support in machine & equipment replacement in public sector (Block Grant)	DEDE	EPPO / ONEP / TGO
Project for integrated capacity development for energy efficiency at community hospitals	DEDE	EPPO / ONEP / TGO
Project to provide subsidy on energy saving by bidding (DSM bidding)	DEDE	EPPO / ONEP / TGO
Project to promote energy efficiency in SMEs factories	DEDE	EPPO / ONEP / TGO
Project to support energy efficiency usage in commercial buildings	DEDE	EPPO / ONEP / TGO
6) Promotion in energy efficiency lighting usage		
Project to support in Light Emitting Diode (LED) replacement in public buildings (both designated and non-designated buildings)	DEDE	EPPO / ONEP / TGO
7) Efficiency improvement in power production		
Efficiency improvement in power production	EGAT	EPPO / OERC / ONEP / TGO

As per the Strategy No. 1.2 “Integrating policies and plans with related parties for driving GHG reductions in renewable energy development” of the NDC Action Plan, the measures related to the industrial sector to be implemented to achieve the GHG emission reduction target are listed as follows:

1) Development of solar power
2) Development of biomass
3) Development of biogas
4) Development of waste-to-energy

The responsible agency and its support agencies for each of measures above are provided in Table 3-5.

Table 3- 5 Responsible agency and its support agencies for each of activity plans (industrial sector)[15]

Measures	Responsible agencies	Support agencies
1) Development of solar power		
Electricity generation from solar	DEDE	EPPO / OERC / EGAT / MEA / PEA / ONEP / TGO

[15] 2018. Thailand’s NDC Action Plan for the Energy Sector 2021-2030. Energy Policy and Planning Office. Ministry of Energy. 42pp.

Measures	Responsible agencies	Support agencies
Thermal generation from solar	DEDE	Related parties
2) Development of biomass		
Electricity generation from biomass	DEDE	EPPO / EGAT / MEA / PEA / MOAC / ONEP / TGO
Thermal energy generation from bio-energy (biomass, biogas, waste)	DEDE	EPPO / EGAT / MEA / PEA / LAO / BMA / MOAC / ONEP / TGO
3) Development of biogas		
Electricity generation from bio-energy (biogas (wastewater/waste))	DEDE	EPPO / EGAT / MEA / PEA / LAO / BMA / ONEP / TGO
Electricity generation from bio-energy (biogas (energy crop))	DEDE	EPPO / EGAT / MEA / PEA / MOAC / ONEP / TGO
4) Development of waste to energy		
Electricity generation from municipal solid waste	DEDE	EPPO / EGAT / MEA / PEA / LAO / BMA / ONEP / TGO
Electricity generation from industrial waste	DEDE	EPPO / EGAT / MEA / PEA / DIW / IEAT / ONEP / TGO

3.3 Review of relevant measures in building and industrial sectors

With respect to the NDC Roadmap and NDC Action Plan discussed in above sections, there are ongoing measures specific only to the building and industrial sectors which are as follows:

(1) Enforcement of Building Energy Code (BEC) for new building
(2) Enforcement of the energy efficiency standards in the designated building / factory

1. Enforcement of Building Energy Code (BEC) for new 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 the local administration organization for building construction / modification permit. There are nine types of targeted building for BEC as listed below.

(1) Hospital
(2) School
(3) Office
(4) Condominium
(5) Exhibition building
(6) Theater

(7) Hotel
(8) Entertainment service
(9) Department store

The 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 with the following standard value given in table 3-6.

Table 3- 6 Standards of OTTV and RTTV for building envelope[16]

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

The power consumption rate for lighting system shall comply with the following standard value given in table 3-7.

Table 3- 7 Standard of power consumption rate for lighting system[17]

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 3-8 and 3-9 respectively.

[16] 2009. The Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedure in Designing Building for Energy Conservation B.E.2552 (2009). Ministry of Energy. 7pp.
[17] 2009. The Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedure in Designing Building for Energy Conservation B.E.2552 (2009). Ministry of Energy. 7pp.

Table 3- 8 COP and EER standards for small air-conditioning system (split type) [18]

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

Table 3- 9 ChP standard for large air-conditioning system (chiller) [19]

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 3-10 and 3-11.

Table 3- 10 Standard of boiler efficiency [20]

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

[18] 2009. The Ministry of Energy Notification Prescribing Minimum standard of COP, EER and ChP for air-conditioning system installed in Building B.E.2552 (2009). 4pp.
[19] 2009. The Ministry of Energy Notification Prescribing Minimum standard of COP, EER and ChP for air-conditioning system installed in Building B.E.2552 (2009). 4pp.
[20] 2009. The Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedure in Designing Building for Energy Conservation B.E.2552 (2009). Ministry of Energy. 7pp.

Table 3- 11 COP standard of air-source heat pump water heater[21]

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

5) Whole building energy performance

If the design for new/modified building does not satisfy 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 for the total energy consumption.

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

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

Figure 3-4 shows these options in qualifying for the BEC standard.

[21] 2009. The Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedure in Designing Building for Energy Conservation B.E.2552 (2009). Ministry of Energy. 7pp.

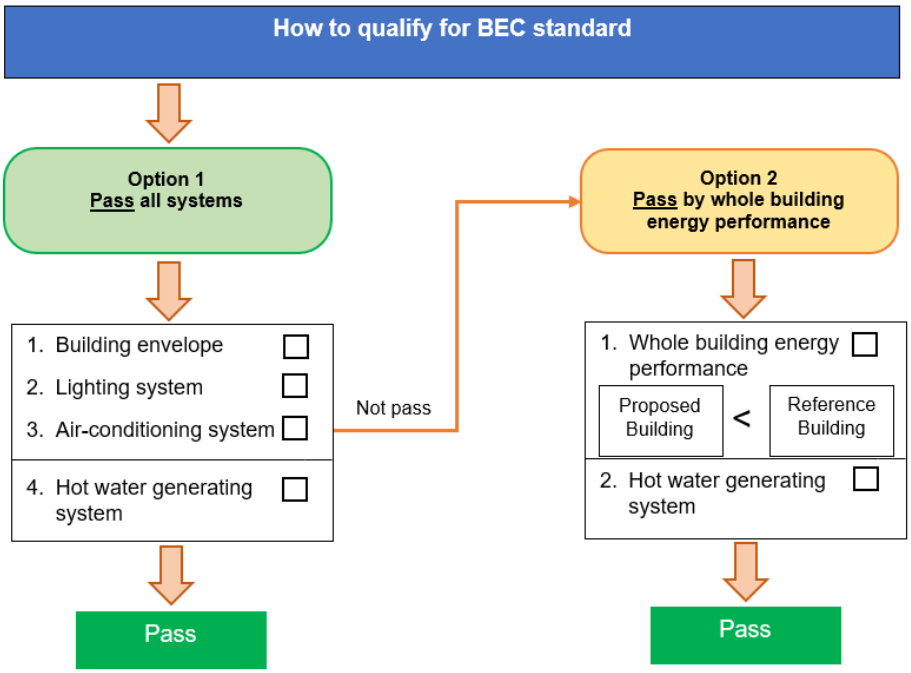


Figure 3- 4 Options for designing building to be qualified under the BEC standard[22]

2. Enforcement of the energy efficiency standards in the designated building / factory

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":

a) 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.

b) 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).

According to the Royal Decree on Designated Factory B.E. 2540 (1997), a factory that satisfies the following criteria is defined as the "designated factory":

a) A single factory 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. (From the workshop on 20 September 2019, DEDE shared that they are reducing threshold for the designated factory from a total capacity 1,000 kilowatt or above to be 800 kilowatt or above)

b) A single factory 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 the owner of the designated building/factory are listed below;

[22] 2018. Guideline for Evaluating the Building Energy Code. Department of Alternative Energy Development and Efficiency. 17pp.

1) Assigning the responsible persons for energy management in each designated building/factory in line with the criteria given in Table 3-12.

Table 3- 12 Number of responsible persons for energy management[23]

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 3-5.

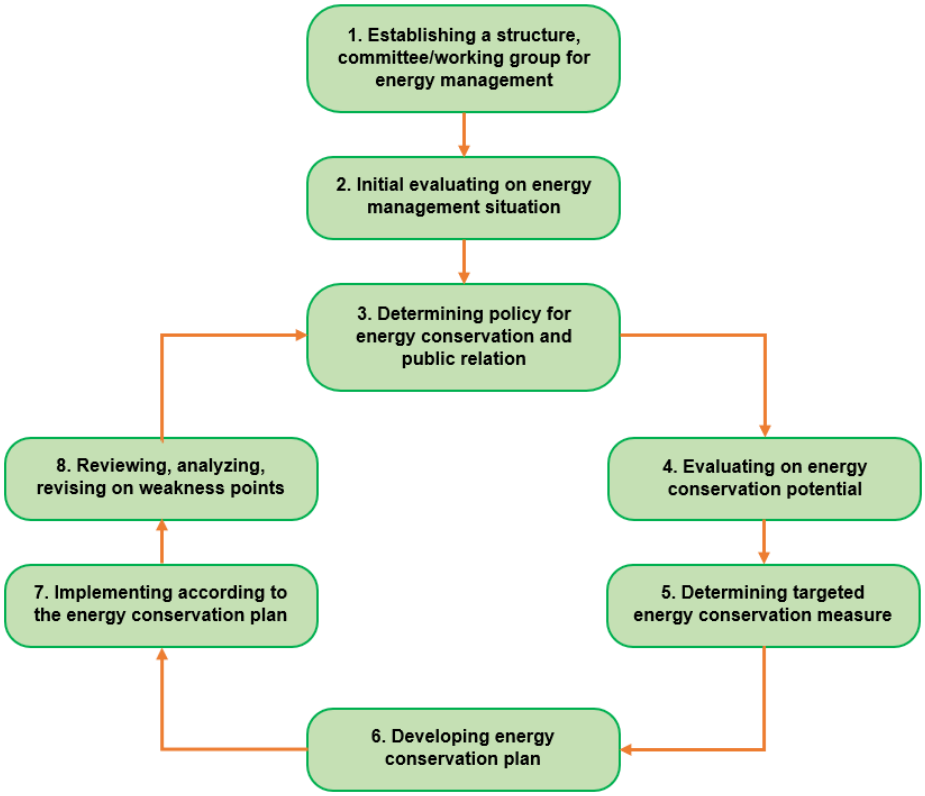


Figure 3- 5 Energy management guideline[24]

3) Submitting the energy management report and the auditing & certification energy report to DEDE before March every year.

Owner of the designated building/factory must develop an energy management report and then send it to a competent official/accredited person for approval. After getting approval and

[23] 2009. The Ministerial Regulation Prescribing Qualifications, Duties and Number of Person Responsible for Energy B.E.2552 (2009). 6pp.

[24] 2009. Manual for explanation on the Energy Conservation Promotion Act B.E.2535 (1992) for designated factory and designated building. Department of Alternative Energy Development and Efficiency. 82pp.

receiving the auditing and certification energy report from the competent official/accredited person, the owner of the designated building/factory must submit the energy management report and auditing and certification energy report to the DEDE before March every year. Figure 3-6 shows the flow chart of steps involved in the submission of the energy management report to the DEDE.

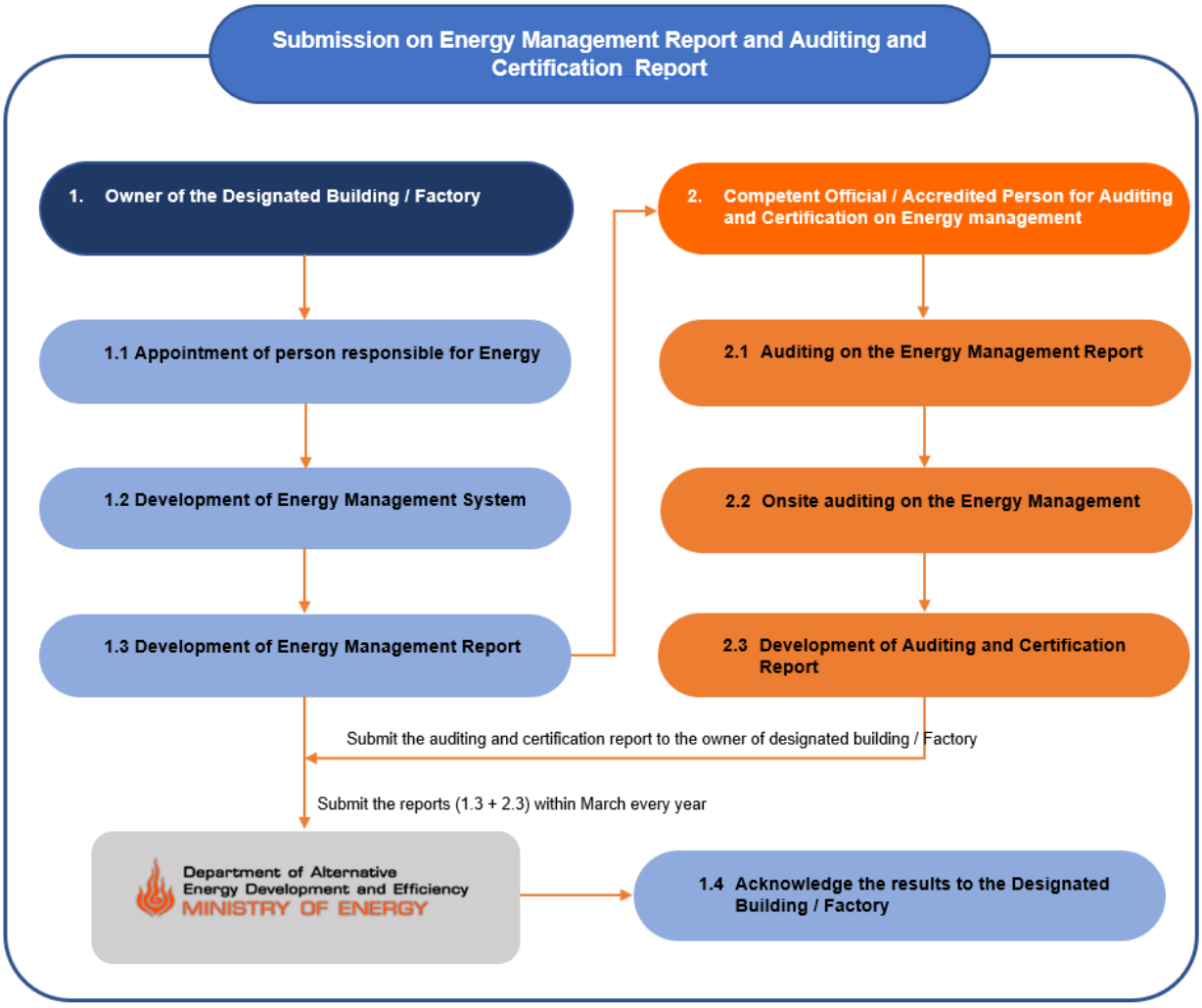


Figure 3- 6 Submission on energy management report for designated building / factory[25]

3.4 Current MRV system and practice that are relevant to above activity plans

Currently, there is no existing MRV practice in the building and industrial sectors. There is no online platform for reporting, storage and retrieval of verified data from different sectors. Different agencies have different formats and methods of data collection and assessment. However, the designated building/factory have to report their energy consumption through the energy management report on an annual basis. This energy management report could be further used for the GHG emission calculation. The steps in the existing reporting practice are listed below.

[25] The energy conservation center of Thailand, 2018, Accessed on 8 November 2019: http://www.ecct-th.org/acf/kittipong_r.pdf

1. The designated building/factory implements the energy conservation measure
2. The designated building/factory measures and records data as required by the energy management report
3. Owner of the designated building/factory develops the energy management report
4. Owner of the designated building/factory seeks and sends the energy management report to a competent official/accredited person for approval.
5. The competent official/accredited person verifies the energy management report and develops an auditing and certification energy report and sends it to the designated building/factory
6. The designated building/factory submits the energy management report and auditing and certification energy report to the DEDE before March every year.

Although this energy reporting system is not MRV for GHG, it provides a great opportunity to develop this system in order to further support GHG reporting. However, it will cover only the designated building/factory since at present non-designated building/factory are not required to submit the energy management report. Therefore, gaps on emission data for non-designated building/factory still remain. Such gaps are covered in the next chapter.

3.5 Current data collection and matrix assessment for building and industrial sectors

As mentioned above, the energy management report is submitted to DEDE on an annual basis, the below tables show the current data collected from both the building and industrial sectors for the year 2017.

The key data for a designated building is shown in table below:

Table 3- 13 Key data for the designated building in year 2017[26]

Type of building	Air condition area (m^2)	Non-air condition area (m^2)	Total area (m^2)	No. of room	No. of bed	Total energy consumption (MJ)
Water supply	30,707	57,673	88,380	-	-	27,177,137
Electricity	75,636	66,700	142,336	-	-	45,690,631
Livestock farm	1,986,715	17,851,138	19,837,853	-	-	1,414,366,783
Hospital	2,505,661	825,177	3,330,838	13,971	3,274,368	2,184,036,487
Hotel	7,648,137	3,093,906	10,742,043	23,887,730	-	7,708,681,807
Department store	14,141,806	3,041,071	17,182,877	38,279	-	15,747,380,418
School	14,226,857	14,824,355	29,051,212	-	785,281	5,427,368,509
Office	11,878,210	17,642,258	29,520,468	228,312	-	8,999,502,587

[26] 2019. Database on Designated Buildings and Factories. Department of Alternate Energy Development and Efficiency. Received and accessed on 13th May 2019

Type of building	Air condition area (m^2)	Non-air condition area (m^2)	Total area (m^2)	No. of room	No. of bed	Total energy consumption (MJ)
Other buildings	10,982,078	6,603,314	17,585,392	113,673	-	7,648,547,780

According to the above data, the major energy intensive building types are departmental stores at 15,747 TJ, followed by offices at 9,000 TJ and hotels at 7,709 TJ as shown in Figure 4-2.

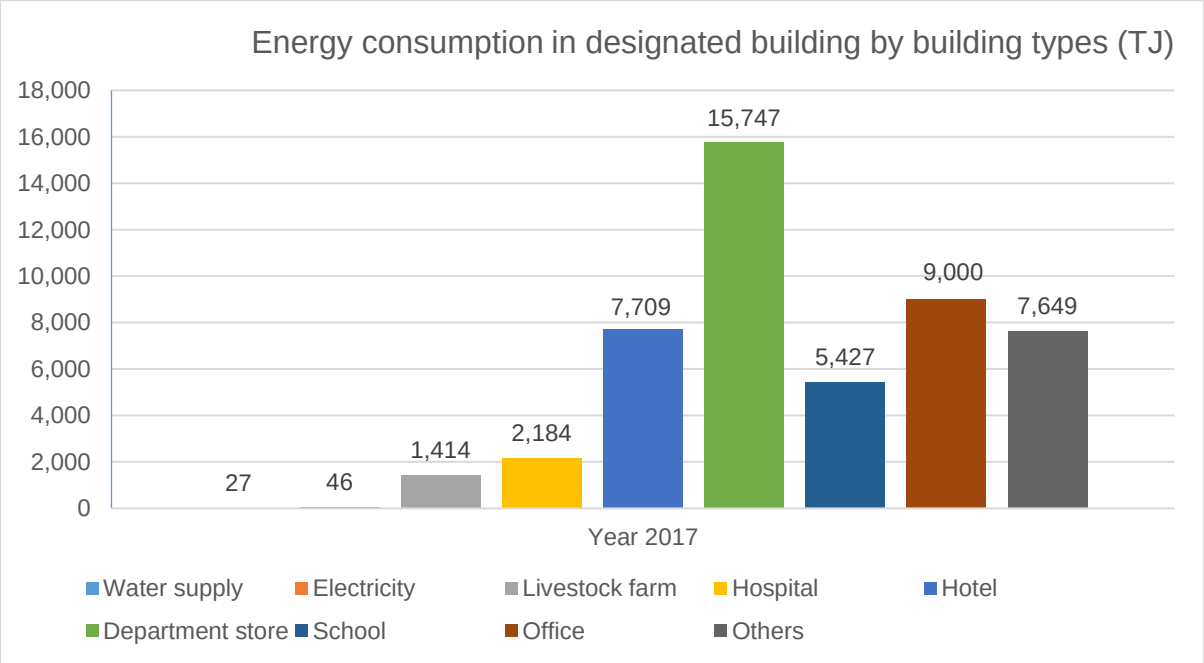


Figure 3- 7 Energy consumption in designated building by building types[27]

It could be observed that the building sector is a crucial sector for GHG emission reduction as this sector is a target sector in the NDC Roadmap and NDC Action Plan, which would contribute to around 1 million tCO_2e of GHG reduction. Since there are many types of buildings, it will be more effective if these building types are prioritized instead of working on all types at the same time. In order to do that, assessment should consider each type's energy consumption, data and information available, readiness of reporting system and potential of GHG reduction as presented below;

[27] 2019. Database on Designated Buildings and Factories. Department of Alternate Energy Development and Efficiency. Received and accessed on 13th May 2019

.

Table 3- 14 Matrix assessment by building type in building sector

Type of building	High energy consumption	Data and information available	Readiness of Reporting system	High GHG reduction potential	Ranking (1st-3rd)
Designated building					
Water supply	Low	High	High	Low-Medium	
Electricity	Low	High	High	Low-Medium	
Livestock farm	Low	High	High	Low-Medium	
Hospital	Medium	High	High	Low-Medium	
Hotel	High	High	High	Low-Medium	3rd
Department store	High	High	High	Low-Medium	1st
School	Medium	High	High	Low-Medium	
Office	High	High	High	Low-Medium	2nd
Other buildings	Medium	High	High	Low-Medium	
Non-designated building	Low-Medium	Low	Low	Medium-High	

As a result, the first three priority building types recommended to take action would be (i) department store, (ii) office and (iii) hotel respectively. The designated building under these three building types should be the first and followed by the BEC building and non-designated building respectively.

As for the industrial sector, the key data for designated factory is shown in table below:

Table 3- 15 Key data for the designated factory in year 2017[28]

Type of industry	Electricity consumption (kWh)	Thermal energy consumption (MJ)	Total energy consumption (MJ)	Product quantity (units)
Paper	2,257,195,759	69,851,909,193	77,977,813,927	Varieties of products, sizes, units
Gas	632,673,529	53,486,092,745	55,763,717,449	Varieties of products, sizes, units

[28] 2019. Database on Designated Buildings and Factories. Department of Alternate Energy Development and Efficiency. Received and accessed on 13th May 2019

Type of industry	Electricity consumption (kWh)	Thermal energy consumption (MJ)	Total energy consumption (MJ)	Product quantity (units)
Water supply	553,509,976	64,233,823	2,056,869,738	93,336,860.79 m^3
Chemicals	4,212,012,095	2,157,555,350,926	370,426,854,609	Varieties of products, sizes, units
Metal product, machinery and equipment	10,807,245,304	331,520,771,515	105,295,880,942	Varieties of products, sizes, units
Wood	10,697,323,684	66,785,515,679	16,524,943,247	Varieties of products, sizes, units
Primary metals	1,223,551,626	12,120,157,393	225,825,972,490	Varieties of products, sizes, units
Textiles	6,989,581,136	200,663,480,399	100,811,513,907	Varieties of products, sizes, units
Stone, gravel and sand	3,904,585,835	86,755,004,901	913,103,901	Varieties of products, sizes, units
Non-metals	148,317,308	379,161,591	269,975,966,624	Varieties of products, sizes, units
Food, beverage and tobacco	13,483,127,339	221,436,708,205	242,113,291,819	Varieties of products, sizes, units
Other products	9,871,271,080	206,576,715,930	42,570,857,331	Varieties of products, sizes, units

According to the above data, the major energy intensive and highest energy consumption in 2017 is by the chemical industry at 370,427 TJ, followed by non-metals industry at 269,976 TJ and food, beverage and tobacco industry at 242,113 TJ as shown below;

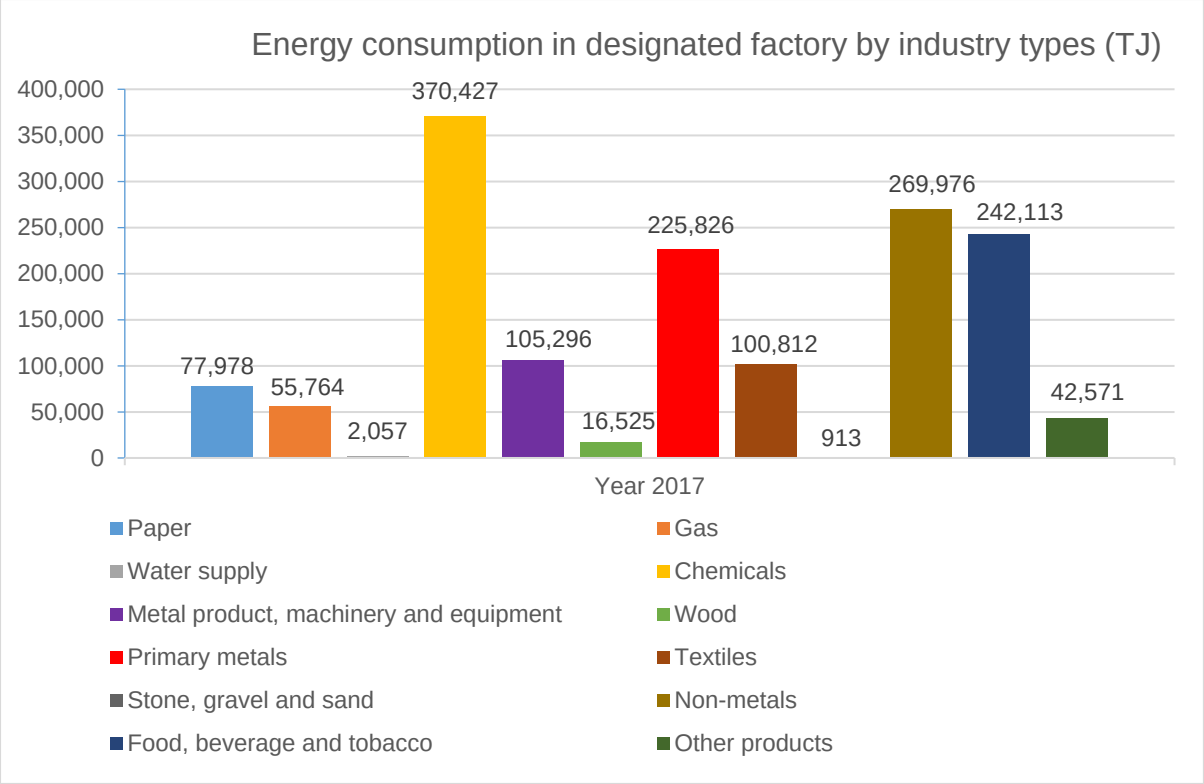


Figure 3- 8 Energy consumption in designated factory by industry types[29]

It could be observed that the industrial sector is a crucial sector for GHG emission reduction as this sector is a significant target sector in the NDC Roadmap and NDC Action Plan which would contribute to around 43 million tCO_2e. Since there are many sub-sectors, it will be more effective if these sub-sectors are prioritized instead of working on all types at the same time. In order to do that, assessment should consider each type's energy consumption, data and information available, readiness of reporting system and potential of GHG reduction as presented below.

Table 3- 16 Matrix assessment by industry type in industrial sector

Type of industry	High energy consumption	Data and information available	Readiness of Reporting system	High GHG reduction potential	Ranking (1^{st}-3^{rd})
Designated factory				Low-Medium	
Paper	Low-Medium	High	High	Low-Medium	
Gas	Low	High	High	Low-Medium	
Water supply	Low	High	High	Low-Medium	
Chemicals	High	High	High	Low-Medium	1^{st}

[29] 2019. Database on Designated Buildings and Factories. Department of Alternate Energy Development and Efficiency. Received and accessed on 13th May 2019

Type of industry	High energy consumption	Data and information available	Readiness of Reporting system	High GHG reduction potential	Ranking (1^{st}-3^{rd})
Metal product, machinery and equipment	Medium	High	High	Low-Medium	
Wood	Low	High	High	Low-Medium	
Primary metals	High	High	High	Low-Medium	
Textiles	Medium	High	High	Low-Medium	
Stone, gravel and sand	Low	High	High	Low-Medium	
Non-metals	High	High	High	Low-Medium	2^{nd}
Food, beverage and tobacco	High	High	High	Low-Medium	3^{rd}
Other products	Low	High	High	Low-Medium	
Non-designated factory	Low-Medium	Low	Low	Medium-High	

As a result, the first three priority industries to be recommended for immediate action would be (i) chemicals, (ii) non-metals, (iii) food, beverage and tobacco respectively. The designated factory under these three industries should be the first and followed by the non-designated factory.

4. RECOMMENDATIONS

Based on the results of the two previous reports on MRV in the Industrial Sector and MRV in the Building Sector (available separately) and stakeholder engagement through workshops and dialogues, the recommendations to strengthen Thailand's MRV systems are formulated and provided below. The recommendations could be divided into two levels; country level and sectoral level (building and industrial sectors) as described below.

4.2 Country Level

Urgency

(1) Given the fact that Thailand will enter into the NDC period in early 2021 and there are no MRV systems in place yet, the country should prioritize developing MRV systems as soon as possible. This aims to ensure that, the results from GHG mitigation actions taken under the NDC Roadmap and NDC Action Plan are covered and present the opportunities available for further effort in addressing the climate emergency.

MRV systems

(2) Although there are no existing MRV systems in place for the country, the annual energy management reporting system is the most relevant and could be used as a strong foundation for the country to further develop its MRV systems. Not only can it save significant amount of time in designing new systems and engaging wide range of stakeholders to find mutual agreements on how the systems should look like, but it can also minimize legal efforts in designing new systems and getting approval from relevant stakeholders.

(3) For designated factory/building, the current energy management reporting could be developed further to capture GHG emissions from these sources. However, for non-designated factory/building. There is still a big gap in terms of GHG reporting. As ONEP is preparing a draft, Climate Change Act and relevant government agencies might have authority to require necessary information/data from relevant sectors (e.g. private sector), which could provide a great opportunity to close this gap by mandating those stakeholders to report their relevant data.

(4) There is lack of information linkage and guidelines between the energy plans/policies and the GHG emission reduction policies (e.g. the Alternative Energy Development Plan and Energy Efficiency Plan). To ensure effective implementation of GHG reduction measures and MRV of those measures, a clear linkage between relevant measures and GHG reduction should be created and clearly communicated.

(5) MRV systems at the sector level and policy level need to use data from a number of organizations altogether. Thus, a common platform should be developed so that all data required for the GHG calculation collected by the lead or responsible agencies can be made available to all the related agencies for ease of convenience and transparency.

(6) Digitalization of MRV can be brought in to improve the accessibility, timeliness, accuracy and transparency of the energy consumption and GHG emission data. This could also help in effective future planning based on traceable results achieved from the previous initiatives.

(7) Many stakeholders share their understanding on the needs for national MRV systems for GHG emission. However, there is a strong concern that GHG reporting requirement at organizational level could add additional burden to them. With this, it is highly recommended that a new report requirement for organizational level should be streamlined with the current system and minimize report burden to those who are involved in this process.

(8) Based on experiences from relevant stakeholders developing their own internal MRV systems, it is found that their current practical challenges are; unclear assumptions; unclear emission factors; data limitation, and others. To move forward with national MRV systems, the government should develop a clear guideline/handbook to address these issues.

Stakeholder Engagement

(9) From relevant stakeholders' point of view, especially private sector, the government should provide a clear direction or targets, on how each sector should contribute to the country's GHG reduction commitment. 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, industries, and other relevant stakeholders working on several climate-related initiatives (e.g. corporate carbon footprint, sustainability reporting, carbon trading). Some of the leading companies are even listed on Dow Jones Sustainability Indices (DJSI). These organizations can play critical roles in helping the country achieve its GHG reduction targets and demonstrate necessary data for the country's MRV systems.

(10) It is also found that the capacity on GHG reporting is still limited to a small group of stakeholders who have been familiar with climate change issue. Since achieving NDC commitment requires economy-wide mitigation actions and effort, it is necessary that the capacity of relevant stakeholders be strengthened; especially those who are working in the priority sectors.

4.2 Sectoral Level (Building and Industrial Sectors)

Industrial Sector

(1) At present, the designated factory is mandated to submit an energy management report on annual basis. This report contains almost all the data required for the GHG calculation. Currently, this is not reported in terms of GHG inventory or emission reduction data. It needs to be further calculated as the GHG inventory or emission reduction data. Thus, GHG report is required to be developed on an annual basis for best MRV practice.

(2) Unlike the designated factory, the non-designated factory has no process or reporting system for the report submission on an annual basis. Therefore, it is required to create a reporting system for the non-designated factory participating in the DEDE's measures on an annual basis and submission until year 2030 (end of NDC period).
(3) The data of Label no.5 should be separately identified in the energy management report for avoidance of double counting.

Building Sector

(4) At present, the designated building is mandated to submit an energy management report on an annual basis. This report contains almost all the data required for the GHG calculation. Currently this is not generally reported in terms 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 an annual basis (calendar year) for the best MRV practice.
(5) Unlike the designated building, BEC and non-designated building 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 building participating in the DEDE's measures to submit the report on an annual basis until 2030 (end of NDC period).
(6) Quantification and monetization of (positive and negative) externalities over the building life cycle should be well-integrated into decision-making processes.
(7) Continuous monitoring and constant modification of the 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.
(8) 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 be combined or linked to the GHG emission term at the earlier stage of the plan development itself, then it would be easy to understand, assume appropriately and calculate the energy demand reduction.
(9) The data of Label no.5 should be separately identified in the energy management report for avoiding on double counting issue.

Cross-cutting

(10) For the GHG emission mitigation measure implemented for the compliance under the energy efficiency standards in the designated building/factory, the data in the energy management report could be used for estimating the resulted GHG emission reductions. But due care must be taken to avoid double counting with other GHG emission mitigation measures (e.g. Label no.5 measure, etc.) in the same designated building/factory. Thus, the data related to the Label no.5 should be identified and segregated in the energy management report.

(11) Based on the NDC Roadmap and NDC Action Plan (Energy sector), some GHG reduction measures are applicable to the non-designated building/factory. It is not clear, for now, on how to engage these non-designated building and factory to submit the required data for the GHG emission report in project operation period on annual basis until 2030 (end of NDC period). Therefore, a reporting system or guideline for this data submission requirement for non-designated building/factory needs to be developed.

(12) Since the GHG reporting format has not been created so far, it should be created by all relevant agencies (e.g., TGO, DIW, DEDE, ONEP and Energy Working Group). For convenience, the GHG report could be processed via online submission to the related agencies

(13) As there is no existing MRV practice in the building and industrial sectors, the proposed MRV practice for both GHG inventory and mitigation measures is based on the existing reporting practice of designated building/factory. The steps in the proposed MRV practice is as follows:

1. Owner of the BEC building or designated building or designated factory implements the BEC standard/energy conservation measure
2. The activity data of the building/factory is verified and compiled by the DEDE.
3. The DEDE submits the activity data to EPPO
4. The EPPO compiles the activity data from the DEDE and other government agencies (other subsectors in energy sector)
5. The ONEP and expert teams estimate the GHG emissions (with support from the TGO)
6. The Energy Working Group reviews the methodology of the GHG emission estimation as part of quality control to ensure that the GHG emission estimation is valid, accurate and compete.
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) approves the GHG emissions for inclusion in the National Communication (NC) and Biennial Update Report (BUR)/ Biennial Transparency Report (BTR)

The proposed MRV practice in building and industrial sectors is shown in Figure 4.1

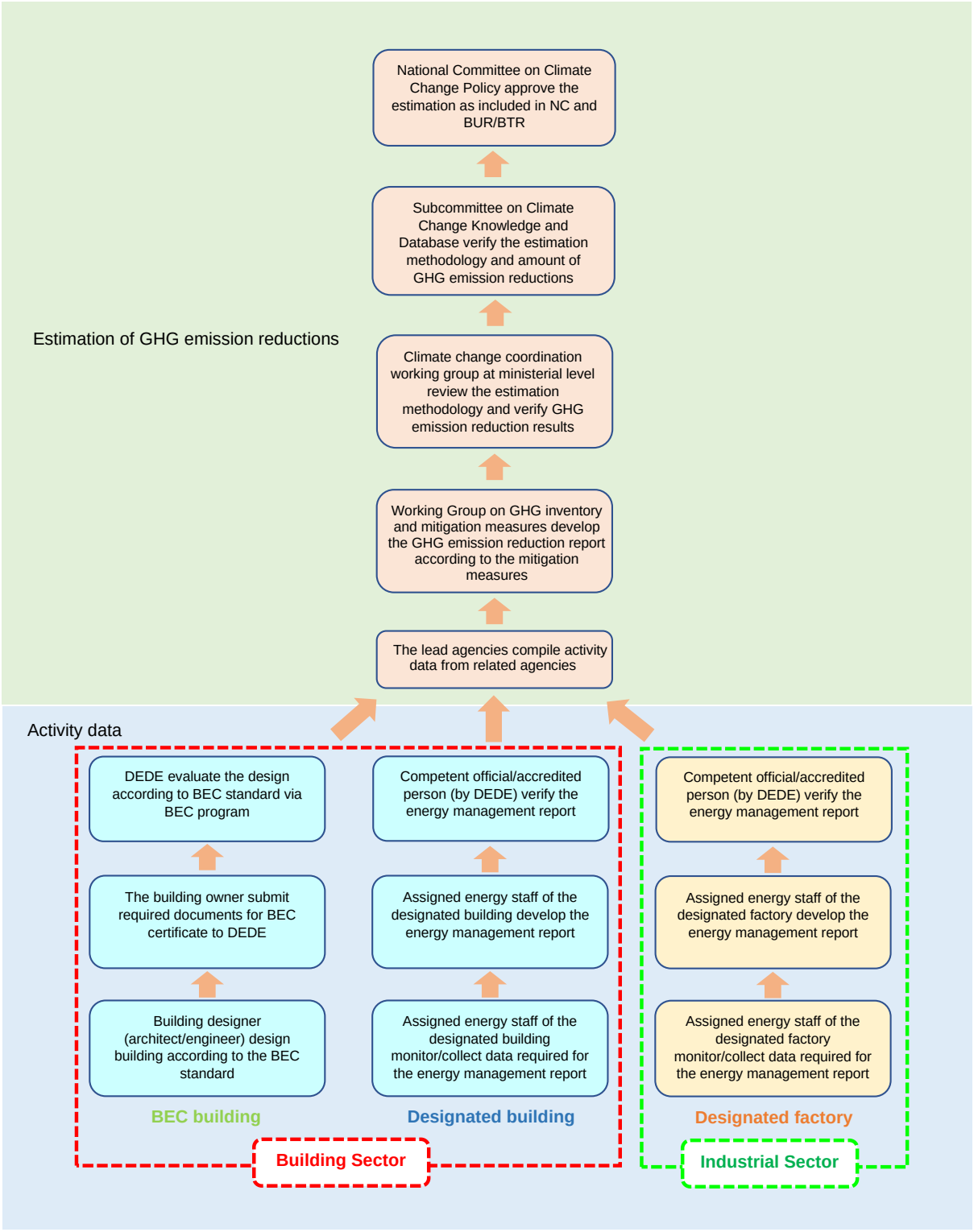
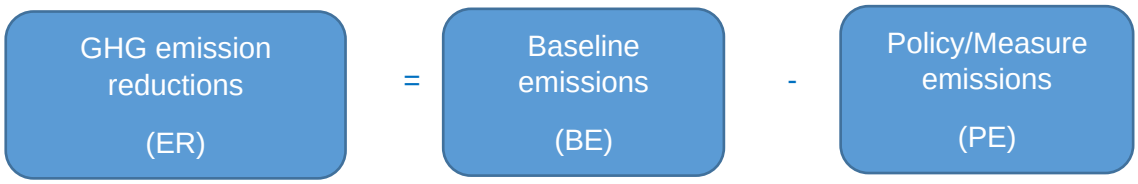


Figure 4- 1 Proposed MRV practice for the building and industrial sectors[30]

(14) With the current MRV context in Thailand, the following GHG emission estimation methodology for the building sector is proposed.

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

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) (baseline or project)

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, saving of electricity would result in reduction of the GHG emissions. There are two approaches for building sector. A) Fixed baseline year emission reduction approach and B) Specific energy consumption approach as shown below;

A. Fixed baseline year emission reductions approach (energy saving multiply by grid emission factor)
This approach is suitable for static building in term of usage area/time (no change of usage area/time).

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

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)

B. Specific energy consumption approach

This approach is suitable for dynamic building in terms of usage area/usage time. For example, the energy consumption of a hotel building varies with the the number of occupied rooms. Therefore, specific energy consumption calculation (energy consumption per area) is more suitable for these dynamic buildings. The emission reduction calculation based on the specific energy consumption formulae is shown below;

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

$PE_y = SEC_{PJ,y} \times Area_{PJ,y} \times EF_{EC,y} \times 10^{-3}$

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

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)

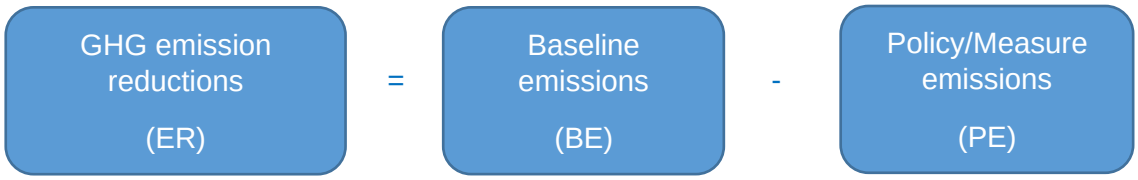
$EC_{PJ,y}$ = Policy/Measure/Project/Activity electricity consumption in year y (kWh/year)

$Area_{PJ,y}$ = Policy/Measure/Project/Activity covered area in year y (m^2)

(15) This report has proposed GHG emission methodology for industrial sector which is shown as following:

In principle, the emission reduction calculation is the same as the building sector, but there are different data parameters. For the industrial sector, the emission is mainly dependent on the production. It varies every year and thus the specific energy consumption approach is more suitable rather than the fixed baseline year emission.

The formula to calculate GHG emission reductions is shown as following;



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) (baseline or project)

EF = CO_2 emission factor (tCO_2/MWh)

Therefore, the GHG emission reductions in terms of specific energy consumption (energy consumption per unit of product) approach is as shown below;

$$BE_y = \sum(SEC_{BL,i,y} \times P_{PJ,i,y}) \times EF_{EC,y} \times 10^{-3}$$

Where

$$SEC_{BL,i,y} = EC_{BL,i,y} / P_{BL,i,y}$$

$$PE_y = \sum(SEC_{PJ,i,y} \times P_{PJ,i,y}) \times EF_{EC,y} \times 10^{-3}$$

Where

$$SEC_{PJ,i,y} = EC_{PJ,i,y} / P_{PJ,i,y}$$

$$ER_y = \sum(SEC_{BL,i,y} - SEC_{PJ,i,y}) \times \sum P_{PJ,i,y} \times EF_{EC,y} \times 10^{-3}$$

Where:

ER_y = Emission reductions in year y (tCO_2/year)

BE_y = Baseline energy consumption in year y (kWh/year)

PE_y = Policy/Measure/Project/Activity energy consumption in year

$SEC_{BL,i,y}$ = Baseline specific energy consumption for industrial type i in year y (kWh/Unit of Product)

$SEC_{PJ,i,y}$ = Policy/Measure/Project/Activity specific energy consumption for industrial type i in year y (kWh/Unit of Product)

$EC_{BL,i,y}$ = Baseline electricity consumption for industrial type i in year y (kWh/year)

$EC_{PJ,i,y}$ = Policy/Measure/Project/Activity electricity consumption for industrial type i in year y (kWh/year)

$P_{BL,i,y}$ = Baseline unit of product in year y (unit of product/year)

$P_{PJ,i,y}$ = Policy/Measure/Project/Activity production in year y (unit of product/year)

EF_{ECy} = CO_2 emission factor (tCO_2/MWh)

In order to calculate the GHG emission as above, the parameters that should be determined in the first step are the baseline parameters such as $SEC_{BL,i,y}$ and $EC_{BL,i,y}$

5. CONCLUSIONS

Currently, there is no existing MRV practice in the building and industrial sectors. There is no online platform of reporting, storage and retrieval of verified data from different sectors. Different agencies have different formats and methods of data collection and assessment. Therefore, the conclusions for the industrial sector and building sector as follows:

Country Level

1. Given the fact that Thailand will enter into the NDC period in early 2021 and there are no MRV systems in place yet. The country should prioritize developing MRV systems as soon as possible. This aims to ensure that, the results from GHG mitigation actions taken under the NDC Roadmap and NDC Action Plan are counted and reported. Also, the MRV systems would allow the country to effectively monitor the GHG level and identify additional opportunities for further actions to reduce GHG emissions.

2. Although there are no existing MRV systems in place for the country, the annual energy management reporting system is the most relevant and could be used as a strong foundation for the country to further develop its MRV systems. Not only can it save significant amount of time in designing new systems and engaging wide range of stakeholders to find mutual agreements on how the systems should look like, but it can also minimize legal efforts in designing new systems and getting approval from relevant stakeholders.

Industrial Sector

3. The designated factory is mandated to report its energy consumption through the energy management report on an annual basis. This energy management report could further be used for the GHG emission calculation.

4. The non-designated factory is not mandated to report its energy consumption through the energy management report. Therefore, it is required to create a reporting system for the non-designated factory participating in the DEDE's measures on an annual basis.

Building Sector

5. The designated building is mandated to report its energy consumption through the energy management report on annual basis. This energy management report could be further used for the GHG emission calculation.

6. The non-designated building is not mandated to report its energy consumption through the energy management report. Therefore, it is required to create a reporting system for the non-designated factory participating in the DEDE's measures on an annual basis.

7. The BEC building is not mandated to report its energy consumption through the energy management report. Therefore, it is required to create a reporting system for this type of building on an annual basis.

Also, there are other potential areas where Thailand's MRV systems could be strengthened. For examples; create linkages between relevant policies (e.g. energy) to GHG emissions; create a common platform for relevant GHG-related data; develop MRV system by using

digitalization; streamline GHG reporting requirement; develop clear guidelines on how to report GHG emissions; set and communicate clear GHG reduction targets or directions to relevant stakeholders; and strengthen stakeholder’s capacity on relevant subject matters.