Provision of Services Related to Enabling Readiness for Up Scaling Investments in Building Energy Efficiency for Achieving NDC Goals in Thailand

Contract No.: UNEP/2020/252 (4700019197)

PROGRESS REPORT 6:

REPORT ON DEVELOP MRV FRAMEWORK FOR EXISTING AND NEW BUILDINGS WITHIN BEC FRAMEWORK (TASK 5)

Prepared for

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Leading the Transition to Clean Energy

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Acronyms

BEC	-	Building Energy Code
BESM	-	Building Energy Simulation Model
CBEEC	-	Commercial Building Energy Efficiency Information Center
CC	-	Cooling Capacity
COP	-	Coefficient of Performance
CTCN	-	Climate Technology Centre and Network
DEDE	-	Department of Alternative Energy Development and Efficiency
DPT	-	Department of Public Works and Town and Country Planning
ECON	-	Economic Building
EEP	-	Energy Efficiency Plan
EER	-	Energy Efficiency Ratio
EIA	-	Environment Impact Assessment
ENCON Act	-	Energy Conservation and Promotion Act
EnPI	-	Energy Performance Indicator
EPPO	-	Energy Policy and Planning Office (EPPO)
EUI	-	Energy Use Indicator
GGGI	-	Global Green Growth Institute
HEPS	-	High Energy Performance Standard
IIEC	-	International Institute for Energy Conservation
INDC	-	Intended Nationally Determined Contributions
KMUTT	-	King Mongkut University of Technology Thonburi
LAOs	-	Local Administration Organizations
LED	-	Lighting Emitting Diode
LPD	-	Lighting Power Density
MOE	-	Ministry of Energy
MOI	-	Ministry of Interior
MRV	-	Measurement, Report and Verification
NAMA	-	Nationally Appropriate Mitigation Actions
NCCC	-	National Committee on Climate Change Policy
NDC	-	Nationally Determined Contributions
NXPO	-	Office of National Higher Education Science Research and Innovation Policy Council
ONEP	-	Office of Natural Resources and Environmental Policy and Planning
OTTV	-	Overall Thermal Transfer Value
PEECB	-	Promoting Energy Efficiency in Commercial Buildings

RTTV	-	Roof Thermal Transfer Value
SEER	-	Seasonal Energy Efficiency Ratio
TBEED	-	Thailand Building Energy Efficiency Disclosures
TGO	-	Thailand Greenhouse Gas Management Organization
UNFCC	-	UN Framework Convention on Climate Change
UNEP	-	United Nations Environment Programme
ZEB	-	Zero Energy Building

EXECUTIVE SUMMARY

This report summarizes progress of the Contract No: UNEP/2020/252 (4700019197) for the provision of Services Related to Enabling Readiness for Up Scaling Investments in Building Energy Efficiency for Achieving NDC Goals in Thailand. The progress report specifically presents the completed project activities in the sixth reporting period of the project (November to December 2021).

This progress report shows the completed deliverable result of Task 5 Develop MRV Framework for Existing and New Buildings within BEC Framework. Key outcomes from the implementation of the project activities during the reporting period are as follows.

STREAMLINING OF DATA FOR DEVELOPMENT OF MRV FRAMEWORK

Review of existing energy data

Although the MRV framework for the BEC program has been recently discussed by EPPO, DEDE and other relevant stakeholders, there is no existing MRV framework in the building sector in Thailand. The activity identifies key activity data required for measurement of GHG emission activities under the BEC program, and it is apparent that one of the main challenges in establishment of the MRV framework for the Thai BEC program is identification of existing data resources which could be practically utilized to support establishment and operationalization of the proposed MRV framework

Review of MRV frameworks

The review focuses on the MRV of emissions type which entails measuring and monitoring the GHG emissions and reductions associated with activities of entities such as countries, sectors/organizations, or facilities, reporting the collected data in a GHG inventory or other forms, and undertaking review and verification. Shown in the figure below are the three levels of the MRV of emissions, and the primary focus of the MRV review in this report is on the MRV framework at the sectoral level with the emphasis on implementation of EE and RE, specifically BEC, in the building sector.

Source: How to Set Up National MRV Systems, GIZ

Figure: Three Levels of MRV of Emissions

Table: Methods for Measurement GHG Emissions in the Building Sector

Measurement Method	MRV Level
International Performance Measurement and Verification Protocol (IPMVP)	Facility Level
Small-Scale Clean Development Mechanism (CDM) Methodology AMS-II.C and AMS-II.E	Facility Level

Measurement Method	MRV Level
ISO 50001 Energy Management Standard (EnMS)	Facility Level
The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard	Facility or Sectoral/Organizational Level

Note that the abovementioned measurement methods are not specifically designed for the building sector, and they may need to be customized or new methods may have to be developed to suit particular needs and circumstances.

Over the past decade, relevant agencies in Thailand have commissioned few projects to develop frameworks related to MRV of emissions at the national and sectoral levels. The following project documents provide guidelines which are relevant to frameworks for MRV of emissions for the building sector in Thailand.

- **Thailand Voluntary Emission Reduction Program: T-VER – Methodology for Energy Efficiency Improvement**
- **Handbook on Measurement, Reporting and Verification (MRV) of Greenhouse Gas Inventory of Thailand**
- **Proposed MRV Framework for the BEC Program** – The Enhancement Thailand's MRV system for Greenhouse Gas Reduction Measures in Energy Sector is a component under the Thai-German Climate Programme: Energy (TGCP-Energy), implemented by GIZ in collaboration with the Energy Policy and Planning Office (EPPO). The main objective of this specific assignment is to develop an effective MRV framework for selected energy measures for GHG emissions reduction, and to support the NDC Action Plan for Energy Sector (2021-2030). The assignment was concluded in early 2021, and two options for the MRV framework for the BEC program are proposed:

  Option 1: Utilization of the BEC program as the main tool for BEC-compliant certification, and estimation of GHG emission inventory and reduction for BEC-compliant buildings.

  Option 2: Utilization of the BEC program as the main tool for BEC-compliant certification, and utilization of aggregated actual energy consumption and estimated savings data of buildings/specific end-uses (technologies) for estimation of GHG emission inventory and reduction for BEC-compliant buildings.

  The proposed approaches for the abovementioned options are illustrated in the below figure. However, the assignment does not specifically recommend which option EPPO or the BEC program should adopt.

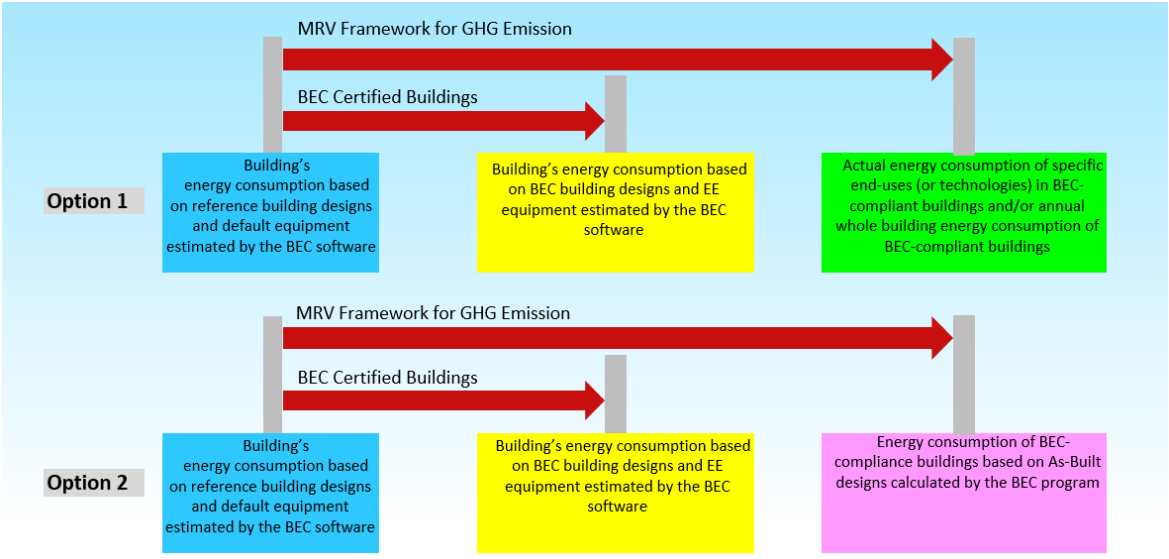


Figure: Proposed MRV Framework Options for the BEC Program

In addition to the abovementioned MRV related project documents, the Department of Alternative Energy Development and Efficiency (DEDE) commissioned multiple studies on specific energy consumption (SEC) for various types of designated buildings (i.e., office, department store, hotel and hospital buildings) from 2005 to

2007. In 2018, TGO also commissioned another SEC study for designated buildings and factories, and office, department store, hotel and hospital buildings were included in the TGO SEC study.

PROPOSED MRV FRAMEWORK

Scope and boundary of MRV

Scope of the proposed MRV framework (also called "project scope") will follow the Thai BEC program which covers any new or retrofitted building with a total floor area of 2,000 m^2 or more, and being classified as one of the following building types:

1. Entertainment service buildings
2. Hotels
3. Entertainment services facilities
4. Medical facilities and hospitals
5. Educational institutions
6. Office buildings
7. Shopping malls and department stores
8. Condominiums
9. Convention halls

The boundary of the proposed MRV framework (or boundary of "project activities") shall cover all the BEC components as summarized in Table 6, and measurement of GHG emission activities (or project activities) under the BEC program requires utilization and performance data of building spaces, equipment and systems of the buildings.

Proposed Approach of MRV Framework for BEC

The TGCP-Energy proposed utilization of the BEC program (Option 1) and aggregation of actual building energy consumption (Option 2) as the potential MRV frameworks for the BEC program. This report, however, does not recommend the BEC program as a viable option for the MRV framework for the BEC program due to the following reasons:

- BEC assessment program is designed for design benchmarking and certification purposes. Building energy consumptions are roughly estimated assuming fixed parameters for the whole building types (sub sector), categorized in three groups of 8, 12 and 24 daily operating hours.
- The calculation assumes fixed loads and operating hours on electricity consuming equipment. Area occupancies are fixed.
- The calculation result is one-time based on designed building envelope, building equipment and system. No operation factor is taken into consideration.

Based on the abovementioned shortfalls, this report proposes adoption of the modified Option 2 which estimates GHG emission of the BEC program through collection of actual building energy consumption, and also utilize specific energy consumption (SEC) data studied by DEDE and TGO for different types of buildings. Utilization of SEC data allows for adjustment of building usage and intensity of project activities over time which will lead to an adjusted baseline data and better confidence in estimation of GHG emission reduction.

The proposed approach will calculate GHG emission reduction based on the following assumptions.

- SEC values for at the BEC baseline (year 2009) are similar to SEC from the sectoral study. No GHG emission reduction claimed between 2005 (NDC base year) and 2009 (BEC base year).
- Consider CO_2 as the main GHG emission.
- Emission factor on the year of activity will be applied.
- Different SEC formula and annual activity data for each building type, as shown in Annex A, will used to adjust baseline energy consumption.

- Calculation of GHG emission from utilization of thermal energy will be excluded from the proposed MRV framework due to negligible fuel energy consumption by different building type in Thailand, and the BEC requirements have delivered virtually no impact on the fuel efficiency improvement in Thai buildings.

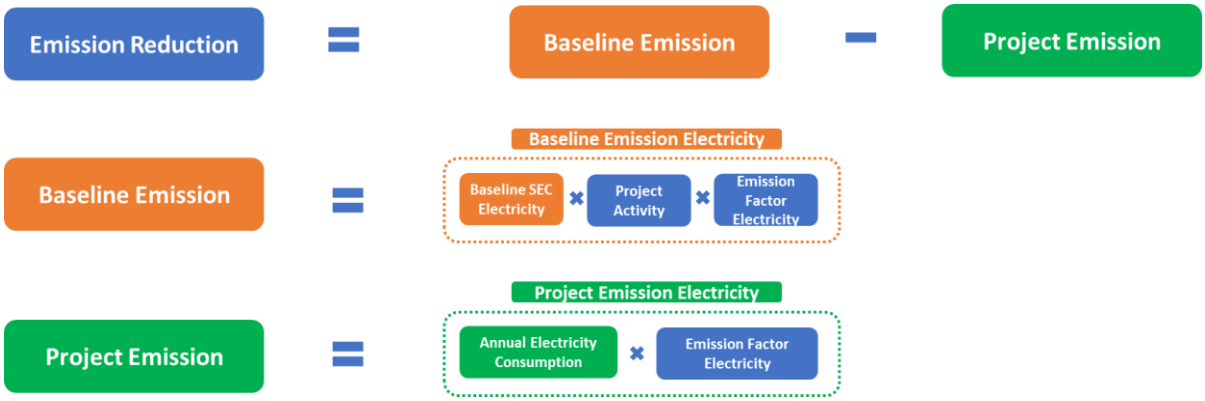


Figure: Proposed Calculation Approach for GHG Emission

Shown in the following Figure are the application of the proposed MRV framework at design, construction and operation of BEC-compliant buildings.

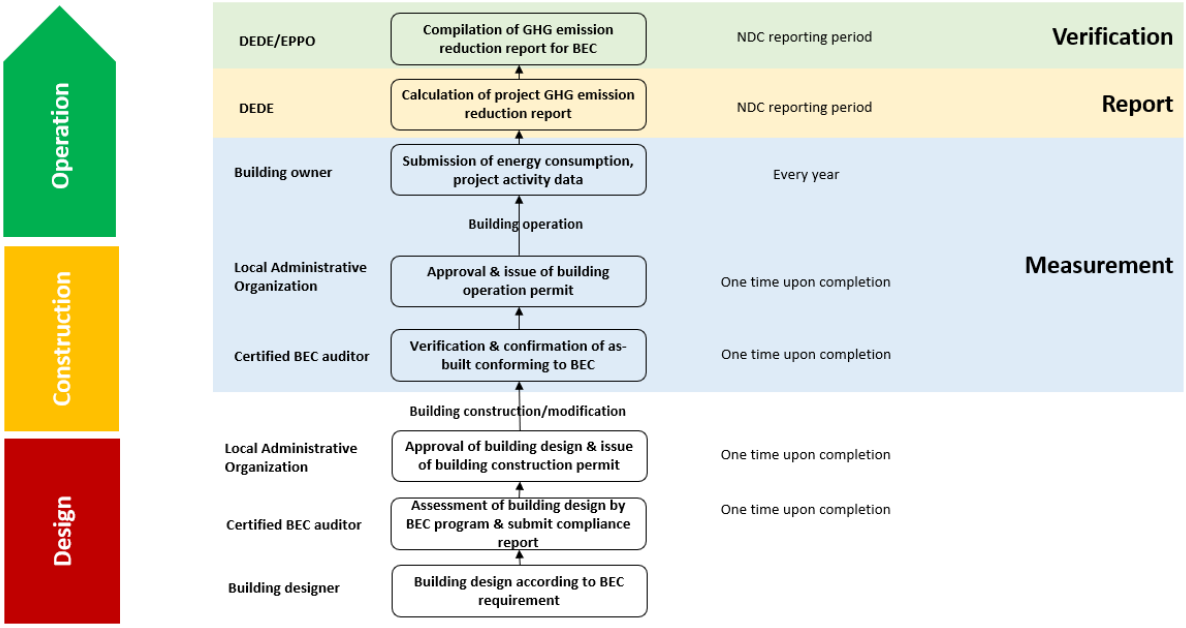


Figure: Proposed MRV Process for BEC Program

RECOMMENDATIONS FOR OPERATIONALIZATION OF MRV FRAMEWORK

The proposed framework for MRV of emissions for the BEC program in Thailand was presented by the project team in the third online consultation workshop organized on December 22nd, 2021. The online consultation workshop was participated by 30 participants from 21 organizations representing government agencies, private sector organization and academia. The consultation workshop has agreed in principle to the concept of the proposed framework for MRV of emissions for the BEC program (see Annex B for the workshop evaluation

results). The workshop also noted the following recommendations for operationalization of the proposed MRV framework.

Recommendation No. 1: Development of data collection & reporting system

- Develop a dedicated BEC database system for energy consumption and building operational data for different BEC-compliant building types.
- Integrate data from the energy management reports for designated BEC buildings into the BEC database system.
- Develop a new reporting system for non-designated BEC buildings for submission of energy consumption and building operational data on an annual basis.
- Enhance the scope of BEC audits after construction completion to include collection of building activity data and establishment of reporting structure.
- Update emission factor for GHG emission inventory and GHG emission reduction calculation.

Recommendation No. 2: Refining the MRV framework for building types without existing SEC data

- **Condominiums:** Condominium cannot be covered by any of available methodologies. The energy accounts are distributed and owned by each residential unit. As a result, occupancy and energy consumption characteristics are scattered. Considering this, collective metering with modern IoT energy monitoring systems are possible. However, condominium contributes only 7% of energy consumption of the building sector in Thailand, and the investment cost on the data collection infrastructure is not considered cost effective. Therefore, it is recommended for DEDE to establish collaboration with the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA) to utilize existing data from their metering system.

- **Other BEC-Compliant Building Types:** It is recommended for DEDE to conduct additional SEC studies for other BEC-compliant building types to establish baseline and calculation of GHG emission reduction.

1 SUMMARY OF TASK 5 ACTIVITIES

This report summarizes the project's progress from November to December 2021 and deliverables under Task 5 Develop MRV Framework for Existing and New Buildings within BEC Framework. The report presents findings from a review of international and national MRV frameworks to assess impacts from EE and RE implementation in the building sector, specifically on GHG emission reductions, energy use and energy savings. The review also identifies key parameters adopted by these MRV frameworks. Based on the review findings, the report also proposes recommendations on the approach and methodology for the MRV framework for the five selected building types with the Thai BEC framework.

The activities undertaken by the IIEC project team during this reporting period are as follows.

Activity 5.1: Streamlining of Data for development of MRV Framework

Based on the energy consumption and benchmark data compiled under Task 1 and results from the energy audits, the project team conduct a comprehensive review of existing energy data and existing methodological and operational MRV framework to assess energy use, energy savings and GHG reductions.

Activity 5.2: Identification of Key Indicators

The activity identifies the scope and key indicators of the MRV framework covering energy use, energy savings and GHG emission.

Activity 5.3: Development of Draft MRV Framework

With the existing data sets and identified key indicators, the project team will design the methodological and operational MRV framework for the five selected building types within the BEC framework.

Activity 5.4: Stakeholder Consultation of MRV Framework

The activity arranges a stakeholder consultation workshop to discuss and finalize the MRV framework for measurement, report generation and systematic verification strategies for GHG emission reductions, energy consumption and energy saving.

2 ACTIVITY 5.1: STREAMLINING OF DATA FOR DEVELOPMENT OF MRV FRAMEWORK

REVIEW OF EXISTING ENERGY DATA

Although the MRV framework for the BEC program has been recently discussed by EPPO, DEDE and other relevant stakeholders, there is no existing MRV framework in the building sector in Thailand. Table 1 lists key activity data required for measurement of GHG emission activities under the BEC program, and it is apparent that one of the main challenges in establishment of the MRV framework for the Thai BEC program is identification of existing data resources which could be practically utilized to support establishment and operationalization of the proposed MRV framework.

Table 1: Availability of energy consumption data and potential sources

Data	As-built	As-operated	Source
Energy Consumption			
Electricity consumption (kWh)		✓ (monthly)	Metering / electricity bills
Fuel consumption (MJ)		✓ (monthly)	Fuel purchase / metering (if any)
Building Areas			
Total floor areas (m^2)	✓	✓	Design / as-built documents
Air conditioned areas (m^2)	✓	✓	Design / as-built documents
Non-air conditioned areas (m^2)	✓	✓	Design / as-built documents
Area functions (m^2)	✓	✓	Design / as-built documents
Area operating hours (h)		✓	Operation management / estimation
Building Utilization			
Area occupancy (%)		✓ (monthly)	Operation management / rental contract
Occupants (person-day)		✓ (monthly)	Operation transaction / estimation
Lighting System			
Lighting inventory (items)	✓	✓	Design / as-built documents
Lighting installed capacity (kW)	✓	✓	Design / as-built documents
Lighting efficiency (lm/W)	✓	✓	Design / as-built documents
Lighting power consumption (kW)		✓	Estimation
Lighting utilization (%)		✓	Operation management / estimation
Lighting operating hours (h)		✓	Operation management / estimation
Air Conditioning System			
Air conditioning inventory (items)	✓	✓	Design / as-built documents
Air conditioning installed capacity (RT, kW)	✓	✓	Design / as-built documents
Air conditioning power consumption (kW)		✓	Estimation / metering (if any)
Air conditioning utilization (%)		✓	Operation management / estimation / metering (if any)
Air conditioning operating hours (h)		✓	Operation management / estimation / metering (if any)
Hot Water Generation System			
Hot water generation inventory (items)	✓	✓	Design / as-built documents
Hot water generation installed capacity (MJ/h)	✓	✓	Design / as-built documents

Data	As-built	As-operated	Source
Hot water generation fuel consumption (MJ/h)		✓	Estimation / metering (if any)
Hot water generation utilization (%)		✓	Operation management / estimation / metering (if any)
Hot water generation operating hours (h)		✓	Operation management / estimation / metering (if any)
Other electricity consuming equipment & system			
Equipment inventory (items)		✓	Specification / estimation
Equipment installed capacity (kW)		✓	Specification / estimation
Equipment power consumption (kW)		✓	Specification / estimation
Equipment utilization (%)		✓	Operation management / estimation
Equipment operating hours (h)		✓	Operation management / estimation
Renewable Energy Generation System			
Solar PV installed capacity (kW)	✓	✓	Design / as-built documents
Solar PV electricity generation (kWh)	✓	✓	Metering

Although there is no online platform for reporting, storage and retrieval of verified data from the building sector, and specifically BEC-compliant buildings, the regulatory requirements for designated buildings in Thailand could partially fulfill the above data requirements. As specified in the Energy Conservation and Promotion (ENCON) Act, each designated building is required to submit an energy management report on an annual basis. These annual energy management report contains almost all the data required for the GHG calculation. However, there are BEC-compliant buildings which are not classified as designated buildings, and an additional reporting system will be required to collect project activity data, i.e., space occupancy, area allocation, number of occupants, operating hours to fulfill the requirements for GHG calculation.

REVIEW OF MRV FRAMEWORKS

Measurement, Reporting, and Verification (MRV) is a concept introduced by the United Nations Framework Convention on Climate Change (UNFCCC) with the aim to develop a structured approach to confirm GHG emission and GHG emission reduction objectively. MRV is central to effectively implementing the Nationally Determined Contributions (NDCs) submitted under the Paris Agreement, which describe countries' mitigation goals and policies. Before the MRV term, some forms of monitoring and evaluation (M&E) had been used by governments and other entities to assess their actions and goals.

Three types of mitigation-related MRV are referenced by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH[1] and World Resources Institute (WRI)[2], and these include:

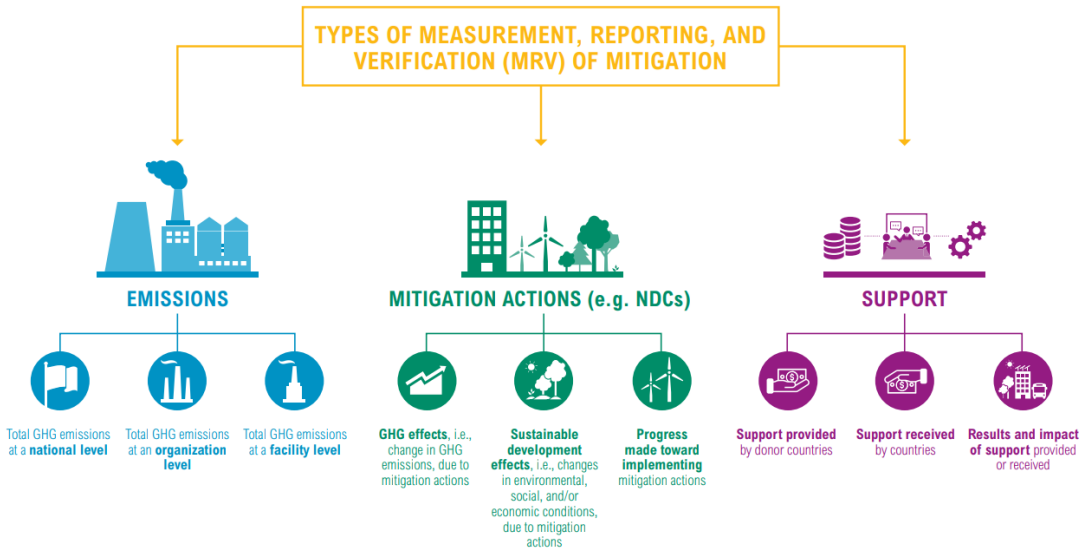
- **MRV of Emissions** - estimation of emissions at national, regional, sectoral/organizational level and/or facility level to understand an entity's emissions profile and report it in the form of an emissions inventory

[1] How to Set up National MRV Systems, GIZ

[2] MRV 101: Understanding Measurement, Reporting, and Verification of Climate Change Mitigation, World Resources Institute (WRI)

- **MRV of Actions** - impacts of mitigation policies and projects (actions) to assess their GHG effects and sustainable development (non-GHG) effects as well as to monitor their implementation. This type of MRV focuses on estimating the change in GHG emissions or other non-GHG variables.

- **MRV of Support** - to track provision and receipt of climate support (e.g., climate finance, technology transfer, and capacity building), monitor results achieved, and assess impact



Source: MRV 101: Understanding Measurement, Reporting, and Verification of Climate Change Mitigation, World Resources Institute (WRI)

Figure 1: Types of Mitigation-Related MRV

The review in this report focuses on the MRV of emissions type which entails measuring and monitoring the GHG emissions and reductions associated with activities of entities such as countries, sectors/organizations, or facilities, reporting the collected data in a GHG inventory or other forms, and undertaking review and verification. Shown in the figure below are the three levels of the MRV of emissions, and the primary focus of the MRV review in this report is on the MRV framework at the sectoral level with the emphasis on implementation of EE and RE, specifically BEC, in the building sector.

Source: How to Set Up National MRV Systems, GIZ

Figure 2: Three Levels of MRV of Emissions

2.1 EXISTING METHODS AND TOOLS FOR BUILDING SECTOR MRV FRAMEWORKS

One of the important considerations in operationalization of MRV is the provision of methodological and technical guidelines. Methods to measure, report, and verify information differ based on what is assessed and at what level. This report specifically focuses on existing methods and tools that could be applicable for undertaking measurement of emissions in the building sector (Sectoral Level MRV). However, MRV of emissions at the sectoral/organizational level may utilize emission data collated from the facility level. Considering this, methods and tools for undertaking measurements at the facility level are also reviewed by this report, and the relevant methods and tools are summarized in the table below.

Table 2: Methods for Measurement GHG Emissions in the Building Sector

Measurement Method	MRV Level
International Performance Measurement and Verification Protocol (IPMVP)	Facility Level
Small-Scale Clean Development Mechanism (CDM) Methodology AMS-II.C and AMS-II.E	Facility Level
ISO 50001 Energy Management Standard (EnMS)	Facility Level
The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard	Facility or Sectoral/Organizational Level

Note that the abovementioned measurement methods are not specifically designed for the building sector, and they may need to be customized or new methods may have to be developed to suit particular needs and circumstances. Brief description of each method is provided below.

2.1.1 IPMVP

The International Performance Measurement and Verification Protocol (IPMVP) published by the Efficiency Valuation Organization (EVO)[3] is an international Measurement and Verification (M&V) protocol describing different methods to determine water and energy savings of energy efficiency projects. IPMVP is one of the most comprehensive frameworks for M&V at the facility level, and has been used as the de-facto M&V standard in many countries (including Thailand).

Since energy or GHG savings cannot be directly measured, because savings represent the absence of energy consumption, savings are determined by comparing measured consumption before and after the implementation of a program. The comparison of before and after energy consumption should be made on a consistent basis, using the following general M&V equation:

Savings = (Baseline Period Energy – Reporting Period Energy) ± Adjustments

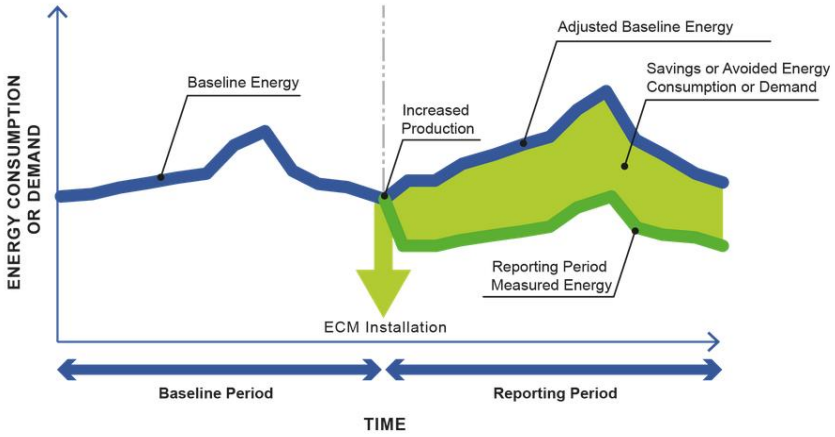
The energy baseline is defined with the information from the initial energy baseline assessment and with the data that has been collected in an appropriate period of time. All changes to the energy-related performance must be measured and assessed on this basis. GHG baseline is easily calculated from the energy consumption baseline using the official grid emission factor of the country. The overall IPMVP framework for baseline establishment and determination of savings are illustrated in Figure 3.

IPMVP presents four M&V options for baseline establishment and savings estimations, including:

[3] www.evo-world.org

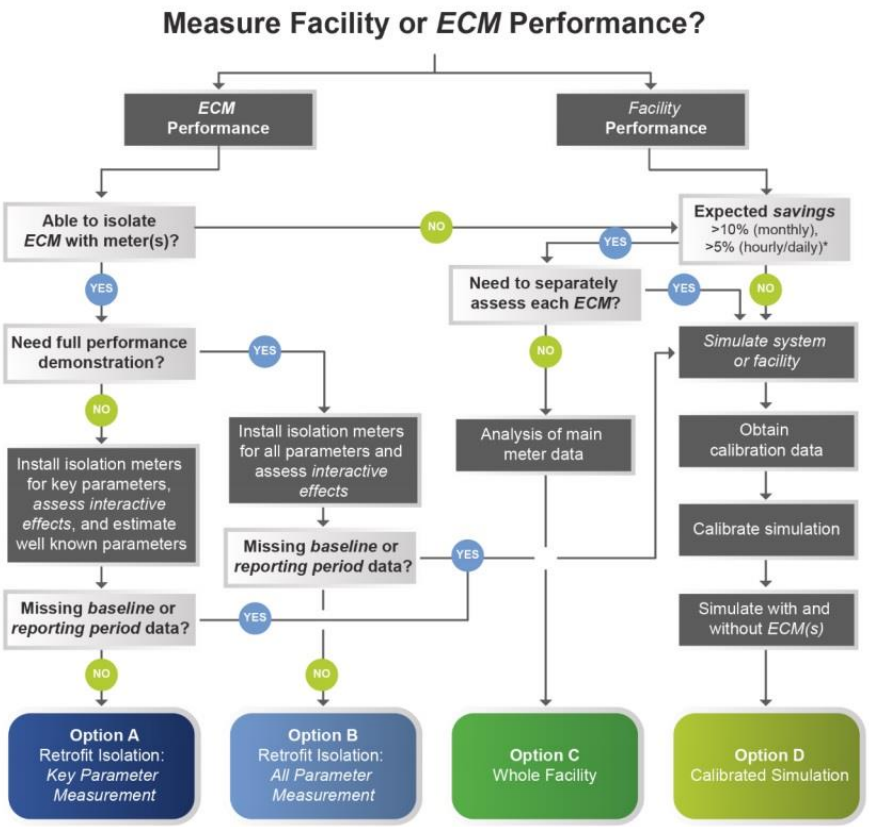
- Option A: Retrofit isolation with key parameter measurement
- Option B: Retrofit isolation with measurement of all parameters
- Option C: Whole facility
- Option D: Calibrated simulation

The IPMVP documents provide detailed guidelines and examples on to apply different IPMVP options for Energy Conservation Measures (ECMs), as shown in Figure 4.



Source: www.evo-world.org

Figure 3: IPMVP Framework



Source: Measurement & Verification – Issues and Examples, IPMVP, EVO 10300-1:2019, February 2019

Figure 4: IPMVP Options

2.1.2 CDM Methodology

The Clean Development Mechanism (CDM) requires the application of a baseline and monitoring methodology in order to determine the amount of Certified Emission Reductions (CERs) generated by a mitigation CDM project activity in a host country. Methodologies are classified into five categories:

- Methodologies for large-scale CDM project activities;
- Methodologies for small-scale CDM project activities;
- Methodologies for large-scale afforestation and reforestation (A/R) CDM project activities;
- Methodologies for small-scale A/R CDM project activities;
- Methodologies for carbon capture and storage (CCS) project activities.

CDM defines energy efficiency as all measures aiming to enhance the energy efficiency of a certain system. Due to the project activity, a specific output or service requires less energy consumption. According to the CDM Methodology Booklet, published in December 2020, there are various CDM methodologies related to measurement of emissions in the building sector. However, the two most relevant CDM methodologies for the Thai BEC framework are the two following small-scale CDM methodologies:

1. AMS-II.C. Demand-side energy efficiency activities for specific technologies
2. AMS-II.E. Energy efficiency and fuel switching measures for buildings

AMS-II.C provides guidelines for measurement of emission impacts from implementation of specific energy efficiency technologies which are relevant to the IPMVP Option A and B. While the AMS-II.E's guidelines look at the impacts of energy efficient at the facility level, which are more relevant to the IPMVP Option C. These two CDM methodologies require different data sets as summarized in Table 3 and Table 4.

Table 3: Key Features of AMS-II.C.

Typical project(s)	• Installation of new energy-efficient equipment (e.g. lamps, ballasts, refrigerators, motors, fans, air conditioners, pumping systems and chillers) at one or more project sites, as retrofit or new construction (Greenfield) projects.
Type of GHG emissions mitigation action	• Energy efficiency (Displacement of more-GHG-intensive service by use of more-efficient technology)
Important conditions under which the methodology is applicable	• The service level (e.g., rated capacity or output) of the installed project energy-efficient equipment is between 90% and 150% of the service level of the baseline equipment; • If applicable: refrigerant used in the project activity shall have no ozone depleting potential (ODP).
Important parameters	At Validation: • If applicable: grid emission factor (can also be monitored ex post) Monitored: • Monitoring shall include annual checks of a sample of non-metered systems to ensure that they are still operating; • Recording the "power" of the equipment installed and metering a sample of the units installed for their operating hours using run time meters; or metering the "energy use" of an appropriate sample of the equipment installed.

Source: CDM Methodology Booklet, UNFCCC, December 2020

Table 4: Key Features of AMS-II.E.

Typical project(s)	• Process energy efficiency improvement(s) affecting either a single production step/element process (e.g. furnace, kiln) or a series of production steps/element processes (e.g., industrial process involving many machines); • Energy efficiency improvement in energy conversion equipment (e.g. boiler, motor) that supplies thermal/electrical/mechanical energy within a facility
Type of GHG emissions mitigation action	• Energy efficiency (Increase in energy efficiency with, optionally, a switch to less-carbon-intensive fuel)
Important conditions under which the methodology is applicable	• Energy use within the project boundary can be directly measured or can be determined using national/international standards; • Improvements in efficiency by the project can be clearly distinguished from efficiency changes/improvements not attributable to the project; • The project output is equivalent to the output produced in the baseline.
Important parameters	At validation: • Energy consumption, emission intensity of energy types, output service level in the baseline; • Documenting of the technical specification of the equipment/systems. Monitored: • Metering the energy use of equipment; • Output; • In case the output parameter cannot be measured, the quantity of input material (feedstock).

Source: CDM Methodology Booklet, UNFCCC, December 2020

2.1.3 ISO 50001 Energy Management Standard

ISO 50001 EnMS is a framework developed for industrial and commercial facilities, and organizations to manage energy. The EnMS institutes a structure and discipline to implement technical and managerial strategies to cut energy consumption and GHG emissions. The standard addresses: energy use and consumption measurement, documentation and reporting of energy use, design and procurement of energy-using equipment, system and processes.

2.1.4 Greenhouse Gas Protocol

GHG Protocol standards and guidance enables companies to measure, manage and report greenhouse gas emissions from their operations and value chains. (Tools available for download) In 2016, at least 92% of Fortune 500 companies responding to CDP used GHG Protocol directly or indirectly through a program based on GHG Protocol.

2.2 INTERNATIONAL MRV FRAMEWORKS FOR BUILDING SECTOR

To date, only a handful of MRV frameworks developed to measure impacts on energy savings and GHG emission from implementation of BEC, EE and RE in the building sector. This report identified two regional (Africa and

Caribbean) and three national (Armenia, India and Vietnam) MRV frameworks related to measurement and reporting of emission in the building sector, and the areas focused for the review include:

- Objectives and scope of the MRV framework
- Overall approach and framework/protocol referenced
- Implementation status.

Findings from the international reviews are summarized in Table 5 on the following page, with the key highlights as given below.

- Most international MRV of emissions for the building sector aggregate data from the facility level MRV frameworks to report the sectoral emission data.
- Most international MRV frameworks reference bottom-up approaches, and huge amount of data is required to enable sound estimation of GHG emissions. Typical data gathering approaches include: energy audits, mandatory reporting of built-up areas and energy efficiency measures, electricity bills.
- Up-to-date information on implementation status of these international MRV frameworks is not available from resources accessed by the project team.

Table 5: Key Features of International MRV of Emissions for Building Sector

Description	Africa	Caribbean	Armenia	India	Vietnam
Nature of MRV Design and Implementation	A project-based capacity building on MRV of GHG emissions and mitigation actions in African countries, funded by Directorate-General for Climate Action (DG-CLIMA)	A project-based MRV development, funded by the Austrian Development Agency (ADA) in the framework of Phase Two of the Latin America and the Caribbean Energy Efficiency Program (PALCEE II).	A project-based development of a MRV framework, funded by UNDP-GCF (De-Risking and Scaling-up Investment in Energy Efficient Building Retrofits project)	A project-based development of a MRV framework, developed as part of a component of the Initiative for Climate Action Transparency project (ICAT) implemented by The Energy and Resources Institute (TERI) and UNEP DTU Partnership (UDP).	A project-based a MRV framework for monitoring and evaluation of the Energy Efficiency Improvement in Commercial and High-Rise Residential Buildings (EECB) in Viet Nam, funded by UNDP-GEF
Objective	The project provides training and materials on MRV for emissions and actions in various sectors. Energy efficiency in buildings is one of them.	The project aims at developing replicable MRV methodology for the countries of the Caribbean Region.	The project objective is to achieve reduction of greenhouse gas emissions through thermal insulation and energy efficiency measures in residential and public buildings.	The project aims at developing an MRV framework for assessing GHG impacts of the Energy Conservation Building Code (ECBC), which was launched in 2007 and revised in 2017. Mandatory for new commercial buildings with connected load of 100 kW or contract demand of 120 KVA and above.	The project has the goal to reduce intensity of GHG emissions from the building sector in Viet Nam through implementation of the Energy Efficiency Building Code (EEBC).
Scope (boundary)	Residential and commercial buildings	Commercial and public buildings	Residential and public buildings (existing buildings)	Commercial buildings	Buildings with gross floor area of 2,500 m^2 or larger
Overall Approach and Method/Tool Referenced	Facility level MRV, bottom-up approach	Facility level MRV, bottom-up approach referencing IPMVP	Facility level MRV, bottom-up approach based on Long Range Energy	Combination of top-down and bottom-up approach (depending on data	Facility level MRV, bottom-up approach based on

Description	Africa	Caribbean	Armenia	India	Vietnam
	based on specific energy efficiency measures		Alternatives Planning System (LEAP) software	available at the state level). Key parameters (e.g., built-up areas, energy performance index) must be collected/estimated to calculate emissions.	built-up areas and Energy Use Index (EUI)
Data Gathering Approach	N/A	Inspection of energy efficiency measures, mandatory and voluntary energy efficiency and energy consumption reporting (including energy audit reports), utility bills	Pre- and post-energy efficiency retrofit energy audits, building inventory, measurement of energy savings	Energy audits, electricity bills	Pre- and post-energy efficiency retrofit energy audits, building inventory, electricity bills
Implementation Status	N/A	N/A	N/A	N/A	Project closed in 2021

2.3 MRV FRAMEWORKS FOR BUILDING SECTOR IN THAILAND

Over the past decade, relevant agencies in Thailand have commissioned few projects to develop frameworks related to MRV of emissions at the national and sectoral levels. The following project documents provide guidelines which are relevant to frameworks for MRV of emissions for the building sector in Thailand.

- **Thailand Voluntary Emission Reduction Program: T-VER – Methodology for Energy Efficiency Improvement** – T-VER is the GHG emission reduction program, developed by the Thailand Greenhouse Gas Management Organization (TGO) to promote and support all sectors to voluntarily participate in GHG emission reduction program and can sell the reduction unit or carbon credit, which called "TVER" under this T-VER program, under voluntary domestic market. In this regard, TGO has prescribed rules and procedures for project development, GHG emission reduction methodology, and certification of emission reduction credit. All projects participated in T-VER program must reduce GHG emission/result in carbon sequestration within Thailand's jurisdiction. T-VER methodologies, issued in 2013 and regularly updated, do not specifically address the MRV requirements at the sectoral level (building sector), but they are applicable for implementation of energy efficiency measures at the facility (building) level.

- **Handbook on Measurement, Reporting and Verification (MRV) of Greenhouse Gas Inventory of Thailand** – The handbook was prepared by the Thailand Greenhouse Gas Emissions Inventory System (TGEIS), and published in 2019 by ONEP. The handbook provides details on scope, responsibilities of involved stakeholders, MRV approaches at the national level for various sectors (e.g., transportation, coal mining and handling, oil and natural gas). However, the building sector is not specifically addressed by this handbook.

- **Proposed MRV Framework for the BEC Program** – The Enhancement Thailand's MRV system for Greenhouse Gas Reduction Measures in Energy Sector is a component under the Thai-German Climate Programme: Energy (TGCP-Energy), implemented by GIZ in collaboration with the Energy Policy and Planning Office (EPPO). The main objective of this specific assignment is to develop an effective MRV framework for selected energy measures for GHG emissions reduction, and to support the NDC Action Plan for Energy Sector (2021-2030). The assignment was concluded in early 2021, and two options for the MRV framework for the BEC program are proposed:

  Option 1: Utilization of the BEC program as the main tool for BEC-compliant certification, and estimation of GHG emission inventory and reduction for BEC-compliant buildings.

  Option 2: Utilization of the BEC program as the main tool for BEC-compliant certification, and utilization of aggregated actual energy consumption and estimated savings data of buildings/specific end-uses (technologies) for estimation of GHG emission inventory and reduction for BEC-compliant buildings.

  The proposed approaches for the abovementioned options are illustrated in Figure 5. However, the assignment does not specifically recommend which option EPPO or the BEC program should adopt.

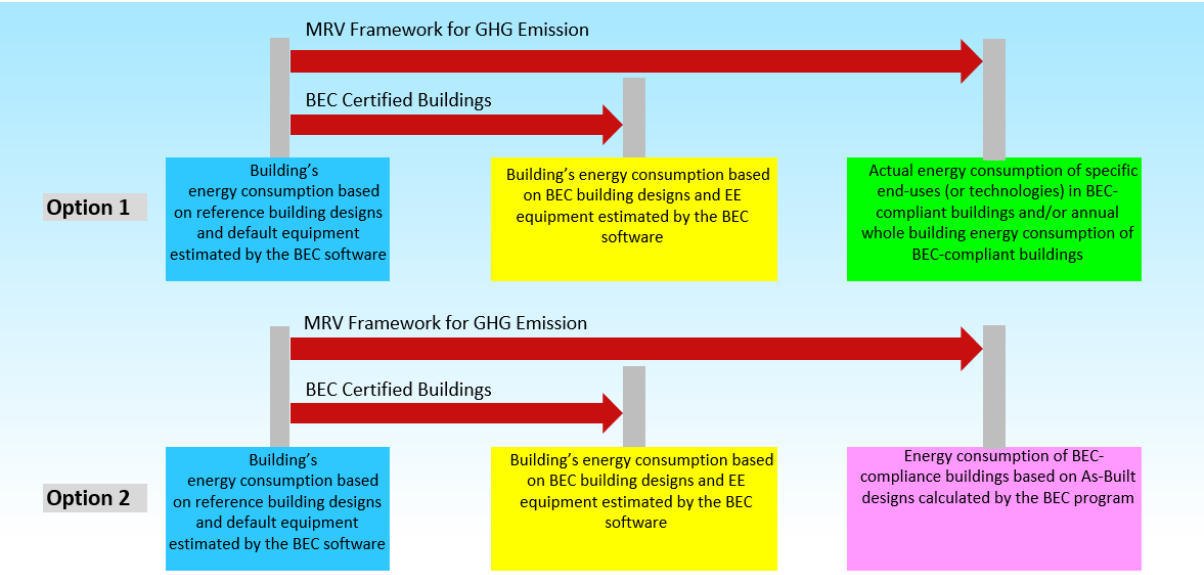


Figure 5: Proposed MRV Framework Options for the BEC Program

In addition to the abovementioned MRV related project documents, the Department of Alternative Energy Development and Efficiency (DEDE) commissioned multiple studies on specific energy consumption (SEC) for various types of designated buildings (i.e., office, department store, hotel and hospital buildings) from 2005 to 2007. In 2018, TGO also commissioned another SEC study for designated buildings and factories, and office, department store, hotel and hospital buildings were included in the TGO SEC study.

3 ACTIVITY 5.2: IDENTIFICATION OF KEY INDICATORS

3.1 SCOPE AND BOUNDARY OF MRV

Scope of the proposed MRV framework (also called "project scope") will follow the Thai BEC program which covers any new or retrofitted building with a total floor area of 2,000 m^2 or more, and being classified as one of the following building types:

1. Entertainment service buildings
2. Hotels
3. Entertainment services facilities
4. Medical facilities and hospitals
5. Educational institutions
6. Office buildings
7. Shopping malls and department stores
8. Condominiums
9. Convention halls

Detailed definition and inclusion of the above building types in the project scope shall follow "Ministry of Energy's Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedure in Designing Building for Energy Conservation B.E. 2563 (2020)" in the Royal Gazette on 12 November 2020. The Thai BEC requirements prescribe the energy efficiency criteria of building materials, equipment and system in the building design to reduce energy and GHG emissions from the operation of the buildings (see Figure 6).

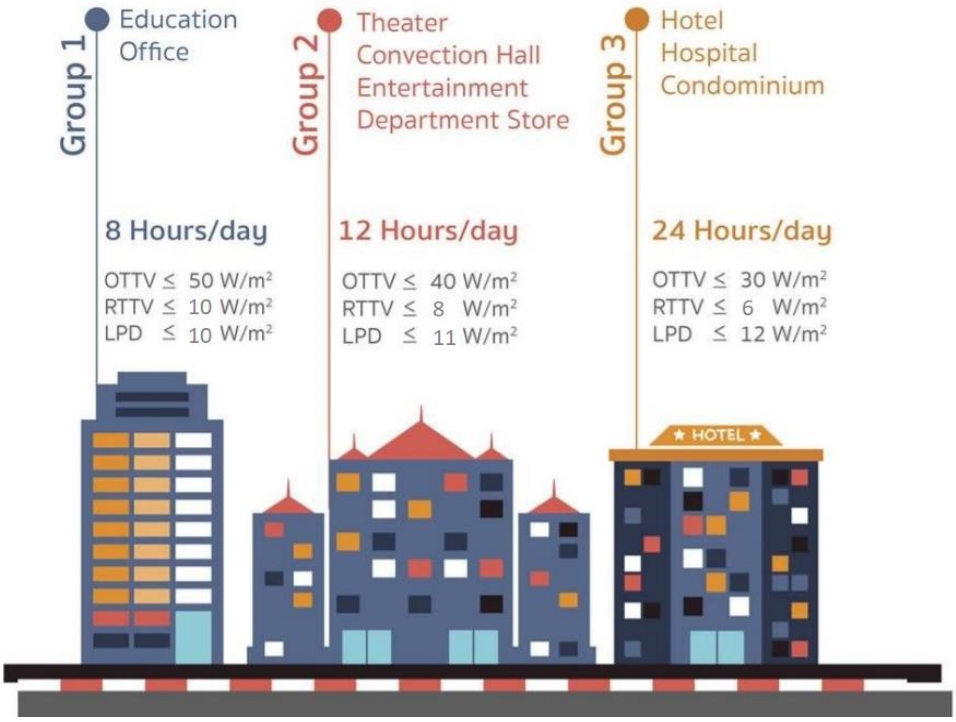


Figure 6 Basic Building Design Criteria for Different Building Types under the BEC Program

The boundary of the proposed MRV framework (or boundary of "project activities") shall cover all the BEC components as summarized in Table 6, and measurement of GHG emission activities (or project activities) under the BEC program requires utilization and performance data of building spaces, equipment and systems of the buildings.

Table 6: BEC Components and Performance Indicators

BEC Component	Indicator	Unit
1. Building Envelope		
▪ Walls (incl. opaque & transparent)	OTTV	W/m^2
▪ Roof	RTTV	W/m^2
2. Lighting System	LPD	W/m^2
3. Air Conditioning System		
▪ Split-type air conditioners	SEER	Btu/h-W
▪ Packaged and central air conditioners	CHP	kW/RT
▪ Absorption chillers	COP	RT/RT
4. Hot Water Generation System		
▪ Fuel-based hot water boilers	Eff	%
▪ Heat pump hot water boilers	COP	RT/RT
5. Renewable Energy Utilization	Output	kWh
6. Whole Building Energy Performance	EUI	kWh/m^2

4 ACTIVITY 5.3: DEVELOPMENT OF DRAFT MRV FRAMEWORK

4.1 PROPOSED APPROACH OF MRV FRAMEWORK FOR BEC

The TGCP-Energy proposed utilization of the BEC program (Option 1) and aggregation of actual building energy consumption (Option 2) as the potential MRV frameworks for the BEC program. This report, however, does not recommend the BEC program as a viable option for the MRV framework for the BEC program due to the following reasons:

- BEC assessment program is designed for design benchmarking and certification purposes. Building energy consumptions are roughly estimated assuming fixed parameters for the whole building types (sub sector), categorized in three groups of 8, 12 and 24 daily operating hours.
- The calculation assumes fixed loads and operating hours on electricity consuming equipment. Area occupancies are fixed.
- The calculation result is one-time based on designed building envelope, building equipment and system. No operation factor is taken into consideration.

Based on the abovementioned shortfalls, this report proposes adoption of the modified Option 2 which estimates GHG emission of the BEC program through collection of actual building energy consumption, and also utilize specific energy consumption (SEC) data studied by DEDE and TGO for different types of buildings. Utilization of SEC data allows for adjustment of building usage and intensity of project activities over time which will lead to an adjusted baseline data and better confidence in estimation of GHG emission reduction.

The proposed approach will calculate GHG emission reduction based on the following assumptions, and the approaches as illustrated in Figure 3-2.

- SEC values for at the BEC baseline (year 2009) are similar to SEC from the sectoral study. No GHG emission reduction claimed between 2005 (NDC base year) and 2009 (BEC base year).
- Consider CO_2 as the main GHG emission.
- Emission factor on the year of activity will be applied.
- Different SEC formula and annual activity data for each building type, as shown in Annex A, will used to adjust baseline energy consumption.
- Calculation of GHG emission from utilization of thermal energy will be excluded from the proposed MRV framework due to negligible fuel energy consumption by different building type in Thailand, and the BEC requirements have delivered virtually no impact on the fuel efficiency improvement in Thai buildings.

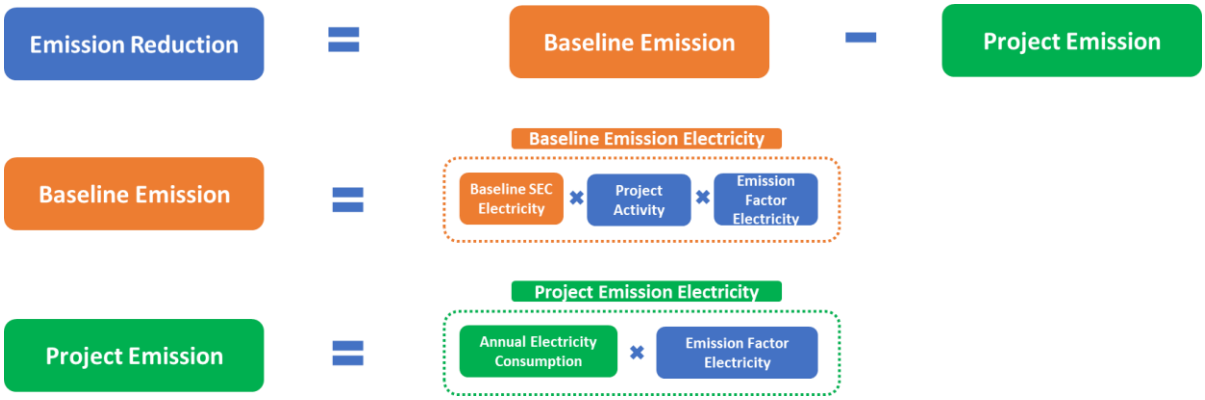


Figure 7: Proposed Calculation Approach for GHG Emission

Shown in Figure 3-3 are the application of the proposed MRV framework at design, construction and operation of BEC-compliant buildings.

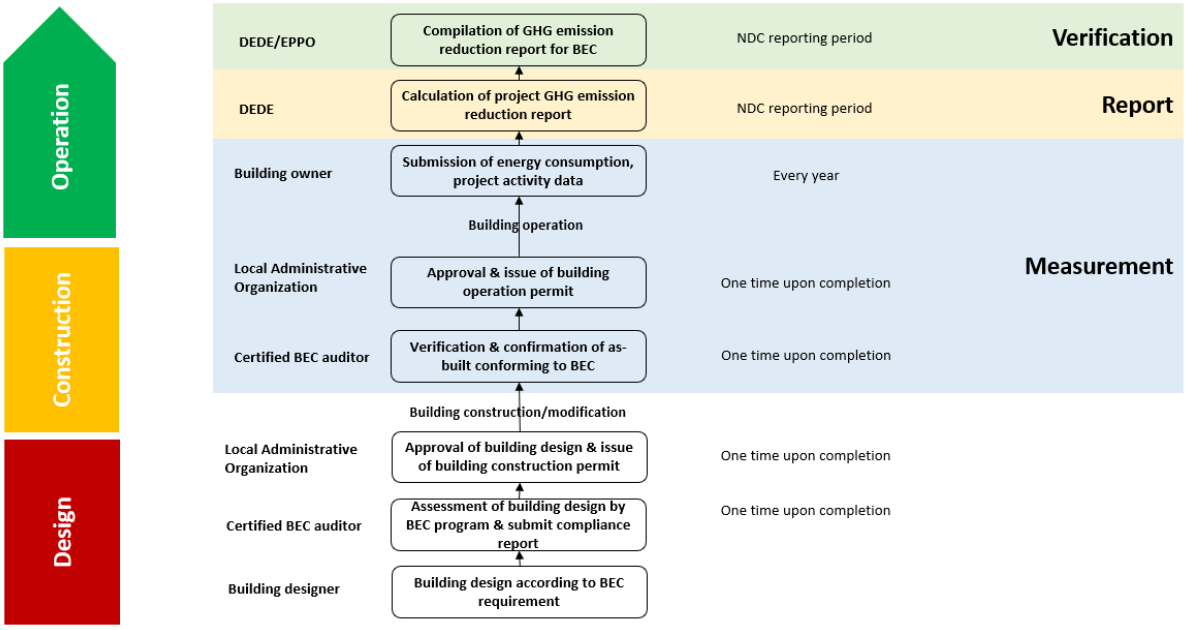


Figure 8: Proposed MRV Process for BEC Program

4.2 Recommendations for Operationalization of MRV Framework

The proposed framework for MRV of emissions for the BEC program in Thailand was presented by the project team in the third online consultation workshop organized on December 22nd, 2021. The online consultation workshop was participated by 30 participants from 21 organizations representing government agencies, private sector organization and academia. The consultation workshop has agreed in principle to the concept of the proposed framework for MRV of emissions for the BEC program (see Annex B for the workshop evaluation results). The workshop also noted the following recommendations for operationalization of the proposed MRV framework.

Recommendation No. 1: Development of data collection & reporting system

- Develop a dedicated BEC database system for energy consumption and building operational data for different BEC-compliant building types.
- Integrate data from the energy management reports for designated BEC buildings into the BEC database system.
- Develop a new reporting system for non-designated BEC buildings for submission of energy consumption and building operational data on an annual basis.
- Enhance the scope of BEC audits after construction completion to include collection of building activity data and establishment of reporting structure.
- Update emission factor for GHG emission inventory and GHG emission reduction calculation.

Recommendation No. 2: Refining the MRV framework for building types without existing SEC data

- **Condominiums:** Condominium cannot be covered by any of available methodologies. The energy accounts are distributed and owned by each residential unit. As a result, occupancy and energy consumption characteristics are scattered. Considering this, collective metering with modern IoT energy monitoring systems are possible. However, condominium contributes only 7% of energy consumption of the building sector in Thailand, and the investment cost on the data collection

infrastructure is not considered cost effective. Therefore, it is recommended for DEDE to establish collaboration with the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA) to utilize existing data from their metering system.

- **Other BEC-Compliant Building Types:** It is recommended for DEDE to conduct additional SEC studies for other BEC-compliant building types to establish baseline and calculation of GHG emission reduction.

5 ACTIVITY 5.4: STAKEHOLDER CONSULTATION OF MRV FRAMEWORK

5.1 SUMMARY OF 3RD STAKEHOLDER CONSULTATION WORKSHOP

The proposed framework for MRV of emissions for the BEC program in Thailand was presented by the project team in the third online consultation workshop organized on December 20nd, 2021. The online consultation workshop was participated by 30 participants from 21 organizations representing government agencies, private sector organization and academia.

Ms. Sirinya Lim, a representative of the Thai NDE, welcomed all participants to the third stakeholder consultation workshop, and the opening remark was given by Mr. Sambit Nayak, the CTCN representative. Following the opening session, the workshop introduction were introduced by IIEC.

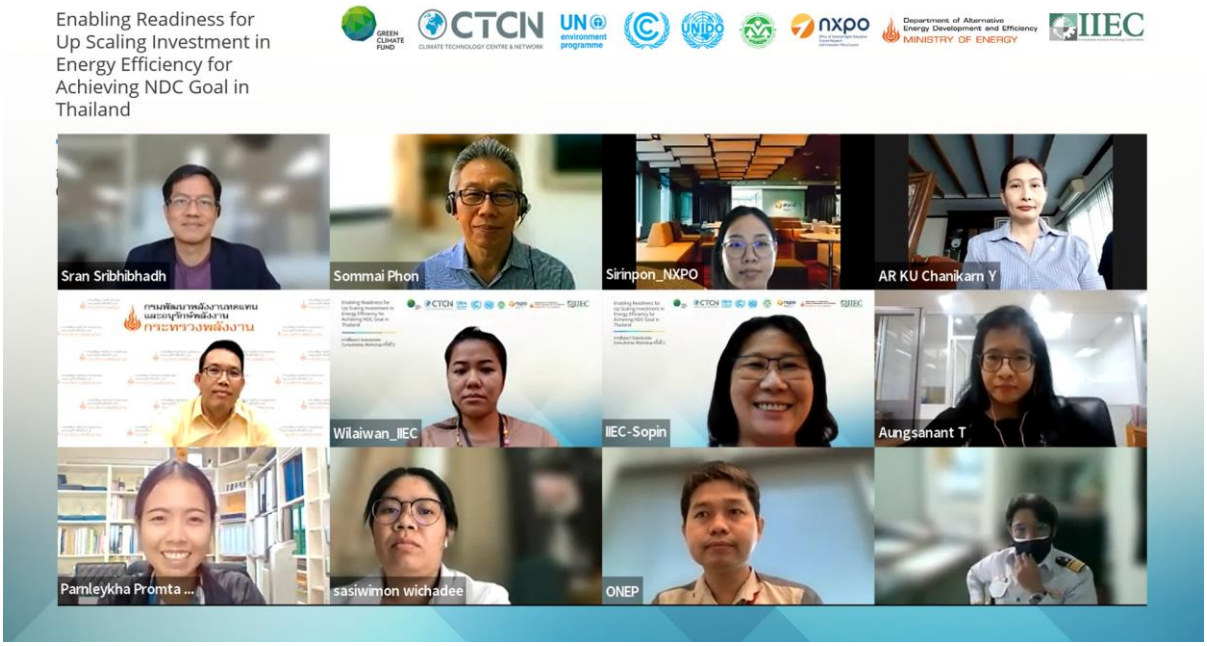


Figure 9 : Proposed Second Stakeholder Consultation Workshop through ZOOM on December 20th, 2021

The workshop agenda and a full list of participants are given in Annex –B and C, and copies of all the presentations are given in Annex-E.

5.2 SUMMARY OF THE PRESENTATIONS

The keynote of each presentation are summarized as follows:

Following the introductory session, Mr. Prakob Eamsa-Ard, a representative of DEDE, updated all participants on the government planning for BEC enforcement in 2022.

The IIEC project team presented the findings from a review of international and national MRV framework for assess impacts from EE and RE implementation in the building sector, specifically on GHG emission reductions, energy use and energy savings. The review focuses on the MRV emission type which entails measuring and monitoring the GHG emission reduction, associated with activities of entities such as countries, sector/organization, or facilities, and reporting the collected data in a GHG inventory. The primary focus of the MRV framework for the building sector, specifically for the BEC building, is on the MRV framework at the sectoral level with emphasis on implementation of EE and RE. One of the important consideration in operationalization of MRV focuses on existing methods and tools that could be applicable for undertaking measurement of emissions in the building sector.

The project team also presented the identification of key parameter and key data required for measurement of GHG emission activities under the BEC program. Based on the review findings, it is apparent that one of the main challenges in establishment of the MRV framework for the Thai BEC program is identification of existing data resources which could be practically utilized to support establishment and operationalization of the proposed MRV framework. Although the MRV framework for the BEC program has been recently discussed by EPPO, DEDE, and other relevant stakeholders, there is no existing MRV framework in the BEC building sector in Thailand. There is also no online platform for reporting, storage and retrieval of verified data from the building sector; specifically actual energy consumption of individual BEC compliant buildings after construction.

Based on the findings, the project team proposes recommendations on the approach and methodology for the MRV framework for the building sector within the Thai BEC framework. The boundary of the proposed MRV framework (or boundary of ''project activities') shall cover all the BEC components, and measurement of GHG emission activities (or project activities) under the BEC program requires additional information of utilization and performance data of building spaces, equipment and systems of the buildings.

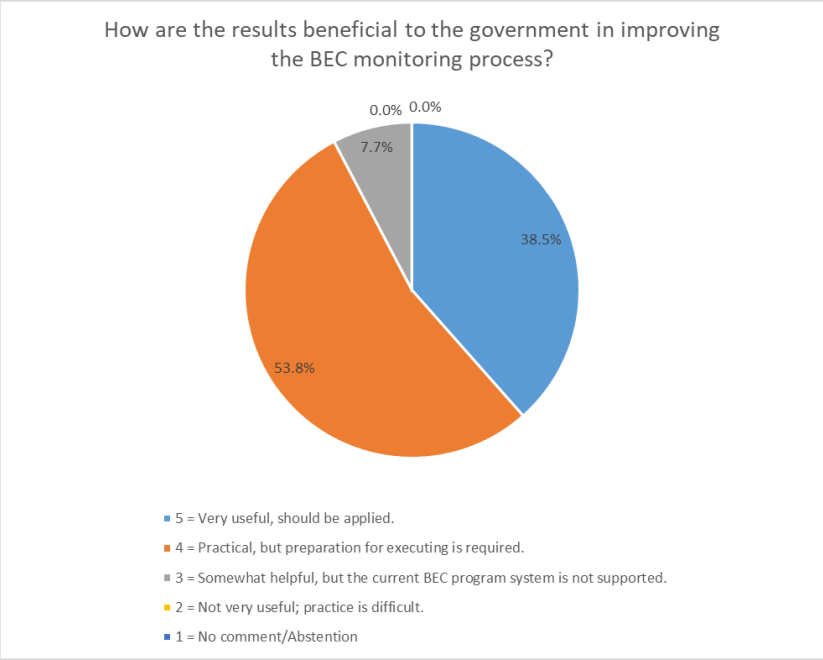
The approach of MRV framework for BEC proposed an adoption of the modified on Option 2 of the TGCP program suggestion, which estimates GHG emission for the BEC program through collection of actual building energy consumption, and also utilize specific energy consumption (SEC) data studied by DEDE and TGO for different types of buildings. Utilization of SEC data allows for adjustment of building usage and intensity of project activities over time which lead to an adjusted BEC baseline data and better confidence in estimation of GHG emission reduction.

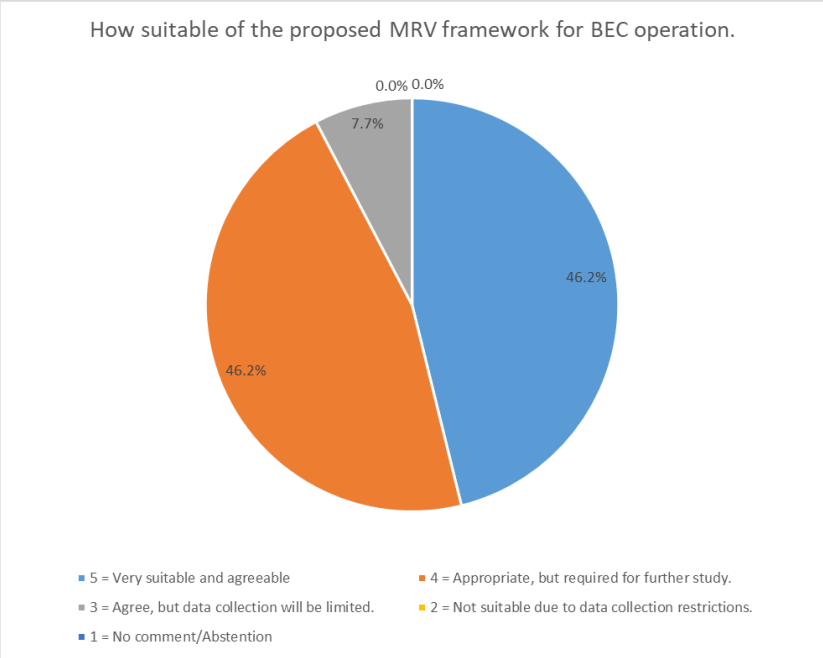
The consultation workshop has agreed in principle to the concept of the proposed framework for MRV of emissions for the BEC program.

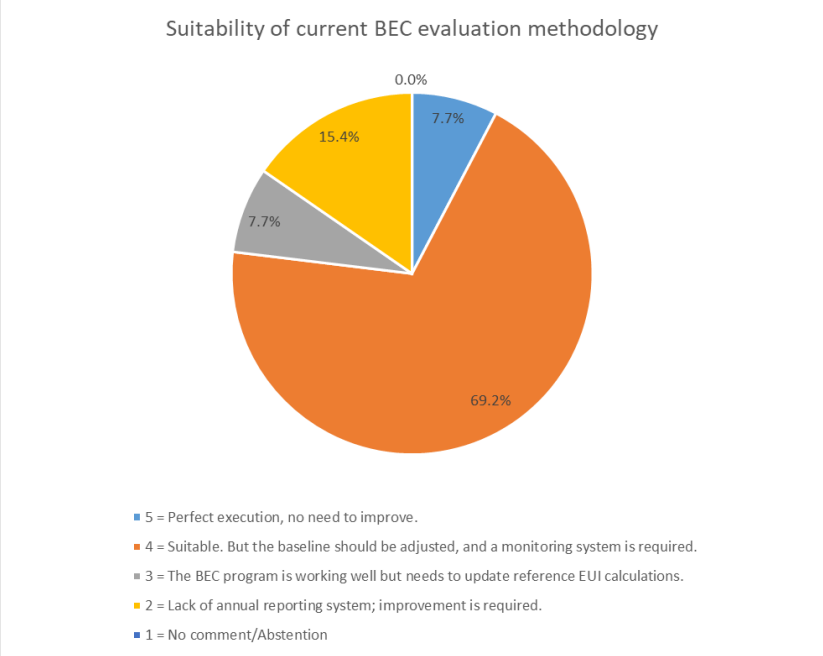
5.3 WORKSHOP EVALUATION

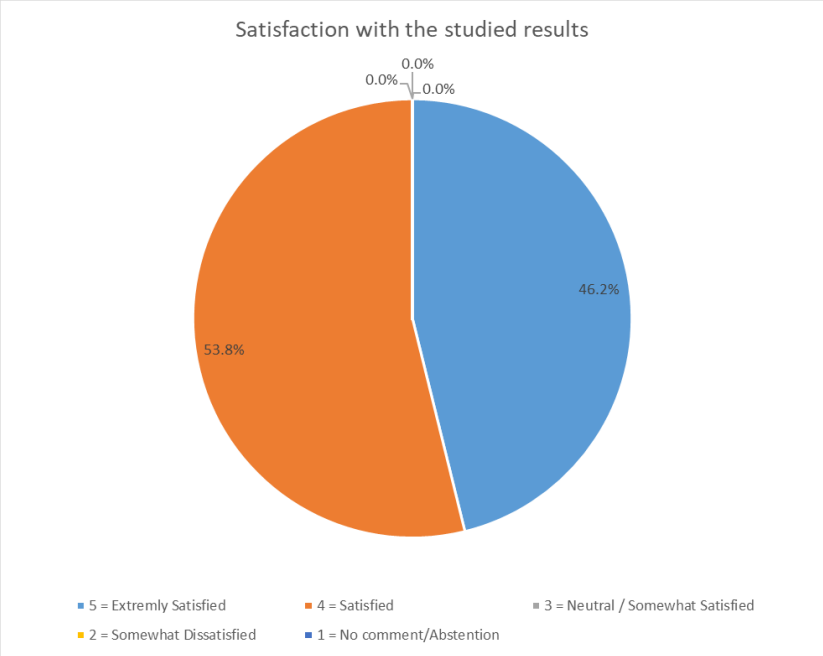
Following the presentations, participants provided their comments and suggestions on the project findings through Zoom, online polls and chat box. The workshop also noted the following recommendations for operationalization of the proposed MRV framework.

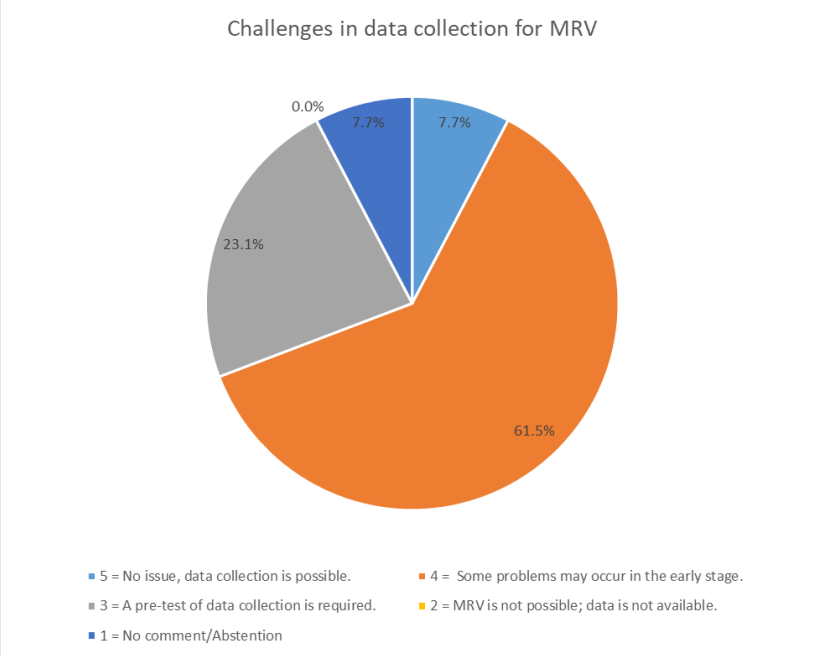
Based on the feedback provided by the participant, over 90% agreed to the suitability and benefits of the proposed MRV framework for the BEC program, and the results of the studies are of satisfactory. However, approximately 60% of the participants are concerned about additional data collection required by the proposed framework.




How suitable of the proposed MRV framework for BEC operation.
0.0%
0.0%
7.7%
46.2%
46.2%
5 = Very suitable and agreeable
4 = Appropriate, but required for further study.
3 = Agree, but data collection will be limited.
2 = Not suitable due to data collection restrictions.
1 = No comment/Abstention


Suitability of current BEC evaluation methodology
0.0%
7.7%
15.4%
7.7%
69.2%
5 = Perfect execution, no need to improve.
4 = Suitable. But the baseline should be adjusted, and a monitoring system is required.
3 = The BEC program is working well but needs to update reference EUI calculations.
2 = Lack of annual reporting system; improvement is required.
1 = No comment/Abstention


Satisfaction with the studied results
0.0%
0.0%
0.0%
46.2%
53.8%
5 = Extremly Satisfied
4 = Satisfied
3 = Neutral / Somewhat Satisfied
2 = Somewhat Dissatisfied
1 = No comment/Abstention


Challenges in data collection for MRV
0.0%
7.7%
7.7%
23.1%
61.5%
5 = No issue, data collection is possible.
4 = Some problems may occur in the early stage.
3 = A pre-test of data collection is required.
2 = MRV is not possible; data is not available.
1 = No comment/Abstention

6 ANNEXES

Annex A	DEDE's Study on SEC of Office, Commercial, Hotel and Hospital Buildings
Annex B	Agenda
Annex C	Participant list
Annex D	References
Annex E	Presentations

6.1 ANNEX A: DEDE'S STUDY ON SEC OF OFFICE, COMMERCIAL, HOTEL AND HOSPITAL BUILDINGS

6.1.1 Office Building SEC

	Category	No. of samples	Value	Unit	R^2
Baseline SEC		**20**	**209.90**	**kWh/m²-y**	**0.84**
By physical shape	Group 1: 2000 m² < area < 10,000 m², height >= 23 m	5	215.80		0.86
	Group 2: area >10,000 m², height < 23 m	5	199.90		0.91
	Group 3: area >=10,000 m², height >= 23 m	10	218.50		0.84

SEC @ activity year (kWh/m²-y)

$$SEC = \frac{total\ energy\ consumption\ per\ year\ (kWh/y)}{\%\ occupancy \times usable\ area\ (m^2)}$$

Energy consumption data

- Energy consumption per year (kWh/y)

Activity Data

- Category: floor area (m²), building height (m)
- Area occupancy (% of usable floor area)
- Usable floor area (m²)

6.1.2 Commercial Building SEC

	Category	No. of samples	Value	Unit	R^2
Baseline SEC					-
By type	Department store	169	240.6	kWh/m²-y	
	Discount store	294	336.4	kWh/m²-y	
	Shopping plaza	91	204.2	kWh/m²-y	
	Supermarket	3	418.4	kWh/m²-y	

SEC @ activity year (kWh/m²-y)

$$SEC = \frac{total\ energy\ consumption\ per\ year\ (kWh/y)}{usable\ area\ excl.parking\ (m^2)}$$

Energy consumption data

- Energy consumption per year (kWh/y)

Activity Data

- Type: of commercial store
- Usable floor area (m²)

6.1.3 Hotel Building SEC

	SEC Equation	Unit	R^2
Baseline SEC			
SEC by usable area	SEC1 = -0.2719 group^2 + 23.342 group + 2.2582	MJ/m^2-month	0.9728

SEC @ activity year (MJ/m^2-month)

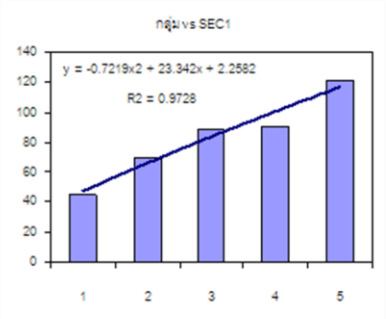
$$SEC = \frac{total\ energy\ consumption\ per\ month\ (MJ/month)}{actual\ usable\ area\ (m^2)}$$

Energy consumption data

- Energy consumption per year (MJ/month)

Activity Data

- Actual usable area (m^2)
- Number of guest rooms (rooms)
- Area of dining and restaurant (m^2)
- Area of catering and meeting rooms (m^2)
- Area of fitness, entertainment and central services (m^2)
- Area of swimming pool (m^2)
- Area of office and retail stores (m^2)
- Laundry operation (kg/month)



Hotel categories

- Apply weighted scoring of seven operational services to group the hotels into five groups.

Operational Services/Score	1	2	3	4	5
1. Number of guest rooms (rooms)	1-100	101-200	201-300	301-600	>600
2. Area of dining and restaurant (m^2)	1-100	101-200	201-300	301-500	>500
3. Area of catering and meeting rooms (m^2)	1-100	101-200	201-300	301-500	>500
4. Area of fitness, entertainment and central services (m^2)	1-100	101-200	201-300	301-500	>500
5. Area of swimming pool (m^2)	1-100	101-200	201-300	301-500	>500
6. Area of office and retail stores (m^2)	1-100	101-200	201-300	301-500	>500
7. Laundry operation (kg/month)	1-5,000	5,001-10,000	10,001-20,000	20,001-40,000	>40,000

Operational Services	Score	Weighting
1. Number of guest rooms (rooms)	1 – 5	42.33
2. Area of dining and restaurant (m^2)	1 – 5	5.30
3. Area of catering and meeting rooms (m^2)	1 – 5	7.25
4. Area of fitness, entertainment and central services (m^2)	1 – 5	21.93
5. Area of swimming pool (m^2)	1 – 5	0.79
6. Area of office and retail stores (m^2)	1 – 5	3.91
7. Laundry operation (kg/month)	1 – 5	18.49

$$Overall\ score\ (\%) = \sum_{i=1}^{7} [service\ score_i \times weight_i\ ] \times 100/500$$

Overall Score (%)	Group
0.00% – 38.40%	1
>38.40% – 58.67%	2
>58.67% – 78.93%%	3
>78.93% – 99.19%	4
>99.19 – 100.00%	5

6.1.4 Hospital Building SEC

	SEC Equation	Unit	R^2
Baseline SEC			
Government hospitals	SEC = (701.64 x AC m^2/bed-day) + 52.032	MJ/bed-day	0.9308
Private hospitals	SEC = (498.17 x AC m^2/bed-day) + 179.74	MJ/bed-day	0.8575

SEC @ activity year (MJ/bed-day)

SEC total energy consumption (MJ/bed-day)

$$SEC = \frac{total\ energy\ consumption\ per\ year\ (MJ/y)}{number\ of\ IPD\ per\ year\ (bed-day/y)}$$

Energy consumption data

- Energy consumption per year (MJ/year)

Activity Data

- Type: government or private
- Number of IPD (bed-day/year)
- Air conditioning area (m^2)

6.2 ANNEX B: AGENDA

Stakeholder Consultation Workshop # 3
Project "Enabling Readiness for Up Scaling Investment in Energy Efficiency for Achieving NDC Goals in Thailand''
Monday, 20th December 2021

ZOOM Online Meeting, Time 9:00 AM - 12:00 PM (BKK time)

Agenda	
08.45 – 09.00	**Online Registration**
09.00 – 09.10	**Welcome Remark and Opening** *By: Representative of NXPO and CTCN (if CTCN available)*
09.10 – 09.30	**Update on the government planning for BEC enforcement in 2022** *By: Representative of DEDE*
09.30 – 10.15	**Review of international and national methodological and operation MRV framework to assess GHG emission for building sector** *By: IIEC*
10.15 – 10.30	Online Digital break
10.30 – 11.30	**Proposed MRV framework for building sector within the BEC framework** *By: IIEC*
11.30 – 12.00	**Q&A and Discussion**
12.00 – 12.10	Online-workshop evaluation survey (5 min) and Wrap up (5 min)
Remark:	Please scan QR Code for registration or confirmation through the email attached here. Email: swachirapuwadon@iiec.org Registration QR code ** The presentation will be conducted in Thai language **

6.3 ANNEX C: PARTICIPANT LIST

Total 30 persons registered from 21 organization as list below:

No.	Name	Organization	Title
1	Mr. Sambit Nayak	Climate Technology Center and Network (CTCN)	Climate Change Specialist
2	Ms. Sirinya Lim	Office of National Higher Education Science Research and Innovation Policy Council (NXPO)	Division Director of Innovation Economy
3	Ms. Sirinporn Daengphuang		Policy analyst
4	Mr. Prakob Eamsa-Ard	Department of Alternative Energy Development and Efficiency (DEDE)	Head of Building standard regulation and enforcement group
5	Assoc.Prof.Dr. Chanikarn Yimprayoon	Faculty of Architecture, Kasetsart University (KU)	Associate Professor
6	Assistant of Professor Dr. Aphichat Srichat	Faculty of Technology, Udon Thani Rajabhat University	Assistant Professor
7	Ms. Khwankhao Prasitsorn	National Housing Authority (NHA)	Senior Officer/Engineer
8	Mr. Jedsada Treepiyarat		Senior Officer/Engineer
9	Mr. Uthai Wongkhuenkaew	Power Supply and Management Services Co., Ltd.	Energy and Efficiency Manager
10	Assoc. Prof. Dr. Sopa Visitsak	Faculty of Architecture, Kasetsart University (KU)	Associate Professor
11	Dr. Nattaree Sridaranon		Lecturer/Researcher
12	Dr. Chuttree Phurat	Thailand Environment Institute (TEI)	Senior Project Manager and Acting director of Green label and Ecolabel Unit
13	Mr. Thanabat Chiaosuwan	Naresuan University (NU)	Electrical engineer Lecturer/Researcher
14	Mr. Jirasak Pukdam	Rajamangala University of Technology Thanyaburi (RMUTT)	Lecturer/Researcher
15	Mr. Sivach Kaewcharoen	Office of Natural Resources and Environment Policy and Planning (ONEP)	Senior Environmental specialist
16	Ms. Sasiwimon Wichadee		Environmental specialist
17	Mr. Piti Anontapant	Thailand Facility Management Association (TFMA)	Association President
18	Mr. Napat techawutthikorn	Electricity Generating Authority of Thailand (EGAT)	Engineer
19	Dr. Pongvipa Lohsomboon	Thailand Greenhouse Gas Management Organization (TGO)	Deputy Director
20	Mr. Jetsada Phraeknanthoe	Bangkok University	Lecturer/Researcher

No.	Name	Organization	Title
21	Mr. Metha Chaiprasop	Future Engineering Consultants Co., Ltd.	Engineer
22	Mr. Thanapong Usupan	Provincial Electricity Authority of Thailand (PEA)	Engineer
23	Mr. Kamolwiz Taninnara	Rachata Co., Ltd.	Project Manager
24	Mr. Chayaphol Thumaksorn	Independent consultant	BEC auditor
25	Mr. James NoDef Godharden		
26	Mr. Sommai Phon-Amnuaisuk	International Institute for Energy Conservation (IIEC)	Director - Asia Pacific
27	Mr. Sran Sribhibhadh		Senior consultant, M&E Expert
28	Ms. Sopin Wachirapuwadon		Project manager
29	Ms. Aungsanant Thipthaweecharn		
30	Ms. Wilaiwan Kunchansombut		

6.4 ANNEX D: REFERENCES

EVO, 2019. Measurement & Verification – Issues and Examples, IPMVP, EVO 10300-1:2019

ICAT, 2020. MRV Framework for Energy Conservation Building Code for Large Commercial Buildings

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UNFCCC, 2020. CDM Methodology Booklet

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6.5 ANNEX E: PRESENTATIONS

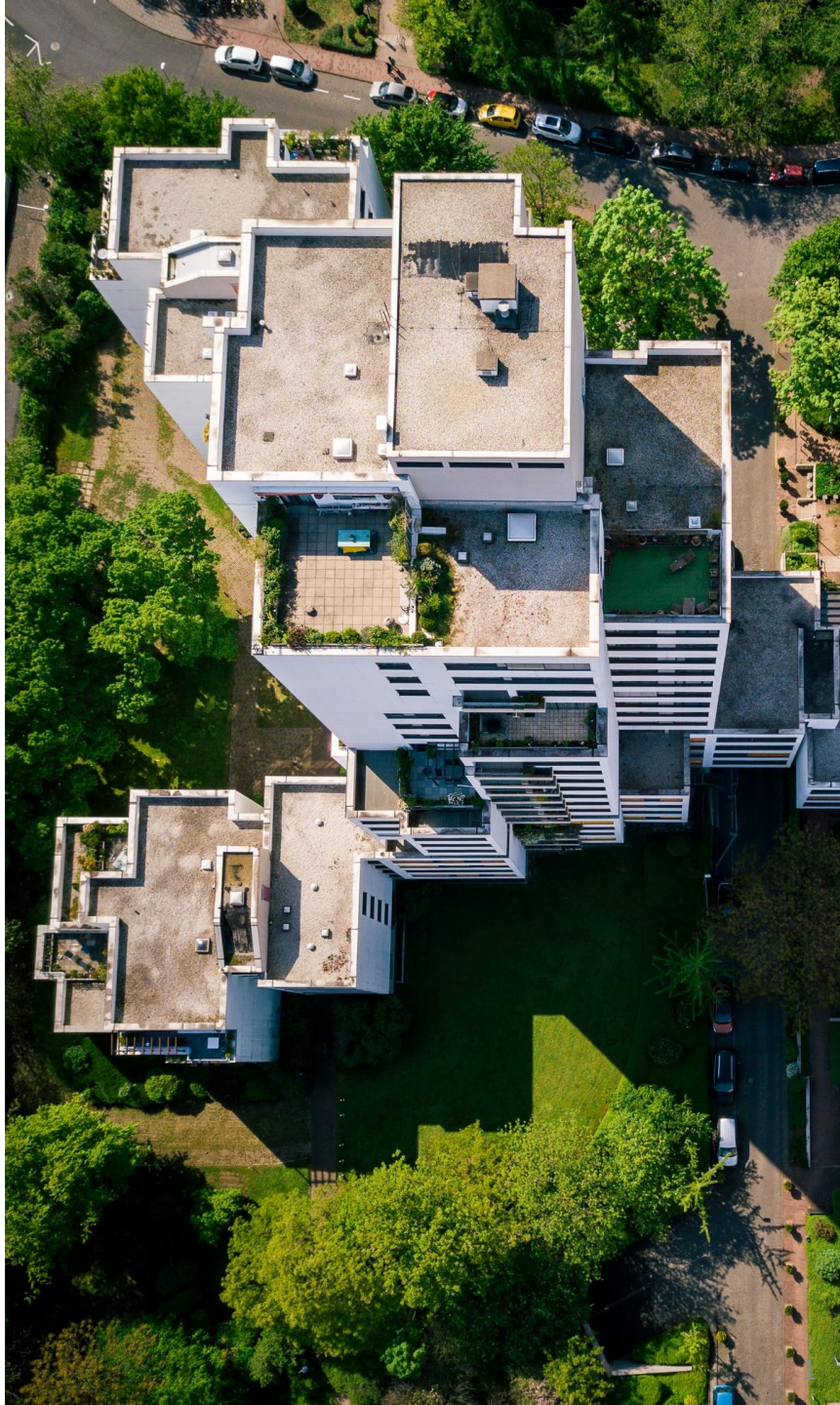
Enabling Readiness for Up Scaling Investments in Building Energy Efficiency for Achieving NDC Goals in Thailand

Review of International MRV Frameworks

CTCN project : Stakeholder Consultation #3

Monday 20 December 2021 **9:00 AM-12:00 PM BKK Time**

International Institute for Energy Conservation (IIEC)



Presentation of Stakeholder Consultation - 3

Presentation Outline

- Types of MRV
- Scope of International MRV Review
- International MRV frameworks for Building Sector
- Key Takeaways

Defining Relevant Types of MRV

Types of MRV

- Measurement, Reporting, and Verification (MRV) emerged under the United Nations Framework Convention on Climate Change (UNFCCC), initially to support NAMA, and, later on, NDC.
  - **M** = **Measurement** (or estimation)
  - **R** = **Reporting** – both national and international
  - **V** = **Verification** – includes both national QA/QC and international oversight
  - Before the MRV term, some form of monitoring and evaluation (M&E) had been used by governments and other entities to assess their actions and goals.

- There are different types of MRV, but the international review focuses on the following mitigation-related MRVs.
  - **MRV of Emissions** (estimation of emissions at national, regional, sectoral levels)
  - **MRV of Actions** (impacts of mitigation policies and actions)
  - **MRV of Support** (financial flows/technology transfer/capacity building and their impacts)

MRV of Emissions & Scope of International Review

The scope for MRV of emissions can be considered at THREE different levels:

National Level

- Historic GHG Inventory – component of BURs and NCs to the UNFCCC
- GHG projections – to help inform national programme , strategy on GHG mitigation, to underpin policy appraisal and planning (link to MRV of NAMA)

Sectoral Level

- To set and track sector emission targets, to engage within sector policy mechanisms (e.g. sector-wide trading mechanisms)
- Also underpin historic inventory and/or projected data

Facility Level

- To monitor and report facility-level or company-level GHG emissions
- To address regulatory requirements or to engage in mechanisms such as Emissions Trading Schemes or CDM projects
- Also underpin historic inventory and/ or projected data

The common parameters across all levels are: EMISSIONS, ACTIVTY DATA, EMISSION FACTORS (and FORECAST DATA for projections).

Bottom-up approaches of Emission Estimation → Top-down approaches of Emission Estimation

Recommended Approach

"Decision of the MRV approach should be based on **a good balance between accuracy and costs** involved in data collection, management and analysis."

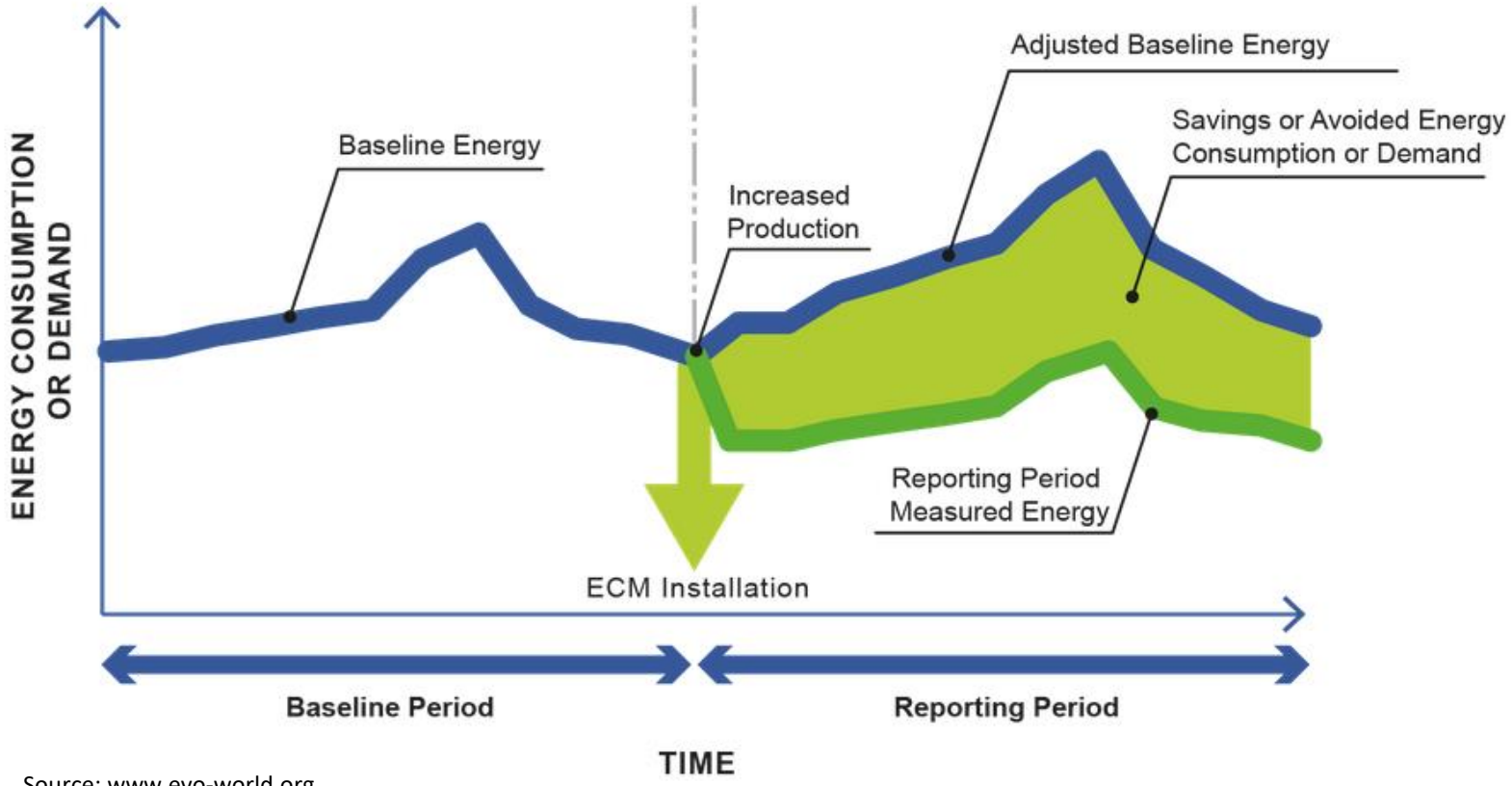
Source: How to Set up National MRV Systems, GIZ

Potential Frameworks and Protocols Adopted by MRV

PROTOCOL	KEY FEATURES	Potential MRV Level
International Performance Measurement and Verification Protocol (IMPVP)	• IPMVP is an international Measurement and Verification (M&V) protocol describing different methods to determine water and energy savings of energy efficiency projects. • IPMVP presents four M&V options for savings estimations. - Option A: Retrofit isolation with key parameter measurement - Option B: Retrofit isolation with measurement of all parameters - Option C: Whole facility - Option D: Calibrated simulation • IPMVP is one of the most comprehensive frameworks for M&V, and has been used as the defector M&V standard in many countries (including Thailand).	Facility Level

Potential Frameworks and Protocols Adopted by MRV

Principles of Baseline Determination under IPMVP



Source: www.evo-world.org

"IPMVP provides a robust guideline and case studies in determination of baseline and how to conduct routine and non-routine adjustment."

Potential Frameworks and Protocols Adopted by MRV

PROTOCOL	KEY FEATURES	Potential MRV Level
CDM Methodology • AMS-II.C. Demand-side energy efficiency activities for specific technologies • AMS-II.E. Energy efficiency and fuel switching measures for building	• CDM methodology documents provide the user with necessary instructions to develop and implement M&V plan per the CDM criteria to qualify for emission reduction certificates. • CDM methodology documents also provide definitions and calculation methods for baseline development. • AMS-II.C. is for energy efficiency activities for specific technologies such as lamps, motors, fans, air conditioners, pumps and chillers. • AMS-II.E. is for energy efficiency measures (such as energy efficient appliance, better insulation, energy management) in new or existing buildings. • Projects need to follow these guildelines to qualify fort emission reduction certificates.	Facility Level

Source: CDM Methodology Booklet, 12th edition, Information updated as of EB 108, December 2020

Potential Frameworks and Protocols Adopted by MRV

PROTOCOL	KEY FEATURES	Potential MRV Level
ISO 50001 Energy Management System (EnMS)	• ISO 50001 EnMS is a framework developed for industrial and commercial facilities, and organizations to manage energy. • The EnMS institutes a structure and discipline to implement technical and managerial strategies to cut energy consumption and GHG emissions. • The standard addresses: energy use and consumption measurement, documentation and reporting of energy use, design and procurement of energy-using equipment, system and processes.	Facility Level
The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard	• GHG Protocol standards and guidance enables companies to measure, manage and report greenhouse gas emissions from their operations and value chains. (Tools available for download) • In 2016, at least 92% of Fortune 500 companies responding to CDP used GHG Protocol directly or indirectly through a program based on GHG Protocol.	Facility/ Organizational Level

International Review of MRV Frameworks for Building Sector

Regions/Countries Reviewed

- Africa
- Caribbean
- Armenia
- India
- Vietnam

Areas focused for the review

- Objectives and scope of the MRV framework
- Overall approach and framework/protocol referenced
- Implementation status

Africa - MRV of Mitigation Actions Energy Efficiency in Buildings

Description	Details
Nature of MRV Design and Implementation	A project-based capacity building on MRV of GHG emissions and mitigation actions in African countries, funded by Directorate-General for Climate Action (DG-CLIMA)
Objective	The project provides training and materials on MRV for emissions and actions in various sectors. Energy efficiency in buildings is one of them.
Scope (boundary)	Residential and commercial buildings
Overall approach and framework/ protocol referenced	Facility level MRV, bottom-up approach based on specific energy efficiency measures
Data gathering approach	N/A
Implementation Status	N/A

Caribbean - MRV for Energy Efficiency in Commercial and Public Buildings

Description	Details
Nature of MRV Design and Implementation	A project-based MRV development, funded by the Austrian Development Agency (ADA) in the framework of Phase Two of the Latin America and the Caribbean Energy Efficiency Program (PALCEE II).
Objective	The project aims at developing replicable MRV methodology for the countries of the Caribbean Region.
Scope (boundary)	Commercial and public buildings
Overall approach and framework/ protocol referenced	Facility level MRV, bottom-up approach based primarily on **IPMVP**
Data gathering approach	Inspection of energy efficiency measures, mandatory and voluntary energy efficiency and energy consumption reporting (including energy audit reports), utility bills
Implementation Status	N/A

Armenia - MRV for Buildings

Description	Details
Nature of MRV Design and Implementation	A project-based development of a MRV framework, funded by UNDP-GCF (De-Risking and Scaling-up Investment in Energy Efficient Building Retrofits project)
Objective	The project objective is to achieve reduction of greenhouse gas emissions through thermal insulation and energy efficiency measures in residential and public buildings.
Scope (boundary)	Residential and public buildings (existing buildings)
Overall approach and framework/ protocol referenced	Facility level MRV, bottom-up approach based on **Long Range Energy Alternatives Planning System (LEAP)** software
Data gathering approach	Pre- and post-energy efficiency retrofit energy audits, building inventory, measurement of energy savings
Implementation Status	N/A

India - MRV Framework for Energy Conservation Building Code for Large Commercial Buildings

Description	Details
Nature of MRV Design and Implementation	A project-based development of a MRV framework, developed as part of a component of the Initiative for Climate Action Transparency project (ICAT) implemented by The Energy and Resources Institute (TERI) and UNEP DTU Partnership (UDP).
Objective	The project aims at developing an MRV framework for assessing GHG impacts of the Energy Conservation Building Code (ECBC), which was launched in 2007 and revised in 2017. (mandatory for new commercial buildings with connected load of 100 kW or contract demand of 120 KVA and above.
Scope (boundary)	Commercial buildings
Overall approach and framework/ protocol referenced	Combination of top-down and bottom-up approach (depending on data available at the state level). Key parameters (e.g., built-up areas, energy performance index) must be collected/estimated to calculate emissions.
Data gathering approach	Energy audits, electricity bills
Implementation Status	N/A

Vietnam – Energy Efficiency Improvement in Commercial and High-Rise Residential Buildings

Description	Details
Nature of MRV Design and Implementation	A project-based a MRV framework for monitoring and evaluation of the Energy Efficiency Improvement in Commercial and High-Rise Residential Buildings (EECB) in Viet Nam, funded by UNDP-GEF
Objective	The project has the goal to reduce intensity of GHG emissions from the building sector in Viet Nam through implementation of the Energy Efficiency Building Code (EEBC).
Scope (boundary)	Buildings with gross floor area of 2,500 m^2 or larger
Overall approach and framework/ protocol referenced	Facility level MRV, bottom-up approach based on built-up areas and Energy Use Index (EUI)
Data gathering approach	Pre- and post-energy efficiency retrofit energy audits, building inventory, electricity bills
Implementation Status	Project closed in 2021.

Key Takeaways

MRV frameworks for sectoral level emissions

- Most international MRV frameworks reviewed are facility level MRV frameworks.
- Sectoral level emissions are based on aggregation of facility level emissions.

Data gathering approach

- Most international MRV frameworks reference bottom-up approaches, and huge amount of data is required to enable sound estimation of GHG emissions.
- Typical data gathering approaches include: **energy audits**, **mandatory reporting** of built-up areas and energy efficiency measures, **electricity bills**.

Implementation status

- Up-to-date information on implementation status of these MRV frameworks is not available.

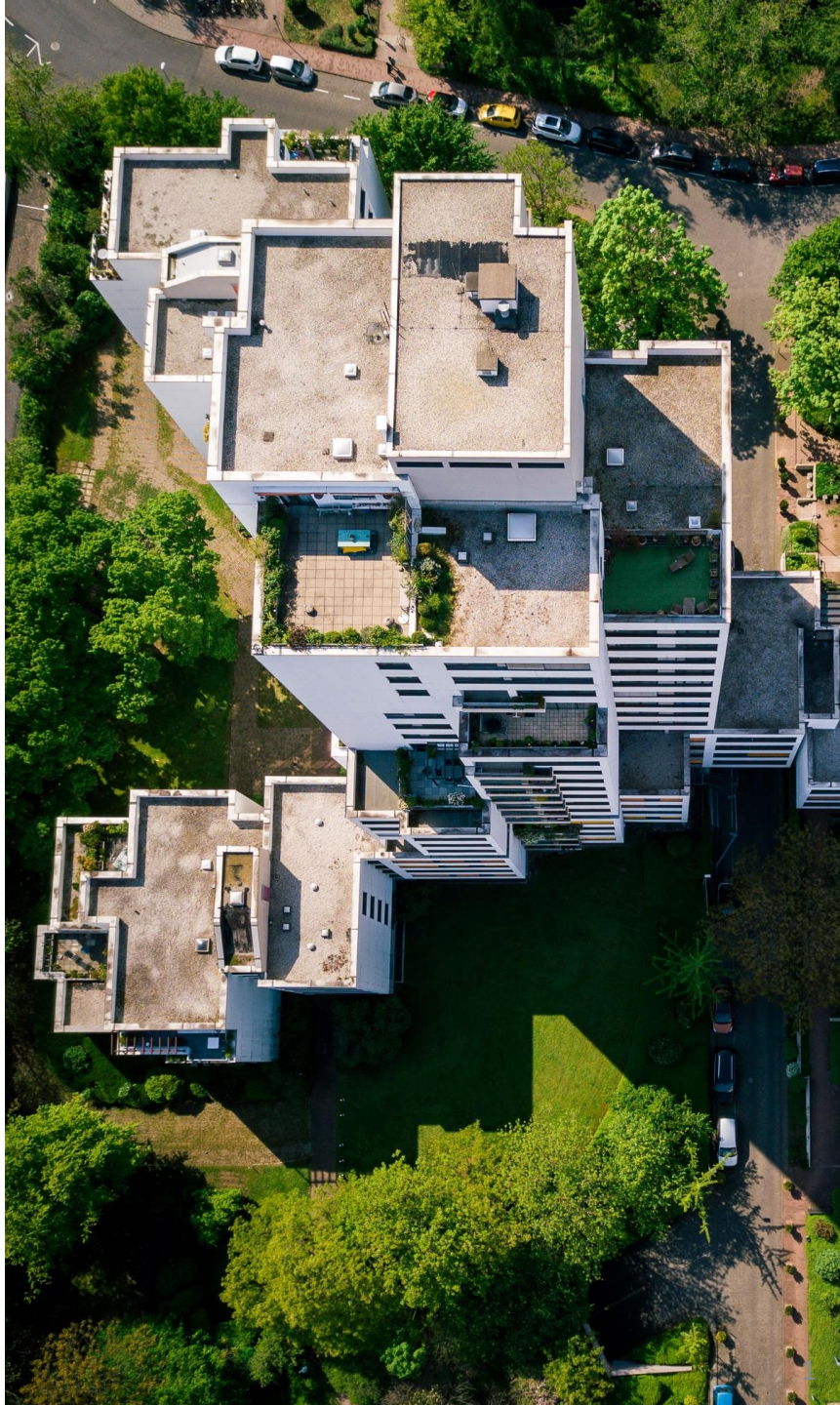
Enabling Readiness for Up Scaling Investments in Building Energy Efficiency for Achieving NDC Goals in Thailand

BEC MRV Framework

CTCN project : Stakeholder Consultation #3

Monday 20 December 2021 **9:00 AM-12:00 PM BKK Time**

International Institute for Energy Conservation (IIEC)



Presentation of Stakeholder Consultation -3

(Activities - Task 5)

Presentation Outline

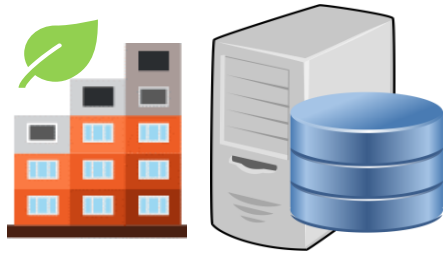
Introduction
- Thailand's National Policy on Climate Change
- BEC contribution to Thailand's NDC

MRV Framework for BEC
- Methodology
- Project Scope & Activities
- Energy Consumption & Activity Data
- Proposed Methodology for MRV
- Calculation of GHG Emission Reduction
- SEC for Estimating GHG Emission Basline
- Proposed Monitoring Plan for MRV
- Recommendation for the Proposed MRV

Conclusion with Q&A

Flow of Project Activities

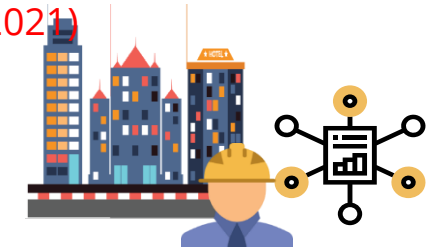
Task 1:
Energy and GHG baseline and consumption benchmarking
(Nov 2020-Mar 2021)



Task 2:
Technology Assessment of Five Building Types within the BEC Framework
(Apr 2020–Jul 2021)

Task 3:
Financial Assessment for New Buildings within the BEC framework
(May 2021-Oct 2021)

Task 4:
Energy Audits on the Five Building Types
(May 2021-Oct 2021)



Task 5:
Develop MRV Framework for Existing and New Buildings within BEC Framework
(Oct 2021–Dec 2021)

Task 6:
Development of Monitoring and Communication materials
(Oct 2021-Dec 2021)

Output-1
Energy and GHG baseline and Benchmark for five building type

Output–2 and Output-3
Technology and Financial Assessment for five building within BEC framework

Output-4
Simulation result on Energy & GHG emission saving potential

Output-5
Draft MRV framework to assess GHG emission reduction

Output-6
Three Handbooks for dissemination

Simulation of Energy and GHG Benchmark

**Input requirement*

Designated and BEC building Database

Assessment of Relevant Technologies with BEC compliance

Prioritized-technologies list

Energy Performance Simulation and Financial assessment

Energy Audit on potential GHG and energy saving option

Key indicators and draft MRV framework

Link

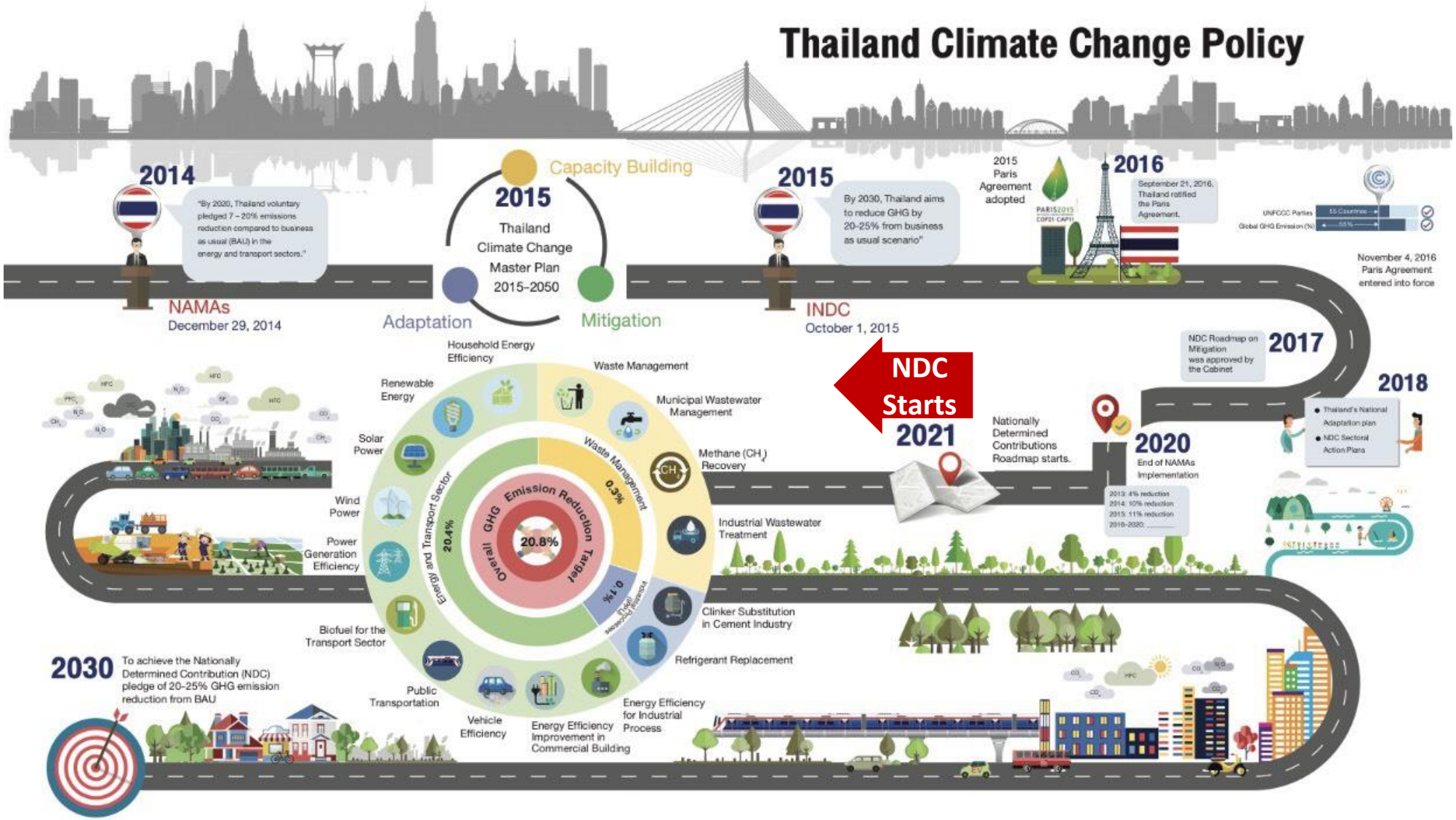
Link

Link

Link

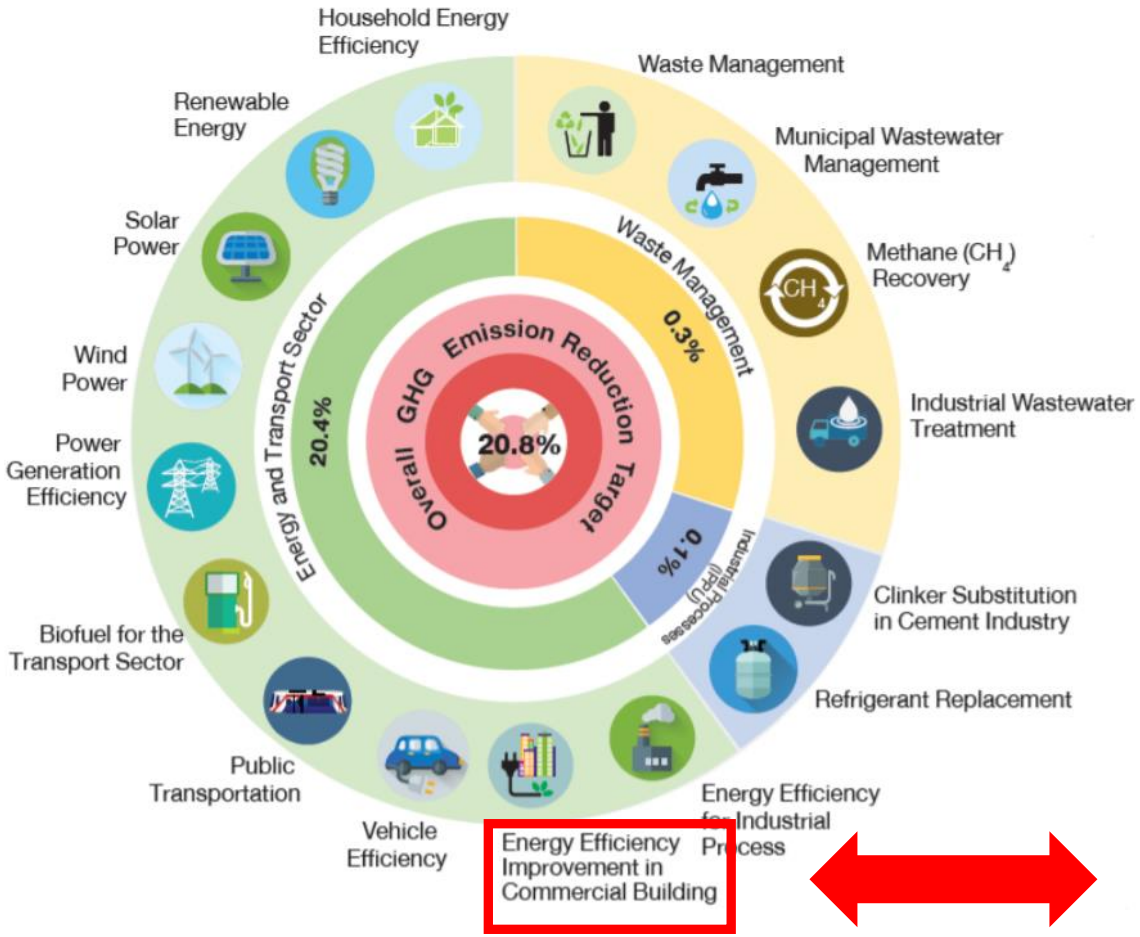
Link

Thailand's National Policy on Climate Change



Source: ONEP, 2016

BEC Contribution to Thailand's NDC



ตารางที่ 3: ค่าเป้าหมายตามแผนอนุรักษ์พลังงาน พ.ศ. 2558-2579

มาตรการ	กลุ่มเศรษฐกิจ				
	อุตสาหกรรม	อาคารธุรกิจ อาคารรัฐ	ที่อยู่อาศัย	ภาคขนส่ง	รวม (ktoe)
1. ความต้องการใช้พลังงานขั้นสุดท้าย ณ ปี พ.ศ. 2579 (กรณีปกติ)					187,142
2. ผลการอนุรักษ์พลังงานที่ผ่านมา ทำให้ EI ปี พ.ศ. 2556 ลดลง คิดเป็นพลังงานที่ประหยัดได้					4,442
3. เป้าหมายการอนุรักษ์พลังงานตามแผนอนุรักษ์พลังงาน ในช่วงปี พ.ศ.2558-2579	14,515	4,819	2,153	30,213	51,700
(1) มาตรการบังคับใช้มาตรฐานการอนุรักษ์พลังงานในโรงงาน/อาคารควบคุม	4,388	768	-	-	5,156
(2) มาตรการบังคับมาตรฐานอาคารก่อสร้างใหม่เพื่อการอนุรักษ์พลังงาน	-	1,166	-	-	1,166

Energy saving target

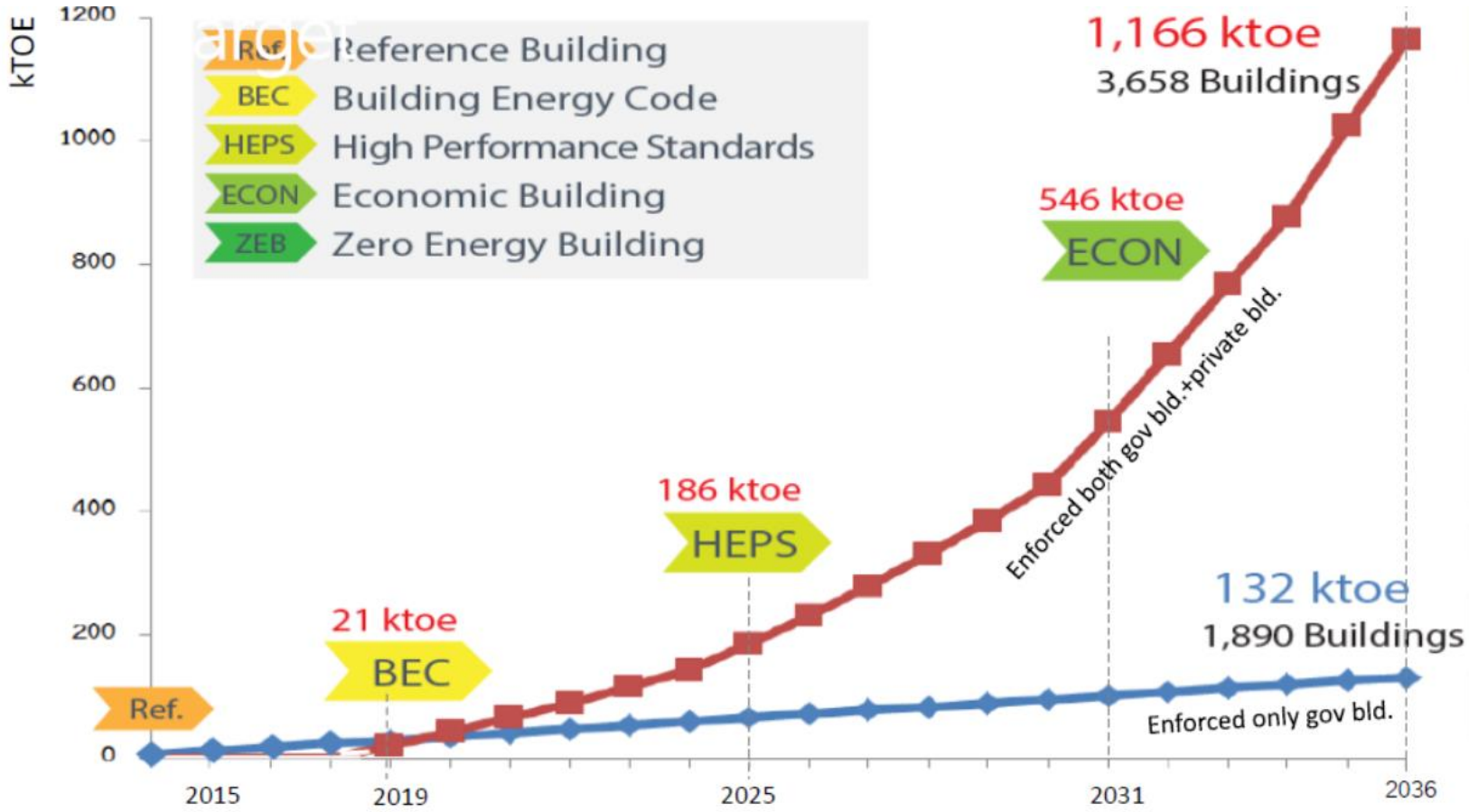
ตารางที่ 10 ค่าเป้าหมายการลดก๊าซเรือนกระจกตามแผนปฏิบัติการลดก๊าซเรือนกระจกของประเทศ สาขาพลังงาน มาตรการลดก๊าซเรือนกระจก

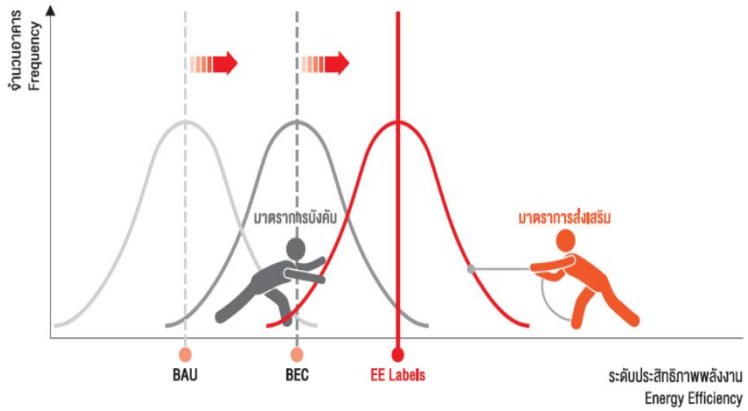
มาตรการ/กิจกรรมหลัก	หน่วยงานรับผิดชอบ		เป้าหมายการลดก๊าซเรือนกระจก ($MtCO_2$)										งบประมาณ (ล้านบาท)		
	หลัก	สนับสนุน	64	65	66	67	68	69	70	71	72	73	64-68	69-73	แหล่งเงิน
ยุทธศาสตร์ที่ 1 ขับเคลื่อนการลดก๊าซเรือนกระจกของประเทศ สาขาพลังงาน															
กลยุทธ์ 1.1 ผนวกนโยบายและแผนงานร่วมกับภาคส่วนที่เกี่ยวข้องในการขับเคลื่อนการลดก๊าซเรือนกระจกจากการเพิ่มประสิทธิภาพการใช้พลังงาน															
แผนงานที่ 1.1.1 การบังคับใช้มาตรฐานการอนุรักษ์พลังงานในโรงงาน/อาคารควบคุม	พพ.	กฟผ./สนพ./สกพ./กรอ./กนอ./ยผ./สผ./อบก.	3.32	3.85	4.38	4.93	5.10	5.26	5.41	5.56	5.71	5.86	1,014	1,210	กองทุนอนุรักษ์ฯ/งบประมาณรัฐวิสาหกิจ
แผนงานที่ 1.1.2 การบังคับมาตรฐานอาคารก่อสร้างใหม่เพื่อการอนุรักษ์พลังงาน	พพ.	ยผ./สผ./อบก.	0.10	0.13	0.17	0.21	0.28	0.34	0.42	0.49	0.57	0.66	2,768	175	กองทุนอนุรักษ์ฯ

Annual GHG emission reduction target

Source: NDC Sectoral Action Plan: Energy, 2018

BEC Contribution to Thailand's NDC





Source: TGP-EEDP, March 2016

OTTV [W/m^2]	BEC	HEPS	ECON	NZEB
Office Building	50	30	20	15
Department Store	40	25	15	10
Condominium	30	15	10	7.5
Hospital	30	15	10	7.5
Hotel	30	15	10	7.5
Educational Institute	50	30	20	15
Convention Center	40	25	15	10

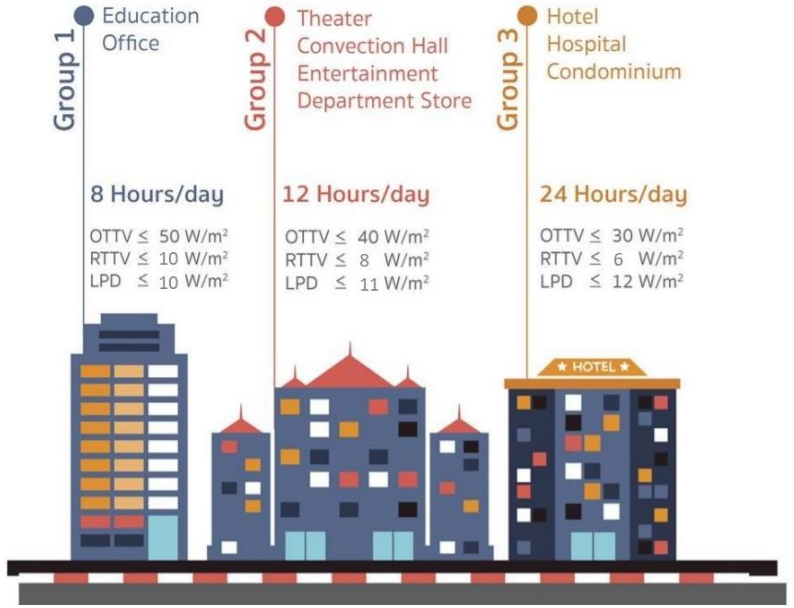
%SAVING BAU ~20-25% ~30-35% ~60-65% >70%

Enforcement → ← Support

Project Scope

New construction or retrofitted buildings with total floor areas in one building of 2,000 m^2 or above and being classified as one of the following building types.

1. Entertainment service buildings
2. Hotels
3. Entertainment services facilities
4. Medical facilities and hospitals
5. Educational institutions
6. Office buildings
7. Shopping malls and department stores
8. Condominiums
9. Convention halls

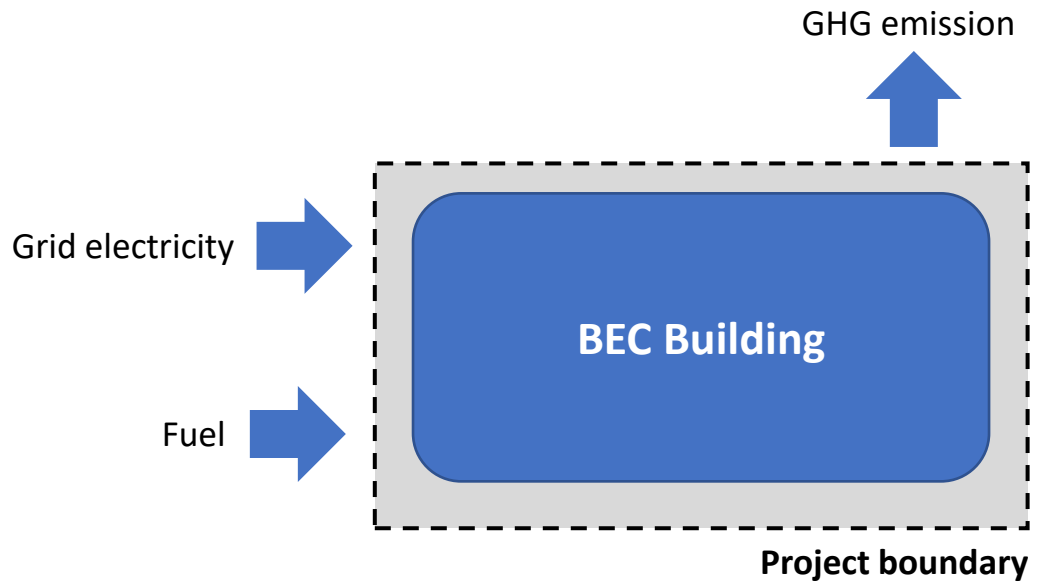


Detailed definition and inclusion of these above buildings in the project scope shall follow “Ministry of Energy’s Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedure in Designing Building for Energy Conservation B.E. 2563 (2020)” in the Royal Gazette on 12 November 2020.

Project Activities

Project activities include building spaces, equipment and systems of the buildings under project scope that consume electricity and fuel as the energy source.

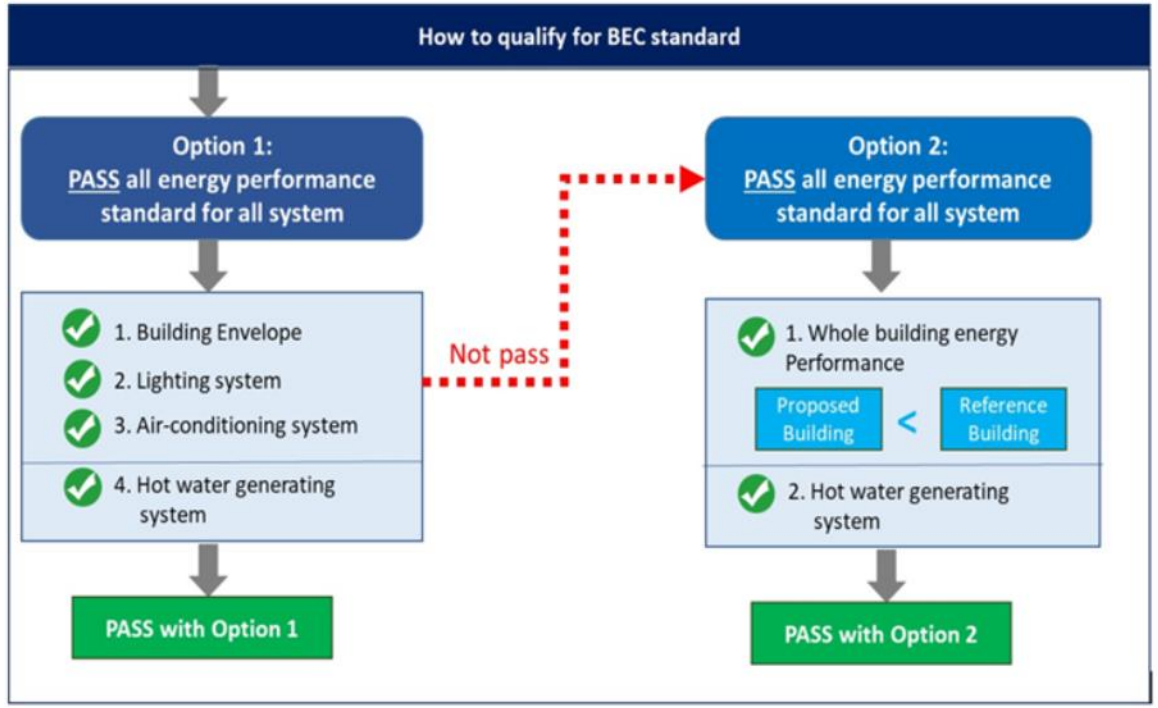
BEC requirements prescribe the energy efficiency criteria of building materials, equipment and system in the building design, which aims to be installed to reduce energy and GHG emissions from the operation of the buildings.



Scenario	GHG Emission Source	Type of GHG	GHG Emission Activities
Baseline	Grid electricity	CO_2	New or retrofitted building with common design consumes electricity from the grid.
Baseline	Fuel	CO_2	New or retrofitted building (mainly hotels and hospitals) consumes fuel in hot water generation system.
Project Activities	Grid electricity	CO_2	New or retrofitted BEC compliant building consumes electricity from the grid.
Project Activities	Fuel	CO_2	New or retrofitted BEC compliant building (mainly hotels and hospitals) consumes fuel in hot water generation system.
Out of project boundary	None	None	None.

BEC Components & Performance Indicators

BEC Component	Indicator	Unit
1. Building Envelope		
▪ Walls (incl. opaque & transparent)	OTTV	W/m^2
▪ Roof	RTTV	W/m^2
2. Lighting System	LPD	W/m^2
3. Air Conditioning System		
▪ Split-type air conditioners	SEER	Btu/h-W
▪ Packaged and central air conditioners	CHP	kW/RT
▪ Absorption chillers	COP	RT/RT
4. Hot Water Generation System		
▪ Fuel-based hot water boilers	Eff	%
▪ Heat pump hot water boilers	COP	RT/RT
5. Renewable Energy Utilization	Output	kWh
6. Whole Building Energy Performance	EUI	kWh/m^2



- BEC requirements are electricity focus assuming electricity is the major energy source of the building.
- All BEC components relate to **saving grid electricity**, except fuel-based hot water boiler in component 4.
- Component 4 is treated as an independent criterion.
- For 10-year database, no building fail to comply with component 4.

Energy Consumption & Activity Data

Energy Consumption & Building Operation Data

Data	As-built	As-operated	Source
Energy Consumption			
Electricity consumption (kWh)		✓ (monthly)	Metering / electricity bills
Fuel consumption (MJ)		✓ (monthly)	Fuel purchase / metering (if any)
Building Areas			
Total floor areas (m^2)	✓	✓	Design / as-built documents
Air conditioned areas (m^2)	✓	✓	Design / as-built documents
Non-air conditioned areas (m^2)	✓	✓	Design / as-built documents
Area functions (m^2)	✓	✓	Design / as-built documents
Area operating hours (h)		✓	Operation management / estimation
Building Utilization			
Area occupancy (%)		✓ (monthly)	Operation management / rental contract
Occupants (person-day)		✓ (monthly)	Operation transaction / estimation

Energy Consumption & Activity Data

Building System Energy Consumption & Operation Data

Data	As-built	As-operated	Source
Lighting System			
Lighting inventory (items)	✓	✓	Design / as-built documents
Lighting installed capacity (kW)	✓	✓	Design / as-built documents
Lighting efficiency (lm/W)	✓	✓	Design / as-built documents
Lighting power consumption (kW)		✓	Estimation
Lighting utilization (%)		✓	Operation management / estimation
Lighting operating hours (h)		✓	Operation management / estimation
Air Conditioning System			
Air conditioning inventory (items)	✓	✓	Design / as-built documents
Air conditioning installed capacity (RT, kW)	✓	✓	Design / as-built documents
Air conditioning power consumption (kW)		✓	Estimation / metering (if any)
Air conditioning utilization (%)		✓	Operation management / estimation / metering (if any)
Air conditioning operating hours (h)		✓	Operation management / estimation / metering (if any)

Energy Consumption & Activity Data

Building System Energy Consumption & Operation Data

Data	As-built	As-operated	Source
Hot Water Generation System			
Hot water generation inventory (items)	✓	✓	Design / as-built documents
Hot water generation installed capacity (MJ/h)	✓	✓	Design / as-built documents
Hot water generation fuel consumption (MJ/h)		✓	Estimation / metering (if any)
Hot water generation utilization (%)		✓	Operation management / estimation / metering (if any)
Hot water generation operating hours (h)		✓	Operation management / estimation / metering (if any)
Other electricity consuming equipment & system			
Equipment inventory (items)		✓	Specification / estimation
Equipment installed capacity (kW)		✓	Specification / estimation
Equipment power consumption (kW)		✓	Specification / estimation
Equipment utilization (%)		✓	Operation management / estimation
Equipment operating hours (h)		✓	Operation management / estimation
Renewable Energy Generation System			
Solar PV installed capacity (kW)	✓	✓	Design / as-built documents
Solar PV electricity generation (kWh)	✓	✓	Metering

Energy Consumption & Project Activity Data

Designated BEC Buildings

- The designated building is mandated by ENCON act to submit an **energy management report on an annual basis**.
- This report contains almost all the data required for the GHG calculation but **not reported in terms of GHG inventory** or emission reduction data.
- Further calculation is required for **conversion and aggregation** of energy consumption to GHG emission reduction.

Non-designated BEC Buildings

- Unlike the designated building, non-designated BEC buildings have **no process or reporting system**.
- **Energy consumption and basic project activity data** i.e. space occupancy, area allocation, number of occupants, operating hours are normally available.
- **The new reporting system is required** for data collection and reporting on an annual basis.

Proposed MRV for BEC

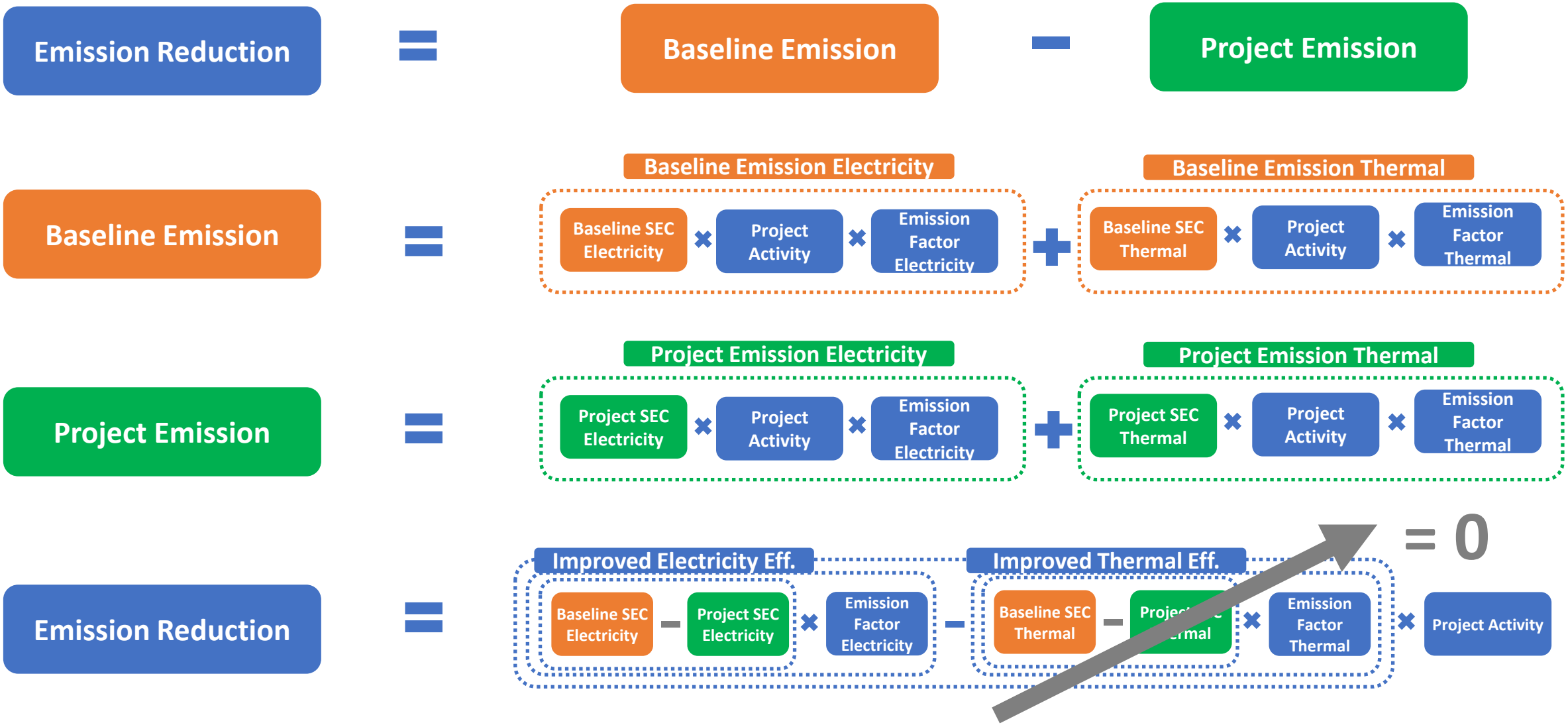
BEC assessment program is not recommended for MRV

- BEC assessment program is designed for **design benchmarking purpose**. Building energy consumptions are roughly estimated assuming **fixed parameters** for the whole building types (sub sector), categorized in three groups of 8, 12 and 24 daily operating hours.
- The calculation assumes **fixed loads and operating hours** on electricity consuming equipment. Area occupancies are fixed.
- The calculation result is **one-time based on designed building envelope, building equipment and system**. No operation factor is taken into consideration.

GHG emission reduction calculation methodology

- Adopt **specific energy consumption (SEC) approach** for establish energy performance baseline for building sub-sector.
- The SEC approach allows **dynamic adjustment** of building usage areas and activities over time.
- Using **commonly available energy consumption and activity data** for calculation.
- Different SEC formula and activity data for each building sub-sector.
- **Neglect fuel improvement impact** on GHG emission due to low portion of fuel energy consumption to building energy consumption and low impact of BEC component 4 on the fuel efficiency improvement.

Calculation of GHG Emission Reduction



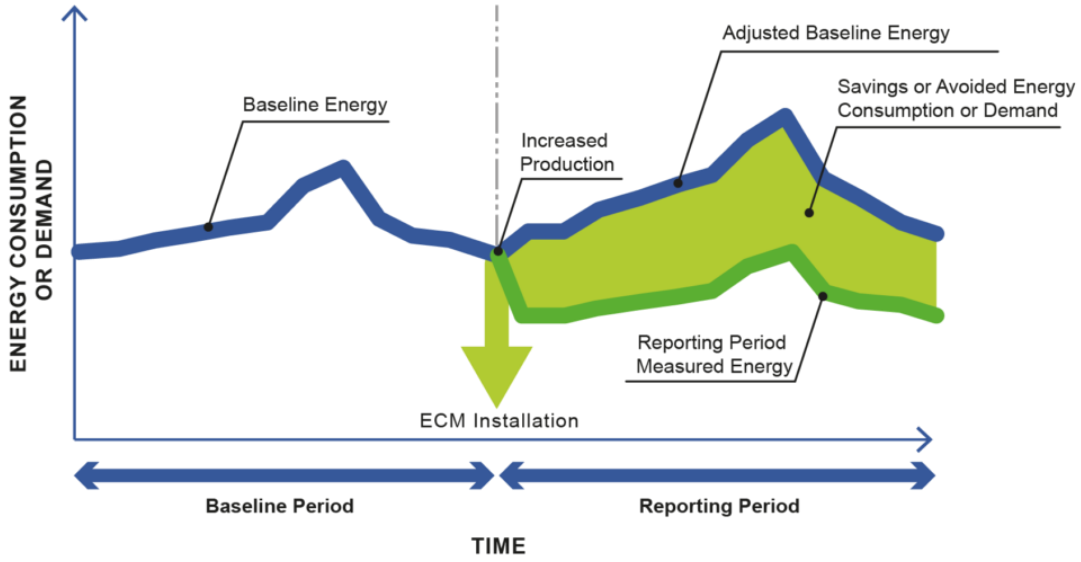
Calculation of GHG Emission Reduction

Options for SEC & Project Activities

DEDE study of building sectoral SEC.

- Office (2007)
- Commercial store (2007)
- Hotel (2005)
- Hospital (2007)

TGO Study of SEC of Designated Factories & Buildings, 2018
Covering in 11 sectors including office, department store, hotel, hospital.



- Assume SECs at BEC baseline (year 2009) are similar to SEC from the sectoral study. No GHG emission reduction claimed between 2005 (NDC base year) and 2009 (BEC base year).
- Consider CO_2 as the main GHG emission.

Emission factor for the year of activity

- Use Thailand Grid Emission Factor for GHG Reduction Project/Activity, announced by TGO (latest Sep. 28, 2017)
  $EF_{Grid,y}$ = 0.5664 tCO_2/MWh
- Use default transmission loss of 3%.

DEDE Study on SEC of Building Sectors

(Recommended Option)

SEC of Office Buildings

	Category	No. of samples	Value	Unit	R^2
Baseline SEC		**20**	**209.90**	**kWh/m²-y**	**0.84**
By physical shape	Group 1: 2000 m² < area < 10,000 m², height >= 23 m	5	215.80		0.86
	Group 2: area >10,000 m², height < 23 m	5	199.90		0.91
	Group 3: area >=10,000 m², height >= 23 m	10	218.50		0.84

SEC @ activity year (kWh/m²-y)

$$SEC = \frac{total\ energy\ consumption\ per\ year\ (kWh/y)}{\%\ occupancy \times usable\ area\ (m^2)}$$

Energy consumption data

- Energy consumption per year (kWh/y)

Activity Data

- Category: floor area (m²), building height (m)
- Area occupancy (% of usable floor area)
- Usable floor area (m²)

Source: Study of SEC of Office Buildings, DEDE, 2007

SEC of Commercial Store Buildings

	Category	No. of samples	Value	Unit	R^2
Baseline SEC					-
By type	Department store	169	240.6	kWh/m^2-y	
	Discount store	294	336.4	kWh/m^2-y	
	Shopping plaza	91	204.2	kWh/m^2-y	
	Supermarket	3	418.4	kWh/m^2-y	

SEC @ activity year (kWh/m^2-y)

$$SEC = \frac{total\ energy\ consumption\ per\ year\ (kWh/y)}{usable\ area\ excl.parking\ (m^2)}$$

Energy consumption data

- Energy consumption per year (kWh/y)

Activity Data

- Type: of commercial store
- Usable floor area (m^2)

Source: Study of SEC of Commercial Store Buildings, DEDE, 2007

SEC of Hotel Buildings

	SEC Equation	Unit	R^2
Baseline SEC			
SEC by usable area	SEC1 = -0.2719 group^2 + 23.342 group + 2.2582	MJ/m^2-month	0.9728

SEC @ activity year (MJ/m^2-month)

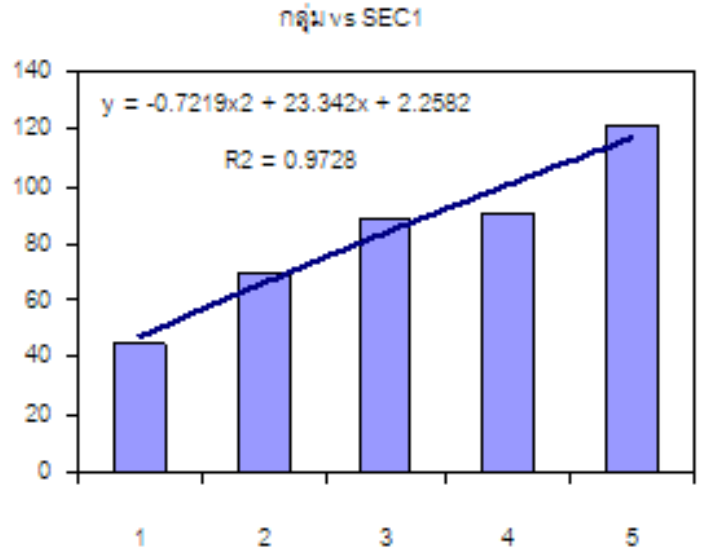
$$SEC = \frac{total\ energy\ consumption\ per\ month\ (MJ/month)}{actual\ usable\ area\ (m^2)}$$

Energy consumption data

- Energy consumption per year (MJ/month)

Activity Data

- Actual usable area (m^2)
- Number of guest rooms (rooms)
- Area of dining and restaurant (m^2)
- Area of catering and meeting rooms (m^2)
- Area of fitness, entertainment and central services (m^2)
- Area of swimming pool (m^2)
- Area of office and retail stores (m^2)
- Laundry operation (kg/month)



Source: Study of SEC of Hotel Buildings, DEDE, 2005

SEC of Hotel Buildings

Hotel categories

- Apply weighted scoring of seven operational services to group the hotels into five groups.

Operational Services/Score	1	2	3	4	5
1. Number of guest rooms (rooms)	1-100	101-200	201-300	301-600	>600
2. Area of dining and restaurant (m^2)	1-100	101-200	201-300	301-500	>500
3. Area of catering and meeting rooms (m^2)	1-100	101-200	201-300	301-500	>500
4. Area of fitness, entertainment and central services (m^2)	1-100	101-200	201-300	301-500	>500
5. Area of swimming pool (m^2)	1-100	101-200	201-300	301-500	>500
6. Area of office and retail stores (m^2)	1-100	101-200	201-300	301-500	>500
7. Laundry operation (kg/month)	1-5,000	5,001-10,000	10,001-20,000	20,001-40,000	>40,000

Operational Services	Score	Weighting
1. Number of guest rooms (rooms)	1 – 5	42.33
2. Area of dining and restaurant (m^2)	1 – 5	5.30
3. Area of catering and meeting rooms (m^2)	1 – 5	7.25
4. Area of fitness, entertainment and central services (m^2)	1 – 5	21.93
5. Area of swimming pool (m^2)	1 – 5	0.79
6. Area of office and retail stores (m^2)	1 – 5	3.91
7. Laundry operation (kg/month)	1 – 5	18.49

$$Overall\ score\ (\%) = \sum_{i=1}^{7} [service\ score_i \times weight_i\ ] \times 100/500$$

Overall Score (%)	Group
0.00% – 38.40%	1
>38.40% – 58.67%	2
>58.67% – 78.93%%	3
>78.93% – 99.19%	4
>99.19 – 100.00%	5

Source: Study of SEC of Hotel Buildings, DEDE, 2005

SEC of Hospital Buildings

	SEC Equation	Unit	R^2
Baseline SEC			
Government hospitals	SEC = (701.64 x AC m^2/bed-day) + 52.032	MJ/bed-day	0.9308
Private hospitals	SEC = (498.17 x AC m^2/bed-day) + 179.74	MJ/bed-day	0.8575

SEC @ activity year (MJ/bed-day)

SEC total energy consumption (MJ/bed-day)

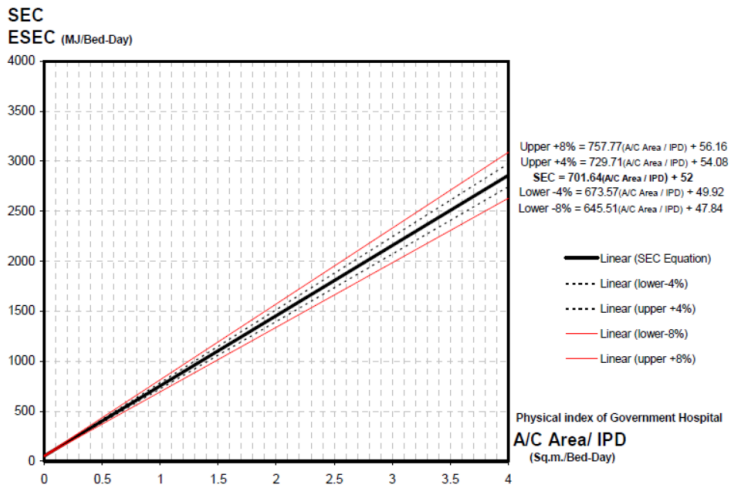
$$SEC = \frac{total\ energy\ consumption\ per\ year\ (MJ/y)}{number\ of\ IPD\ per\ year\ (bed-day/y)}$$

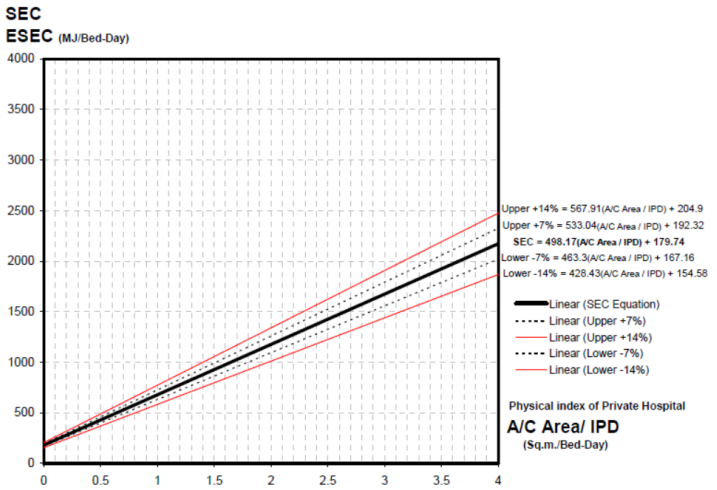
Energy consumption data

- Energy consumption per year (MJ/year)

Activity Data

- Type: government or private
- Number of IPD (bed-day/year)
- Air conditioning area (m^2)





Source: Study of SEC of Hospital Buildings, DEDE, 2007

TGO Study on SEC of Designated Building Sectors (Alternative Option)

Project Activity Data

อาคารสำนักงาน	อาคารโรงพยาบาล
1. พื้นที่สำนักงานทั่วไปที่ใช้งาน <12 ชม.ต่อวัน 2. พื้นที่สำนักงานทั่วไปที่ใช้งาน 12-18 ชม.ต่อวัน 3. พื้นที่สำนักงานทั่วไปที่ใช้งานมากกว่า 18 ชม.ต่อวัน 4. พื้นที่ร้านค้า 5. พื้นที่ส่วนกลาง 6. พื้นที่ไม่ปรับอากาศ 7. จำนวนพนักงานทั้งหมด 8. พื้นที่จอดรถในอาคาร	1. พื้นที่สำหรับผู้ป่วยนอก 2. พื้นที่สำหรับผู้ป่วยใน 3. พื้นที่ส่วนกลาง 4. พื้นที่ร้านค้า 5. พื้นที่ไม่ปรับอากาศ 6. พื้นที่จอดรถในอาคาร 7. จำนวนผู้ป่วยนอก 8. จำนวนผู้ป่วยใน 9. จำนวนบุคลากรทั้งหมด
อาคารโรงแรม	**อาคารศูนย์การค้า**
1. พื้นที่ห้องพักทั้งหมด 2. พื้นที่สำหรับการจัดเลี้ยง 3. พื้นที่ร้านอาหาร 4. พื้นที่สำนักงาน 5. พื้นที่สันทนาการ 6. พื้นที่ไม่ปรับอากาศ 7. พื้นที่จอดรถในอาคาร 8. จำนวนบุคลากรทั้งหมด	1. พื้นที่ปรับอากาศทั่วไป 2. พื้นที่โรงภาพยนตร์ 3. พื้นที่จัดงานที่ไม่เปิดประจำ 4. พื้นที่ไม่ปรับอากาศ 5. พื้นที่จอดรถในอาคาร

Source: Study of SEC of Designated Factories & Buildings, TGO, 2018

SEC of Office Buildings

อาคารสำนักงาน

สำนักงาน ขนาดหม้อแปลง ≤ 3,530 kVA (กลุ่ม 1) - ภาคราชการ	สำนักงาน ขนาดหม้อแปลง ≤ 3,530 kVA (กลุ่ม 1) - ภาคเอกชน
ปริมาณการใช้พลังงานไฟฟ้า (kWh) = 0.001 x พื้นที่สำนักงาน (< 12 ชม./วัน) x อัตราการใช้พื้นที่เฉลี่ย x 12 x 250 + 0.013 x พื้นที่สำนักงาน (12-18 ชม./วัน) x อัตราการใช้พื้นที่เฉลี่ย x 18 x 250 + 0.212 x พื้นที่สำนักงาน (> 18 ชม./วัน) x อัตราการใช้พื้นที่เฉลี่ย x 24 x 365 + 0.279 x พื้นที่ร้านค้า x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 0.143 x พื้นที่ส่วนกลาง x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 30.784 x พื้นที่ไม่ปรับอากาศ + 122.624 x พื้นที่จอดรถในอาคาร + 844.865 x จำนวนพนักงาน	ปริมาณการใช้พลังงานไฟฟ้า (kWh) = 0.028 x พื้นที่สำนักงาน (< 12 ชม./วัน) x อัตราการใช้พื้นที่เฉลี่ย x 12 x 250 + 0.016 x พื้นที่สำนักงาน (12-18 ชม./วัน) x อัตราการใช้พื้นที่เฉลี่ย x 18 x 250 + 0.022 x พื้นที่สำนักงาน (> 18 ชม./วัน) x อัตราการใช้พื้นที่เฉลี่ย x 24 x 365 + 0.213 x พื้นที่ร้านค้า x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 0.019 x พื้นที่ส่วนกลาง x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 63.278 x พื้นที่ไม่ปรับอากาศ + 11.429 x พื้นที่จอดรถในอาคาร + 1,668.104 x จำนวนพนักงาน
สำนักงาน ขนาดหม้อแปลง > 3,530 kVA (กลุ่ม 2) - ภาคราชการ	**สำนักงาน ขนาดหม้อแปลง > 3,530 kVA (กลุ่ม 2) - ภาคเอกชน**
ปริมาณการใช้พลังงานไฟฟ้า (kWh) = 0.035 x พื้นที่สำนักงาน (< 12 ชม./วัน) x อัตราการใช้พื้นที่เฉลี่ย x 12 x 250 + 0.033 x พื้นที่สำนักงาน (12-18 ชม./วัน) x อัตราการใช้พื้นที่เฉลี่ย x 18 x 250 + 0.138 x พื้นที่สำนักงาน (> 18 ชม./วัน) x อัตราการใช้พื้นที่เฉลี่ย x 24 x 365 + 0.390 x [(พื้นที่ร้านค้า x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย) + (พื้นที่ส่วนกลาง x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย)] + 0.391 x (พื้นที่ไม่ปรับอากาศ + พื้นที่จอดรถในอาคาร) + 1,198.492 x จำนวนพนักงาน	ปริมาณการใช้พลังงานไฟฟ้า (kWh) = 0.028 x พื้นที่สำนักงาน (< 12 ชม./วัน) x อัตราการใช้พื้นที่เฉลี่ย x 12 x 250 + 0.02 x พื้นที่สำนักงาน (12-18 ชม./วัน) x อัตราการใช้พื้นที่เฉลี่ย x 18 x 250 + 0.000272 x พื้นที่สำนักงาน (> 18 ชม./วัน) x อัตราการใช้พื้นที่เฉลี่ย x 24 x 365 + 0.017 x พื้นที่ร้านค้า x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 0.042 x พื้นที่ส่วนกลาง x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 61.806 x พื้นที่ไม่ปรับอากาศ + 160.599 x พื้นที่จอดรถในอาคาร + 698.93 x จำนวนพนักงาน

Source: Study of SEC of Designated Factories & Buildings, TGO, 2018

SEC of Department Stores

สมการพลังงาน กลุ่มอาคารประเภทศูนย์การค้า	
ศูนย์การค้า ขนาดหม้อแปลงน้อยกว่า 3,530 kVA (กลุ่ม 1) ศูนย์การค้า	ศูนย์การค้า ขนาดหม้อแปลงน้อยกว่า 3,530 kVA (กลุ่ม 1) ดิสเคาท์สโตร์
ปริมาณพลังงานไฟฟ้า (kWh) = 30.878 x พื้นที่ไม่ปรับอากาศ + 47.121 x พื้นที่จอดรถในอาคาร + 0.061 x พื้นที่ปรับอากาศทั่วไป x จำนวนชั่วโมงการใช้งาน + 0.021 x พื้นที่โรงภาพยนตร์ x จำนวนชั่วโมงการใช้งาน	ปริมาณพลังงานไฟฟ้า (kWh) = 84.746 x พื้นที่ไม่ปรับอากาศ + 15.422 x พื้นที่จอดรถในอาคาร + 0.062 x พื้นที่ปรับอากาศทั่วไป x จำนวนชั่วโมงการใช้งาน + 0.023 x พื้นที่โรงภาพยนตร์ x จำนวนชั่วโมงการใช้งาน
ศูนย์การค้า ขนาดหม้อแปลงมากกว่า 3,530 kVA (กลุ่ม 2) ศูนย์การค้า	ศูนย์การค้า ขนาดหม้อแปลงมากกว่า 3,530 kVA (กลุ่ม 2) ดิสเคาท์สโตร์
ปริมาณพลังงานไฟฟ้า (kWh) = 110.308 x พื้นที่ไม่ปรับอากาศทั่วไป + 4.342 x พื้นที่จอดรถในอาคาร + 0.064 x พื้นที่ปรับอากาศทั่วไป x จำนวนชั่วโมงการใช้งาน + 0.129 x พื้นที่โรงภาพยนตร์ x จำนวนชั่วโมงการใช้งาน + 0.062 x พื้นที่ไม่เปิดประจำ x จำนวนชั่วโมงการใช้งาน	ปริมาณพลังงานไฟฟ้า (kWh) = 38.334 x พื้นที่ไม่ปรับอากาศ + 40.097 x พื้นที่จอดรถในอาคาร + 0.068 x พื้นที่ปรับอากาศทั่วไป x จำนวนชั่วโมงการใช้งาน

Source: Study of SEC of Designated Factories & Buildings, TGO, 2018

SEC of Hotel Buildings

สมการพลังงาน กลุ่มอาคารประเภทโรงแรม

โรงแรม ขนาดหม้อแปลง ≤ 3,530 kVA (กลุ่ม 1) พื้นที่ใช้สอยน้อยกว่า 20,000 ตารางเมตร	โรงแรม ขนาดหม้อแปลง ≤ 3,530 kVA (กลุ่ม 1) พื้นที่ใช้สอยมากกว่าหรือเท่ากับ 20,000 ตารางเมตร
ปริมาณการใช้พลังงานไฟฟ้า (kWh) = 2.124×10^{-5} x พื้นที่ห้องพักทั้งหมด x ชั่วโมงการใช้งาน (16 x 365) x อัตราการเข้าพัก + 0.14 x พื้นที่สำหรับการจัดเลี้ยง x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 0.018 x พื้นที่สำนักงาน x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 0.101 x พื้นที่ร้านอาหาร x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 0.004 x พื้นที่สันทนาการ x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 85.679 x พื้นที่ไม่ปรับอากาศ + 330.331 x พื้นที่จอดรถในอาคาร + 7,398.014 x จำนวนพนักงาน	ปริมาณการใช้พลังงานไฟฟ้า (kWh) = 0.011 x พื้นที่ห้องพักทั้งหมด x ชั่วโมงการใช้งาน (16 x 365) x อัตราการเข้าพัก + 0.005 x พื้นที่สำหรับการจัดเลี้ยง x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 0.025 x พื้นที่สำนักงาน x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 0.045 x พื้นที่ร้านอาหาร x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 0.027 x พื้นที่สันทนาการ x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 121.07 x พื้นที่ไม่ปรับอากาศ + 149.41 x พื้นที่จอดรถในอาคาร + 5,687.94 x จำนวนพนักงาน
โรงแรม ขนาดหม้อแปลง > 3,530 kVA (กลุ่ม 2) - พื้นที่ใช้สอยน้อยกว่าและมากกว่า 20,000 ตารางเมตร	
ปริมาณการใช้พลังงานไฟฟ้า (kWh) = 0.016 x พื้นที่ห้องพักทั้งหมด x ชั่วโมงการใช้งาน (16 x 365) x อัตราการเข้าพัก + 0.054 x พื้นที่สำหรับการจัดเลี้ยง x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 0.006 x พื้นที่สำนักงาน x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 0.122 x พื้นที่ร้านอาหาร x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 0.066 x พื้นที่สันทนาการ x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 52.932 x พื้นที่ไม่ปรับอากาศ + 28.521 x พื้นที่จอดรถในอาคาร + 10,162.943 x จำนวนพนักงาน	

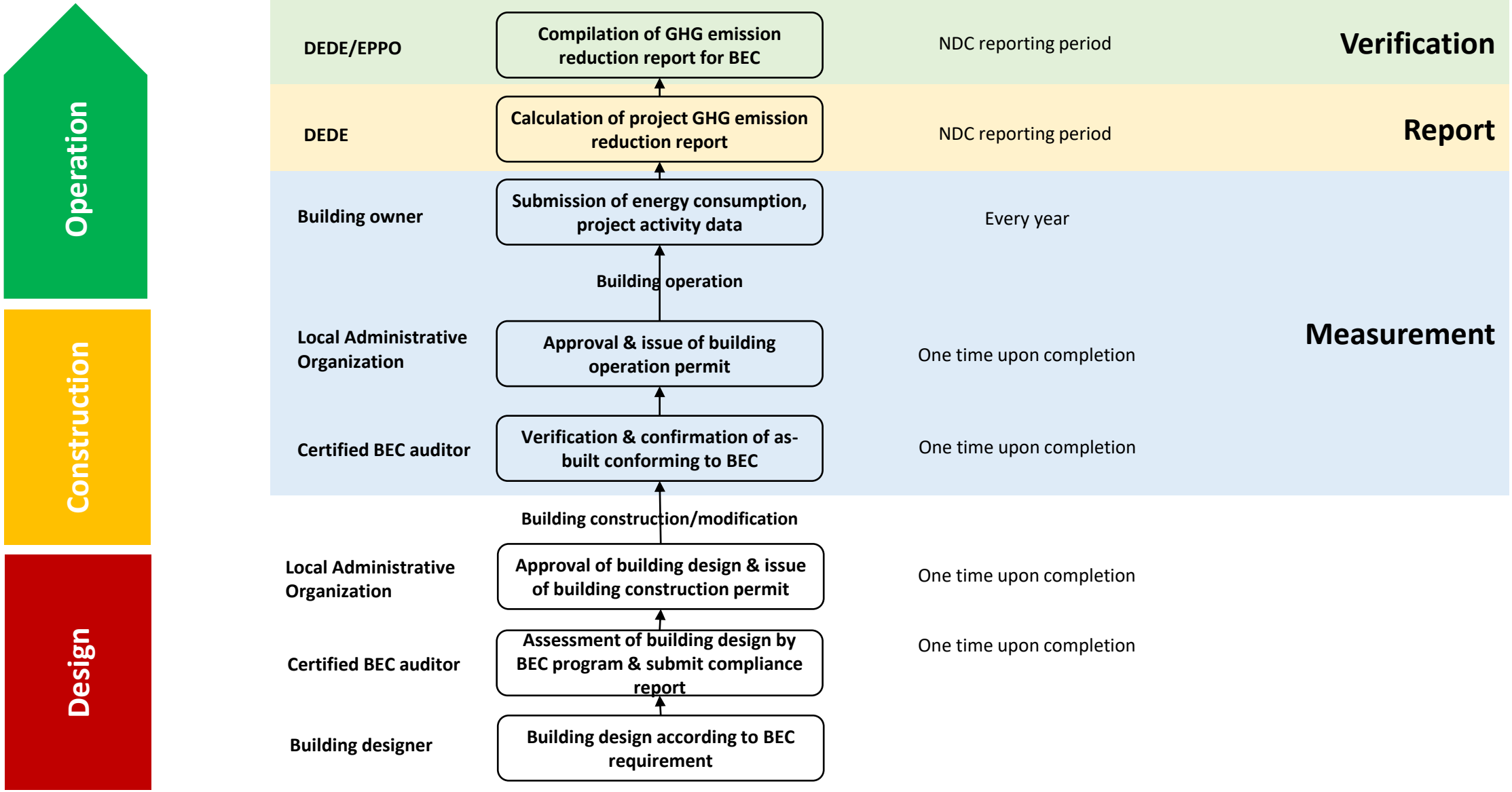
Source: Study of SEC of Designated Factories & Buildings, TGO, 2018

SEC of Hospital Buildings

อาคารโรงพยาบาล
โรงพยาบาล ขนาดหม้อแปลงทุกขนาด (กลุ่ม 1 และ กลุ่ม 2) - ภาคราชการ
ปริมาณการใช้พลังงานไฟฟ้า (kWh) = 0.001 x ([พื้นที่สำหรับผู้ป่วยนอก x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย] + [พื้นที่สำหรับผู้ป่วยใน x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย]) + 0.00018 x ([พื้นที่ส่วนกลาง x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย] + [พื้นที่ร้านค้า x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย]) + 96.897 x (พื้นที่ไม่ปรับอากาศ + พื้นที่จอดรถในอาคาร) + 5.624 x จำนวนผู้ป่วยนอกต่อปี + 0.169 x จำนวนผู้ป่วยในต่อปี + 823.883 x จำนวนบุคลากรทั้งหมด
โรงพยาบาล ขนาดหม้อแปลงทุกขนาด (กลุ่ม 1 และ กลุ่ม 2) - ภาคเอกชน
ปริมาณการใช้พลังงานไฟฟ้า (kWh) = 0.019 x พื้นที่สำหรับผู้ป่วยนอก x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 0.002 x พื้นที่สำหรับผู้ป่วยใน x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 0.0003 x พื้นที่ส่วนกลาง x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 0.308 x พื้นที่ร้านค้า x ชั่วโมงการใช้งาน x อัตราการใช้พื้นที่เฉลี่ย + 35.795 x พื้นที่จอดรถในอาคาร + 27.145 x พื้นที่ไม่ปรับอากาศ + 1.270 x (จำนวนผู้ป่วยนอกต่อปี + จำนวนผู้ป่วยในต่อปี) + 3,393.989 x จำนวนบุคลากรทั้งหมด

Source: Study of SEC of Designated Factories & Buildings, TGO, 2018

Proposed Monitoring Plan for MRV



Recommendation for the Proposed MRV

Development of data collection & reporting system

- Database system for data collection and aggregation of BEC energy consumption and building operation from different BEC building types.
- Integration of data from the energy management reports of the designated BEC buildings to the BEC database.
- New reporting system for the non-designated BEC buildings to submit on an annual basis.
- BEC audit after construction completion could designed for collection of building activity data and establishment of reporting structure.
- Verification process and update of emission factor for GHG emission inventory and GHG emission reduction.

MRV for subsectors with no existing SEC

Condominium

- Condominium cannot be covered by any available methodology. The energy accounts are distributed and owned by each residential units.
- Occupancy and energy consumption characteristics are scattered.
- Collective metering with modern IoT energy monitoring systems are possible but are still very costly with lots of data to manage.
- Condominium contributes to only 7% of energy consumption of the building sector.

Other BEC buildings

- Require similar SEC study to establish baseline and calculation of GHG emission reduction.