

Application of the ICAT Buildings Efficiency Guidance in Indonesia



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Application of the ICAT Buildings Efficiency Guidance in Indonesia

Deliverable #2

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Executive Summary

Buildings contribute significantly to global greenhouse gas (GHG) emissions, both directly through operational energy consumption and indirectly through material production and construction processes. Improving building efficiency is a crucial mitigation strategy to reduce emissions while enhancing energy security and cost savings. Many countries, including Indonesia, are implementing policies and regulations to drive energy efficiency improvements in new and existing buildings to reduce GHG emissions.

As outlined in the enhanced Nationally Determined Contribution, Indonesia is committed to mitigating climate change by reducing GHG emissions up to 31.89% and 43.20% with international support by 2030. Aligning with the commitment, the government of Indonesia, through the Ministry of Public Works (MPW), has implemented the Minister of Public Works Regulation No. 21/2021 on Green Building Requirements. This regulation demonstrates the government's goodwill in aiding the nationwide endeavour to increase building efficiency, to conserve energy, and reduce GHG emissions across different building, residential, and regional scales.

This ICAT-supported study seeks to assess the impact of the Green Building regulation of MPW Regulation No. 21/2021 on GHG emissions using a standardized methodology, namely building efficiency guidance developed by the Initiative for Climate Action Transparency (ICAT). The regulation assessed outlines the categories of new as well as existing buildings' mandatory and recommended requirements to be fulfilled for green buildings. The criteria for green buildings comprise various parameters; however, in this assessment, it focuses on energy efficiency and renewable energy uses. Alongside this regulation, MPW issued a green building roadmap in 2023, which outlines the strategies to achieve the green building development target. In the roadmap, MPW estimated that approximately 37 MtCO₂ reduction can be achieved by the year 2030 through capacity building and implementation of green building policy.

The calculation of baseline GHG emissions for residential, governmental, and commercial buildings in Indonesia uses 2021 as the reference year. The methodology, which follows ICAT guidance, incorporates building population data, floor area, energy use, and emissions factors. Baseline emissions are projected from 2021 to 2024 utilizing the building's construction and demolition rates. From the baseline data above, several improvements on the building model are introduced and simulated with several cases of various parameters. The simulation resulted in energy use intensity improvements of residential, government, and commercial buildings up to 47%, 68% and 58%, respectively. Implementing those improvements, the Ex-Ante scenario of GHG emission, the total emission is **137 MtCO₂**, a reduction of **271 MtCO₂** compared to the baseline emissions by the end of 2030.

Ex-Post emissions are calculated based on the following data:

- By 2021 and 2022, there are two government buildings that implement the Green Building.
- In 2023, 595 residential buildings are implementing Green Building, followed by one government building and one commercial building.
- Finally, in 2024, there are 578 residential buildings that implement green building implementation, and 16 government buildings also implement it.

The Ex-Post GHG emission is calculated to be stagnant from 2022 to 2024, indicating that the emission reduction from the number of buildings implementing the green building policy remained low and only sufficient to compensate for emissions from the construction rate of new buildings. This demonstrates that the period from 2022 to 2024 was still an adjustment period, with green building certification beginning in 2025 on old buildings, including government, commercial, and residential buildings.

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Abbreviation

ASEAN	Association of Southeast Asian Nations
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BAU	Business as usual
BGH	Bangunan Gedung Hijau (Green Building)
BPS	Indonesia Statistical Bureau
Bappenas	National Development Planning Agency / Ministry of National Development Planning
CLASP	Collaborative Labelling and Appliance Standards Program
CM1	Counter Measure 1 (unconditional mitigation scenario)
CM2	Counter Measure 2 (conditional mitigation scenario)
COP	Coefficient of Performance (for Air Conditioner)
EF	Emission Factor
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
EUI	Energy Use Intensity
GBCI	Green Building Council Indonesia
GBH	Green Building and Housing
GDP	Gross domestic product
GoI	Government of Indonesia
GHG	Greenhouse gas
GWh	Gigawatt-hour
GWP	Global warming potential
HVAC	Heat, Ventilation, and Air Conditioning
ICAT	Initiative for Climate Action Transparency
km	Kilometre
kWh	Kilowatt-hour
LPG	Liquified Petroleum Gas
LTS-LCCR	Long-Term Strategy for Low Carbon and Climate Resilience
LSP	Indonesia Professional Certification Agency
MA	Ministry of Agriculture
MCI	Ministry of Communication and Information
MEF	Ministry of Environment and Forestry
MEMR	Ministry of Energy and Mineral Resources
MEPS	Minimum energy performance standard
MMAF	Ministry of Marine Affairs and Fisheries
MOHA	Ministry of Home Affairs
Mol	Ministry of Industry
MoL	Ministry of Labor
MoT	Ministry of Trade
MoTrans	Ministry of Transportation
MtCO ₂	Million tons of carbon dioxide
MW	Megawatt
MPW	Ministry of Public Works
Nb	Number of Buildings

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NCAP	National Cooling Action Plan
NDC	Nationally Determined Contribution
NZE	Net Zero Emission
OTTV	Overall Thermal Transfer Value
PLN	Indonesia National Electricity Company
SDG	Sustainable Development Goal
SE	Share of Energy Carrier
SFH	Single-Family House
SNI	Indonesian National Standards
TR	Ton of refrigeration
ToT	Training of Trainers
UNEP	United Nations Environment Programme
UNOPS	United Nations Office for Project Services
VRF	Variable refrigerant flow
W/W	Cooling energy (watts) / electrical energy (watts)
WWR	Window to Wall Ratio

1. Introduction

Indonesia has committed to reducing its greenhouse gas (GHG) emissions while maintaining economic growth through the e-NDC (Enhanced Nationally Determined Contribution) in 2022. Indonesia has aimed to achieve 31,89% unconditionally and 43,20% with condition reduction in greenhouse gas emissions. As a serious step to achieve the e-NDC target, Indonesia has developed a Long-Term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR 2050), outlining broad pathways to mitigate emissions across the Indonesian economy, with a vision to achieve net-zero emissions by 2060 or sooner.

The ambitious goal of generating net zero emissions by 2060 or sooner is a component of Indonesia's larger economic objective of becoming an advanced economy by 2045, in accordance with the vision outlined in Visi Indonesia 2045. Despite the country's accomplishments, the road to the stated goal of the NZE remains long. By only focusing on economic development with business as usual, the GHG emissions in all sectors will increase, which is critical for the nation's sustainability, endangering Indonesia's future generation to environmental crisis. Thus, by following LTS-LCCR, Indonesia, through relevant ministries and national bodies, creates, monitors, reviews, and executes policies or programs in every sector to incorporate the decarbonization aspect in every business activity, including the building sector.

1.1 Background

Buildings are a critical component of urban infrastructure and play a significant role in energy consumption and carbon emissions. As Indonesia experiences rapid urbanization and economic growth, energy demand in the building sector continues to rise. Addressing building efficiency is essential for reducing greenhouse gas emissions, lowering energy costs, and improving overall sustainability. This section provides an overview of the challenges, policies, and opportunities related to building efficiency in Indonesia.

Buildings consume electricity to run their functions, energizing appliances, for heating/cooling, lighting, electronic equipment, etc. Thus, with the continuous development of buildings in Indonesia, the demand for electricity also keeps increasing. As shown in Figure 1, buildings, which are represented by household and commercial sectors, undergo increasing electricity consumption by approximately two (2) times between 2010 and 2023. The data in 2023 shows that around 60% of electricity is consumed by buildings, making it the sector that consumes the most electricity.

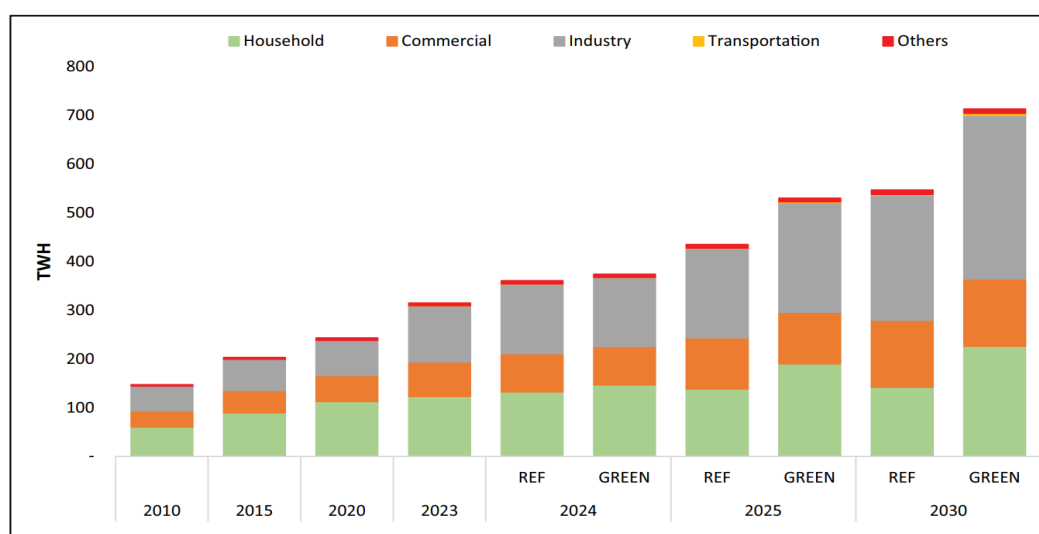


Figure 1. National electricity consumption by sector (IEC, 2024)

For the last decade, all building types have consumed more electricity, with the household, or residential sub-sector, as the biggest consumer, as shown in Figure 2. In 2022 alone, households consumed 68% of electricity, followed by commercial and government, each consuming 29% and 3% electricity, respectively (Figure 3). Based on these data, it can be concluded that buildings contribute significantly to increasing GHG emissions in Indonesia, since most of the electricity in the grid still comes from fossil-fuel-based power plants. Through e-NDC, energy efficiency measures and enhanced energy management practices are prioritized as top strategies for pursuing decarbonization in the building sector.

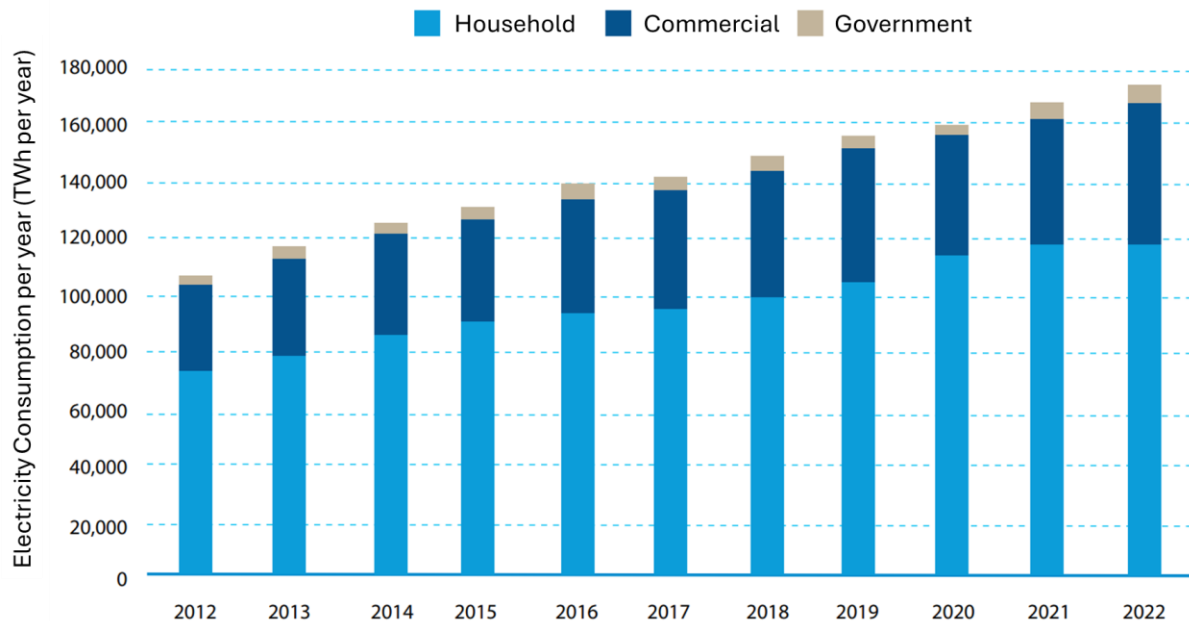


Figure 2. Total electricity consumption of all building types per year (MPW, 2023)

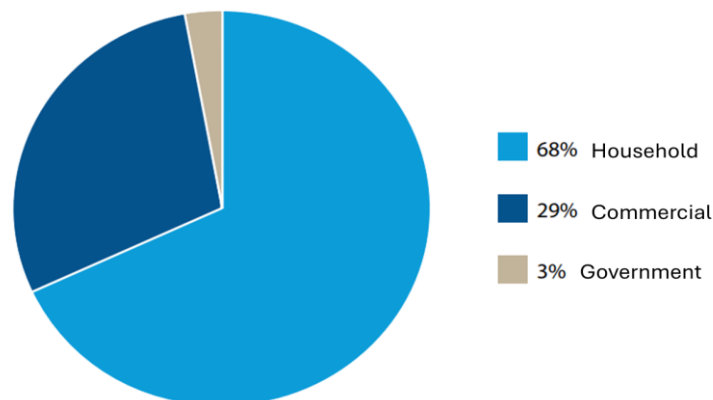


Figure 3. Distribution of electricity consumption in the building sector in 2022 (MPW, 2023)

**Note: Residential consists of household and apartment; the apartment in this project is included in the Commercial building, to align with ICAT Buildings Efficiency Guidance classification.*

For this project, the analyses will only focus on the building operational stage. In fact, improving building efficiency is a crucial mitigation strategy to reduce emissions while enhancing energy security and cost savings. On the other hand, since most electricity used for buildings is derived from fossil-fuel energy, implementation of renewable energy is also considered best practice in reducing buildings' GHG emissions. The most suitable option for Indonesia's geographical condition is to install rooftop Solar photovoltaic (Solar PV) on top of buildings. In fact, many

buildings, especially in metropolitan cities in Indonesia, have applied such measures, with support also coming from the government, through regulations. So, decarbonization in Indonesia's building sector can be achieved through energy efficiency (and energy management) measures and Rooftop Solar PV implementations.

As can be seen in Figure 4, it can be concluded that 90% of CO₂ emissions from building energy consumption originate from electricity use. This illustrates that electricity should be the primary focus of decarbonization intervention efforts in buildings. Although LPG accounts for nearly 50% of total energy demand in households, its CO₂ emissions tend to be relatively low compared to electricity consumption. Furthermore, in 2022, the total GHG emissions generated from building operations were 188 MtCO₂ (MPW, 2023).

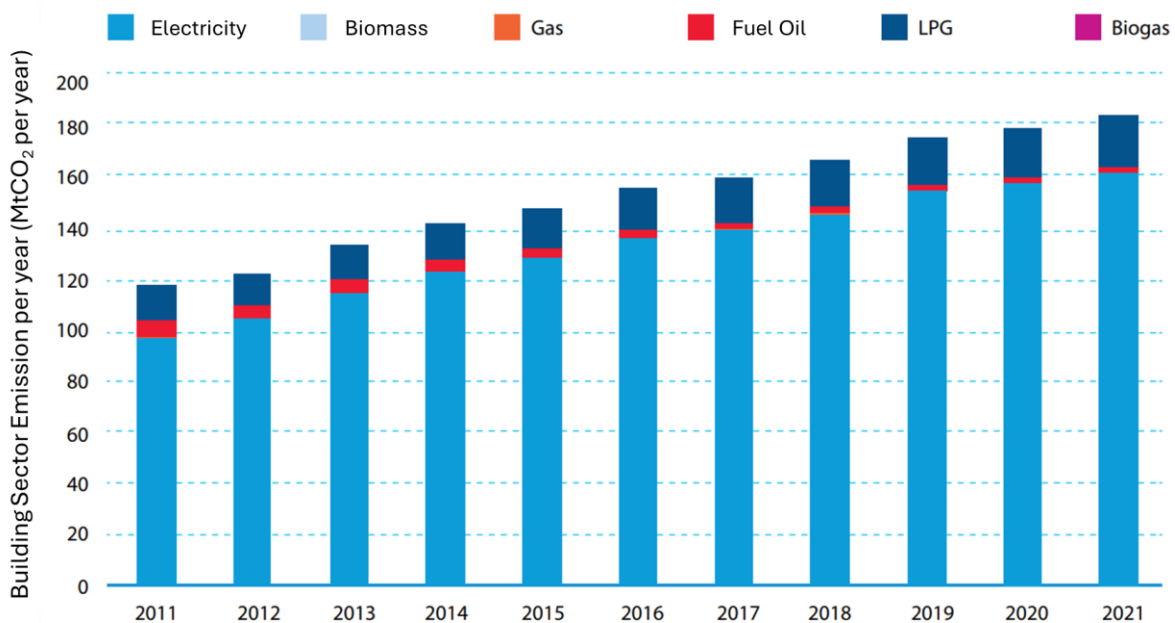


Figure 4. Building sector emission per year (MPW, 2023)

1.2 Objective

The primary objectives of this initiative are:

1. To support Indonesia's NDC and LTS-LCCR 2050 targets by implementing building efficiency measures.
2. To assess the impact of building efficiency policy in residential, government, and commercial buildings in Indonesia with ex-post and ex-ante scenarios.
3. To align building efficiency policies with international best practices, including ICAT Buildings Efficiency Guidance.
4. To facilitate knowledge sharing and best practices for sustainable building management in Indonesia.

1.3 Scope

This project focuses on the ex-ante and ex-post assessment of building efficiency measures in selected residential, government, and commercial buildings across Indonesia. The scope of the assessment includes several activities, as follows:

- Evaluate building energy performance using the criteria outlined in the building efficiency policy
- Utilize ICAT's Building Efficiency Methodology for assessing the policy impact
- Estimate GHG emissions reductions achieved through implemented energy efficiency and renewable energy transition measures.
- Provide recommendations for policy improvements and future building efficiency initiatives.

1.4 Stakeholders in building efficiency

The initiative to increase building efficiency and reduce emission impact in Indonesia will involve many stakeholders derived from multiple backgrounds, whose roles can influence the initiatives relevant to this project. Several stakeholders have been identified whose credibility and status may affect the project. They are listed in [Annex 1](#).

Stakeholders are identified in accordance with the ICAT Stakeholder Participation Assessment Guide, where all stakeholders are affected by and influence the project during the project works, as well as its completion. The stakeholder's identification is based on desk research, interviews, as well as discussions during research and consultancy projects related to renewable energy and building efficiency, as well as data availability and documents issued. Moreover, we also understand each stakeholder profile and characteristic related to the policies in terms of knowledge about the policies, relationship with the policies, policies' effect on them, ability to enhance or hinder the policies, mutual relationships and interests, expectations, willingness, and types of organization they are in. It is depicted in Figure 5.

The stakeholders are categorized based on their influence on the project and how the project will impact their organization.

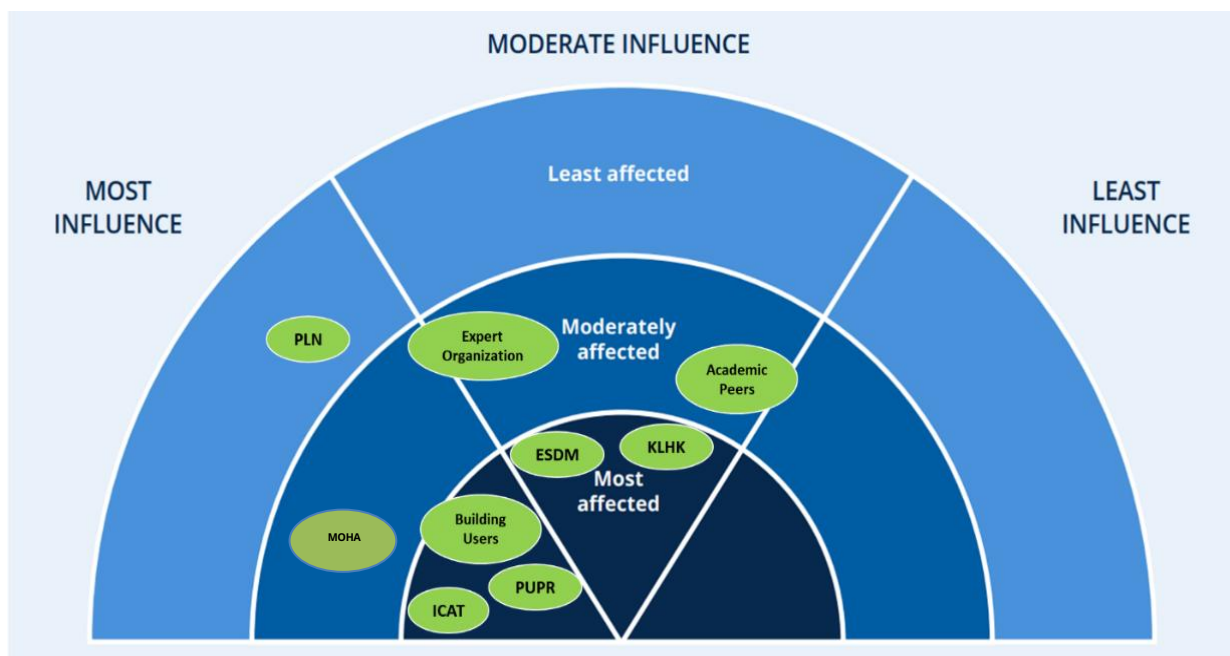


Figure 5. Stakeholder mapping of building efficiency policy

1. Key Stakeholders

a. Initiative for Climate Action Transparency (ICAT)

ICAT is the owner and the funder of this project, whose interests are to seek an organization (in this case, Universitas Indonesia or UI) to apply the ICAT series of

policy assessment guides in developing countries, and Indonesia is one of the representatives. This project aims to target the government of Indonesia (GoI) and its partners that are planning and implementing policies, and/or assessing their impacts in the context of developing and implementing their NDCs, national or subnational low-carbon strategies, nationally appropriate mitigation actions, and other mechanisms.

ICAT has a significant influence on this project, since most of the policy impact assessments will follow the guides developed by ICAT. Aside from the “formal” guidance from the assessment guide document, ICAT, as the project owner, will have authority to decide the requirements of the project, in which UI, represented by our team, will carry out each activity and develop deliverables as required.

The work and completion of this project significantly impact ICAT by providing feedback on the assessment guide as well as giving insights about the implementation of building efficiency in Indonesia, as one of the representatives of developing countries.

b. Ministry of Public Works and Housing

Specifically for this project, the GoI is represented by the Ministry of Public Works (MPW/PU), which issued a regulation of Minister of Public Works Regulation No. 21/2021 on Green Building, as the most relevant national reference in carrying out the policy impact assessment on building efficiency.

PUPR has a major influence on this project, as the policy maker. Moreover, the selection of building types will highly consider the recommendation from PUPR, in which PUPR possibly has priority buildings included in their national strategic project.

The policy impact assessment conducted in this project will become a lesson learned by PUPR to improve regulations, especially in the technical aspect, including a more detailed consideration of building decarbonization in Indonesia. In other words, this project will greatly refine and improve PUPR in issuing forthcoming regulations.

c. Ministry of Energy and Mineral Resources

The Directorate General of New and Renewable Energy within the Ministry of Energy and Mineral Resources (MEMR) is the frontier ministry in supporting the GoI to achieve the NDC target by issuing policies and regulations related to energy transition, renewable energy, and energy efficiency. Specifically in the context of energy efficiency, the Directorate General of New and Renewable Energy and Energy Conservation, as part of MEMR, can issue policies or regulations regarding energy efficiency related to the building, e.g., energy-efficient appliances (air conditioner, electric fan, electric stove, etc).

d. Ministry of Home Affairs (MOHA)

MOHA plays a vital role in supervising, guiding, and coordinating with regional governments. It ensures local adoption of national green building policies, supports capacity building, and monitors and harmonizes local regulations with national climate and sustainability goals.

e. Building Users

Building users, in this context, refer to building managers and owners, for whom the policy impact assessment will be conducted. Furthermore, different types of building users will have distinct intention regarding this project. For instance, residential building users may only focus on the energy efficiency approach, since it will directly bring electricity cost savings for them. Meanwhile, commercial building users’ motives may also include both energy efficiency and GHG emissions

reduction, since the former leads to cost savings, while the latter can become part of a portfolio as a climate change mitigation action, especially for buildings managed or owned by the government (governmental or state-owned buildings). The building users selected should be those who have implemented Minister of Public Works Regulation No. 21/2021 on their buildings. The policy impact assessment will rely heavily on the historical data of the buildings, mainly related to energy consumption and GHG emissions. Thus, the building users will have a significant impact on the smoothness of the project, especially on their cooperation in providing the required data and the completeness of the data themselves.

The impact of policy impact assessments on building users is that they can serve as a criterion for analysing their efforts to participate in achieving the country's NDC. On the other hand, the results of the assessments can become a basis for building on users in developing future strategies to further reduce both energy consumption and GHG emissions. In other words, the policy impact assessment will help users make their buildings more efficient.

f. Building or Property Developers and Contractors

Large- and small-scale developers and contractors implementing design, procurement, and construction of office buildings, apartments, houses, etc. The regulations, policies, or codes related to green buildings will undoubtedly affect every process chain of the building development. For example, in PUPR 21 2021, the regulation regarding passive cooling will affect the building design, which also impacts material selection throughout the construction process.

2. Non-key Stakeholders

a. The Ministry of Energy and Mineral Resources

The Ministry of Energy and Mineral Resources (MEMR/ESDM) is the frontier ministry in supporting the GOI to achieve the NDC target by issuing policies and regulations related to energy transition, renewable energy, and energy efficiency. Specifically in the context of energy efficiency, ESDM plays a critical role in planning national energy targets. The influence of ESDM in this project is to provide deeper insights into energy efficiency, especially that which is related to buildings. The data or project cases (which can be disclosed) by ESDM can provide a more comprehensive understanding to the UI team in carrying out the assessment. On the other hand, this project will directly impact ESDM by providing more perspectives on energy savings actions, specifically in the building sector, which can help refine ESDM policies or regulations in the future.

b. Indonesia National Electricity Company

Indonesia National Electricity Company (PLN) plays a significant role in this project, since the main energy supply of the buildings is derived from electricity. Moreover, in Indonesia, most energy regulations or policies issued by ESDM, especially in electricity, are mandated to PLN as the only electricity supplier in Indonesia. Furthermore, in Indonesia, the Independent Power Producer companies must sell their electricity to PLN for on-grid purposes, making PLN the only on-grid electricity "owner" to regulate, monitor, and distribute electricity for users. The study case of this project can give insights for PLN to oversee the direct impact (in terms of energy savings and GHG emissions reduction) of building efficiency realization in building users.

c. Ministry of Environment and Forestry

The Ministry of Environment and Forestry addresses greenhouse gas emissions

across various sectors, including the building sector. In fact, most of the LTS-LCCR (mentioned in the technical proposal) are mainly developed by KLHK to support Indonesia in achieving its NDC targets. The work on estimating GHG emissions in this project will surely influence and impact KLHK. The publicly accessible data and project cases from KLHK can provide information for the UI team to commence the project. Moreover, the dissemination session of this project will invite KLHK to engage them as the GoI representative who mainly deals with GHG matters in the country.

d. Expert Organizations

An expert organization will be invited during the Focus Group Discussion (FGD) in the dissemination session to present the selected case study and gain feedback on it. The participation of an expert organization is necessary, as they have notable experience conducting research, studies, or projects related to renewable energy and building efficiency in Indonesia. UI team proposes to invite expert organizations from:

- ASHRAE – Indonesia Chapter
American Society of Heating, Refrigerating and Air-Conditioning Engineers – Indonesia Chapter (AIC) was established on November 27, 2007. As of 2018, this organization has 205 members who collaborate on HVAC&R, energy efficiency, indoor air quality, and sustainability in the building industry. The access to global networks surely gives AIC the extensive technical resources, including standards, guidelines, handbooks, journals, software, and mobile applications, which are utilized by various stakeholders involved in HVAC&R for the built environment. The organization regularly reviews, revises, and republishes its standards to address evolving industry needs and concerns.
- Green Building Council Indonesia
Green Building Council Indonesia (GBCI) is an independent not-for-profit organization founded in 2009 by leading professionals and companies in the building industry in Indonesia. Our main mission is to transform market and industry players to be more responsible and sustainable. We have four main programs, namely Rating Development, Training and Education, Green Building Certification, and Stakeholder Engagement.
- Building Engineers Association Indonesia
Building Engineers Association Indonesia (BEAI) is a professional organization that comprises Indonesian building engineers. The main activity of BEAI includes providing training, capacity development, and certifications for its members to be qualified as certified and credible experts in building engineering. BEAI also conducts events to socialize and disseminate government regulations, standards, and knowledge related to building engineering, particularly building efficiency.
- Air Conditioning Experts Association
Air Conditioning Experts Association - *Asosiasi Ahli Refrigerasi dan Tata Udara* Indonesia (A2RTU) is an association that aims to collect, develop, and advance refrigeration and air conditioning techniques in Indonesia through study, research, training, mediation, advocacy, and discussion in the field of refrigeration and air conditioning for the better benefit of the Indonesian people.
- Green Building Experts Association
Green Building Experts Association - *Ikatan Ahli Bangunan Hijau Indonesia*

(IABHI) is an organization that serves as a platform for communication, consultancy, coordination, and capacity development that unifies green building experts, practitioners, private or public institutions, both at the national and international levels.

e. Academic Peers

During case study development, peer reviews are necessary to improve the case study. We propose peers from national and international organizations for technical reviews of the case study, with supporting feedback and credible advisories, since the peers are those experienced in building efficiency.

2. Building Efficiency Policy

The Ministry of Public Works (MPW) has taken significant steps in promoting building efficiency through policy and regulation development. For the building efficiency sector, the Indonesian Ministry of Public Works and Housing (PUPR) has issued regulation in 2021, using the terminology of Green Buildings (Bangunan Gedung Hijau, BGH) as follows:

- Minister of Public Works Regulation No. 21/2021 on Green Building
Minister of Public Works Regulation No. 21/2021 on Green Building outlines the categories of new as well as existing building mandatory be classified as green buildings with numbers of floors and floor area as criteria. The criteria for green buildings comprise various parameters; however, in this assessment, we will focus on energy use efficiency to assess building efficiency. In the attachment of the regulation, the criteria assessments of energy use efficiency are outlined, which include building insulation, ventilation system, air conditioning system, lighting system, transportation system inside building, calculation of energy efficiency, and electrical power system. Each criterion assessment has a score point, and buildings that are categorized as green buildings must have a total score point of 46 for energy use efficiency, with a minimum of 45% of the total score point must be fulfilled to meet the category of green building.
- Circular letter No. 01/SE/M/2022 concerning technical guidelines for assessing the performance of green buildings
This is a circular letter issued by PUPR to outline technical details on assessing the green building as outlined in Minister of Public Works Regulation No. 21/2021 on Green Building. This letter includes detailed parameters to be measured for estimating energy uses using national standards, SNI (Indonesian National Standard) of SNI 6197:2020, SNI 6389:2020, SNI 6390:2020, SNI 03-6573-2001, SNI 03-2396-2001, followed by detailed calculations to measure energy use in buildings.

Minister of Public Works Regulation No. 21/2021 on Green Building Performance Assessment defines the criteria for energy efficiency in buildings, including HVAC, lighting, and electronic appliances, as well as renewable energy measures through rooftop solar PV. This regulation replaces PUPR Regulation No. 02/PRT/M/2015 concerning Green Buildings. This change was made due to the increasing need for sustainable development, especially in the property and construction sectors. This regulation seeks to improve the quality of buildings by adjusting to international standards related to energy efficiency and reducing environmental impacts. Additionally, as a supplementary document to the regulation, the Surat Edaran (Letter) No.01/SE/M/2022 provides technical guidelines for green building assessments based on national standards (SNI 6197:2020, SNI 6389:2020, SNI 6390:2020, etc.). These policies serve as a foundation for improving building efficiency in Indonesia.

These regulations apply to:

1. New buildings (under construction or to be built).
2. Existing buildings (which already exist and want to obtain green building certification).
3. Building renovations (which change more than 50% of the building's floor area).

According to the regulations, buildings are assessed based on compliance with administrative and technical requirements. This assessment is applied at various stages, from planning and implementation to utilization and building maintenance.

Based on the assessment, buildings will receive green building certification at three levels:

- Pratama (45%-65%) – initial level of compliance with green standards.
- Madya (65%-80%) – intermediate level with higher achievements.
- Utama (80%-100%) – the highest level with full compliance with standards.

This certification is issued by an institution appointed by the government after an audit and verification process.

With the implementation of this regulation, it is expected that:

- Reducing energy and water consumption lowers building operational costs.
- Improved environmental quality, especially in reducing carbon emissions and construction waste.
- Better comfort and health for occupants, with improved air quality and natural lighting.
- Support for sustainable development programs in line with global targets, such as the SDGs (Sustainable Development Goals).

For the context of this project, aligning with ICAT Building Efficiency Guidance, the first criteria will be selected for the impact assessment.

The implementation of the Regulation of the Minister of Public Works and Public Housing (Permen PUPR) No. 21 of 2021 concerning the Assessment of Green Building Performance (BGH) has made significant progress in supporting Indonesia's greenhouse gas (GHG) emission-reduction target. The following are some of the latest achievements and initiatives:

1. **Establishment of a Green Building Roadmap**
The government has prepared a Roadmap for the Implementation of Green Building Development for the period 2023-2028. This document considers population distribution, energy and water consumption, and the experience of BGH implementation in various regions of Indonesia. The aim is to provide strategic guidance in the implementation of adaptive and sustainable BGH throughout Indonesia.
2. **Inter-Ministry Collaboration**
To strengthen synergy in BGH development, three main ministries—the Ministry of PUPR, the Ministry of Energy and Mineral Resources (ESDM), and the Ministry of Environment and Forestry (KLHK)—have launched a joint roadmap and signed a memorandum of understanding (MoU). This step aims to align policies and programs related to BGH, thereby supporting the achievement of national emission-reduction targets.
3. **Emission Reduction Target in the Building Subsector**
The government is targeting a reduction of almost 37 million tons of CO₂ in the building subsector by 2030. This target is part of Indonesia's commitment in the updated Nationally Determined Contribution (NDC), aiming to reduce emissions by 31.89% independently or up to 43.2% with international support by 2030.
4. **Training for Green Building Experts**
The Ministry of PUPR actively organizes training for experts in the field of BGH. This training aims to increase human resources' capacity to design, build, and evaluate buildings that meet green standards, thereby encouraging the implementation of the concept of sustainable development in the construction sector.

Several projects have implemented the BGH concept in accordance with PUPR Regulation No. 21/2021. For example, the Nusantara Student Dormitory project in Surabaya has achieved a Main level BGH certificate with a standard fulfillment rate of 85%. This shows that implementing BGH standards can be achieved with proper commitment and planning.

Overall, the implementation of PUPR Regulation No. 21/2021 shows positive progress in supporting Indonesia's emission targets. Collaboration between ministries, the preparation of roadmaps, and the expansion of human resource capacity are strategic steps toward realizing sustainable development through the implementation of Green Buildings.

Alongside this regulation, MPW issued a green building roadmap in 2023 that outlines strategies to achieve the green building development target, aligning with the e-NDC and LTS-LCCR. In the roadmap, MPW estimated that approximately 37 MtCO₂ can be reduced by 2030 through a combination of green building implementation and capacity-building activities across different building types.

While capacity building does not directly reduce greenhouse gas emissions, it plays a critical enabling role by strengthening institutional and technical capacities required to implement the regulation effectively. These activities aim to improve stakeholder knowledge, promote consistency in functional certificate evaluations, and build the long-term capacity among local governments, assessors, and building professionals. Examples include training programs, development of technical guidelines, and knowledge-sharing platforms. Together, these efforts help ensure that green building measures are applied correctly and consistently, creating the necessary conditions for sustained and impactful GHG emission reductions

The strategy to carry out capacity building based on MPW's green building roadmap include several key points, as follows:

- a. Technical capacity improvement of the BGH (Green Building) implementer
 - Dissemination of information regarding policy (national and regional) down to the province/regency/city levels
 - Development of a technical competency module for the BGH implementer
 - Conduct technical training to boost the adoption and implementation of BGH
 - Adoption and application of BGH technical competence by a credible certification agency which is legally authorized by the government, like LSP (Professional Certification Agency)
 - Conduct of training of trainers (ToT) to accelerate the number of green building experts, and practice
- b. Inclusion of BGH in curriculum (study subjects) for senior high school (Science major) and universities (engineering or environmental science majors)
- c. Socialization of BGH to building owners and managers, not only limited to governmental buildings, but also commercial and residential buildings (private developers).
 - Development of socialization material about BGH and BGH certification
 - Conduct of socialization about BGH and its certification
 - Development of easily accessible information platform (website, social media) about BGH, its certification, implementation, and practice

The roadmap aims at the following reductions:

- 3 million tons from Government Buildings;
- More than 14 million tons from Commercial Buildings;
- 19 million tons from Residential Buildings.

For both government and commercial buildings, the largest GHG emission reduction will come from energy efficiency. On the other hand, for household buildings, rooftop solar PV is the best option due to lower electrical loads compared to government and commercial buildings.

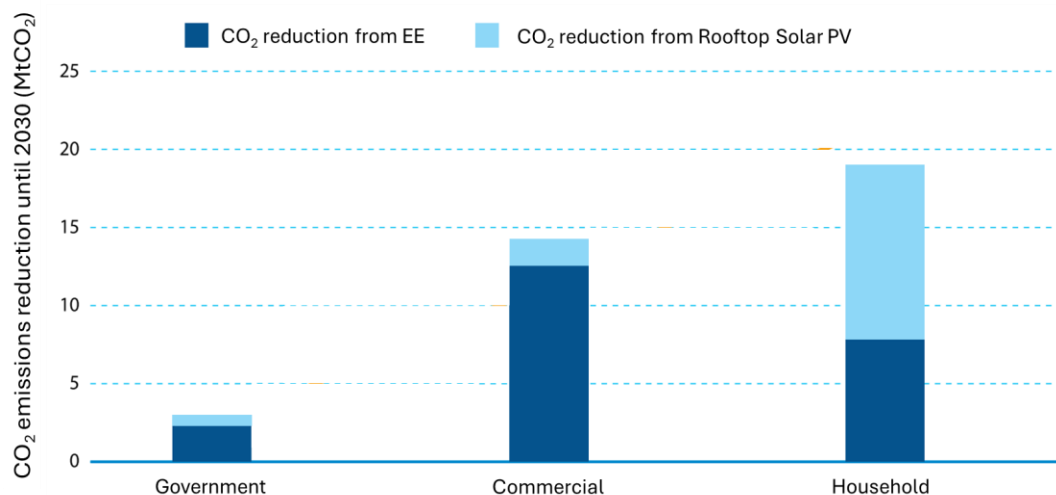


Figure 6. Projection of CO₂ emissions reduction in the building sector in 2030 (MPW, 2023)

The implementation of green building will be applied for existing and new buildings, and MPW's roadmap also outlines the strategy for both. As shown in Figure 6, green buildings will be primarily implemented in existing government buildings. In contrast, new commercial and household buildings are primarily aimed at incorporating green building features into their developments.

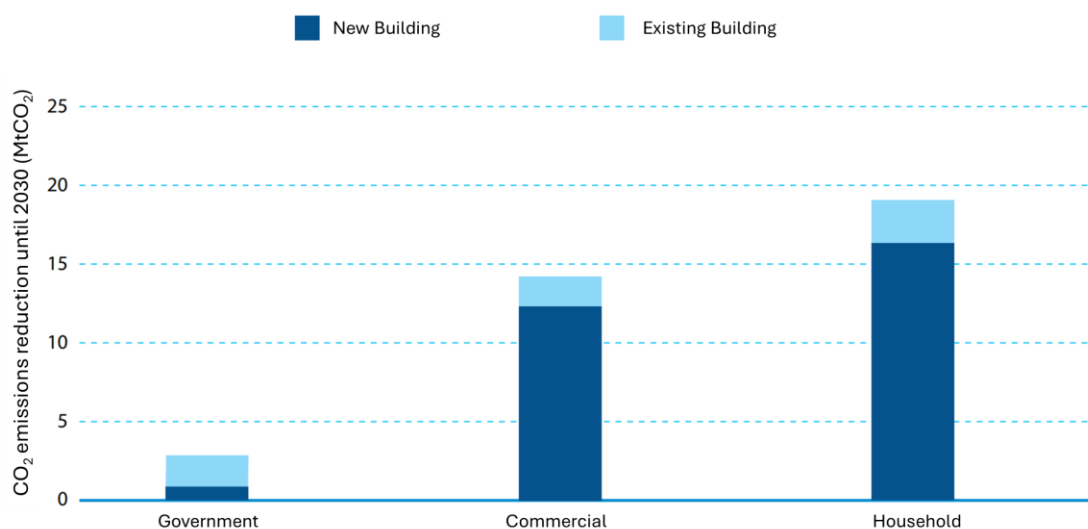


Figure 7 Green building implementation for new and existing buildings in 2030 (MPW, 2023)

Both regulation and its attachment outline several criteria with a total of 377 parameters to determine whether a building can be considered a "green building", which include:

- Reduction of (on-grid) energy consumption (energy efficiency and Solar PV);
- Reduction of water consumption (efficient water use and wastewater treatment);
- Independent waste management;
- Use of local and environmentally friendly building materials;
- Optimization of yard and environmental green open space functions; and
- Site management.

Initial stakeholder consultations have been performed to develop the project implementation plan. The project team has also analysed Minister of Public Works Regulation No. 21/2021 on Green Building (*Permen PUPR No. 21 Tahun 2021*). Based on the regulation, several parameters have been sorted for assessing green building criteria that can meet the principle of efficient use

of building energy. The selected energy efficiency assessment criteria have been aligned with the GHG Assessment boundary in the ICAT Buildings Efficiency Guidance, namely, parameters that can cause significant emission impacts on green building policies, originating from heating and cooling, hot water use, lighting, appliances, and electricity supply.

There were 71 assessment parameters obtained, where each parameter has its own points. In this case, we group the assessment parameters into 3 (three) groups based on emission sources as mentioned above. Each assessment criterion has a point score, and green buildings must have a total energy-efficiency score of 46. In determining these assessment parameters, we prioritize assessing two mandatory building categories: New Buildings and Existing Buildings with Mandatory Categories. Work assessment stages for new buildings start from planning, construction, and utilization, while for existing buildings, only at the utilization stage. The parameters are detailed in [Annex 2](#).

The project team has consulted relevant stakeholders in data collection and performed calculations and analysis of the impact of the building efficiency policy of *Minister of Public Works Regulation No. 21/2021* on GHG emissions. Finally, in this project, impact assessments are conducted using ICAT Buildings Efficiency Guidance, assessing the MPW's green building regulation (including its attachment) and roadmap.

Table 1. Checklist of recommended information to describe the policy being assessed

Information	Description	Example
Title of policy	Policy name	Building code for new buildings
Type of policy	The type of policy, such as regulatory, support, etc. Also include building stock type and building use targeted by the policy	The code includes two parts: Energy use intensity (EUI) standards (primary energy) for new buildings differentiated by types of residential housing buildings: <ul style="list-style-type: none"> - Single-family house (SFH): 100 kWh/m²/year - Apartment block (AB): 80 kWh/m²/year
Status of the policy	Whether the policy is planned, adopted or implemented	Enacted and in force
Date of implementation	The date the policy comes into effect (not the date that any supporting legislation is enacted)	Came into force on 1 January 2013
Date of completion (if relevant)	If relevant, the date the policy ceases, such as the date a tax is no longer levied or the end date of an incentive scheme with a limited duration (not the date that the policy no longer has an impact)	Ongoing
Implementing entity or entities	The entity that implements the policy, including role of various local, subnational, national, international or other entities	Federal ministry

Information	Description	Example
Objectives and intended impacts or benefits of the policy	The intended impact(s) or benefit(s) the policy intends to achieve (e.g., the purpose stated in the legislation or regulation)	Reduction of energy consumption in buildings, ensure safe building environment and quality of life
Level of the policy	The level of implementation, such as national level, subnational level, city level, sector level or project level	National
Geographical coverage	The jurisdiction or geographic area where the policy is implemented or enforced, which may be more limited than all the jurisdictions where the policy has an impact	Country
Sectors, targeted	Which sectors or subsectors are targeted	Emissions associated with electricity, steam and direct fossil fuel (energy carriers) use in buildings for lighting, heating, cooling, provision of hot water (end use)
Greenhouse gases targeted	Which GHG the policy aims to control, which may be more limited than the set of GHG that the policy affects	CO ₂ (CH ₄ and N ₂ O to lesser extent)
Other related policies or actions	Other policies or actions that may interact with the policy assessed	Mandatory share of 30% of renewable energy for new public buildings A loan incentive scheme for converting to wood pellet heating systems and for installation of solar thermal units Energy taxes

3. Policy Impact Assessment Methodology

The assessment follows the guidance of ICAT, with policies/regulations references as outlined previously. The methodological framework in accordance with ICAT Buildings Efficiency Guidance, as highlighted in Figure 8, ICAT Building Efficiency policy impact assessment guide

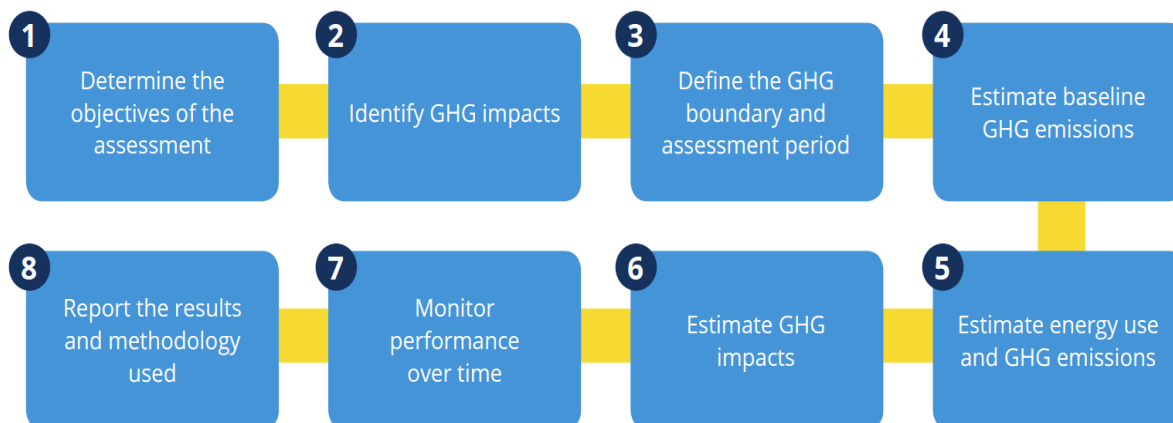


Figure 8. ICAT Building Efficiency Policy Impact Assessment Guide

1. Determine the objectives of the assessment
 - a. General objectives include estimating the GHG impacts of policies to determine policies aligned with the NDC and building efficiency targets, as well as ensuring their cost-effectiveness.
 - b. Ex post objectives, including policy effectiveness assessment, policy implementation improvement, best practices sharing, and tracking of progress towards the NDC goals.
2. Identify GHG impacts
 - a. Identification of intermediate effects, which include changes in behaviour, technology, processes, or practices that result from a policy. This identification includes identifying participating stakeholders (who affect or influence the policy), identifying inputs (resources to implement the policy), and activities (certification, audit, construction, retrofit, and improvement).
 - b. Identification of GHG impacts of the policy and all associated GHG sources from tables 6.2 and 6.3 from ICAT Buildings Efficiency Guidance
 - c. Development of a causal chain to outline the cause-and-effect relations of how policies cause intermediate effects, which then lead to GHG impacts. This causal chain helps identify unforeseen intermediate effects and GHG impacts, and shows how policies can affect emissions.

Figure 9 below shows a causal chain modified from the ICAT Guidance (Chapter 10.2). It is necessary to alter the causal chain to accommodate the specific policy and local conditions in Indonesia.
3. Define the GHG assessment boundary and period

GHG impacts are categorized by source: heating and cooling, lighting and appliances, and electricity supply. Moreover, GHG impacts are classified by likelihood and relative magnitude to determine which GHG sources generate the most significant impacts. The Ex-Ante assessment period is defined as 2021 to 2030, while the Ex-Post period is defined as 2021 to 2024.

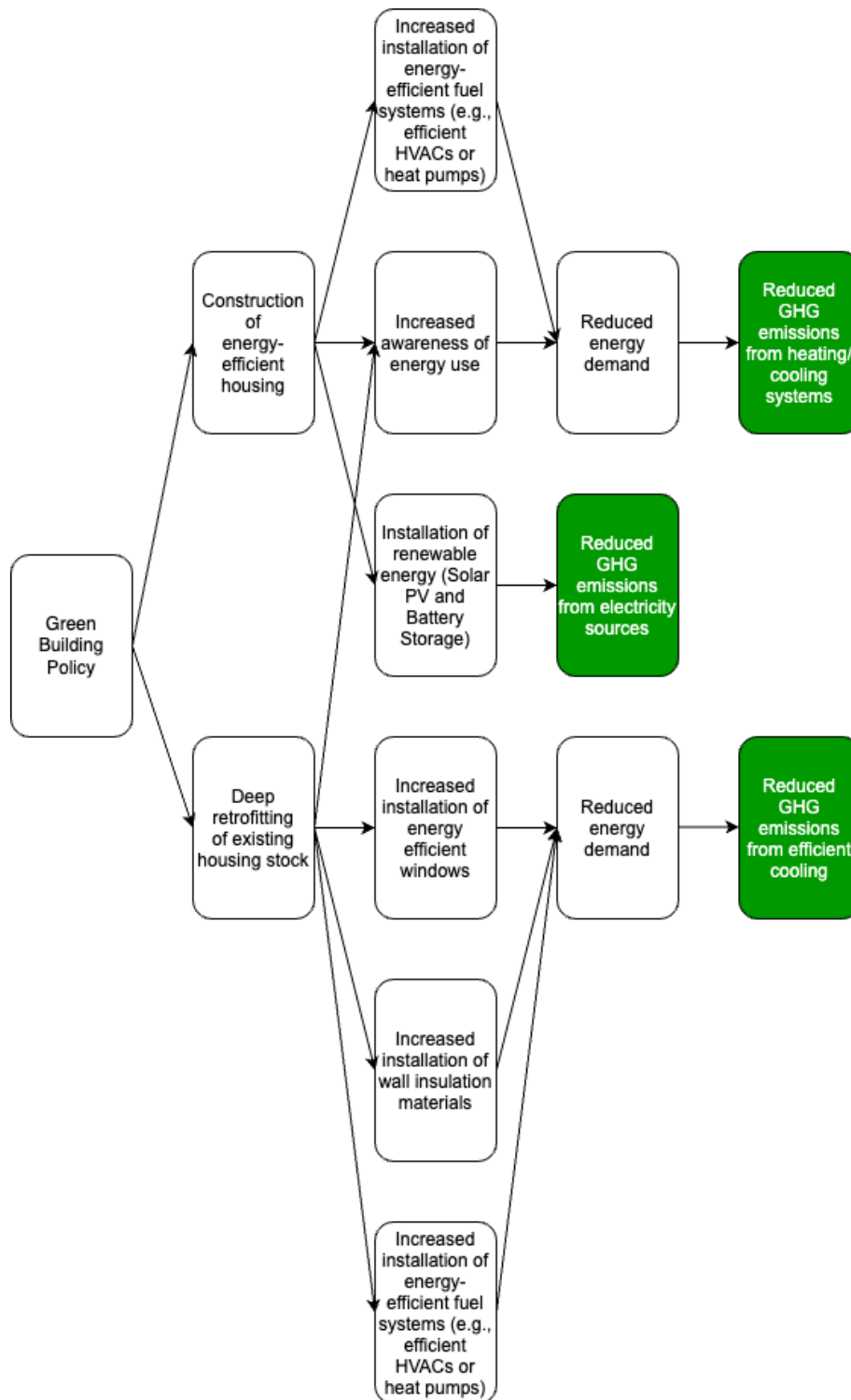


Figure 9. Causal chain for green building policy impact

4. Estimate GHG emissions and energy use for baseline and ex-post scenarios
Details on the methodology are given in the respective chapter of this report.
5. Estimate GHG impacts: Ex-Ante assessment

The key parameters of ex-ante assessment are average annual specific energy use per m² by building type in climate zone, share of energy carrier in fuel mix by building type in climate zone, average floor area per building by building type in climate zone, and energy carrier

emission factors.

a. Account for regulatory and financial support policies

Regulatory Policies

Perform qualitative analysis and identify the likelihood and relative magnitude of regulatory policies affecting key parameters for GHG estimation. Moreover, estimates of the magnitude of the effect on key parameters are necessary, based on assumptions about how certain appliances contribute to the average annual specific energy use for each year of the assessment period. Such assumptions can be based on historical developments projected into the future, on building development blueprints, on relevant field studies, or on expert judgment. The estimation is performed in accordance with the building codes outlined in the attachment to Minister of Public Work Regulation No. 21/2021, which details the building codes by number of floors and floor area.

Financial support policies

In Indonesia, the application of carbon taxes and carbon credits has not yet been regulated and is excluded from the assessment.

b. Account for other barriers

Identify barriers that may hinder the success of policy implementation, including financial, institutional and administrative, market, lack of trained and skilled personnel, public acceptance, energy poverty and access, technology, and lack of information. Where applicable, each key parameter for GHG estimates is evaluated in relevance with the likelihood and relative magnitude of each barrier.

Each identified barrier's effects on key parameters will be determined by considering: (i) the effect factor for each barrier on each relevant key parameter; (ii) overlaps between barriers; (iii) the overall effect factors calculation with uncertainty range. With these calculated overall effect factors, the key parameters for ex-ante assessment are updated by subtracting the overall effect factor value from each key parameter.

c. Estimate GHG emissions ex-ante

In ex-ante assessment, the objective is to estimate the emission reductions due to implemented policies for new buildings, as outlined in the territorial buildings development plan. The baseline scenario used key parameters assuming no energy efficiency or renewable energy implemented as concrete steps towards green building regulation. On the other hand, GHG emissions are calculated using ex-ante key parameters according to equation 7.1 above. The emission reduction is calculated by subtracting GHG baseline emissions from estimated GHG emissions under the policy scenario for each year of the assessment.

6. Estimate GHG impacts: Ex-Post assessment

Ex-post impact assessment is a backward-looking assessment of the GHG impacts achieved by a policy to date. The GHG impacts can be assessed during the policy implementation period or in the years after implementation. Referring to ICAT guidance, we aim to achieve two main objectives for GHG impacts estimation for the Ex-post scenario, which include:

a. Compare historical GHG emissions in the buildings sector to a sectoral target

Analyse the historical and current GHG emissions of each building, as representative of each sector, and compare these data with Indonesia's NDC target, followed by detailed regulations that outline the target, for example, the Ministry of Energy and Mineral Resources regulations.

b. Estimate achieved GHG emission reductions of implemented policies

Comparing the GHG emissions before and after a policy is applied, to observe any reduction in GHG emissions. This objective requires determining a baseline scenario to serve as the basis for calculating GHG emission reductions. The calculation requires subtracting baseline emissions from the ex post estimated policy scenario.

For ex-post assessment, the baseline scenario uses historical data from each building assessed. These historical data are obtained from building past electricity consumption, procurement documents in which any energy carrier equipment added or removed, as-built drawings, building historical modifications (identifying retrofit, refurbishment, or renovation), as well as conducting in-depth interviews with each building management personnel.

The baseline estimate will follow the steps outlined in point 4 (adoption from chapter 7 of ICAT guidance document), except that there is no direct measurement, since the latest condition of the building after the policy is different than before the policy was implemented. On the other hand, the ex-post assessment follows similar steps (as in point 4).

7. Monitor performance over time

Monitoring serves two objectives: evaluation of the policy's performance (monitoring trends in performance parameters to understand whether the policy is on track and being implemented as planned) and estimation of the policy's GHG impacts

8. Report the results and methodology used

Reporting the results, methodology, and assumptions used is important to ensure the GHG impact assessment is transparent and gives decision-makers and stakeholders the information they need to interpret the results correctly. As referred to in the ICAT guidance, in chapter 11, the report will include several pieces of information about the assessment process and the GHG impacts resulting from the policy.

For analysis in the baseline scenario, there are some relevant data were collected from the Green Building Secretariat at the Ministry of Public Works, Indonesia. Table 2 Data requirements for the ICAT Buildings Efficiency Guidance baseline GHG emission below lists specification data and potential sources for GHG baseline emission calculation in Indonesia regarding the ICAT Buildings Efficiency Guidance.

Table 2. Data requirements for ICAT Buildings Efficiency Guidance baseline GHG emission

No	Data Parameter	Unit	Coverage	Potential Data Sources
1	Number of buildings per building type in climate zone up to year	Integer	National (which use PUPR Regulation)	
	Existing buildings			<ul style="list-style-type: none"> - National, subnational or municipal statistics bureaus (i.e., can include statistics from census or household surveys, tax or property databases (for building information), energy databases (for building energy use data)) - Related studies in the field - Expert judgment
	Retrofitted buildings			<ul style="list-style-type: none"> - National, subnational or municipal statistics bureau - Related studies in the field - Expert judgment
	New buildings			<ul style="list-style-type: none"> - National, subnational or municipal statistics bureau - Related studies in the field

No	Data Parameter	Unit	Coverage	Potential Data Sources
				- Expert judgment
2	Average annual specific energy use per m ² by building type in climate zone up to year	kWh per m ²	For Building which use PUPR Regulation	<ul style="list-style-type: none"> - National, subnational or municipal statistics bureau (can include statistics from surveys like census or household survey), tax or property databases (for building information), energy databases (for building energy use data)) - Related studies in the field - Expert judgment
3	Share of energy carrier in fuel mix	(% of total fuel mix	For Building which use PUPR Regulation	<ul style="list-style-type: none"> - National, subnational or municipal statistics bureau (can include statistics from census or household surveys, tax or property databases (for building information), energy databases (for building energy use data)) - Related studies in the field - Expert judgment
4	Average floor area per building-by-building type in climate zone up to year	m ² per building	For Building which use PUPR Regulation	<ul style="list-style-type: none"> - National, subnational or municipal statistics bureaus (i.e., can include statistics from census or household surveys, tax or property databases (for building information), energy databases (for building energy use data)) - Related studies in the field - Expert judgment
5	Energy carrier emission factors	g CO ₂ per kWh	For Building which use PUPR Regulation	<ul style="list-style-type: none"> - National, subnational or municipal statistics bureaus (i.e., can include statistics from census or household surveys, tax or property databases (for building information), energy databases (for building energy use data)) - Related studies in the field - Expert judgment

Also, for further analysis in Ex-Ante and Ex-Post GHG Emission analysis for building, we identified the data requirement below in Table 3: regarding Minister of Public Works Regulation No. 21/2021 on Green Building.

Table 3. Data requirements for building efficiency policy impact assessment

No	Data Type	Unit	Initial Year	Finish Year	Notes	Reference	Data Availability
1	Building Type	Number of buildings	2021	2024	a) Residential b) Government Non-Residential c) Commercial Non-Residential	BGH Team	Available from SIMBG https://simbg.pu.go.id/
2	Construction Rate	%	2021	2024	a) Residential b) Government Non-Residential c) Commercial Non-Residential	BGH Team	Available from Buku Informasi Statistik Infrastruktur PUPR Tahun 2022 https://data.pu.go.id/buku-informasi-statistik-infrastruktur-pupr-tahun-2022-0
3	Demolition Rate	%	2021	2024	a) Residential b) Government Non-Residential c) Commercial Non-Residential	BGH Team	Available from Buku Informasi Statistik Infrastruktur PUPR Tahun 2022 https://data.pu.go.id/buku-informasi-statistik-infrastruktur-pupr-tahun-2022-0
4	Annual specific energy use per m ²	kWh/m ²	2021	2024	a) Residential b) Government Non-Residential c) Commercial Non-Residential	BGH Team	Available on Roadmap Bangunan Gedung Hijau (BGH) https://ciptakarya.pu.go.id/admin/assets/upload/fi

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No	Data Type	Unit	Initial Year	Finish Year	Notes	Reference	Data Availability
							le/laporan/2024/10/09/62583_Peta%20Jalan%20Penyelenggaraan%20dan%20Pembinaan%20Bangunan%20Gedung%20Hijau%20(BGH).pdf
5	Energy carrier mix (natural gas or electricity)	%	2021	2024	a) Residential b) Government Non-Residential c) Commercial Non-Residential	BGH Team	Available from Ministry of Energy and Mineral Resources (MEMR) Indonesia (https://www.esdm.go.id/id/publikasi/statistik)
6	Average floor area	m ² /building	2021	2024	a) Residential b) Government Non-Residential c) Commercial Non-Residential	BGH Team	Conversion from m ² /personnel to m ² /building. Data source from SIMANTU (https://simantu.pu.go.id/epel/edok/16799_MD_PROG_PEMBIAYAN_2.pdf)
7	Emission Factor	gCO ₂ /kWh	2021	2024	(natural gas or electricity)	IPCC or Ministry of Environmental	Available
8	Factor of Barrier Effects	%	2021	2024		Analysis	Available

The availability of data from these 8 data types is used in calculating baseline, ex ante, and ex-post GHG Emissions in Buildings in Indonesia, referring to the ICAT Buildings Efficiency Guidance, and used against Minister of Public Works Regulation No. 21/2021 on Green Building. The majority of the data to be used will come from the BGH Roadmap, SIMBG, SIMANTU, and PUPR Information Book. Furthermore, it comes from the Ministry of Energy and Mineral Resources, the Ministry of Environment and Forestry, and various analyses.

4. Estimating Overall Baseline Emission

This chapter estimates baseline emissions for residential, governmental, and commercial buildings in Indonesia, using 2021 as the reference year. The methodology follows ICAT Guidance, incorporating building population data, floor area, energy use, and emissions factors. Baseline emissions are projected from 2021 to 2024 using construction and demolition rates, with key data sourced from PLN Consumer Data and national reports. Influencing factors include national and local policies, such as green building regulations and spatial planning. The emission estimation method relies on multiplying activity data by local emission factors from PLN and the Ministry of Energy. Key uncertainties include variations in building population data and in the distribution of energy mixes.

4.1 Methodology

The method chosen for estimating baseline emissions is described in Chapter 7.3 of the ICAT Guidance. Emissions are calculated by multiplying the activity data by the local emission factors. All information used for the baseline of GHG emission impact of building population was obtained from secondary data published by the respective agencies. Activity data, in this case, annual grid emission factors, is acquired from and released by the State Electric Company (PLN). Another emission factor, natural gas, is acquired from and released by the Ministry of Energy and Mineral Resources.

The approach for estimating the overall baseline emissions analyses of three type of building in Indonesia: 1) Residential building; 2) Governmental building; and 3) Commercial building, which are relevant for the estimation of the overall GHG emission. The baseline of 2021 is used as the starting point, serving as the basis for the Minister of Public Works Regulation No. 21/2021 , which initiates implementation.

A concrete approach for estimating the baseline emission for building in calculating the impact of PERMEN PUPR No. 21 year 2021 is listed below (as in section 7.2 of the ICAT Guidance):

- Developing a data requirements list, based on the causal chain for building population data, total floor area, baseline construction rate, baseline demolition rate, annual specific energy, and share of energy use, etc.
- Compiling data and checking data quality on baseline construction rate, baseline demolition rate, annual specific energy, and share of energy use. For this assessment, the period is 2021 – 2024.
- Identifying and converting the appropriate baseline data metrics, such as energy units and volume.
- Selecting the assessment period for fuel pricing by using an ex-post approach for the 2021 – 2024 period.

4.2 Baseline emissions

The expected baseline scenario demonstrated the trend in emissions from residential, governmental, and commercial building consumption without the intervention of green building policy. A clear baseline scenario is needed to compare the impact of various policy options. Also, the baseline scenario depends on whether national or local policy already exists. In the baseline, the building population was forecast using the construction and demolition rate. The initial population in 2021 is taken from PLN Consumer data, which is detailed as follows:

- 1) Residential buildings: 78,327,897.

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- 2) Government buildings: 238,629.
- 3) Commercial buildings: 4,640,565.

Indonesia has only one climate zone. The construction and demolition rates are used as projection scenarios to generate data from 2022 to 2024. Matching the data to energy and emissions, the total floor area is required. The method refers to Chapter 7.3 of the ICAT guidance, where baseline calculations for Sections 7.3.1-7.3.7 can be achieved by multiplying activity data by an emission factor to determine base-year emissions.

As in any baseline, GHG emission impact assessments from the building population are uncertain projections due to other influencing policies and actions. Here are some of the policies that may affect the building population.

National policies:

- Roadmap for building and construction
- Green building regulation
- Renewable energy in buildings

Local policies:

- Spatial and regional plan
- Number of residents

The following points should be considered as uncertainties:

- The building population over time, being calculated by the Indonesian Statistical Bureau (BPS) can be different from data from PLN, according to the electrification ratio in Indonesia
- Uncertainty over the share of the energy mix in each building

Table 4. Building baseline emission calculation

Estimate Number of Building							
Building	Building Type	Baseline Demolition Rate	Baseline Construction Rate	Number of buildings per building type			
				2021	2022	2023	2024
Building Type A	Residential	0.20%	2%	78,327,897	79,891,322	81,485,953	83,112,412
Building Type B	Government Non-Residential	0.20%	2%	238,629	243,392	248,250	253,205
Building Type C	Commercial Non-Residential	0.20%	2%	4,640,565	4,733,191	4,827,665	4,924,025
Estimate Annual Specific Energy							
Building	Building Type	Annual Specific Energy Use (kWh/ m ²)	Average annual specific energy use per m ² (kWh/m ²)				
			2021	2022	2023	2024	
Building Type A	Residential	136.00	136.00	136.00	136.00	136.00	136.00
Building Type B	Government Non-Residential	284.52	284.52	284.52	284.52	284.52	284.52
Building Type C	Commercial Non-Residential	242.87	242.87	242.87	242.87	242.87	242.87
Share of energy carrier							
Building	Building Type	Share of Energy Use	Share of energy carrier (%)				
			2021	2022	2023	2024	
Building Type A	Residential	Natural Gas	49%	49%	49%	49%	
		Electricity	51%	51%	51%	51%	
Building Type B	Government Non-Residential	Natural Gas	12%	12%	12%	12%	
		Electricity	88%	88%	88%	88%	
Building Type C	Commercial Non-Residential	Natural Gas	12%	12%	12%	12%	
		Electricity	88%	88%	88%	88%	
Average floor area per building							
Building	Building Type	Baseline floor area of new buildings	Average floor area per building for new buildings (m ²)				
			2021	2022	2023	2024	
Building Type A	Residential	1.00%	39.1	39.5	39.9	40.3	
Building Type B	Government Non-Residential	1.00%	355.5	359.0	362.6	366.2	
Building Type C	Commercial Non-Residential	1.00%	81.5	82.4	83.2	84.0	

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Energy Emission Factor						
Building	Building Type	Share of Energy Use	Emission Factor (gCO ₂ /kWh)			
			2021	2022	2023	2024
Building Type A	Residential	Natural Gas	181	181	181	181
		Electricity	870	870	870	870
Building Type B	Government Non-Residential	Natural Gas	181	181	181	181
		Electricity	870	870	870	870
Building Type C	Commercial Non-Residential	Natural Gas	181	181	181	181
		Electricity	870	870	870	870
Baseline Emission for Each Year						
Building	Building Type	Emission Type	Emission (MtCO ₂)			
			2021	2022	2023	2024
Building Type A	Residential	Natural Gas	37.08	38.20	39.35	40.53
		Electricity	184.01	189.56	195.28	201.17
Building Type B	Government Non-Residential	Natural Gas	0.52	0.54	0.55	0.57
		Electricity	18.49	19.05	19.62	20.21
Building Type C	Commercial Non-Residential	Natural Gas	1.99	2.05	2.11	2.17
		Electricity	70.40	72.52	74.71	76.96
Total Emission			312.48	321.91	331.62	341.62

Figure 10 shows that CO₂ emissions from 3 building types, with residential buildings occupying the first and highest position, range from 221 to almost 242 MtCO₂. Government buildings take the last position with the smallest number of emissions, increasing from 19 to nearly 21 MtCO₂. Lastly, the commercial building emissions rose from 72 to 79 MtCO₂. The increase corresponds to the rise in the number of residential buildings, driven by economic and population factors. Meanwhile, Figure 11 shows that the baseline of CO₂ emissions for all buildings continues to increase from 312 to almost 342 MtCO₂ between 2021 and 2024. The residential sector accounted for the largest share of emissions, 71%, driven by electricity use.

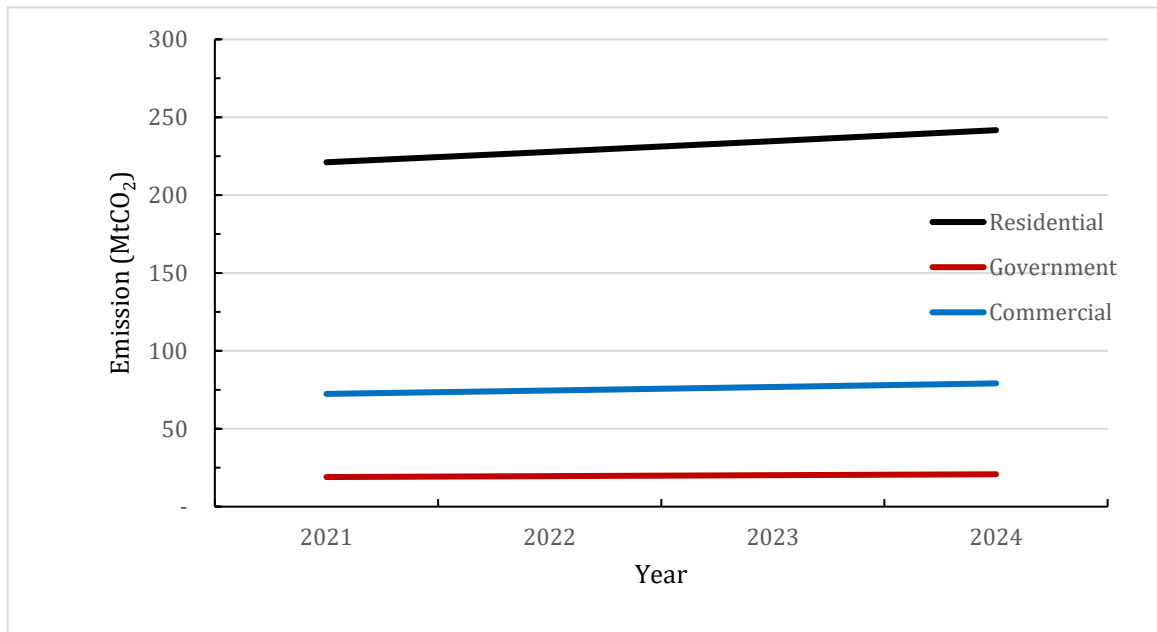


Figure 10. Baseline CO₂ emission based on building type

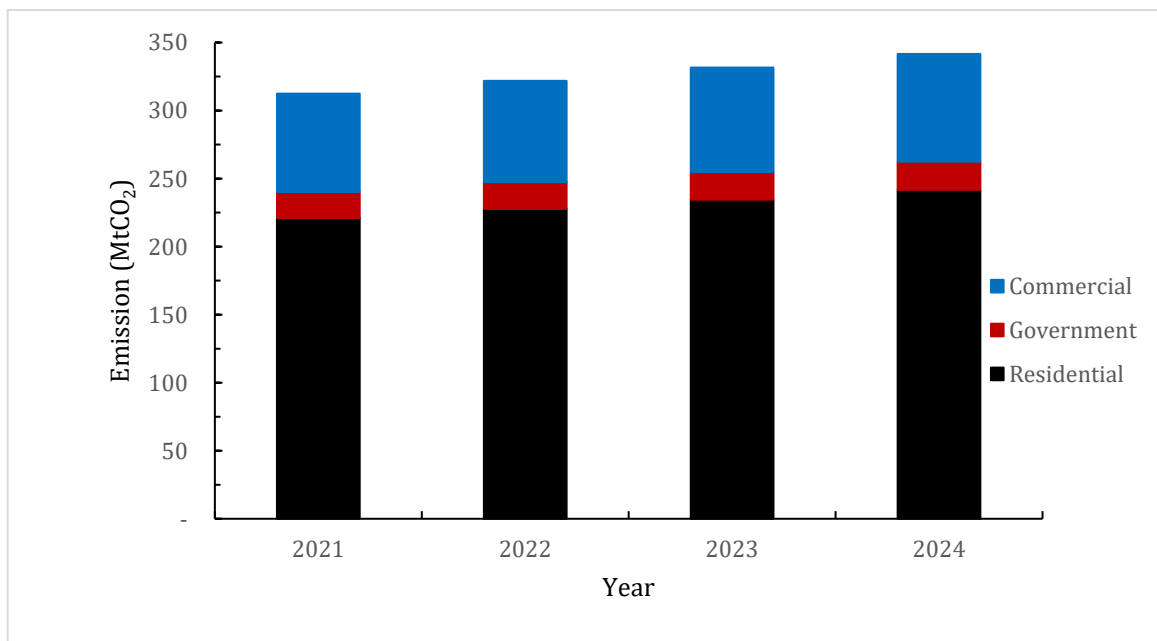


Figure 11. Total baseline CO₂ emission from the building

5. Ex-Ante Impact Assessment

Based on section 8 of the guidelines, the policy that is assessed, namely PUPR Regulation No. 21 of 2021, is assumed to be a type of regulatory policy without complementary financial support; therefore, the following steps need to be taken:

- Estimating the expected policy impact on parameter values
- Following the guidelines for regulatory policies (Section 8.2)
- Considering other constraints (Section 8.4)
- Estimating GHG impacts (Section 8.5)

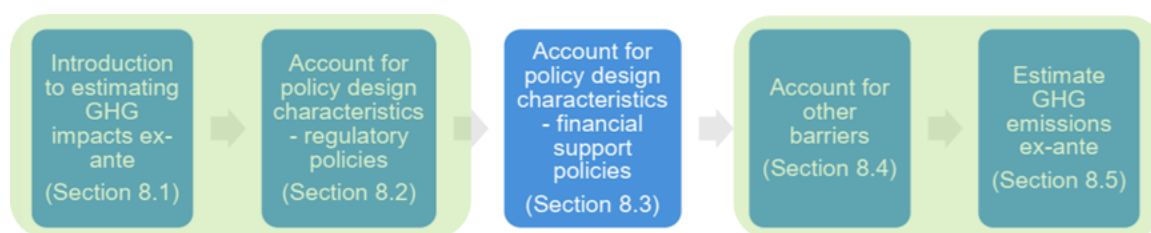


Figure 12 Steps on estimating Ex-Ante emission

5.1 Expected Policy Impact

After establishing the baseline GHG emissions in the previous chapter, the estimated emission reductions resulting from the implemented policy in buildings will be assessed. As outlined in the ICAT Buildings Efficiency Guidance, ex-ante emission reductions are calculated by subtracting the ex-ante policy scenario emissions from the baseline emissions, after which both the policy scenario emissions and baseline emissions are projected.

The ex-ante calculation in this study serves two objectives: first, to assess the impact of policy implementation on emission reductions; and second, to estimate the gap between the expected future impact of implementing the regulation and the sectoral targets set or expected to be achieved through this policy.

- Assessment Period:
The assessment period is a long-term one, spanning from the enforcement of the relevant regulation through 2030, in alignment with Indonesia's targets set in the Nationally Determined Contribution (NDC).
- Sectoral Target:
In the context of achieving the targets outlined in the NDC, the implementation and development of green buildings until 2030 is expected to contribute to a reduction of approximately 37 million tons of CO₂. This reduction aligns with the targeted greenhouse gas emission savings through independent efforts within the Energy Sector, as stated in the green building roadmap.

5.2 Methodology

The method chosen for ex-ante emission estimation is described in Chapter 8.1 of the ICAT Buildings Efficiency Guidance. Emissions are estimated by multiplying activity data by local emission factors. All information used in the calculation, such as building population, average floor area, share of energy, and annual network emission factors, follows the values from the emission baseline calculation in the previous section.

The relevant estimation parameters we use for estimating ex-ante GHG impacts follow Ex-Ante

equation:

$$E_a = N_b \times EUI_a \times SE_a \times A_b \times EF_a \quad (\text{eq.1})$$

- Number of buildings by building type in climate zone up to year (N_b)
- Improved average annual specific energy use per m^2 per building type in climate zone up to year in kWh/m^2 (EUI_a)
- Share of energy carrier in fuel mix % of total fuel mix (SE_a)
- Average floor area per building-by-building type in climate zone up to year in m^2 (A_b)
- Energy carrier emission factors in gCO_2 per kWh (EF_a)

5.3 Defining the Estimation Parameters

The key estimation parameters affected by regulatory policies are the average annual specific energy use (EUI, $kWh/m^2/year$) and the share of each energy carrier type in the fuel mix.

In the previous discussion, we conducted a selection process for 377 green building assessment parameters outlined in Minister of Public Works Regulation No. 21/2021 on Green Building. These parameters were then narrowed down and aligned with the ICAT Buildings Efficiency Guidance, resulting in 71 relevant parameters. Subsequently, each parameter was further reviewed to identify those that could be quantified and used for simulating their impact on EUI reduction. As a result, 8 priority parameters were selected.

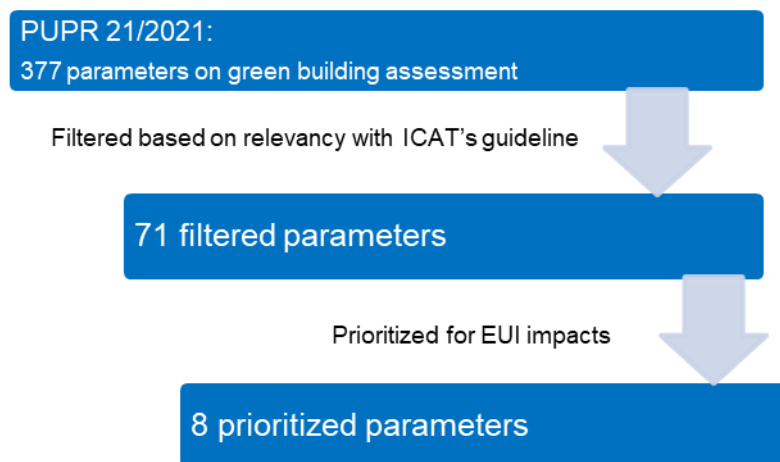


Figure 13. Key parameters selection from the building efficiency policy

The ex-ante scenarios for the first estimation parameter, i.e., average annual specific energy use (EUI), consider the following green building policy parameters.

- Set point temperature ($^{\circ}Celsius$)
- Window-to-wall ratio (%)
- AC type
- Conditioned area (% m^2 of conditioned area per m^2 of total building area)
- Lux level (LUX)
- Lamp power density ($watt/m^2$)
- Lamp type
- Lighting automation

The selected parameters are then used to estimate the improvement in the EUI for each building category relative to the reference model. An *EnergyPlus* simulation is used to assess the improved EUI relative to the baseline. The EUI value (kWh/m²) is calculated by dividing the total annual electricity consumption (kWh) by the Residential Area (m²). In calculating the GHG emission baseline, it has been determined that the basic EUI used for emission estimation for each building type is based on the Green Building Roadmap.

The ex-ante scenarios for the second estimation parameter, i.e., the share of the energy carrier, are calculated based on the implementation of renewable energy sources, specifically rooftop solar photovoltaic (PV) in the building.

5.4 Energy Efficiency Potential

In this simulation, two building types are considered: Residential and Non-Residential. Energy Savings are calculated through a comparison of the Energy Use Simulation (Energy Consumption) of a building model with design assumptions that include 1) Base Case and 2) Improved Case. The previously selected parameters will be used as input in the simulation process.

The simulation was conducted by creating a building model in *DesignBuilder* software, followed by an *EnergyPlus* simulation to determine the Net Site Energy (kWh) consumed by the building. Various parameter adjustments were made to observe the energy-saving patterns resulting from changes in input parameter values.

There are 3 simulation case studies conducted, namely:

- Case 1: Residential buildings
- Case 2: Government buildings
- Case 3: Commercial buildings

Case 1

General Building Information

Building Type	: Residential building
Building Category	: Existing building
Weather Data	: Jakarta, Indonesia
Total Building Area	: 297,35 m ²
Total Window Area	: 42,71 m ²
Building Orientation (Longest Wall)	: Nort-West



Figure 14. Residential building model

Table 5. Energy efficiency model results for residential building

Case Scenario	Base Case	Improved Case
Building Envelope		
Building Orientation (Longest Wall)	North	North
Building Ratio (E/W to N/S)	4:3	4:3
Total Building Area (m ²)	339,84	339,84
Total Window Area (m ²)	42,71	29,91
OTTV (W/m ²)	12,37	8,72
Cooling and Ventilating System		
AC Type	Split with Inverter	Split with Inverter
COP	3,3	3,3
kW/TR	0,92	0,92
Set Point Temperature (°C)	23	25
Conditioned Area (%)	62%	53%
Lighting System		
Lamp Type	T-8 Fluor	LED
Illumination levels (LUX)	150	100
Lamp Power density (watt/m ²)	7,5	5
Lighting Automation	NO	YES
Annual Energy Consumption (kWh/year)	46.218	24.530
EUI (kWh/m²)	136	72,18
Energy Reduction (%)		47 %

For simulations in residential buildings, the reference values follow the SNI standards for residential building types. The retrofit in residential buildings includes replacing a split air conditioner unit with a variable refrigerant flow unit. For this retrofitting assumption, the budget is not considered.

Table 6. Energy efficiency improvement scenarios of residential buildings

Scenario	Parameter								Annual Energy Consumption (kWh/year)	Result EUI (kWh/m ² /year)	Saving		
	Set Point Temp (Celcius)	Ac Type	WWR (%)	Conditioned Area (%)	Illumination Level (LUX)	Lamp Power Density (watt/m ²)	Lamp Type	Lighting Automation			kWh/m ²	(%)	Kumulatif (%)
Baseline	23	Split with Inverter	35%	62%	150	7,5	T-8 Fluor	NO	46.218	136			
Improve 1	25	Split with Inverter	35%	62%	150	7,5	T-8 Fluor	NO	45.634	134,28	1,72	1%	1%
Improve 2	25	Split with Inverter	35%	62%	150	5	LED	NO	41.080	120,88	13,4	10%	11%
Improve 3	25	Split with Inverter	35%	62%	100	5	LED	NO	38.246	112,54	8,34	6%	17%
Improve 4	25	Split with Inverter	35%	62%	100	5	LED	YES	36.764	108,18	4,36	3%	20%
Improve 5	25	Split with Inverter	30%	62%	100	5	LED	YES	29.026	85,41	22,77	17%	37%
Improve 6	25	Split with Inverter	30%	53%	100	5	LED	YES	24.530	72,18	13,23	10%	47%

Detailed explanation as follows:

Improvement 1:

Parameter : Set Point Temperature (°C)

The set-point temperature was increased from 23 °C to 25 °C in accordance with SNI 6390:2020. This adjustment lowers the cooling demand, enabling the HVAC system to operate more efficiently without compromising comfort.

Result :

EUI decreased from 136 to 134.28 kWh/m²/year, a savings of 1.72 kWh/m² or 1% from the baseline.

Improvement 2:

Parameter : Lamp Power Density (Watt/ m²) and Lamp Type

The lamp type was upgraded from T-8 fluorescent to LED. LEDs provide higher luminous efficacy and reduced heat generation.

Result :

EUI reduced to 120.88 kWh/m²/year, saving 13.4 kWh/m² or 10% from the baseline, achieving a cumulative saving of 11%.

Improvement 3:

Parameter : Illumination/ Lux level (LUX)

Lighting levels were adjusted from 150 LUX to 100 LUX in accordance with SNI 6197:2020 standards for workplace lighting. This ensures adequate illumination while reducing unnecessary energy consumption.

Result :

EUI decreased to 112.54 kWh/m²/year, a saving of 8.34 kWh/m² or 6%, bringing the cumulative savings to 17%.

Improvement 4:

Parameter : Lighting Automation

Lighting control systems were implemented to automatically adjust artificial lighting based on occupancy and daylight availability, reducing wastage.

Result :

EUI reduced further to 108.18 kWh/m²/year, saving 4.36 kWh/m² or 3%, with cumulative savings of 20%.

Improvement 5:

Parameter : Window-to-Wall Ratio (WWR)

The WWR was reduced from 35% to 30%, decreasing the building's OTTV and lowering cooling demand in compliance with SNI 6389:2020.

Result :

EUI dropped to 85.41 kWh/m²/year, a significant saving of 22.77 kWh/m² or 17%, raising cumulative savings to 37%.

Improvement 6:

Parameter : Conditioned area

The proportion of air-conditioned space was reduced from 96% to 53%, with non-critical areas using natural or mechanical ventilation instead of air conditioning.

Result :

EUI reached 72.18 kWh/m²/year, saving 13.23 kWh/m² or 10%, leading to a cumulative saving of 47% from the baseline.

Case 2

General Building Information

Building Type	: Government building
Building Category	: Existing building
Weather Data	: Jakarta, Indonesia
Total Building Area	: 2,181 m ²
Total Window Area	: 768.98 m ²
Building Orientation (Longest Wall)	: North



Figure 15 Government building model

From the case base data above, several improvement cases are carried out on each parameter that we have determined, so that the value of the improved case is obtained, which we can optimistically obtain a potential energy savings of 68 % as described in Table 7 below.

Table 7. Energy efficiency model results for the government building

Case Scenario	Base Case	Improved Case
Building Envelope		
Building Orientation (Longest Wall)	West	West
Building Ratio (E/W to N/S)	2:1	2:1
Total Building Area (m ²)	3871,64	3871,64
Total Window Area (m ²)	768,98	639,76
OTTV (W/m ²)	32,41	26,83
Cooling and Ventilating System		
AC Type	Split Duct	FCU, Air Cooled Chiller
COP	2,93	4,21
kW/TR	1,2	0,92
Set Point Temperature (°C)	23	25
Conditioned Area (%)	100%	66%
Lighting System		
Lamp Type	Conventional	LED
Illumination levels (LUX)	350	300
Lamp Power density (watt/m ²)	11,9	7,5
Lighting Automation	NO	Yes
Annual Energy Consumption (kWh/year)	1.101.555	348.996
EUI (kWh/m²)	284	90
Energy Reduction (%)		68%

Table 8. Energy efficiency improvement scenarios of government buildings

Scenario	Parameter								Annual Energy Consumption (kWh/year)	Result EUI (kWh/m ² /year)	Saving		
	Set Point Temp (Celcius)	Ac Type	WWR (%)	Conditioned Area (%)	Illumination Level (LUX)	Lamp Power Density (watt/m ²)	Lamp Type	Lighting Automation			kWh/m ²	(%)	Kumulatif (%)
Baseline	23	Split Duct	35%	100%	350	11,9	T-8 Fluor	NO	1.101.555	284,52			
Improve 1	25	Split Duct	35%	100%	350	11,9	T-8 Fluor	NO	1.019.733	263,39	21,13	7%	7%
Improve 2	25	FCU, Air Cooled Chilled	35%	100%	350	11,9	T-8 Fluor	NO	632.466	163,36	100,03	35%	43%
Improve 3	25	FCU, Air Cooled Chilled	35%	100%	300	11,9	T-8 Fluor	NO	604.265	156,07	7,29	3%	45%
Improve 4	25	FCU, Air Cooled Chilled	35%	100%	300	11,9	T-8 Fluor	YES	558.919	140,37	15,70	6%	51%
Improve 5	25	FCU, Air Cooled Chilled	35%	100%	300	7	LED	YES	493.021	127,34	13,03	5%	55%
Improve 6	25	FCU, Air Cooled Chilled	30%	100%	300	7	LED	YES	440.525	113,8	13,54	5%	60%
Improve 7	25	FCU, Air Cooled Chilled	30%	66%	300	7	LED	YES	348.996	90,14	23,66	8%	68%

Detailed explanation as follows:

Improvement 1:

Parameter : Set Point Temperature (°C)

The set point temperature was increased from 23 °C to 25 °C, in accordance with the reference value in SNI 6390:2020

Result :

The EUI value decreased by 21 kWh/m² or 7%, compared to the baseline.

Improvement 2:

Parameter : AC type

The selection of the type of AC significantly affects how a building can handle the cooling load and the kW/TR or COP of air conditioning equipment must comply with SNI 6390:2020. In this improvement case, there is a change in the type of AC from the Split Duct type to FCU, Air Cooled Chiller, with a higher COP value and lower kW/TR.

Result :

There is a decrease in the EUI value of 100 kWh/m² or 35 % compared to the baseline value. In this building model, the impact on reducing energy consumption is significant. The impact of changing the split AC type to an FCU (Air Cooled Chiller) can be considered when calculating embodied carbon emissions, which can be calculated in a separate study.

Improvement 3:

Parameter : Illumination/ Lux level (LUX)

The determination of the illumination level (lux) in a room affects the number and power of lamps needed to achieve the required lighting level; the value must be in accordance with SNI 6197:2020 regarding conservation in lighting systems. In this building, the room's primary function is a workspace, so the lux level is set to 300 Lux per SNI standards.

Result :

There is a decrease in the EUI of 7 kWh/m², or 3%, compared to the baseline.

Improvement 4:

Parameter : Lighting Automation

It is simulated that in the basic case, there is no lighting control/lighting automation. With lighting control, the daylight illuminance at the work desk can be adjusted, and the percentage of zones in the workspace that receive lighting can be adjusted.

Result :

There is a decrease in the EUI of 15 kWh/m², or 7%, compared to the baseline.

Improvement 5:

Parameter : Lamp Power Density (Watt/ m²) and Lamp Type

The lamp type has been changed from T-8 Fluor to LED, which have a higher efficacy (lumens/watt), enabling it to meet the lux level in improvement 3 with a lower power density than conventional lamps. Improvement 5 is closely related to improvement 3. After the value is determined, the selection of lamps needs to be considered.

Result :

The EUI value decreased by 13 kWh/m² or 5%, compared to the baseline.

Improvement 6:

Parameter : Window-to-wall ratio (%)

The Window-to-Wall Ratio (WWR) affects the building's Overall Thermal Transfer Value (OTTV), which simultaneously affects the building's cooling load. The WWR is adjusted to achieve an OTTV value that complies with SNI 6389:2020 on building envelopes, where the OTTV must not exceed 35 W/m².

Result:

There is a decrease in the EUI value of 13 kWh/m² or 5 % compared to the baseline value. With OTTV value decreasing from 32,41 W/m² to 26,83 W/m²

Improvement 7:

Parameter : Conditioned area

Conditioned area reduced from 100% to 66%. Changes in the conditioned area include reducing energy for air conditioning and replacing it with natural or mechanical ventilation in rooms that do not require a specific temperature or have a high infiltration rate, such as corridors and toilets. The maximum possible percentage reduces the conditioned area without compromising work comfort. The amount can vary depending on the building utilization.

Result :

The EUI value decreased by 23 kWh/m², or 8%, compared to the baseline.

Case 3

General Building Information

Building Type	: Commercial building
Building Category	: Existing building
Weather Data	: Jakarta, Indonesia
Total Building Area	: 4031,83 m ²
Total Window Area	: 992,40 m ²
Building Orientation (Longest Wall)	: North

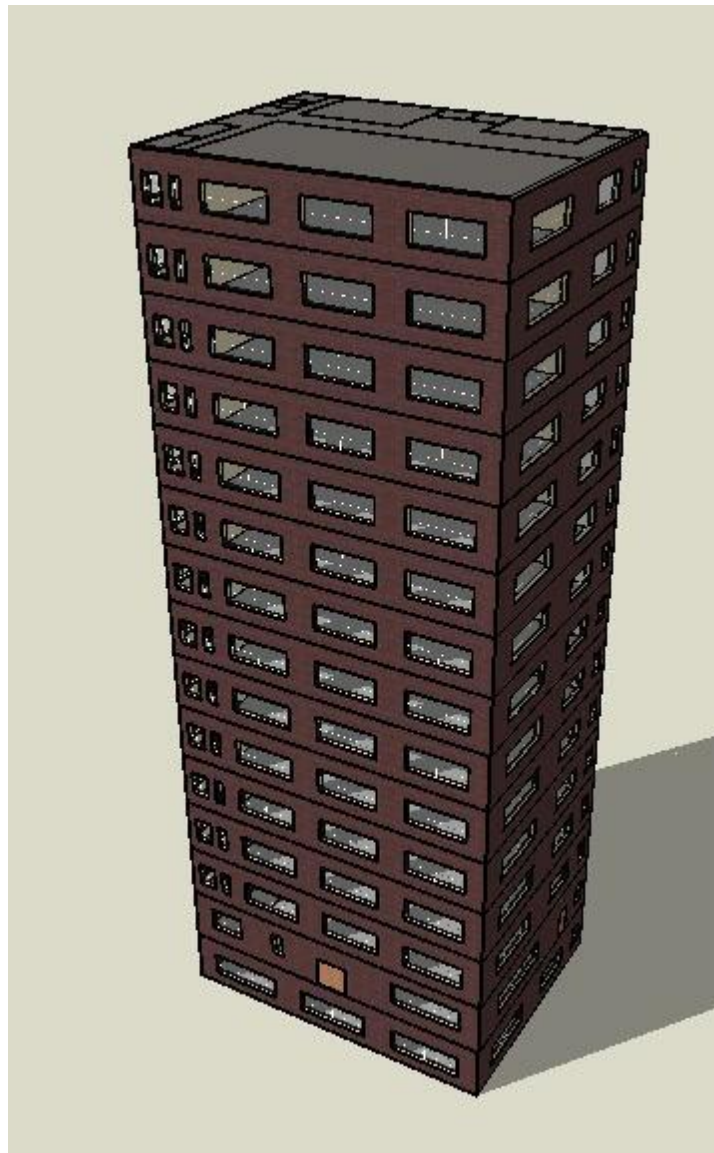


Figure 16. Commercial building model

Table 9. Energy efficiency model results for commercial building

Case Scenario	Base Case	Improved Case
Building Envelope		
Building Orientation (Longest Wall)	West	West
Building Ratio (E/W to N/S)	4:3	4:3
Total Building Area (m ²)	4031,83	4031,83
Total Window Area (m ²)	992,40	785,20
OTTV (W/m ²)	32,41	24,33
Cooling and Ventilating System		
AC Type	Variable Refrigerant Flow	FCU, Water Cooled Chiller
COP	3,8	4,52
kW/TR	1,2	0,92
Set Point Temperature (°C)	23	25
Conditioned Area (%)	96%	63%
Lighting System		
Lamp Type	T-8 Fluor	LED
Illumination levels (LUX)	350	300
Lamp Power density (watt/m ²)	11,9	7
Lighting Automation	NO	YES
Annual Energy Consumption (kWh/year)	979.211	414.618
EUI (kWh/m²)	242,87	102,84
Energy Reduction (%)		58%

In this new building simulation, it is assumed that there is one parameter adjustment for the building orientation to the initial design; this parameter is only found in the green building assessment for the new building category.

Table 10. Energy efficiency improvement scenarios of commercial buildings

Scenario	Parameter								Annual Energy Consumption (kWh/year)	Result EUI (kWh/m ² /year)	Saving		
	Set Point Temp (Celcius)	Ac Type	WWR (%)	Conditioned Area (%)	Illumination Level (LUX)	Lamp Power Density (watt/m ²)	Lamp Type	Lighting Automation			kWh/m ²	(%)	Kumulatif (%)
Baseline	23	VRF	35%	96%	350	11,9	T-8 Fluor	NO	979.211	242,87			
Improve 1	25	VRF	35%	96%	350	11,9	T-8 Fluor	NO	936.322	232,23	10,64	4%	4%
Improve 2	25	FCU, Water Cooled Chilled	35%	96%	350	11,9	T-8 Fluor	NO	638.311	158,32	73,91	30%	35%
Improve 3	25	FCU, Water Cooled Chilled	35%	96%	300	11,9	T-8 Fluor	NO	612.245	151,85	6,47	3%	37%
Improve 4	25	FCU, Water Cooled Chilled	35%	96%	300	11,9	T-8 Fluor	YES	526.841	130,67	21,18	9%	46%
Improve 5	25	FCU, Water Cooled Chilled	35%	96%	300	7	LED	YES	482.844	119,76	10,91	4%	51%
Improve 6	25	FCU, Water Cooled Chilled	35%	63%	300	7	LED	YES	424.089	105,19	14,57	6%	57%
Improve 7	25	FCU, Water Cooled Chilled	30%	63%	300	7	LED	YES	414.618	102,84	2,35	1%	58%

Detailed explanation as follows:

Improvement 1:

Parameter : Set Point Temperature (°C)

The set point temperature was increased from 23 °C to 25 °C, following the reference value outlined in SNI 6390:2020

Result :

This adjustment resulted in a reduction in EUI by 10 kWh/m², equivalent to a 4% decrease compared to the baseline.

Improvement 2:

Parameter : AC type

The choice of an air conditioning system significantly influences a building’s cooling capacity and efficiency. In accordance with SNI 6390:2020, the AC type was changed from a VRF system to a Fan Coil Unit (FCU) with a water-cooled chiller, offering a higher COP and lower kW/TR.

Result :

This modification led to a reduction in EUI by 73 kWh/m², or 30%, compared to the baseline. Additionally, this change substantially improved overall energy efficiency.

Improvement 3:

Parameter : Illumination/ Lux level (LUX)

The lux level in workspaces was adjusted to 300 LUX in accordance with SNI 6197:2020, which specifies lighting standards for energy conservation.

Result :

The change reduced the EUI by 6 kWh/m², representing a 3 % decrease from the baseline.

Improvement 4:

Parameter : Lighting Automation

The baseline case assumed no automated lighting control. Introducing daylight-responsive lighting reduced energy use by ensuring only designated zones received artificial light when necessary.

Result :

EUI decreased by 21 kWh/m², representing a 9% improvement over the baseline.

Improvement 5:

Parameter : Lamp Power Density (Watt/m²) and Lamp Type

Lighting was upgraded from T-8 fluorescent lamps to LED fixtures with higher luminous efficacy, in line with required lux levels. This change complemented Improvement 3 by using lower-power lighting while maintaining brightness standards.

Result :

The EUI was reduced by 10 kWh/m² or 4% compared to the baseline.

Improvement 6:

Parameter : Conditioned area

The conditioned floor area was reduced from 96% to 63%, with AC replaced in non-critical spaces (e.g., corridors, toilets) by natural or mechanical ventilation.

Result :

This change reduced the EUI by 14 kWh/m², a 6 % improvement over the baseline.

Improvement 7:

Parameter : Window-to-wall ratio (%)

The WWR was adjusted to achieve an OTTV (Overall Thermal Transfer Value) compliant with SNI 6389:2020, reducing solar heat gain and cooling demand.

Result:

EUI decreased by 2 kWh/m² or 1 %, with OTTV dropping from 32.41 W/m² to 24.33 W/m².

5.5 Barrier Analysis

Potential Barriers for building energy efficiency in Indonesia are identified as follows:

Table 11. Barriers for building energy efficiency

Barrier category	Barrier
Financial barriers	No financial instrument exists to incentivize households to renovate to higher standards, or no funding for new buildings to comply with a building code or high efficiency program
	Households or small and medium-sized enterprises are unwilling to invest in renovation work due to high upfront costs and long payback times for calculated energy savings
	Lenders are unwilling to finance projects due to perceived or real risks associated with energy efficiency loans to households/SMEs (often due to a lack of information, uniformity and standards, for example in calculating energy savings)
	Banks are unwilling to finance residential energy efficiency measures due to high transaction costs associated with small and dispersed projects and developers
Institutional and administrative barriers	No government unit is clearly responsible for implementing energy efficiency policies or enforcement is insufficient
	Cities and national government may have different energy efficiency requirements that are not compatible, thus reducing compliance
	A large informal housing sector leading to buildings not going through normal building permitting process, which limits the means of building code enforcement
	High corruption levels can decrease compliance with standards
Lack of trained and skilled personnel barriers	Insufficient number of trained architects, construction workers, etc. to adequately implement the requirements of building codes and other standards
	Households or project promoters do not have access to advice on energy efficiency, making them less likely to initiate energy efficiency projects
Technology barriers	Households increase cooling energy consumption to achieve improved thermal comfort, due to lower energy bills after renovation work
Lack of information policies	Increased energy efficiency is not specified in the policy or design because the methods to calculate the benefits of energy efficiency beyond energy and emissions savings are not readily available.
	Building users, managers and construction companies are not adequately informed about regulatory standards

Further evaluation on the likelihood and relative magnitude of barriers is presented below.

Table 12. Barrier analysis of building energy efficiency

Year: 2021			
Parameter	Barrier	Likelihood (<i>Very likely, Likely, Possible, Unlikely, Very unlikely</i>)	Relative magnitude (<i>Minor, Moderate, Major</i>)
<i>Number of buildings per type(b) in climate zone(z)</i>	Financial barriers		
	Risk-averse financiers (e.g., local private banks) may be unwilling to grant loans due to increased construction costs caused by mandatory efficiency requirements	Very likely	Moderate
	Institutional and administrative barriers		
	Informal housing sector is not likely to comply with (or is not subject to) building permitting processes. Informal housing represents 10% of the sector	Very likely	Moderate
	Lack of trained and skilled personnel barriers		
	Insufficient number of trained architects, construction workers, etc. to adequately implement the requirements of building codes and other standards	Very likely	Moderate
	Technology barriers		
	High local content requirements that reduce the supply of energy-efficient building components	Likely	Moderate
	Lack of information policies		
Lack of awareness about the availability of financial support instruments by eligible single-house project developers	Likely	Minor	
Year: 2022			
<i>Number of buildings per</i>	Lack of trained and skilled personnel barriers		

<i>type(b) in climate zone(z)</i>	Insufficient number of trained architects, construction workers, etc. to adequately implement the requirements of building codes and other standards	Likely Change to <i>likely</i> from <i>very likely</i> in 2018 as market is expected to adapt relatively fast	Minor Change to <i>minor</i> from <i>moderate</i> in 2018 as market is expected to adapt relatively fast
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Determination of how the identified barriers affect the estimation parameters is presented below.

Table 13. Determination of the identified barriers affecting the average annual specific energy use

Parameter	Barrier	Effect factor analysis	Barrier overlap	Overall effect factor
<i>Average annual specific energy use per m² per new building by type(b) in climate zone(z)</i>	Economic and financial barriers			
	High cost of some code-compliant air conditioners	+ 3-4%	Moderate overlap with high subsidies for electricity consumption	+ 2-3%
	Institutional and administrative barriers			
	High share of informal housing	+ 5-10%	No overlap with other barriers	+ 5-10%
	National code for new residential buildings has different requirements than several city-level codes	+ 2%	No overlap with other barriers	+ 2%
	Market barriers			
	High subsidies for electricity consumption	+ 5%	Minor overlap with high cost of energy-efficient air conditioners	+ 3.5%
	Lack of skilled personnel			
	No training programmes have been organised for building contractors	+ 3-5%	No overlap with other barriers	+ 3-5%
National code for new residential buildings has different requirements than	+ 3%	No overlap with other barriers	+ 3%	

	several city-level codes			
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Table 14 Determination of the identified barriers affect the average number of buildings

Parameter	Barrier list	Effect factor analysis	Barrier overlap	Overall effect factor
2021				
Number of buildings per type(b) in climate zone(z)	Economic and financial barriers			
	Risk-averse financiers (e.g., local private banks) may be unwilling to grant loans due to increased construction costs caused by mandatory efficiency requirements	Minus 2-3%	No overlap with other barriers	Minus 2-3%
	Institutional and administrative barriers			
	Informal housing sector not likely to comply with or is not subject to building permitting processes. Informal housing represents 10% of the sector.	Minus 2.5-5% (from originally 5-10% due to 50% reduction effect due to policy intervention)	No overlap with other barriers	Minus 1-2%
	Lack of trained and skilled personnel barriers			
	Insufficient number of trained architects, construction workers, etc. to adequately implement the requirements of building codes and other standards	Minus 6-7%	No overlap with other barriers	Minus 3-4%
	Lack of information policies			
	Lack of awareness about the availability of financial support instruments by eligible single-house project developers	Minus 4-7%	No overlap with other barriers	Minus 2-5%
Aggregation of total effect of barriers on parameter				Minus 8 - 14%
2022				
Number of buildings per	Lack of trained and skilled personnel barriers			

type(b) climate zone(z)	in Insufficient number of trained architects, construction workers, etc. to adequately implement the requirements of building codes and other standards	Minus 0-1%	No overlap with other barriers	Minus 0-1%
Aggregation of total effect of barriers on parameter				Minus 8 - 13%

The estimated baseline emissions calculation in the previous section indicates that baseline CO₂ emissions across all building types have increased from 2021 to 2024. This data has been projected until the end of the assessment period in 2030.

5.6 Ex-Ante Emission

Baseline Emission

The estimated baseline emissions calculation in the previous section indicates that baseline CO₂ emissions across all building types have increased from 2021 to 2024. This data has been projected until the end of the assessment period in 2030.

The following is the baseline emission projection through 2030, based on previous baseline calculations through 2024. As a result, the baseline emissions are estimated to reach 408 MtCO₂ by the end of 2030. This result will serve as the foundation for assessing GHG emission reductions due to policy impacts.

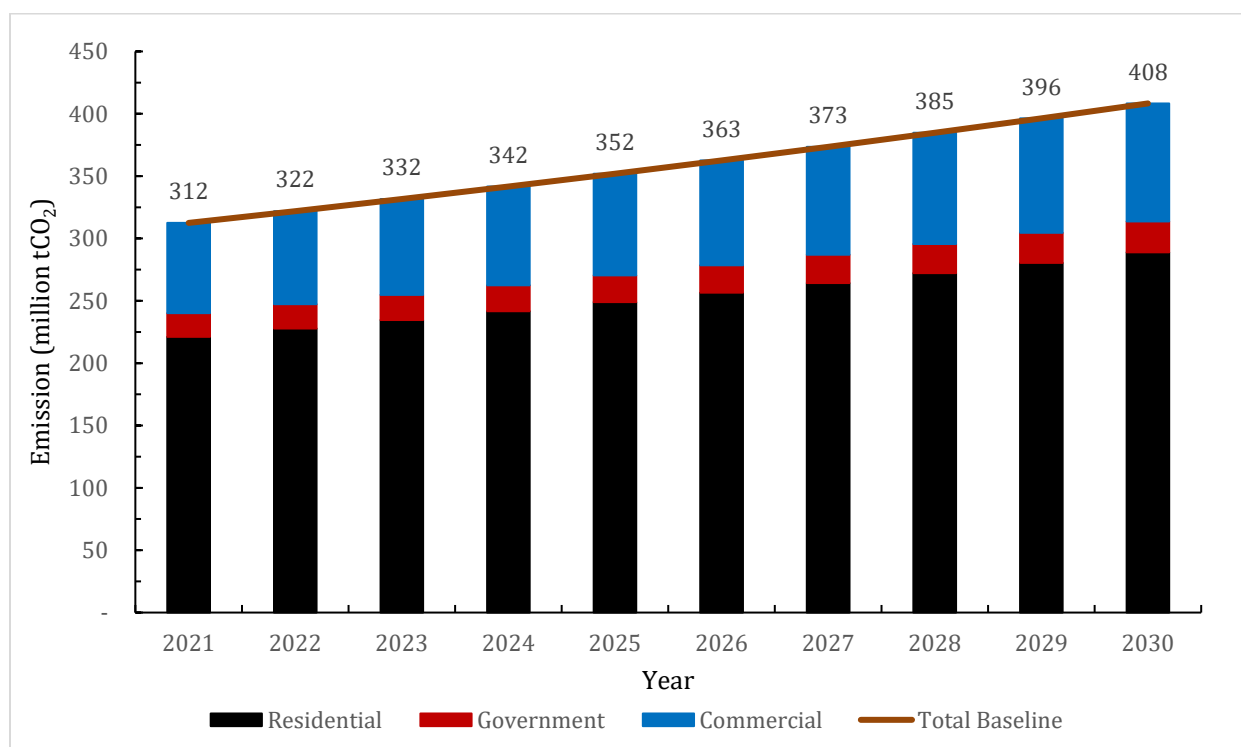


Figure 17. Baseline emissions up to 2030

With the number of buildings population as the baseline, as follows:

Table 15. Building population and its projection

Estimate Number of Building													
Building	Building Type	Baseline Demolition Rate	Baseline Construction Rate	Number of buildings per building type									
				2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	0,20%	2%	78.327.897	79.891.322	81.485.953	83.112.412	84.771.336	86.463.372	88.189.181	89.949.437	91.744.828	93.576.054
Building Type B	Government Non-Residential	0,20%	2%	238.629	243.392	248.250	253.205	258.259	263.414	268.672	274.034	279.504	285.083
Building Type C	Commercial Non-Residential	0,20%	2%	4.640.565	4.733.191	4.827.665	4.924.025	5.022.309	5.122.554	5.224.800	5.329.087	5.435.456	5.543.948

Best-case Scenario Emission

In this scenario, the primary objective of the assessment is to estimate GHG emission reductions resulting from the implementation of the regulation, which applies to both new buildings (mandatory) and existing buildings (mandatory).

In addition to the expected decrease in Energy Use Intensity (EUI) due to regulatory enforcement, it is assumed that the number of buildings aligns with the policy implementation timeline, starting after the regulation was enacted in 2022. This scenario aims to achieve 100% adaptation of existing buildings by the end of the assessment period in 2030.

As a baseline, it is assumed that 10% of the existing building population will adopt the green building policy, with an annual increase of 5%. Following the introduction of the Green Building Roadmap, which supports the policy, the adoption rate is expected to accelerate by 7%, reaching approximately 12% per year.

As a reference, a study on the minimum green building (GB) standards in Singapore (ref.) suggests that BGH-certified buildings could increase by 8%.

For new buildings, compliance with green building principles is mandatory under the policy. The final objective of this scenario is to calculate the GHG emission reductions by subtracting the estimated emissions in the policy scenario from the baseline emissions.

Based on Eq.1, the values of each variable in the GHG estimation calculation for this Ex-Ante scenario will be determined. For this scenario, the variables Number of buildings (N_b) and average annual specific energy use (EUI) will be described in more detail, while the other variables remain as in the previous baseline calculation.

- **Number of Buildings (N_b)**

Based on the given scenario assumptions, 10% of the existing building population is expected to adopt the green building policy, with an

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annual increase of 5%. After the introduction of the Green Building Roadmap in 2024, the adoption rate is expected to accelerate by 7%, reaching approximately 12% per year. As a result, the number of buildings in this scenario is as follows:

Table 16 Number of buildings implementing the policy

Number of Building (Existing Building - Non green building)											
Building	Building Type	Number of buildings per building type									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	78,327,897	70,495,107	69,317,056	62,701,031	58,533,608	54,743,595	51,755,933	49,113,452	46,926,053	44,959,553
Building Type B	Government Non-Residential	238,629	214,766	214,766	214,766	214,766	214,766	214,766	214,766	214,766	214,766
Building Type C	Commercial Non-Residential	4,640,565	4,176,509	4,176,509	4,176,509	4,176,509	4,176,509	4,176,509	4,176,509	4,176,509	4,176,509
Number of Building (Existing Building - green building)											
Building	Building Type	Number of buildings per building type									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Implementation rate		0	10%	15%	27%	39%	51%	63%	76%	88%	100%
Building Type A	Residential	-	7,832,790	10,574,266	18,784,922	24,578,804	30,027,741	34,707,439	39,075,729	43,023,384	46,785,275
Building Type B	Government Non-Residential	-	23,863	28,626	33,484	38,439	43,493	48,648	53,906	59,268	64,738
Building Type C	Commercial Non-Residential	-	464,057	556,682	651,157	747,517	845,800	946,046	1,048,292	1,152,579	1,258,947
Number of Building (New Building)											
Building	Building Type	Number of buildings per building type									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	-	1,563,425	1,594,631	1,626,460	1,658,924	1,692,036	1,725,809	1,760,256	1,795,391	1,831,227
Building Type B	Government Non-Residential	-	4,763	4,858	4,955	5,054	5,155	5,258	5,363	5,470	5,579
Building Type C	Commercial Non-Residential	-	92,626	94,474	96,360	98,284	100,245	102,246	104,287	106,369	108,492

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- **Improved average annual specific energy use (EUI)**

From the modelling and simulation results for Residential and Non-Residential buildings, the percentage (%) reduction in EUI was obtained and then multiplied by the Baseline EUI value. As a result, the Final EUI (kWh/m²) is determined, as shown in the table below, which will be used to calculate the GHG emission estimates.

Table 17. Improvement of EUI

Estimate Annual Specific Energy						
Building	Building Type	Baseline EUI (kWh/m ²)	EUI Saving from Energy Efficiency (in %)		Final Annual Specific Energy Use (kWh/m ²)	
			percentage	percentage	Existing Building	New Building
Building Type A	Residential	72.18	49.5%	51.7%	35.73	37.32
Building Type B	Government Non-Residential	90.14	50.4%	51.4%	45.43	46.33
Building Type C	Commercial Non-Residential	102.83	50.4%	51.4%	51.83	52.85

- **Share on Energy Carrier (SE)**

Table 18. Share of energy carriers' scenario

Share of energy carrier													
Building	Building Type	Share of Energy Use	Improvement	Share of energy carrier (%)									
				2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	Natural Gas	Electricity increase 2%	49%	48.2%	47.3%	46.3%	45.4%	44.5%	43.6%	42.7%	41.9%	41.0%
		Electricity		51%	51.8%	52.7%	53.7%	54.6%	55.5%	56.4%	57.3%	58.1%	59.0%
Building Type B	Government Non-Residential	Natural Gas		12%	11.7%	11.5%	11.2%	11.0%	10.8%	10.6%	10.4%	10.2%	10.0%
		Electricity		88%	88.3%	88.5%	88.8%	89.0%	89.2%	89.4%	89.6%	89.8%	90.0%
Building Type C	Commercial Non-Residential	Natural Gas		12%	11.7%	11.5%	11.2%	11.0%	10.8%	10.6%	10.4%	10.2%	10.0%
		Electricity		88%	88.3%	88.5%	88.8%	89.0%	89.2%	89.4%	89.6%	89.8%	90.0%

The use of Natural Gas in the form of LPG in the residential sector is extensive due to its use for cooking, as well as a government program for

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subsidized gas. This is not the case for the government and commercial sectors. For example, in the residential sector, the use of Natural Gas decreases as more electricity is used as an energy source, e.g., an electric stove for cooking. The figures in the table below follow the projected emissions baseline calculation until 2030.

- **Average floor area (A)**

The figures in the table below follow the projected emissions baseline calculation until 2030.

Table 19. Average floor area

Average floor area per building												
Building	Building Type	Baseline determination of average baseline floor area of new buildings	Average floor area per building for new buildings (m ²)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	1,00%	39.1	39.5	39.9	40.3	40.7	41.1	41.5	41.9	42.3	42.7
Building Type B	Government Non-Residential	1,00%	355.5	359.0	362.6	366.2	369.9	373.6	377.3	381.1	384.9	388.8
Building Type C	Commercial Non-Residential	1,00%	81.5	82.4	83.2	84.0	84.8	85.7	86.6	87.4	88.3	89.2

- **Energy carrier emission factors (EF)**

In the ex-ante scenarios, the emission factors of both Natural Gas and Electricity decrease by 2% and 3 %, respectively, as established in the roadmap. The figures in the table below follow the projected emissions baseline calculation until 2030.

Table 20. Energy carriers emission factor

Energy Emission Factor													
Building	Building Type	Share of Energy Use	Improvement Reduction %	Emission Factor (gCO ₂ /kWh)									
				2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	Natural Gas	2%	181	177.38	173.83	170.36	166.95	163.61	160.34	157.13	153.99	150.91
		Electricity	3%	870	843.90	818.58	794.03	770.20	747.10	724.69	702.95	681.86	661.40
Building Type B	Government Non-Residential	Natural Gas	2%	181	177.38	173.83	170.36	166.95	163.61	160.34	157.13	153.99	150.91
		Electricity	3%	870	843.90	818.58	794.03	770.20	747.10	724.69	702.95	681.86	661.40
Building Type C	Commercial Non-Residential	Natural Gas	2%	181	177.38	173.83	170.36	166.95	163.61	160.34	157.13	153.99	150.91

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		Electricity	3%	870	843.90	818.58	794.03	770.20	747.10	724.69	702.95	681.86	661.40
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Using Equation 1, the relevant parameters above are calculated for each stage of BGH implementation in a building according to the best-case scenario. The results of the calculation of GHG emissions (MtCO₂) for this optimistic scenario from 2022 to 2030 are as follows:

Table 21 Ex-Ante best-case emission

Emission for Each Year (Existing Building - Non green building)												
Building	Building Type	Emission Type	Emission (Million tCO ₂)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	Natural Gas	37.08	17.18	16.39	14.38	13.02	11.81	10.83	9.97	9.24	8.59
		Electricity	184.01	87.78	86.13	77.70	72.29	67.34	63.37	59.82	56.83	54.11
Building Type B	Government Non-Residential	Natural Gas	0.52	0.14	0.14	0.14	0.13	0.13	0.12	0.12	0.12	0.11
		Electricity	18.49	5.18	5.09	5.00	4.91	4.82	4.73	4.65	4.56	4.48
Building Type C	Commercial Non-Residential	Natural Gas	1.99	0.73	0.71	0.69	0.67	0.65	0.63	0.61	0.59	0.58
		Electricity	70.40	26.35	25.89	25.43	24.97	24.53	24.09	23.65	23.23	22.81
Total Emission			303.61	306.77	312.48	137.37	134.34	123.33	115.99	109.27	103.77	98.83
Emission for Each Year (Existing Building - green building)												
Building	Building Type	Emission Type	Emission (Million tCO ₂)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	Natural Gas	-	0.94	1.24	2.13	2.71	3.21	3.60	3.93	4.19	4.42
		Electricity	-	4.83	6.50	11.52	15.03	18.28	21.03	23.56	25.79	27.87
Building Type B	Government Non-Residential	Natural Gas	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
		Electricity	-	0.23	0.27	0.31	0.35	0.39	0.42	0.46	0.50	0.54
Building Type C	Commercial Non-Residential	Natural Gas	-	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.06	0.06
		Electricity	-	1.02	1.20	1.38	1.55	1.73	1.90	2.06	2.23	2.39
Total Emission			-	7.05	9.25	15.39	19.68	23.66	27.01	30.08	32.78	35.30
Emission for Each Year (New Building)												
Building	Building Type	Emission	Emission (Million tCO ₂)									

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		Type	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	Natural Gas	-	0.20	0.19	0.19	0.19	0.19	0.19	0.18	0.18	0.18
		Electricity	-	9.15	9.32	9.48	9.63	9.79	9.94	10.08	10.22	10.36
Building Type B	Government Non-Residential	Natural Gas	-	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
		Electricity	-	0.059	0.059	0.059	0.059	0.059	0.060	0.060	0.060	0.060
Building Type C	Commercial Non-Residential	Natural Gas	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
		Electricity	-	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total Emission			-	9.72	9.88	10.04	10.20	10.35	10.49	10.64	10.78	10.92
Emission for Each Year (Total)												
Building	Building Type	Emission Type	Emission (Million tCO ₂)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	Natural Gas	37.08	18.32	17.82	16.70	15.92	15.21	14.61	14.08	13.62	13.19
		Electricity	184.01	101.76	101.96	98.70	96.95	95.40	94.34	93.46	92.85	92.35
Building Type B	Government Non-Residential	Natural Gas	0.52	0.15	0.15	0.15	0.14	0.14	0.14	0.13	0.13	0.13
		Electricity	18.49	5.47	5.41	5.36	5.32	5.27	5.22	5.17	5.12	5.08
Building Type C	Commercial Non-Residential	Natural Gas	1.99	0.77	0.75	0.74	0.72	0.70	0.69	0.67	0.66	0.64
		Electricity	70.40	27.67	27.38	27.10	26.83	26.55	26.29	26.02	25.76	25.50
Total Emission			312.48	154.14	153.48	148.75	145.87	143.28	141.28	139.54	138.14	136.89

Ex-Ante emissions benchmark

In this benchmark scenario, based on the Ministry of Public Work's green building implementation roadmap, the number of buildings is determined according to the sectoral target for green building, where policy assessment parameters and implementation are planned to start:

For new buildings: Implementation begins in 2024.

For existing buildings: Modifications will commence in 2025.

The assumed implementation rate is:

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17% annually for Type B buildings (Government buildings), achieving 100% coverage by 2030.

2% annually for Type A and C buildings (Residential and Commercial buildings).

As in the previous scenario, to calculate the Ex-Ante equation, the values of each variable in the GHG estimation for this Ex-Ante scenario must be explained. In particular, the variable Number of buildings (Nb) will be adjusted according to the established Green Building Roadmap, while other variables will remain consistent with the previous baseline calculation.

Number of Buildings (Nb)

Based on the given scenario assumptions, the Green Building Roadmap states that the implementation focus will begin with New Buildings in 2024, with modifications for Existing Buildings starting in 2025.

The modification rates are as follows:

- 17% per year for Government Buildings, aiming to achieve 100% modification before 2030.
- 2% per year for Commercial and Residential Buildings.

As a result, the adjusted number of buildings (Nb) in this calculation is determined as follows:

Table 22. Number of buildings implementing the policy - roadmap

Number of Buildings (Existing Building - Non green building)											
Building	Building Type	Number of buildings per building type									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	78,327,897	79,891,322	81,485,953	83,112,412	84,771,336	86,463,372	88,189,181	89,949,437	91,744,828	93,576,054
Building Type B	Government Non-Residential	238,629	243,392	248,250	253,205	258,259	263,414	268,672	274,034	279,504	285,083
Building Type C	Commercial Non-Residential	4,640,565	4,733,191	4,827,665	4,924,025	5,022,309	5,122,554	5,224,800	5,329,087	5,435,456	5,543,948
Number of Building (Existing Building – green building)											
Building	Building Type	Number of buildings per building type									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Implementation Rate			0%	0%	0%	2%	4%	6%	8%	10%	12%
Building Type A	Residential		-	-	-	1.629.719	3.259.308	4.890.722	6.525.812	8.166.337	9.813.972
Implementation Rate			0%	0%	0%	17%	34%	51%	68%	85%	100%

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Building Type B	Government Non-Residential		-	-	-	43.045	87.808	134.341	182.697	232.929	279.504
Implementation Rate			0%	0%	0%	2%	4%	6%	8%	10%	12%
Building Type C	Commercial Non-Residential		-	-	-	98.481	200.892	307.353	417.984	532.909	652.255
Number of Buildings (New Building)											
Building	Building Type	Number of buildings per building type									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	-	-	-	1.626.460	1.658.924	1.692.036	1.725.809	1.760.256	1.795.391	1.831.227
Building Type B	Government Non-Residential	-	-	-	4.955	5.054	5.155	5.258	5.363	5.470	5.579
Building Type C	Commercial Non-Residential	-	-	-	96.360	98.284	100.245	102.246	104.287	106.369	108.492

- **Improved average annual specific energy use (EUI)**

There is no difference in the EUI improvement value between this scenario and the optimistic scenario. The percentage (%) reduction in EUI is obtained from modelling and simulation results for Residential and Non-Residential buildings, then multiplied by the Baseline EUI value. As a result, the Final EUI (kWh/m²) is determined, as shown in the table below, which will be used to calculate the GHG emission estimates.

Table 23. Improvement of EUI - roadmap

Estimate Annual Specific Energy						
Building	Building Type	Baseline EUI	EUI Saving from Energy Efficiency		Final Annual Specific Energy Use	
		(kWh/m ²)	%	%	(kWh/m ²)	(kWh/m ²)
			Existing Building	New Building	Existing Building	New Building
Building Type A	Residential	61,20	49,5%	51,7%	30,29	31,64
Building Type B	Government Non-Residential	185,67	50,4%	51,4%	93,58	95,43
Building Type C	Commercial Non-Residential	235,25	50,4%	51,4%	118,57	120,92

- **Share on Energy Carrier (SE)**

The figures in the table below follow the projected emissions baseline calculation until 2030.

Table 24. Share of energy carriers' scenario - roadmap

Share of energy carrier													
Building	Building Type	Share of Energy Use	Improvement	Share of energy carrier (%)									
				2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	Natural Gas	Electricity increase 2%	49%	48,2%	47,3%	46,3%	45,4%	44,5%	43,6%	42,7%	41,9%	41,0%
		Electricity		51%	51,8%	52,7%	53,7%	54,6%	55,5%	56,4%	57,3%	58,1%	59,0%
Building Type B	Government Non-Residential	Natural Gas		12%	11,7%	11,5%	11,2%	11,0%	10,8%	10,6%	10,4%	10,2%	10,0%
		Electricity		88%	88,3%	88,5%	88,8%	89,0%	89,2%	89,4%	89,6%	89,8%	90,0%
Building Type C	Commercial Non-Residential	Natural Gas		12%	11,7%	11,5%	11,2%	11,0%	10,8%	10,6%	10,4%	10,2%	10,0%
		Electricity		88%	88,3%	88,5%	88,8%	89,0%	89,2%	89,4%	89,6%	89,8%	90,0%

- **Average floor area (A)**

The figures in the table below follow the projected emissions baseline calculation until 2030.

Table 25. Average floor area - roadmap

Average floor area per building												
Building	Building Type	Baseline determination of average baseline floor area of new buildings	Average floor area per building for new buildings (m ²)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	1,00%	39,1	39,5	39,9	40,3	40,7	41,1	41,5	41,9	42,3	42,7
Building Type B	Government Non-Residential	1,00%	355,5	359,0	362,6	366,2	369,9	373,6	377,3	381,1	384,9	388,8
Building Type C	Commercial Non-Residential	1,00%	81,5	82,4	83,2	84,0	84,8	85,7	86,6	87,4	88,3	89,2

- **Energy carrier emission factors (EF)**

The figures in the table below follow the projected emissions baseline calculation until 2030.

Table 26. Energy carrier emission factors - roadmap

Energy Emission Factor													
Building	Building Type	Share of Energy Use	Improvement Reduction	Emission Factor (gCO ₂ /kWh)									
				%	2021	2022	2023	2024	2025	2026	2027	2028	2029
Building Type A	Residential	Natural Gas	2%	181	177,38	173,83	170,36	166,95	163,61	160,34	157,13	153,99	150,91
		Electricity	3%	870	843,90	818,58	794,03	770,20	747,10	724,69	702,95	681,86	661,40
Building Type B	Government Non-Residential	Natural Gas	2%	181	177,38	173,83	170,36	166,95	163,61	160,34	157,13	153,99	150,91
		Electricity	3%	870	843,90	818,58	794,03	770,20	747,10	724,69	702,95	681,86	661,40
Building Type C	Commercial Non-Residential	Natural Gas	2%	181	177,38	173,83	170,36	166,95	163,61	160,34	157,13	153,99	150,91
		Electricity	3%	870	843,90	818,58	794,03	770,20	747,10	724,69	702,95	681,86	661,40

Using Equation 1, the relevant parameters above are calculated for each stage of green building implementation in a building according to the benchmark roadmap scenario. The results of the calculation of GHG emissions (million tCO₂) for this optimistic scenario from 2022 to 2030 are:

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Table 27 Ex-Ante emission - roadmap

Emission for Each Year (Existing Building - Non BGH)												
Building	Building Type	Emission Type	Emission (Million tCO ₂)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	Natural Gas	16,68	16,51	16,33	15,84	15,37	14,91	14,47	14,06	13,65	13,27
		Electricity	82,81	84,35	85,85	85,62	85,32	85,01	84,68	84,34	83,98	83,61
Building Type B	Government Non-Residential	Natural Gas	0,34	0,34	0,33	0,32	0,27	0,21	0,15	0,10	0,05	-
		Electricity	12,06	12,09	12,11	11,90	9,89	7,88	5,86	3,83	1,80	-
Building Type C	Commercial Non-Residential	Natural Gas	1,93	1,90	1,88	1,83	1,77	1,72	1,66	1,61	1,56	1,51
		Electricity	68,19	68,32	68,45	67,24	66,01	64,77	63,53	62,28	61,02	59,76
Total Emission			182,01	183,51	184,97	182,74	178,63	174,50	170,36	166,22	162,06	158,14
Emission for Each Year (Existing Building - BGH)												
Building	Building Type	Emission Type	Emission (Million tCO ₂)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	Natural Gas	-	-	-	-	0,15	0,30	0,43	0,56	0,67	0,79
		Electricity	-	-	-	-	0,84	1,68	2,51	3,34	4,15	4,96
Building Type B	Government Non-Residential	Natural Gas	-	-	-	-	0,01	0,02	0,03	0,03	0,04	0,05
		Electricity	-	-	-	-	0,33	0,66	1,00	1,33	1,66	1,96
Building Type C	Commercial Non-Residential	Natural Gas	-	-	-	-	0,00	0,01	0,01	0,02	0,02	0,03
		Electricity	-	-	-	-	0,17	0,35	0,52	0,70	0,87	1,05
Total Emission			-	-	-	-	1,51	3,01	4,50	5,97	7,43	8,83
Emission for Each Year (New Building)												
Building	Building Type	Emission Type	Emission (Million tCO ₂)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	Natural Gas	-	-	-	0,16	0,16	0,16	0,16	0,16	0,15	0,15
		Electricity	-	-	-	8,04	8,17	8,30	8,42	8,55	8,67	8,79
Building Type B	Government	Natural Gas	-	-	-	0,003	0,003	0,003	0,003	0,003	0,003	0,003

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	Non-Residential	Electricity	-	-	-	0,122	0,122	0,122	0,123	0,123	0,123	0,123
Building Type C	Commercial Non-Residential	Natural Gas	-	-	-	0,02	0,02	0,02	0,02	0,02	0,02	0,02
		Electricity	-	-	-	0,69	0,69	0,69	0,69	0,69	0,70	0,70
Total Emission			-	-	-	9,03	9,16	9,29	9,42	9,54	9,66	9,78
Emission for Each Year (Total)												
Building	Building Type	Emission Type	Emission (Million tCO ₂)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building Type A	Residential	Natural Gas	16,68	16,51	16,33	16,01	15,68	15,37	15,06	14,77	14,48	14,21
		Electricity	82,81	84,35	85,85	93,65	94,34	94,99	95,62	96,22	96,80	97,36
Building Type B	Government Non-Residential	Natural Gas	0,34	0,34	0,33	0,33	0,28	0,23	0,18	0,14	0,09	0,05
		Electricity	12,06	12,09	12,11	12,02	10,34	8,66	6,98	5,28	3,59	2,08
Building Type C	Commercial Non-Residential	Natural Gas	1,93	1,90	1,88	1,85	1,80	1,75	1,70	1,65	1,60	1,55
		Electricity	68,19	68,32	68,45	67,93	66,87	65,81	64,75	63,67	62,59	61,50
Total Emission			182,01	183,51	184,97	191,78	189,31	186,81	184,28	181,73	179,15	176,75

5.7 Assessment Results

Returning to the objective of the ex-ante calculation, as stated at the beginning of this chapter, which is to assess the impact of policy implementation on baseline emissions until 2030. The projected emissions under the best-case scenario relative to the baseline before policy implementation in 2021 are shown in Figure 18. The baseline projection is 312 million tons of CO₂, decreasing to almost 137 million tons by 2030 under the best-case scenario.

The emission reduction in the best-case scenario is compared to the benchmark roadmap BGH in Figure 19. As depicted, the best-case scenario results in an emission reduction of 271 MtCO₂ compared to the benchmark roadmap BGH, which yields 109 MtCO₂.

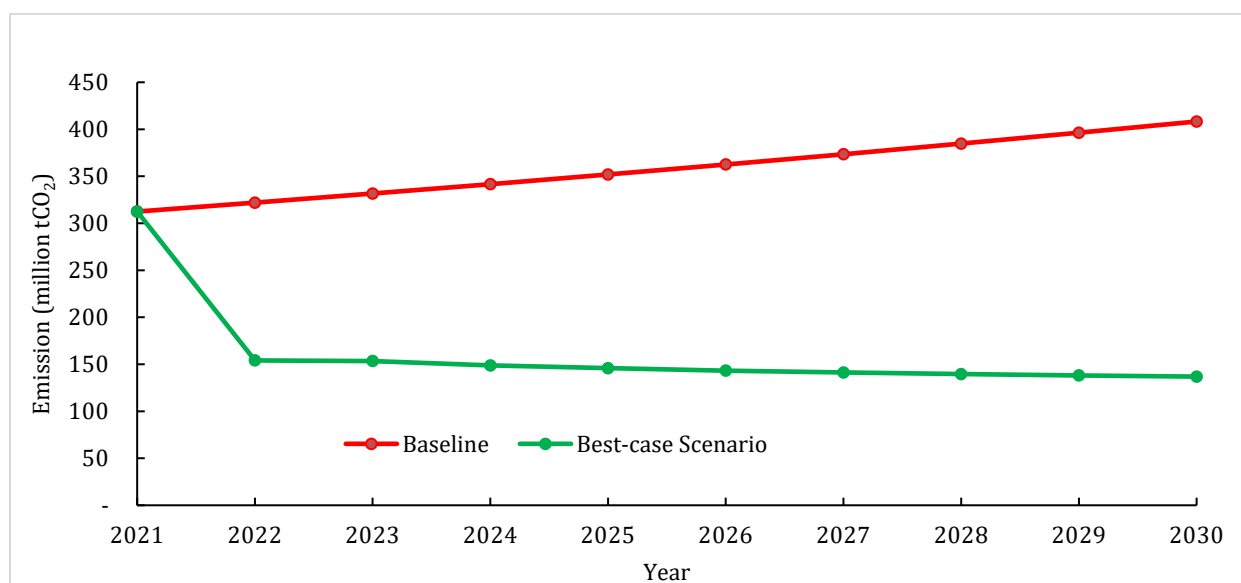


Figure 18. Emission impact of the best-case scenario

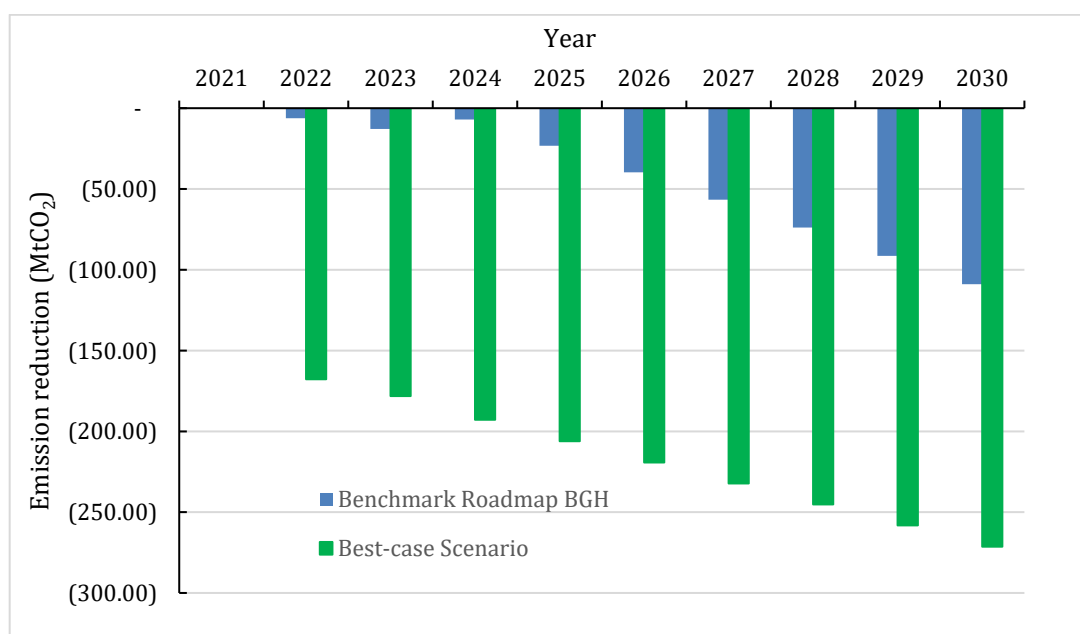


Figure 19. Ex-ante emission reduction in the best-case scenario and the benchmark roadmap of BGH

6. Ex-Post Impact Assessment

As explained in the previous chapter, in accordance with the Minister of Public Works Regulation No. 21/2021 on Green Building, which has begun to apply the Green Building (BGH) rules, some new buildings are now applying these rules, as evidenced by a study on GHG impact conducted after their application.

5.1 Methodology

This assessment estimates GHG emission reductions from an environmental perspective, based on implementing the Green Building Policy as a new policy for the planning and construction of new buildings in the national territory. An ex-post approach was used for this policy, with 2021 as the base year and 2022, 2023, and 2024 as the assessment years. The calculations used were based on ICAT's emission impact assessment guidelines modified to accommodate the policy objectives of the Green Building Policy. The following steps were taken in the estimation: (1) identifying data availability and quality; (2) assessing total emissions from Green Building Policy implementation; and (3) evaluating the overall Green Building Policy impact in the assessment year.

Primary and secondary data were collected and used for this calculation as described in the Table 28 below. Unfortunately, data on Green Building implementation is not available in official government statistics. However, this type of data was obtained from Green Building implementation data from 2022 through the Green Building Secretariat, Ministry of Public Works. Based on this data, the GHG Impact Assessment (Ex-Post) for Green Building will be conducted.

Table 28. Data requirements for Ex-Post assessment

No	Data Category	Type of Data	Source
1	Building Type	Secondary	Indonesia Green Building Roadmap
2	Construction Rate	Secondary	Ministry of Public Works Building Roadmap
3	Green Building Number	Primary	Green Building Secretariat
3	Demolition Rate	Secondary	Ministry of Public Works Building Roadmap
4	Annual specific energy use per m ²	Primary	Ministry of Energy and Mineral Resources
5	Energy carrier mix (natural gas or electricity)	Secondary	Ministry of Energy and Mineral Resources
6	Average floor area	Secondary	Indonesia Green Building Roadmap
7	Emission Factor	Secondary	Ministry of Energy and Mineral Resources

The Green Building Policy consists of implementing rules for new buildings that follow low-emission principles from planning, construction, and operation. In this case, Green Building implementation is focused on Government Buildings and Commercial Buildings. This is followed by Residential Buildings for the R2 and R3 electricity categories. This is closely related to a government-issued building certification.

After establishing the GHG emissions baseline in the previous chapter, the estimated emission reductions resulting from policies implemented in buildings will be assessed. As outlined in the ICAT Buildings Efficiency Guidance, ex-post emission reductions are calculated by subtracting ex-post scenario emissions from baseline emissions. Then the policy scenario and baseline emissions are projected.

The assessment period is a long-term one, spanning 2022 to 2024, the period since the enactment of the regulation in question, in accordance with Indonesia's targets set out in its Nationally Determined Contributions (NDCs).

In order to achieve the targets, set in the NDC, the implementation and development of green buildings by 2024 is expected to contribute to the reduction of approximately 37 million tonnes of CO₂. This reduction is in line with the target of saving greenhouse gas emissions through independent efforts in the Energy Sector, as stated in the Green Building Roadmap.

Green Building policies can have a significant impact on air pollution and GHG emissions if they focus on green planning, construction, and operations. Based on the roadmap issued by the Green Building Secretariat, the focus of BGH implementation is as follows: 1) The primary focus will be on Government Buildings (Segmentation P-2), starting in 2024 for ALL New Buildings, and in 2025 for Existing Buildings (through customisation or retrofit); 2) Commercial Buildings (Segmentation B-3 such as private offices, malls, hospitals, and others) are also targeted in the implementation of this BGH roadmap. In Commercial Buildings, the focus on New Buildings will start in 2024, and Existing Building stock from 2025, with a conversion rate of 2% per year; and 3) It is also expected that New Households (R2 and R3 Segment) can achieve energy savings through the application of best practices from BGH. In 2024, the implementation of BGH will focus on New Households, especially high-energy users in the R2 and R3 segments that depend on air conditioning units ("AC").

Boundaries

- Number of buildings (historic data from 2021 until 2024), the number has been adjusted to the construction and demolition rate.
- Adjusted share of energy mix.

Assumption:

- Emission impact of the Green Building policy is assessed only for the year 2022-2024:
 - Green building implemented number based on the Green Building Secretariat Data.
- The other data are based on the Ministry of Public Works and the Ministry of Energy and Mineral Resources.
- Green Building is assumed to be zero emission due to the limited number of implemented buildings.

Justification (expert judgement):

- Due to the limited data and their limited quality, the methodology is adjusted based on the consultation with experts

5.1 Ex-Post Emissions

According to the Green Building Secretariat, the number of Green Buildings in Indonesia is as follows:

1. By 2021 and 2022, two government buildings have implemented the Green Building.
2. In 2023, 595 residential buildings are implementing Green Building, followed by one government building and one commercial building.
3. Finally, in 2024, 578 residential buildings and 16 government buildings implement green building practices.

The table below shows the parameters and steps used to estimate the impact of the Green Building Policy.

Table 29. Ex-Post assessment

Estimate Number of Building							
Building	Building Type	Baseline Demolition Rate	Baseline Construction Rate	Number of buildings per building type			
				2021	2022	2023	2024
Building Type A	Residential	0.20%	2%	78,327,897	79,891,322	81,485,953	83,112,412
Building Type B	Government Non-Residential	0.20%	2%	238,629	243,392	248,250	253,205
Building Type C	Commercial Non-Residential	0.20%	2%	4,640,565	4,733,191	4,827,665	4,924,025
BGH Implementation							
Building	Building Type	Number of buildings use BGH					
		2021	2022	2023	2024		
Building Type A	Residential	0.00	0.00	595.00	1173.00		
Building Type B	Government Non-Residential	2.00	2.00	3.00	19.00		
Building Type C	Commercial Non-Residential	0.00	0.00	1.00	1.00		
Estimate Annual Specific Energy							
Building	Building Type	Annual Specific Energy Use	Average annual specific energy use per m2 (kWh/m2)				
			(kWh/m2)	2021	2022	2023	2024
Building Type A	Residential	136.00	136.00	136.00	136.00	136.00	136.00
Building Type B	Government Non-Residential	284.52	284.52	284.52	284.52	284.52	284.52
Building Type C	Commercial	242.87	242.87	242.87	242.87	242.87	242.87

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	Non-Residential					
Share of energy carrier						
Building	Building Type	Share of Energy Use	Share of energy carrier (%)			
			2021	2022	2023	2024
Building Type A	Residential	Natural Gas	49%	49%	49%	49%
		Electricity	51%	51%	51%	51%
Building Type B	Government Non-Residential	Natural Gas	12%	12%	12%	12%
		Electricity	88%	88%	88%	88%
Building Type C	Commercial Non-Residential	Natural Gas	12%	12%	12%	12%
		Electricity	88%	88%	88%	88%
Average floor area per building						
Building	Building Type	Baseline determination of average baseline floor area of new buildings	Average floor area per building for new buildings (m2)			
			2021	2022	2023	2024
Building Type A	Residential	1.00%	39.1	39.5	39.9	40.3
Building Type B	Government Non-Residential	1.00%	355.5	359.0	362.6	366.2
Building Type C	Commercial Non-Residential	1.00%	81.5	82.4	83.2	84.0
Energy Emission Factor						
Building	Building Type	Share of Energy Use	Emission Factor (gCO2/kWh)			
			2021	2022	2023	2024
Building Type A	Residential	Natural Gas	181	181.00	181.00	181.00
		Electricity	870	870.00	870.00	870.00
Building Type B	Government Non-Residential	Natural Gas	181	181.00	181.00	181.00
		Electricity	870	870.00	870.00	870.00
Building Type C	Commercial Non-Residential	Natural Gas	181	181.00	181.00	181.00
		Electricity	870	870.00	870.00	870.00
Baseline Emission for Each Year						
Building	Building Type	Emission Type	Emission (Million tCO2)			
			2021	2022	2023	2024
Building Type A	Residential	Natural Gas	37.08	38.20	39.35	40.53
		Electricity	184.01	189.56	195.28	201.17
Building Type B	Government Non-Residential	Natural Gas	0.52	0.54	0.55	0.57
		Electricity	18.49	19.05	19.62	20.21
Building Type C	Commercial Non-Residential	Natural Gas	1.99	2.05	2.11	2.17
		Electricity	70.40	72.52	74.71	76.96
Total Emission (Ex Post BGH)			312.48	321.9066	331.6133	341.6117
Total Emission (Baseline)			312.48	321.9067	331.6153	341.6167

Total Emission Interval	Approach Year	+0.00016	+0.00197	+0.00499
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The Ex-Post GHG emissions are stagnant from 2022 to 2024, indicating that the emission reduction from the number of buildings implementing the green building policy remained low and insufficient to compensate for emissions from the construction of new buildings. This demonstrates that the period from 2022 to 2024 was still an adjustment period, with green building certification beginning in 2025 on old buildings, including government, commercial, and residential buildings.

Due to limited time and the enforcement of the policy, the ex-post calculation results in a minimal emission reduction. The study considers the assumption that certified green buildings emit zero emissions to achieve notable reduction results.

7. Conclusion and Recommendation

This study seeks to assess the impact of the Green Building regulation of the Ministry of Public Works of Indonesia, Ministry of Public Work Regulation No. 21/2021, on GHG emissions using building efficiency guidance developed by the Initiative for Climate Action Transparency (ICAT). The regulation assessed outlines the mandatory and recommended requirements for new and existing buildings to be green. The assessment focuses on energy efficiency and renewable energy uses parameters of the policy. Alongside this regulation, MPW issued a green building roadmap in 2023, which outlines the strategies to achieve the green building development target. In the roadmap, MPW estimated that approximately 37 MtCO₂ reduction can be achieved by the year 2030 through capacity building and implementation of green building policy.

The calculation of baseline GHG emissions for residential, government, and commercial buildings in Indonesia uses 2021 as the reference year, incorporates building population data, floor area, energy use, and emissions factors. Baseline emissions are projected from 2021 to 2024 utilizing the building's construction and demolition rates. From the baseline data above, several improvements on the building model are introduced and simulated with several cases of various parameters. The simulation resulted in energy use intensity improvements of up to 47%, 68%, and 58% for residential, government, and commercial buildings, respectively. Implementing those improvements, the Ex-Ante scenario of GHG emissions shows a total of **137 MtCO₂**, a reduction of **271 MtCO₂** compared to the baseline.

Ex-Post emissions are calculated based on the following data:

- By 2021 and 2022, there are two government buildings that implement Green Building.
- In 2023, 595 residential buildings are implementing Green Building, followed by one government building and one commercial building.
- Finally, in 2024, 578 residential buildings and 16 government buildings implement green building practices.

The Ex-Post GHG emissions are stagnant from 2022 to 2024, indicating that the emission reduction from the number of buildings implementing the green building policy remained low and insufficient to compensate for emissions from the construction of new buildings. Further enforcement of the regulation is needed to achieve the roadmap target and maximize the potential reduction in GHG emissions.

These findings provided constructive feedback for refining the ICAT guidance, going beyond its original use for the ICAT building efficiency as summarized below:

- a. Going beyond its original use as for the ICAT building efficiency guidance, there is a need for more granular classifications of residential buildings (e.g., houses vs. apartments); the addition of electricity source(s), e.g., solar panels, in the share of energy carrier, implementation levels and further classification of house and apartments to improve the applicability of the guidance.
- b. The use of Natural Gas is predominantly high in residential buildings, as opposed to Government and Commercial buildings, which is specific to the Indonesian context. This is due to the LPG energy subsidy program, one of the forms of Natural Gas, given to low-income households in residential buildings.
- c. The guidance could provide more practical examples of how to balance trade-offs between accuracy and conservativeness and real-world situations, e.g., when data is scarce or must be obtained through proxy values.

- d. The guidance could better illustrate how to incorporate diverse perspectives (builders, developers, financial institutions, and vulnerable groups) into the quantitative assessment during stakeholders' participation.
- e. The guidance could include minimum MRV system requirements (e.g., frequency of data collection, mandatory vs. voluntary audits), as well as examples of digital tools (e.g., databases, dashboards).
- f. The guidance could provide a qualitative assessment framework for information policies, e.g., awareness campaigns and training, due to the difficulty of quantification, as these are identified as a key barrier to practical implementation.
- g. The guidance could provide standardized adjustment factors or rules for common overlaps, e.g., between building codes and appliance MEPS, so that practitioners can avoid over- or underestimation.
- h. The guidance could include capacity-building pathways and references to international finance instruments, e.g., GCF readiness funds and ESCO models, to address the capacity challenges of implementing agencies with limited resources.

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Annex 1

Stakeholders Identification for Building Efficiency in Indonesia.

Stakeholders	Roles in Building Efficiency Initiative
Public Sector at National Level	
Ministry of Public Works (MPW)	Leading ministry in building sector, who is responsible for formulation, implementing, and monitoring national policies related to buildings in Indonesia. MPW issued the green building regulations, called Minister of Public Works Regulation No. 21/2021 on Green Building, which is the main policy assessed in this project.
Ministry of Energy and Mineral Resources (MEMR)	Leading ministry in energy sector, responsible for monitoring and developing strategies on energy transition, namely the use of renewable energy and implementation of energy efficiency. MEMR also boost the initiative to enhance energy efficiency in building sector through PSBE (Penghargaan Subroto Bidang Efisiensi Energi). This award recognizes building owners or managers with outstanding achievements in energy efficiency.
Ministry of Environment and Forestry (MoEF)	Leading ministry responsible for coordinating activities related to climate change; MoEF is the institution responsible in developing Indonesia eNDC, in which GHG emissions reduction is the main topic outlined, and MoEF is responsible any GHG emissions reduction initiatives in every sector, including buildings.
Public Sector at Regional/Local level	
Local Governments	Responsible for distributing, allocating, and managing yearly Anggaran Pendapatan dan Belanja Daerah or APBD (local budget and expenditure) including budgeting for the governmental or public building sub-sectors in the region.
Local Planning Agencies (BAPPEDA)	Responsible for elaborating national into regional mid-term development plans to serve as planning guidelines for sectoral offices in the local governments, including budgeting.
Local City Landscape / Spatial Offices (Dinas Tata Kota) at Provincial Level	Responsible for managing the construction and spatial planning of buildings in the region, in line with government regulations regarding regional building sector management, including building efficiency.
Local Environmental Agencies (BPLHD, BLH)	Responsible for environment-related activities as mandated by MoEF, including managing and supervising any effort on GHG emissions reduction
State-Owned Enterprises	

Stakeholders	Roles in Building Efficiency Initiative
National Electricity Company (PLN)	Most of buildings in Indonesia used on-grid electricity, where PLN is the only institution (company) rightful to distribute on-grid electricity to users.
National Residence (PERUMNAS)	A state-owned enterprise in Indonesia focused on national housing development. It is a public company where all shares are owned by the government and plays a crucial role in urban development.
National Developers & Contractors (WIKA, WASKITA, Adhi Karya, etc.)	These stakeholders are developers and contractors, responsible for carrying out procurement and construction of new infrastructures, including large scale buildings across Indonesia.
Private Sectors	
Building or Property Developers and Contractors	Large- and small-scale developers and contractors implementing design, procurement, and construction of office buildings, apartments, houses, etc.
Building Utility Suppliers <ul style="list-style-type: none"> - Mechanical (AC, heating appliances, building transportation systems, etc.) - Electrical (transformers, panels, cables, etc.) - Plumbing (pump, piping, valve, etc.) - Lighting 	GHG emission reduction initiative will trigger this stakeholder to develop more eco-friendly utilities, for instance, air conditioner with green refrigerant, high efficiency motors, LED lamps, etc, which contribute directly to decarbonization in building sector.
Building Management Company	Most large-scale buildings have building managers who are responsible for managing the energy uses of the building, including conducting maintenance, repair, and monitoring of all energy appliances inside the buildings.
Consulting firms	Performing consultancy services on buildings, e.g. energy audit, HVAC technical assessments, power quality analysis, etc.
Development Agencies	
C40 CITIES	C40 Cities is a global network comprising nearly 100 mayors from leading cities around the world (including Jakarta) that are committed to addressing the climate crisis through joint actions and initiatives, with building topics become one of the priorities.
Indonesia Climate Change Trust Funds (ICCTF)	Established by the Government of Indonesia as a national trust fund aimed at supporting emissions reduction and promoting low carbon development initiatives.

Stakeholders	Roles in Building Efficiency Initiative
Indonesia Business Council for Sustainable Development (IBCSD)	An association led by CEOs of various companies operating in Indonesia that focuses on promoting sustainable development through sustainable economic growth and ecological responsibility, adhering to the Sustainable Development Goals (SDGs) as a guiding framework.
Expert Organizations (related to buildings)	
ASHRAE - Indonesia	ASHRAE Indonesia's mission is to advance the arts and sciences of HVAC and refrigeration, aiming to create a healthy and sustainable built environment. The chapter serves as a platform for information and communication about refrigeration, heating, ventilation, and air conditioning (RHVAC) in Indonesia.
Building Engineers Association - Indonesia	Professional organization for building engineering experts in Indonesia. Provides training and certification for members, fosters a managerial spirit in engineering, and promotes awareness of regulations related to building management.
GBCI (Green Building Council Indonesia)	GBCI was established to promote sustainable building practices in the country. It operates through collaboration among various stakeholders, including professionals in the construction sector. GBCI also develops certification systems aimed at assessing and promoting green building initiatives.
IABHI (Ikatan Ahli Bangunan Hijau Indonesia)	IABHI) or the Indonesian Green Building Experts Association, is a professional organization dedicated to promoting green building practices and sustainability in the built environment in Indonesia. IABHI's activities include providing training and certifications, raising awareness on environmental issues, advocating for sustainable practices, and helping align the construction industry with eco-friendly standards and regulations.
A2RTU	An association in Indonesia aimed at advancing the fields of refrigeration and air conditioning through studies, research, and training. A2rtu also plays an important role in advocating for sustainable and energy-efficient practices, especially considering Indonesia's growing demand for cooling and climate control solutions in both residential and commercial buildings.
Academic Institutions	
State and Private Academic Institutions	Academic Institutions, especially in engineering field, includes studies and research on building sectors, in which green building become part of the research focus, starting from green design, green materials and appliances, and innovative energy efficiency measures.

Stakeholders	Roles in Building Efficiency Initiative
Non-Government Organizations, Communities, and Media	
NGOS related to building, energy, or environment	Play important roles as multipliers and raise awareness of building efficiency at both national and local levels.
Communities related to building, energy, or environment	Communities who have concerns on environment, including green building scattered across regions in Indonesia, holding meetings, discussions, and environmental campaign, e.g. through social media.
Local, national, and international media	Campaign for awareness-raising on building efficiency.

Annex 2

Assessment Parameter of regulation *Permen PUPR No. 21 Tahun 2021*.

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
New Building (Mandatory)	Planning	A.1.a	A building with its longest wall facing the North-South direction, with a maximum tilt angle of 15° relative to the North-South axis.	1	Heating and Cooling	Reduced GHG emissions from reduced energy use
New Building (Mandatory)	Planning	A.1.b	A building with its longest wall oriented along the East-West axis, with a length exceedingly twice that of the North-South direction, and featuring engineered modifications to the building envelope (façade) and/or openings along the East-West axis.	2	Heating and Cooling	Reduced GHG emissions from reduced energy use
New Building (Mandatory)	Planning	A.2.a	Roofing and pavement materials with a solar reflectance (albedo) value of at least 0.3.	1	Heating and Cooling	Reduced GHG emissions from reduced energy use
New Building (Mandatory)	Planning	A.9.b	Engineering the integration of natural air and light into the building.	1	Heating and Cooling	Reduced GHG emissions from reduced energy use
New Building (Mandatory)	Planning	B.1.a	The building envelope has an accumulated Overall Thermal Transfer Value (OTTV) and Roof Thermal Transfer Value (RTTV) of a maximum of 35 Watt/m ² . Note: If the building is planned without an air	5	Heating and Cooling	Reduced GHG emissions from reduced energy use

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
			conditioning system, it will receive full value.			
New Building (Mandatory)	Planning	B.1.b	The ratio of transparent building envelope to solid building envelope, or the Window to Wall Ratio (WWR), should be less than 30%. Note: If the building is planned without an air conditioning system, it will receive full value.	4	Heating and Cooling	Reduced GHG emissions from reduced energy use
New Building (Mandatory)	Planning	B.2	Buildings with air-conditioned spaces but designed not to condition certain passive areas (such as corridors, lift lobbies, toilets, etc.) and are equipped with natural ventilation or mechanical ventilation so that thermal comfort is still met.	3	Heating and Cooling	Reduced GHG emissions from reduced energy use
New Building (Mandatory)	Planning	B.3.a	It is planned to use Air Conditioning (AC) with a room temperature of no lower than 25°C±1°C and a relative humidity of 60% ±10%. Note: If the building is planned without an air conditioning system, it will receive full points.	2	Heating and Cooling	Reduced GHG emissions from reduced energy use
New Building (Mandatory)	Planning	B.3.b	The kW/TR or COP of air conditioning equipment must comply with SNI 6390:2020 or the latest edition. Note: If the building is planned without an air	5	Heating and Cooling	Reduced GHG emissions from reduced energy use

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
			conditioning system, it will receive full points.			
New Building (Mandatory)	Planning	D.2.a	Each room, including those equipped with air conditioning systems, must be designed with a ventilation system and provided with a fresh air supply in accordance with the requirements of SNI 03-6572-2001 or the latest edition, considering CO ₂ and/or CO levels.	3	Heating and Cooling	Reduced GHG emissions from reduced energy use
New Building (Mandatory)	Planning	D.2.b	Every enclosed space in a building with high density and/or the potential for CO ₂ accumulation must be equipped with CO ₂ sensors with alarms and an automatic mechanical ventilation system to ensure that the comfort threshold for CO ₂ concentration (1000 ppm) is not exceeded.	3	Heating and Cooling	Reduced GHG emissions from reduced energy use
New Building (Mandatory)	Planning	D.3.a	Rooms are designed without using air conditioning units that use refrigerants.	5	Heating and Cooling	Reduced GHG emissions from reduced energy use
New Building (Mandatory)	Planning	D.3.b.1)	If a room must use an air conditioning unit, the unit should be selected with a refrigerant that has an Ozone Depletion Potential (ODP) of zero.	3	Heating and Cooling	Reduced GHG emissions from reduced energy use

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
New Building (Mandatory)	Planning	D.3.b.2)	Air conditioning units should use refrigerants with a Global Warming Potential (GWP) of no more than 700.	2	Heating and Cooling	Reduced GHG emissions from reduced energy use
New Building (Mandatory)	Construction	A.1.b.2 .d)	Compliance of indoor air quality technical planning criteria with its construction implementation.	7	Heating and Cooling	Reduced GHG emissions from reduced energy use
New Building (Mandatory)	Construction	B.5.a.2)	Has energy management procedures from the planning stage, control and monitoring of planning to the evaluation of electricity consumption in the project. Note: Optimizing the use of Air Conditioning (AC) or replacing AC with natural ventilation where possible.	1	Heating and Cooling	Reduced GHG emissions from reduced energy use
New Building (Mandatory)	Operation	B.2.a.2)	Compliance with energy efficiency criteria according to construction implementation: Air Conditioning System: Compliance of air conditioning equipment efficiency with testing and commissioning results. If an air conditioning system is not used, full points are awarded.	9	Heating and Cooling	Reduced GHG emissions from reduced energy use
Existing Building (Mandatory)	Operation	A.3.d	Documentation of results and operational parameter	1	Heating and Cooling	Reduced GHG emissions

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
			data of equipment in the form of logbooks (AC, elevators, generators, etc.) stored for at least the last 12 months (for periodic reporting).			from reduced energy use
Existing Building (Mandatory)	Operation	B.4.a	Compliance with indoor air quality criteria in accordance with construction implementation. Compliance with indoor air quality parameters includes temperature, relative humidity, air speed, CO ₂ concentration, and PM2.5.	12	Heating and Cooling	Reduced GHG emissions from reduced energy use
Existing Building (Mandatory)	Operation	A.6.a.1).a)	The building envelope has an Overall Thermal Transfer Value (OTTV) and Roof Thermal Transfer Value (RTTV) of no more than 35 Watts/m ² .	5	Heating and Cooling	Reduced GHG emissions from reduced energy use
Existing Building (Mandatory)	Operation	A.6.a.1).b)	The ratio of the transparent building envelope to the solid building envelope (Window to Wall Ratio) is less than 30%.	3	Heating and Cooling	Reduced GHG emissions from reduced energy use
Existing Building (Mandatory)	Operation	A.6.a.2)	Buildings with rooms equipped with air conditioning systems but are planned not to condition some or all passive spaces (corridors, lift lobbies, toilets, etc.) and are equipped with natural or mechanical ventilation to maintain thermal comfort.	2	Heating and Cooling	Reduced GHG emissions from reduced energy use

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
Existing Building (Mandatory)	Operation	A.6.a.3).a)	Planned to use Air Conditioning (AC) with a minimum room temperature of 25°C±1°C and relative humidity of 60% ±10%.	1	Heating and Cooling	Reduced GHG emissions from reduced energy use
Existing Building (Mandatory)	Operation	A.6.a.3).b)	The kW/TR or COP of air conditioning equipment must comply with SNI 6390:2020 or the latest edition.	4	Heating and Cooling	Reduced GHG emissions from reduced energy use
Existing Building (Mandatory)	Operation	A.6.c.2).a)	Rooms are designed not to use air conditioning units that use refrigerants.	4	Heating and Cooling	Reduced GHG emissions from reduced energy use
Existing Building (Mandatory)	Operation	A.6.c.2).b).(1)	If a room must use an air conditioning unit, the unit should be selected with a refrigerant that has an Ozone Depletion Potential (ODP) of zero.	2	Heating and Cooling	Reduced GHG emissions from reduced energy use
Existing Building (Mandatory)	Operation	A.6.c.2).b).(2)	Air conditioning units should use refrigerants with a Global Warming Potential (GWP) of no more than 700.	1	Heating and Cooling	Reduced GHG emissions from reduced energy use
Existing Building (Mandatory)	Operation	C.2.a.2)	Compliance with energy efficiency criteria according to construction implementation: Air Conditioning System: Compliance of air conditioning equipment efficiency with testing and commissioning results. If an air conditioning	4	Heating and Cooling	Reduced GHG emissions from reduced energy use

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
			system is not used, full points are awarded.			
Existing Building (Mandatory)	Operation	C.4.a	Compliance of indoor air quality criteria with the implementation of renovation construction.	8	Heating and Cooling	Reduced GHG emissions from reduced energy use
New Building (Mandatory)	Planning	A.9.b	Engineering to introduce natural air and light into the building.	1	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)
New Building (Mandatory)	Planning	B.4.a.1)	The artificial lighting system in rooms is planned to have maximum power and lighting levels according to SNI 6197:2020 or the latest edition.	2	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)
New Building (Mandatory)	Planning	B.4.a.2)	There is one switch for rooms smaller than 30 m ² .	2	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
						efficient lighting and appliances)
New Building (Mandatory)	Planning	B.4.a.3)	Use of occupancy sensors/lighting controllers in rooms with specific functions as required by SNI 6197:2020 or the latest edition.	2	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)
New Building (Mandatory)	Planning	B.4.b.1)	Areas that receive natural light according to standards have separate lamp grouping from areas that do not receive natural light.	4	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)
New Building (Mandatory)	Planning	B.4.b.2)	Areas that receive natural light according to standards are equipped with light intensity (lux) sensors that can adjust the lighting according to the standard illumination level.	2	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
New Building (Mandatory)	Planning	B.5.b.4)	Use energy-saving lighting and AC systems for at least 30% of total usage during construction activities. Note: Replacing conventional lights with LED lights.	3	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)
New Building (Mandatory)	Planning	D.3.a	Have conducted and have a report on energy audits for equipment.	1	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)
New Building (Mandatory)	Construction	D.3.b	Have regulations on energy conservation in the company (green policies).	1	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)
New Building (Mandatory)	Operation	A.1.a.2)	Have documentation in the form of SOPs regarding energy-saving measures	5	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
			within the energy management system.			energy use (due to increased use of energy efficient lighting and appliances)
New Building (Mandatory)	Operation	A.3.d	Documentation of results and operational parameter data of equipment in the form of logbooks (AC, elevators, generators, etc.) stored for at least the last 12 months (for periodic reporting).	2	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)
New Building (Mandatory)	Operation	B.2.a.1)	Compliance with energy efficiency criteria according to construction implementation: Ventilation System: Compliance with the minimum fresh air flow rate, particularly in high-density rooms (2.3 m ² /person).	1	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)
New Building (Mandatory)	Operation	B.2.a.3)	Compliance with energy efficiency criteria according to construction implementation: Lighting System: Compliance with room illumination levels (lux).	3	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
						efficient lighting and appliances)
New Building (Mandatory)	Operation	B.2.a.4)	Compliance with energy efficiency criteria according to construction implementation: Building Transportation System: Compliance with elevator waiting times during peak hours as per SNI 03-6573-2001. If no elevators are used, full points are awarded.	1	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)
Existing Building (Mandatory)	Operation	A.6.a.4).a).(1)	The artificial lighting system in rooms is planned to have maximum power and illumination levels according to SNI 6197:2020 or the latest edition.	1	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)
Existing Building (Mandatory)	Operation	A.6.a.4).a).(2)	There is one switch for rooms smaller than 30 m ² .	1	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
Existing Building (Mandatory)	Operation	A.6.a.4).a).(3)	Use of occupancy sensors/lighting controllers in rooms with specific functions as required by SNI 6197:2020 or the latest edition.	1	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)
Existing Building (Mandatory)	Operation	A.6.a.4).b).(1)	Areas that receive natural light according to standards have separate lamp grouping from areas that do not receive natural light.	3	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)
Existing Building (Mandatory)	Operation	A.6.a.4).b).(2)	Areas that receive natural light according to standards are equipped with light intensity (lux) sensors that can adjust the lighting according to the standard illumination level.	1	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)
Existing Building (Mandatory)	Operation	C.2.a.3)	Compliance with energy efficiency criteria according to construction implementation:	2	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
			Lighting System: Compliance with room illumination levels (lux).			energy use (due to increased use of energy efficient lighting and appliances)
Existing Building (Mandatory)	Operation	C.2.a.4)	Compliance with energy efficiency criteria according to construction implementation: Building Transportation System: Compliance with elevator waiting times during peak hours as per SNI 03-6573-2001. If no elevators are used, full points are awarded.	1	Hot Water, Lighting and Appliance	Reduced GHG emissions from reduced energy use (due to increased use of energy efficient lighting and appliances)
New Building (Mandatory)	Planning	B.6	There is a plan to reduce electricity consumption by calculating lower energy consumption compared to the baseline*). For every 2% reduction in energy consumption, 1 point is awarded, with a maximum of 5 points. *) The baseline is a reference value for energy efficiency calculated based on SNI and regulations on energy conservation. The referenced SNI includes: a. SNI 6197:2020 (Energy conservation in lighting systems);	5	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
			b. SNI 6389:2020 (Energy conservation of building envelopes); c. SNI 6390:2020 (Energy conservation of air conditioning systems in buildings); or the latest edition.			
New Building (Mandatory)	Planning	B.7.a	The building is planned to have grouped electrical loads, each equipped with a kWh meter, and an electricity submeter is available for main power sources greater than 100 kVa.	2	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid
New Building (Mandatory)	Planning	B.7.b	Buildings with centralized air conditioning systems must use a Building Management System (BMS) to control electricity consumption in the building.	3	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid
New Building (Mandatory)	Construction	A.1.b.2 .b)	Compliance of energy efficiency technical planning criteria with construction implementation.	8	Electricity Supply	
New Building (Mandatory)	Construction	B.7.c	There is a plan to utilize renewable energy sources for electricity supply.	2	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid
New Building (Mandatory)	Construction	B.5.a.1)	A table of planned electricity usage for all equipment and tools, both in the project area and at the project office, is available.	3	Electricity Supply	Reduced GHG emissions due to reduced electricity

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
						demand from the grid
New Building (Mandatory)	Construction	B.5.b.1)	If using electricity from PLN, a kWh meter is installed on the main panel and distribution panels for construction activities.	2	Electricity Supply	
New Building (Mandatory)	Construction	B.5.b.2)	If using a generator as a power source, an operational feasibility test is included to ensure optimal equipment performance.	2	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid
New Building (Mandatory)	Construction	B.5.b.3)	Monitoring of electricity and carbon fuel usage is conducted periodically (monthly).	2	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid
New Building (Mandatory)	Operation	B.2.b	Monitor and record actual monthly energy consumption over the last 6 months, create trends in graph form, and evaluate any deviations (increases or decreases) in energy consumption from the previous month.	4	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid
New Building (Mandatory)	Operation	B.2.d	Maintain energy consumption such that there is no increase in actual energy consumption exceeding 10% of the reference energy consumption and/or	2	Electricity Supply	Reduced GHG emissions due to reduced electricity demand

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
			planned energy consumption. The reference energy consumption is the actual energy consumption over 6 months from the previous year.			from the grid
New Building (Mandatory)	Operation	B.2.d	If able to achieve a 10% reduction in energy consumption from the reference energy consumption and/or planned energy consumption, an additional 1 point is awarded.	1	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid
Existing Building (Mandatory)	Operation	A.6.a.6)	There is a plan to reduce electricity consumption by calculating lower energy consumption compared to the baseline*). For every 2% reduction in energy consumption, 1 point is awarded, with a maximum of 5 points. *) The baseline is a reference value for energy efficiency calculated based on SNI and regulations on energy conservation. The referenced SNI includes: a. SNI 6197:2020 (Energy conservation in lighting systems); b. SNI 6389:2020 (Energy conservation of building envelopes); c. SNI 6390:2020 (Energy conservation of air conditioning	5	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
			systems in buildings); or the latest edition.			
Existing Building (Mandatory)	Operation	A.6.a.7) .a)	The building is planned to have grouped electrical loads, each equipped with a kWh meter, and an electricity submeter is available for main power sources greater than 100 kVa.	1	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid
Existing Building (Mandatory)	Operation	A.6.a.7) .b)	Buildings with centralized air conditioning systems must use a Building Management System (BMS) to control electricity consumption in the building.	2	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid
Existing Building (Mandatory)	Operation	A.6.a.7) .c)	There is a plan to utilize renewable energy sources for electricity supply.	1	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid
Existing Building (Mandatory)	Operation	C.2.a.1)	Compliance with energy efficiency criteria according to the implementation of renovation construction. Compliance with the minimum fresh air flow rate, particularly in high-density rooms (2.3 m ² /person).	1	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid
Existing Building (Mandatory)	Operation	C.2.b	Monitor and record actual monthly energy consumption over the last 6 months, create trends in graph form, and evaluate any	2	Electricity Supply	Reduced GHG emissions due to reduced electricity

Ordo/ Building Category	Work Assessment Stage:	No	Performance Assessment Parameters:	Points	Emission source	GHG Impact (ICAT)
			deviations (increases or decreases) in energy consumption from the previous month.			demand from the grid
Existing Building (Mandatory)	Operation	C.2.d	Maintain energy consumption such that there is no increase in actual energy consumption exceeding 10% of the reference energy consumption and/or planned energy consumption. The reference energy consumption is the actual energy consumption over 6 months from the previous year.	1	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid
Existing Building (Mandatory)	Operation	C.2.d	If able to achieve a 10% reduction in energy consumption from the reference energy consumption and/or planned energy consumption, an additional 1 point is awarded.	1	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid
Existing Building (Mandatory)	Operation	C.2.e	Re-commissioning: perform measurement and verification of the efficiency of main system equipment and make improvements to restore the efficiency of the main system equipment to its original state for at least the last 6 months for the first time or every 6 months thereafter.	3	Electricity Supply	Reduced GHG emissions due to reduced electricity demand from the grid