Lab. SYNERGY UNIVERSITY OF SEOUL AIM ASIA-PACIFIC INTEGRATED MODEL

Estimation of Greenhouse Gas Reduction Potential in Existing Buildings using the CEA Model
: Focus on Aging Apartment Complexes at Bundang Newtown

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Introduction

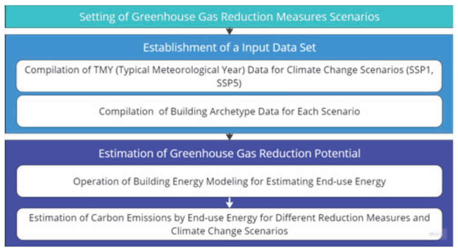
- As the international awareness of the climate crisis grows, each countries are striving to achieve the long-term goals of the Paris Agreement through their 'Nationally Determined Contributions' (NDCs). Among them, operations of buildings account for 26% of global energy-related emissions. Therefore, it is necessary to reduce GHG emissions from the building sector to achieve global carbon neutrality.
- In the case of South Korea, over 75% of buildings are more than 15 years old, so it is essential to reduce GHG emissions by improving energy efficiency of existing buildings. In particular, Apartments built in the 1990s, when the construction of large-scale residential areas was active due to population growth, accounted for 34% of all apartments. In the 2020s, as they are aging and approaching the end of their replacement life, it is essential to remodel and reconstruct them by introducing GHG reduction measures.
- Therefore, this study estimates the greenhouse gas reduction potential in order to forecast the effectiveness of applying greenhouse gas reduction measures in old apartment complexes. In addition, considering the change in building energy demand due to climate change, we considered the change in the effectiveness of GHG reduction measures and the change in potential volume due to climate change in the future.

Purpose

- What is the ***Greenhouse Gas Reduction Potential of applying GHG Mitigation Measures*** in an Aging Apartment Complex?
- How much does ***the effectiveness and reduction potential*** of GHG reduction measures ***change with climate change?***

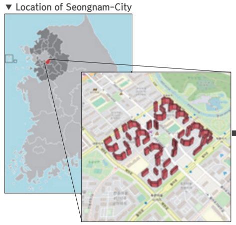
Process and Study Area

Ⅰ. Process



Ⅱ. Study Area

▼ Location of Seongnam-City



▲ Study Area in Bundang Newtown, Seongnam City (Parktown Apt.)

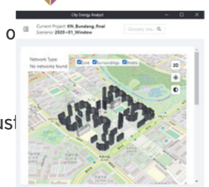
- This study chose Parktown Apartment, situated in Bundang-gu, Seongnam-si, Gyeonggi-do, as the designated area for assessing the potential reduction effects of greenhouse gas emission measures in aging apartment complexes.
- Parktown Apartment is a complex constructed in the 1990s, making it a suitable subject for analysis due to the potential demand for reconstruction or renovation.

Method

Ⅰ. Buildng Energy Modeling

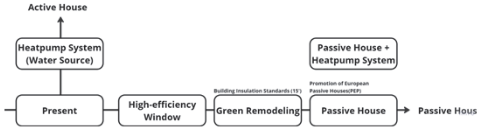
- To determine the potential reduction of greenhouse gas emissions, we estimated the energy demand for each reduction measure according to end-use categories using the UEBM model. Then, this estimated energy demand was employed to calculate greenhouse gas emissions.
- For the energy consumption estimation, we utilized the City Energy Analyst (CEA) tool, a one of the Urban Building Energy Model (UBEM). CEA is an open-source simulation-based tool that optimizes urban energy systems by considering design options and energy infrastructure effects at the city level.
- To estimate energy demand for the Study Area using the CEA model, the *Demand* module must be activated. This module requires building data, weather data, and technical specifications. Building data includes location-related details and simplified building characteristics like height, floor area, construction year, window-to-wall ratio, and usage.

City Energy Analyst



Ⅱ. Scenario Structure and Building Archetype Data

- In this study, the following scenario structures were created based on Passive and Active House Technologies. Subsequently, building archetype data corresponding to these scenarios were input into the CEA model for analysis.



▲ Building Archetype Scenario Strucure

	Window			Roof			Wall			Floor
	Thermal transmittance	Solar heat gain coefficient	Emissivity of external surface	Thermal transmittance	Solar absorption coefficient	Emissivity of external surface	Thermal transmittance	Solar absorption coefficient	Emissivity of external surface	Thermal transmittance
Present	3.373	0.719	0.84	0.407	0.9	0.94	0.582	0.9	0.9	0.58
15' Insulation Standards	1.2	0.52	0.03	0.15	0.4	0.84	0.21	0.4	0.84	0.18
Passive Houses(PEP)	0.8	0.474	0.03	0.15	0.4	0.84	0.2	0.4	0.84	0.15

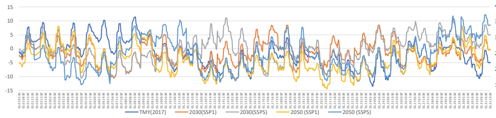
▲ Building Archetype Dataset

Scenario	Window	Roof	Wall	Floor	Heating(Eff)
Present	Present	Present	Present	Present	Distric Heating(0.5)
H-Eff. Window	15' Standards	Present	Present	Present	Distric Heating(0.5)
Green Remodeling	15' Standards	15' Standards	15' Standards	15' Standards	Distric Heating(0.5)
Passive House	PEP	PEP	PEP	PEP	Distric Heating(0.5)
Heatump	Present	Present	Present	Present	Heatpump (3.1)
P. House with Heatpump	PEP	PEP	PEP	PEP	Heatpump (3.1)

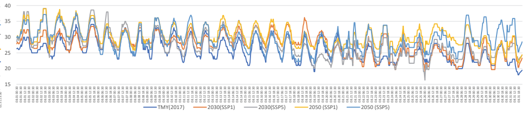
◀ Building Archetype Scenario Input data

Ⅲ. Typical Meteorological Year Data

- For this study, TMY (Typical Meteorological Year) data in EPW file format for the Seongnam region (2007~2021) from Lawrie, L & Crawley, D (2022), made available as open-source, was utilized. Additionally, temperature data for SSP scenarios provided by the KMA were used to construct TMY data for the years 2030 and 2050.

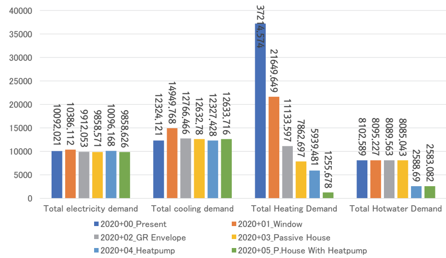


▲ Dry-bulb Temperatures in January for TMY and Scenario Data at Seongnam City (Unit : ℃)

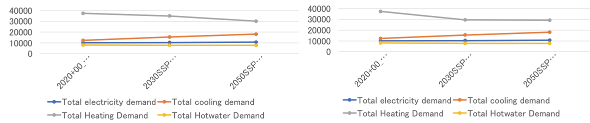


▲ Dry-bulb Temperatures in August for TMY and Scenario Data at Seongnam City (Unit : ℃)

Results and Conclusion

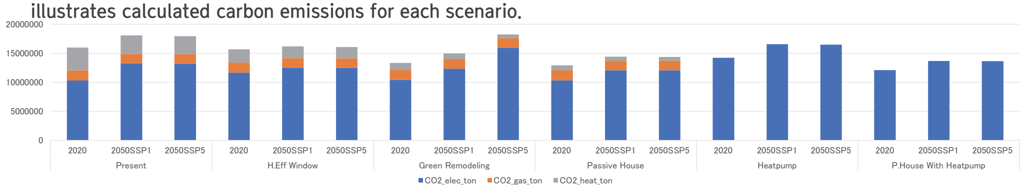


▲ Estimated End-use Energy Demand by GHG Reduction measures in Study Area in Bundang Newtown (Unit : MWh/yr)



▲ Estimated End-use Energy Demand by SSP Scenario in Study Area in Bundang Newtown (Unit : MWh/yr)

- **Greenhouse gas reduction measures notably impact building heating energy demand.** Without these measures, heating energy demand is 37,124 MWh/year. In contrast, the Passive House approach reduces it to about 7,862.69 MWh/year, a 78.8% reduction. Introducing the Heatpump measure alongside further reduces heating energy demand to around 1,255.678 MWh/year, achieving a reduction of about 96%.
- End-use energy demand changes according to the SSP scenarios. Heating energy demand decreases by 19.3% in 2050 under SSP1 and by 21.5% under SSP5. Conversely, Cooling energy demand increases by 47.2% under SSP1 and by 46.6% under SSP5 in 2050.
- **Carbon emissions also vary based on climate change scenarios and building archetype scenarios.** The graph below illustrates calculated carbon emissions for each scenario.



Acknowledgements

This work was supported by the Korea Environment Industry & Technology Institute (KEITI) through the Climate Change R&D Project for New Climate Regime, funded by Korea Ministry of Environment (MOE;) (RS-2023-00218794).