Energy



Climate change mitigation, Smart city

Energy demand modeling and decarbonization of residential and commercial building stock

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Abstract

This study develops simulation models to estimate energy demand and carbon dioxide emissions for the Japanese residential and commercial building stocks. The developed models (1) quantify the demand of the building stock as the sum of the energy demand of individual households and commercial buildings, (2) simulate human activity in estimating the energy demand, and (3) use a building stock model that represents the heterogeneity of the stock composition and changes over time, which is designed to provide the analytical capabilities needed for the decarboniza-tion of the building stocks.

Background & Results

Decarbonizing the residential and commercial building stocks is an imperative to mitigate climate change. The Japanese government has set a goal of halving carbon dioxide emissions from 2013 levels by 2030 and achieving carbon neutrality by 2050. To realize this goal, it is necessary to introduce various technological measures, such as improving the energy efficiency of buildings, building systems, and energy-consuming appliances, electrifying the energy source for space heating, cooling, and water heating, and the use of renewable energy sources such as solar power generation. Lifestyle changes, including behavioral changes, have also been attracted attention. To achieve the carbon dioxide emission reduction targets, it is necessary to address the question, "when and to what extent will these measures need to be introduced?"

As a result of applying the developed method to the Japanese commercial building stock covering the offices, hotel, medical, retail, and school buildings, it was found that A) significant reductions in carbon dioxide emissions are achievable, B) the expected increase in electricity demand due to electrification for space heating, cooling, and water heating can be avoided by improving energy efficiency through the introduction of various energy conservation technologies, and C) the dissemination of energy efficiency measures is expected to reduce CO₂ emissions by 27 MtCO₂/year by 2030 and has a potential to reduce by 43 MtCO₂/year, compared to 148 MtCO₂/year in FY2013.

Significance of the research and Future perspective

We are currently using the developed models to assess Japan's progress in reducing carbon dioxide emissions in the residential and commercial building stocks and to develop decarbonization scenarios for Japan that include behavioral and lifestyle changes. In addition to this, we are developing an agent-based human behavior simulation model that stochastically simulates people's time use and travel behavior, and estimating energy demand of electric vehicles based on the behavior simulation result to analyze changes in energy demand comprehensively.



Energy demand quantification procedure for the Japanese commercial building stock



Estimated energy consumption for the Japanese commercial building stock



Contributions of factors providing reduction in \mbox{CO}_2 emissions. ECM: Energy conservation measures

Patent	
Treatise	Yamaguchi, Yohei; Yoshizawa, Shinya; Shimoda, Yoshiyuki et al. Feasibility assessment of net zero-energy transformation of building stock using integrated synthetic population, building stock, and power distribution network framework. Applied Energy 2023; 333: 120568. doi: 10.1016/J.APENERGY.2022.120568 Li, Yuanmeng; Yamaguchi, Yohei; Shimoda, Yoshiyuki. Impact of the pre-simulation process of occupant behaviour modelling for residential energy demand simulations. J Build Perform Simul 2022; 15: 287–306. doi: 10.1080/19401493.2021.2022759 Yamaguchi, Yohei; Kim, Bumjoon; Shimoda, Yoshiyuki et al. Building stock energy modeling considering building system composition and long-term change for climate change mitigation of commercial building stocks. Appl Energy 2022; 306: 117907. doi: 10.1016/J.APENERGY.2021.117907
URL	http://www.see.eng.osaka-u.ac.jp/seeue/seeue/
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