Effects of Lifetime Changes of Residential Buildings on CO2 Emissions

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In 2020, the Japanese government has proposed to set the 40% CO2 emissions reduction target in construction and residential buildings sector by 2030 compared to 2013 levels. To achieve the reduction goal, it is crucial to make an effective policy to the construction and residential buildings sector accounting for 40% of the total CO2 emissions in Japan. An important research question is to what extent lifetime changes of the residential buildings affect CO2 emissions from the lifecycle perspective? Few studies addressed this related research question. MÃ¼ller (2006) used the lifetime distribution of housing and estimated stock dynamics for forecasting material flows for housing in Netherlands. However, MÃ¼ller (2006) did not specify an appropriate lifetime distribution function in the housing sector statistically.

The novelties of this study are the following. This study is the first attempt to specify an appropriate lifetime distribution function in the housing sector statistically. In doing it, I used the detailed real estate data including older houses sold in Japan and complied lifetime data for older houses that were sold as a worthless attachment of land. The maximum likelihood method was used to select the appropriate lifetime distribution model for housing in Japan. The second attempt of this study is to develop and demonstrate a comprehensive life-cycle assessment (LCA) framework considering the dynamics of residential buildings stock and flows by combining the specified lifetime distribution analysis with an environmentally extended input-output analysis. This study estimated the life-cycle CO2 emissions for housings in Japan using the comprehensive life-cycle assessment (LCA) framework that includes important life-cycle stages: production of housings, energy use in housings, and disposal of older houses. In estimating the life-cycle emissions, the time series dataset of CO2 emission intensity by the 3EID database (i.e., Embodied Energy and Emission Intensity Data for Japan Using Input-Output Tables) was used.

The results show that normal distribution was selected as the most appropriate lifetime distribution for housing in Japan. From the specified lifetime distribution, this study further estimated the average lifetime for housing as approximately 35 years.

It was further found that the lifecycle CO2 emissions for housings have decreased during the study period between 1970 and 2020, because construction starts of new houses and housing stocks have decreased during the study period. The reduction rate of CO2 emissions in 2020 compared to 2013 was 18.5%, implying that an additional substantial reduction of 22.5% is required in order to reach the target of a 40% reduction in 2030.

A detailed look at the life-cycle emissions shows that the use stage accounts for more than half of the total life-cycle emissions from housing, whereas the production stage of new houses also emitted a large amount of CO2 emissions, accounting for 30% of total stages of residential buildings lifecycle. This indicates that the production stage is an important stage in mitigating the lifecycle emissions. This study also finds a significant CO2 reduction potential of extending the lifetime of housing and discuss effective supply- and demand-side policies of residential buildings for a decarbonized society.