MA3　建築部門における緩和策のポテンシャル分析

－Sufficiency・Efficiency・Renewables の観点から－

Analysis of mitigation measures in the building sector considering Sufficiency, Efficiency and Renewables options

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Abstract: In the decarbonization of the building sector, mitigation measures can be organized from three perspectives: Sufficiency, Efficiency, and Renewables. Though various mitigation measures have been implemented from these perspectives, more effort is still necessary to achieve the 1.5 °C target. This thesis analyzed mitigation measures that could bring about further decarbonization: Lifestyle changes (Sufficiency) and the large-scale installation of building-integrated photovoltaic (BIPV) modules on building façades (Renewables). Their effects were clarified while considering Efficiency. Regarding the latter, a model for estimating the hourly power generation potential of building surfaces, including building façades, was developed and applied to commercial building stock in Tokyo, Japan. The results showed that the generated PV power would be capable of satisfying 15%–48% of the annual electricity demand of the building stock in 2050, based on the extent to which the PV potential of building surfaces, especially façades, was exploited.

Keywords: Building, decarbonization, building-integrated photovoltaics, lifestyle change

1. Introduction

Achieving a decarbonized society and limiting the rise in temperature below 1.5 °C is an urgent challenge. In the decarbonization of the building sector, mitigation measures can be organized from three perspectives: Sufficiency, which involves avoiding causes of demands, including behavioral changes and reducing building floor area; Efficiency, which focuses on high-efficiency satisfaction of demands; and Renewables, which aims to reduce the carbon intensity in meeting demands. Though various mitigation measures have been implemented from these perspectives, more effort is still necessary to achieve the 1.5 °C target. This study analyzed mitigation measures that could bring about further decarbonization: Lifestyle changes (Sufficiency) and the large-scale installation of building-integrated photovoltaic (BIPV) modules (Renewables). This paper predominantly describes the latter's content, published by the academic journal *Solar Energy*.

A BIPV module is a photovoltaic (PV) module integrated with building components such as roofs and

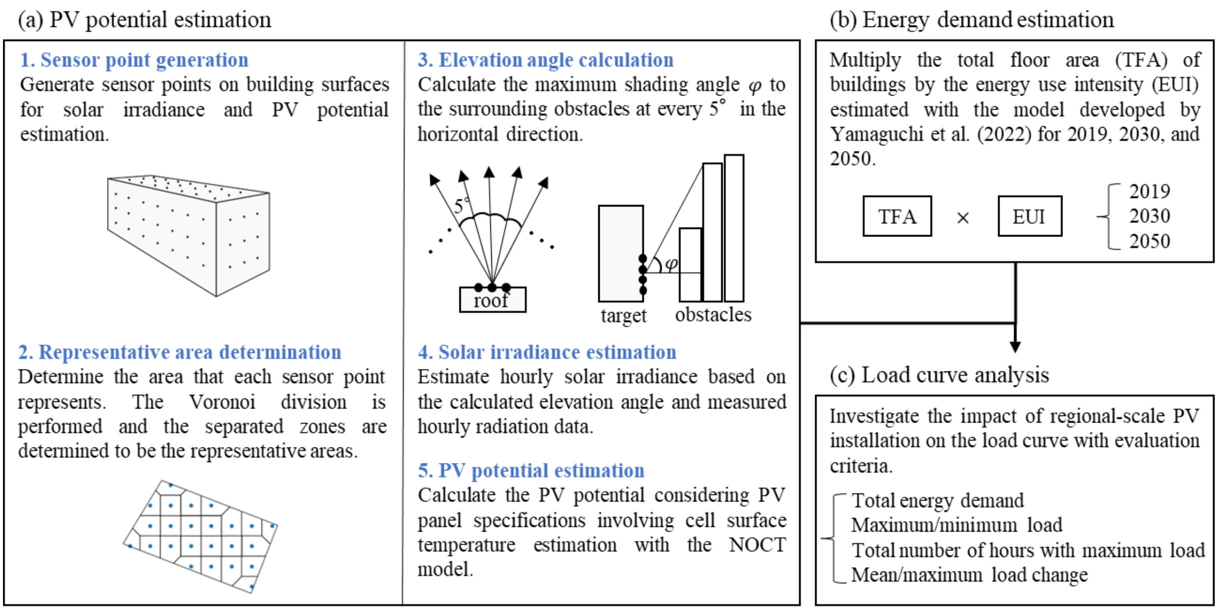

Fig. 1. Workflow of this study. (a) follows the workflow proposed by Cheng et al.[1)]

walls. It can be used on the building facade, allowing for the effective use of limited urban space for decarbonization. The considerable potential of the use of BIPV modules has been demonstrated. Earlier studies have provided significant knowledge about the PV potential of buildings. However, a detailed investigation of the large-scale installation of BIPV modules on building façades has not been undertaken. The objectives of this study were two-fold: (1) To estimate the potential of large-scale installation of PV modules on building surfaces, including the façade, on an hourly basis. (2) To analyze the effect of large-scale BIPV installation in terms of the PV potential and load matching.

2. Methods

The contribution of the PV installation on building surfaces, including façades, to decarbonizing building stock was evaluated on a regional scale using the GIS data of commercial building stock in Tokyo, considering energy demand reduction, electrification, and economic efficiency of the PV installation on an annual basis (considered by setting the irradiance threshold: a surface is considered qualified for PV installation if it has an irradiance value larger than the threshold value). Furthermore, the effect of the large-scale BIPV installation on building façades was analyzed with a focus on the hourly PV potential and the hourly balance between the energy produced and energy consumed in the target building stock. The parameters and workflow used in this study are presented in Table 1 and Fig. 1.

Table 1. Parameters used in this study

Parameter	Description
Conversion efficiency of PV modules	20%
Temperature coefficient of PV modules	−0.35%/°C
Weather data period	April 1st, 2019, to March 31st, 2020
Utilization factor for rooftops	0.2 (hospital), 0.25 (hotel), 0.3 (others)
The tilt angle of roof-mounted PV	35°

3. Results and Discussions

Analytical results showed that the generated PV power would be capable of satisfying 15%–48% of the annual electricity demand of the building stock in 2050, based on the extent to which the PV potential of building surfaces, especially façades, was exploited. This demonstrates the usefulness of BIPV for achieving a decarbonized society. Additionally, hourly estimation results showed that if a higher economic efficiency is pursued, the use of large-scale installation of BIPV together with rooftop-mounted PV could increase the PV power generation without altering the hourly PV power fluctuation (Fig. 2). However, electricity demand and generation analyses revealed the negative impacts of the larger-scale BIPV installation on the power system: The reduction in asset utilization and the increase in the need for flexibility. The findings of this study promise to be helpful to policymakers in formulating guidelines for the use of BIPV modules.

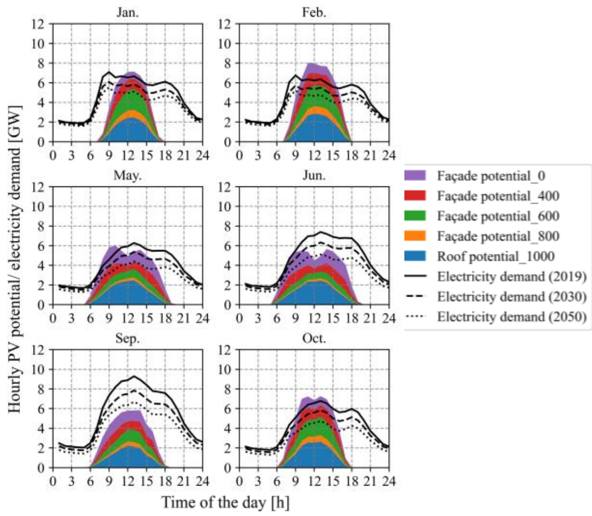

Fig. 2. Average hourly PV potential and electricity demand for sunny days in each month

4. Conclusion

This thesis contributes to achieving the 1.5 °C target by providing knowledge on mitigation measures in the building sector. Future studies include integrating the model created and findings from this thesis into comprehensive modeling studies. Intersectoral efforts not limited to the building sector are significant, as lifestyle changes are highly relevant to people's mobility and consumption of goods, as well as energy consumption in buildings.

Reference

1) Cheng, L., Zhang, F., Li, S., Mao, J., Xu, H., Ju, W., Liu, X., Wu, J., Min, K., Zhang, X., Li, M., 2020. Solar energy potential of urban buildings in 10 cities of China. Energy 196, 117038. https://doi.org/10.1016/j.energy.2020.117038