Estimation of the Installation Potential of Solar Cells Reflecting Shadow Effect, Geographic Information, and Latest/Future Technology Trends: Analysis in Tokyo Area

Summary

In order to maximize the introduction of photovoltaics (PVs) power in urban areas with high electricity demand and a large grid capacity such as Tokyo, it is important to estimate the potential to install PVs in the buildings. As a result of quantifying the effect of shadows between buildings in order to consider the installation to the wall surface and estimating by assuming the average efficiency of solar cells by 2030 as 25.5% and the installation cost as 128,000 yen/kW, the potential of installing PVs in Tokyo was 91.1 GW and the annual power generation was 79.5 TWh. This amount of power generation almost covers the power demand (83.6 TWh) [1] of Tokyo in 2019. In addition, as a result of estimating the changes in the potential of installing PVs and the cumulative installation amount corresponding to the improvement of the PV power generation efficiency and the change in the installation expansion rate, it was estimated that the potential of installing PVs will decrease if the installation expansion precedes and the power generation efficiency improvement is delayed. It was suggested that it is important to develop technology to improve the maximum power generation efficiency in addition to the installation expansion.

Proposals for Policy Development

- Assuming that the efficiency of solar cells newly installed in 2030 will be improved by about 25%, it was found that there is a potential to secure 100% or more of the power demand by combining wall installations in residential areas in Tokyo. Therefore, it is appropriate to set challenging goals for the installation of PVs toward 2030 and 2050.
- Since securing a balance between supply and demand of renewables between the seasons is also an urgent issue, it will be necessary to promote the installation expansion of PVs on the building-wall surface.
- In PV, it was found that the improvement rate of the conversion efficiency and installation speed of solar cells affect the final installation potential, so it is required to promptly proceed with research and development to improve the conversion efficiency of solar cells while maintaining costs.

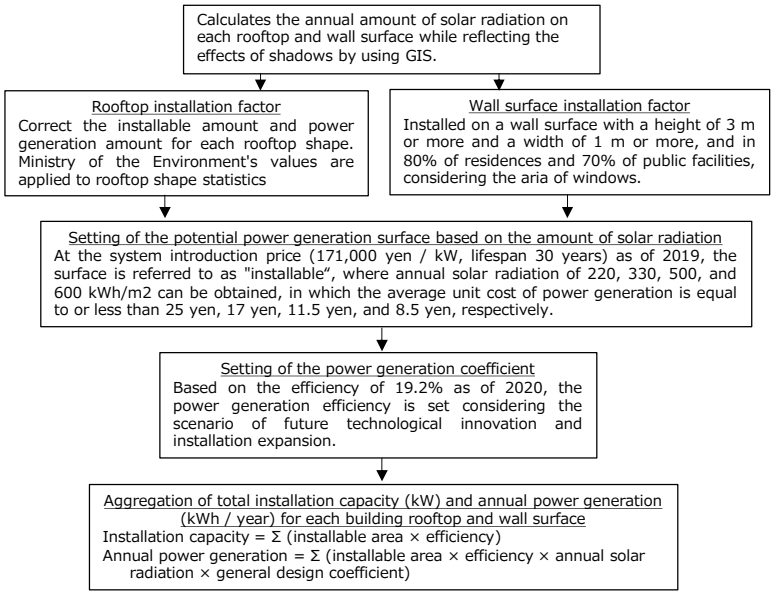

Fig. 1 Outline of installation potential estimation

Table 1 Installable area, total solar radiation and installation potential, and annual power generation in Tokyo (efficiency is set as 25.5% (existing facility:16.6%))

		Total area [km²]	Installable area [km²]	Installation area total solar radiation [TWh/year]	Installation potential [GW]	Annual power generation [TWh/year]
Ministry of the Environment	Residential rooftop	173.0	98.5	118.4	8.3	9.6
	Residential wall surface	-	-	-	-	-
	Public facility rooftop	46.6	36.0	32.2	2.6	2.36
	Public facility wall surface	-	6.7	7.4	0.49	0.54
This survey	Residential rooftop *	176.4+32.0	158.0	180.2	34.5	40.9
	Residential wall surface	257.7	122.7	66.1	27.5	14.8
	Public facility rooftop**	24.4+58.5	20.0+46.9	22.7+54.6	4.2+10.1	4.9+11.7
	Public facility wall surface	3.3 + 12	3.3 + 12.0	6.2 + 29.1	2.5+12.2	1.4+6.5

*Ministry of the Environment excludes houses with a rooftop area of less than 50 m²
**Public facilities (schools, factories, etc.) and Large-scale buildings

1. Calculation of PV power generation installation potential considering the effects of shadows

In estimating the installation potential (Fig. 1), each city, ward, and village in Tokyo was included in the calculation range, and the wall surface (height above 3 m above the ground) and roof (directly above the roof) were included in the calculation. The amount of solar radiation every 15 minutes was calculated every 15 days for a year, and the total solar radiation on the installation surface and the total power generation when the power generation efficiency was set to 25.5% were estimated (Table 1). The total solar radiation on an installable wall surface was 0.35 times that of a rooftop for residential systems, 0.53 times for public facility systems (high-rise buildings, etc.), and 0.27 times for public facility systems (schools, factories, etc.). The annual power generation in Tokyo was 79.5 TWh, compared to the Ministry of the Environment's estimation of 11.7 TWh [2].

2. Change of installation potential due to improvement of power generation efficiency and installation expansion scenario

Multiple scenarios for technological development (improvement of power generation) and scenarios for installation expansion were created, and how the installation potential changes under each scenario was examined (Fig. 2).

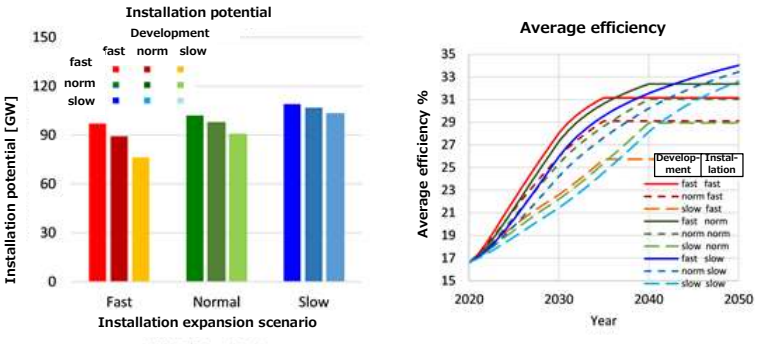

Fig. 2 (Left) Power generation efficiency improvement scenario, installation potential for each installation speed scenario;
(Right) Average efficiency of installed solar cells for each scenario

In cases where the installation expansion is accelerated, if technological innovation is slow, the proportion of panels installed with low efficiency will increase, and the installation potential will eventually decrease. In cases where the installation expansion is slow, the influence of slow technology innovation will be reduced, but the installation will be significantly delayed as a whole. Furthermore, it was found that when technological innovation becomes sluggish, the average efficiency further decreases.

[1] Agency for Natural Resources and Energy, Electricity Survey Statistics Table (2019), https://www.enecho.meti.go.jp/statistics/electric_power/ep002/results.html

[2] Entrusted Work Concerning the Development and Disclosure of Basic Zoning Information Concerning Renewable Energies, Ministry of the Environment (2019, etc.)