Design Targets for Independent Energy Systems for Continued Living after a Disaster (Research period: FY2020 - FY2022)

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1. Background and purpose

One measure to enable people to continue living in their houses under the conditions of continuous power outage after a disaster is to use a system that combines photovoltaic power generation and storage batteries ("independent energy system"). To ensure the effectiveness of an independent energy system, it is important that the building owner and designer can determine whether the system has adequate performance against disasters and changing conditions. However, as for continued living in a house after a disaster, since there are no design targets developed for independent energy systems in house design, there are no performance indicators that serve as a basis to determine whether the performance is suitable, and the development of such indicators is an urgent issue. Thus, we started "Research on Design Targets of Independent Energy Systems for Continued Living in a house after a Disaster" in 2020. This research provides insights into the electricity applications necessary to continue living in a house after a disaster, quantify the requirements for independent energy systems in house design, and organize these results into design targets for independent energy systems to continue living in a house after a disaster. In FY2022, we studied methods to calculate the amount of electricity needed to stay at home and the amount of electricity supplied by independent energy systems, assuming that residents would use their devices during a power outage. In this report, we present the outline of the calculation method and the results for a house that uses only photovoltaic power generation as an example of the application of the calculation method.

2. Outline of the calculation method and examples of application

To calculate the residential electricity demand (electricity consumption) and the amount of electricity generated by photovoltaic power generation, the calculation method based on the "Act on the Improvement of Energy Consumption Performance of Buildings", (enforced in April 2016; hereinafter referred to as the "2016 Energy Conservation Standards") was applied. **Table 1** shows the calculation conditions for the application examples listed below.

The use of devices during a power outage was set up as shown in **Table 2**, assuming that in addition to the case where the family spends time as usual, the use of various devices is restricted based on the assumption that the family gathers in certain rooms (in this case, living room, dining room, kitchen and the couple's bedroom). The devices to be used during power outage was prioritized based on the results of a questionnaire survey conducted in previous years regarding inconveniences in daily activities during power outage.

Table 1: Calculation conditions

Item			Setting
Region			A3 category in 6 areas of the 2016 Energy Conservation Standards (Warm with moderate annual insolation)
Setting of a house	House plan		A standard house that meets the 2016 Energy Conservation Standards
	Floor area		120 m^2 (equivalent to a 4-person household under the 2016 Energy Conservation Standards)
	Outer shell performance		2016 Energy Conservation Standards
	Device performance		Average performance at the time of calculation
	Heating / cooling system		Air conditioner
	Hot-water supply system		Electric heat pump
	Other		Equivalent to all electrification
Photovoltaic power generation	Panel	Number of faces	1 face
		Angle of direction	South
		Angle of inclination	30 degrees
	Power conditioning system	Rated load efficiency	92.7 %
	Array	Capacity	4.0 kW
		Installation method	Roof-mounted
Power outage situation	Date and time of occurrence		Midnight on the day when the annual maximum temperature is reached (July 23)
	Device use level	Lv.0	Use the devices as usual
		Lv.1	Limit the use to some extent
		Lv.2	Limit the use to maximum in order to ensure safety

Table 2: Device usage level settings during power outage (Change point from Lv.0 Change point from Lv.1)

Use	Set device usage levels in the event of power outage		
	Lv.0: As usual	Lv.1: Limited to some extent	Lv.2: Ensure safety and limit to the maximum
Heating	- Use in each room when occupied (except when sleeping).	- Limit the use to living room, dining room, kitchen and master bedroom. - When the average outside air temperature from 12:00 to 14:00 is 13°C or higher, stop the heating system during the same time zone.	- Limit the use to living room, dining room, kitchen and master bedroom. - Unconditionally stop the heating system from 12:00 to 14:00.
Cooling	- Use in each room when occupied.	- Limit the use to living room, dining room, kitchen and master bedroom. - When the average outside air temperature from 16:00 to 24:00 is 25°C or lower, stop the cooling system during the same time zone. - When the average outside air temperature from 23:00 to 8:00 in next morning is 25°C or lower, stop the cooling system during the same time zone.	- Limit the use to living room, dining room, kitchen and master bedroom. - Unconditionally stop the cooling system from 16:00 to 8:00 in next morning.
Ventilation	- 24-hour use.	- 24-hour use.	- 24-hour use.
Lighting	- Use in each room according to the life schedule.	- Limit the use space to the first floor. - Light reduction to 50%.	- Limit the use space to the first floor. - Light reduction to 10%.
Hot water supply	- Use according to the life schedule.	- Use according to the life schedule.	- Use according to the life schedule.
Other	- Use in each room according to the life schedule.	- Limit appliances to those used in living room, dining room, kitchen and master bedroom (refrigerator, electric rice cooker, TV, PC, etc.).	- Stop the use of any device.

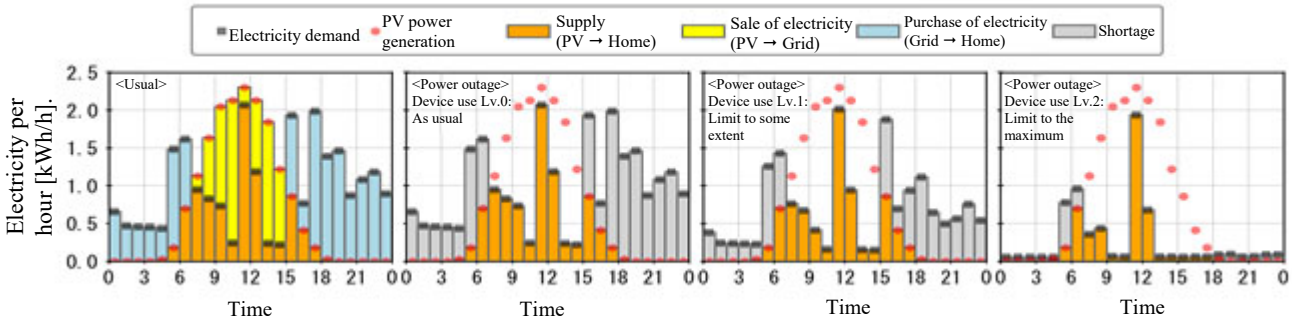

Figure: Example of application of the calculation method developed in this research (Assumption for the day of power outage: Time changes in residential electricity demand and supply from photovoltaic power generation, etc. for the 24 hours from the power outage)

As a result of the calculation, **Fig. 1** shows the time variation of electricity demand and supply from photovoltaic power generation, etc. for the 24 hours from the occurrence of the power outage (July 23, 0:00). As shown in the **Figure**, the calculation method developed in this research can reproduce the suppression of electricity consumption by residents who refrain from using devices during power outage and the supply situation from photovoltaic power generation.

4. Future development

We plan to compile technical data to study the design targets of independent energy systems for continued living after a disaster by organizing the results obtained from the questionnaire survey conducted in previous years on the inconveniences of daily activities during power outage and a parametric study to which the calculation method described in this report was applied.