論　文　要　旨
Thesis Abstract

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主論文題名　（Title）

Operation Strategy and Evaluation of Battery Storage and Power Converter towards Zero Energy in Commercial Building

内容の要旨　（Abstract）

Climate changes caused by emitted greenhouse gases leads to many environmental issues such as the change of water availability, highly probable of increasing extinct species, declination of food production in some areas, elevate sea level and increase floods possibility, etc. The main cause is carbon dioxide, which is majority emitted in energy utilization. Realizing this problem, many parties start to act towards energy revolution where they try to change the primary source of energy to be the clean or cleaner one. To promote the penetration of clean energy, utilities in many countries also make regulation about feed-in-tariff.

In building scale, the concept of zero energy building (ZEB) is arising there from the effort to reduce the energy consumption. ZEB concept focus on a low-energy building with considerably reduced energy consumption through efficiency gains, and then balanced the energy needs with renewable energy supplies. In order to support the realization of ZEB, we need generation system such as photovoltaic (PV) system, battery as energy storage and power converter as interface of various element in building distribution system. All of elements has lifetime, however battery has the shorter one, which is also influenced by its operation. Power converter helps to convert power in form of ac to dc and vice versa. It also can connect different voltage level of dc power. After all, additional power converter will give additional loss that has to bear with. Therefore, introduction of the operation strategy of battery and power converter is necessary. The different element to be used may also lead to different reliability system. In addition, we need to evaluate its performance economically. Expectedly, this research can give direction for building operator who want to achieve zero energy.

There are many challenges in order to realize ZEB. Many dispersed power generations that may need to be connected together with the utility grid. Increasing number of components also will give the control more complex tasks. The main challenges to realize ZEB that will be investigated in this study are including energy storage, power converter, and economic operation of system.

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We proposed the control of battery charge-discharge operation by considering the battery lifetime. The aim is to make the battery lifetime longer by using carefully operation strategy. Other than using detail model simulation, we also use the proposed average model to make the simulation time shorter. We also compared the reliability system between ac-grid and dc-grid system in commercial building. The loss of load expectation (LOLE) is used to measure the reliability of system. Realizing ZEB means the need of connection between several types generation, storage, and load will increase. Based on the actual data from real system, we studied the converter loss and explained here. This study also discussed about the potential of power schedule optimization considering converter loss as the countermeasure. Finally, we introduced peak-time of electricity pricing parameters. Using the proposed peak-time pricing ratio, we done the economic evaluation using general model, also using extended model that considered the converter loss.

In conclusion, this research is addressed to answer three mains challenges to achieve ZEB: energy storage, power converter, and economic operation. Energy storage—Battery lifetime can be indicated by using some indicators, such as State of Health (SOH), State of Life (SOL), and Remaining Useful Life (RUL). By considering the lifetime parameter, we can expect the battery lifetime become longer compared to common operation. In addition, PV with battery system has a potential to reduce the electricity charge. Power converter—Avoid low power operation is necessary to keep high performance of converter. Except the sizing design, the operation controls also hold significant effect of maintaining efficiency converter in operation condition. Considering the role of converters, the reliability evaluation in commercial building indicates reliability of dc-grids can be higher than the usual ac-grids. Economic operation—We proposed some price parameters, which can be used to evaluate the system benefit that is intended to be applied in preliminary economic study of system planning. Hence, it is still a deliberation that which system is better to be used, whether ac or dc system. This study shows that load composition has impact of the potential benefit if we change from current ac-system to dc-system. Each converter efficiency and battery size also have influence to the annual cost reduction.

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