

Potential of DC Microgrid in Container

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Distributed renewable energy resources, particularly photovoltaic (PV) generation, are being increasingly deployed to achieve carbon neutrality. Microgrids integrate distributed generation, storage, and loads near demand, promoting local use of renewable electricity. For systems containing DC devices such as PV, batteries, and battery electric vehicles (BEVs), DC microgrids can reduce conversion stages and associated losses.

This study developed a containerized DC microgrid integrating PV, a stationary battery, AC loads, and bidirectional DC vehicle-to-everything (V2X) around a three-port converter. The test system consisted of a 30 kW PV system, a 172 kWh stationary battery, a 20 kW DC V2X interface, AC loads, and a 50 kW-class three-port power converter. The converter coordinated PV and V2X power, battery charging and discharging, and supply to the AC loads. The reduced conversion stages were intended to decrease system losses.

Field tests were conducted using practical loads at an accommodation facility renovated from a closed elementary school. A kitchen and a gymnasium designated as a local evacuation shelter were used as the principal loads. PV, battery, AC-load, and V2X power were measured to evaluate efficiency, response to PV fluctuations, BEV supply, and absorption of surplus PV energy.

The three-port-converter-based system achieved an average efficiency of 94.8% and a maximum efficiency of 96%. During operation, the rectifier and stationary battery compensated for rapid changes in PV output and demand, maintaining stable load supply. DC V2X allowed the BEV to supplement the stationary battery. When PV generation was unavailable or insufficient, electricity discharged from the BEV supported the AC loads. When the stationary battery was nearly full, BEV charging absorbed surplus PV energy and expanded system storage capacity. Thus, DC V2X improved response to PV fluctuations and renewable energy utilization, with the BEV complementing stationary storage.

Automotive components, high-frequency isolation, and integrated circuits reduced converter volume to approximately one tenth of the conventional configuration. The compact design enabled the 50 kW-class DC microgrid to be installed in a 20-ft container, while compatibility with standard racks allowed the output capacity to be increased. Trailer transport extends potential use to disaster relief, outdoor events, mountainous construction sites, and regional peak-demand management. The containerized system therefore has potential as a mobile energy hub integrating power conversion, storage, and supply functions where required.

Figure 1: Comparison of conversion stages using a three-port power conversion unit

Figure 2: Conceptual configuration of the DC microgrid in a container

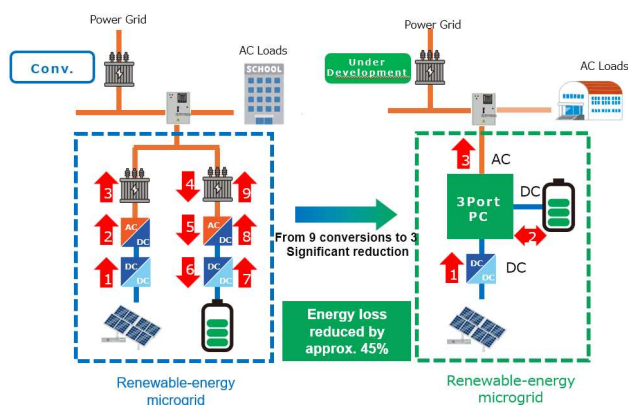


Fig.1 Comparison of conversion stages using a three-port power conversion unit

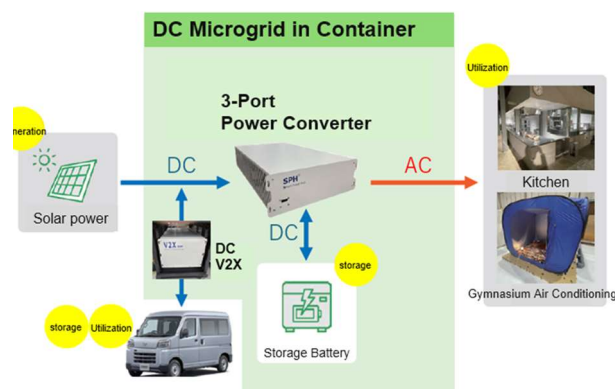


Fig.2 Conceptual configuration of the DC microgrid in a container