Containerized Microgrid Solutions with Decentralized Controls for Rapid Response Situations

Samantha Janko
Graduate Research Assistant
The Polytechnic School
Ira A. Fulton Schools of Engineering
Arizona State University
Mesa, Arizona, 85212
sjanko@asu.edu

Nathan Johnson
Assistant Professor
The Polytechnic School
Ira A. Fulton Schools of Engineering
Arizona State University
Mesa, Arizona, 85212
nathanjohnson@asu.edu

Abstract**—**Rapidly deployable solutions are needed to address electrical demands following extreme weather events or conflict, military stationing, and off-grid or weak-grid applications. This need escalates when considering the scope of disaster relief in which the loss of electricity can cost lives during critical operations such as surgery, search and rescue, and vaccine refrigeration that require a consistent source of power. Traditional diesel and gasoline generators are the primary source of electricity backup during a disaster, but fuel shortages can result in delays in relief efforts during the critical hours and days following a crisis situation. Rapidly deployable solutions involving diesel or gas generators, solar photovoltaic (PV), and battery storage can meet immediate needs, operate for longer periods without fuel resupply, and form the basis for a more resilient electrical infrastructure. The addition of advanced controls can permit seamless integration into existing infrastructure. This poster describes the design of a containerized microgrid system for disaster response and how advanced control algorithms and self-organization strategies can be used to interconnect multiple containerized systems for scalability and grid integration.

Inspired by events such as Hurricane Katrina (2005), the 2010 Haiti Earthquake, and Hurricane Matthew (2016), a 20kW containerized microgrid was developed to provide an independent and sustainable power source for disaster response. The complete system fits inside a standard 20ft shipping container for simplified logistics via road, air, or sea. Water sanitation and shade structures can be added to provide clean water and shelter. The designed system meets electricity requirements for a command center, clinic, cellular communications, kitchen, short-term lodging and public lighting, and other critical loads needed to stabilize development in the wake of a natural or anthropogenic disaster that destroys or disables local electrical infrastructure. Deploying modular and self-contained microgrids has the potential to reduce human harm following disaster by providing a decentralized network of electrical generation assets designed to meet critical loads for human survival and well-being. The inherent flexibility, modularity, and scalability in the design can be easily tailored for different scenarios involving different disasters, needs, local renewable resources, fuel availability, and physical deployment space.

The containerized microgrid can be configured to operate either independently (islanded) or attached to a larger grid system using a plug-and-play electrical interface and intelligent controls. Multiple microgrids can be networked using principles of self-organization from nature to attain network-level objectives such as reduced operation cost, improved reliability and service restoration times, and more effective utilization of distributed energy resources. The network of microgrids can therefore serve as a reconfigurable set of assets that can moved and recombined to meet changing needs while the population recovers and rebuilds. Load sharing and power trading between microgrids ensures that the microgrids operate using the least amount of fuel, help manage overloaded lines, improve power quality, and minimize load shedding during the recovery phase.