Classification of Real-World Microgrids Based on a Morphological Analysis

Completed Research

Jana Gerlach
Leibniz Universität Hannover
gerlach@iwi.uni-hannover.de

Sarah Eckhoff
Leibniz Universität Hannover
eckhoff@iwi.uni-hannover.de

Oliver Werth
Leibniz Universität Hannover
werth@iwi.uni-hannover.de

Tobias Kraschewski
Leibniz Universität Hannover
kraschewski@iwi.uni-hannover.de

Tim Brauner
Leibniz Universität Hannover
brauner@iwi.uni-hannover.de

Michael H. Breitner
Leibniz Universität Hannover
breitner@iwi.uni-hannover.de

Abstract

Microgrids integrate distributed energy resources into an energy network reliably and efficiently. However, research of real-world examples at the international level is limited. We conduct a morphological analysis for microgrid design options to examine the status quo of academic literature. We identify 18 dimensions with 60 characteristics divided into the five layers governance, business, intelligence, communication, and physical. Subsequently, we classify 30 real-world microgrids with diverse types and locations using our morphological box. Our analysis reveals future research requirements regarding social aspects, business models, critical success factors, and maturity levels. We provide a framework supporting decision-makers to identify microgrid design options and promote socially, economically, and environmentally sustainable, resilient, and decentralized energy supply.

Keywords

Real-world microgrids, morphological analysis, classification, future research agenda.

Introduction

The United Nations' Sustainable Development Goals call for increased awareness of climate change mitigation, the use of affordable and clean energy resources, and sustainable urban and community development. These calls are well reflected in the growing dissemination of distributed renewable energy resources, representing a paradigm shift from centralized, carbon-intensive, and low-end-use efficiency energy systems. It becomes an ambitious challenge to control and operate a considerable number of distributed energy resources (DERs) within the network safely and efficiently, making Information and Communication Technologies (ICTs) increasingly necessary. In this context, microgrids (MGs) have emerged (e.g., Sachs et al. 2019) that enable a sustainable transformation towards decentralized energy systems. There are various overlapping definitions of MGs; the Consortium for Electric Reliability Technology Solutions (CERTS) defines MGs as "interconnected sources of DERs (such as solar and wind power), energy storage, and electrical loads that can operate either independently or connected to a surrounding electricity grid" (CERTS 2019). The European Commission defines MGs in the framework of the *More Microgrids* project as "low-voltage distribution systems with distributed energy sources, devices and controllable loads operated connected to the main power network or islanded, in controlled, operated way" (European Commission 2012). MGs are divided into different types, including campus,