Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 100 (2016) 352 – 359

Energy Procedia

3rd International Conference on Power and Energy Systems Engineering, CPESE 2016, 8-12 September 2016, Kitakyushu, Japan

# Heuristics-based Central Controller in Resilient Microgrids (RMGs) for Transportation Systems

Hossam Gaber [a,c,*] , Ahmed M. Othman [a,b] , Kartikey Singh [a]

*a Faculty of Energy Systems and Nuclear Science, University of Ontario Institute of Technology, Canada*
*b Elec. Power & Machine Depart, Faculty of Eng., Zagazig University, Egypt*
*c Faculty of Engineering and Applied Science, University of Ontario Institute of Technology, Canada*

**Abstract**

This paper presents a Microgrid (MG) with central controller based on heuristics technique to manage the performance of MG applied to transportation system. Distributed Energy Resources (DER) are widely used in MGs to match the various load types and profiles. One potential application is the integration with the regional transportation and railway infrastructures as a new green technology. This goal will be enable interconnected Smart Energy Grids to work transparently with the recent energy storage. Railway transportation with microgrids model is proposed to balance energy flows between trains moving and braking energy, energy storage system and a main power utility network. An energy central controlling and optimization tool for the interconnected railway- microgrids can be used for energy management application and for achieving the economical cost during the operation, leading to Resilient Microgrid (RMG). Also, the present research achieves enhancing in MG dynamic performance, in addition to ensure other improvements in the power management. Digital simulations have been validated the results to show the effectiveness and improved performance using the proposed strategy.


Peer-review under responsibility of the organizing committee of CPESE 2016

*Keywords:* Microgrid (MG), Railway Transportation, Central Control, Energy Management

## 1. Introduction

Microgrid (MG) should have various technical objectives for achieving control, stability and reliability criteria to the performance. Distributed Energy Resources (DERs) are important in the operation of MG; they are wind turbine, solar photovoltaic, micro turbines, fuel cells and others. Railway systems have already started to use hybrid storage

* *E-mail address:* hossam.gaber@uoit.ca


Peer-review under responsibility of the organizing committee of CPESE 2016
doi:10.1016/j.egypro.2016.10.188

devices to increase the efficiency of railway systems by storing energy which is generated while breaking with help of power electronic converters and also smoothes out the load transients. With the advancement of technology and power electronics along with the storage systems, railways are not anymore just passive loads but if considered as a part of a larger picture i.e., a Microgrid, they are active elements participating into the load management and demands of the network [1-3]. With the rising concern about the efficiency and environmental impact of railways, it has become significant to use techniques for converting mechanical energy of railways into electrical energy during braking using regenerative braking. During the braking period, there are two options available. Energy during braking can be transported to another train which is consuming power while accelerating and the other way is to dissipate this energy if no other train is available. To get an efficient system, we can organize the train schedules in an optimized fashion. With advancement in the field of power electronics, on board storage devices has been developed which increases the efficiency of the system even more. In order to further increase the economic effects related to energy flows of the railway system, it is necessary to implement a higher control system to take into account the possibility of different electricity prices throughout the day or changing acceptable power exchange levels imposed by the power utility. With the help of microgrids, the integration of railway system with existing grid has been more optimized than ever. It has brought possibility of dynamical optimization of the railway system total power consumption by means of distributed regenerative braking, renewable energy sources and storages. A microgrid structure is formed with railway system supply substation, where trains which are breaking act like distributed sources and the energy storage systems are present in the substation. The task of microgrid control here will be to determine the energy exchange with grid, storage elements and transfer between accelerating and decelerating trains. As it's possible, there may be a price profile for the utility consumption. This must also be taken into account by the microgrid for optimal economic operation. It needs to account for the current state of the storage system and must be able to make decisions on from where to transfer the power. As discussed earlier, with help of train schedules we can further optimize the running cost of trains [4, 5]. Modern Artificial Intelligent (AI) techniques have many applications in various areas of power systems. Adaptive AI controllers and optimizer can be compared with conventional ones to show their effectiveness. Particle swarm optimization (PSO) is considered as an evolutionary method with emerging intelligence to work on searching the global optimal solutions with flexibility inside the problem space [8, 9]. PSO realizes remarkable impacts with effective universal property that is independent in solving different numerical optimization problems. Therefore, the positive options from PSO application can be obtained to properly select and control MGCC parameters. The system response, for the operating cases with related MGCC parameters, will show the effect to get the significant setting of those parameters to enhance the response. Without adapting the MGCC parameters, we may loss the benefits that can be obtained from installing the MGCC where that may impair the system response. MGCC has been validated for enhancing the performance of the MG with DERs.

## 2. MG Design and Configuration

The design of MG with hardware demonstrations is presented in Energy Safety and Control Laboratory (ESCL), University of Ontario Institute of Technology (UOIT). The design of MG includes Micro-Gas turbine, Hydrogen fuel cell, Wind Turbine (WT), Photovoltaic (PV). Various types of DC and AC loads are presented such as: resistive loads, motorized dc series motor loads, linear AC loads, non-linear AC loads and three phase induction motorized loads. Fig. 1 shows MG configuration including the architecture of the Microgrid central controller (MGCC). In this case MGCC manages the flow of power and determines which source(s) to be used to meet the demand of transportation load and also determines the amount of power injected by the micro sources to the grid. As shown, there are two paths for power flow for micro sources. One path is for power flow from the micro sources to the grid or to the transportation load and is named as 2 and 3 in the figure and the second path is for when the micro sources don't have enough power to meet their local load and need power from the grid and is named as 1 and 4. For the subsequent operation of different paths, a three phase breaker is provided in each path whose operation is governed by the MGCC. Also the power injected by the micro sources is controlled by MGCC as MGCC provides the reference signal to PQ controllers attached to the converters. Signals are named as pv_ref and wind_ref.

That MG has different AC/DC DER units that are supplying different AC and DC loads. The AC sources are DFIG wind turbine generator and micro-gas turbine generator. The DC sources are battery, fuel cell stack based on Hydrogen and PV arrays. For full operation utilization, there are boost converters, AC/DC, DC/AC and DC/DC