# Optimal Energy management and Control of Micro-grids with Renewable energy sources

## Abstract

Submitted by


# Kallol Roy

***(PhD Registration No: 1021914001 of 2019)***


***Doctor of Philosophy (Engineering)***


**Department of Power Engineering,**

**Faculty Council of Engineering and Technology**

**Jadavpur University**

**Kolkata, India**


**2022**

# Research Title: Optimal Energy management and Control of Micro-grids with renewable energy sources

Micro grids are local energy providers which can reduce energy expense harmful environmental pollutants and increase system reliability by utilising energy resources. They are considered to be one of the promising alternatives to existing centralised system. Micro grid can be defined as a small power system consisting of power converter based generation, energy storage devices, small classic synchronous generation and various types of loads. This configuration with a proper control could provide lots of advantages to consumer such as better power quality, higher reliability, more flexibility and less operation and generation cost. Adequate amount of demand side delivery in micro grid has significant importance due to limitations of using non-dispatch able resources. The problem of demand-supply mismatch exists in these systems if energy generation resources are not adequate to supply the requested load and no proper energy management system is employed.

A new hybrid energy management system and control techniques has been proposed in this thesis to achieve individual source level control to get desired power quality and reliability and the load level control to achieve economic operation at optimum cost and overall system control. Here, First chapter explains the introduction and literature review about the energy management of MG connected system for multi-objective function with various control approaches. Second chapter describes about the microgrid and its type, topologies of ac, dc & hybrid microgrid, basic components of microgrid and merits and demerits of microgrid. Next chapter, it formulates the mathematical problem on the above objective functions. Here, the illustration of MG architecture i.e micro grid architecture model utilizing proposed method, micro grid architecture utilizing proposed hybrid controller, construction of MG connected system with proposed controller, problem formulation, implementation of hybrid method for energy management system, overview of energy system and description of the proposed system are described. Fourth chapter portrays the soft-computing techniques that are used in energy management system. In this section the brief explanation of methodologies of soft computing techniques are elaborated. Fifth chapter presents the simulation result and discussion. Here, the research work has been carried out in different stages and presented in form of case-studies.

In case-study 1, a simple multi-objective function with reduction of fuel cost and emission has been formulated to minimize the fuel cost as well as operation and maintenance cost by the optimal energy management of MG sources. Here, a hybrid ABC strategy, the IABC and CS-BAT based modelling and management of Microgrid System (MG) has been presented. The ABC algorithm is designed in two phases based on objective functions. The initial phase of ABC demonstrates that MG's optimal configuration at low fuel costs. By least cost functionality, the second phase of ABC has been achieved with minimal O&M costs. At IABC, the scout bee phase has been relocated with GSA technology that promises for enhancing the search capability of scout bees. At hybrid CS-BAT here, the configuration of optimal MG is acquired by solving the proposed multiobjective function along with load requirement. The performance of proposed system is examined with previous systems, viz online management, ABC, ABC-ABC, IABC and ABC-FA. The comparative outcomes portrays that proposed system to identify optimal parameters is the most effective technique when meeting the load requirement at the lowest fuel cost and it is more efficient than existing techniques.

In case-study 2, a novel SOGSNN algorithm has been proposed to solve the similar objective function as mentioned in the previous case-study but this time with different operating scenario of MG units with optimal load forecasting. The proposed SOGSNN method is the combined performance of GSA-ANN and SSA, hence it is named SOGSNN. The purpose of the SOGSNN method is to reduce the fuel costs, emissions and operation with maintenance costs with optimal use of RES. The optimization issue involves a kind of energy sources that can be performed in the MG like, photovoltaic, wind turbine, micro turbine, BESS. Control operations needs to the optimization issue to reflect few extra considerations with optimal load forecasting. The proposed hybrid technique is implemented in MATLAB/Simulink platform along its proficiency is assessed with various current approaches. The efficacy of the SOGSNN method is examined with other exiting techniques such as ABC, BFO and ANFASO technique. The comparative result provides the proposed method is more efficient than other previous approaches.

In case-study 3, the problem has been made more complex for better techno-economic analysis by considering multi objective problem formulation. The proposed hybrid technique is in terms of a combination of ANFIS and ASOA approach. The intention of the proposed technique is to reduce overall fuel cost and increase the use of RES with considering the generation cost of PV & wind power. The optimization issue involves maximum uses of energy sources that can be found in the MG like battery storage, photovoltaic, micro turbine

and wind turbine sources. The control operations have been added to the optimization issue to reveal few another considerations that are mostly found in the smaller generation scheme. The proposed method is implemented in MATLAB/Simulink, also their effectiveness is analyzed with different existing methods. From the experimental outcomes, it clearly shows that the use of optimum power generating costs and energy sources for micro grid that the optimization works best and provides the optimum power scheme for the generators after carry out the objective functions. The proposed approach is compared with other previous methods like GA, ABC and BFA. Furthermore, the use of the proposed technique has led to a minimization of almost 25% in the entire cost of generating power.

In the fourth case-study of the work, a novel RBFNN-SSA method has been proposed for solving the multi objective problem in order to avoid premature convergence. For maximum techno-economic benefits, the multi objective problem has been formulated in such a way that it can minimizing various objectives including yearly economic loss which includes annual capital cost , annual replacement cost, annual fuel cost, annual operation and maintenance cost as well as optimal forecasting load demand. Here, maximizing usage of MG sources and minimizing the operational cost is performed by the RBFNN-SSA method. The proposed RBFNN-SSA is implemented in MATLAB/Simulink platform and then the proficiency is assessed and tested with the exiting techniques viz IABC, BFOANN, ALO, GOAPSNN methods.

Sixth chapter presents the conclusion and future scope of that proposed microgrid connected system.

Kallol Roy

Signature of Candidate:

Date: 13.06.22.

Signature of Supervisor(s):

(Signature with date, seal)

1. 13/6/22

Professor
Dept. of Power Engineering
Jadavpur University
Salt Lake, 2nd Campus
Kolkata-700 098

2. 13.6.22

Dr. Atis Chandra Mandal
Professor
Department of Physics
The University of Burdwan
Burdwan-713104