Chapter 14
Economic Operation of Smart Micro-Grid: A Meta-Heuristic Approach

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ABSTRACT
Presently, economic operation of micro-grid is a major concern in smart grid environment. This is a very complex problem, which can be solved with the help of various meta-heuristic techniques. Therefore, this chapter provides a comparative analysis of four different renowned meta-heuristic techniques with reference to the problem of optimal operation of micro-grid (MG). Genetic algorithm (GA), particle swarm optimization (PSO), differential evaluation (DE), and firefly (FF) algorithm are utilized for this purpose.

1. INTRODUCTION
Since 1990s, the deregulation of the electricity supply industry started in different parts of the world. The deregulated electricity market structure can be retail or wholesale, in which generation, transmission and distribution sectors functioned as separated entities (Khan et al., 2014, 2016). Electricity market deregulation is required for changing the situation in which micro-grids are considered as threats to the valued energy sources those are fairly compensated (Khan et al. 2014 and 2013, Khan and Agnihotri, 2012). All these three sectors are fully unbundled into different utility services and are allowed to supply and compete in wholesale and retail electricity market. After deregulation, traditional electricity grid is converted into the smart structure since 2010. The key feature of this smart system is the incorporation of the renewable energy sources at different levels such as distributed level and bulk level. International energy agency predicted that the energy generation from the renewable energy sources is increased up

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to three times till 2035 (Khan and Singh, 2017; Mulualem and Khan 2017). Further, the total energy production from the renewable energy sources will be increased to 31%, in which hydro, wind and solar will provide 50%, 25% and 7.5%, respectively. The two major issues with renewable energy generation are intermittency and climate dependency of renewable sources. These problems make integration of these sources with conventional grid more difficult and complex. The above discussed problems can be minimized with the help of energy storage devices. These devices incorporated various conventional storage systems such as batteries and heat buffers along with advanced storage techniques such as fuel cell technology, electric vehicle technology etc. Therefore, there was a necessity to develop such a system which incorporates different renewable energy sources with energy storage options to mitigate the issues related with renewable energy sources. This necessity is fulfilled with the development of micro-grid system (Khan and Singh, 2017; Fanuel et al. 2018). It is the combination of different type of loads (domestic, commercial, industrial) with various renewable energy sources such as solar photo voltaic, wind, micro turbine and small hydro along with energy storage devices such as battery energy storage, heat buffer, flywheel storage, and electric vehicle technology. Moreover it also incorporates advanced generation techniques for example fuel cell technology and combined heat and power (CHP) technology. In smart grid structure, micro-grid technology provides a holistic approach for the integration of renewable energy sources. It has several benefits over the conventional grid system as it’s minimise energy losses, improve reliability and enhance energy management. Further, at distribution level, micro-grid technology provided better solution of energy scarcity, generation coordination and control problems due to its better performance with respect to distributed generation technology (Khan and Singh, 2017; Kifle et al. 2018). There are two different modes of operation available in micro-grid technology. These are as follows:

1. Grid connected operation mode
2. Islanded operation mode

As per the requirement of operation, any mode can be selected. Therefore the problems of coordination, control and operation are very important from micro-grid point of view. Moreover costs are also associated with micro-grid’s generation, operation and maintenance in a similar way as conventional grid. Therefore, economic operation of micro-grid refers the optimization of the micro-grid costs associated with generation, maintenance and operation etc (Khan and Singh, 2017). It is a cost minimization problem under various systems constrains.

Different Meta-heuristics methods are proposed by various researchers for solving the cost optimization problem of micro-grid. Meta-heuristic optimization techniques, which are depended on population, is mainly categorised into two categories:

1. Swarm intelligence
2. Evolutionary algorithms

Some renowned evolutionary methods are further classified as follows:

1. Differential evaluation (DE)
2. Evolution Programming (EP)
3. Evaluation strategy (ES)
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