Chapter 5
Power Management in Microgrids:
A Multi Agent Petri Nets Based Approach

Tarek Jellad
ENIS, Tunisia

Khaled Taouil
ENIS, Tunisia

Zied Chtourou
ENIS, Tunisia

ABSTRACT

Conventional power generation stations used to be centralized and located far from customers. The transport and distribution infrastructure incur power losses that are mainly due to cabling resistance. Distributed power generation resources located close to customers are sought as a solution to minimize transport power losses. They are also good alternatives in situations where connection to the grid is not possible due to geographical or economical reasons. Furthermore, the adoption of renewable energies as alternatives for the scarce fossil energy sources paves the way to more distributed energy production. These Distributed energy resources, when located in a limited region, can be interconnected with loads and eventually storages to form a microgrid. A microgrid can operate in off-grid, on-grid, or alternate between these modes while optimizing power quality and cost. Multi-Agent Systems (MAS) and Petri nets could be put into contribution for high level planning of energy exchanges within a microgrid. This strategy has been validated on the basis of a dynamic model for the simulation and optimization of power exchanges between different DERs.

DOI: 10.4018/978-1-4666-4450-2.ch005

INTRODUCTION

Power generation facilities used to be centralized and located far from the demand. This is due to the gas emissions inherent to fossil energy sources or to the dependence to natural resources such as dams or lakes. The generated power is then conveyed to the customers through overhead or underground lines. These transport and distribution operations are accompanied with substantive power losses. Moreover, the scarcity of fossil energy resources is continually pushing towards adopting renewable energy resources to satisfy part or the totality the energy needs.

The development of decentralized production means of electric power particularly from renewable energy opens the way for new modes of operation within microgrids. These structures are a concept which refers to a small-scale power system with a cluster of loads and distributed generators operating together with energy management, control and protection devices and associated software (Ustun, Ozansoy, & Zayegh, 2011). Microgrids could work on-grid, off-grid or continuously alternate between both modes.

To ensure optimal management of the energy produced by the various units of the microgrid, many features could be envisaged as shedding, deletion and dispatching of potential loads (Huang, Wang, & Jiang, 2012). However these functionalities couldn't be available only if we have the necessary information on production units mostly related to weather conditions and predicted loads of different consumers. Local facilities must be equipped by advanced sensors and smart meters to ensure local monitoring from IHM devices (Shekara, Wang, & Devabhaktuni, 2011).

Several approaches have been proposed for managing electric energy, (Huang, Lu, & Zhang, 2001; Kumar, Chowdhury, & Paul, 2011; Dursun, & Kilic, 2012; Alvarez, Campos, Arboleya, & Gutiérrez, 2012; Zhao, Chen, Zhong, Lin, Wang, & Zhang, 2012). Management of peak consumption remains among the main problems related to electrical energy distribution. Moreover, the difficulty of electrical energy storage (Toledo, Filho, & Diniz, 2010) and the lack of real time information on production and loads status complicate the maintenance of the energy balance within microgrids (Basak, Chowdhury, Halder, & S. Chowdhury, 2012).

For reasons related to energy saving and environment preservation, the final consumer is attracted by new pricing practices and services offers. He becomes an active actor in the electric energy system. He can proceed voluntary to change his consumption patterns exploiting new possibilities of information and communication technologies (Alvial-Palavicino, Garrido-Echeverría, Jiménez-Estévez, Reyes, & Palma-Behnke, 2011).

Demand-response strategy was adopted in the U.S. to avoid large-scale blackout (OpenADR protocol) (Haaser, 2011). This demand-response strategy can be applied in microgrid to ensure optimal management of the energy under conditions of intermittent renewable generation sources, mainly due to changes in climatic conditions, and keep use of non-renewable production sources to minimum(Lu, Fakham, Zhou, & François, 2010).

Microgrid power management system must be capable of achieving a solution to a multi-objective combinational problem. In fact, the control solution should meet local power demands considering realistic constraints such as: emissions concerns, fuel availability and cost, weather conditions, the spot-market price of electricity, etc (Colson, 2009). However, it is difficult to find an optimal solution that satisfies simultaneously numerous competing objectives using traditional optimization derivative and non-derivatives methods (Andersson, 2001). As a formulation of this multi-objective multi-constraint problem, some researches propose to optimize a global cost function using GA (Genetic Algorithms) (Mohamed &Koivo, 2010; Mohammadi, Hosseinian, & Gharehpetian, 2012; Mohamed, &Koivo, 2012). In the literature, it is also common to adopt a Pareto optimal approach to solve the distribution energy management problem (Sathyanarayana, 2010). Recent works use emerging computational techniques like those