Coordinative Optimization Control of Microgrid Based on Model Predictive Control

Changbin Hu, College of Electrical and Control Engineering, North China University of Technology, Beijing, China
Lisong Bi, College of Electrical and Control Engineering, North China University of Technology, Beijing, China
ZhengGuo Piao, College of Electrical and Control Engineering, North China University of Technology, Beijing, China
ChunXue Wen, College of Electrical and Control Engineering, North China University of Technology, Beijing, China
Lijun Hou, Resource Electric Tianjin Ltd, Tianjin, China

ABSTRACT

This article describes how basing on the future behavior of microgrid system, forecasting renewable energy power generation, load and real-time electricity price, a model predictive control (MPC) strategy is proposed in this article to optimize microgrid operations, while meeting the time-varying requirements and operation constraints. Considering the problems of unit commitment, energy storage, economic dispatching, sale-purchase of electricity and load reduction schedule, the authors first model a microgrid system with a large number of constraints and variables to model the power generation technology and physical characteristics. Meanwhile the authors use a mixed logic dynamical framework to guarantee a reasonable behavior for grid interaction and storage and consider the influences of battery life and recession. Then for forecasting uncertainties in the microgrid, a feedback mechanism is introduced in MPC to solve the problem by using a receding horizon control. The objective of minimizing the operation costs is achieved by an MPC strategy for scheduling the behaviors of components in the microgrid. Finally, a comparative analysis has been carried out between the MPC and some traditional control methods. The MPC leads to a significant improvement in operating costs and on the computational burden. The economy and efficiency of the MPC are shown by the simulations.

KEYWORDS

Forecast Uncertainties, Microgrid, Model Predictive Control (MPC), Optimization Control, Receding Horizon Control

1. INTRODUCTION

In the past two decades, Renewable Energy (RES), such as wind and photovoltaic, is considered the key to solve the increasingly severe energy crisis and environmental problems. Therefore, microgrid that is integrated with distributed energy resources, loads, energy storages and other units attracts the extensive attention. Microgrid improves the reliability of the distributed generation system, and realizes the integrated operation of the distributed generation, and loads (Bie, Li & Wang, 2011). It reduces the pollution emission of the electrical power system and has become an important part of the smart grid construction.

DOI: 10.4018/IJACI.2018070105

Copyright © 2018, IGI Global. Copying or distributing in print or electronic forms without written permission of IGI Global is prohibited.
Due to the Intermittent and volatility of distributed renewable energy, the forecast of renewable energy power generation is necessary. According to the historical trend and meteorological data, we use physical simulation and scientific statistical methods to forecast the renewable energy generation. However, because of the limitations of existing methods, the current prediction accuracy is quite low. In wind power generation, for example, one hour of the prediction error up to 10% (Dongliang et al., 2012). Conti, Nicolosi, Rizzo and Zeineddin (2012) present a real-time microgrid scheduling strategy. Although the short-term power prediction error is small, they ignore the coordination of distributed generation units and energy storage equipment in a long-time operation. Palma-Behnke et al. (2013) propose a multi-period micro-grid economic scheduling, in which power prediction error increases with time, leading to scheduling plans deviate from the actual situation.

At the same time, with the introduction of energy storage devices and the diversity of load control (Jagatheesan et al., 2016), the energy management of microgrid is faced with more problems and challenges. In order to solve the complex optimization problems and improve the economy, a lot of researches have focused on the improvement of the optimization algorithm and the development of a reasonable modeling framework (Mhetre, Deshpande & Mahalle, 2016), network-aware energy conservation scheduling DENS algorithm applied in cloud data center is put forward to realize the full utilization of all kinds of resources in the cloud data center (Zhang, Qi and Deng, 2017). Liao (2012) presents a new modeling method and scheduling strategy, and verify the accuracy and validity of the mathematical model by genetic algorithm. Different heuristic methods are proposed in the hybrid energy storage microgrid control (Zhou & Francois, 2011). Jagatheesan, Anand, Dey, Omar and Balas (2016) consider different cost functions and ant colony optimization technique-based pid controller to achieve high quality of power supply. However, these schemes cannot solve the errors brought by uncertain factors such as intermittent renewable energy generation and load forecasting in microgrid systems.

Model Predictive Control (MPC) is a kind of computer control algorithm which is put forward in the background of industrial demand. It mainly includes three core parts: prediction model, rolling optimization and feedback correction. MPC is a multivariable controller with the following advantages: 1) it has less requirements on the model of the controlled object, only focus on its forecasting function. 2) it has good dynamic control performance by using rolling optimization. 3) it can effectively deal with system constraints, handle multi-variable system and realize Multi-objective optimization. The MPC is usually proposed to solve the unit commitment problem of wind turbines (Meibom et al., 2011) and applied to power system dispatching. A new control strategy is proposed (Zeng, Wu, Zhang, Liang & Zhang, 2014), which combines the MPC and the hierarchical optimization, to promote the integration of renewable energy by the energy storage systems. The control strategy is divided into the day-ahead scheduling and real-time scheduling to complete their respective objective. Gulin, Matuško and Vašak (2015) investigate a stochastic model predictive control for the closed-loop power management by using chance constraints in the microgrid. Jiang, Liu and Wang (2014) set up a mixed logical dynamical model by analyzing the hybrid property of Microgrid in detail. Therefore, MPC owns important theoretical significance and practical application value for the coordinative optimization control of microgrid.

In the process industry and other fields, a controlled object becomes complex because of the introduction of electromagnetic valves, potential switches and some other discrete devices. With the increasing requirements for the precision of industrial process, the traditional method has been difficult to meet the actual needs, so some scholars began to develop the hybrid logic dynamic (Mixed Logic Dynamical, MLD) system. MLD system is described by the interdependent internal laws of physics, the rules of logical expression and the constraints of the operation. It mainly uses the inequality to describe the propositional logic relations and the inherent characteristics of the system.

Microgrid is also a system which combines both discrete and continuous dynamic characteristics. Power flow, voltage and some other physical quantities can be expressed as continuous variables. The generators off/on states and the energy storage systems charge/discharge states can be expressed as
Application of Fuzzy Optimization in Forecasting and Planning of Construction Industry
www.igi-global.com/chapter/application-fuzzy-optimization-forecasting-planning/5326?camid=4v1a

Teaching Machines to Find Names
www.igi-global.com/chapter/teaching-machines-find-names/10446?camid=4v1a