Chapter 13
Application of AI in Smart Grid Under Electricity Deregulation

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ABSTRACT

The integration of advanced metering infrastructure, control, and communication technologies in smart grids enables the collection of large amounts of multi-type, high-dimensional data on electric power grid operations. However, standard modelling, optimization, and control technologies face limitations in processing this data. This article addresses the growing application of artificial intelligence (AI) in smart grids. The motivation stems from the need to enhance the efficiency, reliability, and economic performance of smart grids in a deregulated market. conventional technologies faced challenges in handling complex data. The AI methods overcome these challenges. Results indicate improvements in predictive maintenance, demand forecasting, load balancing, and energy trading. AI's superior performance in enhancing grid stability and market efficiency. The study concludes the transformative potential of AI in creating a more reliable, efficient, and economically viable energy infrastructure.

1. INTRODUCTION

The smart grid is revolutionizing the conventional electric power grid by making it an electronically controlled network instead of an electromechanical system. According to the US Department of Energy's Smart Grid System Report, these smart grid systems include a number of different parts, including

DOI: 10.4018/979-8-3693-7112-1.ch013

digital sensing, information management, control technologies, communication technologies, and field devices. Together, these parts enable the coordination of various electric processes.

The smart grid represents a significant evolution in the conventional electric power grid, transforming it from an electromechanical system into an electronically controlled network. This advancement is driven by the integration of digital sensing, information management, control technologies, communication technologies, and field devices, as highlighted in the US Department of Energy's Smart Grid System Report. These components work together to enable the coordination of various electric processes, fundamentally changing how grids are planned and operated.

The evolution of the electric power grid from a traditional electromechanical system to a smart grid represents a pivotal advancement in energy infrastructure worldwide. This transformation is underpinned by the integration of sophisticated technologies such as digital sensing, information management systems, advanced control mechanisms, communication technologies, and a multitude of field devices. These components collectively form the backbone of what is known as the smart grid, enabling unprecedented levels of control, monitoring, and optimization in electric power distribution and management.

1.1 Background

Smart grid technologies have brought about substantial improvements in three key areas: process monitoring and measurement, data exchange, and data analysis. First, they enable automated process monitoring and real-time measurement, allowing data to be relayed to operation centers seamlessly. Second, these technologies facilitate the exchange of data across systems and devices, ensuring cohesive grid management. Third, they provide operators with access to analyzed data from various digital technologies, aiding in informed decision-making.

The deployment of smart grid technologies has revolutionized several critical aspects of grid operation:

- **Process Monitoring and Measurement:** Smart grids enable automated monitoring of grid processes and real-time measurement of electricity usage across different points in the grid. This capability enhances the ability of grid operators to identify anomalies, respond to emergencies promptly, and optimize overall grid performance.
- **Data Exchange and Integration:** Digital technologies within smart grids facilitate seamless data exchange and integration across different systems and devices. This interconnectedness enables more efficient coordination of grid operations and enhances the reliability and resilience of the grid.
- **Data Analysis and Decision Support:** Perhaps most significantly, smart grids leverage advanced analytics to analyze vast amounts of data generated by grid operations. This data-driven approach empowers grid operators with actionable insights, facilitating informed decision-making aimed at improving efficiency, reducing costs, and enhancing grid stability.

The introduction of smart grid technologies has significantly impacted three main areas of grid planning and operation. First of all, it makes process monitoring and measurement possible. Data may be automatically adjusted and relayed to operation centers. It also makes data exchange across systems and devices easier. Finally, it gathers, examines, and makes data from digital technologies available to operators across the grid. In addition, smart grids tackle a number of issues, such as defect detection, smart grid security, load forecasting, and power grid stability evaluation. Large-scale high-dimensional