Modern Power Systems

Subjects: Energy & Fuels | Engineering, Electrical & Electronic

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Modern power systems include various technological innovations such as distributed renewable energy sources, energy storage devices, electric vehicle charging stations and advanced communication systems. Since many of these components are owned and managed by private entities, the planning and management of modern power systems is gradually changing, and is becoming a great challenge for utility companies and regulators.

Power systems | Renewable energy sources | Energy storage | Electric vehicles

1. Introduction

Power systems are going through a transformative change due to the penetration of new disruptive technologies. This transformation, which is sometimes referred to as 'The Energy Transition', mainly refers to two major changes: the increasing integration of renewable energy sources and the increasing use of electric vehicles [1][2]. Legacy electric grids were not planned with these technological innovations in mind, so they have to significantly change in order to support them [3][4][5]. Furthermore, these technologies can be purchased and managed by any citizen; hence, the way they will develop depends on the opinions of many people. For example, they may be integrated in a centralized manner by big companies or crowd funding, or in a distributed small scale manner in residential areas. As a result, the private sector is becoming a key player in the energy market, and its influence on the development of electrical grids is gradually growing. Consequently, electric utilities and governments that have worked in a centralized manner for over a century have to fundamentally change the ways they plan and operate the electric grid, and they need to find new ways to predict and control the behavior of multiple entities operating within a single system.

2. Current Status

The research community currently understand quite well the behavior of each player in the power system, be it a grid operator, a consumer, an energy source, or a storage system. Yet, recent studies show that the interactions among these players are at least as important as the individual behavior of each of them [6][7]. The current approach of most studies is to forecast the development of power systems by solving optimization problems from the perspective of one entity with unlimited knowledge and control span [8][9][10][11][12]. While this approach might have been relevant for many years, it is gradually becoming unrealistic due to the decentralization and deregulation of the energy market. A major challenge is therefore to predict the development of a power system, taking into account the different objectives of the many players. This can be done, for example, based on game theory, which studies strategic interaction among rational players.

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