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Enterprise-wide optimization for industrial demand side management: fundamentals, advances, and perspectives

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Abstract

The active management of electricity demand, also referred to as demand side management (DSM), has been recognized as an effective approach to increase power grid performance and consumer benefits. Being large electricity consumers, the power-intensive process industries play a key role in DSM. In particular, enterprise-wide optimization (EWO) for industrial DSM has emerged as a major area of interest for both researchers and practitioners. In this work, we introduce the reader to the fundamentals of power system economics, provide a definition of DSM that reflects more strongly the consumer's perspective, and present a comprehensive review of existing works on EWO for industrial DSM. The review is organized into four parts, which correspond to the four main challenges that we identify as: (1) accurate modeling of operational flexibility, (2) integration of production and energy management, (3) decision-making across multiple time and space scales, and (4) optimization under uncertainty. Finally, we highlight research gaps and future opportunities in this area.

Keywords: enterprise-wide optimization, demand side management, electricity markets

1. Introduction

In the light of increasing volatility in electricity price and availability, demand side management (DSM), which refers to the active management of electricity demand, has been recognized as an effective approach to improving power grid performance and consumer benefits. For electricity consumers, DSM constitutes the opportunity to benefit from financial incentives by adjusting their electricity consumption. Especially for the process industry, which is a major electricity consumer, DSM is becoming increasingly critical for maintaining profitability.

Industrial DSM integrates production and energy management, which requires detailed understanding of the production process as well as knowledge about power system economics. Since decision-making in industrial DSM is highly complex, a systems approach has to be taken in order to find optimal solutions while considering all relevant options and critical constraints. We can establish such a systematic framework for DSM by leveraging the methodologies in mathematical modeling and optimization that have been developed in the area of process systems engineering (PSE). In particular, enterprise-wide optimization (EWO) (Grossmann, 2005, 2012) has proven to be very effective in industrial DSM. Typically, electricity

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