Energy 114 (2016) 981–994

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Review

Electricity demand response in China: Status, feasible market schemes and pilots

Weilin Li, Peng Xu*, Xing Lu, Huilong Wang, Zhihong Pang

College of Mechanical and Power Engineering, No. 4800 Cao'an Road, Tongji University, Shanghai, 201804, China

ARTICLE INFO

Article history:
Received 3 May 2016
Received in revised form
1 August 2016
Accepted 23 August 2016

Keywords:
Demand response
China
Current status
Feasible strategies
Pilot

ABSTRACT

Demand Response (DR) has been extensively developed and implemented in the US and Europe. However, DR hardly exists in many developing countries for similar problems such as rigid power market and state monopoly. With the increasing imbalance between supply and demand in China's power industry, the government has issued new policies on DR and approved the first batch of pilot cities. China is setting a good example of how to encourage DR under monopolistic electric market and open up the market to aggregators and DR suppliers. This paper summarizes the current DR status, feasible DR market schemes and DR pilot projects in China. First, electric power system reform, renewable energy policies and power industry development are reviewed, highlighting the problems associated with the current dispatch mechanisms of DR policies and markets. New DR programs and DR-related policies are also introduced. On this basis, the driving forces and challenges associated with DR in China are analyzed. The major challenge is the lack of a suitable market mechanism for the current Chinese power industry. Hence, this paper presents six feasible strategies that fully utilize the existing policies. Additionally, the latest DR applications in different pilot cities are summarized and analyzed.

Contents

* Corresponding author.
E-mail addresses: weilinli@163.com (W. Li), xupengwb@gmail.com (P. Xu), 651828037@qq.com (X. Lu), 656762508@qq.com (H. Wang), 547257718@qq.com (Z. Pang).

http://dx.doi.org/10.1016/j.energy.2016.08.081
0360-5442/

1. Introduction

The booming economy in China has resulted in a surging demand for electricity. With escalating demand and increased investments in renewable energy generation, electricity supply-demand mismatch is becoming increasingly prominent [1]. The power grid in China has exhibited higher peak loads, and the peak-valley difference has gradually widened. Especially during extreme weather events, network operation may be seriously jeopardized. There are two approaches to minimizing this threat: enlarging the peak regulation capacity from the supply side or implementing a demand response (DR) to relieve the pressure associated with peak loads [2]. Wang et al. [3] stated that peak shaving by means of demand-side bidding could yield greater economic benefits than operating at peak load by comparing the electricity price models of the two schemes. In addition, renewable energy has gradually attracted attention in China, whereas its integration to the grid is hard due to the feature of intermittency [4]. Currently, coal-fired reserve units are mostly used to offset the utilization of renewable energy because renewable energy is less reliable. Continually increasing coal-fired power plant capacities would result in the lower utilization rate of the renewable power generation. However, DR resources could promote the integration of renewable energy into the power grid, reducing the installation of units and the expansion of transmission lines.

DR, a measure used in certain circumstances (such as network congestion or emergency situations), has been extensively developed in the US and Europe, whereas it has only recently gained attention in China [5,6]. It can be defined as “changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.” [7] DR also refers to a wide range of actions which can be taken at the customer side of the electricity meter in response to particular conditions within the electricity system (such as peak period network congestion or high prices) [5]. Unlike DR, Demand side management (DSM), which has been introduced in china for approximate thirty years [8], is a relatively broader concept that incorporates many actions, ranging from the replacement of energy-efficient appliances to the reduction of energy consumption to the shifting of times when electricity is used to the implementation of complex dynamic pricing mechanisms [9]. It can be universally divided into two categories: energy conservation and DR. Energy conservation is an approach that cuts the power load and promotes long-term stability, whereas DR is the most effective approach for minimizing temporal or short-term electricity shortages, which can be devastating (see Fig. 1).

DR can be generally categorized into price-based programs (also called time-based retail rates) and incentive-based programs [6]. Moreover, DR encompasses another special category in China that focuses on policy-guided programs because the Chinese power industry is currently based on the model of a vertically integrated monopoly. As the name implies, policy-guided programs are launched by administrations and serve as key measures of current demand side management (DSM) in China, which mainly focuses on mitigating the power deficit. The time-of-use tariff and tiered tariff are also widely used throughout the nation, but incentive-based DRs have not been used in any grid market in China, excluding pilot studies.

In July 2012, China's Ministry of Finance (MOC) and the National Development and Reform Commission (NDRC) jointly put forth “Interim Measures for management of central government funding for cities piloting DSM” [10], supporting the development of the power demand response, including scientific research, publicity, training, evaluation and assessment. For example, it explicitly states that DR participants are awarded ¥100 (15.4USD) for each kW load curtailment during the peak periods. In November 2012, Suzhou, Beijing, Tangshan and Foshan were approved to become the first batch of cities piloting DSM based on the respective reported implementation plans [11]. The pilot cities are capable of adopting flexible DR policies, taking full advantage of the time-of-use tariff and differential power pricing to achieve peak load shifting and power supply and demand equilibrium dynamically. These pilots also consider critical peak pricing and interruptible tariffs to develop in-depth and well-rounded DR. However, most efforts have focused on medium- and long-term curtailment in these pilot cities, while the quick and short-term DR was investigated until 2014. According to the NDRC requirements, an experimental program was conducted in Shanghai, which was the first short and fast domestic DR application. On April 9, 2015, NDRC together with MOC proclaimed the “Announcement concerning the improvement of the power emergency mechanism and the trial work on DSM in pilot cities” [12]. It also indicated that effective long-term mechanisms should be established, and specific characteristics should be highlighted based on the previous DSM pilot programs in Beijing, Suzhou, Tangshan and Foshan and the DR pilot program in Shanghai. These actions suggest that DR is becoming increasingly valued in China and is shifting from conceptualization to implementation.

Wang et al. [13] reviewed the DR in China in 2010, analyzed the scenario and made suggestions for DR implementation at that time. Nevertheless, dramatic DR changes have occurred over the past four years in China due to not only new policies but also approval of the first pilot cities nationwide. Especially during the past two years, experimental programs in pilot cities have been implemented under the current power industry mechanism, building momentum for future development in China. Hence, it can be