Renewable and Sustainable Energy Reviews 47 (2015) 270–283

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

A review of demand side management business models in the electricity market

Mahdi Behrangrad

Panasonic Corporation, Corporate research and development division, Energy solution center, Nishi-Kadoma district, Corporate R&D division, PC 1006 Kadoma, Kadoma City, Osaka 571-8501, Japan

ARTICLE INFO

Article history:
Received 16 July 2014
Received in revised form
29 January 2015
Accepted 8 March 2015

Keywords:
Demand side management
Demand response
Energy efficiency
Business model
Smart grid
Electricity market
Renewable energy

ABSTRACT

Demand side management (DSM) can be defined as modifications in the demand side energy consumption pattern to foster better efficiency and operations in electrical energy systems. DSM activities, which are classified into "energy efficiency (EE)" and "demand response (DR)" are becoming more popular due to technological advances in smart grids and electricity market deregulation. However, it can be argued that ensuring DSM sustainability requires creating suitable business models. Business models are influenced by different factors such as electricity market regulation, mechanisms, power system characteristics and infrastructure. The proliferation of smart grid infrastructure, distributed generation, intermittent renewable energy resources and energy storage devices has affected DSM business models considerably. Therefore, in this paper, possible business models for EE and DR providers in different electricity market segments are analyzed and reviewed. The analysis covers three types of characteristics: DSM transaction characteristics, renewable energy correlation and DSM load control characteristics. In DSM transaction characteristics, the value proposition of DSM such as added value offered to the DSM purchaser and transaction triggers are discussed. In renewable energy correlation, the effect of increased renewable energy penetration on the business model is evaluated. In DSM load control characteristics, load control and aggregation aspects such as response speed, duration, advance notice, location sensitivity and actual usage frequency are analyzed.

Contents

E-mail addresses: behrangrad.mahdi@jp.panasonic.com, m.behrang.r@gmail.com

http://dx.doi.org/10.1016/j.rser.2015.03.033
1364-0321/

1. Introduction

The modus operandi of generation-based electrical energy systems is accepted to be non-optimal and unsustainable in the long run due to economic limitations and environmental considerations. However, demand side management (DSM) is proving itself to be a promising complementary resource to generation side resources. DSM was first introduced by the Electric Power Research Institute (EPRI) in the 1980s as a series of activities that utilities undertake to change their load shape and/or energy consumption pattern for benefit maximization, investment delay, and reliability enhancement [1]. With the advancement of electricity market liberalization, DSM has further evolved into following two groups [2]:

1- Energy efficiency (EE), reducing the energy required for the provision of services or products.
2- Demand response (DR), changes in electrical 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 [2].

While technological hurdles were previously cited as one of the main challenges for DSM proliferation, this has changed due to technological advances in smart grids. The advancement of technologies such as grid-device bilateral communication, communication-powered smart appliances, computationally powerful local controllers, cloud-based aggregation mechanisms and economically viable energy storage resources can be named in this regard. It can be argued that finding a suitable business model is the next big challenge for DSM sustainability in a market-driven electricity system [3,4]. However, to the best knowledge of the author, there are no papers that comprehensively analyze available DSM business models. The main motivation of this paper is to review and analyze the business models associated with DSM in the electricity market context.

In this paper, DSM business models are analyzed in relation to segments of a typical electricity market: system operation, generation, transmission/distribution, energy retailing and load, as shown in Fig. 1. The system operator (SO) is the stakeholder responsible for achieving the reliable operation of the power system through economically efficient measures such as maintaining system load-generation balance. The generation stakeholder generates electrical energy and can be a fossil fuel-based generator or an intermittent renewable energy resource, such as wind or solar generation. The transmission/distribution stakeholder is responsible for maintaining the secure and reliable transmission and distribution of generated electricity while respecting electricity market transactions to the extent that they do not violate security constraints. The retailing of electricity to loads will be performed by the retailing stakeholder. The load stakeholder is the energy-consuming entity exposed to rates and tariffs enforced by other stakeholders such as the retailer and transmission and distribution stakeholder. In this paper, the term demand resource provider (DRP) is used to describe the stakeholder that turns DSM activity into a business by offering its added value to another stakeholder. DRP can be a DR aggregator, ESCO, load-curtailing entity, load curtailment provider, or load owner.

In this paper, business models are analyzed based on the classification shown in Fig. 2. Here, it should be noted that a stakeholder can handle more than one segment in some electricity markets. As an example, an SO could also handle the transmission/distribution segment, in which case business models related to the transmission/distribution segment can be incorporated with those of the SO. In addition to the stakeholder's role in electricity markets, DSM business models are affected by other factors, such as market structure, generation and transmission network capacity, and electricity tariff structure. Additionally, for a single business model, DSM actions and characteristics could vary in different electricity markets. Therefore, in this paper, typical DSM characteristics are provided for each business model.

Three groups of characteristics are analyzed for each DR business model in this paper, as shown in Table 1. These groups are as follows:

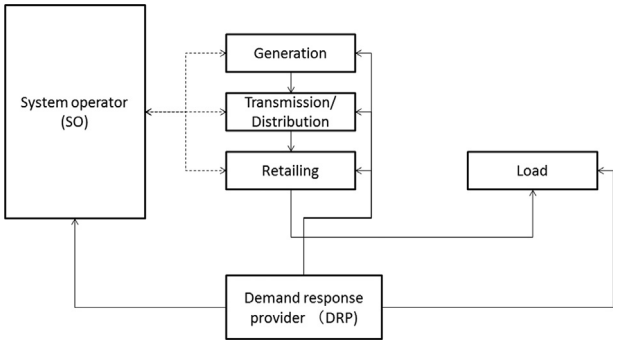

Fig. 1. DRP and energy market segments.