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Conceptual framework for introducing incentive-based demand response programs for retail electricity markets

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ABSTRACT

Enduring expansions and advancement in the knowledge driven energy-economy era promise a power system that is cost-effectively competent, environmentally responsive, flawless and operationally acquiescent. This imminent power system will depend on latest communication technologies, computational easiness, and monitoring and control strategies attributable to the consumers or end users. Amid the numerous advances related to this development, a strategic and significant component is demand side management (DSM). Demand response can play an important and pertinent role in the milieu of DSM, and incentive-based demand response program (IBDRP) is getting customer focus in many parts of the world. This study tries to bring out major aspects to be considered while introducing IBDRP in retail electricity markets. Document analysis, a well-known qualitative research methodology, is used for analyzing various IBDRP schemes practiced globally, with the help of the ATLAS.ti software and utilizing the snowball sampling technique. For better understanding, the results of the axial coding are arranged in three stages: pre-implementation stage, implementation stage, and post-implementation stage. Based on the importance and their frequency of appearance, ten most prominent codes were identified, and the strength of their interrelationships is presented on a multilevel scale with three different ranks. One of the major and important outcomes of this research is that, with the help of the proposed conceptual framework, a proper implementation framework can be built, which can be used for developing most appropriate IBDRP for any retail electricity market.

1. Introduction

Any reduction in the power demand is equivalent to the generation of a similar amount of electricity. In fact, the impact will be more while considering the loss in the network. This gives a wide acceptance to demand side management (DSM) and its major division demand response (DR), in different regions and processes [1]. By proper implementation of different DR programs, an impressive reduction of 28798 MW and 28934 MW was estimated for 2013 and 2014, respectively in the United States of America (USA), which is equivalent to a reduction of around 6% in their peak power [2].

Federal Energy Regulation Commission (FERC) classified DR into price-based DR programs (PBDRP) and incentive-based DR programs (IBDRP) (Fig. 1).

These two programs functions in different ways. In PBDRP, the price of electricity varies with time, while consumers are motivated by giving incentives for reducing consumption in IBDRP.

According to the recent reports published by FERC, in 2013, 9% increase in interest for the adoption of IBDRP in comparison to PBDRP was witnessed among the consumers in the USA [2]. This increased acceptance may motivate new electricity markets to implement IBDRP across the globe.

From Fig. 1, it is evident that IBDRP programs such as direct load control (DLC), interruptible load (IL) and demand bidding/buyback (DBBB) are related to retail market, while ancillary services, emergency DR program, and capacity market program are linked to the wholesale market. Since the retail electricity market deals with different types of end users and consumers, this study focuses on the various functional and implementation aspects of introducing IBDRP, in retail electricity markets.

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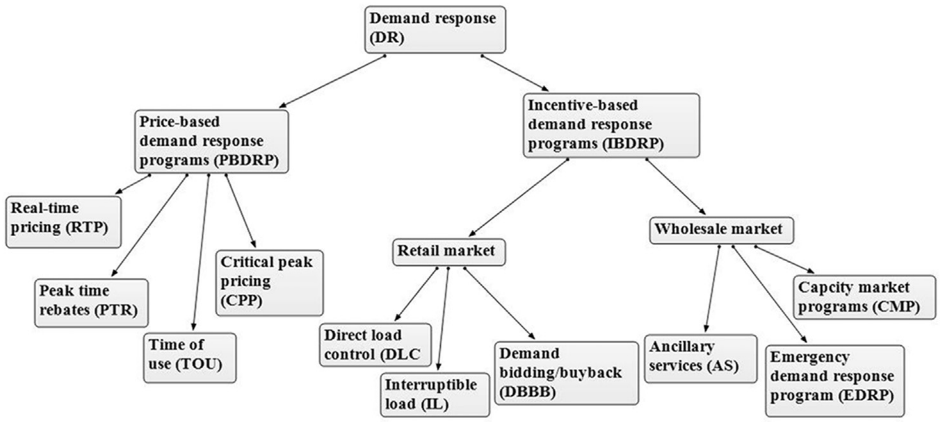

Fig. 1. Demand response and its subdivisions.

1.1. Implementation benefits of IBDRP

Any reduction in the power demand will directly or indirectly benefit different entities such as utility companies, consumers, country, environment, etc. The summary of the benefits is presented in Table 1.

The main features of the different IBDRPs in the retail market are summarized in Table 2. This table brief how these programs are visualized based on the suitability of selecting different consumers.

1.2. Major studies conducted in the field of IBDRP

A range of studies are conducted in the area of IBDRP; some of these are presented in Table 3.

As there was no study found in the referred documents, which consolidates the different aspects such as challenges, requirements, and activities involved while introducing IBDRP into a new electricity market, this study focused on this area.

1.3. Main contribution of this study

This study discusses the main facets to be considered while introducing IBDRP for the retail electricity market, which can be utilized as a base tool for developing an implementation framework (IF) for any electricity market.

Table 2
Main features of common IBDRP in the retail market.

Features	Program	Description	Reference Numbers
Minimum load	DLC	Few kilowatts	[8]
	IL	100 kW	[23,24]
	DBBB	10 kW	[25]
Strategies	DLC	Cycling operation	[5,6,10,26–30]
		ON/OFF control	[5,6,10,11,18,31]
	IL	Instant reduction	[23,24]
		Remote tripping	[32]
	DBBB	Day-ahead bidding	[22,24,33,34]
		Day-of bidding	[24]
		Single hourly bidding	[33]
		Real time bidding	[22,34]

1.4. Objective of the study

- To make a conceptual framework (CF) for introducing IBDRP into the retail electricity market.
- To establish the most prominent parameters to be considered while developing the framework.
- To introduce general guidelines for upgrading CF to an IF in any retail electricity market.

In this work, an attempt is made to draw a big picture for implementing IBDRP by collecting information from different

Table 1
Benefits of IBDRP to different entities.

Reference numbers	Effect	Utility companies	Consumers	Country	Environment
[3–9]	Delay in constructing new power plants and transmission lines	Capital savings			Protected vegetation
[3,6,10–13]	Reduced peak power demand and energy consumption	Low operational expenses	Financial benefits, such as reduced electricity bill, and monetary benefits, such as rewards	Reduced per capita electricity consumption	Low greenhouse gas emissions
[4,11,13]	Reduced generation costs during the peak time	Low operational expenses			
[7,8,11,14–22]	Less use of fossil fuels	Low operational expenses		Energy reserve, reduction in per capita CO_2 emission	Low greenhouse gas emissions
[8]	Reduced blackouts	Consumer retention	Improved reliability	Better living standards	
[9,10]	Integration of renewable energy	Low transmission loss	Uplifting to prosumers	Better image	Low greenhouse gas emissions
[8,10]	Motivation		Behavioral changes		

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