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Review

Distributed generation and distribution pricing: Why do we need new tariff design methodologies?

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ABSTRACT

Due to the increasing amount of DG (distributed generation) in distribution grids, new challenges are arising in the distribution sector in many countries. Depending on the DG penetration, location, concentration, size and generation technology, the DG impact on network costs can be either negative or positive. These additional costs or benefits can be allocated to the DG owners through network tariffs. New cost allocation methodologies, based on a cost causation principle, are therefore required.

This paper addresses several issues arising within network tariff design due to the integration of DG. Furthermore, it reviews the methodologies proposed so far to tackle those issues. Recommendations for setting up a new, cost causation-based, methodology are finally drawn.

Contents

1. Introduction 370
2. Tariffs: objectives, principles and traditional approaches 371
3. General issues related to tariff design 372
4. New challenges arising within tariff design from the DG integration 372
5. Current tariffs and innovative proposals 373
5.1.1. DG and distribution tariffs in different countries 373
5.2. Innovative proposals from the literature 374
6. How to tackle the challenges: discussion 375
Acknowledgments 376
References 376

1. Introduction

In many European countries, the amount of distributed generation (DG) [1] in the distribution networks considerably increased in the last years, mainly due to the EU energy targets, first of all the so-called "202020" targets, and to related national energy policies enforced [2].

Since DG is likely to affect the network planning and operation and, consequently, cause increased or lower network costs than in the traditional passive network scenario, the distribution sector needs to cope with the challenges arising from the integration of an increasing amount of DG [3].

There are two main, and complementary, tools for an efficient integration of DG: a sound *economic regulation of the Distribution System Operators* (DSOs), which is able to take into account the additional costs arising from the DG integration and remunerate the DSOs with this respect, and *network tariffs for grid users*; the latter represents the focus of this paper.

Distribution tariff design consists, at a first stage, in determining the total allowed revenue for the different distribution companies and, at a second stage, in allocating it to the users of the distribution network, i.e. in deciding the *tariff structure*. This paper focuses on the second stage of the process [4].

Tariff design is characterized by a significant degree of flexibility: MW- or MWh-charges, as well as mixed options, can be

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adopted, and DG may have or not have to pay network charges, depending on the regulation [5]. The shares of total network costs ascribable to the transmission and distribution activities considerably vary across EU member states [6]. This confirms high diversification among national practices concerning network tariff regulation and cost allocation; similarly diverse are the definitions adopted for distribution and transmission grids, the technical differences in the networks themselves and their operational efficiency.

Several studies have been identified in the literature about the guiding principles of tariff design and the methodologies followed so far for tariff design. Not much, however, has been written on the new DG-caused challenges within tariff design, such as a need for new cost allocation methodologies for consumers and DG owners to fairly share the total cost of the distribution activity, taking into account the additional costs and benefits caused by the DG itself. In fact, DG owners are still exempt from distribution tariffs, or load-tailored schemes are applied to DG; an example of the latter is the combination of volumetric tariffs with net metering, described in more details in Section 4.

Innovative DG tariff schemes have been proposed by some utilities in several countries [7]. However, a systematic review of the challenges posed by an increasing level of DG penetration within the distribution tariff design process is missing. Therefore, a comprehensive and methodical review, along with recommendations on how to address the open issues, represents the main contribution of this paper.

The remainder of the paper is structured as follows: in Section 2, the objectives, founding principles and traditional approaches to the tariff design are explained; an overview of the tariff design issues inherent in the electricity network characteristics is presented in Section 3; Section 4 deals with the new issues arising in the tariff design process due to the DG integration in distribution grids; Section 5 describes the DG charging options currently available in different countries, and innovative methodologies for DG pricing proposed by either utilities/Regulators or in the literature; finally, Section 6 provides a conclusive discussion on the open issues and recommendations on how to tackle them.

2. Tariffs: objectives, principles and traditional approaches

The distribution tariff represents the grid-related component of a so-called *access* or *comprehensive tariff*, which includes the cost for the energy and for any renewable support scheme that might be in place, the so-called retailing costs and other fees.

The distribution tariff, also known as *Distribution Use of System (DUoS) charge*, has to be computed independently of the other components of the access tariff [8]. The DUoS charge is meant to cover the recurrent operating and capital costs for network maintenance and expansion [5] and is paid by network users periodically. However, the distribution tariff cannot be considered separately from the so-called *connection charge*: this fee is meant to cover, partially or totally, the initial non-recurrent cost of the connection, and is paid by the network users only when they connect to the grid [9]. Depending on the charging approach, connection charges can account only for the direct costs of the connection (*shallow charges*), or include the costs of the network reinforcement necessary for the connection itself (*deep charges*). This implies that the charging method and the level of this charge determine which share of the connection cost is covered by the customer whose connection drove such a cost; this share is consequently socialized among all network users via DUoS charges, as shown in Fig. 1 [10].

Typically, the structural elements of an electricity tariff are [11]:

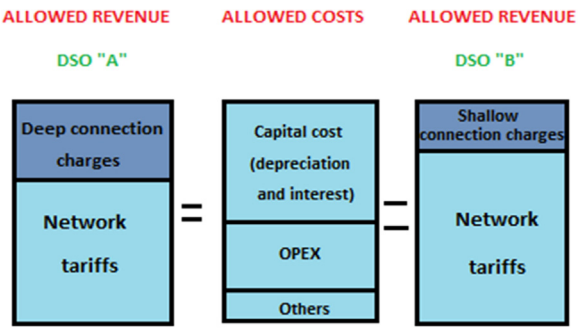

Fig. 1. Different contribution to the total distribution allowed revenue from connection charges and network tariffs under shallow and deep charging approaches [10].

- A *fixed charge* (€/period): invariant fee, meant to cover the infrastructure supply and delivery costs regardless of the customer's consumption.
- A *volumetric charge* (€/kWh/period): proportional to the energy consumed by each customer, and meant to cover the variable network costs connected to the energy transport; it may fluctuate by time of the day within the considered period.
- A *capacity charge* (€/kW/period), also known as *demand charge*: collected on the maximum power, rather than on the energy, used during a specific time range, regardless of the duration or frequency of that consumption level. It is meant to cover the fixed costs of the infrastructure shared with other customers, in proportion to the capacity that each of them requires. With respect to the design of capacity charges, several different options are available: on one hand, one might have the residential customer specify the amount of standby power desired; on the other hand, the customer's metered maximum power consumption can be used in place of a contract capacity or in conjunction with it. The capacity prices may depend either on the maximal demand of the total network or on a subsection of the grid, to which the customer is connected.

Furthermore, different options can be identified within a capacity charge-based approach, in terms of charge structure [10]:

- A *flat* charge, consisting of a fixed price for a pre-defined capacity;
- A *variable* charge, with different prices for each defined capacity level;
- A *ToU* (Time of Use) charge, characterized by a price per kW which depends on the time of consumption.

Traditionally, the distribution tariff design process, also known as *rate design*, is composed of two main tasks [8]:

1. A calculation of the so-called revenue requirement for the regulated utilities;
2. A decision on the tariff structure to be adopted.

While the first task has so far received much attention in the literature, the second one still represents an open question and it is becoming increasingly relevant [8].

A broad consensus exists in the literature on that a proper rate design should have the dual objective of promoting an optimal *short-term* usage of the grid and an efficient *long-term* grid development [4,8,12]. It is challenging, however, to combine those two objectives in reality, since their achievement rests on the application of different, and often conflicting, principles.

The fundamental principles the rate design theory lies upon can be classified in the following categories [4,5,8]: