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Interruption costs of service sector electricity customers, a hybrid approach

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ABSTRACT

A power outage brings in economic losses for both the customers and the utilities. Studying these unwanted events and making solid predictions about the outcomes of the interruptions has been an attractive area of interest for the researchers for the last couple of decades. By making use of a customer survey study conducted in Finland, this paper benefits from both the reported cost data collected from customers and from the analytical data that are available and then presents a new hybrid approach to estimate the customer interruption costs of service sector customer segment. Making use of Value Added information of the customers is a common practice for the cost normalization purposes. This paper verifies the approach by comparing the findings of the customer survey and the econometric model suggested here. This study is a unique source in terms of providing a reliable, easy to apply, and a straightforward model for calculating the economic impacts of power outages.

Introduction

Starting from 1980s many countries restructured their power sector putting aside non-competitive, monopolistic and regulated model. Along with this revolutionary change came the emphasis on the significance of electric power reliability and therefore its economic worth. The authorities, the utilities and surely the costumers are asking for continuous electric supply with a certain level of power quality. However discussions arise with the questions of "What is the monetary worth of this?" and "Who is going to pay for it?" The answer of the second question is not in the scope of this study. To answer the first question, there have been numerous studies done so far [1–21]. However, there is no widely accepted methodology to come up with a credible and acknowledged solution to estimate the worth of electric power reliability yet. This makes studying the estimation of the electric power interruptions an attractive area of interest for the members of the electric power society.

The electric power customers could be divided into customer sectors of industrial, service (or commercial), residential, etc. regarding their power consumption characteristics. To make better estimations and to reach sector specific results, this paper focuses on estimating the costs of power outages for the service sector customers only. Before going through detailed analysis, understanding the nature of the power interruptions is compulsory. The interruptions could roughly be grouped into three types. Momentary interruptions, as the name calls, are the ones that last for a very short time, typically some seconds, or even less than 1 s. Sporadic interruptions, on the other hand, are caused by severe weather conditions such as floods, hurricanes or thunder storms. These types of interruptions pose great dangers for all the parties that benefit from the electric power system since they tend to last longer durations and they end up with quite high economic damages in the power infrastructure. The last type is the chronic interruptions. There are many factors that might end up with chronic interruptions. Insufficient power generation, faults in the power system due to aging or lack of maintenance, the faults resulted from power system operation or overloading of the system are of some examples that end up with an unwanted and unexpected interruption [22]. The duration of these interruptions might be from minutes to hours depending on the severity of the fault that occurred. Since the frequency of these interruptions is much higher than the others, in this paper, the authors focused only on the chronic interruptions and sought for a methodology to come up with credible and sound estimates about the economic consequences of these events.

To fully understand the results of the interruptions, the impacts caused by these events must be analysed and classified thoroughly. In the case study report of the 1977 New York blackout by the US Department of Energy the impacts of interruptions were grouped into two main categories: direct and indirect impacts [23]. The

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direct impacts include the direct effects of power cuts that cause economic losses such as sales loss, lost manufacturing, interruption of services, suspension of transportation, spoiled materials, damages on the electric equipment and on electronic data, other damages and accidents resulted from interruptions or, worst of all, injuries and deaths. The analysis of these events is relatively easy when they are compared to the indirect impacts. The indirect effects of power outages compose of arsons, looting, public disorder and crimes due to blackouts, possible sharp increases in the insurance rates, property losses, overtime payments, cancellation of social activities, lost tax revenues, the costs for recovering from looting and so on. When these indirect impacts are checked, it is obvious that the effects of some of those can only be seen after a considerable amount of time passes after the interruption. These long time effects make the analysis of the indirect impacts rather a challenging and a difficult task. The comprehensive report [23] and the significant study focusing on factors affecting customer outage costs [24] show that the economic worth of the indirect impacts can be much higher than that of direct ones. Nevertheless, as pointed out earlier, to analyse indirect economic results of the power interruptions is a tedious and demanding task, which can only be achieved by a large scale and extensive study that will take place after a major blackout event such as the infamous New York City blackout of 1977.

There are two main aspects when the customer interruption cost (CIC) assessments are done. The first matter is the methodology of collecting necessary input data and corresponding tools for the estimations and suggestions about the economic correspondence of the CICs. When the proper tool for the data collection is selected, another challenging point arises. How the raw data can and should be interpreted to get as bias free as possible results is the second phase of a complete and credible CIC analysis.

Section 'Customer interruption cost analysis approaches' of this paper presents different methodologies that are used to estimate the economic impacts of the power interruptions. Section 'The customer survey' includes the finnish service sector customer survey study and presents several customer damage functions (CDF) that are adopted throughout the paper. Moreover, the problem of strategic responses is pointed out and a remedy for zero and extreme responses is proposed. The hybrid model that combines the indirect analytical method and customer survey methodology is suggested in Section 'The hybrid model'. Comments, discussions and conclusions are summarized in Section 'Discussion and conclusions'.

Customer interruption cost analysis approaches

Being a popular area of interest, there are many proposed CIC assessment methodologies. Among all, three approaches are a step forward and they have been extensively preferred by the electric power society. In CIGRE Task Force report of 2001 these are grouped as indirect analytical methods, customer surveys and case studies [25].

Indirect analytical methods

The key idea behind this approach is to make use of publicly declared and available, easy to reach and objective data to study CICs. These data include the gross domestic product (GDP), the annual energy consumption, the peak power reached, the turnover or the created Value Added of a country, region or a customer group [26–28]. This method can be favoured in terms of being easy and straightforward, demanding much lower times to follow, being much cheaper and most importantly, resulting in highly objective estimations when compared to the other ones. For instance, defining a customer damage function (CDF) by dividing the GDP to the annual energy consumption of a country gives a rough idea about the monetary losses experienced by that country within a certain time of period. Nevertheless, the proposed customer costs via this method yield average results since all customer segments with distinct electric power consumption characteristics are analysed together. The market dynamics demand for customer specific results with as low error margin as possible. This fact makes the analytical methods less attractive and less preferable by the researchers and professionals.

Customer surveys

These are by far the most popular tools chosen and utilized by the electric power society and utilities to make estimations about outage costs [29–37]. In customer surveys, the customer, who is in the best position to assess his/her losses, is taken as the correspondent. This achieves the goal of being customer specific and thus the approach is regarded as superior to the other ones. By designing hypothetical outage scenarios with a carefully prepared questionnaire, the customer is asked to estimate the economic losses incurred during that predefined scenario. There are three main ways to collect the desired data. The first one is the Willingness to Accept (WTA) method. In WTA, the customer is asked to define an amount of compensation that he/she is willing to accept to experience a hypothetical outage. The other one is the Willingness to Pay (WTP) method. Here, in order to avoid a defined outage, the customer mark out an amount of money that he/she is ready to pay. In theory, an objective evaluation of the WTA and WTP results are expected to be identical. The economic value of a certain interruption in a certain environment must be unique by nature since, for example, the worth of one specific spoiled material is the same and it should be independent from whoever evaluates the costs of it. Nevertheless, author experiences and another customer survey study [38] show that there is a considerable gap between WTA and WTP figures. This is a quite an expected situation when the behavioural bias of a human being is considered. It can be expected that one tends to exaggerate his/her losses and he/she is ready to demand a higher compensation in case of the same situation while the same one is willing to pay much less to avoid it. This phenomenon makes the credibility of these methods quite low. However, by setting lower and higher bounds to the expected outage costs, it is a valuable tool to make use of WTA and WTP studies [38]. The third and the final way of data collection tool for the customer surveys is the Direct Worth (DW) approach. With the DW approach the customer is directly asked to provide answers for the economic value of the distinct outage scenarios. Directly assessing the economic loss reduces the biases that are resulted from the correspondent. Therefore, this technique is considered as more reliable when compared to the first two ones. However, there are major concerns about the credibility of this process as well. The problem of zero responses and strategic responses is a critical challenge for the ones carrying out these studies. A further inspection and the possible remedies offered to handle these challenges are presented in Section 'The customer survey' of this paper in detail.

Case studies

The last and the least preferred technique by the researchers to mention is the case study approach. The case studies are done after massive and major blackouts that affect large areas and large populations causing serious and severe economic losses. Among others, this type of study yields most accurate and reliable data since they are carried out just after the actual events. The correspondents are in a better situation to estimate the losses when the event is recently experienced. On the other hand, however,