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Power interruption costs to industries in Cameroon

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HIGHLIGHTS

- We estimated the power-interruption cost to industries in Cameroon.
- Advance suspension notices could help in reducing outage cost by 19.83–33%.
- Power interruptions have a significant negative effect on industries in Cameroon.

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ABSTRACT

This study focusses on the estimation of power interruption costs to industries in Cameroon. Those interruptions are the result of perturbations sustained by the power network. A normalised direct worth (NDW) approach was used as a direct method for assessment, while the compensatory estimation method (CEM) was used for indirect assessment. A survey was conducted with a representative sample of industries in Cameroon using a questionnaire as the main research instrument. The results show that power interruption losses are very significant. Using the direct method for assessment, the average outage cost varies from €3.62/kWh to €5.42/kWh for a 1-h interruption and from 1.96/kWh to €2.46/kWh for a 4-h outage. The study finds that advance suspension notices could help in reducing outage costs by 19.83–33%. With the indirect method, the total capital costs and total running costs of generators are approximately €180,040,180.08 and €4,305,510.6, respectively, while the average cost per unused kWh of electricity stands at €3.37/kWh. The study concludes that power interruptions have a significant negative effect on industries in Cameroon.

1. Introduction

This study focusses on the power interruption costs to industries in Cameroon. Industrial production has become largely dependent upon electricity with the automation of the majority of industrial processes. In the industrial sector of Cameroon, for instance, the energy types consumed in 2008 were as follows: electricity (75.01%), fuel oil (24.6%) and diesel fuel (0.39%) (SIE, 2010). The electricity supply to industries is frequently disrupted by power outages whose total duration is, on average, 35 h/week (Foumane, 2007). To ensure continuous industrial production even in periods of power outages, Cameroonian industrial companies increased their capacity to generate electricity: it moved from 336 GWh in 1997 to 462 GWh in 2007, a growth rate of 37.5% in 10 years (Tamo Tatietse et al., 2010). Extra expenses are high, given that the cost of 1 kWh of self-generated electricity in Cameroon is estimated at €0.63/kWh, while that produced and sold by Applied Energy System (AES-SONEL), the company in charge of the production, transport and distribution of electricity in the country, is €0.12/kWh (Tamo Tatietse et al., 2010). The unpredictable supply of electricity generally leads to an increase in business uncertainty and a low return on investment, which seriously hampers businesses' prosperity.

When electricity is temporarily unavailable, this is referred to as an interruption. According to the recommendations of the Institute of Electrical and Electronics Engineers (IEEE), an interruption is defined as the complete loss of supply voltage or load current (IEEE, 1995). There are two main durations of power interruption: short interruptions and long interruptions (Tristiu, 2003). Short interruptions are those in which the voltage falls below 0.1 relative units for a period shorter than or equal to 1 min. Long interruptions are those in which the voltage falls to zero for a period above 1 min (Willis, 1997). The effect of interruptions on customers varies depending on the type of customer, the time of occurrence, the duration of the interruption, the frequency of occurrence, etc. Traditionally, for many customers, the impact of a 1-min interruption is much lower than the impact of a 1-h interruption. However, due to the modernisation of industry and

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the increased use of electrical equipment and electronics, the effect of interruptions has changed over the years. Industries prefer a long-duration interruption to several interruptions of very short duration (Diboma, 2007).

The cost estimation of interruptions in industries has been reviewed in the literature (Panya and Pattaraprakorn, 2010), and several methods were developed and applied in several countries. The European Union (EU), in its C10-eqs-41-03, specifies the framework and the methodologies for the study of cost estimation of interruptions and fluctuation of voltage. Two approaches characterise these methods (presented in section 2): direct and indirect approaches. Direct approaches have a major disadvantage, which is that they rely on customer estimations of the damage caused by the interruption of their activities. C ustomers tend to overestimate the cost of interruptions, which leads to wrong estimates. Indirect approaches aim at estimating the cost of interruptions based on models, and these approaches determine margins of reliable costs. Because power interruption disrupts production, industries must take them into account when planning their activities and must choose between several procedures and actions to limit the impact of the unavailability of energy. To make rational choices, industries need an accurate estimate of the costs of power interruptions; however, each of the different methods has limitations that could affect the reliability of the results. To overcome the weaknesses of different methods, in this article, two complementary approaches are used to estimate these costs. A normalised direct worth (NDW) approach was used as a direct method for assessment, whereas the compensatory estimation method (CEM) was used for indirect assessment.

This article focusses on the determination of the cost of power interruptions to industries in Cameroon. It examines the quality of electricity supply to industry and contains proposals for strengthening the performance of the energy sector. Towards this end, *in situ* measurements were carried out, and a survey was conducted in a sample of industries. Both quantitative and qualitative data were collected. Quantitative data are related to the quality of the electricity supply, the costs of lost production, extra charges engendered by interruptions and savings that can be achieved as a result of power interruption costs recorded in industries. Qualitative data are related to consumers' satisfaction and consumers' opinions on issues connected to the electricity supply and its impact on industrial production. A survey framework was used to elicit outage costs. The article is organised as follows: following this introduction, section 2 presents an overview of the methods of estimation encountered in the literature, section 3 focusses on the materials and methods used in this study, section 4 presents the results, section 5 presents some policy recommendations to improve the Cameroonian energy sector and to mitigate power outages and section 6 offers a conclusion.

2. Overview of methods of estimation of power interruptions

In the literature, three main methods are used for the estimation of power interruption costs to industrial companies, namely 1) analytical methods, 2) case studies of blackouts and 3) customer survey methods. Analytical methods consist of three categories of estimation of power interruption costs, namely proxy methods, reliability demand models and consumer surplus measures. Several proxy methods have been used for the estimation of interruption costs to industries (see Bental and Ravid, 1982; Caves et al., 1992; Bernstein and Hegazy, 1988; Beenstock et al., 1997).

Bental and Ravid (1982) developed an estimation model for power interruption costs based on the determination of marginal costs of electricity self-generation. According to this model, the marginal cost of power outage is equal to the cost of the self-generated electricity, assuming that firms operate essentially with the aim of maximising their profits. The authors estimated the expected marginal cost of back-up power and determined that the marginal outage cost for the USA and Israel is US$1.16/kWh and US $0.21/kWh, respectively (Bental and Ravid, 1982). Adenikinju combined the marginal cost (MC) method and the production function approach to estimate the power interruption costs to industries in Nigeria. According to Adenikinju, the value of unsupplied electricity in Nigeria in the year 2000 was N19.7/kWh (Adenikinju, 2005). This combined model enabled him to infer the mitigated costs arising from the installation of private generators and to understand why, in spite of the high MC of private generators, firms are still investing in the self-generation of electricity. The average cost of back-up generators is, on average, 3 times the cost of the publicly supplied electricity, which was about N5.28/kWh in Nigeria in 2000 (Adenikinju, 2003). Proxy methods were also used to estimate the ratio of the electricity consumption output (see Telson, 1975) and the price of electricity (Chowdhury and Koval, 1999). Telson, in a study carried out in 1975, argued that the output per kWh consumed provides an upper bound on the cost of electric power interruptions (Telson, 1975). The power interruption cost was estimated to be US$0.57/kWh of unsupplied electricity. The loss per kWh unsupplied in Shanghai was estimated to be €0.83/kWh (Tianquing and Xiaohuo, 2009). Although proxy methods are useful when we estimate or bound outage cost, their major disadvantage is that they do not differentiate outage costs by outage characteristic, nor do they provide information on the distribution of outage costs across industries.

Reliability demand models are based on the evaluation of reliability indicators of the electrical network (Panya et al., 2010; Willis and Garrod, 1997; Munasinghe and Sanghvi, 1988). In an article focussing on the estimation of outage costs of industries in Thailand, the authors used average outage duration and average outage frequency as they assessed the effect of reliability. The results, which come from a survey sample of 800 industries, show that unplanned outage costs negatively impact industries (Panya et al., 2010). Because it is difficult to estimate the value of reliability to customers, most power industries have only considered investment as they specify the reliability level.

The consumer surplus approach used the existing information on customer response to price changes to infer the value of the reliability (Caves et al., 1990; Sanghvi, 1983). The curve of the consumer surplus approach to outage cost estimation was drawn and permitted the estimation of power interruption costs for partial or total outage (Sanghvi, 1983). Sanghvi estimated price elasticity using hourly usage and price variables from a Wisconsin (USA) time-of-use experiment. According to Caves (1990), this approach presents some disadvantages: first, the demand curve drawn and the implied outage costs depend upon the advance warning time and second, the example extrapolating the demand curve back to the vertical axis, where usage is zero, is inappropriate because in many mathematical demand models the zero-point usage is not defined (Caves et al., 1990).

In case studies of blackout, where both the direct and indirect effects of power interruption are included, the indirect costs far outweigh the direct costs. For instance, the economic cost of the northeast power outage on 14 August 2003 in the USA was estimated to be US$6 billion. According to Chowdhury, this method is questionable because case studies are useful in demonstrating the importance of a reliable electricity supply but do not provide results from which general cost estimations can be made (Chowdhury and Koval, 1999).

The customer survey method consists of three categories: 1) contingent valuation method (CVM), 2) contingent ranking method (CRM) and 3) direct cost method. In the CVM method,