CEER RECOMMENDATIONS ON ESTIMATION OF COSTS DUE TO ELECTRICITY INTERRUPTIONS AND VOLTAGE DISTURBANCES

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ABSTRACT

Real knowledge of costs due to electricity interruptions and voltage disturbances is of great importance to National Regulatory Authorities (NRAs) in their work on developing and improving regulations on electricity interruptions and voltage disturbances. During 2010, the Council of European Energy Regulators (CEER) prepared Guidelines of Good Practice (GGP) on Estimation of Costs due to Electricity Interruptions and Voltage Disturbances [1]. In order to help prepare these GGP, a consultancy study was commissioned by CEER and carried out by SINTEF Energy Research [2]. This paper introduces the content of these GGP and highlights some important elements within.

INTRODUCTION

There is a growing and European-wide interest in cost-estimation studies to reveal costs due to electricity interruptions and voltage disturbances. Activity in this area is witnessing different levels of development across European countries and CEER deemed useful to try to set out European guidelines in this domain. CEER's main objectives are (1) to provide a set of recommendations for NRAs and other interested parties on how to design and develop nationwide cost-estimation studies; and (2) to highlight possible problems (already experienced by some countries), in order to improve the effectiveness of future studies and the quality and comparability of their results. This work is also based on the practical experience available in some countries. The CEER GGP also highlight three national experiences of these types of studies (from Italy, The Netherlands and Norway, not included in this paper), which can be useful for NRAs that want to set up studies in future, including how study results can be used for regulatory interventions.

REGULATORY NEEDS

Cost-estimation studies are an important tool to be able to estimate an optimal level of **continuity of supply**. The optimal level can be different for different regions (urban versus rural) and for different types of customers (industrial versus domestic) and will certainly evolve with time as end-user equipment, customer requirements and network investment costs change. In order for NRAs to be able to implement proper financial incentives regarding continuity of supply, it is of great importance that sufficient knowledge about customers' real costs and their willingness to pay and willingness to accept is available in order to introduce or to improve such regulations. The different impact on society costs and on customer costs is also important to consider due to the goal of many national acts and regulations.

Voltage quality is subject for increasing interest to many NRAs, taking into account that, after the implementation of the 3rd Package, all European NRAs have legal power to introduce voltage quality requirements. Some NRAs already have experience in setting requirements and performing cost-estimation studies [3]. But costs due to voltage disturbances on a national level are still unknown or uncertain in many European countries. Improved knowledge on costs due to voltage disturbances will be important input to NRAs on where to focus voltage quality regulation.

COST-ESTIMATION GUIDELINES

The CEER guidelines for studies on costs due to **electricity interruptions and voltage disturbances** include recommendations on:

- Definition of objectives;
- Choice of consultants;
- Specification of customer groups;
- Choice of cost-estimation method;
- Choice of normalisation factor and clarification of data needs;
- Check for available data;
- Choice of conduction method (means by which the survey/case analysis is performed);
- Design of questionnaires and scenarios;
- Sample selection;
- Test of questionnaires;
- Survey conduction: how to conduct the survey/case analysis;
- Selection of cases;
- Analysis of cases; and
- Cost analysis.

The CEER recommendations cover a few additional aspects, specifically for case-based studies on **costs due to voltage disturbances**:

- Deployment of measurement instruments;
- Logging of events; and
- Analysis of log forms and measurement data.

The CEER recommendations include flow-charts for cost-estimation studies on costs due to electricity interruptions and voltage disturbances and related checklists for each step of the process. Below, some important elements are highlighted.

Cost-elements

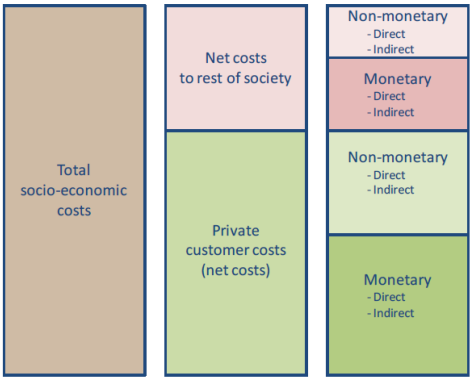

Figure 1 - Total socio-economic costs of electricity interruptions and voltage disturbances

In Figure 1, a principal overview is provided of the different cost-elements that can pose costs on total and different parts of society when electricity interruptions or voltage disturbances occur. Different methodologies exist to best reveal the different cost-elements. All cost-elements are well described in [2]; below we briefly describe the "net costs to the rest of society" because this might be less known to the reader. The term "rest of society" includes costs and consequences for other people or parties than the electricity customer, but who are affected due to their relation to the customer or the customer's public or commercial services. This cost category includes monetary and non-monetary costs. One example is clients of a production facility who do not receive the intended delivery on time, which may cause spill-over effects where clients in turn lose production and are not able to serve their clients on time. This is also valid for the users of infrastructure such as water supply and telecommunication. Another example is the costs and inconvenience of passengers if an electricity interruption disrupts train traffic. Spill-over costs are not necessarily negative; other companies may benefit from an interruption that affects a competitor e.g. if they can increase their sales and production.

Objectives and possible use of results

The first step for NRAs in advance of performing a cost-estimation study is to set up a clear objective for the use of the results from the study. From CEER's point of view, these objectives should be defined through a pre-study.

CEER believes that from a regulatory point of view the results from a cost-estimation study on **electricity interruptions** could be used for estimating society costs for interruptions including spill over costs in the value chain; for setting financial incentives or requirements to pursue an optimal level of continuity; for setting compensations for customer e.g. after large (long) interruptions; for achieving general knowledge about customer valuation and expectations of continuity of supply; for contributing to understand customer satisfaction; and for contributing to regulatory approval of investment plans or licence applications applied from transmission or distribution system operators. For these purposes, it is important to clearly define kinds of interruptions which are important to investigate and whether to cover all types of customers.

CEER believes that from a regulatory point of view the basic aim of the results of a cost-estimation study on **voltage disturbances** is to get information on the consequences as input on where to focus regulation. It must be considered whether it is important to cover all types of customers and phenomena, or a few specific groups or specific phenomena, only.

Choice of consultants

CEER believes that one of the most important tasks for NRAs, before conducting a nationwide cost estimation study, is to choose the best consultants to assist or to carry out the work based on the NRA's objective. Consultants are either used for the complete cost-estimation study or for its parts (especially for choice of cost-estimation method; design of questionnaires, conduction of the study; selection and analysis of cases, deployment of measurement instruments, analysis of log forms and measurement data and cost analysis). Different tasks require different expertise. CEER believes it is imperative that the consultants have proper knowledge and experience of survey methodology and conduction, economics, mathematics, statistics, the electrical power system and the technical details of interruptions and voltage disturbances, depending on which parts the consultant will be involved in. The NRAs should in any case be involved in the consultants' work, ensuring regulatory supervision at each stage of the process including quality assurance of the estimated costs.

Customer grouping

CEER recommends that customer grouping should be connected to the statistical classification of economic activities in the European community (NACE Rev.2). It is, primarily, recommended, for cost-estimation studies on both **electricity interruptions and voltage disturbances**, to group customers in Households, Commercial services

(without infrastructure), Public services (without infrastructure), Industry (without large customers), Large customers and Infrastructure.

Customers included in a cost-estimation study related to **voltage disturbances** need, to some extent, knowledge about these disturbances and related consequences to be able to respond accordingly. Industrial companies, infrastructure customers and large customers, having their own personnel with electricity and voltage quality knowledge, may be able to deliver good quality answers to consequences and costs due to at least some voltage disturbances. CEER recommends that at least the customer groups Industry, Large customers and Infrastructure are included in cost-estimation studies on voltage disturbances.

Cost-estimation approaches and methods

The typical structure for a cost-estimation study can be divided into a survey-based and a case-based approach. The first approach typically includes the design of a questionnaire which is sent out to a large representative sample. The latter approach focuses on a few single cases with direct interviews in order to identify consequences of interruptions or voltage disturbances for these typical cases. **Regarding studies on costs due to electricity interruptions**, CEER recommends using the following estimation methods for each of the customer groups: Households (direct worth, contingent valuation i.e. willingness to pay and willingness to accept), Commercial services (direct worth), Public services (direct worth, contingent valuation), Industry (direct worth), Large customers and Infrastructure (direct worth in case studies). In order to be able to check the accountability of the cost estimates, CEER recommends triangulation by using more than one cost-estimation method on each of the customer groups. For this purpose, methods to be used in combination with those recommended above are the preparatory action method for Households and the preventative cost method for Commercial services, Public services and Industry.

Regarding studies on costs due to voltage disturbances, a combination of a questionnaire survey and a limited number of case studies seems to be a good approach. CEER recommends using the same survey-based methods for Households, Commercial services and Public services for estimation of voltage disturbance costs as for interruption costs, described above. For Industry, the primary recommendation is a case-based study, but a good approach could alternatively be to use a case-based approach for some customers and the survey-based method for a representative sample of the whole group. CEER recommends a case-based approach for Large customers and Infrastructure. Case studies should include measurements of voltage quality data and logging of events, problems and costs/consequences in a journal prepared by the customer, depending on the objective defined for the study. The case-based studies on costs due to voltage disturbances are laborious, but they can ensure that the consequences can be assigned to different types of voltage disturbances, which is the great challenge in assessing the costs of voltage disturbances.

Normalisation factor

Replies from respondents during a cost-estimation study are normally stated in absolute values. These data must be transformed into normalised data in order to be able to compare data from different respondents, and to group respondents with similar cost characteristics but different electricity consumption. CEER recommends that an electrical variable is chosen as the normalisation factor, more specifically, using a normalisation factor based on electricity demand or load, preferably a constant such as annual electricity consumption, average load, peak load or interrupted power **for costs due to electricity interruptions** and load (in kW) **for costs due to voltage disturbances**.

Conduction method

The conduction method is closely related to the cost-estimation method and is also highly country-specific, therefore, the choice of method has to be carefully considered on a national level. The timing of the study is usually not dependent on the seasons of the year, and can be conducted at any time during the year, still it is important to avoid expected busy time periods or holidays.

Regarding costs due to both electricity interruptions and voltage disturbances; CEER recommends approaching households by telephone since this gives higher response rates than mailed questionnaires and also reduces the risk of misunderstanding the questions. Commercial services, Public services and Industry should be approached by web-based questionnaires. In order to ensure that the person with the most appropriate competence is addressed, the contact person should be identified by phone in a first step. Large customers and Infrastructure are quite demanding, so cost-estimation should be based on case studies, hence to use telephone or face-to-face interviews for these two groups.

Design and test of questionnaires and scenarios

In general, a questionnaire should contain two parts, one asking for the specific customer characteristics and one asking for the cost estimates for different interruption or voltage disturbance scenarios. The part on voltage disturbances must include carefully selected simplified scenarios, e.g. damage to electrical equipment due to transient overvoltage and voltage swells, malfunction of electrical equipment due to voltage dips, malfunction due to supply voltage variations, unstable lightning due to flicker or rapid voltage changes. Questions should be focussed towards the consequences rather than the voltage disturbances themselves.

CEER recommends testing all aspects of the survey: firstly in a focus group, and secondly with a pilot study. The experience from the pilot gives a possibility to evaluate the realism in the estimates for the time, resources and budget needed to perform the final cost-estimation study.

COUNTRY-SPECIFIC CHARACTERISTICS

CEER recommends that the general advice on cost-estimation studies should be adjusted for certain country-specific characteristics. This is because the people and companies in different countries are using electricity for different purposes due to, *inter alia*, different climate, different use of electrical equipment and appliances, historical development and cultural characteristics. Therefore, they value the availability of electricity differently. Any design of cost-estimation studies should therefore be adapted to country-specific characteristics. Some elements in the study approaches can be adapted irrespective of country-specific characteristics, while several elements may be quite different from country to country. CEER sets out some key elements that in particular need to be investigated on a national level, before designing and performing a major cost-estimation study: objective of the cost-estimation study; worst case scenarios and use of electricity; conduction method and expected response rates; choice of customer groups and standard industrial classification; choice of interruption scenarios and voltage disturbance phenomena; and data available for the normalisation factor(s).

CONCLUSIONS

CEER prepared GGP on estimation of costs due to electricity interruptions and voltage disturbances, with the support of a consultancy report by SINTEF Energy Research. The consultancy report includes a comprehensive overview of cost-estimation methods and the scientific reasoning behind, description of all necessary steps during a cost-estimation study and related recommendations for the choices to be taken, and points out the elements that need further consideration according to country-specific characteristics. The CEER report sets out the CEER recommendations on these issues, drawing from the work undertaken by the consultant. CEER draws in addition the following conclusions from its work on this issue:

C-1: Results from cost-estimation studies on customer costs due to electricity interruptions are of key importance in order to be able to set proper incentives for continuity of supply.

C-2: Results from cost-estimation studies on customer costs due to voltage disturbances are important input on the consequences of various voltage disturbances when deciding where to focus regulation.

C-3: Society costs should be considered in addition to customer costs when doing a cost-estimation study, as these can differ significantly.

C-4: National Regulatory Authorities should perform nationwide cost-estimation studies regarding electricity interruptions and voltage disturbances.

C-5: A pre-study should be performed in advance of a main study in order to define the objectives and to clarify country-specific characteristics, budget and consultancy needs, possible funding partners, timeline and possibilities in general for the main study.

C-6: These GGP [1] – including the SINTEF consultancy report [2] – should be used as a reference when performing a nationwide cost-estimation study, always taking into account country-specific issues and needs.

C-7 – Results and experiences from cost-estimation studies shall be disseminated among interested stakeholders.

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