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IMPORTANCE AND DIFFICULTIES OF COMPARING RELIABILITY ASSESSMENT METHODS AND CRITERIA

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Abstract. Due to the importance of reliable electricity supply and the evolutions in the electrical grid, it can be expected that reliability assessment methods that are applied nowadays need to be adapted. At this moment, deterministic methodology (N-1) is commonly used, while risk-based methodologies are widely available in academic works and are used in other industries. However, because of the straightforward and transparent character of the currently used N-1 criterion, stakeholders of the power system are not eager to apply other methods. Probabilistic methods are better suited to take growing uncertainty and complexity in the grid due to the increased amount of renewable energy sources and other evolutions into account. Such methodologies are well-known for a long time, but difficulties in correctly weighing the benefits of using these methods has prevented them from being used in practice. Through a literature survey, this paper indicates the need for a comparison between these probabilistic methods and the deterministic methods that are currently used. Difficulties in comparing various methods are shown illustratively through the reliability assessment of a basic test system.

Keywords: Deterministic, Probabilistic, Reliability, Risk assessment methodology

INTRODUCTION

Reliability of electricity supply plays a major role in the economics and social well-being of a modern society and directly influences the quality of life. A one day blackout could lead to costs that are about 0.5% of the GDP, which has to be added with possible social consequences such as diseases, deaths and injuries [1]. Therefore, the power system can be seen as the most important infrastructure these days, so a correct assessment of the reliability level is of the utmost importance. At the same time is the power industry a very capital intensive sector and reliability comes at a cost. In order to be able to take a decision, a reliability criterion is used which allows to decide between acceptable and unacceptable levels of reliability.

The deterministic N-1 criterion is currently used to assess reliability in transmission systems, but shortcomings of this method appear due to evolutions in the power system. Therefore, the application of other methods need to be considered. Firstly, this paper will describe the importance of comparing different reliability methods based on a literature survey. Secondly, different methods are compared using a small test system and arising difficulties are presented. Definitions of terms used in this abstract regarding reliability and security will be given in the full paper.

IMPORTANCE OF COMPARING RELIABILITY ASSESSMENT METHODS

The aim of the power system is to supply all customers with electrical energy as cost effective as possible with an acceptable degree of reliability and quality. However, the frequency of interruptions and blackouts increased in the recent past [2]. This excites the interest of different stakeholders to re-establish the security of electricity supply at the expected level or at least prevent further degradation in the coming years. The probability of being disconnected and the energy not supplied can be reduced by increased and cost effective investments in the power system. This leads to conflicts between economical and reliability considerations, because the worth of investments with respect to costs needs to be proven [1,3].

Next to that, the power system is also one of the most complex systems, which is continuously evolving. Some evolutions of the last decades are the increasing degree of interconnection, deregulation, privatization, unbundling and the increasing amount of renewable energy sources. The restructuring to enable European wide competition has led to increasing awareness of cost effectiveness and changing concerns of different stakeholders. Therefore, reliability issues have to be combined with economic metrics, such as social welfare, to come to an economically viable reliability level [3]. The increase of renewable energy sources in the system has led to higher uncertainties, which require larger reliability margins and hence lead to a system that is used in a less cost-effective manner.

The currently used N-1 reliability criterion states that the system should be able to withstand the loss of any one of its main elements (lines, transformers, generators, etc.) without significant degradation of service quality at all times. This reliability model has been developed based on a centrally planned and operated nature

of generation, transmission and distributions [3]. Due to various shortcomings, such as supposing that different contingencies are equally severe and that they occur equally likely, it is not well suited to handle the increasing complexity and utilization of the electric power system and does not recognize some important aspects that influence the reliability [1,4]. It also does not give an incentive based on economic principles. Using N-1, all grid elements are equally important, and all generators and consumers have equal weight.

Other reliability criteria and assessment methods that help to overcome these issues are needed [3,4]. These have to handle uncertainties that are an implicit part of the electric power system, which will lead to reliability assessment methods with probabilistic characteristics. A lot of research is already done on these probabilistic methods and their application [5]. In the system development phase, probabilistic indices are already used to determine the generation reserve, but transmission system operators (TSOs) apply them rarely to determine overall power system reliability during the planning, maintenance or operation of the power system [4]. This is also due to the difficulties in correctly weighing the benefits of using them rather than a deterministic approach.

To convince the stakeholders to apply other criteria, a thorough evaluation and comparison of these other reliability assessment methods and criteria with the currently used N-1 criterion is needed. This allows to quantify the benefits of using other reliability criteria that will make it easier to make economically justified investments in the power grid, which will improve reliability and social welfare.

COMPARING RELIABILITY ASSESSMENT METHODS

Methodology

The reliability of a basic reliability test system as used in [6] is assessed using Matlab and the Matpower tool [7]. Different reliability indices and criteria are used: on the one hand the deterministic N-1 criterion and on the other hand some probabilistic methods are applied such as the loss of load probability (LOLP), energy not served (ENS), risk calculation …

For this simple system, it is tested for which contingencies the service quality is no longer guaranteed, i.e. the voltage at the buses is too low or the branches are overloaded. In these cases load will be shed to overcome the fault situation. The influence of adaptations (e.g. extra lines) to the system on reliability is investigated. In this manner, it is shown that different methods will result in varying conclusions. The difficulties that arise in evaluating the reliability of the system can be investigated.

Difficulties in comparing

Different reliability assessment methods are based on different fundamental (mathematical) methods. While the N-1 criterion has a binary outcome (reliable or not reliable), the ENS index is a quantitative value that represents the amount of energy not served in a certain period of time. Assessment methods like a probabilistic security analysis [8] can give the probability of being secure, but what is the practical meaning of a system that is 99% secure? These are only a few examples of manners to express the reliability of the power system each of them with a totally different kind of outcome. The largest difficulty of the comparison is to determine a correct metric to benchmark different reliability assessment methods to the currently used N-1 criterion.

CONCLUSIONS

Due to evolutions in the power system, the N-1 criterion seems superseded. Stakeholders want more detailed information in order to fine-tune the reliability level of the power system in a cost effective way. Other methods are already developed, but they are not used in practice and their benefits are not well quantified. Therefore, comparing reliability assessment methods and criteria is important. However, in order to compare and benchmark different methods, it is important to find a correct metric that expresses the benefits of using one method rather than another. This is a difficult task due to the different mathematical nature of various methods.

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