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Short Communication

Analysis of major failures in Europe's power grid

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ABSTRACT

Power grids are prone to failure. Time series of reliability measures such as total power loss or energy not supplied can give significant account of the underlying dynamical behavior of these systems, specially when the resulting probability distributions present remarkable features such as an algebraic tail, usually considered the footprint of self-organization and the existence of critical points. In this paper, 7 years (from 2002 to 2008) of Europe's transport of electricity network failure events have been analyzed and the best fit for this empirical data probability distribution is presented. With the actual span of available data and although there exists a moderate support for the power-law model, the relatively small amount of events contained in the function's tail suggests that causal factors other than self-organization or a critical state might be significantly ruling these systems' dynamics.

1. Introduction

There has been in recent years an increasing awareness about infrastructure networks security and reliability [1–3]. Modern society's functional capacity relies on an optimal operation of infrastructure and information networks such as roads, railways, gas and oil pipes or Internet. Particularly vital, and at the same time prone to failure, are electric power transmission networks. These are extremely complex engineered systems, composed of multiple and interconnected elements, whose reliability depends both on each component's behavior and, at the same time, on the many different dynamical interactions that span over and rule the overall connectivity of the system.

Although it is not always the case, a malfunction of a power transmission system shows usually itself as a blackout. This is a direct consequence of a cascading failure involving several of its composing and linking elements. This fact turns the study of the details of failures in power transmission networks from a traditional engineering point of view a hard task, if not an impossible one most of the times. In order to reduce the inherent complexity of this detailed approach, some new ways have been proposed in recent years. One of them is that of ignoring the details of particular failures and to focus on the study of global behaviors and dynamics of time series with approximate global models. Concepts such as criticality and self-organization have been applied to characterize blackout data, suggesting that the frequency of large blackouts is governed by non trivial distribution functions such as power laws and, consequently, that power systems are designed and operated near a critical point. (For a comprehensive review on this approach, see Ref. [4] and references therein).

This paper analyses for the first time, and as far as we know, the statistics of major electric transmission network events in the European power grid from this aforementioned complex systems approach. Following essentially the statistical analysis presented in Ref. [5], we estimate the basic parameters of the power-law model, then calculate the goodness-of-fit between the data and the power law and finally we compare the power law with alternative hypotheses via a likelihood ratio test. The paper is organized as follows. In Section 2 European major events data is presented and explained. In Section 3 blackout data is analyzed. Finally, Section 4 summarizes our main results.

2. UCTE major events data

European power network reliability data can be found in the Union for the Co-ordination of Transmission of Electricity (UCTE) web page, publicly available from 2002 onwards in monthly statistics format [6]. The UCTE is the association of Transmission System Operators (TSOs) in continental Europe and manages data from 24 different European countries. Due to the complexity of events, sometimes involving more than one TSO, types of interruptions

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