Comparing the Effects of Failures in Power Grids Under the AC and DC Power Flow Models

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Abstract—In this paper, we compare the effects of failures in power grids under the nonlinear AC and linearized DC power flow models. First, we numerically demonstrate that when there are no failures and the assumptions underlying the DC model are valid, the DC model approximates the AC model well in four considered test networks. Then, to evaluate the validity of the DC approximation upon failures, we numerically compare the effects of single line failures and the evolution of cascades under the AC and DC flow models using different metrics, such as yield (the ratio of the demand supplied at the end of the cascade to the initial demand). We demonstrate that the effects of a single line failure on the distribution of the flows on other lines are similar under the AC and DC models. However, the cascade simulations demonstrate that the assumptions underlying the DC model (e.g., ignoring power losses, reactive power flows, and voltage magnitude variations) can lead to inaccurate and overly optimistic cascade predictions. Particularly, in large networks the DC model tends to overestimate the yield. Hence, using the DC model for cascade prediction may result in a misrepresentation of the gravity of a cascade.

Index Terms—Power grids, AC versus DC, power flows, cascading failures, contingency analysis

1 Introduction

Power grids are vulnerable to external events, such as natural disasters and cyber-attacks, as well as to internal events, such as unexpected variability in load or generation, aging, and control device malfunction. The operation of a power grid is governed by the laws of physics [1], and the outage of an element may result in a cascade of failures and a blackout [2]. The recent blackouts in Turkey [3], India [4], U.S. and Canada [5] had devastating effects and as such motivated the study of power grid vulnerabilities to cascading failures (e.g., [2], [6], [7], [8]).

high for some particular networks [13]. Motivated by these observations, *we study the effects of line failures and cascades under both the linearized DC model and a nonlinear AC model* by performing simulations on four test networks.

First, we numerically evaluate the accuracy of the DC power flow model when there are no failures. We demonstrate that when there are no failures, the assumptions underlying the DC power flow approximation (i.e., negligible active power losses, reasonably small phase angle differences between the neighboring nodes, and small variations