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GROUP TITLE/ABSTRACT

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"Analyzing Extreme Deviations in Power Grid State Estimation Models"

The power grid is operated using state estimation algorithms that (by applying steady-state assumptions) solve linear systems of equations to assess fitness of the current operating condition. Greater fidelity can be included by relaxing the steady-state assumption and including power generation dynamics modeled by systems of ordinary differential equations coupled to the linear steady state system. A third, even higher fidelity approach is to include very rapid transient effects which relies on further complex dynamic differential equations. For all models, the goal is to quantify the fitness of the current state (or possible next states) based on the collection of contingencies (failure models) that may occur.

For large grid systems, nonlinear optimization is often used to solve for several contingencies simultaneously. As an alternative, brute-force methods may also be used to serialize evaluation of given contingencies, followed by some sort of search over the solutions for an optimal solution. In practice, this is a useful for contingencies that occur via naturally occurring faults that have an associated distribution, as well as "rare-event" faults. This optimization framework does not support when considering large-scale events such as cyber-attacks or natural failures such as weather or earthquakes. These cases lead to large deviations from steady/current-operating state and cause poor numerical conditioning and failures. This model failure does not imply operating system failure, only our inability to predict how it will behave.

We propose development of new mathematical approaches to handle cases of extreme deviations in grid state estimation models. These approaches could include discrete or continuous optimization and won't rely on proximity to a solution. This project is expected to result in new algorithms with provable reliability and convergence properties for large deviations. Base models will be representative grid/cyber systems and validation would occur in partnership with appropriate testbed practitioners.