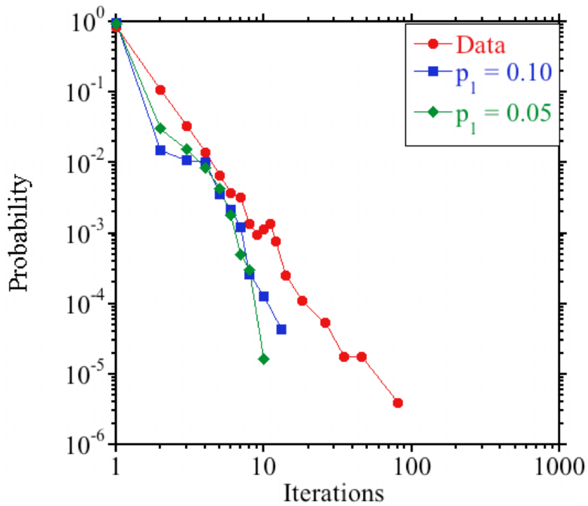

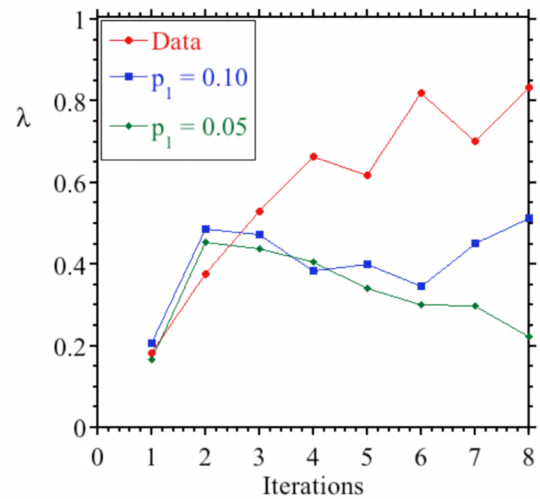

Fig. 11. The distribution in the number of iterations of the cascade and the parameter λ from OPA for the WECC 1553 bus network and parameters of Table 4 compared with the data.

6. Discussion of OPA validation

Using WECC parameters and the WECC 1553 bus network, a very reasonable agreement is obtained between the statistical data on blackouts from the Western interconnect and the OPA results. This serves to substantially validate the OPA model for estimating the statistical distributions of blackout size in terms of lines outaged and load shed on this 1553 bus network.

A set of parameters has been found giving sufficient agreement with WECC data to allow the use of the 1553 bus network case as a reference case to study the long-term WECC blackout statistics. Using this model and these parameters, it is now possible to determine and explore critical clusters of lines that are more vulnerable lines during cascading events [16] and metrics associated with large blackout risk [17].

Not so well predicted is the cascade propagation for later generations of the cascade. We strongly suspect that this discrepancy can be resolved by using larger network models of WECC, and we are continuing to investigate how the match of OPA with the WECC data scales with the size of the system model.

OPA simply represents only one cascading failure mechanism, namely cascading line overloads and outages, using standard and basic power system modeling assumptions such as DC load flow and LP generator redispatch. However, OPA is distinguished from other cascading simulations by also representing the complex feedback by which the power system slowly evolves and self-organizes over time, responding with system upgrades to both load growth and the blackouts. It is well known in the context of control theory that feedback loops strongly determine system performance and that feedback makes the system performance relatively insensitive to the modeling of the plant being controlled. The analogy between complex systems and control systems makes it plausible to suggest that the modeling of the complex system feedback loop that regulates the long-term system reliability may well be crucial for the promising results in validating OPA on the WECC, and that modeling the complex systems feedback in OPA makes the results less sensitive to modeling of the cascading outage mechanisms.

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