

Recovery capability evaluation of multi-energy distribution system based on heterogeneous information network

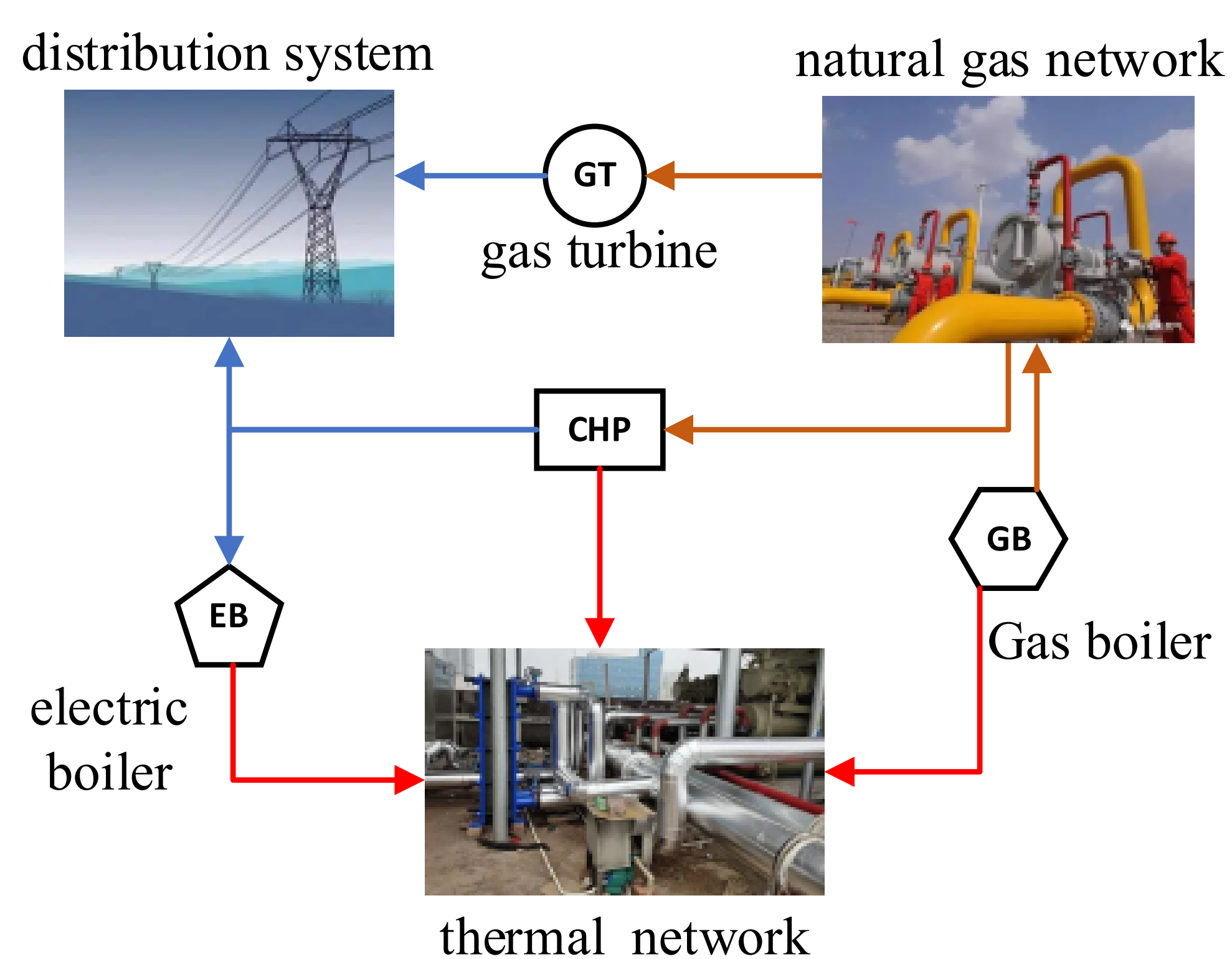
Shanshan Shi¹, Jian Zhou¹, Xiaobo ling¹, Yong Cui¹, Qiqi Zhang¹, Jianan Zhu², Qian Ai²
 1 State Grid Shanghai Electric Power Company, Shanghai, China
 2 Shanghai Jiao Tong University, Shanghai, China

Introduction

In the distribution system with multiple coupling nodes, the recovery strategy is complicated and difficult to be evaluated directly using a single network. This paper proposes a fault reconstruction methodology and evaluation indexes considering multi-energy coupling. First, an electric-thermal-gas heterogeneous information network (HIN) model is established and transformed into a three-layer bidirectional graph to analyse fault characteristics of different nodes. Then, the paper proposes a fault recovery and reconstruction strategy considering multi-energy coupling and a set of fault scenarios is generated by Monte Carlo simulation. Finally, based on the flexibility of the multi-energy, the fault recovery resilience index of the distribution system is generated.

Methods

The multi-energy coupling system utilizes coupling components to closely connect the distribution system with the thermal system and the natural gas system by the coupling the line, as shown below:



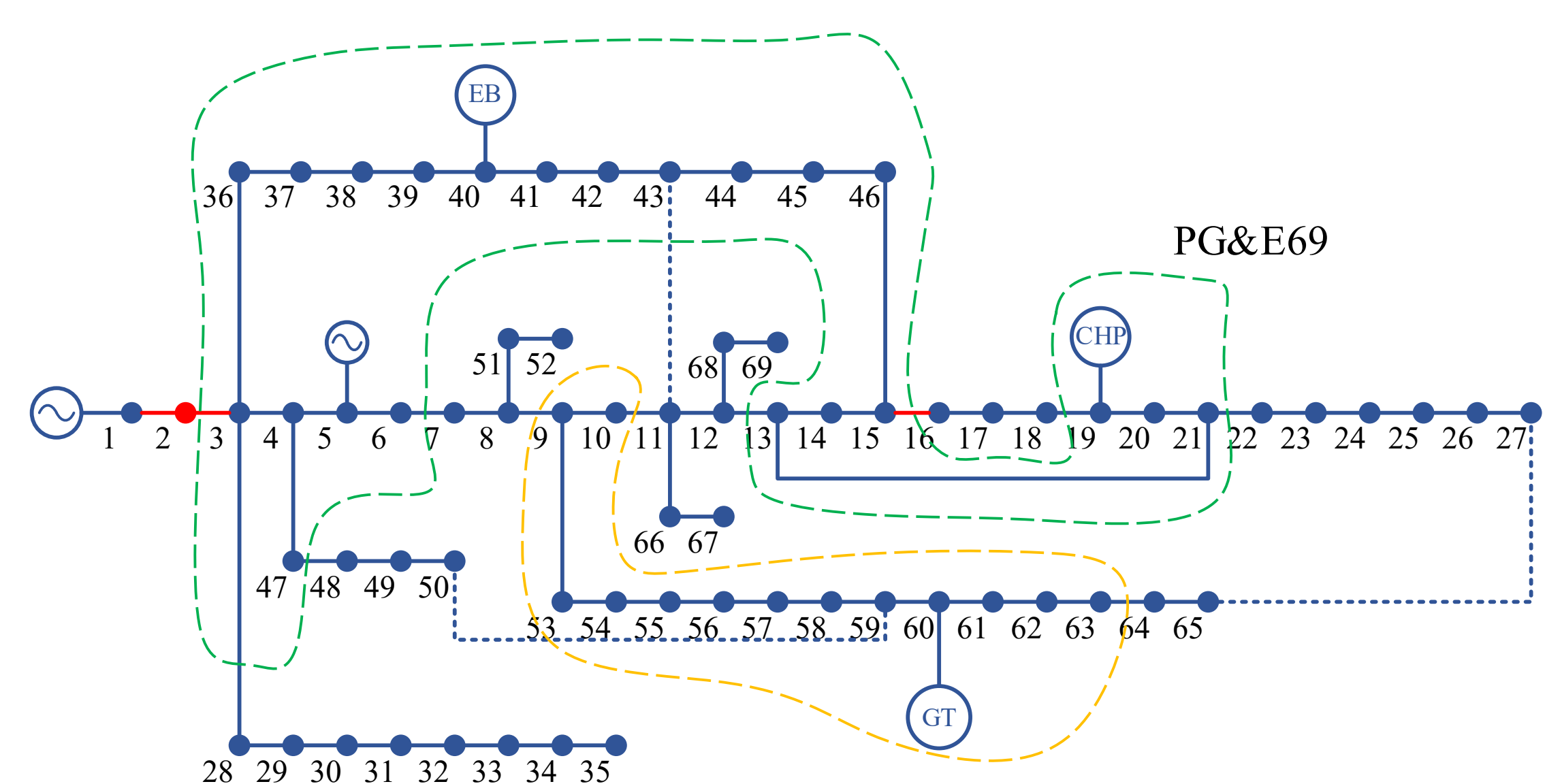
This paper establishes a three-layer HIN model of electricity, heat and gas, and the complex network structure is described by graphs. The Monte Carlo method is used to simulate various failure scenarios, and the average recovery rate of the load under each scenario is calculated as the evaluation index.

Results

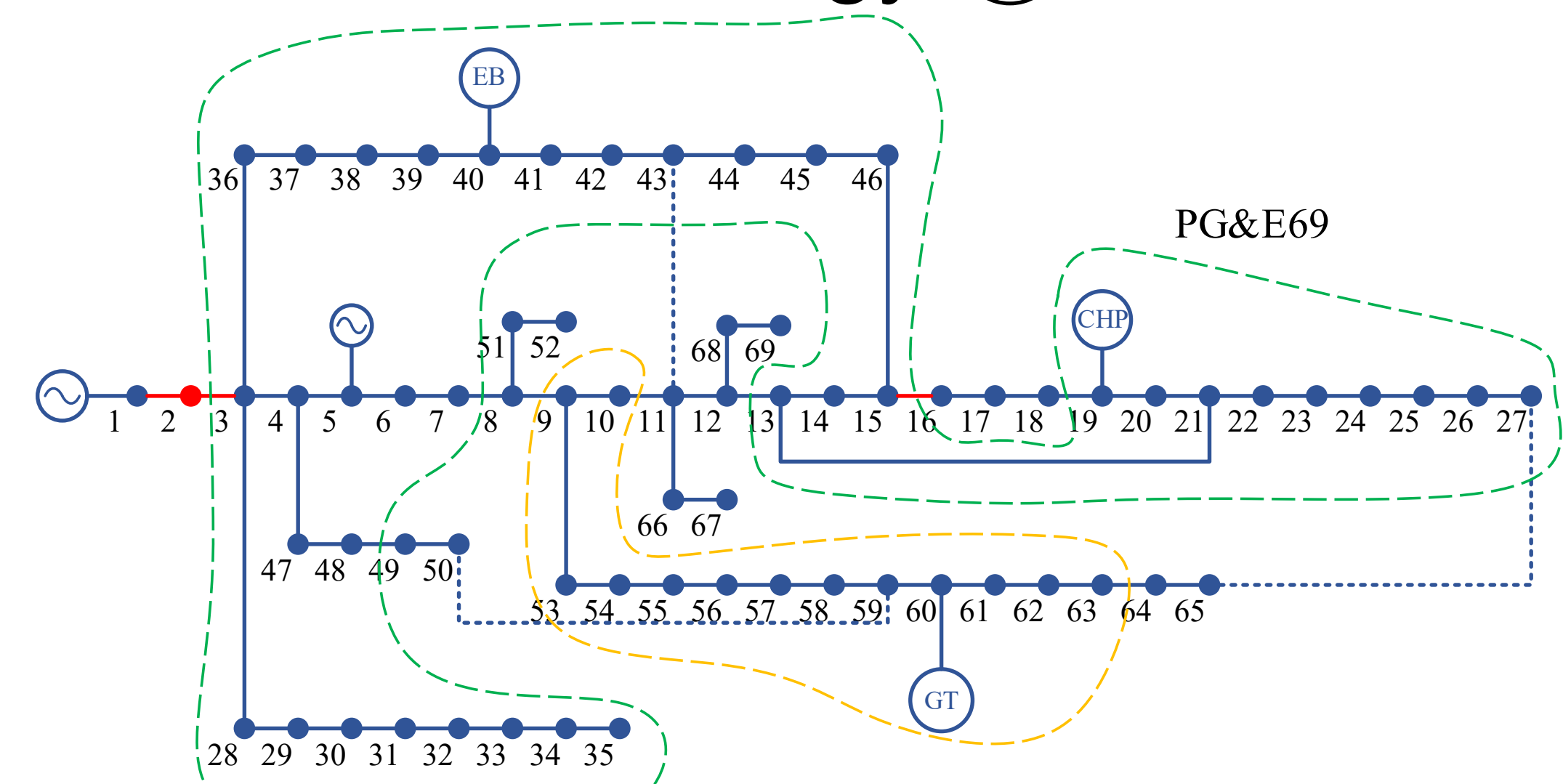
The proposed strategy is validated on a PG&E 69 power distribution system, a 32-node thermal network, and an 11-node natural gas network.

The power supply recovery strategies in the following two scenarios are analyzed respectively. The results are shown below:

- ① The strategy of active disconnection control of the distribution system powered by traditional distributed sources;
- ② The strategy of active disconnection control of the distribution system considering multi-energy coupling;



strategy ①



strategy ②

conclusion

- The complex network theory provides a new method and research way for analysing the multi-energy system structure, which can fully consider the multi-energy coupling effect and tap the energy supply potential of the multi-energy coupling system.
- Using the recovery strategy proposed in this paper to simulate faults in multiple scenarios, the weak parts in the power system can be found and improved in time.