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Transición energética en la 4ta revolución industrial

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Expansion Planning of Distribution Networks Comprising Reliability: An Enhanced Model Incorporating Post-Fault Reconfiguration

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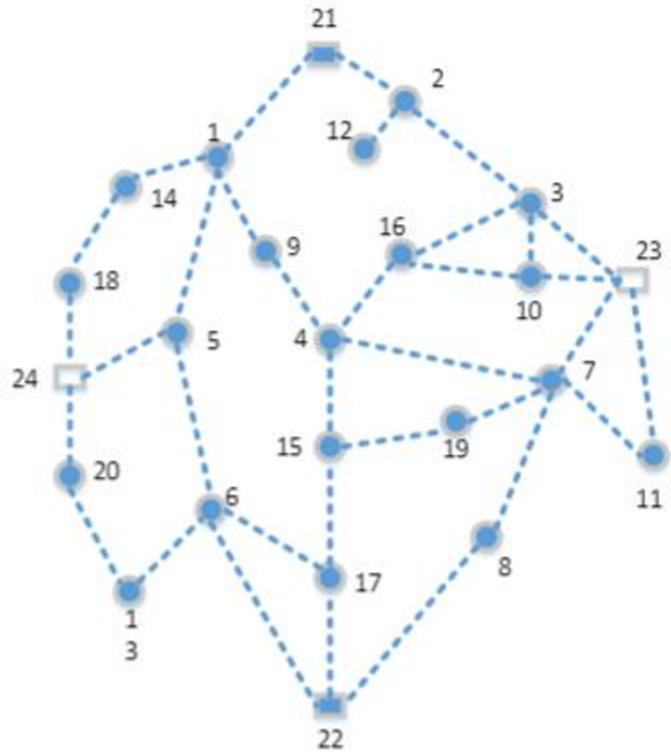
I. Introduction

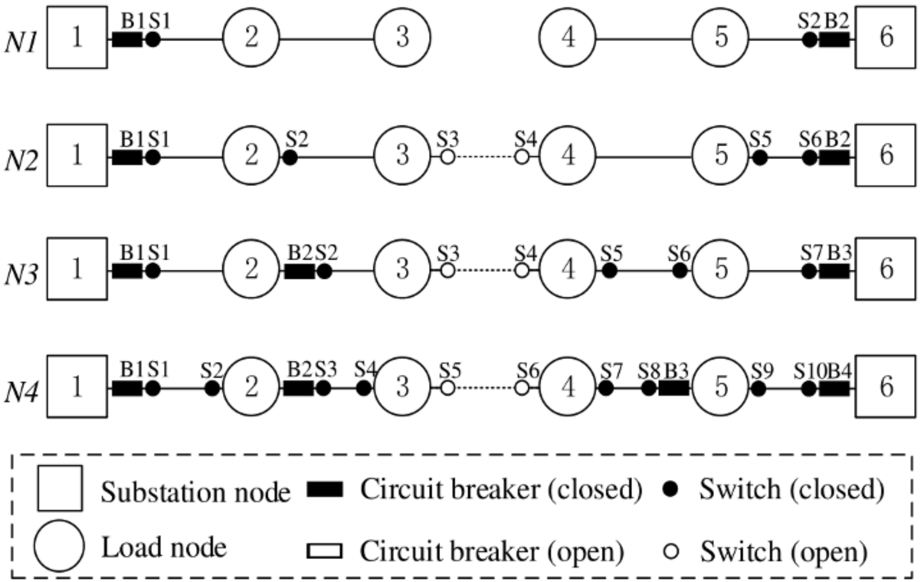
Different expansion planning models have been proposed in the literature to consider not only the optimal asset allocation in the network but also to include the reliability assessment. However, most of the models cannot integrate the effect of post-fault reconfiguration into the reliability assessment due to the complex dependence between reliability and the network topology as well as the high number of switching possibilities.



I. Introduction: Motivation

Paper [17] is the only one that incorporates post-fault reconfiguration into the reliability-constrained expansion planning model. Although this constitutes a major advance in approaching the mathematical model for reliability-constrained planning problems, a detailed review of the proposed set of constraints for modeling post-fault reconfiguration may reveal some inconsistencies, mainly related to the radial representation of the system and some nonlinearities in the network representation that were not addressed.

II. Theoretical aspects



Load node	Customer Interruption Frequency (1/year)				Customer Interruption Duration (hour/year)			
	2	3	4	5	2	3	4	5
N1	0.8	0.8	0.6	0.6	1.75	1.75	2.2	2.2
N2	0.8	0.8	0.6	0.6	1.06	0.825	0.84	0.84
N3	0.5	0.8	0.6	0.6	1	0.825	0.34	1.7
N4	0.5	0.8	0.6	0.4	0.075	0.135	0.34	0.24

$$\lambda_{12} = 0,5; \lambda_{23} = 0,3; \lambda_{45} = 0,2; \lambda_{56} = 0,4$$

$$\tau_{12}^{SO} = 0,15; \tau_{23}^{SO} = 0,2; \tau_{45}^{SO} = 0,5; \tau_{56}^{SO} = 0,6$$

$$\tau_{12}^{RS} = 2; \tau_{23}^{RS} = 2,5; \tau_{45}^{RS} = 3; \tau_{56}^{RS} = 4$$

$$CID_i = \sum_{ij \in L} \tau_{ij}^{SO} \lambda_{ij} I_{ij} + \sum_{ij \in L} \left(\tau_{ij}^{RS} - \tau_{ij}^{SO} \right) \lambda_{ij} I_{ij}; i \in N$$

$$CIF_i = \sum_{ij \in L} \lambda_{ij} I_{ij}; i \in N$$

III. Mathematical model

Min Cost: Investment +Operation

Active and reactive power Flow	Operational limits	Investment limits	Radiality	Logical constraint for reliability

III. Mathematical model: logical constraints

- avoid nodal interruption records in state s on branches that do not belong to the normal operation topology and that are not interrupted
- If the interruption in the branch ij affected a branch of the normal operating topology, then the nodes connected with them are directly affected by the interruption.
- Establish that if two adjacent nodes i,j are connected in the normal operating state topology, then they are equally affected by each interruption in the network.
- If a demand node i is not affected by a branch interruption, then its connection in the post-fault reconfiguration topology must be guaranteed
- If the interruption on branch ij is a real interruption, and that branch does not have a switch, then the nodes connected to the branch cannot be reconnected
- For the case of a branch ij outside the interrupted zone and without a switch, the adjacent nodes i,j are equivalently affected by the reconfiguration, i.e., both are reconnected, or both remain disconnected
- If a branch ij is part of the normal operating topology and is not operating in the post-fault reconfiguration topology, both nodes connected to the branch are not restored.

IV. Results

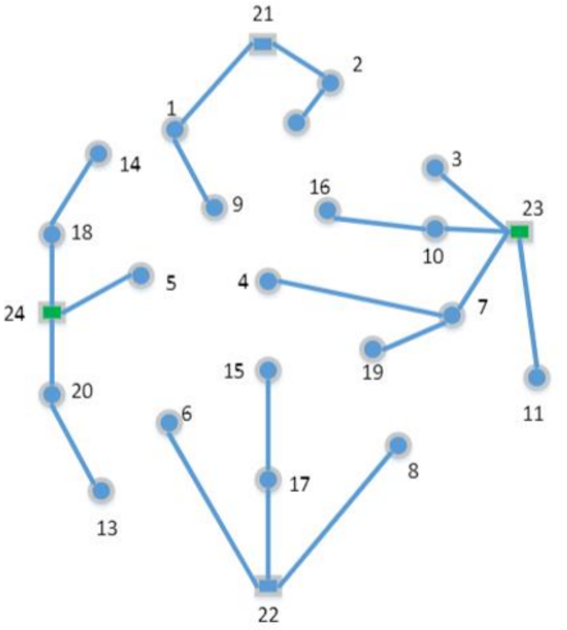


Fig. 2. Investments for Case I

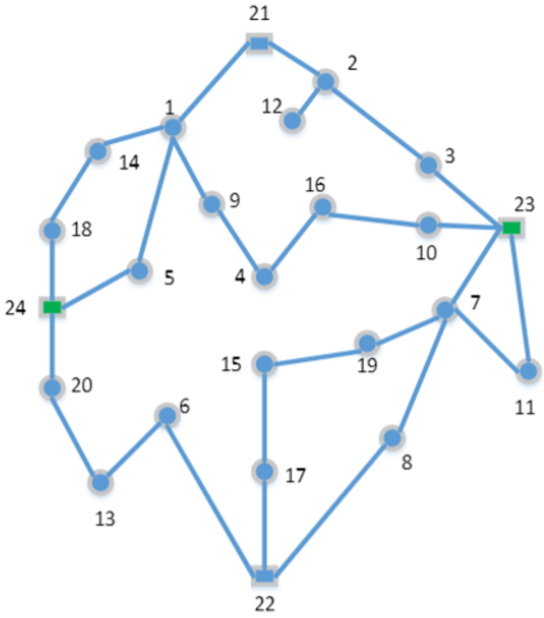


Fig. 3. Investments for Case II

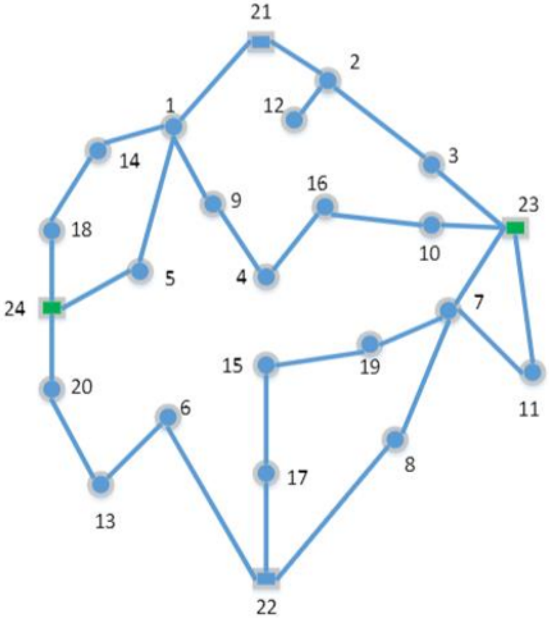


Fig. 4. Investments for Case III

IV. Results

TABLE I
PRESENT VALUES OF COSTS (10^3 \$)

Cost Description	Case I	Case II	Case III
Investment in Branches	469.32	654.73	580.37
Investment in Substations	660.00	660.00	800.00
Total Investment	1,129.32	1,314.73	1,380.37
Energy Cost	88,622.77	88,629.05	88,646.54
ENS Cost	2,230.38	683.15	1,770.61
Total Cost	91,982.47	90,626.93	91,797.52

V. Conclusions

1. This paper proposed a mixed-integer linear programming model that can include the influence of post-fault reconfiguration in the reliability-constrained expansion model. Differently from previous approaches, the model is not based on the use of fictitious flows and does not consider that all branches are switchable.
2. The model is based on logical relationships that can be represented by linear constraints, whereby the post-fault reconfiguration topologies of the network under planning can be obtained using scenarios.
3. The results show that the model can effectively integrate reliability assessment into the expansion planning problem.
4. The numerical results show that the model can provide expansion plans by integrating reliability assessment with post-fault reconfiguration. Importantly, the model has the flexibility to represent the case when not all branches are switchable

VI. Questions