Scalable Computing: Practice and Experience, ISSN 1895-1767, http://www.scpe.org
© 2023 SCPE. Volume 24, Issues 3, pp. 429–438, DOI 10.12694/scpe.v24i3.2288

DISTRIBUTION NETWORK PLANNING METHOD CONSIDERING THE COUPLING OF TRANSPORTATION NETWORK AND DISTRIBUTION NETWORK

ZHUORAN SONG [*], JIANFENG LI[†], TAO JIANG[‡], AND SICHEN LU[§]

Abstract. This paper introduces a novel distribution network planning method that addresses the limitations of conventional approaches. The existing methods primarily focus on optimizing component objectives using reliability analysis, which results in inadequate operational power control performance due to neglecting the coupling degree analysis of distribution network subprojects. To overcome this limitation, the proposed method incorporates the coupling of the traffic and distribution networks into the planning process. The method involves modeling the transportation network and analyzing the coupling characteristics of the planning items. Specifically, the energy efficiency coupling degree is calculated to assess the degree of coupling. Based on this analysis, the planning nodes are strategically deployed, and a comprehensive planning model is constructed. The model is then subjected to constraints and solved to obtain an optimal distribution network planning scheme. To evaluate the effectiveness of the proposed method, experiments are conducted to assess its operational power control capability. The experimental results demonstrate that when the proposed method is employed for distribution network planning, it reduces operating power and achieves a more desirable planning outcome. The novelty of this work lies in integrating the coupling analysis of the traffic network and the distribution network into the planning process. Considering the interdependencies between these networks, the proposed method enables a more comprehensive and efficient distribution network planning scheme. This approach enhances operational power control performance and improves the overall effectiveness of distribution network planning.

Key words: transportation networks; distribution network coupling; planning methods; linear programming.

1. Introduction. The main considerations for distribution network planning are planning demand, regional traffic conditions, and local construction levels. The traffic situation in the area will affect the configuration of the distribution network nodes, while the local construction level will have a limiting effect on the effectiveness of the distribution network planning. In general, the planning demand is based on economic efficiency. Different objective functions can be constructed by setting indicators such as planning cost economy, expected production economy and energy efficiency. The volume of traffic in the regional traffic situation and the route's load capacity also impact the planned route. To facilitate the study, the mathematical planning of the distribution network generally defaults to a level of construction that meets the planning needs. Currently, distribution network route planning can be carried out mainly by relying on models or expert commentary methods.

Model construction means that parameters such as the distribution network's energy efficiency or construction costs are used as objective functions, which are constructed and solved to obtain the optimal planning solution under this result. The evaluation analysis method combines principle component analysis or grey correlation method to analyze the feasibility of the distribution network planning results. By calculating the distribution network benefits or planning costs under different planning results, the best planning results can be obtained. Both of these methods are commonly used in distribution network planning projects and can produce optimal planning solutions for different planning needs, which is a goal-oriented planning method.

However, there are some limitations to these two planning methods. Firstly, the model construction method can only be used for a single planning objective. In contrast, in planning large distribution networks, there are often multiple benefits to be considered, including economic, social, and production benefits [17]. Many large distribution networks are planned to ensure the lowest possible construction costs while requiring the highest possible operational efficiency. Model-building methods cannot meet the multiple planning needs of large

[*]State Grid Liaoning Electric Power Supply Co., Ltd, Shenyang, 110006, China (jianfengleo@outlook.com)
[†]State Grid Liaoning Electric Power Supply Co., Ltd, Shenyang, 110006, China
[‡]State Grid Liaoning Electric Power Supply Co., Ltd, Shenyang, 110006, China
[§]State Grid Liaoning Electric Power Supply Co., Ltd, Shenyang, 110006, China

Table 2.1: Traffic Network Influencing Factors

Elements of influence	Specific explanations
Natural factors	Terrain
	Geological conditions
	River flow
Social factors	Urban distribution
	Economic conditions
Technological factors	Technological level
	Level of road construction

distribution network projects. The expert commentary method, based on the collection of expert questionnaires and the analysis of expert opinions, is highly subjective, cannot accurately and objectively analyze the actual benefits of different planning projects, and is not comprehensive enough to meet the planning needs in terms of reliability. In addition to their limitations, the two planning methods also share a common limitation, namely the excessive coupling of sub-projects [10]. The degree of sub-project coupling refers to the overlap of energy and output benefits between different sub-projects in the planning results. Both conventional planning methods do not consider the collar of sub-projects, resulting in an overlap of energy efficiency between sub-projects in the planning results. Therefore, to avoid the limitations of the above planning method, the coupling between the sub-projects needs to be analyzed, and by identifying the deeper coupling between the sub-projects and dealing with the duplication, each sub-project can achieve its energy efficiency, thus ensuring that the energy efficiency of the overall project is maximized.

By analyzing the coupling characteristics of the distribution network sub-projects, the cost of construction resources can be effectively allocated when input planning, thus reducing planning expenditure and providing higher economic efficiency. In response, this paper proposes a new distribution network planning method that incorporates transport network and distribution network coupling factors into the planning scheme, and improves the economic planning efficiency of the distribution network by calculating the coupling degree of sub-projects and constraining the planning results so that sub-projects with duplicated energy benefits can be processed [9].

Ultimately, the motivation behind this research is to contribute to advancing distribution network planning methods, provide more accurate and efficient planning schemes, and support the development of sustainable and optimized distribution networks. By addressing the limitations of existing methods, the research aims to offer practical solutions to enhance the operational performance of distribution networks and meet the evolving demands of modern power systems.

2. Traffic network model construction and planning project benefit coupling degree calculation. To carry out rational planning of the distribution network, this paper first models the traffic network and analyses the coupling situation of the planned projects based on which the grid planning nodes are deployed. Considering that the traffic flow has a large degree of influence on the project site planning, the traffic network around the distribution network is firstly modeled [1]. The traffic network mainly consists of passing road sections and traffic line hub nodes, and one passing road section will exist in every two traffic hub nodes. Each traffic section corresponds to its own traffic flow and load capacity, determining the maximum travel time of different traffic sections. In addition, there are combinations of traffic demand nodes in the area around the distribution network, each of which includes a start node and an end node for the realization of different sections of traffic demand [4]. Depending on the traffic demand, the node combinations can generate different traffic routes, for example, a start node can match multiple end nodes, and the routes can be found efficiently by using the depth search algorithm. The main influencing elements of the traffic network are shown in Table 2.1.

Table 2.1 shows that transportation networks are affected by three main factors: natural, social, and technological. Since the issue discussed in this paper is distribution network planning, this paper focuses on social factors to analyze it, i.e., economic conditions and traffic demand factors [3]. In this regard, the traffic flow on each driving route will be accumulated on different traffic routes, and the traffic flow accumulation formula is shown below.

$$x_a = \sum_w \sum_k f_k^w \delta, \forall w, \forall k \in T_k^w, \forall a \in T_A \tag{2.1}$$

where x_a represents the accumulated traffic flow of road section a in a certain statistical period, w represents a traffic demand node combination, k represents the driving route corresponding to the node combination; f_k^w represents the traffic flow under the driving route corresponding to the traffic demand node combination; δ represents the accumulated times, T_k^w represents the set of all driving routes under the traffic demand node combination, T_A represents the set of passing road sections [20]. At the same time, the traffic volume under each combination of traffic demand nodes should meet the route demand, so the following expression can be obtained.

$$\sum_{k \in T_k^w} f_k^w = q_w \tag{2.2}$$

where, q_w represents the traffic flow demand under the route for a certain combination of traffic demand nodes in a certain statistical period. In this paper, the road section travel time is chosen as the main indicator to measure the traffic capacity of a traffic section, and the specific calculation formula is shown below.

$$t_a = t_a^0 \left[1 + 0.15 \left(\frac{x_a}{c_a} \right)^2 \right] \tag{2.3}$$

where t_a represents the passage time of the road section a, c_a represents the maximum traffic flow under the passage section, t_a^0 represents the free passage time under the passage section [11]. Through the above formula can be seen that when the traffic flow of section a is lower than the maximum traffic flow, the team is in a free flow state; when the traffic flow of area a exceeds the maximum traffic flow, at this moment, can be seen as a traffic congestion situation, the passage time will be affected by the actual traffic flow [11].

After completing the above analysis for the traffic network, the distribution network benefit coupling needs to be analyzed. In the distribution network planning, there is benefit coupling between different planning sub-projects [19]. In other words, the functions of two sub-projects in a distribution network planning project may be duplicated, thus resulting in a less efficient operation of the distribution network as a whole [5]. A reasonable analysis of the coupling of distribution network benefits can effectively ensure that the sub-projects do not have overlapping parts in terms of functions and benefits, and ensure the maximum efficiency of the distribution network project. Firstly, assuming that the distribution network planning projects are x_i , I represents the total number of expected planning projects, and assuming that the planning timing expectation is ζ_i , the timing benefit function of distribution network benefit coupling can be constructed, and the specific function expression is shown below [6].

$$f(\zeta_i) = \begin{cases} \dfrac{G_i - G_{\min}}{G_{\max} - G_{\min}}, \zeta_i \in + \\ \dfrac{G_{\max} - G_i}{G_{\max} - G_{\min}}, \zeta_i \in - \\ 0 \le f(\zeta_i) \le 1 \end{cases} \tag{2.4}$$

where G_i represents the efficacy parameter generated after the distribution network planning is completed; $f(\zeta_i)$ represents the orderliness of the planning result, the value of which ranges from 0 to 1, and the closer the value is to integer, the higher the orderliness of the planning result at this moment [18]. $G_{\max}$ and $G_{\min}$ represent the steady-state values of the planning items in the case of maximum and minimum planning orderliness, respectively. According to the above equation, the timing function of the coupling benefits of the distribution network can be obtained, and the above timing expectation values are weighted to obtain the following expressions.

$$\zeta = [\zeta_1, \zeta_2, ..., \zeta_I] \cdot \begin{bmatrix} \omega_1 \\ \omega_2 \\ ... \\ \omega_I \end{bmatrix} \tag{2.5}$$

Table 3.1: Correspondence between the main station of the distribution network and the regional scale

Regional scale	Distribution network main station size
Large cities	Large Main Station
Medium-sized cities	Medium Main Station
Small Cities	Small main station
County	Front extension main station

where represents the coupling weight value of the ith subproject for the jth subproject in the distribution network project. The coupling benefit equation for the distribution network project planning can be constructed by combining the above two formulas, and the specific expression is shown below [12].

$$O = \frac{\prod_{i=1}^{I} \zeta_i}{\left[\prod_{i=1,2,\ldots,I-1} (\zeta_i + \zeta_{i+1}) \cdot (\zeta_i + \zeta_{i-1})\right]^{1/I}} \tag{2.6}$$

The value of O represents the benefit coupling degree, which ranges from 0 to 1. The closer the value is to integer, the higher the efficacy overlap between the sub-projects in the planning result at this moment. The above calculation of project effectiveness coupling degree can effectively correct the planning results [7].

3. Distribution network project planning node deployment. The planning of the distribution network project needs to be reasonably matched with the regional construction scale and the total number of sites, as shown in Table 3.1.

According to the above table, it can be seen that the corresponding site size varies for different size cities. For larger cities, a large master station needs to be matched, while for smaller counties and other areas, the distribution grid master station can be selected from the front extension master station [17]. In this paper, we focus on large cities with corresponding large distribution network master stations for distribution network planning analysis. In general, the reliability level of the distribution network master station in large cities is higher, and the distribution equipment level is higher, and the power supply mode of composite power supply is generally adopted so that the power can be restored faster for some power outages or blackouts, which also puts more requirements on the distribution network planning of large cities. First of all, the distribution network needs to be able to supply the required amount of power with minimum energy consumption. Therefore, when planning the distribution network, it is necessary to take into account the demand for power in different areas and the distance from the proposed planning center [15]. For areas with high demand, the distance between the distribution network center and the area needs to be reduced in order to reduce transmission losses.

The conventional distribution network planning method is mainly through the analysis of the planning demand, based on which the planning nodes are deployed in combination with the power supply efficiency of each region, and then different nodes are connected between them, and the planning path can be determined. The planning results obtained by this method have more planning routes, which can be reasonably selected for different planning needs and the specific geological conditions of the study area. However, due to the lack of consideration of the planning cost, the planning results under the traditional method have low planning efficiency and the algorithm has low robustness and cannot complete the corresponding path search task within the specified time. Therefore, in this paper, the conventional distribution network planning method is optimized, and the optimal planning path is obtained by searching the planning paths under different nodes with the planning efficiency as the objective function, so that the coupling efficiency of the planning paths can be effectively avoided [8].

In this regard, firstly, the nodes of the planning project need to be reasonably deployed, and the specific nodes need to be spiritually adjusted according to the power supply demand of the study area and the construction level of electrical energy equipment. In this paper, six planning nodes are selected for the power supply demand characteristics of the main station of large urban distribution network, and the construction level of distribution network under each node can meet its corresponding power supply demand. The nodes

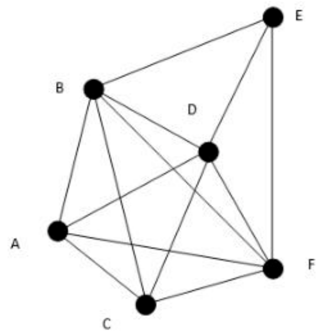

Fig. 3.1: Initial planning results of distribution grid gridding

are barrier-free and can be connected flexibly. First of all, the planning paths connected by the distribution network planning nodes need to have a single nature. Too many repetitive planning paths not only cause waste of planning resources, but also create a large electric pressure on the operation of the main distribution network in large cities. Therefore, it is necessary to search for the best planning paths under different nodes in order to maximize the benefits of the planning results. In order to meet the planning requirements of the distribution network master in large cities, the planning paths under each node need to be analyzed to avoid duplicate paths as much as possible [2].

In order to improve the planning effect, this paper chooses the grid method to divide the planning nodes of the project, for which, the gridization parameters need to be simulated. Combined with the algorithm, it can be assumed that the initial set of ant colony size is V , and the initial set of planning lines is E . The initial planning results can be obtained through the ant colony seeking control, as shown in Figure 3.1.

In the initial planning result of the above figure, assuming that the total length of the distribution grid gridding search path is p_{ij}, the grid connection matrix expression can be obtained as shown below.

$$A = p_{ij} \times e^t \tag{3.1}$$

where e^t represents the search path parameter. Since each individual in the ant colony population has variability in search performance, individual variability is also taken into consideration when grid planning is performed for the distribution network, and the obtained grid node planning degree is calculated as shown below.

$$d_i = \frac{\sum_{i=1}^{V} V \times D}{r_i} \tag{3.2}$$

where D represents the diagonal element due to the distribution grid gridding, the value is mainly related to the joint probability density, and r_i represents the characteristic value of the difference in search performance of different individuals under the ant colony population. Assuming that the distribution grid gridding chunking matrix is, the total number of ant colony collections under the optimal planning route can be calculated according to the above formula, which is shown below.

$$U = \frac{\ln(V \times E)}{u_{ij}} \tag{3.3}$$

where, represents the probability of effective connection distribution, through the above steps can be completed for the initialization of the grid results, the final results of the optimization of node deployment, as shown in Figure 3.2.

The above figure shows that, compared with the initial grid planning results, the optimized node deployment structure diagram in this paper has only one path between each node and it is the optimal path, so it can satisfy the power supply efficiency while controlling the energy consumption to the minimum, thus improving the energy

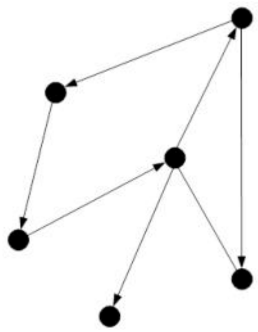

Fig. 3.2: Node deployment structure under optimal path planning

efficiency of distribution network planning [14]. The above steps can be completed for the effective deployment of the planning nodes to ensure a single node planning path, which helps to provide comprehensive planning benefits.

4. Distribution network planning model construction. After the construction of the traffic network model and the calculation of the coupled benefit values, the distribution network planning model is constructed by combining the grid diagram of the planning nodes deployed in this paper with the energy efficiency as the objective function and the linear regression method. The control expression of energy efficiency of distribution network is shown as follows [16].

$$\max g(x) = mk_1x_1 + k_2x_2 + ..., k_nx_n \tag{4.1}$$

where $g(x)$ represents the standardized control model of energy efficiency of the distribution network, k represents the efficiency parameter of the planning project, m represents the linear synchronization parameter, and n represents the number of linear planning. Considering the energy cost and expected energy efficiency of the distribution network construction, this paper takes the maximum energy efficiency constraint as the objective function, and the obtained function expressions are shown below.

$$\max \sum C(P_{en,i}) = \sum C_1(P_{DG,L}) + \sum C_k(P_{B,H}) \tag{4.2}$$

where $P_{en,i}$ represents the maximum energy efficiency under the ith planning path under linear planning; $P_{DG,L}$ represents the energy efficiency load under the standardized energy efficiency control model; $P_{B,H}$ represents the optimal control objective under the source network load; C_k represents the energy load parameters of the distribution network; C_1 represents the energy cost consumed by the distribution network construction, C represents the total energy consumption of the planning path, B represents the energy efficiency control objective; H represents the constraint parameters of the objective function. On the basis of the above objective function, the constraints are applied to the planning model. First, the energy consumption brought by the operating load of the distribution network under different planning results needs to be calculated as shown in the following formula [13].

$$P'_{F,r} = P_{F,r} + P_{loss,r} \tag{4.3}$$

where $P'_{F,r}$ represents the total power consumption values of electrical equipment due to operating load in the distribution network, $P_{F,r}$ represents the power consumption of individual electrical equipment in the normal state, $P_{loss,r}$ represents the power consumption of the distribution network in a single path under the optimal planning line, F represents the energy load of the distribution network, r represents the storage load, and *loss* represents the transmission path with the largest energy consumption. In general, the energy consumption generated by the main station of the distribution network in a large city should run the load in the operation process is generally within 10%, so this paper takes the historical operation data of a distribution network as

Table 4.1: Constraints

Control items	Upper limit conditions	Lower limit conditions
$P_{DG,L}$	$P_{DG,L}(\max) \leq L$	$P_{DG,L}(\min) \geq H$
$P_{B,H}$	$P_{B,H}(\max) \leq H$	$P_{B,H}(\min) \geq B$
$P_{F,r}$	$P_{F,r}(\max) \leq r$	$P_{F,r}(\min) \geq L$

the research object and constructs the constraints of the objective function, i.e., the upper and lower limits of the operation energy consumption, by analyzing the operation energy consumption ratio in the historical data, as shown in Table 4.1.

Based on the above constraints, the objective function is solved to achieve a reasonable planning for the distribution network. The specific solution process is shown below.

Firstly, the optimal control boundary of the energy efficiency of the distribution network is calculated, and the value is mainly obtained by summing the upper limit condition parameters and the lower limit condition parameters of the control project. Then the energy efficiency control model is calculated for the specific model parameters of the energy transmission power, and the actual increment is calculated according to the size of the transmission power, and the specific calculation formula is shown below.

$$\Delta P = P_{T0} - P_T \tag{4.4}$$

where ΔP represents the actual incremental power output of the distribution network, P_{T0} represents the statistical output power value, and P_T represents the warning output power under the energy efficiency control model. The above equation can control the actual incremental deviation of output power, and select a suitable planning path according to the ideal deviation value, and then optimize the planning path to ensure the optimal energy efficiency of the distribution network under the planning path and to meet the regional power supply demand. Through the above steps, the distribution network planning model can be constructed, and the control planning effect of the model is constrained by combining the constraints designed in this paper, and the model is solved to obtain the best planning path and scheme. Combining the contents of this section with the above-mentioned results of traffic network model construction and coupling benefit calculation, and grid-based planning node deployment, the design of the distribution network planning method considering the coupling of traffic network and distribution network is completed. The proposed method aims to control the actual incremental deviation of output power in order to optimize the planning path and ensure the optimal energy efficiency of the distribution network while meeting the regional power supply demand. By selecting a suitable planning path based on the desired deviation value, the planning path is further optimized to achieve the desired control effect. The construction of the distribution network planning model involves combining the formulated constraints and utilizing the designed control measures outlined in this paper. By solving the model, the best planning path and scheme can be obtained, ensuring efficient and reliable operation of the distribution network. Furthermore, the completed design of the distribution network planning method takes into account the coupling of the traffic network and the distribution network. This includes the construction of the traffic network model, calculation of coupling benefits, and deployment of planning nodes based on the grid. By integrating these components with the aforementioned steps, a comprehensive and effective distribution network planning method is achieved

5. Experiment and analysis.

5.1. Experimental preparation. In order to prove that the distribution network planning method considering the coupling of traffic network and distribution network proposed in this paper is better than the conventional distribution network planning method in terms of planning classification effect, after the design of the theoretical part is completed, an experimental session is constructed to test the actual planning effect of the method in this paper. In order to ensure the experimental effect, two conventional distribution network planning methods are selected for comparison, namely the distribution network planning method based on reliability analysis and the distribution network planning method based on temporal correlation.

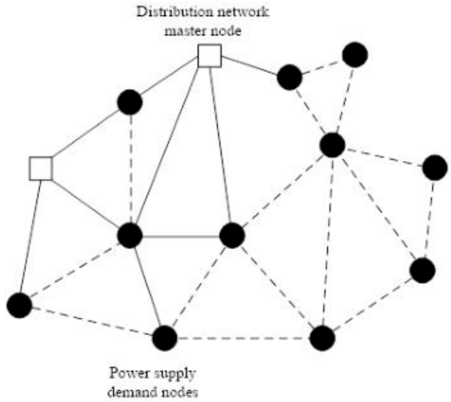

Fig. 5.1: Distribution network system node diagram

Table 5.1: Distribution network modeling parameters

Modelling parameters	Specific configuration
Power Plate Cap/MV	55
Lower Power Plate Limit/MV	60
O&M factor	28.63
Installation cost	30.1
Source supply climb rate/M	150
Source Network Supply Down Climb Rate	165

The experimental object selected for this experiment is a 24-node distribution network system with a rated voltage of 20 kV under the system, which contains a total of four main distribution stations and 10 power supply demand nodes, the specific structure of which is shown in Figure 5.1.

In order to improve the accuracy of the experimental results, MATLAB software is used to model the above distribution network system in this experiment. To facilitate the modeling, line parameters of the original distribution network system and substation-related data are extracted in this paper to facilitate the subsequent rational planning of the distribution network for energy efficiency, and the specific modeling parameters are shown in Table 5.1.

The distribution network system was modeled according to the contents of Table 5.1, and the modeling results were planned using three methods to compare the energy efficiency costs under different planning methods.

5.2. Analysis of test results. The comparison criterion chosen for this experiment is the planning performance of the planning method, and the specific measurement index is the optimal control power of the distribution network under different planning methods, the lower the value represents the better planning effect of the algorithm, and the specific experimental results are shown in Figure 5.2.

The above experimental results show that the optimal control power of the distribution network model under different planning methods also varies at different control times. By observing the power change curves, it can be seen that the control power of the distribution network under the two conventional planning methods is higher, which indicates that the energy consumption of the distribution network is larger at this moment. The model with the coupling of traffic network and distribution network proposed in this paper has lower optimal control power, which proves that the planning method proposed in this paper has better planning performance and can reasonably control the operating power of the distribution network while meeting the planning requirements.

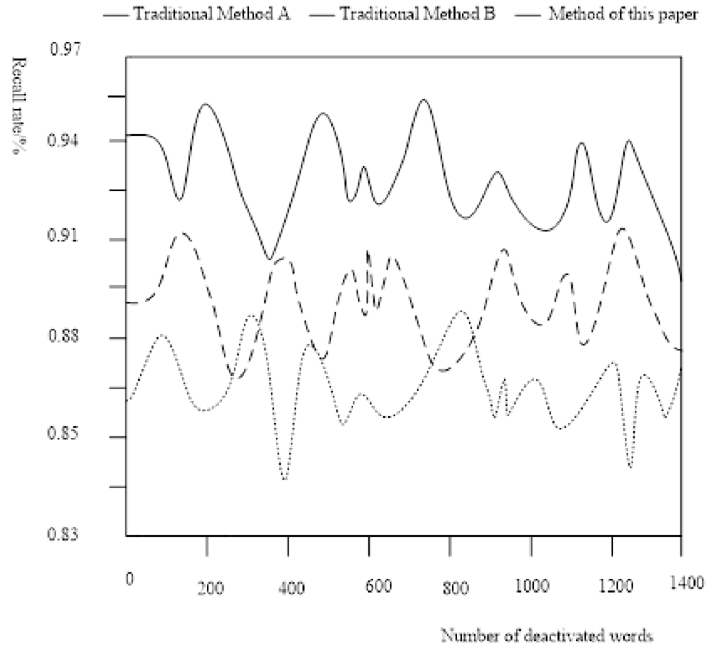

Fig. 5.2: Algorithm recall comparison results

6. Conclusion. This research paper proposes a distribution network planning method that considers the coupling of the traffic network and the distribution network. By incorporating the traffic network model and analyzing the coupling degree of sub-projects, the distribution network planning model is constructed to effectively control the operation of the power grid. This approach ensures the distribution network meets the power supply demand in the area while minimizing power wastage, resulting in improved economic and energy efficiency.

Future research should focus on investigating the distinct power characteristics of AC and DC systems in greater detail. Understanding these differences will contribute to further enhancing the effectiveness and applicability of the distribution network planning method. By exploring the unique requirements and challenges posed by AC and DC systems, it will be possible to develop more tailored and optimized planning strategies for both types of power networks. This will ultimately contribute to the advancement of energy-efficient and sustainable distribution network planning practices.

REFERENCES

[1] I. C. Barutcu, *Examination of the chance constrained optimal wt penetration level in distorted distribution network with wind speed and load uncertainties*, Engineering, Technology & Applied Science Research, 11 (2021), pp. 7311–7320.

[2] P. Bhatt, *Harmonics mitigated multi-objective energy optimization in pv integrated rural distribution network using modified tlbo algorithm*, Renewable Energy Focus, 40 (2022), pp. 13–22.

[3] B. Canizes, V. Silveira, and Z. Vale, *Demand response and dispatchable generation as ancillary services to support the low voltage distribution network operation*, Energy Reports, 8 (2022), pp. 7–15.

[4] G. S. Chawda and P. Kumar, *Mitigation of nonlinear load influence on the power quality of the low-voltage distribution network using dstatcom*, in Active Electrical Distribution Network, Elsevier, 2022, pp. 229–241.

[5] R. Cheng, Q. Li, Y. Zhang, W. Deng, Y. An, and M. Chen, *Three-phase power cooperative management of distribution network with high distributed energy resources penetration*, Energy Reports, 8 (2022), pp. 239–250.

[6] C. Ding, T. Nie, and Y. Chen, *A distribution network solid-state dc circuit breaker with current limiting function*, Energy Reports, 8 (2022), pp. 986–994.

[7] Y. Ding, T. Lu, Z. Wang, H. Wu, and X. Lu, *A full time scale resilience improvement strategy of distribution network*

under extreme weather, Energy Reports, 8 (2022), pp. 1019–1025.

[8] W. Guo and H. Wang, *A protection scheme for active distribution network based on the cooperative control of inverter-interfaced distributed generators*, Energy Reports, 8 (2022), pp. 342–352.

[9] L. Gutierrez-Lagos, K. Petrou, and L. Ochoa, *Quantifying the effects of mv-lv distribution network constraints and der reactive power capabilities on aggregators*, IET Gener. Transm. Distrib, 15 (2021), pp. 2019–2032.

[10] I. M. Jawad and W. S. Majeed, *Congestion mitigation in distribution network by integrated distributed generations for improving voltage profiles and minimizing the losses*, Journal of Engineering and Sustainable Development, 25 (2021), pp. 78–87.

[11] B. Khan, K. Redae, E. Gidey, O. P. Mahela, I. B. Taha, and M. G. Hussien, *Optimal integration of dstatcom using improved bacterial search algorithm for distribution network optimization*, Alexandria Engineering Journal, 61 (2022), pp. 5539–5555.

[12] W. Lin, B. Xia, Y. Tang, T. Zhang, and Y. Qi, *Aoi research on pmu cloud side cooperative system of active distribution network*, Energy Reports, 8 (2022), pp. 677–686.

[13] Y.-J. Lin, C. Jing, C. Cao, and K. Bai, *Distributed power supply access distribution network planning with timing characteristics*, Computer Simulation, 39 (2022), pp. 51–55.

[14] P. J. Mitchell, S. G. Bolam, H. L. Close, C. Garcia, J. Monk, and K. Alliji, *Distribution of demersal fish assemblages along the west coast of st lucia: Implications for planning no-take marine reserves*, Aquatic Conservation: Marine and Freshwater Ecosystems, 31 (2021), pp. 1354–1366.

[15] H. Nykyforchyn, L. Unigovskyi, O. Zvirko, M. Hredil, H. Krechkovska, O. Student, and O. Tsyrulnyk, *Susceptibility of carbon pipeline steels operated in natural gas distribution network to hydrogen-induced cracking*, Procedia Structural Integrity, 36 (2022), pp. 306–312.

[16] W. Song and J. Zhu, *A goal-reference-point decision-making method based on normal cloud model and its application in distribution network planning evaluation*, Information Sciences, 577 (2021), pp. 883–898.

[17] Q. Wei, J. Zheng, W. Tang, and Q. Wu, *Equivalent model of active distribution network considering uncertainties of wind turbines, photovoltaics and loads*, in IOP Conference Series: Earth and Environmental Science, vol. 645, IOP Publishing, 2021, p. 012086.

[18] Z. Wu, L. Ye, P. Liao, C. Li, Z. Zhou, S. Li, and J. Sun, *State estimation of distribution network based on hybrid measurement combined with multi-source asynchronous data*, Energy Reports, 8 (2022), pp. 1778–1783.

[19] R. Xu, C. Chen, D. Chen, G. Zhou, Y. Jin, X. Wu, W. Wang, X. Feng, S. Liu, and Z. Lin, *Maximum openable capacity optimization method of active distribution network considering multiple users access*, Energy Reports, 8 (2022), pp. 43–50.

[20] K. Yu, B. Xue, F. Gu, H. Hua, Y. Yuan, and Q. Li, *A novel pet model based volt/var control of ac–dc hybrid distribution network*, Energy Reports, 8 (2022), pp. 2672–2685.

Edited by: Sathishkumar V E
Special Issue on: Scalability and Sustainability in Distributed Sensor Networks
Received: May 15, 2023
Accepted: Jul 9, 2023