Research on Source-Load Collaborative Planning Method of Active Distribution Network Based on DG Initialization Site Selection

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Abstract: At this critical juncture of the energy transition, distributed energy resources (DG) are springing up. DG initialization and siting have become a major issue in power system planning. It involves not only the efficient use of energy and the stability of the network, but also the balance between economic costs and environmental impacts. Therefore, source-grid-load collaborative planning has become a key step in realizing the intelligence of active distribution networks.

1 INTRODUCTION

First of all, we need to recognize that DG does not exist in isolation, and its value is reflected in its interaction with the grid (Zheng and Xuan, et al. 2023). The traditional power grid is a passive transmission system, but when the DG is properly initialized and situated (Zhou and Hu, et al. 2023), the entire network is transformed into an intelligent system that can proactively respond to changes in demand and supply (Lin and Yan, et al. 2023). This shift means greater energy efficiency, greater system stability, and more flexibility in the market.

2 RELATED CONCEPTS

2.1 Mathematical Description of DG Initialization Siting

Next, we need to explore how to do an effective DG initial site selection. This process involves complex data processing and model analysis, including but not limited to load forecasting, variability assessment of renewable energy (Liao and Zhang , et al. 2023), analysis of network constraints, etc. With the support of advanced algorithms and optimization techniques (Jin, 2023), we can ensure that the layout of the DG meets the economic, technical and environmental requirements to the greatest extent.

$$\lim_{x\to\infty}(y_i \cdot t_{ij}) = \lim_{x\to\infty} y_{ij} \geq \max(t_{ij} \div 2) \quad (1)$$

In addition, we need to consider social factors. The location of DG should avoid densely populated areas as much as possible to reduce the impact on residents' lives.

$$\max(t_{ij}) = \partial(t_{ij}{}^2 + 2 \cdot t_{ij}) \succ mean(\sum t_{ij} + 4)\frac{\Delta y}{\Delta x} \quad (2)$$

At the same time, considering that the development of DG may change the local employment structure and economic model, we need to actively cooperate with local governments and communities at the planning stage to ensure that the project can be widely accepted and supported by the society (Lei and Wu, et al. 2023).

Of course, technological innovation is the core driving force for the development of DG (Liu Ying, Song Limin, et al. 2023). Whether it is the breakthrough of energy storage technology, the application of cloud computing and big data, or the combination of the Internet of Things and artificial intelligence, it provides the possibility for the efficient operation of DG (Zhu and Liu, et al. 2023).

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In the context of source-grid-load coordination, these technologies not only optimize the allocation of resources, but also improve the adaptive ability of the system.

$$F(d_i)=\frac{n!}{r!(n-r)!}\sum t_i \bigcap \xi \cdot \sqrt{2} \rightarrow \square\, y_i \cdot 7 \tag{3}$$

2.2 Selection of Collaborative Planning Methods

Finally, let's look to the future. With the access of new loads such as electric vehicles and smart homes, DG and its distribution network will become more complex and changeable (Guo, 2022). However, as long as we adhere to the scientific source-grid-load collaborative planning, and continue to explore and innovate, we can ensure the sustainability, safety and flexibility of the power system and welcome the arrival of the smart grid era.

$$g(t_i)=\ddot{x}\cdot z_i \prod F(d_i)\frac{dy}{dx}-w_i \tag{4}$$

In summary, the active distribution network source-grid-load collaborative planning of DG initialization and site selection is a multi-dimensional and interdisciplinary work, which requires us to comprehensively consider technical, economic, social and environmental factors (Zhang and Lei, et al. 2022). Through careful planning and implementation, we can ensure the optimal allocation of DG resources and lay a solid foundation for building an efficient, green and reliable future power grid.

$$\lim_{x\to\infty} g(t_i)+\lim_{x\to\infty} F(d_i)\le \bigcap \max(t_{ij}) \tag{5}$$

In today's fast-paced economic environment, the initialization and siting of distributed generation (DG) systems has become a key component of power system planning. With the advancement of technology and the rise of renewable energy, the layout of DG projects is no longer a single-dimensional decision-making process, but a comprehensive task involving multi-factor collaborative analysis.

$$g(t_i)+F(d_i)\leftrightarrow mean(\sum t_{ij}+4) \tag{6}$$

2.3 Analysis of Collaborative Planning Methodological Schemes

First of all, DG initialization refers to the start-up and construction phases of a distributed generation project, which involves an in-depth assessment of the technical, environmental, economic, and social impacts of the project. A successful DG initialization plan not only ensures the smooth implementation of the project, but also lays a solid foundation for stable operation in the future.

$$No(t_i)=\frac{g(t_i)+F(d_i)}{mean(\sum t_{ij}+4)}\frac{-b\pm\sqrt{b^2-4ac}}{2a} \tag{7}$$

Site selection was a crucial step in the DG project. Proper siting not only ensures efficient distribution and use of energy, but also maximizes economic benefits while minimizing social and environmental costs. Therefore, the site selection process must take into account multiple aspects such as geographical location, environmental impact, policies and regulations, market demand, network access, and cost-effectiveness.

$$Zh(t_i)=\bigcap\ [\sum g(t_i)+F(d_i)] \tag{8}$$

In DG initialization and site selection, collaborative analysis methods are particularly important. Synergy means that the various elements of decision-making are not considered in isolation, but are interrelated and interactive. For example, an environmental impact assessment should consider not only the direct impact of the construction and operation phases of the project, but also its potential impact over its entire life cycle.

$$accur(t_i)=\frac{\min[\sum g(t_i)+F(d_i)]}{\sqrt{2}\sum g(t_i)+F(d_i)}\times 100\% \tag{9}$$

Economic assessment is equally complex, including not only initial investment, operating costs, and earnings projections, but also policy incentives, the time value of capital flows, and long-term market dynamics. The social impact assessment takes into account the direct and indirect impacts of the project on the lives of local residents, such as noise, landscape change and employment opportunities.

$$accur(t_i) = \frac{\min[\sum g(t_i) + F(d_i)]}{\frac{1}{2}\sum g(t_i) + F(d_i)} + randon(t_i \quad (10)$$

Another important aspect is technical analysis, which involves the selection, performance, reliability and impact of DG systems on the existing power system. Technological advancements have provided more options for DG projects, such as wind power, solar photovoltaics, small-scale hydropower, and biomass, each with its own unique advantages and limitations.

3 OPTIMIZATION STRATEGIES FOR COLLABORATIVE PLANNING METHODS

Network access was another key factor in the location of the DG. Since distributed generation often needs to be connected to the main grid, the capacity, stability and acceptability of the grid become technical parameters that must be considered. A reasonable network access scheme can ensure the smooth connection of DG to the grid and avoid instability or damage to the power grid.

4 PRACTICAL EXAMPLES OF COLLABORATIVE PLANNING APPROACHES

4.1 Introduction to Collaborative Planning Methods

In conclusion, the synergistic analysis of DG initialization and site selection requires us to adopt a comprehensive and systematic way of thinking, integrate various factors, and find the best solution through accurate calculations and scientific decision-making methods. This requires not only specialized knowledge and skills, but also interdisciplinary cooperation and efficient exchange of information.

As the energy landscape continues to change in the future, DG projects will play an increasingly important role.

Table 1: Collaborative planning approach requirements

Scope of application	Grade	Accuracy	Collaborative planning approach
Source-network-load collaborative planning algorithm	I II	85.00 81.97	78.86 78.45
Source-network-load collaborative planning model	I II	83.81 83.34	81.31 78.19
Source-network-load collaborative planning strategy	I II	79.56 79.10	81.99 80.11

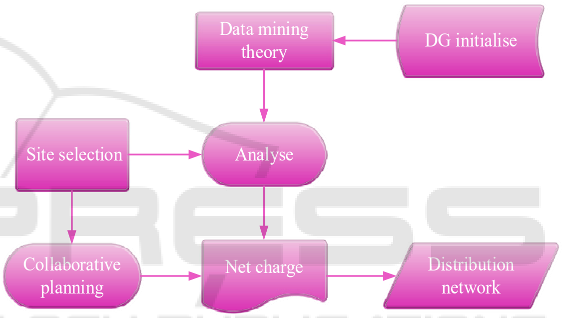

Figure 1: The analysis process of the collaborative planning method

Through effective synergistic analysis, we can ensure that the initialization and site selection of DG projects are more scientific, rational and efficient, so as to promote the use of renewable energy, improve energy security, reduce environmental impact, and make positive contributions to the sustainable development of social economy.

4.2 Collaborative Planning Methods

In today's business environment, Data General (DG) companies face stiff competition and ever-changing market conditions. In this context, there is a subtle but profound relationship between the DG initialization process, i.e., the initial setup, configuration and start-up of a company, and its location strategy.

Table 2: Overall picture of the collaborative planning approach scenario

Category	Random data	Reliability	Analysis rate
Source-network-load collaborative planning algorithm	85.32	85.90	83.95
Source-network-load collaborative planning model	86.36	82.51	84.29
Source-network-load collaborative planning strategy	84.16	84.92	83.68
Mean	86.84	84.85	84.40
X6	83.04	86.03	84.32
		P=1.249	

4.3 Collaborative Planning Methods and Stability

This relationship not only affects the operational efficiency of the enterprise, but also directly relates to many aspects such as enterprise cost management, market expansion and even brand image.

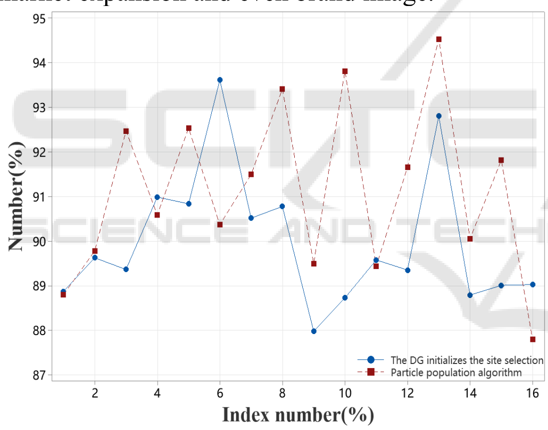

Figure 2: Collaborative programming methods for different algorithms

First of all, the core of DG initialization is to ensure that the company's basic framework can be adapted for future development. This involves enterprise resource planning (ERP), supply chain management, human resource allocation, and technological innovation. In this process, site selection became a decisive factor. A strategic location can provide DG with easy access to logistics, attract highly qualified talent, and access to a wider network of customers and partners. Therefore, the success of DG initialization depends to a large extent on its ability to establish its own base of operations in a favorable geographical location.

Table 3: Comparison of the accuracy of collaborative planning methods of different methods

Algorithm	Survey data	Collaborative planning approach	Magnitude of change	Error
DG initializes site selection	85.33	85.15	82.88	84.95
Particle swarm arithmetic	85.20	83.41	86.01	85.75
P	87.17	87.62	84.48	86.97

Furthermore, DG's location decision is closely linked to its long-term development strategy. A forward-looking site would provide DG with room to expand, both physically and marketably.

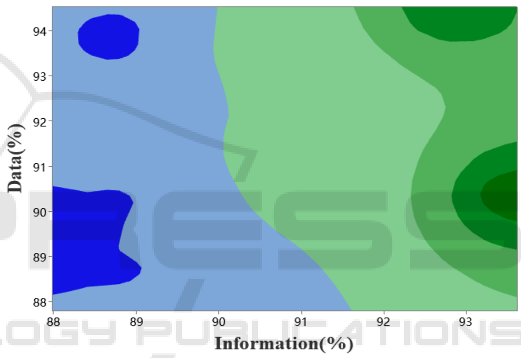

Figure 3: DG Initialization Site Selection Collaborative Planning Method

For example, if DG chooses to set up its headquarters in a science and technology park, it will not only provide sufficient technical support and talent for its R&D activities, but also enhance its competitiveness and influence in the industry. In addition, such a location can also bring preferential policies to DG, such as tax exemptions, financial support, etc., which are advantages that cannot be ignored in the process of DG initialization.

4.4 Rationality of Collaborative Planning Methods

However, site selection is not a simple decision-making process. It requires a comprehensive consideration of various factors, including transportation accessibility, labor costs, local policy environment, market demand analysis, etc. DG's in-depth research and accurate judgment in these aspects will directly affect the efficiency and cost of its initialization.

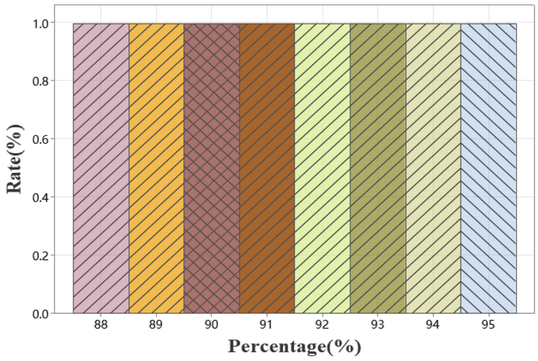

Figure 4: Collaborative programming methods for different algorithms

Finally, DG also needs to consider its brand positioning and market image. A good location can enhance the brand value of DG and attract more customer attention.

4.5 The Effectiveness of Collaborative Planning Approaches

In summary, the relationship between DG initialization and site selection is complex and close. A reasonable location strategy can provide a solid foundation for the initialization of DG and help enterprises occupy an advantageous position in a highly competitive market.

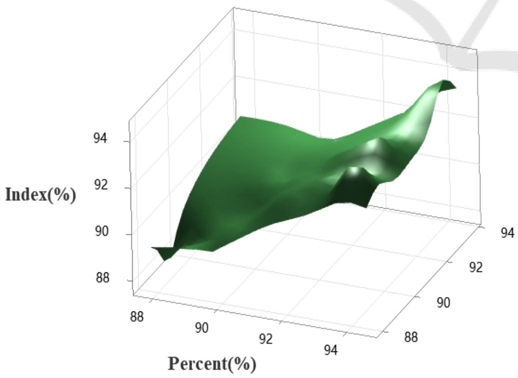

Figure 5: Collaborative programming methods for different algorithms

A missiting can lead to increased transportation costs, brain drain, missed market opportunities, and even legal risks for non-compliance with environmental requirements. Therefore, the DG must treat site selection as a strategic issue during the initialization phase, rather than just as a simple administrative task.

Table 4: Comparison of the effectiveness of collaborative planning methods of different methods

Algorithm	Survey data	Collaborative planning approach	Magnitude of change	Error
DG initializes site selection	82.21	85.92	84.59	82.85
Particle swarm arithmetic	83.73	84.23	84.41	83.55
P	84.20	87.39	84.76	83.90

For example, businesses located in economically prosperous areas are often perceived as more dynamic and innovative, which is extremely beneficial for DG in the market and brand building.

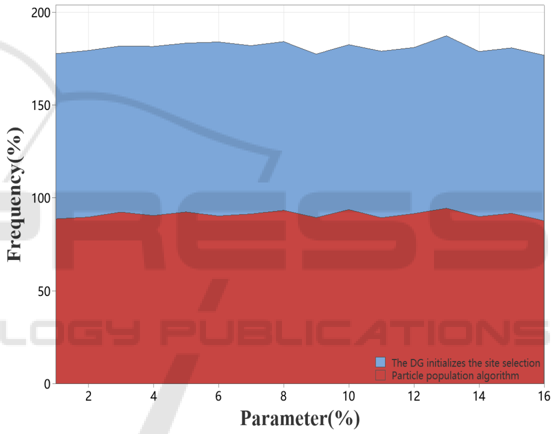

Figure 6: DG initializes the collaborative planning method of site selection

As a result, companies need to invest in data management and cleaning to ensure data reliability. Second, algorithm design and parameterization require specialized knowledge, which requires the finance team to have some data analysis capabilities or work closely with data scientists.

5 CONCLUSIONS

Conversely, a wrong location decision can have a series of negative impacts on DG, and even affect the long-term development of the company. As a result, DG must place a high priority on its site selection strategy during the initialization process, ensuring that every decision step supports its business goals and growth vision. Only in this way will DG be able to establish a strong foothold and succeed in the ever-changing business world.

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