



Analysis of the Expansion of 20 kV Electricity Distribution Channels in Housing

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Abstract: The increasing demand for electricity in residential areas demands the expansion of efficient and reliable distribution channels. This study aims to analyze the technical, economic, social, and environmental aspects of the expansion of 20 kV electricity distribution channels in housing. From a technical point of view, the use of a voltage of 20 kV was chosen to support the efficiency of transmission and long-distance distribution with minimal power loss.

Economically, the project requires a significant initial investment, but can provide long-term benefits in the form of cost efficiencies and reduced power outages. From a social perspective, improving electricity reliability can improve the quality of life of residential communities, although socialization and coordination are needed to minimize disruptions during the construction phase.

Environmental analysis shows the importance of selecting environmentally friendly materials and designing paths that minimize the impact on local ecosystems. The results of the analysis show that the expansion of 20 kV electricity distribution channels in housing is a feasible and sustainable solution, with a significant positive impact on socio-economic development and community comfort.

Keywords: Distribution Line Expansion, Medium Voltage, Residential Power Grid, Voltage Drop, Energy Efficiency, Power Loss, Peak Load, Network Planning.

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I. Introduction

The rapid development of residential areas in line with population growth and changes in energy needs requires adjustments to electricity distribution infrastructure. The demand for electricity in housing is increasing in line with the increasing use of modern electrical devices and the development of people's energy consumption patterns. This creates a challenge for the electricity distribution system which must be able to meet power demand in a stable, reliable, and efficient manner.

One of the efforts to overcome this problem is to expand the electricity distribution channel using a voltage of 20 kV. The use of this voltage aims to improve the efficiency of power distribution and reduce power losses on the grid, so that it can cover a wider area and accommodate the ever-increasing electricity demand. The 20 kV power distribution system has advantages in terms of capacity, stability, and wider range, which makes it an ideal choice for ever-growing housing needs.

However, the expansion of 20 kV electricity distribution channels in housing is inseparable from various aspects that need to be analyzed in depth, both from technical, economic, social, and environmental aspects. This analysis is important to ensure that the expansion of distribution channels can be carried out optimally and

sustainably, by minimizing negative impacts on the environment and surrounding communities. In addition, community participation in the planning and implementation process is also an important factor that affects the success of this project.

This study aims to provide a comprehensive analysis of the expansion of 20 kV electricity distribution channels in housing, focusing on identifying existing challenges and opportunities. Through in-depth analysis, it is hoped that this project can not only meet the energy needs of residential areas, but also provide long-term benefits for the quality of life of the community and encourage local economic growth.

II. Literature Review

The literature review is to provide a theoretical foundation and the results of previous research that are relevant to the results of the analysis and planning for the expansion of medium-voltage electricity distribution channels (20 KV) in residential areas

2.1. The Role of Distribution Channels in the Electric Power System

According to Nasution (2019), electricity distribution channels play an important role in distributing electrical energy from power plants to end consumers, including housing. Efficient and reliable

distribution of electricity is essential to maintain the continuity and quality of electricity supply, especially in residential areas that have diverse energy consumption patterns. In this context, a 20 kV distribution channel is the right choice because it is able to distribute power in a large capacity with high efficiency.

2.2. Voltage 20 kV for Residential Distribution

Based on a study by Wirawan et al. (2021), the use of 20 kV voltage on distribution lines offers several advantages, such as reduced power losses and increased power distribution range. The 20 kV distribution system is ideal for areas with high power requirements because it can reduce the repetitive use of transformers required at lower voltages, thereby increasing efficiency and reducing operational costs.

2.3. Capacity and Reliability of Electricity Distribution Network

According to research conducted by Siregar and Hadi (2020), the expansion of distribution channels must pay attention to network capacity in accordance with the growth of electricity demand in residential areas. The reliability of the power grid is essential to prevent outages and disruptions, especially in residential infrastructure that tends to have high variations in daily loads. Capacity additions through voltage increases of up to 20 kV can also help minimize disruptions due to overloads.

2.4. Economic Analysis on Distribution Network Expansion

Rinaldi (2018) explained that economic analysis is an important part of the expansion of the distribution network. The initial investment cost for network construction, the right selection of materials, and long-term operational costs are the main considerations. Although the initial investment in the 20 kV distribution line project is relatively large, this study shows that the resulting efficiency can provide long-term cost savings, both in terms of operations and maintenance, as well as reduce the economic impact of power outages.

2.4. Social Impact of Electricity Distribution Infrastructure

A study by Santoso (2017) stated that the expansion of the electricity distribution network in residential areas can improve the quality of life of the community by providing more reliable and stable access to electricity. Community participation also needs to be considered in project planning to prevent social rejection and educate the public about the benefits of expanding the distribution network for local communities. Good socialization will help increase support and ensure the success of the project.

2.5. Environmental Aspects in Electricity Distribution Expansion Projects

According to research by Suparman et al. (2019), electricity infrastructure projects such as the expansion of distribution channels need to pay attention to environmental impacts. The selection of environmentally friendly materials, distribution channels that consider local vegetation and ecosystems, and the application of technologies that reduce carbon emissions are important aspects in environmental impact analysis. This is to

ensure that the expansion project is not only economically and technically beneficial, but also has good ecological sustainability.

2.6. Smart Grid Technology in Electricity Distribution

Smart Grid technology plays an important role in improving the efficiency and reliability of electricity distribution channels. According to Putra and Dewi (2020), the implementation of Smart Grid in a 20 kV distribution system allows real-time monitoring and management of the network, which increases reliability and minimizes recovery time in the event of an outage. This is especially relevant for residential areas that require uninterrupted electricity supply.

2.7. The Importance of Regular Maintenance and Monitoring

According to Iskandar (2019), the sustainability of the performance of the 20 kV distribution network depends on regular maintenance and a good monitoring system. Periodic maintenance can detect and prevent damage to the network and extend the life of the equipment. With proper monitoring, operators can respond more quickly to load changes and disturbances, which will ultimately improve the stability of the network in the housing.

Several studies show that the expansion of 20 kV electricity distribution channels in residential areas requires a comprehensive analysis from technical, economic, social, and environmental aspects. The use of 20 kV is proven to improve the efficiency and range of distribution, and offers a sustainable solution to the growing electricity demand. In addition, community involvement, attention to environmental aspects, and the application of Smart Grid technology are important elements in supporting the success and sustainability of this project.

III. Methodology

The methodology in the analysis of the expansion of the 20 kV electricity distribution line in this housing aims to identify technical, economic, social, and environmental needs, as well as determine the necessary steps to ensure the success of the project. This methodology includes the stages of data collection, needs analysis, network design, and impact and sustainability evaluation.

3.1. Literature Studies

The initial stage is to conduct a literature study to gain an in-depth understanding of the basic concept of 20 kV distribution lines and their practical applications in residential distribution networks. Previous research related to efficiency, reliability, cost analysis, and environmental impact was also reviewed to identify relevant factors and technical challenges that may be faced.

3.2. Field Data Collection:

Primary data is collected from residential locations that will experience an expansion of distribution channels. The data collected includes:

- **Electrical Load Requirements:** Determination of load profiles in residential areas based on the number of houses, power needs, and fluctuations in demand.
- **Existing Infrastructure Conditions:** An inventory of existing distribution channels, transformer capacity, and

the physical condition of the network to determine the feasibility and need for upgrades.

- **Social and Environmental Aspects:** Survey of social and environmental impacts around residential areas and the level of community participation and acceptance of the expansion of distribution channels.

3.3. Load and Capacity Requirements Analysis:

Data obtained from the field is used to analyze electrical power needs and determine the required network capacity. This analysis includes the calculation of the maximum load, the planning of the transformer capacity, and the calculation of the voltage drop to ensure the stability of the 20 kV voltage throughout the distribution area.

3.4. 20 kV Distribution Network Design:

Based on the needs analysis, the design of the distribution network is carried out by considering the following factors:

- **Network Trase Selection:** Determine the optimal path to reduce physical resistance and minimize environmental impact.
- **Component Selection:** Determine the type of cables, poles, transformers, circuit breakers, and other equipment that suits the needs of 20 kV distribution.
- **Smart Grid Integration:** Designing a Smart Grid system that enables real-time network monitoring and management to improve distribution reliability.

3.5. Economic Analysis:

After the network design is completed, an economic analysis is carried out to calculate the total project cost, including installation, equipment, operation, and long-term maintenance costs. This analysis aims to measure the financial feasibility of the project and calculate the payback period as well as economic benefits in the long term.

3.6. Social and Environmental Impact Analysis

Based on social and environmental data, an impact analysis was carried out to assess the potential disturbances that may arise in the community and the environment around the housing. These include:

- **Social Impact:** Analyze public perception and acceptance, and develop socialization strategies to increase public participation and understanding of the project.
- **Environmental Impacts:** Analyze impacts on ecosystems, vegetation, and land use, and formulate mitigation measures to minimize environmental disturbances.

3.7. Sustainability and Maintenance Evaluation

This stage involves planning routine maintenance and evaluating the performance of the 20 kV distribution network after project implementation. This evaluation aims to ensure that the distribution system can continue to operate optimally, monitor the condition of components, and make repairs if necessary. The utilization of Smart Grid technology helps monitor the system in

real-time, allowing for quick response to disturbances and maintaining long-term network stability.

3.8. Preparation of Reports and Recommendations

After all stages of analysis are completed, the data and results of the study are compiled in the form of a report that includes conclusions and recommendations related to project implementation. The report will include the results of the technical, economic, social, and environmental analysis as well as recommendations for necessary repairs and maintenance.

Using this methodology allows a comprehensive analysis of technical, economic, social, and environmental aspects in the expansion of 20 kV electricity distribution channels in housing. With this approach, it is hoped that this project can run effectively, minimize negative impacts, and provide long-term benefits for residential communities and electric power system managers.

IV. Discussion

In analyzing the expansion of 20 kV electricity distribution channels in housing, several factors need to be taken into account to ensure the reliability of electricity supply and operational efficiency. This discussion includes load analysis, voltage drop calculation, cable size selection, and power loss analysis. The following is a detailed explanation accompanied by an example of manual calculation.

4.1. Electrical Load Analysis in Housing

In the expansion of the 20 kV distribution, an analysis of the peak load to be served is required. For example, if a residential area has 500 houses with an average consumption of 1.5 kW per house, the total load can be calculated as follows:

$$P_{total} = \text{Number of Houses} \times \text{Power per House}$$

$$P_{total} = 500 \times 1.5 \text{ kW} = 750 \text{ kW}$$

With a power factor ($\cos \phi$) of 0.9, the real power (S) can be calculated:

$$S = \frac{P_{total}}{\cos \phi}$$

$$= \frac{750}{0.9}$$

$$= 833.33 \text{ kVA}$$

So, the distribution network must be able to handle a load of 833.33 kVA.

4.2. Voltage Drop Calculation

In distribution networks, voltage drops must be kept within tolerance limits (generally 5%). Assume the length of the cable from the substation to the farthest point of load is 3 km, and the electric current is calculated from the total power:

$$I = \frac{S}{\sqrt{3} \times V}$$

$$I = \frac{833.33 \times 10^3}{\sqrt{3} \times 20 \times 10^3}$$

$$= 24.04 \text{ A}$$

Suppose the cable used is a cable with a cross section of 95 mm² with resistance (R) and reactance (X) per kilometer of 0.2 Ω/km and 0.1 Ω/km, respectively. The voltage drop (ΔV) is calculated by the formula:

$$\Delta V = I \times (R \times \cos \phi + X \times \sin \phi) \times L$$

$$\Delta V = 24.04 \times (0.2 \times 0.9 + 0.1 \times 0.436) \times 3$$

$$\begin{aligned} \Delta V &= 24.04 \times (0.18 + 0.0436) \times 3 \\ &= 24.04 \times 0.2236 \times 3 \\ &= 16.14 \text{ V} \end{aligned}$$

Voltage drop percentage:

$$\begin{aligned} \text{Voltage Drop Percentage} &= \frac{\Delta V}{V} \times 100 \\ &= \frac{16.14}{20000} \\ &= 0.0807\% \end{aligned}$$

This voltage drop is still within the tolerance limit of 5%, so it is safe to use.

4.3. Cable Size Selection

The selection of cable size is based on the current rating (I) to be channeled and the heat resistance of the cable. Based on previous calculations, the required current is 24.04 A. A 95 mm² cable is capable of carrying a current of up to 250 A, making it safe to use for this capacity.

4.4. Calculation of Power Loss on Cables

Power losses due to cable resistance can be calculated to determine the efficiency of the system. With a cable resistance of R = 0.2 Ω/km, a cable length of 3 km, and a current of 24.04 A, the power loss (P_{loss}) is:

$$P_{\text{loss}} = I^2 \times R \times L$$

$$P_{\text{loss}} = (24.04)^2 \times 0.2 \times 3$$

$$\begin{aligned} P_{\text{loss}} &= 578.57 \times 0.2 \times 3 \\ &= 347.14 \text{ W} \end{aligned}$$

This power loss is relatively small compared to the total power, so the efficiency of the system remains high.

4.5. Economic Evaluation

The total cost of this distribution project includes installation costs, cable and transformer purchase costs, and maintenance costs. If the estimated cost of equipment and cables is Rp 150 million and the labor cost is Rp 50 million, then the total project cost is:

$$\text{Total Project Cost} = 150 \text{ million} + 50 \text{ million} = 200 \text{ million Rupiah}$$

With a stable electricity distribution capacity, it is hoped that this project will provide savings in maintenance costs and improve the reliability of electricity supply in the housing.

From the analysis and calculations above, the expansion of the 20 kV distribution channel in residential areas provides a reliable solution to meet the increasing power needs. With voltage drops that are within tolerance limits and minimal power losses, these distribution systems can be implemented efficiently. Economic

evaluations show that the initial investment required can pay off in the long run through improved reliability and maintenance cost savings.

V. Conclusion

Based on the analysis of the expansion of 20 kV electricity distribution channels in residential areas, it can be concluded that this distribution system is an effective and efficient solution in meeting the increasing electricity demand in residential areas. The use of a voltage of 20 kV allows for more reliable power distribution and is able to cover a large area with minimal power loss. Technical calculations showed that the voltage drop was within the tolerance limits, and the selection of a 95 mm² cable proved to be capable of safely delivering the required power.

In addition, economic analysis shows that while the initial investment is significant, the costs are proportional to the long-term benefits generated, especially in the form of operational savings and improved quality of electricity services. The expansion of this network also has a positive impact on the quality of life of the residential community through a more stable electricity supply, as well as supporting sustainable infrastructure development.

Overall, the 20 kV power distribution line expansion project in residential areas is a feasible strategic step from a technical, economic, and social perspective.

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