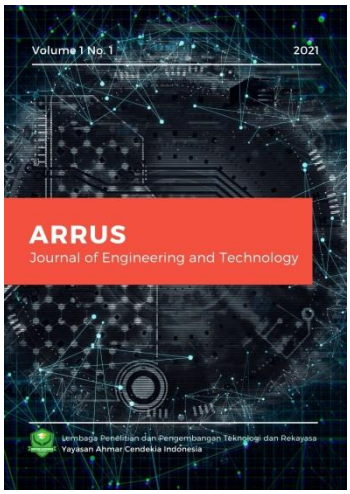
https://doi.org/10.35877/jetech540

OPEN ACCESS

ISSN : 2776-7914 (Print) / 2807-3045 (Online)



*Corresponding author: Rosyid Ridlo Al Hakim, Department of Electrical Engineering, Faculty of Engineering and Computer Science, Jakarta Global University, Depok, Indonesia

E-mail: rosyidridlo@student.jgu.ac.id

REVIEW ARTICLE

Techno-Economic Study of Substation Electric Power in Indonesia: A Mini-Review

Rosyid Ridlo Al Hakim[1,*], Eko Ariyanto[1], Yanuar Zulardiansyah Arief[1,2]

[1]Department of Electrical Engineering, Faculty of Engineering and Computer Science, Jakarta Global University, Depok, Indonesia. Email: rosyidridlo@student.jgu.ac.id

[2]Department of Electrical and Electronics, Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS), Sarawak, Malaysia. Email: ayzulardiansyah@unimas.my

Abstract: Energy is something that people need every day. One of the energies that are glorified to meet people's energy needs is electrical energy. The need for electrical energy in Indonesia continues to increase in line with economic growth and the increasing population. One of the components of electric power that is useful for delivering electric current to transmission networks is a substation. With the feasibility of techno-economic, it is possible to know the feasibility of the quality of an electric power system based on financial analysis. This paper provides a mini-review of the techno-economy of substation electricity and its maintenance in several regions in Indonesia today. The research stages consist of literature study, identification of article titles, article abstract screening, complete article selection, and mini-review reviews. Several studies are still not widely applied to the calculation of the cost of energy consumption to customers. In addition, the basic cost of providing electricity, the profit from electricity sales, and the payback period method need to be improved in research related to the techno-economic analysis of electrical energy. It is important to do this to determine the potential feasibility and the estimated advantages and disadvantages of an electric power system.

Keywords: Energy Economics, Engineering Economics, Load Analysis, Power-Loss.

1. Introduction

Energy is something that people need every day (Al Hakim, Pangestu, et al., 2021). One of the energies that are glorified to meet people's energy needs is electrical energy(Al Hakim, 2020). The need for electrical energy in Indonesia continues to increase in line with economic growth and increasing population(Al Hakim, Ropiudin, et al., 2021; Arief et al., 2019). One of the components of electric power that is useful for delivering electric current to transmission networks is a substation. Substations can deliver electricity to the load from the generating center(Istiyono, 2020).

The quality of electrical energy is very important to study because it is related to the smooth flow of electric power from the power plant to the load. A non-linear load is a load in which the output waveform of current and voltage is not the same as the incoming waveform. Substations play a role in the distribution system of electric power and the quality of distribution of electrical energy. With the feasibility of techno-economics, it is

https://doi.org/10.35877/jetech540

ISSN : 2776-7914 (Print) / 2807-3045 (Online)

possible to know the feasibility of the quality of an electric power system based on financial analysis(Istiyono, 2020). This paper provides a mini-review on the techno-economy of substation electricity and its maintenance in several regions in Indonesia today. The methodology of this paper is based on a mini-reviewed literature study related to the purpose of this paper.

2. Research Method

This research methodology is used in the form of a mini-review research method refers to (Al Hakim, Satria, et al., 2021). The research stages consist of literature study, identification of article titles, article abstract screening, full-text selection, and mini-review.

2.1. Literature Study

The first stage in the mini-review research method is a literature study. Literature studies or literature studies based on research articles are carried out through the Google Scholar portal (www.scholar.google.com) by using search keywords in the keywords "Economic Analysis of Substation Energy, Substation Techno-Economic Analysis, Substation Loss Analysis, Substation Loss and Load Analysis, Substation Economics, Substation Maintenance Economics".

2.2. Identification of Article Titles

The next stage is the identification of the title of the article based on the search results of the literature study. Title identification adjusts the focus of the mini-review. Title identification is closely related to keyword search results for each selected article(Al Hakim, Satria, et al., 2021). Based on the results of the identification of the title of the article, it will be used for the screening stage of the abstract of the article based on the suitability of the title of this mini-review article in the form of techno-economy of substation electricity and its maintenance.

2.3. Article Abstract Screening

The next stage is the article abstract screening stage. This stage is carried out based on the titles of articles that have been selected in the previous stage, then a screening of the abstract reading of the article is carried out to see the suitability of the article with this mini-review study. Abstracts for selected articles will provide a general explanation of the scope of the article. The selected abstracts are adapted to the purpose of writing this mini-review study(Al Hakim, Satria, et al., 2021).

2.4. Full-text Selection

The next stage is followed by reading the full article (full-text) of each article that has been selected in the previous stage and then the last stage is carried out, namely a mini-review review.(Al Hakim, Satria, et al., 2021). In limiting the scope of this mini-review study, the article was chosen because it is following the aspects of energy economic analysis in the case of substations and maintenance.

3. Results and Discussion

The results of the mini-review focus on the analysis of power-loss, techno-economics, and economic losses and advantages of each article discussed. In order to focus the study, each method used is not disputed. Meanwhile, the results and conclusions of the analysis are the key to this mini-review study. The articles obtained based on the mini-review research method obtained a number of scientific articles whose coverage was in several regions in Indonesia. The total articles that have been mini-reviewed will be analyzed based on the results and conclusions (explained in Table 1). The results of a mini-review of eight scientific articles on techno-economic studies of substation electric power and its maintenance can be seen in Table 1.

https://doi.org/10.35877/jetech540

ISSN : 2776-7914 (Print) / 2807-3045 (Online)

Table 1: Mini-review result

Research by	Methodology	Case Study	Result	Analysis and Conclusion
(Istiyono, 2020)	Electric Transient and Analysis Program (ETAP) software simulation	150 kV Substation	Planning costs 245,700,000,000.00* with a payback period of 3 years and 8 months	Substation construction can provide benefits for industry X
(Saputra & Harjanto, 2019)	Reliability index analysis using the SAIDI, SAIFI, CAIDI, and economic aspects of the non-delivery energy (NDE) method	20 kV Substation distribution network	The results of the reliability index to be unreliable, but the economic benefits obtained will reduce losses about 314,450,864*	Need to increase the value of the reliability index to increase the economic benefits of energy
(Rifal et al., 2020)	Electric Transient and Analysis Program (ETAP) software simulation	150 kV Substation	The condition of the power flow with a voltage drop of 4.27% equivalent to 6.41 kV, power loss in a month is 207,525 kWh with a rupiah value of 237,620,276*	Still within the tolerance limits set by SPLN No. 1:1978 (in Indonesian rules) with a voltage tolerance limit of +5% and -10%
(Aribowo & Desmira, 2016)	Descriptive analysis of percentage (power loss value, corona loss value, total power loss, transmission power, transmission efficiency	500 kV Substation	The value of transmission efficiency is 98.41% and 98.32% (power loss 13,290,306,78 Watt or normal), corona loss 2,430,758,95 Watt, power loss 13,290,306,78 Watt	Power losses caused by the corona factor 18.28%, the remaining losses due to other factors (conductors, nature, insulator dirtiness, and so on)
(Suwardana et al., 2017)	Electric Transient and Analysis Program (ETAP) software simulation	Substation type: KA 1495	The percentage of transformer loading is 83.96% and ETAP is 84.77%, the percentage of load imbalance is 55.62% and ETAP is 55.07%, power loss is 56.5138 Watt and ETAP is 56.9325 Watt	To minimize power losses that occur in the system, it is recommended to do load equalization
(Baqaruzi & Muhtar, 2020)	Single line diagram analysis	20 kV Substation	For the large loss of rupiah, the values obtained are 19,860*, 100,863*, and 120,723*	The use of Distributed Generation (DG) in feeders can improve the quality of power from the distribution of electric power
(Hetri Voly, 2020)	Failure Mode Effect Analysis (FMEA) Method	20 kV Substation	The value of rupiah lost due to energy not being channeled to 6 feeders is 924.217,037*. The highest lost value of rupiah was 355,832,713* with an ENS of 242,511.8 kWh/year and the smallest was 85,603,169* with an ENS of 58,341.4	There are components or equipment that are estimated to be outdated, so maintenance needs to be done

https://doi.org/10.35877/jetech540

ISSN : 2776-7914 (Print) / 2807-3045 (Online)

			kWh/year	
(Firdaus et al., 2020)	Energy Economics Analysis	500 kV Substation	Total material costs 191,974,059*; total cost of installation services 14,553,004*; total distribution costs 206,527,063*; energy usage cost/year 4,718,259*/ year; basic cost of electricity supply/year 4,312.110*/ year; electricity sales profit 16,245,960*/ year; cost of production 1,341*; payback period 12 years	The average lifespan of a power grid is between 20 to 25 years, and this is quite advantageous

Note: * indicates cost in IDR (Indonesian Rupiah).

Several cost metrics are used to evaluate the economic viability of a power plant. Levelized cost of electricity (LCOE) is a widely used cost measure for comparative analysis(Arief et al., 2019). In Table 1, the most widely used method is a simulation using the Electric Transient and Analysis Program (ETAP) software. This software is used for network distribution simulation, starting from distribution transformer data, cable length data used, old customer load, construction data (Firdaus et al., 2020).

Based on Table 1, most researchers carry out a techno-economic analysis of substation electricity and its maintenance by analyzing the results of power losses both in rupiah and technical terms. In addition, the greater the capacity of the substation planned or used, the greater the possibility of the value of power loss and loss of rupiah if the planning and maintenance of the substation and its equipment are not carried out properly. The payback period values studied in Table 1 range from 3 to 12 years.

Some of the studies in Table 1 have not been widely applied to the calculation of energy consumption costs for customers. In addition, the basic cost of providing electricity, the profit from electricity sales, and the payback period method need to be improved in research related to the techno-economic analysis of electrical energy. It is important to do this to determine the potential feasibility and the estimated advantages and disadvantages of an electric power system.

4. Conclusion

This mini-review study is still limited to case studies of substations used for techno-economic analysis. The methods used are still varied and not rigid on one method only. Many methods can be applied to the techno-economic study of the energy of an electric power system. Further research is needed related to techno-economic studies of electrical energy in electric power systems, especially substations with a certain capacity.

References

Al Hakim, R. R. (2020). Model Energi Indonesia, Tinjauan Potensi Energi Terbarukan untuk Ketahanan Energi di Indonesia: Sebuah Ulasan. *ANDASIH Jurnal Pengabdian Kepada Masyarakat*, *1*(1), 11–21.

Al Hakim, R. R., Pangestu, A., Jaenul, A., Sinaga, D. W., Saputra, E. Y., & Arief, Y. Z. (2021). Implementasi PLTS Di Desa Pulisan, Sulawesi Utara, Indonesia Sebagai Perwujudan Program Desa Energi. *Prosiding Seminar Nasional Penelitian Dan Pengabdian 2021, "Penelitian Dan Pengabdian Inovatif Pada Masa Pandemi Covid-19,"* 762–767.

ISSN : 2776-7914 (Print) / 2807-3045 (Online)

Al Hakim, R. R., Ropiudin, Muchsin, A., & Lestari, F. S. (2021). Analisis Kenaikan Tagihan Listrik Selama Pendemi Covid-19 Berdasarkan Perilaku Konsumtif Energi Listrik di Indonesia. *JURNAL CAFETARIA*, *2*(1), 25–35. https://doi.org/10.2020/akuntansi.v2i1.279

Al Hakim, R. R., Satria, M. H., Arief, Y. Z., Pangestu, A., Jaenul, A., Hertin, R. D., & Nugraha, D. (2021). Aplikasi Algoritma Dijkstra dalam Penyelesaian Berbagai Masalah. *EXPERT: Jurnal Manajemen Sistem Informasi Dan Teknologi*, *11*(1), 42–47. https://doi.org/10.36448/expert.v11i1.1939

Aribowo, D., & Desmira, D. (2016). Analisis Kerugian Daya pada Saluran Transmisi Tegangan Ekstra Tinggi 500 kV Unit Pelayanan Transmisi Cilegon Baru - Cibinong. *VOLT : Jurnal Ilmiah Pendidikan Teknik Elektro*, *1*(1), 29–36. https://doi.org/10.30870/VOLT.V1I1.816

Arief, Y. Z., Anwari, M., Wicaksono, T., & Djaja, A. F. (2019). Tinjauan Aspek Yuridis dan Tekno-Ekonomi Rencana Pembangunan Pembangkit Listrik Tenaga Nuklir (PLTN) di Indonesia. In Bandung (Ed.), *Seminar Nasional Energi, Telekomunikasi dan Otomasi (SNETO 2019)* (pp. 24–33). Institut Teknologi Nasional Bandung.

Baqaruzi, S., & Muhtar, A. (2020). Analisis Jatuh Tegangan dan Rugi-rugi Akibat Pengaruh Penggunaan Distributed Generation Pada Sistem Distribusi Primer 20 KV. *E-JOINT (Electronica and Electrical Journal Of Innovation Technology)*, *1*(1), 20–26. https://doi.org/10.35970/E-JOINT.V1I1.216

Firdaus, A. D., Paryoto, D., & Junaidi, A. (2020). Analisis Kajian Ekonomi Teknik dalam Sistem Jaringan Tegangan Listrik Di Perumahan G-Land Ciwastra Park. *Thesis*. Institut Teknologi PLN.

Hetri Voly. (2020). Analisis Nilai Keandalan dan Nilai Ekonomi Sistem Jaringan Distribusi 20 Kv Pada PT. PLN (Persero) Rayon Duri Menggunakan Metode FMEA (Failure Mode Effect Analysis). *Thesis*. Universitas Islam Negeri Sultan Syarif Kasim Riau.

Istiyono, Y. P. (2020). Analisa Tekno Ekonomi Pembangunan Gardu Induk 150kV Terotomasi Untuk Industri. *Journal of Electrical Power, Instrumentation and Control) Teknik Elektro-Universitas Pamulang*, *3*(1), 97–106. https://doi.org/10.32493/epic.v3i1.4902

Rifal, R., Utomo, S. B., & Haddin, M. (2020). Analisis Perhitungan Rugi-Rugi Daya pada Saluran Transmisi Tegangan Tinggi 150 kV Gardu Induk Tambak Lorok – Bawen dengan menggunakan Etap 12.6.0. *Prosiding Konferensi Ilmiah Mahasiswa Unissula (KIMU) Klaster Engineering*.

Saputra, D., & Harjanto, A. (2019). Analisis Indeks Keandalan Dan Aspek Ekonomi Sistem Distribusi 20 kV Penyulang J6 PT.PLN (Persero) Up3 Balikpapan. *Academia*, *1*(1), 1–7.

Suwardana, I. W., Sutawinaya, I. P., & Wulandari, I. A. R. (2017). Studi Analisis Rugi-Rugi Daya pada Penghantar Netral Akibat Sistem Tidak Seimbang di Jaringan Distribusi Gardu KA 1495 Penyulang Citraland Menggunakan Simulasi Program ETAP 7.0. *Logic : Jurnal Rancang Bangun Dan Teknologi*, *14*(3), 157. https://doi.org/10.31940/LOGIC.V14I3.340