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Analysis of technical and economics overhead transmission line 150 kV construction from mine mouth coal fired power plant to external customer substation

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Abstract: Mine Mouth Steam Coal Fired Power Plant (PLTU) has a capacity of 2x18 MW while the power supplied to internal consumers is 3.6MW or around 10% of the total generating capacity (20% of one generating unit). To operate according to its specifications, the load is increased by operating the load bank. Excess generating capacity can be sold to external consumers outside the mining area, so it is necessary to build one circuit overhead transmission line 150 kV as long 48.38 Km. The construction of overhead transmission line 150 kV from the PLTU to the external consumer substation can increase sales of electricity and can replace the loadbank function. This study aims to evaluate the technical feasibility and economic aspects of the construction overhead transmission line 150 kV from the PLTU to an external consumer substation. The research method uses financial indicators IRR, NPV and ROI. Overall, the construction of one circuit overhead transmission line 150kV can increase sales of electricity and replace the function of load bank. The NPV value is IDR 1,604,887,094 with an IRR of 12.53%, and ROI of 9.03 years.

Keywords: Mine Mouth Steam Coal Fired Power Plant; Loadbank; Overhead transmission line 150kV; Economic analysis

1. Introduction

The Mine Mouth Coal Fired Power Plant (PLTU) in Central Kalimantan has two generating units with a gross capacity of 2x18MW which only one generating unit operates to meet the demand for electric power in the mining area. Electrical energy is transmitted to internal customers using a 36kV overhead transmission line as long about 120 km. PLTU has a minimum load to operate according to its specifications. Currently, the internal customer load is still below the minimum generation load, so it is necessary to operate the load bank. The provided loadbank has a total capacity of 5.2MW. The minimum generation load is around 40% while the average customer load is about 3.6MW or around 20% of the generator capacity. The small internal load and the operation of the loadbank cause the PLTU's cost of generation (BPP) to be high. Excess generator capacity can be transmitted to external loads by build a one-circuit 150kV overhead transmission line with 150 mm2 ACSR conductor as long 48.38km from the PLTU to the external customer substation. Construction of a 150kV overhead transmission line can increase PLTU electricity sales and replace the use of load banks.

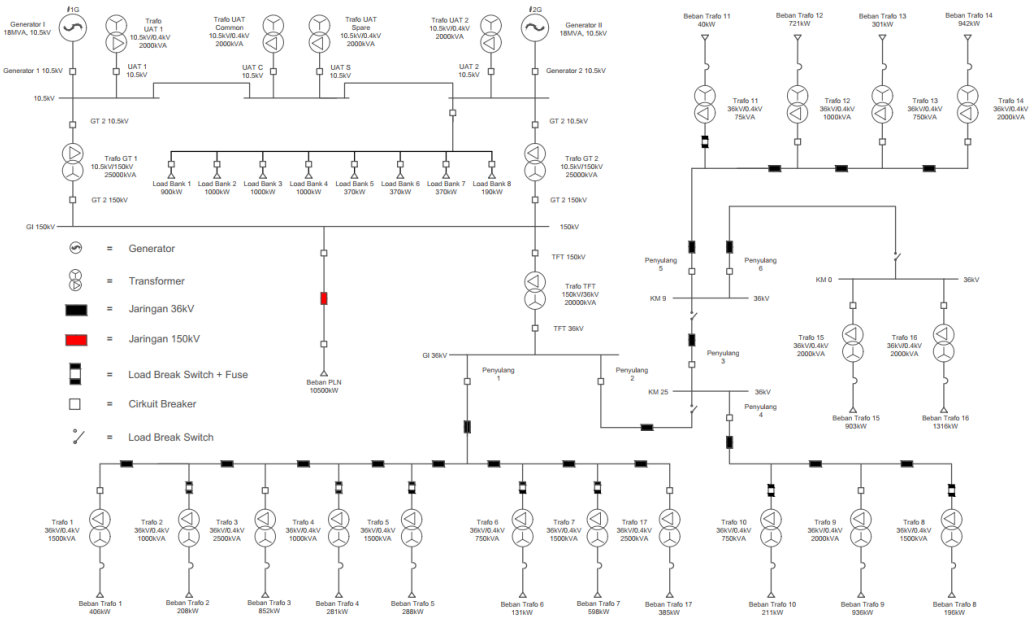

Figure 1. Single line diagram

2. Methods

Steps and flowcharts

This study aims to evaluate the technical and economic aspects of the construction of a 48.38km single-circuit 150kV overhead transmission line from the mine mouth power plant to the external consumer substation. The research was conducted by evaluating the calculation of the investment cost of the power plant, the investment cost of the 150kV transmission, the sale of electricity, the load projection, the projected increase in internal electricity rates and generation costs. This research was conducted through several steps as shown in the flowchart as follows:

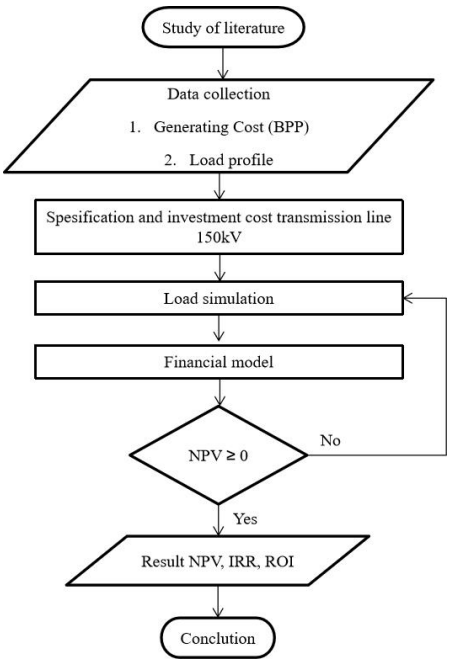

Figure 2. Steps

Power generation economics approach

To calculate electricity rates, a cost-based approach is used, namely pricing starting from identifying costs for production (cost of raw materials, human resources, etc.). The various technical and economic parameters are divided into several components, including:

1. Component A is a capital cost component, such as depreciation costs, loan interest, & margin return on equity (ROE).
2. Component B is the cost of fixed Operation & Maintenance (O&M), administration, & staffing.
3. Component C is the cost of fuel.
4. Component D is variable O&M costs such as lubricating oil, chemicals & water.
5. Component E is the cost of distribution or transmission.

These components are then divided by the production of electrical energy (kWh) in a year to see the amount of production costs per component or in total.

Investment 150kV transmission line

150kV Transmission line investment of 143 towers with 150mm2 ACSR conductors for one circuit as long 45.38km from the PLTU to the external consumer substation was obtained from transmission vendor offers. Investment is divided into 2 parts, namely investment in goods and investment in installation services.

Economic analysis methods

Economic analysis is divided into 3 steps:

a. Data collection, including:
   - Investment cost for power plant
   - Investment cost for 150kV transmission line
   - Generating cost
   - Eksternal sales electricity tariff
   - Internal sales electricity tariff
   - Electricity production data
   - Internal electricity demand projection
   - Internal tariff projection
   - Generating cost projection

b. Data processing to get cash flow. Cash flow is obtained by adding up all the components of income and expenses. The value of each year's cash flow is then converted to a uniform annual cash flow to calculate the time of return on investment (ROI).
c. Economic calculation to get NPV, IRR, and ROI parameters.

NPV is the difference between the present value of cash inflows and the present value of cash outflows in a given period.

$$NPV = \sum_{t=0}^{N} \left(\frac{Rt}{(1+i)^t} \right) \quad (1)$$

N = Total Period t = Time of Period Rt = Cash at Time Period i = Discount Rate

IRR is the discounted value 'i' which makes the NPV of the project equal to zero. IRR is an indicator of the level of efficiency of an investment.

$$NPV = \sum_{t=0}^{N} \left(\frac{Rt}{(1+IRR)^t}\right) = 0 \quad (2)$$

N = Total Period t = Time of Period Rt = Cash at Time Period IRR (i) = Discount Rate
The term ROI is used to define the time period needed so that the investment made at the start of the project can be returned.

$$\text{ROI} = \frac{Initial\ Investment}{Uniform\ Annual\ Cashflow} \quad (3)$$

In the calculation used a discount value of 12.5%. Economic analysis is calculated from investment costs compared to sales of electricity using some data, these data include investment costs for power plant, investment costs for 150kV overhead transmission line, sales of electricity, electricity rates, projected load increases, projected increases in electricity rates and generation costs.

3. Results

The electricity production that is sold to PLTU's internal customers is 3.6MW or around 20% of the generating capacity so that the main cost of generation is relatively high.

Table 1. PLTU internal customer load

Customer		Peak load (kW)	Average load (kW)
GD 01	Customer 1	406	170
GD 02	Customer 2	280	83
GD 03	Customer 3	852	631
GD 04	Customer 4	281	154
GD 05	Customer 5	288	115
GD 06	Customer 6	131	99
GD 07	Customer 7	598	383
GD 08	Customer 8	196	78
GD 09	Customer 9	936	339
GD 10	Customer 10	211	120
GD 11	Customer 11	40	13
GD 12	Customer 12	721	257
GD 13	Customer 13	301	159
GD 14	Customer 14	942	589
GD 15	Customer 15	903	219
GD 16	Customer 16	1,316	190
GD 17	Customer 17	385	49

The main cost of generation with a load of 10% of the total generating capacity (20% of one generating unit) is 25.14c$/kWh with a current power plant investment value of around Rp.831,447,516,799. The construction of a 150kV transmission line from the PLTU to an external consumer substation along 45.38km one circuit using a 150mm2 ACSR conductor requires an investment cost of IDR 73,067,812,793.

Table 2. Construction cost of 150kV transmission line

Cost component	Amount
Investment in goods	53,903,106,093
investment in installation services	11,923,752,279
PPN	11%
Total	73,067,812,793

The 150kV transmission is used to send 7.7 MW of electricity to external customer substations. The selling price to external consumers is 90% of local area electricity generation cost, while the electricity tariff to internal customers is 20 c$/kWh. The assumptions used as the basis for calculating the economic analysis are as follows.

Table 3. Key assumption

Assumption	Value (%/Year)
Internal electricity demand projection	5.0
Internal tariff projection	4.0
fix O&M cost projection	3.0
Variable O&M cost projection	2.0
Coal cost projection	3.0

The following table discusses the assumptions used and cash flow calculations to derive the economic metrics of NPV, IRR and ROI.

Table 4. Financial model of construction overhead transmission line 150kV

Year...			0	1	2	3	....	20
Assumption							....	
Time of Period	20	Years					....	
Discount Rate	12.5	%					....	
Cash Flow Calculation							....	
Power plant investment estimation	831,447,516,799	Rp	831,447,516,799					
Transmission line 150kV investment	73,067,812,793	Rp	73,067,812,793				....	
Electricity sales net income				79,552,294,035	83,431,749,893	87,859,457,431	....	331,944,963,311
Cash Flow			(904,515,329,592)	79,552,294,035	83,431,749,893	87,859,457,431	....	331,944,963,311
Financial indicators								
NPV	1,604,887,094	Rp						
IRR	12.53%							
ROI	9.03	Years						

The assumption of selling electricity to external customers continues to decline throughout the year in line with the projected increase in the PLTU's internal load.

Figure 3. Power sales projection

The current PLTU average load is 3.6 MW or around 20% of the one generating capacity. Loadbank operation is required to achieve a minimum generation load. The relatively small internal load and the use of a loadbank cause high cost of generation. Selling electricity to external consumers can reduce the cost of generating electricity and replace the use of load banks. The external load distance from the PLTU is around 48.38km, so it is necessary to build a 150kV transmission line to connect between the PLTU and external consumer substations. The selling price of electricity to external customers is quite high compared to the selling price of electricity for PLTU in general. However, the high cost of generating electricity in the local area, the selling price of PLTU electricity is still at an economic level.

4. Conclusion

That the construction of a 48.38km transmission line 150kV using a 150mm2 ACSR conductor to transmite excess capacity from the mine mouth steam coal power plant to external consumers is feasible because the additional investment cost for the 150kV transmission line of Rp.73,067,812,793 produces a positive NPV of Rp.1,604,887,094 with an IRR of 12.53% and the entire capital can be returned in 9.03 years.

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