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POTENTIAL UTILIZATION OF MAGNETIC GENERATOR ENERGY (EGM) AS A SUBSTITUTE FOR ALTERNATIVE ENERGY SOURCES IN THE STEEL PRODUCTION PROCESS OF PT. XYZ - INDONESIA

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Abstract. The availability of raw material resources for the steel industry is one of Indonesia's supporting capacities to achieve steel industry independence. Indonesia has the largest iron ore processing company in Southeast Asia, namely PT. XYZ. Production activities of PT. XYZ includes the production of raw materials, the production and sale of semi-finished steel, and the production of steel such as steel billets, HRC and CRC, steel wire rods (WR), reinforcing steel, profile steel, and steel pipes according to the specifications required by consumers. The fulfillment of industrial production capacity cannot be separated from energy needs. Reducing costs in the energy sector without reducing production capacity is one solution in increasing production capacity. This research was conducted to determine the potential use of magnetic generators as a strategy to increase production efficiency of PT. XYZ by using the theory of cost effectiveness. This research was conducted through discussions with various related parties and stakeholders in order to determine the standard requirements for the type of energy supply for industry. Then, a literature study related to the supply of energy types was carried out in accordance with the limitations of the problem, namely the energy potential of a magnetic generator. Based on the results of the research and discussion that have been described, it can be concluded that the analysis of the break-even point of EGM and existing electrical energy shows that EGM with a capacity of 10 kW is able to achieve profits after a minimum steel production capacity of 2,055.94 tons and a return on investment in the third year which means more faster than the theoretical service time capability of 20 years. By considering the results of the break even point (BEP) and cost effectife analysis (CEA) analysis, it is concluded that from the economic aspect, EGM has the potential as an alternative to substitute new energy sources at PT. XYZ.

Keywords: magnetic generator; alternative energy; steel industry; break even point; cost effective analysis.

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INTRODUCTION

The steel industry as a raw material industry is in tier four in the Defense Industry cluster classification (Bacak, 2015). Steel plate is one of the results of processing in the steel industry which comes from iron ore which is processed using a blast furnace with various treatment processes so that it becomes the desired steel plate (Yellishetty, Ranjith, & Tharumarajah, 2010). Indonesia has the largest iron ore processing company in Southeast Asia, namely PT. XYZ which is located in the city of Cilegon, Banten. Production activities of PT. XYZ includes the production of raw materials, the production and sale of semi-finished steel, and the production of steel such as steel billets, HRC and CRC, steel wire rods (WR), reinforcing steel, profile steel, and steel pipes according to the specifications required by consumers.

The availability of abundant raw material resources for the steel industry is one of Indonesia's supporting capacities to achieve steel industry independence (Kaur, Bhardwaj, & Lohchab, 2017). Data from the Ministry of Industry in 2014 shows that Indonesia has abundant reserves of raw materials for the steel industry, namely 4,7 billion tons of resources and 329,5 million tons of reserves. The number of sources of raw material reserves are spread over various islands in Indonesia, namely Sumatra, Java, Kalimantan, Sulawesi, Nusa Tenggara, Maluku and Papua. This is a great opportunity to support the sustainability of the national steel industry so that it can become a national steel provider and become part of the global supply chain in the global market (Müller, Kiel, & Voigt, 2018). The current availability of steel production, in fact, is still not in line with the capacity and consumption of the steel industry per capita. Indonesia's per capita steel consumption level is still the lowest among ASEAN countries. PT. XYZ shows that Indonesia's steel consumption per capita is 51,30 kg/yr for the period 2017, on the other hand, the highest steel consumption per capita in ASEAN is Singapore at 497,68 kg/yr, Malaysia 294,16 kg/yr, Thailand 243,65 kg/yr, Vietnam 230,92 kg/yr, and the Philippines 93,61 kg/yr.

Steel production capacity in Indonesia is always below the level of consumption with an average production capacity of around 50% of the total demand in 2016-2020. The condition of the national iron and steel industry capacity has not been able to meet domestic needs in accordance with the level of national steel consumption and production. The production capacity affects the price level of the steel products produced. This condition is an opportunity for imported steel products to fill the gap. Weak price competitiveness has not only resulted in the division of the domestic market portion but has also resulted in depressed domestic steel demand. This is due to downstream industry players who have a tendency to prefer imported products on the grounds of lower prices. The fulfillment of industrial production capacity cannot be separated from energy needs. The industrial sector is the sector that consumes the largest energy after the transportation sector (Atabani, Badruddin, Mekhilef, & Silitonga, 2011); (Abdelaziz, Saidur, & Mekhilef, 2011). Sectoral energy consumption in units of BOE (Barrel Oil Equivalent) in 2018 was 875 million BOE as shown in Figure 1.

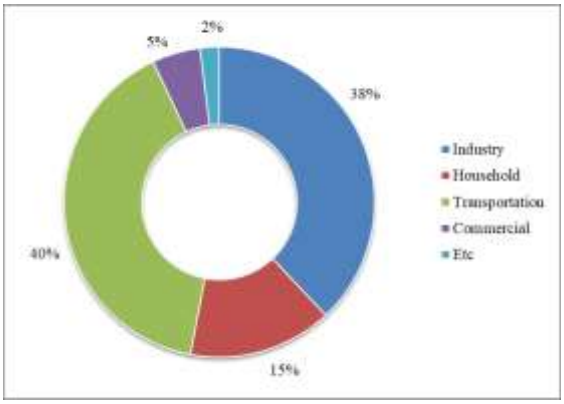

Figure 1. Composition of Sectoral Energy Consumption
Source: BPPT (2020)

Figure 2. Composition and Types of Sectoral Energy Consumption
Source: BPPT (2020)

Reducing costs in the energy sector without reducing production capacity is one solution in increasing production capacity (Matar, Murphy, Pierru, & Rioux, 2015). Energy prices that tend to increase can be caused by a decrease in the availability of non-renewable energy sources which one day sooner or later will be exhausted while energy demand continues to increase in line with economic growth, population, and developments in people's living standards (Hakim, Suryantoro, & Rahardjo, 2021); (Sasana & Aminata, 2019). This phenomenon is very reasonable because the demand for energy needs from year to year is increasing.

The availability of non-renewable energy sources is not only doubtful but also a contributor to greenhouse gas emissions (Pearson, Brown, Murray, & Sidman, 2017); (Zaidi, Hou, & Mirza, 2018). Indonesia is one of the largest emitters of greenhouse gases in the world, so development efforts towards decarbonization (net zero emission) have become a global concern. The political commitment of the Indonesian government to implement the SDGs (Sustainable Development Goals) is carried out by the signing of Presidential Regulation Number 59 of 2017 concerning the Implementation of Achieving Sustainable Development Goals. The Presidential Regulation Number 59 of 2017 is also a commitment so that the implementation and achievement of the SDGs is carried out in a participatory manner by involving many parties. One of the SDGs goals related to energy issues is clean and affordable energy, ensuring accessibility to energy that is reliable, sustainable and modern for all. Derivative regulations that serve as guidelines for the implementation of the focus on renewable energy sources are a follow-up to these activities. Some of these regulations are for example the regulation of the Minister of Energy and Mineral Resources Number 50 of 2017 concerning the Utilization of Renewable Energy Sources for the Provision of Electricity (Böttger, Götz, Theofilidi, & Bruckner, 2015).

The national steel industry is one of the industrial sectors that use the dominant energy of gas and coal which is converted into heat energy for heating blast furnaces in iron ore smelting or electrical energy to drive production machines (He & Wang, 2017). Coal and gas are converted into heat energy for direct or indirect combustion, namely for heating water to produce hot steam that can drive an electric generator. The existence of these energy sources will sooner or later run out and can lead to contradictory supply and demand. The need for costs in meeting the energy needs of the production process is getting higher from year to year, which is one of the things that can reduce the production capacity of the steel industry. These types of energy sources can affect product prices so that they become less competitive and have an impact on weakening industrial competitiveness. Based on this information, it was found the identification of problems in energy fulfillment in the steel industry production process so that alternative fuels are needed with abundant availability and are environmentally friendly. From historical data in 2011 for several industries that were collected by the Ministry of Energy and Mineral Resources, information was obtained that currently the specific energy consumption of the Indonesian steel industry is 900 kWh/ton, while India is 500 kWh/ton and Japan is 350 kWh/ton .

Magnetic generator energy is energy from nature which has unlimited capabilities. The use of magnetic generator energy or EGM (especially in the context of use in Indonesia) is still not optimal due to limited knowledge about it. Magnetic generator energy is a generator of electrical energy by utilizing the attractive and repulsive forces of permanent magnets which rotate the magnetic field-producing rotor against the coil so as to produce an electromotive force (EMF). If the magnet is given an external magnetic field, the electrons in the atom will change their motion in such a way that it produces an atomic magnetic field that is opposite to the external magnetic field (Xu, You, & Ueda, 2013). Such conditions are very likely to be exploited by engineering in such a way as to obtain a perpetual orbital rotational force so that it rotates the generator shaft orbitally to generate electricity. The magnetic field generated by the EMF is also called a back electromotive force (back EMF) and will inhibit the rate of rotation of the induced magnet and as an effort to anticipate it is to use a special bifilar coil.

Technology in the energy sector is an important factor in increasing the production capacity of the steel industry. Alternative power sources can be an attraction in developing a power architecture to generate electricity. The stator and rotor with a V-Gate pattern use magnetic generator energy with an optimal angle of 5 degrees and a base distance of 24 mm producing 7.524 Watts of electricity. Optimization of the DC motor on the number of stator magnets so as to produce a mechanical power of 29.936 Watt. Magnetic generator energy has the advantage that it can be used in the long term, is more practical and efficient compared to other energy sources (Prayogo et al., 2020). The focus of this research is limited to analyzing the energy potential of a magnetic generator if it is applied as an energy supply in the steel production process of PT. XYZ, while the research subfocus is the comparison of the energy cost-effectiveness of electrical energy from a magnetic generator to the cost-effectiveness of electrical energy at PT. XYZ at this time.

METHODS

This research was conducted through discussions with various related parties and stakeholders in order to determine the standard requirements for the type of energy supply for industry. Then, a literature study related to the supply of energy types was carried out in accordance with the limitations of the problem, namely the energy potential of a magnetic generator. The research method used in this study is a qualitative approach with a quasi-qualitative type of research, with data collection techniques used are literature study, observation, FGD and in-depth interviews. The design of this research is to determine the strategy of developing Magnetic generator energy in supporting the production capacity of PT. XYZ. The research design is divided into several stages, as follows:

1. Diagnosis Stage (Initialization and Identification Stage). The formulation of the background, identification of problems and objectives are carried out at this stage. Problem boundaries are determined to provide boundaries and research focus. At this stage, a preliminary field test is carried out to explore the research problems to be carried out.
2. Data Collection and Processing Stage. Data collection related to the problem is carried out at this stage. Data were obtained by conducting observations,

interviews, questionnaires and document studies.

3. Data Analysis Stage. Data analysis was carried out after the data collection stage was completed. The data that has been obtained is then analyzed using the theory used. Interactive steps in the analysis are carried out in the form of data reduction, data presentation, and drawing conclusions or verification.
4. Discussion Stage. At this stage, a discussion regarding the title of the research is carried out based on the results of data analysis that has been obtained. The theory that forms the basis of research and other theories that are in accordance with the research focus are then linked to produce a complex discussion.
5. Final Stage. Researchers draw conclusions from the results of the discussion stages that have been carried out. The conclusion of the development strategy is formulated and then recommendations or suggestions are formulated for further researchers and related research subjects.

The research was conducted in two main locations, namely PT. XYZ and PT. A B C. The research was carried out for four months starting from September 2021 to December 2021. In this study, the main informants and supporters of PT. XYZ (research and technology division), and the main resource person PT. ABC. The main object of this research is the potential utilization of magnetic generator energy as an alternative source of substitution energy in increasing the production capacity of PT. XYZ. In this study, researchers used triangulation to check the validity of the data. After obtaining the research results, then re-validation was carried out to the PT. XYZ to check the relevance to the current real conditions.

RESULTS AND DISCUSSION

National Steel Industry - Indonesia

The steel industry is one part of the base metal industry which is included in the upstream industry and is included in the strategic industry in Indonesia. The steel industry plays an important role in supplying the main raw materials for development in various fields ranging from infrastructure, production of capital goods, transportation equipment to defense applications such as warships, combat vehicles and weapons (Ministry of Industry, 2014). Indonesia has enormous potential to develop the steel industry and because of its very importance, the steel industry becomes very strategic for the strength and prosperity of a country as presented in Figure 3.

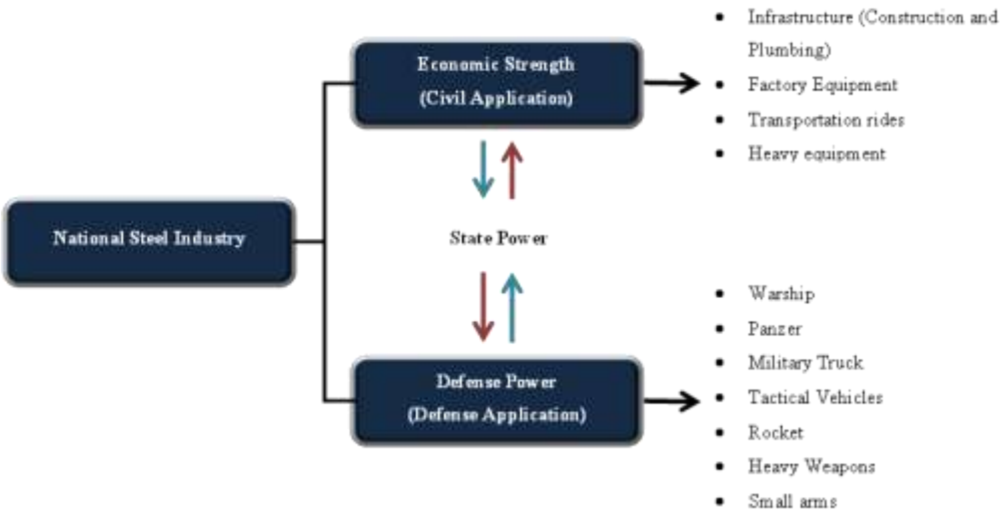

Figure 3. The Role of the National Steel Industry
Source: IISIA (2015)

The scope of the steel industry is very broad, covering a long value chain from upstream to downstream. The upstream supply chain of the steel industry starts from the process of mining products in the form of iron sand into iron ore. Although the process is not considered as part of the steel industry and is a supplier industry in the steel industry supply chain, its existence is very strategic in determining the competitiveness of the steel industry in a country. Furthermore, the iron ore is processed again in a steel smelting furnace to be continued into pellets which are the raw material for making steel. Pellets are processed again in steel kilns to produce intermediate steel products that produce raw materials for downstream industries as end products. Based on the process flow and the relationship between these raw materials and products, the national steel industry is divided into the following classifications (Ministry of Industry, 2014):

a. Upstream Steel Industry. In the upstream steelmaking process, there are two main systems, namely blast furnace technology and Direct Reduction Iron (DRI) technology.
b. Intermediate Steel Industry. Based on the value chain flow, the intermediate steel industry can be grouped into two groups, namely the manufacture of crude steel and the manufacture of semi-finished steel products.
c. Downstream Steel Industry. In the upstream steelmaking process, there are two main systems, namely the manufacture of finished flat product steel and the manufacture of finished long product steel.

Energy Use in the National Steel Industry-Indonesia

Energy is a very basic need in industrial development, therefore the supply of energy to achieve industrial growth targets is very important. From historical data on several industries that were collected by the Ministry of Energy and Mineral Resources, information was obtained that currently the energy intensity of the steel industry in

Indonesia is 900 kWh per tonne (Pengkajian & Teknologi, 2012). This means, to produce 1 (one) ton of steel in Indonesia requires 900 kWh of energy. It is recorded that there are 7 types of industries that consume large amounts of energy, either used as fuel or used as raw materials. The seven industries are the steel industry, the cement industry, the fertilizer industry, the ceramic industry, the pulp and paper industry, the textile industry and the palm oil processing industry (Pengkajian & Teknologi, 2012). When compared to other input factors, energy costs in these seven industries are even higher than labor costs, and are ranked second after raw material costs.

The steel industry is an energy-intensive industry. The iron and steel industry is included in the category of energy user industry above 6.000 TOE (equivalent to tons of oil). The distribution of energy use in the iron and steel industry can be seen in Figure 4. The problems faced by the steel industry today are the weak and unintegrated structure of the steel industry in Indonesia, such as the high import of raw materials so that it cannot meet the needs of the downstream industry and the difficulty of supplying natural gas. accompanied by rising energy prices.

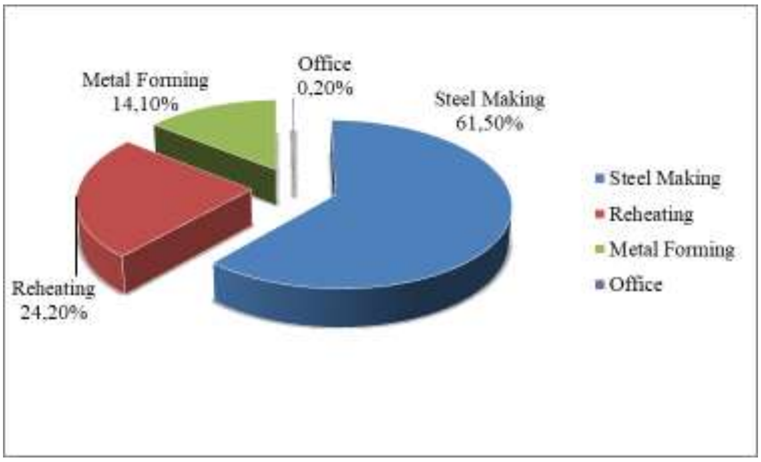

Figure 4. Distribution of Energy Use in the Steel Industry
Source: BPPT (2013)

In the Figure 4 above, it can be seen that the steel industry uses energy for the scrap smelting process, heat treatment and metal forming as well as the finishing process. The largest percentage of energy consumption is for the steel making process of 61,5%, reheating 24,2%, metal forming (rolling) 14,1%, and 0,2% for the office (Pengkajian & Teknologi, 2012).

In this study, researchers observed the potential and strategy of developing magnetic generator energy in terms of efficiency and cost effectiveness when applied to the steel making process carried out at the Hot Strip Mill 2 (HSM 2) unit, arguing that the use of various types of energy is greatest in the production flow of steel products. at PT. XYZ is found in the steel making process. The existence of HSM 2 in all facilities and steel production lines is presented in Table 1. In Table 1 it is shown that the largest energy use is Hot Strip Mill, namely the use of natural gas by 88% and the use of electricity by 58% of the entire steel production process (PT. XYZ , 2018).

Table 1. Energy Sources and Proportion of Energy Consumption in the Steel Production Process of PT. XYZ

No	Source of Energy	Usage Allocation	Percentage (%)
1	Natural gas	Cold rolling mill	10
		Hot strip mill #2	0
		Blast furnace complex	2
		Hot strip mill	88
2	Electricity	Cold rolling mill	23
		Hot strip mill #2	3
		Blast furnace complex	12
		Hot strip mill	58
		Others	4

Source: PT. XYZ (2018)

Potential Development of Magnetic Generator Energy at PT. XYZ

1. Analysis of Break Even Point (BEP)

Based on the results of research on data on electrical energy consumption, electrical energy costs, steel production capacity In HSM 2 (2019-2020), researchers carried out data processing followed by calculations aimed at obtaining the value of each energy being compared, namely the total cost (TC), the break-even point of production capacity (Q.BEP), the break-even point of time capacity (T.BEP) and the effective cost. The calculation of the break-even point analysis on production capacity (Q.BEP) and against time (T.BEP) will produce answers regarding the minimum amount of steel production (tonnes) and in what period of year the company will benefit if it invests in the purchase & operation of magnetic generators. The next calculation is carried out to obtain the effective cost of the two energy sources using CEA. The effective costs of the two energies are compared, if the effective cost of magnetic generator energy (Ce_2) is less than the effective cost of existing electrical energy (Ce_1) or if it is expressed by the equation that fulfills the equation $Ce_2 < Ce_1$ then the magnetic generator is more effective and has the potential to be researched and developed. as a new alternative energy at PT. XYZ.

The component of the use of existing energy costs consists of 2 types of components, namely the fixed cost component (FC_1) and the variable cost component (VC_1). FC_1 in steel production uses electrical energy used by PT. XYZ is currently considered Rp. 0,- because there is no fixed cost or initial investment in obtaining energy. PT. XYZ is only the end user or consumer of electrical energy distributed by the State Electricity Company (PLN). VC_1 in steel production uses electrical energy used by PT. XYZ currently comes from PLN whose value depends on the amount of energy consumption in kWh units. The amount of electrical energy consumption is influenced by its production capacity, so the variable costs are:

Variable Cost (VC_1), 10 kW 1 year = 1 year production capacity (Q) x Specific electrical energy costs
= 513,99 Ton x Rp. 167.550,06/Ton
= Rp. 86.118.336,00

Total Cost (TC_1), 10 kW 1 year = FC_1 (Fix Cost) + VC_1 (Variable Cost)
= Rp. 0,00 + Rp. 86.118.336,00
= Rp. 86.118.336,00

The component of using magnetic generator energy costs consists of 2 types of components, namely a fixed cost component (FC_2) and a variable cost component (VC_2). FC_2 in steel production uses a simulation of electrical energy from a magnetic generator in the form of an initial investment of purchasing 1 unit of GM with an output power capacity of 10 kW. The FC_2 value based on GM reference products manufactured by Infinity Sav is $15.000 USD or Rp. 212.840.250 installed as stated on the official infinitysav.com page. The value of VC_2 is the operational cost and maintenance (O&M) cost consisting of the replacement cost of moving components and their lubrication as well as the cost of labor (labor). O&M costs and labor costs are required to manage, operate, and maintain a GM unit. The amount of O&M costs calculated for GM is approached to the O&M costs of wind turbines. The consideration is that the wind turbine generator is one of the clean electric energy generators without CO_2 emissions and without variable costs in the form of fuel like generators in general. The basic difference between a magnetic generator and a wind turbine generator is only in the rotor drive. Wind turbine generators use wind as the main driver of the rotor while magnetic generators use magnetic force.

GM's assumed O&M costs are $39,7 USD/kW Year (EIA, Capital Cost Estimates for Utility Scale Electricity Generating Plants, 2016). By using the USD exchange rate against the Rupiah in 2021, the amount of the O&M fee is equivalent to Rp. 570.018,56/kW yr, so the O&M cost of a magnetic generator with a power capacity of 10 kW is:

Rp. 570.018,56/kW yr x 10 kW = Rp. 5.700.185,60/yr

Fix Cost (FC_2), 10 kW 1 year = Rp. 215.500.952,00 (initial investment cost)

Variable Cost (VC_2), 10 kW 1 year = Rp. 5.700.185,60

Total Cost (TC_2), 10 kW 1 year = FC_2 (Fix Cost) + VC_2 (Variable Cost)
= Rp. 215.500.952,00 + Rp. 5.700.185,60
= Rp. 221.201.137,60

The calculation of TC_1 and TC_2 is the total cost of a 10 kW magnetic generator for 1 year, then the calculation of cash flow during the product cycle time (20 years) and plotting the results of these calculations are presented in Figure 5 Break-even Point Q.BEP and T.BEP.

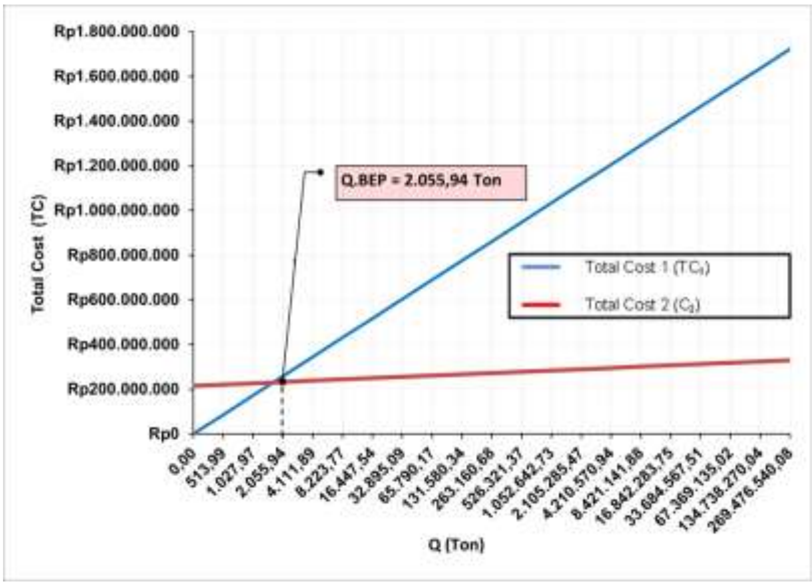

Figure 5. Break-even Point Q.BEP
Source: Analysis of Research Result (2021)

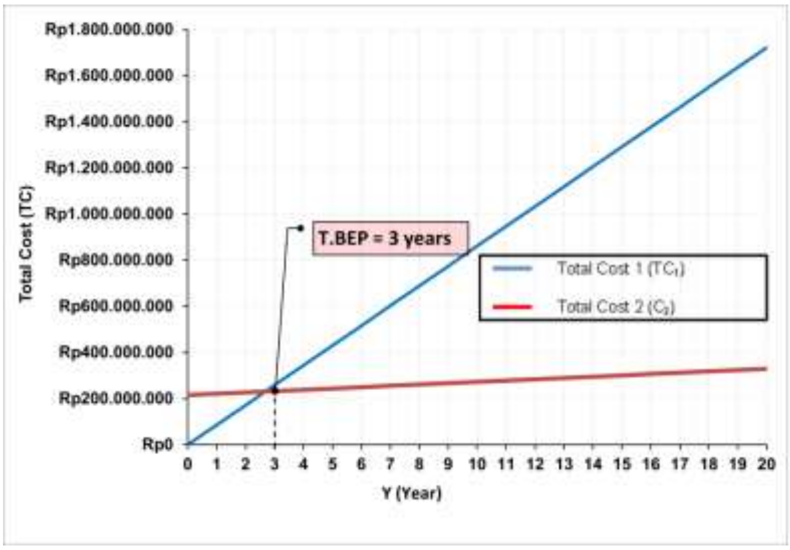

Figure 6. Break-even Point T.BEP
Source: Analysis of Research Result (2021)

From the calculation or break-even analysis, it is known that the investment of a magnetic generator with a capacity of 10 kW which is implemented in the steel industry is able to generate more profits compared to the previous use of electrical energy when the minimum production capacity (Q.BEP) = 2.055,94 tons steel and occurs in the period (T.BEP) = 3rd year.

2. Cost Effective Analysys (CEA)

The cost-effective analysis (CEA) process in the initial process is the same as the break-even point analysis (BEP) process, which starts with calculations to obtain cost components in the form of variable costs and fixed costs. The calculation of BEP analysis is based on cost components without considering the influence of "time value of money", while the CEA is based on cost components in the form of fixed costs and variable costs that consider the value of money against time. The total investment costs that will be incurred until the end of the project period are depreciated or affected by inflation. By using the cost component data that has been calculated in the previous subchapter, it is processed using the following formulation:

$$NPC = I_0 + \sum_{t=0}^{t=n} \frac{(O_t + M_t)}{(1+r)^t}$$

$$C_e = \frac{NPC}{(P/A)_{r,n}}$$

$$P/A_{r,n} = \frac{(1+r)^n - 1}{r(1+r)^n}$$

Description: NPC = Net Present Cost

Io = Investment cost at t = 0

Ot = Operational costs at t = n

Mt = Operational & Maintenance costs (O&M) at t = i

T = Time from t = 0 till t = n

N = End of project cycle

R = Interest rate

Ce = Cost Effective throughout the project cycle

(P/A)r,n = Annualized NPC at certain value of r and n

Based on the results of the calculation of the cost-effective analysis, it is known that the total discounted cost during the cycle time n = 20 years of existing electrical energy (NPC_1) = Rp. 1.170.376.290,53, while the discounted total cost of magnetic generator energy (NPC_2) = Rp. 329.504.664,00, the effective costs of Ce_1 and Ce_2 are as follows:

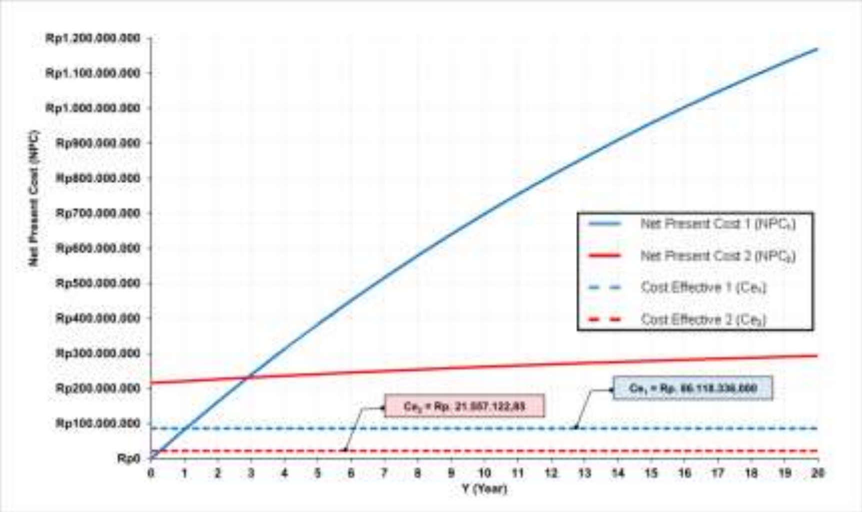

Figure 7. NPC and CE
Source: Analysis of Research Result (2021)

The results of the CEA calculation show that the effective cost of existing energy (Ce_1) is Rp. 86.118.336,00, while the effective cost of GM energy (Ce_2) is Rp. 21.557.122,85, in other words that the effective cost of magnetic generator (Ce_2) < the effective cost of existing electrical energy (Ce_1). The two analyzes (BEP and CEA) are limited by the condition that the economic variables other than the fixed cost and variable cost components are assumed to be the same (ceteris paribus). With the results of the two analyzes, it can be interpreted that EGM is feasible and has the potential to be developed and applied as a new alternative energy to replace the old energy (derived from electricity), because the cost of production factors from energy components can be minimized. The cost of steel production which can be minimized through the development and application of the magnetic generator will have an impact on the competitiveness of PT. XYZ.

CONCLUSIONS

Based on the results of the research and discussion that have been described, it can be concluded that the analysis of the break-even point of EGM and existing electrical energy shows that EGM with a capacity of 10 kW is able to achieve profits after a minimum steel production capacity of 2.055,94 tons and a return on investment in the third year which means more faster than the theoretical service time capability of 20 years. From the comparison of the cost-effective analysis (CEA) between EGM and existing electrical energy, it is known that the effective cost of EGM with a capacity of 10 kW is smaller than the effective cost of existing energy, namely (Ce_2 = Rp. 21.557.122,85) < (Ce_1 = Rp. 86.118.336,00), then the application of EGM in PT. XYZ will be more effective than existing electrical energy. The results of the two analyzes are limited by the condition that the economic variables other than the fixed cost and variable cost components are assumed to be the same (ceteris paribus). With the value of the results of the BEP and CEA analysis, it is concluded that from a review of the economic aspects of EGM, it has the potential as an alternative to substitute new energy sources at PT. XYZ, of course, this requires further studies that are more in-depth and technical in nature.

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