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ANALYSIS OF TECHNOLOGY SELECTION TO REDUCE CO_2 EMISSIONS IN SPONGE IRON PLANT USING ENVIRONMENTAL MANAGEMENT ACCOUNTING (EMA)

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ABSTRACT

The most chemical compund containing in Green house gases is CO_2, which caused green house effect is produced by industrial activities. One of the method to reduce CO_2 is by applying environmentally friendly alternative technologies in the industry. The use of alternative technology has become attention as it relates to the cost of investment and company operational. Environmental Management Accounting (EMA) contains energy flow, physical material and monetary data of a production process. From the information, we can determine production process that produces the highest emissions, then improvement scenarios are made. Through calculation of environmental costs with the EMA, the amount of savings can be obtained from the difference of environmental costs between existing and repair condition. From feasibility study, two of three alternatives are feasible. With an incremental analysis obtained that alternative technologies which investment cost is bigger and feasible to applied is Zero Reforming Process where the NPV is Rp 692.652.410.725, IRR value is 54,23% and payback period 1,23 years. This alternative can save environmental cost 5,9% also reduce CO_2 emmision by 62% from existing condition.

Keywords :
Cleaner production, waste reduction, environmental costs, Environmental Management Accounting (EMA), feasiblity study

1. Introduction

The environmental conditions lately, make the government issued a regulation that requires every company to perform environmental management at each business activity and confirms that there are consequences to be borne by the company or other parties who pollute the environment. Nowadays, issues being discussed is CO_2 emissions that potentially lead the greenhouse effect. One cause of CO_2 emissions comes from the industrial world. Companies must have to do something to reduce industrial wastes in order not to pollute the environment. The process of waste handling system obtain special attention from the company leaders relating to the selection of alternative technologies will be used which is associated with greater cost. Many companies failed to give particular attention to the waste generated, because it is not financially profitable but spend a substantial investment.

But the problems would be different if the application of large investment of environmental friendly technologies is able to generate added value things such as energy saving. This strategy may result in additional revenues or reductions in the amount of raw materials used and expected to increase corporate profits. So, it's important to conduct a feasibility study analysis to the adoption of new technologies in an enterprise, to determine whether the investment issued feasible. Company X is one of steel factories in Indonesia who applies the concept of environmental friendly production processes by using the direct reduction method in producing sponge iron. This process uses natural gas as fuel that contains a lot of H_2 and CO and then through this content, the CO_2 emissions is created.

2. Theoritical Review

2.1 *Environmental Management Accounting* (EMA)

Definition of EMA according to the International Federation of Accountants (Jasch, 2004) is a managerial accounting with a focus on physical information from the flow of energy, water and materials including waste, as well as monetary information related to cost, revenue and savings. Meanwhile, according to (Schaltegger, 2002) EMA is defined as the identification, collection, analysis and use of two types of information to decision-making. Two types of informations are:

- physical information from the use, flow, and processing of energy, water and materials
- Information monetary environment

Based on the information, EMA can be divided into two, called the Monetary Environmental Management Accounting (MEMA), and the Physical Environmental Management Accounting (PEMA) (Schaltengger, 2002). MEMA is in touch with the environmental impacts of corporate activities which are depicted with monetary units and generate information for use internally. PEMA is used as an information tool for internal party decision-making. However, in contrast to understand, information obtained from PEMA is physical, such as quantity, number, weight, etc.. PEMA is designed to collect data in the form of physical environmental impacts. Schaltegger, and Burrit Hahn (2000) categorized the EMA based on the orientation of the past and focuses on short-term and long-time as shown by Table 1 in below

Table 1 *Framework* EMA

Environmental Management Accounting (EMA)				
	Monetary EMA (MEMA)		*Physical EMA (PEMA)*	
	Past Oriented Tools	*Future Oriented Tools*	*Past Oriented Tools*	*Future Oriented Tools*
Short Term Focus	*Annual environmental expenditure or cost, transition fom bookkeeping and cost accounting*	*Monetary environmental budgeting and investment appraisal*	*Material, energy and water flow balances*	*Physical environmental budgeting and investment appraisal*
		Calculating costs, savings and benefit of projects	*Environmental performance evaluation and indicators, benchmarking*	*Setting quantified performance targets*
Long Term Focus	*External disclosure of environmental expenditures, investments and liabilities*		*External environmental reporting and other reporting to agencies and authorities*	*Design and implementation of environmental management systems, cleaner production, pollution prevention, design for environment*

Source : Schaltengger (2002)

This study is belong to the category of past-oriented tools of MEMA and oriented in the short term focus, where the environmental cost calculations will be performed on the existing condition. The purpose of this study is long term focus-oriented future of PEMA and long term focus and past-oriented tools of MEMA. Therefore, there will be some choices of alternative technologies and details of the environmental costs fom each alternative. Basically, there are several ways to reduce CO_2 emissions. One of them is by improving the thermal efficiency of combustion engine. Improved the thermal efficiency is by providing treatment to the combustion engine in the direct reduction process. It happens in the Reformer machine. There are three alternative technologies that are expected to reduce the amount of CO_2 emissions, they are:

1. implementation of Zero Reforming Process (ZR),

2. Reformer Improvement and
3. building the new Reformer.

Implementation of this technology, will improve thermal efficiency so they can lower the amount of CO_2 emissions. After determination of alternative technologies, calculate the environmental costs of alternative technologies in order to obtain the savings that will be input in the feasibility studies. Result of the feasibility study will determine the type of technology will be applied.

2.2 Environmental Costs

Environmental costs are monetary or non monetary impacts that occur as a result of the company's activities that affect environmental quality (Schaltengger, 2002). United States Environmental Protection Agency - U.S. EPA (1997) classifies environmental costs into five categories:

- Conventional Cost is the cost of raw materials, utilities, capital goods, and supply issues
- Potentially hidden costs is the cost of qualified suppliers, evaluate alternatives, the machine that causes pollution, etc
- Contingent cost, for example, the cost of repairs and replacement for accidental release of contaminants into the environment, replacement and penalties
- Image and Relationship Cost represents is the cost associated with the environment to affect the subjective perception of management, customers, communities, and government.
- Societal cost is the cost impact on the environment and the business community. This fee is also called external costs or externalities.

2.3 Cost Accounting

- Feasibility Study

1. Net Present Value (NPV)

   This method calculates the difference between the current investment value / present value of current revenue / now in the future. A project is said to be economically feasible if the value of NPV is positive (greater than zero). NPV formula is as follows

$$NPV = -A_0 + \sum_1^n \frac{A_t}{(1+r)^t} \qquad (1)$$

Where :

A_0 = Investment cost in year 0

A_t = Net cashflow in year t

r = Benefit rate requisited

n = Planning horizon

2. Internal Rate of Return (IRR)

   The calculation of the interest rate that equates the value of current investments with net present value of cash receipts in the future. An investment plan is feasible if the IRR is greater than the bank rate prevailing (Minimum attractive Rate of Return / MARR). If the opposite happens, then the investment plan is deemed not worth. Using the formula PW (Present Worth), the IRR is i '% in this value:

$$\sum_{i=0}^n Rt \left(\frac{P}{F}, i'\%, t\right) = \sum_{i=0}^n Et \left(\frac{P}{F}, i'\%, t\right) \qquad (2)$$

Where :

Rt = Net saving in year t

Et = Net expenses including the invesment cost in year t

n = Planning Horizon

3. Payback Period

Payback period is the period of time that indicates the occurrence of a cumulative revenue equal to the amount of investment in the present value. The smaller repayment period, the faster process of return of an investment. The formula of payback period is as follows:

$$Payback\ Period = \frac{cost}{annual\ profit} \quad (3)$$

3 Data Gathering and Calculations

Figure 1 below is the material flow diagram of direct reduction process of sponge iron :

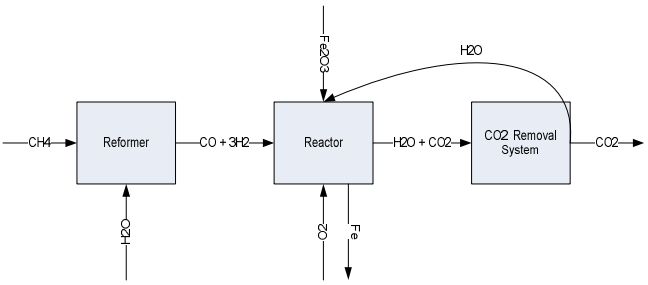

Figure 1 Material Flow Diagram

The process begins at the Reformer machine where the reforming process occurs between natural gas (CH_4) and steam (H_2O), which will produce gas process (CO and H_2). In the Reactor, the process gas will react with iron ore (Fe_2O_3) through high temperature. The high temperature combustion process produced by the Oxygen (O_2) that creates pure iron (Fe). The process that occurs at the Reactor flown toward CO_2 Absorption System unit. In this

unit, H_2O is by product of output will be piped to the Reactor for reuse in the reduction process of iron ore. Meanwhile, the result CO_2 discharged into the air as a non-product output.

Calculation of Environmental Cost. Environmental costs in this study is the cost of raw materials, energy usage, labor costs and production equipment that cause pollution, maintenance costs and costs of CO_2 pollution.

3.1 Existing Condition

Table 2 below are the details of the use of resources to produce each ton of sponge iron, on the existing condition:

Tabel 2. Quantities of The Resources

Clasifications	Quantity/ton sponge iron
CH4 (Nm^3)	411,38
O2 (Nm^3)	10,25
N2 (Nm^3)	25,95
Electricity (Kwh)	81,78
Water (m^3)	2,84

The number of direct labour on the existing condition are 120 people as supervisors, 123 people as a foreman and 95 workers of outsourcing. Meanwhile, the maintenance workers are 84 people as supervisors, 118 people as operators, and 97 people as outsourcing labours. The amount of CO_2 emissions produced by the company every hour is 47 tons / hour. Because Indonesia does not have regulations relating to the cost of CO_2 pollution that must be borne by the company, so in this study the cost of CO_2 pollution will use the tax for corporate emitters

of CO_2 in Norwegian state. Table 3 below is a summary of the environmental costs that are required on the existing condition:

Table 3. Existing Environmental Costs

Classifications	Total Cost (Rp)
Raw Material	5.069.060.369.465
Energy	65.655.077.005
Production Labour	11.185.200.000
Maintenance	15.010.981.994
CO_2 Pollution	205.476.480.000
Total	5.366.388.108.464

3.2 First Alternative Technology's Environmental Cost (ZR)

In the first alternative technology, some changes happen in the quantity of resources. This change is related to the increase of thermal efficiency in the production process. Table 4 below are the details of the resources use to produce each ton sponge iron :

Tabel 4 Quantities of The Resources

Classifications	Quantity/Ton Sponge Iron
CH4 (Nm^3)	311
O2 (Nm^3)	75
N2 (Nm^3)	19
Electricity (Kwh)	77,8
Water (m^3)	3,1

The first alternative technology is capable to reduce the number of direct labor, as many as 8 people as supervisors and 16 people as operators. Meanwhile, the maintenance workers, as many as 51 people as supervisors, 71 people as operators, and 59 people outsourcing labours. The amount of CO_2 emissions can be saved amounted to 29.15 tons /

hour. Thus, CO_2 produced in the first alternative condition decreased by 17.85 tons / hour. Table 5 below is a summary of the environmental costs that are required on an alternative technology:

Tabel 5. Environmental Costs of The First Alternative Technology

Classifications	Total (Rp)
Raw Materials	4.887.996.891.332
Energy	63.650.549.442
Production Labour	10.369.200.000
Maintenance	10.160.794.167
CO_2 Pollution	205.476.480.000
Total Cost	5.366.388.108.464

3.3 Second Alternative Technology's Environmental Cost (*Reformer Improvement*)

In the second alternative there is also some changes in quantity of resources used. However, the magnitude of change in the quantity of resource use is not very significant because the production system applied not much different from the existing condition. The second alternative technologies is expected to be able to save CO_2 emissions by 8.7 tons / hour. Table 6 below is a summary of the environmental costs of alternative 1:

Tabel 6. Environmental Cost of Second Alternative Technology

Classifications	Total (Rp)
Raw Materials	5.054.673.291.788
Energy	65.655.077.005
Production Labour	11.185.200.000
Maintenance	15.010.981.994
CO_2 Pollution	167.441.472.000
Total Cost	5.305.468.430.723

3.4 Third Alternative Tecnology's Environmental Cost (Building a New Reformer)

The cost amount of the third alternative technology's environmental costs are same with the second alternative technology. It is caused by the similarity of production processes that do not result in changes in the quantity of resources usage. Table 7 below is the summary of the environmental costs of three alternative technologies:

Tabel 7 Environmental Cost of Third Alternative Technology

Classifications	Total (Rp)
Raw Materials	5.054.673.291.788
Energy	65.655.077.005
Production Labours	11.185.200.000
Maintenance	15.010.981.994
CO_2 Pollution	167.441.472.000
Total Cost	5.305.468.430.723

After the calculation of total environmental cost of each alternative technology is done, there will some savings which is got from the differences of existing condition and alternative conditions. Table 8 below is the savings of each alternative :

Tabel 8. Environmental Cost Saving from Each Alternative

Alternative	Savings (Rp)
1st	253.627.463.319
2nd	52.422.085.677
3rd	52.422.085.677

3.5Feasibility Study

The methods used to determine the investment feasibility of alternative technologies in this study are:

1. Net Present Value (NPV)

2. Internal Rate of Return (IRR)

3. Payback Period

Table 9 below are the results of NPV, IRR, and the payback period of each alternative technology obtained from the calculation of investment feasibility studies:

Tabel 9. Result of Feasibility Study

Alternative	NPV (Rp)	IRR (%)	Period (Years)
1	692.652.410.725	54,23	1,23
2	79.409.165.681	25,86	3,1
3	-206.642.332.675	-3,29	12,25

Through the feasibility study, two of the three alternative technologies are feasible. They are the first and second alternative. Incremental analysis will be used to determine the best alternative. Through calculations, the 1st alternative (ZR) is the best alternative that is feasible to apply.

4.Discussion and Analysis

4.1 First Alternative Technology's Environmental Costs

The biggest savings of the alternative one is CO_2 pollution cost, with savings 62.02%. Then, the second largest saving is maintenance cost. The third biggest saving is the raw materials cost. The fourth is the cost savings of direct labor in the production process. The last saving is energy use. The total savings of ZR process is 5.9% from the existing condition with total savings of Rp 253.627.463 319.

4.2 Second Alternative Technology's Environmental Cost

The highest saving is CO_2 pollution cost that is equal to 22.65%. Saving also occur in raw material cost, that is equal to 2.07%. The increase in thermal efficiency will reduce consumption of natural gas usage. While on the other auxiliary raw materials did not change the quantity, because the amount needed on the condition of Reformer Improvement from the existing condition is same.

From all of the savings obtained, the total savings of the second alternative, Reformer Improvement, amounted to 0.9%, with total savings of Rp 52.422.085.677.

4.3 Third Alternative Technology's Environmental Costs

Third alternative is building a new Reformer. But, since the production system is same with the second alternative, so the environmental cost is same with the second alternative. So it can be concluded that the environmental costs of 3rd alternative is same with 2nd alternative, Rp 52,422,085,677, or 0.9% of the existing condition.

4.4 Feasibility Study of The First Alternative Technology

After the calculation of feasibility study, the value of the Net Present Value (NPV) is Rp 692.652.410.725 and the value of Internal Rate of Return (IRR) is approximately 54.23%, which means the required rate of return acceptable to the project. Because the IRR is greater than the Minimum Attractive Rate of Return (MARR) of 10.35%, it can be concluded that the investment is worth, with payback period for 1.23 years or about 14 months.

4.5 Feasibility Study of The Second Alternative Technology

Through the financial analysis, NPV is Rp 79,409,165,681 and the IRR value is 25.86% which represents the required rate of return acceptable to the project. Because the IRR is greater than the MARR for 10.35%, it can be concluded that the investment is also feasible to do with the payback period fo 3.1 years.

4.6 Feasibility Study of The Third Alternative Technology

Through the financial analysis, the NPV is Rp (-206.642.332.675) and the IRR value is (-3,29%) which represents the required rate of return acceptable to the project. Because the IRR is less than the MARR for 10.35%, it can be concluded that the investment is not feasible to do.

4.7 Incremental Rate of Return Analysis

Through the calculation, obtained information that two of the three technologies are feasible. They are ZR and Reformer Improvement. The amount of investment cost by ZR is greater than Reformer Improvement. However, big savings derived by ZR is also greater than Reformer Improvement. So, it is necessary to do analysis of alternative selection to determine whether a large investment costs incurred are comparable with big savings will be obtained. Based on calculations, the IRR value generated amounted to 82.65%. Because the IRR is greater than the MARR, so the best alternative for the selected technology is an alternative with the highest investment costs. It is the 1st alternative (ZR).

4. Conclusion

So, the conclusion from this study are as follows:

1. The 1st alternative, Zero Reforming Process is choosen because of the saving obtained is comparable with the investment issued, in accordance from the results of feasibility studies. The NPV value obtained is Rp 692.652.410.725, the IRR is 54.23%, and payback period is 1.23 years.
2. The amount of environmental cost savings if the first technology applied is 5.9% from the existing condition, approximately Rp 253.627.463.319.
3. The amount of CO_2 emissions that can be saved is 29.15 tons / hour with CO_2 emissions of pollution cost savings amount to 62% of the existing condition.

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