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Environmental Issues in Producing Methanol as an Alternative Clean Energy for the Future

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Abstract:PT Kaltim Methanol Industri process natural gas into methanol through a series of the process. At each stage, a number of materials and energy in and out system. In addition to raw materials such as natural gas, steam and oxygen, the process of making Methanol require auxiliary materials such as catalysts. Although not participate in reaction, this catalyst requires periodic replacement in accordance with a shelf life. Stakeholders of PT Kaltim Methanol Industri, i.e. the community surrounding the company, local government and buyers / consumers of methanol began to aggressively pay attention to aspects of environmental management in PT KMI. Three-dimensional environmental management in PT Kaltim Methanol Industri, namely the conservation of natural resources, hazardous materials and waste management and Empowerment of local community, through a formal approach / institutional, technological and socio-economic. To assure the performance of its environmental management, PT KMI since 2005 has been implementing an environmental management system ISO14000: 2004. Audit and verification of the environmental performance of PT KMI quite satisfactory, such as the local government through PROPERDA as well as the Central Government through the National PROPER. The challenge ahead in environmental management in PT KMI will be more complex, given the aging of the plant equipment, availability of raw materials, changes in regulations and the requirements of stake holders increasingly stringent. PT Kaltim Methanol Industri is committed to actively improve the quality of the environment through the efforts of sustainable environmental management.

Keywords:commitment, dimensions, audit, challenges, sustainable

1. Introduction

Natural gas reserves (proven) in Indonesia based on the status of 2008 is about 170 TSCF with an annual production of about 2.87 TSCF (Ministry of Energy and Mineral Resources, accessed from http://www.esdm.go.id, dated October 29, 2015). Expected to be exhausted within 50 years, if not discovered new gas reserves. Limited availability of natural gas is one of the limiting factors for the industry. The concept of sustainable production that incorporate environmental aspects in every stage of the production process need attention and development.

To implement the concept of sustainable production it is necessary to have a good environmental management system supported by the standard that governs the system. PT KMI in this case is applying the ISO 14001:2004 as a tool to ensure their performance of the environmental management. Surrounding communities, local government as well as other stakeholders is fully concerned with environmental issues prevailing in PT KMI.

In line with the corporate culture of PT Kaltim Methanol Industri that is to contribute to sustainable energy and a better life, the management of PT KMI has established Company policies related to environmental management, as follows:

- To develop the company plan on continuous improvement efforts with orientation to the management system and the performance which always sustain and improve the safety quality, occupational health and environment and product quality.
- To conduct the development of all employee for the ability and competency in executing the job through a directed and continuous program in order to eliminate the possibility of incident, accident, occupational related disease, environment pollution and deviation of product quality.

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- To make every effort for the continuous prevention of environment pollution.
- To strive for optimizing the natural resources utilization in the company activities.
- To conduct the comprehension of the partners related to the safety, health and environment
- To establish the harmony working relationship among employees, labor associates, partners, government institution and community surrounding the company area.
- To implement corporate social responsibility in accordance with the company ability.

PT KMI shall consider efficiency in energy utilization, in addition to optimizing production capacity.

The efficiency of the production process can be expressed as the ratio of energy per unit mass of methanol produced, the number of days on-stream and others. While the environmental aspects can be expressed within the parameters of the frequency of spills of chemicals into the environment, the level of emissions from the combustion chamber, the volume of use of toxic and hazardous materials, etc.

Environmental management in PT KMI strived for compliance with applicable laws and regulations. Assessments and performance evaluation conducted by outside parties for environmental management in PT KMI provide good results. PT KMI in two consecutive years 2012 and 2013 achieved gold flag for PROPER from East Kalimantan Province and green flag for 2014. While at the national level, PT KMI obtains PROPER Blue. Efforts to improve our performance in environmental management continue. Obstacles to the fulfillment of regulation is sought a way out through intensive communication and closer coordination with local authority and institution as well as similar industry.

1.1. Methanol Production

Methanol with the chemical formula CH_3OH is a liquid substance at room temperature and atmospheric pressure. There are many routes for producing Methanol, one of which is from natural gas. The process of making methanol from natural gas in PT Kaltim Methanol Industri (KMI) using combined reforming and Low Pressure Methanol Synthesis of Lurgi. There are three stages of making methanol, namely reforming, Synthesis and Purification by Distillation. Schematic of the production process can be described in the following block diagram:

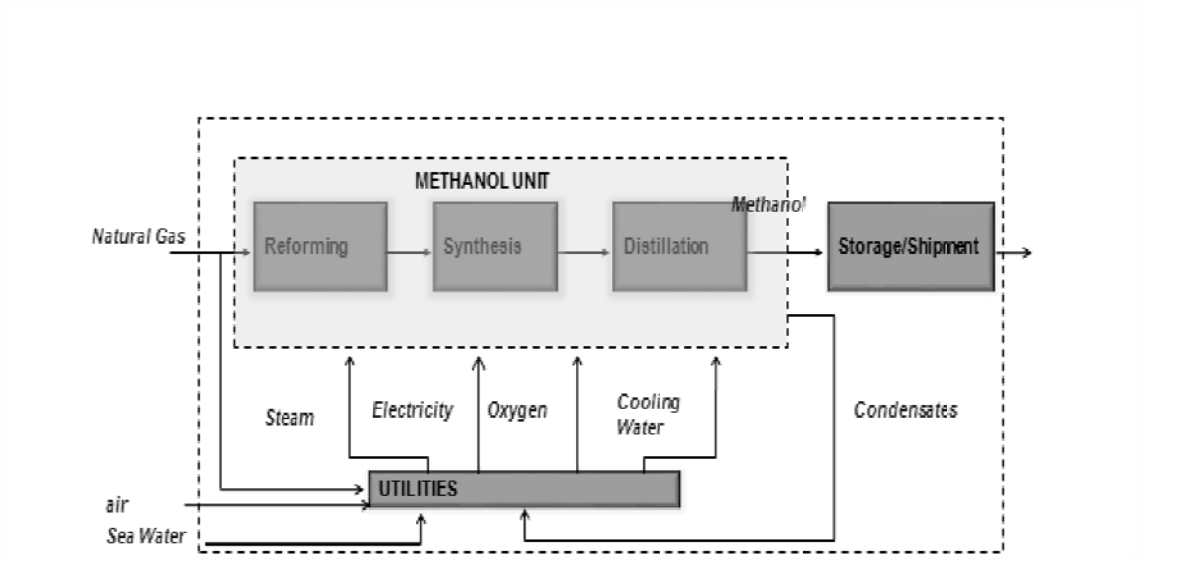

Figure 1. Simplified Flow Diagram for Methanol Production

Main raw material for producing methanol is natural gas, in which 83-86% of its component is methane. Reforming unit consists of a unit of natural gas purification, steam reforming and Autothermal reactor. The catalytic reaction takes place in the steam reformer and the necessary heat is obtained from natural gas combustion in the furnace. The heat that is not consumed by the reforming reaction was taken back by a series of heat exchangers, before eventually released into the atmosphere through the stack.

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Gaseous Oxygen with ultra-high purity (>99.5%) is needed for combustion and partial oxidation of hydrocarbons in Autothermal reactor. Heat generated is recovered by a series of waste heat recovery system. The reactions that occur in a reforming unit are as follows:

Desulphurization

$RSH + H_2 \longleftrightarrow RH + H_2S$ (over CoMo Catalyst)

$H_2S + ZnO \longleftrightarrow ZnS + H_2O$ (over ZnO adsorbent)

$H_2S + CuO \longleftrightarrow CuS + H_2O$ (over CuO adsorbent)

Pre-reformer (Nickel based catalyst)

$CnHm + nH2O \longleftrightarrow nCO + (n+m/2)H_2O$

$CO + H_2O \longleftrightarrow CO_2 + H_2$

$CO + 3H_2 \longleftrightarrow CH_4 + H_2O$

Steam reformer (Nickel based catalyst)

$CH_4 + H_2O \longleftrightarrow CO + 3H_2$

$CO + H_2O \longleftrightarrow CO_2 + H_2$

Autothermal reactor (Nickel based catalyst)

$CH_4 + H_2O \longleftrightarrow CO + 3H_2$

$CO + H_2O \longleftrightarrow CO_2 + H_2$

$CH_4 + O_2 \longleftrightarrow CO + H_2 + H_2O$

$CH_4 + O_2 \longleftrightarrow CO_2 + H_2O$

Reformed gas output of the Autothermal reactor, after passing a series of waste heat recovery system, further compressed to a pressure of about 78-80 bar before entering the synthesis reactor. Synthesis reactor is an isothermal tubular reactor with a feed gas reacts in the tube containing copper-based catalyst. Because the reaction is exothermic, the heat produced must be immediately taken by the Boiler Feed Water flowing counter-current to the shell side of the reactor, to generate steam pressure of 40 bar.

A small fraction of unreacted gases is purged from synthesis loop in order to limit the accumulation of inert gases. Most of the purge gas is returned to the process in reforming unit and only small amount is employed as reformer fuel. The main reaction is as follows:

$CO + 2H_2 \longleftrightarrow CH_3OH$

$CO_2 + 3H_2 \longleftrightarrow CH_3OH + H_2O$

Raw methanol produced from synthesis unit is routed to methanol distillation unit to separate from impurities. Dissolved gasses (e.g. CO, CO_2, CH_4, H_2, N_2) are driven out of the raw methanol by simply flashing it at low pressure into the expansion vessel. The remaining dissolved gas and the light ends are carried out in the first column of distillation unit. Finally, the methanol is separated from the heavy ends in the pure methanol columns. Control of Try-Methylene Amine in methanol is performed in a distillation unit by adding caustic soda to the first column.

Energy for methanol production derived mainly from the burning of natural gas. Most of this energy is used for the reforming reaction. Some are used to generate steam. Steam turbines used to drive the turbines, including turbine electric generator. The power plant also makes use of diesel generators, especially during plant start-up and turn around. Plant energy consumption is directly influenced by the availability of the plant, which is measured in days on-stream. The higher on-stream factor means the lower un-scheduled shutdown. Wasted gas is also lower.

The Company's policies give us a guidance for managing environmental issue. Frame work is set up by adopting environmental management system ISO 14001: 2004. The performance of environmental management system is verified by both internal and external parties for continuous improvement. Internal audit for Environmental Management System is regularly carried out every six months. External verification is carried out by local/provincial government through PROPERDA and national level through PROPER. Voluntarily, PT Kaltim Methanol Industri becomes an active member of the Responsible Care Indonesia.

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Environmental management is not only limited to the Hazardous material, but also the conservation of non-renewable natural resources such as natural gas. It is demonstrated by the efforts that have been made in improving production efficiency. Furthermore, KMI has formed a team of energy management and appoint energy manager and energy auditors.

2. Aspects And Environmental Impacts on Methanol Production

PT Kaltim Methanol Industri has been operating since 1998. A number of issues related to environmental management, including:

1. Toxic and hazardous waste of offices and activities that are not directly related to the methanol production process.
2. The methanol production process involves the use of catalysts and resin in large quantities. Most of the catalysts have the characteristics of toxic and hazardous materials. They sure are periodically replaced according to their service time.
3. In the process of making methanol, some byproducts like Tri-Methylene Amine are formed. These impurities and must be separated from the main product, to get methanol with grade AA and customer demand.
4. How to reduce natural gas and energy wasted because of plant shut down
5. How to give a positive impact for the surrounding community

2.1. Efforts On Managing Environmental Impacts On Methanol Production

Control measures carried out at each stage of the production process by involving all units. The first step is the identification of hazard and risk analysis of each routine and non-routine activity. Each activity has a high risk needs to be controlled to reduce the risks. The owner of the risks has responsible to control, review and internalization the risks.

Figure 2. Frame work of environmental management at PT Kaltim Methanol Industri

In general, the efforts of environmental management in PT Kaltim Methanol Industri has three dimensions; hazardous material and waste management, conservation of natural resources and community development around the company area. Below are presented some examples of environmental management efforts:

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2.1.1. Hazardous waste management

Hazardous waste management in PT KMI refers to PP 101 2014. HSE unit responsible for coordinating the handling of waste, according to the procedure that had been developed by the HSE. Working units shall submit hazardous waste it generates to HSE unit. All hazardous waste will be recorded in the balance sheet of hazardous waste, packaged and labeled in accordance with applicable regulations. Hazardous waste is stored in a temporary storage area and according to the storage period shall be disposed to authorized company. The next action is to get a third party to manage the waste, in accordance with the requirements set out in regulation. Here is an example of efforts to reduce the B3 waste that has been done by PT KMI:

2.1.2. Selection of Catalysts

Catalyst is widely used in the process of making methanol. Periodically, these catalysts need to be replaced because it has exhausted its useful lifespan. Because it contains heavy metals such as Nickel, catalyst is treated as toxic and hazardous waste. Technological developments in the manufacture of catalysts have provided options in catalyst selection. As an example of the selection of the catalyst is what has been done by PT KMI towards reforming unit.

Natural gas before entering the reforming unit, it must first be purified of impurities such as sulfur compounds. Sulfur contained in natural gas is a poison for most catalysts, such as Reformer Nickel based catalyst and Synthesis Copper-based Catalysts. The initial design of the purification unit is to absorb Sulfur by using Zinc Oxide, which is placed on the up-stream of the Pre-reformer and steam reformer. The Arrangement of old design purification unit is not capable of taking organic sulfur from natural gas, so that a reforming catalyst becomes not adequately protected from sulfur poisoning. As a result, the life of catalyst becomes shorter. The first modification is done by adding a CoMo-based catalyst to convert organic sulfur to H2S. This modification is quite successful in reducing sulfur carried into reforming unit, mainly to the pre-reformer. Modification of the second stage is to separate the bed of CoMo Catalyst from ZnO and put it in a vessel right before ZnO vessel. This is because the service life of CoMo and ZnO are different and handling of both catalysts and adsorbent is difficult if they are in a single vessel. This effort provides flexibility in the absorption of sulfur. Modification of the next stage is to add some amount of Copper based Polisher on down stream of ZnO, to help the absorption of sulfur at lower temperatures, especially during start-up. Modification of this process results in some advantages, including the service life of the catalyst in a reforming unit to be much longer. Thus, reducing the hazardous waste generated.

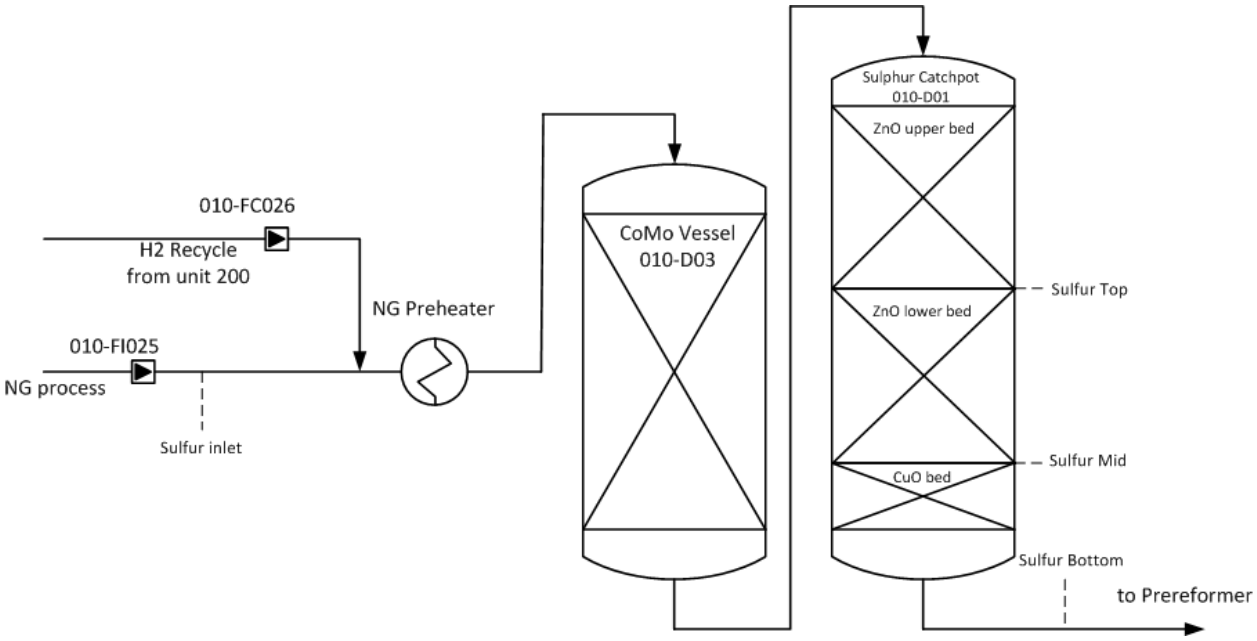

Figure 3. The arrangement of Desulfurization unit at PT KMI

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Pre-reformer catalyst located on the downstream Nickel desulfurizer contains fairly high, reaching 30-40% (wt), with a volume of about 16 M3. These catalysts are highly susceptible to sulfur poisoning. After modification of the above process, coupled with the selection of the type of catalyst then the catalyst service life can be extended from the previous less than 2 years, to more than 7 years (2008-2016)

2.1.3. Alternative Purification Process of Methanol from Try-Methyl Amine

Raw methanol produced from reactions in the synthesis unit contains a number of impurities, such as Try Methyl Amine (TMA), N (CH3) 3. TMA can be in a form of free or salt, depending on the degree of acidity of its environment. As the salt, it formed cation [(CH3) 3N-H] + which is not volatile. The addition of NaOH solution into the pre-run 030-D01 distillation column will raise the pH of the solution in the column, so that more TMA will be in a form of free TMA which is volatile. This free TMA will come out with others who also have a low boiling point, from the top of the column pre-run 030-D01, as off gas.

TMA separation by adjusting pH consumes a lot of caustic soda (NaOH). Caustic soda as toxic and hazardous materials requires special handling. Other TMA separation method then considered, i.e. by using ion exchange. In 2010, after a joint study with Lurgi, it was decided to apply ion exchange; the process takes place at TMA catch pot. Starting in 2010, TMA catch pot put into operations. The result is quite good; with caustic soda consumption can be reduced by over 60%, as the graph below:

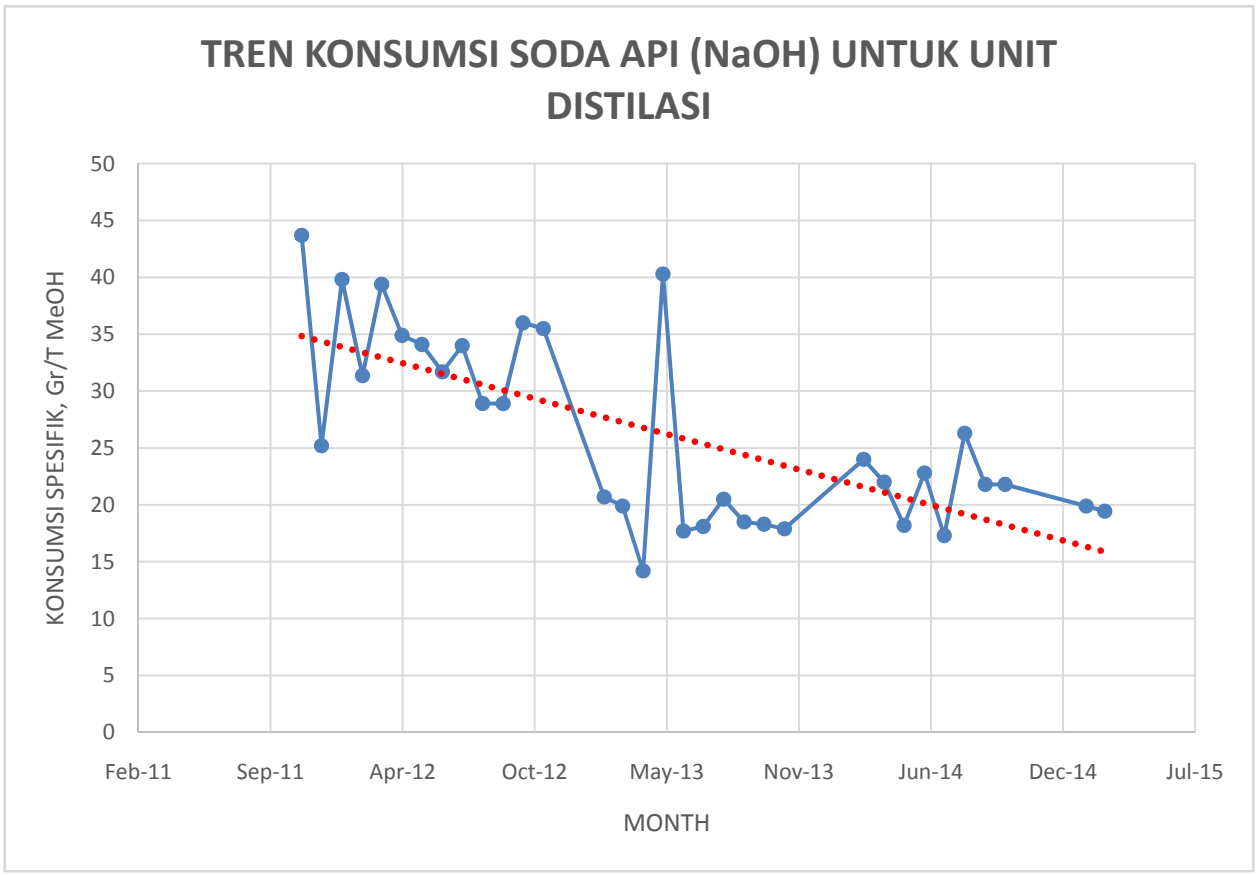

Figure 4. Caustic Soda Consumption in Distillation Unit

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2.2. Conservation of Natural Resources

2.2.1. Reduction in domestic waste and Energy saving

Some efforts made to conserve natural resource is related to reduction of domestic waste from office activities such as paper use and energy saving. Paper use reduction targets set for all working units. Every section manager responsible for internalization of paper reduction program. All employees must have awareness of the preservation of natural resources to get support for reduction of paper consumption, for example by utilizing used paper. These efforts followed up by applying a digital system for mailing and data/document storage. This Digital Management System is accessible for all employees. Energy saving is targeted both for plant operation and office activities. Simple ways to gain energy saving in office is campaigned to all employees. This requires a change in employee mind so they get accustomed with it. For example, to switch off electrical equipment while it's not in use, turn off the light every time they are finished with the job before going home and replace the lamps with an energy saving one.

A little change in the working culture combined with a touch of technology, paper consumption can be reduced by up to 50%. After the reduction of use of paper work program implemented, the achievement of targets is evaluated and the evaluation results provide input to management and all working units to improve this program.

TAHUN	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
JUMLAH KERTAS (RIM)	1288	1140	996	1000	802	822	756	586	781	550

Figure 5. Trend of Paper Consumption after Applying Reduction Program

2.2.2. Optimizing natural gas utilization through improvement in plant reliability

In line with one of PT KMI management policies for optimizing natural gas utilization, one way that can be done is to reduce downtime due to unscheduled shutdown. The more frequent unscheduled shutdown, the greater the volume of natural gas that is flared during start-up.

Efforts to improve the reliability have been done since the beginning of plant operation in 1998. This continuous process is able to improve plant reliability by reducing unscheduled shutdown. In 2011, to sharpen the targets and focuses on those items of critical plant equipment, a task force had been assigned to conduct Asset Life Study. The resulting report provides a framework and recommendations to management in terms of maintenance and inspection of the plant assets. The work of the task force has also become a reference for Plant Life Extension Team which was formed later on in 2014, to undergo a risk assessment of the plant equipment. Through risk assessment, risk levels for equipment are mapped and recommended plan of actions for high risk are proposed, to maintain and improve plant

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reliability and availability. Through the efforts above unscheduled shutdown, in average can be reduced from over 10 days the previous years, to less than 5 days (2012-2014).

2.3. Community Development

PT KMI operational activities give effect to the socio-economic development of society in Bontang, particularly to the community surrounding the KMI operation area. Community development activities are kind of corporate social responsibility focusing on health, environment, education and development of young generation, as well as the development of small-scale households.

Some examples of community development activities in the community surrounding PT KMI area is:

1. Trees plantation through the making of city forestry in Sekambing area , including Methanol park, in collaboration with a university in Indonesia
2. The Green village program, partnering with one of the neighborhood association in Guntung village to become a Pilot project
3. Development of micro scale business in Guntung village, include training to produce snack foods made from fish, equipment aid, training for certification of products and product marketing
4. The mass circumcision, blood donors, foster parents, and scholarships for high achievers from poor families
5. Partnership with the Kutai National Park in the conservation of natural resources, including Orang Utan

3. Conclusion

Environmental management is not only a matter of handling waste but also include natural resource management and economic and social dimensions. Based on the efforts of environmental management in PT Kaltim Methanol Industri, we conclude that:

1. The management of environmental aspects and impacts of the activities of the methanol production starts from the beginning of the process until the final product
2. Modification process is quite effective approach, not only for the production process but also for the improvement of environmental performance. Reducing in utilization of toxic and hazardous materials such as caustic soda and catalyst is the indication.
3. Plant reliability will be one of the determining factors in managing the environment, particularly the natural resources and energy. Risk assessment will help in mapping the risk, so measures will be more focused and planned better.
4. Empowering communities surrounding the company area through the partnership will be able to give a positive impact to socioeconomic and gain a strong support to the company in carrying out its activities

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