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Green Value Stream Mapping: A Tool For Increasing Green Productivity (The Case of PT. NIC)

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Abstract

The role of the environment in business success is increasing from day to day. One of the ways to harmonize the goals of making a profit with the environment is by achieving green productivity. Green productivity means that companies can increase their productivity and at the same time improve their environmental performance. To reach that goal one of the ways is that businesses apply value stream mapping and make all the activities to be green which is known as a Green Value Stream Mapping. A combination of secondary data collection and Focus Group Discussions involving all relevant production staffs was conducted to get the initial data and the ideas to improve the performance of electricity, LPG, and water consumption at PT NIC Semarang. Compared to the initial data of the Current State Green Value Stream Mapping, the improvements resulted from the Future State Green Value Stream Mapping were a 51.4% decrease in electricity consumption, a 24.42% decrease in LPG consumption, and a 60% decrease in water consumption. From this empirical study, two important outcomes of future implications were found. For the food industry, implementing GVSM should be adjusted in such a way that the experiments to reach the Future State Green Value Stream Mapping will not affect the quality of the final products and that FGDs are very effective to generate ideas of improvements and getting commitments from production staffs to implement the improvements.

Keywords: green value stream mapping, green productivity, Semarang

INTRODUCTION

The role of the environment in business success is increasing from day to day (Corbett and Classen, 2006; Hawkens, et al., 2010; Pampanelli, et al., 2014). In the manufacturing process, the integration of environmental concerns with business activities can be accomplished by applying the leaning production process (Seth and Gupta, 2005) of eliminating pure waste activities for unnecessary actions, eliminating or decreasing operations without value-added, and enhancing net operations activities to increase value-added (Monden, 2012: 405). To reach those goals one of the ways is that businesses apply value stream mapping and make all the activities to be green which is known as Green Value Stream Mapping (Asian Productivity Organization, 2006; Wills, 2009; Muñoz-Villamizar, et al., 2019).

PT. NIC is a foreign direct investment company, established in 1996. PT NIC Semarang, the location of the study, which was established in 2011 had two lines of production: sweet and white bread. PT NIC Semarang was experiencing a problem with its energy consumption, especially in sweet bread production. PT NIC could not meet the target of 0.3 mmbtu/1000 POC (Product Output Control) for the use of Liquified Petroleum Gas (LPG). The consumption of LPG at the beginning of the study was 0.32 mmbtu/1000 POC. From the initial observation, there was also a possibility to improve the performance in two other areas, electricity for the makeup area and water consumption by reusing wastewater for other purposes.

The makeup area was chosen because the process for improving the electricity consumption would not cause any problem with the quality of the products. The makeup area is the area where bread dough is cut into smaller pieces and filled with jams and then they are arranged into the baking dishes. In one shift the machines in this area could be turned on and off 100 times.

LPG was mostly used in the oven process. Although from the initial observation, it seems that there was no room for improvement, Focus Group Discussions involving all the employees of the operation department will be held to look for the ways to meet the target of of 0.3 mmbtu/1000 POC.

The consumption of water could be divided into three categories each using a separate water meter: watering the garden, production utilities, and flushing toilets. From the observation, there was a possibility to use wastewater which in some cases was still of good quality for other purposes. However, by applying Green Value Stream Mapping (GVSM), it can be more convincing than merely doing observation to get the possibilities of improving the performances. The costs of electricity, LPG, and water contributed 35% of total production costs. That is why we chose this area for our study.

GVSM was first developed in the 1990s by the Asian Productivity Organization (APO) to implement the concept of green productivity (Verma and Sharma, 2016; Dadashzadeh and Wharton, 2012). The first company which implemented GVSM was Toyota Motor of Japan in the 1980s. Green productivity means that companies can increase their productivity and at the same time improve their environmental performances (Asian Productivity Organization, 2006).

Green Value Stream in manufacturing was discussed in detail by Wills (2009). According to Wills all the activities in the manufacturing processes are seen in the value of the business stream or operation from the perspective of the environment. There are seven possibilities of waste. Those are in inventory, movement, defects, transportation, overproduction, excess processing, and waiting. The green wastes can be in the form of energy, water, materials, garbage, transportation, emissions, and biodiversity.

Three steps that should be conducted to implement GVSM are mapping all the activities, conducting a waste audit and energy audit (Hadipuro, 2020) in all the manufacturing activities to eliminate non-value-added activities, and using Pareto Law to eliminate wastes as the results of the waste audit, and decreasing the energy consumption as the results of the energy audit. Pareto Law means that the focus will be on the activities which produce the biggest waste and use the biggest energy and try to look for improvement in those activities.

This article is based on the results of an applied research. The originality or the value of this article is that this article deals with experimental design in natural conditions. Improvements were made during the real production processes. It means that there were many constraints to be dealt with in implementing GVSM. The main constraint was that improvements should be made without affecting the taste or the quality of the final products.

According to Verma and Sharma (2016), VSM and GVSM are quick, easy and comprehensive energy and material flow – time flow and transportation flow (Zhu, Zhang and Jiang, 2019) - analysis within the process of production. The strength of GVSM is that this approach makes it possible to create a visualization towards the formulation process flow (Dimyati and Singgih, 2019; Kurdve, et al., 2011) and simple to use (Faulkner and Badurdeen, 2014) compared to the similar approaches of 5 S, Poka Yoke, Kaizen, Kanban, Just-in-Time (Nallusamy, 2016) to eliminate non-value adding activities, waste and reduce energy consumption.

By applying GVSM, hopefully, PT NIC will increase its productivity and at the same time conserve the environment, which eventually will decrease costs and increase profits. This paper will be divided into five sections. After the introduction section, a literature review on GVSM will be elaborated. The next section is about the research methodology, which will be followed by the results and discussion. This paper will end with the conclusions and future implications.

LITERATURE REVIEW

If VSM is related to Lean Manufacturing, GVSM deals with Green Manufacturing. GVSM is a diagnostic tool that provides the insights of production efficiency (or productivity) and environmental (or green) performance at the same time (Fearne and Norton, 2009; Faulkner, et al., 2012), and provides ability to reduce waste and energy use. In other words, GVSM is a tool to increase Green Productivity (Marizkaa, Djatna, and Arkeman, 2015; Prayugo and Zhong, 2021; Zhu, Zhang, and Jiang, 2019).

Value stream process means that companies put processes into place or in a 'one-page picture' starting from the time a customer places an order until the customer has received the product in his/her facility, identify wastes, and try to look for the procedure to eliminate wastes (Wills, 2009: 14; Magnier, 2009). By adding the word 'green', it means that wastes eliminated are green wastes or wastes that can harm the environment because of the excessive usage of natural resources or because the wastes can degrade the quality of the environment.

Seven wastes that can be identified and classified are defects, overproduction, unnecessary transport or conveyance, waiting, excessive inventory, unnecessary movement, over-processing or incorrect processing (Ohno, 1988 in Alabay, 2008), and unused employee creativity (Liker, 2004). Wastes in the form of excessive use of energy and water are mentioned by Verrier, et al. (2014) in Chugani et al. (2017).

According to Magnier (2009), there are four important steps to eliminate green waste:

1. Determine and pick the product or product family.
2. Draw the current state map.
3. Determine and draw the future state map.
4. Develop an action plan to make the future state become the new current state.

To make the future state, Hadipuro (2020) proposes four steps to take after drawing the current state:

1. Eliminate processes that do not contribute to a value-added creation.
2. Perform a waste audit for all the activities and focus on the activity which produces the biggest amount of waste. Try to eliminate the waste as much as possible. Following Pareto Law, by focusing on this activity, the possibility to achieve green productivity

is bigger than focusing on the activity with the lower amount of waste. Wastes in green productivity are considered inefficiency. Green wastes include emissions, liquid and solid wastes, and toxic waste.

3. Perform an energy audit. For the same reason as in a waste audit, the focus will be on the activity which uses the biggest energy. Energy includes electricity, fuel, water, and other natural resources used.
4. Conduct the first three steps continuously until there is no possibility to improve.

The business green value stream is a central base layer that is very important to implementing a lean approach (Alabay, 2008). The lean approach which brings lower green wastes in manufacturing also includes workflow or logical directions of activity, repeatable or machine processes, and time used for a certain process. The lean process will result in heightened employee morale and quality, improve productivity, and reduce costs at the same time. That is why GVSM can result in an increase of productivity and a decrease of the environmental impact, which is known as Green Productivity. Green Productivity Index is measured by comparing the benefits (output) obtained from the Future State Map with the environmental impact (input) resulted in from the GVSM program. An increase in Green Productivity Index means that Green Productivity is achieved.

METHODS

The object of the study is the improvement of green productivity in energy and water usage from January to August 2020 in the production of bread, by applying GVSM.

The study belongs to an experimental design in natural conditions. It means that the improvement was made during the real production processes. Therefore, there are many things to be considered and one of the most important things to consider was that the experiments to reach the improvement should be made without delaying the processes and with the smallest number of impacts on the quality of the final products.

Sweetbread line production was chosen because the experiment was conducted to reduce green waste in this case the improvement of the electricity, LPG, and water usage would potentially decrease the production costs. The costs for electricity, LPG, and water contributed up to 35% of total production costs. Among the three kinds of products of sweet bread, white bread, and sandwich sold by PT. NIC Semarang, sweet bread in 2020 reached 40 to 50% of the total capacity, while the rest of the capacity was divided into two other production lines of white bread and sandwich. Sweetbread was also chosen because there were more than 10 variants of the product, which means that there were lots of repeated activities conducted in its production, and from the initial observation there were possibilities to improve to decrease green waste. As Alabay (2008) suggests that repeatable process is one of the activities that might produce green waste.

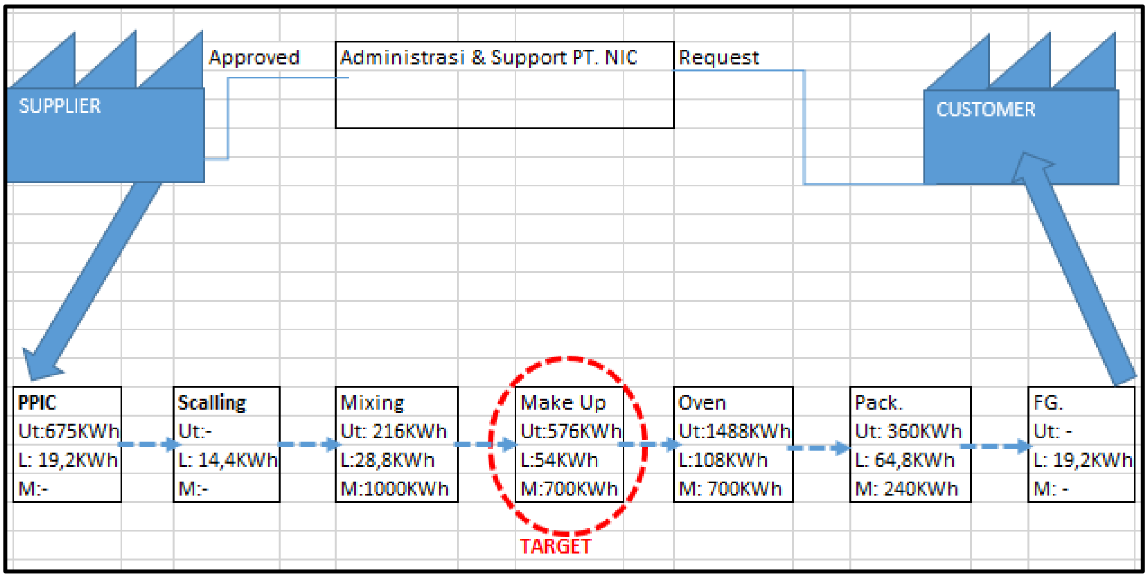
The process of mapping the activities in producing sweet bread was conducted by observing the activities involved in producing sweet bread. The initial data of the electricity, LPG, and water consumption during the study were collected from the secondary data of the company's electricity, LPG, and water consumption. The data about the machines used to produce sweet bread were collected from all the machine manual books. The results of these steps would be the Current State Green Value Stream Mapping.

The electricity, LPG, and water audit to improve involved all the relevant employees in sweet bread production, and the method used to identify the potencies for improvement, including the omission of non-value-added activities, was Focus Group Discussions (FGDs). The relevant employees consisted of the supervisor team, team shift leaders, and machine operators. Experiments to achieve the improvement were conducted, and the best possibilities constituted the Future State Green Value Stream Mapping. The data, in this case the Current State Green Value Stream Mapping, then were analyzed and diagnosed by the participants of the Focus Group Discussion. All participants with different educational backgrounds and work experiences were asked to propose changes to develop the Future State Green Value Stream Mapping which contributed to an increase in Green Productivity.

RESULTS AND DISCUSSION

The Improvement in the Electricity Consumption

The results from the observation and the data about the consumption of the electricity for each machinery used in the production of sweet bread is presented in Figure 1 which includes production processes starting from Production Planning and Inventory Control (PPIC) to Finished Goods.



Source: secondary data (2020)

Note: Ut = Utilities; L = lamps; M = machines

Figure 1. Production Processes and the Consumption of Electricity for Each Process

Figure 1 is the Current State Green Value Stream Mapping for electricity consumption. The biggest electricity consumption was at oven process. However, from the FGD, the makeup process was recommended to be improved for the Future State Green Value Stream Mapping for electricity consumption. The only reason was that experiments in the makeup process would not affect the quality of the product.

The electricity for the machines in the makeup process was recommended by the participants of the FGD because the frequency to start and off the machine was 100 times for each shift of production. There were two shifts of production at PT NIC Semarang. Table 1 shows the machines used in the makeup area and their frequency of being on and off for each shift.

Table 1. The Frequency of Turning On and Off Machines in the Makeup Area (times)

No	Machine	Frequency *Shift* 1	Frequency *Shift* 1	Total
1	*Dough lifter*	100	100	200
2	*Rounder*	1	-	1
3	*Molder*	1	-	1
4	Fermentation	1	-	1

Turning on and off a dough lift machine will result in a power surge which becomes the source of inefficiency. Dough lift functions to lift bread dough to be put in a divider machine which divides bread dough into smaller pieces. Theoretically, power surge caused by the process of turning on and off a machine can be overcome by using an inverter. This solution was also suggested by the participants of the FGD. Figure 2 shows the fluctuation of the electricity consumption because of turning on and off the machine.

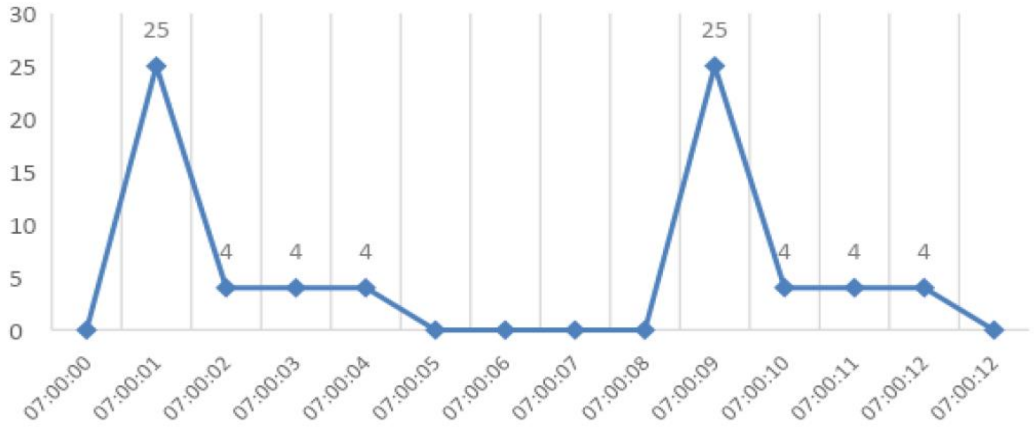


Figure 2. Power Surge Resulted from One Cycle of Turning On and Off A Dough Lift Machine

In one cycle of 12 minutes period, the power surge happened in minute 1 when the machine starts, and in minute 9 because of the process of turning off the machine. During the FGD a proposal of using an inverter was raised. An inverter can reduce the power purge. The result can be seen in Figure 3. The power surge after inverter installation is shown by the red line. The red line is smoother compared to the blue one before an inverter installation.

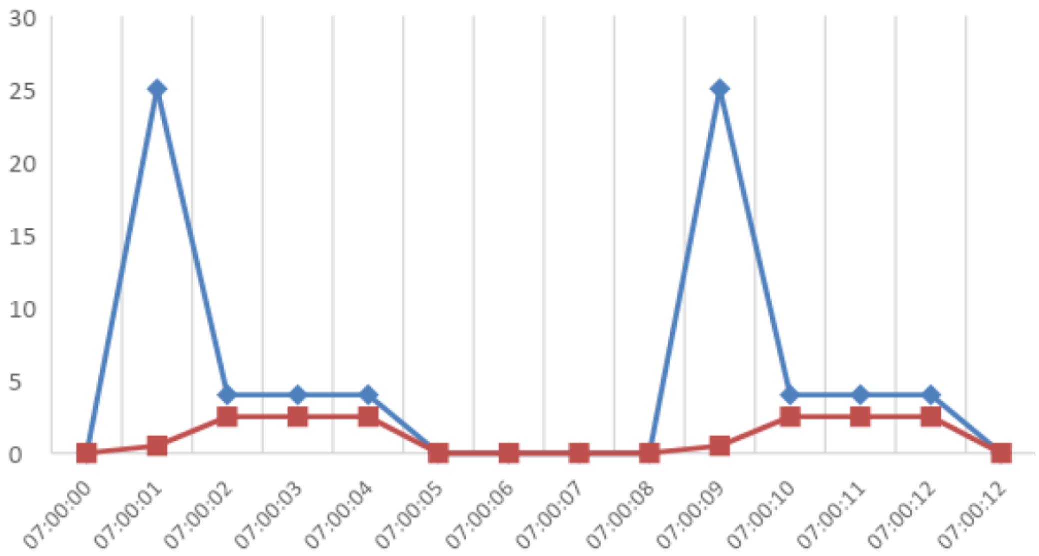


Figure 3. Power Surge Comparison before and after Inverter Installation

The Future State Green Value Stream Mapping is shown in Figure 4. Compared to the Current State Green Value Stream Mapping, there was a decrease in the Future State of Green Value Stream Mapping of 51.4% from 700 kwh to 340 kwh for electricity consumption of the dough lift machine in the makeup process per day. With the tariff per kwh Rp. 1,500, the improvement resulted in the decrease of Rp. 510,000 per day.

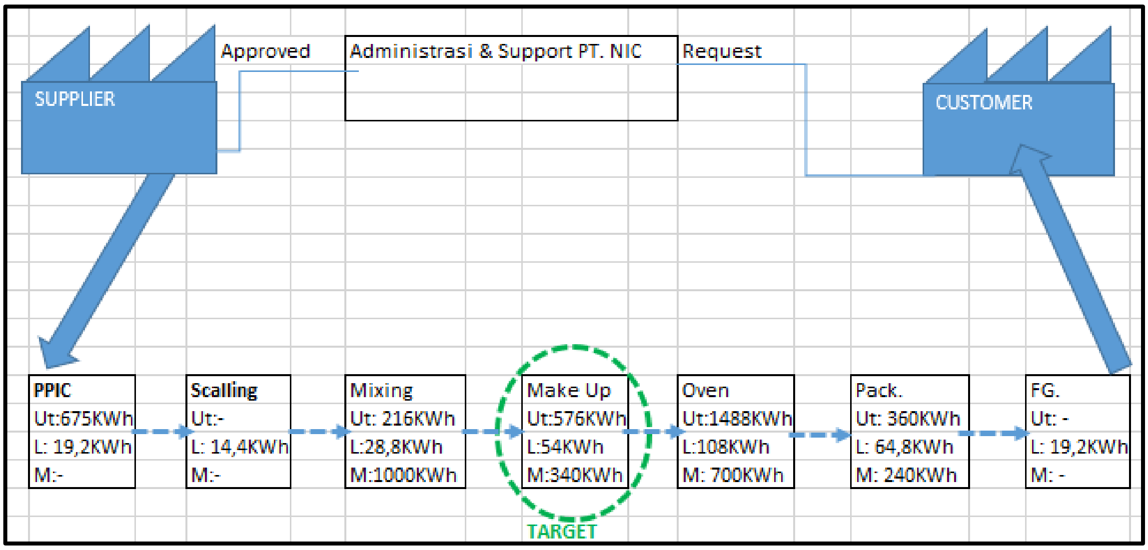


Figure 4. The Future State Green Value Stream Mapping for Makeup Process

LPG Consumption Improvement

Mostly, LPG was used for bread baking in the oven process. Bread baking can be done if only the temperature inside the oven was 200°C. The Current State Green Value Stream Mapping of standard operating procedure was that operators started to turn on the oven 30 minutes before the baking started.

In the FGDs, it was decided to review the standard operating procedure and do a small research on the time needed from turning on the oven to the needed temperature of 200°C. The result was that the time needed to reach the 200°C temperature was only 20 minutes. This new standard of Future State Green Value Stream Mapping was applied from the beginning of May 2020. Table 2 shows the comparison between the Current State Green Value Stream Mapping of 30 minutes heating process from January to April 2020, and the Future State Green Value Stream Mapping of 20 minutes heating procedure from May to August 2020. In average the Current State Green Value Stream Mapping used 7.5 kilogram/1000 POC and the new standard of Future State Green Value Stream Mapping used only 5.7 kilogram/1000 POC. In rupiah, there was an average decrease of Rp. 88,696 or 24.42%. On average from January to April 2020 the cost for LPG was Rp. 363,230, while on average from May to August the cost was Rp. 274,534 per 1000 POC.

Table 2. LPG Consumption and Cost of the Current State Green Value Stream Mapping and the Future State Green Value Stream Mapping in 2020

Month	POC	Total Consumption (ton)	Total Cost (Rp)	Average Consumption (kilogram/1000 POC)	Cost/1000 POC
January	4,607,919	41.2	494,009,646	8.9	107,209
February	4,353,096	30.8	370,130,827	7.1	85,027
March	4,763,637	33.0	395,557,205	6.9	83,037
April	4,394,930	32.2	386,566,243	7.3	87,957
May	4,647,981	28.8	345,614,840	6.2	74,359
June	4,620,669	24.6	295,156,815	5.3	63,878
July	4,063,174	24.9	298,452,153	6.1	73,453
August	4,905,855	25.7	308,304,732	5.2	62,844

Water Consumption Improvement

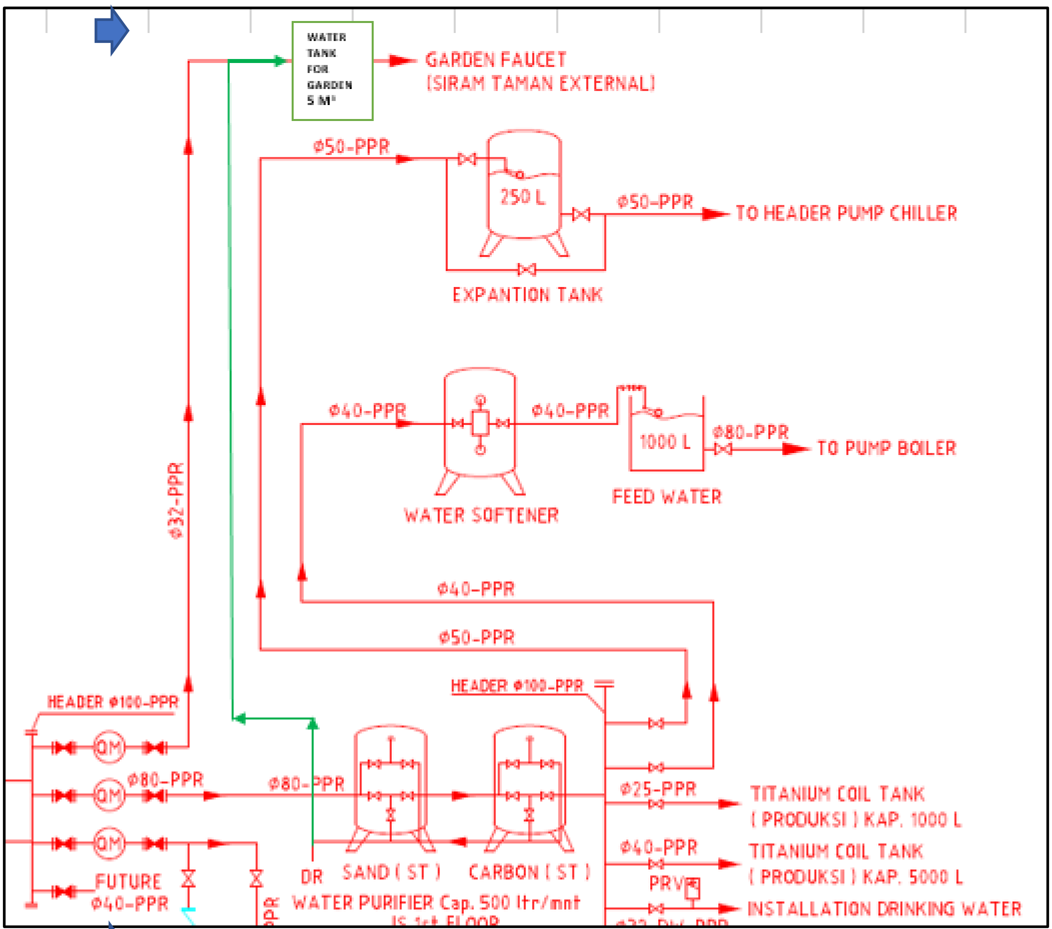
There were three water meters used for all water consumption: a water meter for gardening, a water meter for utilities, and a water meter for toilets. From FGDs, the improvement for water consumption for gardening was chosen. The reason was that:

1. No contamination risk to the final products.
2. No human risk for the employees, compared for example with water consumption for toilets.

The possibilities to use backwash water were identified and from the water quality test, backwash water from the Carbon Sand Filter met the requirements for watering the gardens.

Figure 5 shows the modification of the piping system: an additional piping system was added to catch backwash water from Carbon Sand Filter to be stored in the water tank for gardening.

The modification of the Current State to the Future State Green Value Stream Mapping was started effectively in April 2020. Figure 6 shows the water consumption of the Current and the Future State Green Value Stream Mapping. The consumption for gardening decreased from 129 cubic meters in March 2020 to 48 and 38 cubics in April and May 2020, more than 60% decrease after the modification. In rupiah, the decrease was from Rp. 812,700 in March 2020 to Rp. 302,400 and Rp. 239,400 in April.



Note: additional piping system from Carbon Sand Filter to Water Tank for Gardening

Figure 5. Piping Modification from Carbon (ST) to Water Tank for Gardening

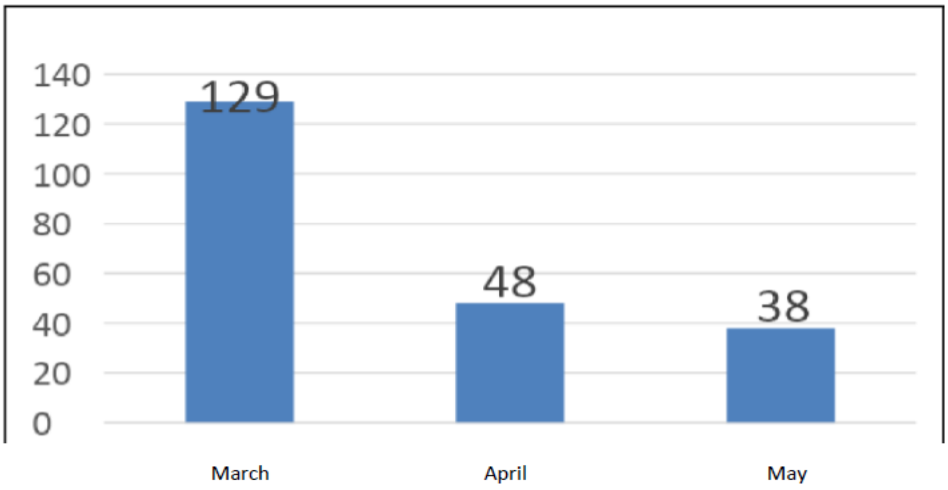


Figure 6. Water Consumption for Gardening of the Current and the Future State Green Value Stream Mapping

Discussion

GVSM was proved to be effective to improve green productivity. The productivity increased because the company could save the costs from the natural resource consumption. The green itself was shown from the decrease in the consumption of the electricity, LPG and water of the Current State compared to the Future State Green Value Stream Mapping.

However, there were some adjustments to implement GVSM in the food industry, such as PT NIC. The Pareto Law, energy and waste audit should be used by considering the impacts on the product quality. If we considered only the Pareto Law, it should be the oven area that we had to seek the ways to improve the electricity consumption from the Current State to the Future State Green Value Stream Mapping. However, experimenting with changes in the oven area might cause problems with the product quality. Therefore, we chose to improve the electricity consumption in the makeup area, where experimentation in the production scale did not affect the quality of the products. The electricity consumption in the oven area was 1,488 kwh for the utilities, 108 kwh for lighting, and 700 kwh for machinery or 2,296 kwh in total; while for the makeup area the consumption of the electricity was 576 kwh for utilities, 54 kwh for lighting, and 700 kwh for machinery or 1,330 kwh in total (compared to 2,296 kwh in the oven area).

The same consideration was used when we tried to decrease the water consumption by using wastewater from the Current State to the Future State Green Value Stream Mapping. We chose to improve water consumption for gardening, instead of for utilities and toilets. Experimentation in the production line for water consumption for utilities was risky in terms of their impact on the final products. There might be objections if we used wastewater for toileting activities. Although the water quality test conducted showed that the wastewater was safe to be used for toilet activities for the Future State Green Value Stream Mapping, employees might still have a feeling that the wastewater was not safe enough for cleaning their bodies.
FGDs involving all the relevant production staff were effective to generate ideas where improvement should be made. There were two advantages of involving all the relevant production staff. First, they know in detail very well the problems that can be solved by implementing GVSM and the impacts of the experimentation to achieve improvements. Second, by involving them they get a feeling that the improvement is their idea. This kind of sense of belonging makes it easier to implement the Future State GVSM. And, it can be seen from their idea to shorten the time of starting the machine from 30 minutes to 20 minutes for the oven process. Without such sense of belonging, they would prefer to use the 30 minutes time which would make them more relaxed in working compared to 20 minutes which was more tightened.

CONCLUSIONS AND FUTURE IMPLICATIONS

Implementing GVSM has resulted in savings for electricity costs of Rp. 510,000 per day or a decrease of 51.4% consumption, for LPG a saving of Rp. 88,696/1000 POC or a decrease of 24.42%, and for water a saving of Rp. 510,300 per month or a 60% decrease in its consumption. However, this is not the final Future State GVSM. Continuous improvement should be applied so that this Future State of GVSM will become the Current State of GVSM for the next improvement.

Two main constraints met during GVSM implementation at PT NIC were that:

1. making improvements during the real production processes made it difficult to do experiments since experiments should be done without interrupting the processes,
2. the experiments should not affect the quality of the final products.

In the future, experiments can be conducted at the laboratory scale or during holidays when the production processes stop.

Theoretically, GVSM implementation should be adapted to the type of industry, in our case the food industry where the choices of the area to be improved should be customized in such a way that will not affect the quality of the final products. We apply the Pareto law, waste and energy audit only for the area in which improvements do not affect the final product quality. This is the first main contribution of this article. There have been many publications on the deployment of GVSM for food industries, such as mentioned by De Steur, et al. (2016). However, they do not mention about the modification needed in applying GVSM for food industries.

FGDs were effective for two reasons. First, from FGDs we can generate ideas for improvements which are originated from real problems. Second, FGDs can generate a sense of belonging to the ideas for improvement which will make it easier for implementing the Future State GVSM. The second contribution of this article is about the method used to involve all employees, in this case the FGD.. Many publications have stressed the importance of involving all stakeholders, such as Wills (2009), Faulkner and Badurdeen (2014), Henrique, et al. (2016), Lee, et al. (2021), Garza-Reyes, et al. (2018), and Rosenbaum, et al. (2014). However, they do not mention how to involve all stakeholders in the application of GVSM.

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