TUGAS AKHIR – TI 141501

PENINGKATAN EFISIENSI PENGGUNAAN AIR PADA PT. PANCA TUNGGAL CIPTA KARYA SENTOSA

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WATER EFFICIENCY IMPROVEMENT AT PT. PANCA TUNGGAL CIPTA KARYA SENTOSA

FINAL PROJECT

Proposed to Fulfill the Requirement to Obtain
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PENINGKATAN EFISIENSI PENGGUNAAN AIR DI PT. PANCA TUNGGAL CIPTA KARYA SENTOSA

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ABSTRAK

Konsep Industri Hijau dikembangkan untuk menyelesaikan permasalahan lingkungan di dunia. Industri hijau merubah perusahaan-perusahaan manufaktur sehingga industri-industri tersebut dapat memberikan kontribusi nyata kepada pembangunan industri yang berkelanjutan dengan lebih efektif. Pemerintahan Indonesia mendukung secarah penuh pengimplementasian konsep ini di Indonesia. Salah satu program penunjangnya adalah Program Penghargaan Industri Hijau. Selain itu, Pemerintah Kota Surabaya juga menciptakan suatu program untuk mendukung pelaksanaan Program Penghargaan Industri Hijau tersebut. Program pendukung tersebut adalah Program *Pilot Project* Industri Hijau. PT. Panca Tunggal Cipta Karya Sentosa adalah salah satu peserta dalam program ini. Di perusahaan ini, efisiensi penggunaan air menjadi salah satu permasalahan utama. Dengan melakukan *Root Cause Analy*sis (RCA), dapat diketahui bahwa tidak adanya *water loss control program*, tidak adanya program inovasi dalam penggunaan air, tidak adanya SOP dalam penggunaan air, dan rendahnya pengetahuan pegawai adalah akar permasalahan dalam rendahnya efisiensi dalam penggunaan air. Untuk menyelesaikan permasalahan tersebut, penelitian ini mengajukan beberapa rekomendasi perbaikan. Dari sudut pandang kualitatif yang diuji melalui metode *Analytical Hierarchy Process (*AHP), SOP penggunaan air menjadi rekomendasi yang terpilih. Sedqangkan dari sudut pandang kuantitatif yang diuji melalui metode *Net Present Value* (NPV), water loss control program adalah rekomendasi yang terpilih. Untuk itu, metode Brown-Gibson dilakukan untuk mengombinasikan kedua nilai tersebut. Di akhir perhitungan, diketahui bahwa SOP penggunaan air and *water loss control program* adalah dua rekomendasi yang terpilih. Dua rekomendasi tersebut tepilih karena selisih nilai kombinasi dari keduanya sangatlah kecil.

Keywords : *Analytical Hierarchy Process (AHP,) Brown-Gibson Method, Industri Hijau, Program Penghargaan Industri Hijau, Program Pilot Project Industri Hijau, Net Present Value (NPV), Root Cause Analysis (RCA).*

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WATER EFFICIENCY IMPROVEMENT AT PT. PANCA TUNGGAL CIPTA KARYA SENTOSA

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ABSTRACT

Green Industry concepts emerged in order to solve environmental problem. Green Industry principles transform manufacturing and allied industry sectors so that they can contribute to sustainable industrial development more effectively. Indonesian government supports this concept by creating Green Industry Awarding Program. Moreover, to support that program, Surabaya government created a program namely Green Industry Pilot Project. PT. Panca Tunggal Cipta Karya Sentosa is one of the participants in Green Industry Pilot Project. In this company, water issue becomes the concern. By conducting Root Cause Analysis (RCA), it is known that inexistence of water loss control program, inexistence of water save innovation program, inexistence of water use procedure, and employee's lack of knowledge are the root causes of water problem in the company. In order to solve the causes, several recommendations are developed. Furthermore, by doing qualitative analysis through Analytical Hierarchy Process (AHP), water use SOP is selected as the most preferable recommendation. On the other hand, quantitative analysis through Net Present Value (NPV) is conducted and thus resulting water loss control program as the most preferable recommendation. In order to combining both qualitative and quantitative analysis, Brown-Gibson Method is done. This last step brings water use SOP and water loss control program as the most preferable recommendations of all. Two recommendations are selected since the final value of both recommendations are extremely close.

Keywords : *Analytical Hierarchy Process (AHP,) Brown-Gibson Method, Green Industry, Green Industry Awarding Program, Green Industry Pilot Project, Net Present Value (NPV), Root Cause Analysis (RCA).*

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I believe this research is imperfect. For that, I welcome any positive critics and constructive advices. Hopefully, this research could contribute to the academic world and especially improve the management of PT. Panca Tunggal Cipta Karya Sentosa.

Surabaya, June 29th 2015

Author

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CHAPTER 1
INTRODUCTION

In this chapter, the background, the problem formulation, the objectives, the benefits, the scope, and the research structure are explained in detail to give an overview about the nature of the research.

1.1 Background

Environmental damages become a hot issue nowadays. Reinert (United Nations Industrial Development Organization, 2011) suggested resource scarcity, ozone depletion, natural disaster, climate change, global warming, and increasing number of both type of disease and patient of diseases become the proof that environmental damage has affected the world in many sides (US Environmental Protection Agency, 2008).

Regarding to this issue, environmental movement in industry becomes an emerging concept in the world. Experts believe that the environmental movement could be accomplished by optimizing the industrial activity. One of the proposed actions is the Green Industry concept (United Nations Industrial Development Organization, 2011).

United Nation Industrial Development Organization (2011, p.04) stated that the concept of Green Industry transforms manufacturing and allied industry sectors so that they can contribute to sustainable industrial development more effectively. Green Industry is verified by proven methods and practices to reduce pollution and resource consumption in all sectors of existing industry and create an affordable, appropriate and reliable environmental aspect of a new industry. Green Industry concepts has been proven as a good idea for business, environment and climate as well as for communities, consumers, and for enterprises' improvement in developing and transition countries. The most important point is Green Industry concepts could unleash the business and innovation potential which are arising from a process of continuous improvement. Green Industry concepts emphasizes to

minimize waste and reduce emissions. By implementing green industry concepts, society hopes a better industry system that is responsible to environmental.

Fortunately, Indonesian government has created a policy to consider this issue. This policy is stated in Undang-Undang Republik Indonesia Nomor 3 Tahun 2014 pasal 3 ayat c Tentang Perindustrian. One of the statements is that industrialization is organized in order to create an independent, competitive, leading, and green industry (Kementrian Perindustrian Indonesia, 2014). It means that Indonesian government has appealed all industry upon Indonesia to operate their business "greenly". Driven by this purpose, Indonesian government created a program. This program is Green Industry Awarding Program.

Green Industry Awarding Program is created to support the world's goal to reduce the emission of greenhouse gas. This statement is convinced by the prior President of Indonesia, Susilo Bambang Yudhoyono, at International Conference in Copenhagen that Indonesia is eager to reduce the emission of greenhouse gas until 26% in 2020 (Kementrian Perindustrian Republik Indonesia, 2014).

Figure 1.1 Green Industry Official Announcement by Industry Minister of Indonesia, Mohamad S. Hidayat
(Kementrian Perindustrian Republik Indonesia, 2011)

Following the policy, Surabaya government puts this concern to its vision which is "Becoming a better Surabaya as a service and commerce city which is intellect, humane, dignified, and environmentally-insightful" and its last mission which is "Creating more-habitable Surabaya city through physically and socially

infrastructure development evenly and environmentally-insightful" (Pemerintah Kota Surabaya, 2010). Moreover, Surabaya government translated Green Industry Awarding Program to Green Industry Pilot Project. Green Industry Pilot Project is purposed to trigger companies in Surabaya to implement the principal of Green Industry (Anityasari & Rachman, 2014).

From the company perspective, the implementation of Green Industry concepts may lead a lot of benefits. Green Industry concepts drives the company to improve the efficiency of the business process. Efficiency Improvement is associated to income and profit earning. For example, the company could do it through reusing of production waste. By doing that, the company becomes less reliant on virgin materials and thus could save procurement cost. Further benefits of efficiency improvement include increasing labor productivity due to working conditions restoration, increasing product quality due to defect minimization, and reducing non value-added activity (United Nations Industrial Development Organization, 2011). Von Weizsäcker et al (United Nations Industrial Development Organization, 2011) claimed that calculations show typical short payback periods and lower annual costs of green industry investment. Hence, it could be concluded that Green Industry concepts helps enterprises earn more profit by decreasing resource and improving productivity.

Green Industry concepts is known to have significant spin-off effects. Cost savings or new income flows can be utilized to drive enterprise expansion, to create new jobs, and to invest in further resource development. Experience shows that enterprises frequently utilize such cost savings or additional income to invest in environmental technologies, upgrades, and expansions, or to develop new green processes or products. By improving environmental performance, enterprises are in a better position to face changing of business climate (United Nations Industrial Development Organization, 2011).

At the same time, the company could take their role to the world in solving the environmental problem that has been explained before. It will also raise the image of the company as a green company through the certificate given from this program.

Through this program, Surabaya government expects to push the economic growth of the city. By implementing Green Industry concepts, the company could increase the profit and thus enhance the economic growth. Automatically, it will raise the employee's living standard. Hence, in the advance expectation it will increase the economic growth of the whole city.

This program take a book titled Pedoman Penilaian Penghargaan Industri Hijau as the guidance. This book contains all the regulation about the awarding. The criteria of this awarding is deployed and explained clearly here. Based on the criteria, there are 5 level of company in green industry implementation which are 5^{th} level with score of 90.1-100%, 4^{th} level with score of 80.1-90%, 3^{rd} level with score of 70.1-80%, 2^{nd} level with score of 60.1-70%, and 1^{st} level with score of 50-60% (Kementrian Perindustrian Republik Indonesia, 2014).

Previously, a research had been conducted to choose 10 companies which are ready to participate in Green Industry Pilot Project. Several pictures of observation in previous research are provided in Figure 1.3 and 1.4.

Figure 1.2 Observation in Pilot Project Research (1)
(Anityasari & Rachman, 2014)

Figure 1.3 Observation in Pilot Project Research (2) (Anityasari & Rachman, 2014)

The research used Analytical Network Process (ANP) and Technique for Order Preference by Similarity to Idea Solution (TOPSIS) as the selection methods. Refer to the report by (Anityasari & Rachman, 2014), it has been found that 3 companies are in 4th level of Green Industry certification, 2 companies is in 3rd level, 1 company is in 2nd level, and 4 companies are in the 1st level. Table 1.1 explains briefly about the product and the level of each company.

Table 1.1 Recap of Green Industry Pilot Project Companies Readiness Level

Company	Product	Level 1	Level 2	Level 3	Level 4
PT. Putra Jaya Dewata	Coffee and Havermut				✓
CV. Profil 88	Plastic and Metal Water Tank		✓		
UD. Levis	Syrup and Alcohol	✓			
PT. Panca Tunggal Cipta Karya Sentosa	Plastics Household			✓	
UD. Asli	ACCU	✓			
PT. Sentral Bahana Ekatama	Helmet				✓
PT. Panca Aditya Sejahtera	Lamp				✓
UD. Cahaya Sukses	Plastics Household	✓			
Gading Mas Plastik	Plastics Household	✓			
PT. Damai Sentosa	Cooking Oil			✓	

1st level companies are considered to achieve low level of Green Industry certification since it has 50-60% score for the whole company performance. 2nd level companies are considered to achieve medium-low level of Green Industry certification since it has 60.1-70% score for the whole company performance. 3rd level companies are considered to achieve medium level of Green Industry certification since it has 70.1-80% score for the whole company performance. 4th level companies are considered to achieve high level of Green Industry certification since it has 80.1-90%score for the whole company performance. All the scoring is according to the Pedoman Penilaian Penghargaan Industri Hijau book.

Moreover those companies run their business in several sectors classified as food and beverages, high technology, chemical, and agricultural industry (Anityasari & Rachman, 2014). Figure 1.5 shows the proportion of companies' business sector.

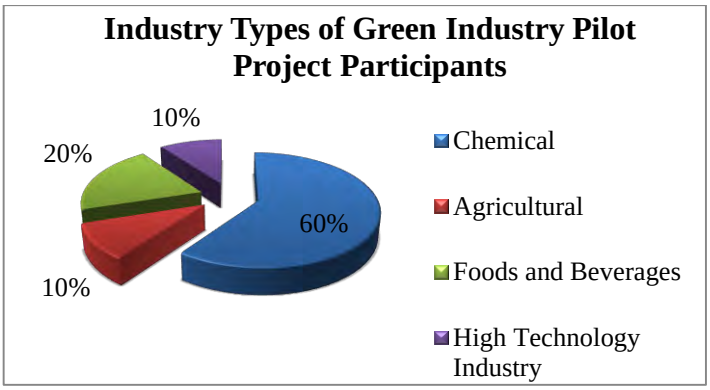

Figure 1.4 Recap of Green Industry Pilot Project Companies Business Sector

Based on the result of the previous research, this research will focus on PT. Panca Tunggal Cipta Karya Sentosa as one of the Pilot Project participants. This company is chosen in this research based on the job description of project team.

Generally, PT. Panca Tunggal Cipta Karya Sentosa runs their business in plastic industry. It produces many kind of plastic household and stationery product like plastic jar, hanger, clip board, and bucket. This company distributes their product to the retailer of plastic product. Their main customer are household store, minimarket and stationery store around Surabaya. PT. Panca Tunggal Cipta Karya

Sentosa executes their production process using 8 plastic injection machines, several supporting machine such as drilling and clamping machine, and cooling tower. Cooling tower is required to produce coolant water which is used to cool down the injection machine temperature along the production process.

PT. Panca Tunggal Cipta Karya Sentosa has several concerns in order to implement green industry concept in their production activities. The concerns are about the water use efficiency and defect reduction. The improvement in these two sectors become important since it will improve the performance of the company and will support the company to implement Green Industry. Water use and defect problem will be solved by two separated research principles by two different researchers in one team.

Figure 1.5 Initial Observation to PT. Panca Tunggal Cipta Karya Sentosa
(Anityasari & Rachman, 2014)

Figure 1.6 Plastic Injection Process, the Main Process of PT. Panca Tunggal Cipta Karya Sentosa
(Anityasari & Rachman, 2014)

Based on the interview that has been done to the owner of the company, water problem appears since there is not direct PDAM stream to the company location. On the other side, the company could not use land water since the area of the company is in coast where the water is brackish thus not suitable for metal formed machine. As conclusion, the company should buy from the outside supplier which makes the price of water becomes quite expensive. In addition, the company needs about a tank in a day.

Unfortunately, there is inefficiency of water use in the company since the amount of water produced is less than the amount of water processed. They also does not have a good system to manage the water use. This causes loss to the company in quite high number. Especially in the cooling towers, the water that is produced from these towers is not as much as the amount of the water that is processed in the towers. The exact amount of the gap is still not recognized because the company does not have a comprehensive record of water use in the company. By doing the efficiency in the water, company estimates that the water efficiency could be improved up to 60% and the company could reduce the cost of water by 1.5 million rupiahs in a month (Bambang, 2015).

Through this research, it is expected that the company will improve their performance especially in water use efficiency. Water use efficiency is selected by considering the existing condition of PT. Panca Tunggal Cipta Karya Sentosa which utilizes water in several activities. Based on the initial observation, the activities are coolant water production, injection machine cooling system, and other non-operational activities. Considering that, the author acknowledges opportunity in improving company performance in this sector.

1.2 Problem Formulation

Based on the elaboration above, the problem that is addressed in this research is how to improve water efficiency at PT. Panca Tunggal Cipta Karya Sentosa.

1.3 Objectives

The objectives of the research are:

1. To identify the main problem and the root cause of inefficiency of water use using RCA approach.
2. To solve the root causes of problem by proposing several recommendation alternatives.
3. To select the most suitable recommendation considering the company condition using qualitative and quantitative perspective.

1.4 Benefits

The benefits that could be achieved through the research for the author, the company, and the government are:

1. For The Author
    a. To implement the theory studied through Industrial Engineering under-graduated program to the real case of industry.
    b. To open the author's mindset about the government regulation in Indonesia, especially in Surabaya.
    c. To understand Industrial Engineer's roles in solving problem of industry.
2. For The Company
    a. To improve the performance of the company.
    b. As a milestone for the company to achieve green industry standardization.
    c. To gain better brand image through green industry certification.
    d. To become a pilot project to other company in term of green industry.
3. For The Government
    a. To implement central government regulation about green industry standardization that is stated in UU No. 13 Tahun 2014 pasal 3 ayat c.
    b. To acquire better city image as a green city from industry point of view.
    c. To fasten the economics growth of city.

1.5 Assumptions

The assumptions used in the research are:

1. The interest rate which is used in NPV calculation is 7.5%. This number is derived from the value of interest rate of Central Bank Indonesia in June 2015 (Bank Indonesia, 2015). Central Bank Indonesia is selected because this bank is the representative of finance regulation in Indonesia.
2. The value of water use reduction when implementing water loss control program is 30%. It is derived from the historical data of several company which is written on water loss control program manual (United States Environmental Protection Agency, 2001).
3. The value of water use reduction when implementing water reuse program is 20%. This number is derived from a report of water reuse activities at plastic industry in India (India Government, 2013).

1.6 Research Scope

The scope of the research are:

a. The object observed is PT. Panca Tunggal Cipta Karya Sentosa. This object is derived from the previous observation about potential companies to implement green industry concepts.
b. The observed activities are the activities that involve water in the production processes.
c. Primary data are taken from measurement and secondary data are taken from journals, books, and other trusted literatures. The data are taken from October 2014 until March 2015.

1.7 Report Structure

Report will be structured as follows:

1. Chapter 1 contains the background, the objectives, the benefits, the research scope, and the report structure.

2. Chapter 2 conducts literature review. This chapter discusses the basic theories about the object, methods, and other additional knowledge that will be used in the research.
3. Chapter 3 presents how the author will do the research. This chapter clarifies the methodology used in the research.
4. Chapter 4 presents the data collection and processing. This chapter elaborates the data and processes it to the final recommendation that later will be analyzed.
5. Chapter 5 gives a deep analysis about the recommendation that will be developed according to previous chapter. The analysis leads the author to the recommendation priority.
6. Chapter 6 provides the development of specific recommendation regarding to the previous chapter. It will be the guidance for the company to implement the recommendation.
7. Chapter 7 presents the conclusion of the research along with the suggestions.

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CHAPTER 2
LITERATURE REVIEW

In this chapter, basic knowledge about the theories in the research are explored. This chapter discusses the concept of Green Industry, the regulation of Green Industry Awarding Program, the illustration of water efficiency in industry, the elaboration of Root Cause Analysis approach, and the explanation of Analytical Hierarchy Process method.

2.1 Green Industry

Green Industry is industrial production and development that does not come at the expense of the health of natural systems or lead to adverse human health outcomes. Green Industry is aimed at mainstreaming environmental, climate and social considerations into the operations of enterprises. It provides a platform for addressing global, interrelated challenges through a set of immediately actionable cross-cutting approaches and strategies that take advantage of emerging industry and market forces (United Nations Industrial Development Organization, 2011).

2.1.1 Green Manufacturing

Definition of Green Manufacturing which is proposed by the US Department of Commerce (Dornfeld, 2012) is expressed as the creation of manufacturing products that uses materials and processes that minimize negative environmental impacts, conserve energy and natural resources; accentuate employees', communities', and consumers' safety; and prosper from the perspective of economy. On other side, Sustainable development has been defined by the World Commission on Environment and Development as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainability has also been associated with the triple bottom line approach where environmental, economic, and social factors have to be met. Reflecting to these definitions, sustainable development and green manufacturing can be related as in Figure 2.1.

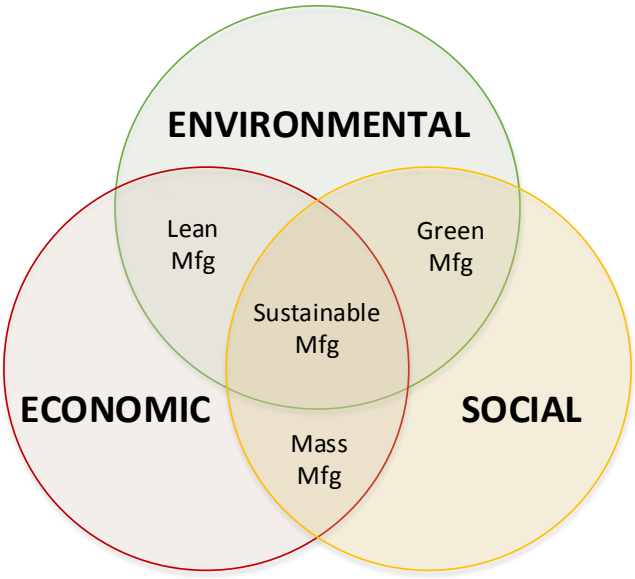

Figure 2.1Sustainable Development Triple Bottom Line

2.1.1.1 Motivations for Green Manufacturing

There are several driver to apply green manufacturing concept in a company. Those concepts are regulatory pressure, economics incentive, and competitive advantages. Regulatory pressure is usually conducted by the government which is aware to the significant environmental effect of industry. Regulatory pressure occurs to control the environmental impact, especially the wastes and emission. Government in several countries have developed policies, re gulations, and laws in order to achieve significant progress in advancing the environmental performance of industrial production activities. Besides that, several country also developed national programs on emissions management for example Toxic Release Inventory by United States. Moreover, green manufacturing themed conferences and workshops are often held to motivate the industry to implement sustainable strategies in industrial production.

The second driver of green manufacturing implementation comes from economic perspectives. Green manufacturing has been proven to reduce the cost in several aspects. It has been reported that the US manufacturers spend approximately US$ 4170 billion per year in waste treatment and disposal costs. By implementing green manufacturing, waste treatment and disposal costs should be able to be reduced since green manufacturing prevents waste occurrence. Appropriate to that

statement, green manufacturing would improve the profit margin of the manufacturing industry. A recent survey on the US commercial carpet manufacturers indicates that 84.6% of the manufacturers that adopt emission control strategies such as recycling water and diverting solid waste from landfills, and 100% of the manufacturer that adopt pollution prevention strategies like reducing raw material use and energy consumptions have successfully decreased their manufacturing cost.

Moreover, the competitive advantages that could be taken by the company are also the main driver of green manufacturing implementation. Due to the public's awareness and concerns about environment, green manufacturing can enhance the image of companies and thus increase the market share and the revenues of the companies. A recent analysis of 4000 manufacturing facilities in seven OECD countries found that there is a positive correlation between environmental performance and commercial success (Dornfeld, 2012).

2.1.1.2 Barriers to Green Manufacturing

Although green manufacturing is supported by several positive factors as its drivers, manufacturing companies still face barriers and challenges to implement it. The barriers are simply deployed into three categories which are economic barrier, technological barrier, and managerial barrier.

First barrier is economic barrier. Economics barrier refers to the capital cost or investment cost. Green manufacturing practices concern a lot on the emission control and waste management. To deal with those problems, green manufacturing needs high capital cost since its high requirements of facilities and knowledge. Moreover, the capital cost of green manufacturing may take a long time to be paid back.

Second major consideration is technological barrier. Manufacturing industry relies on certain processes, technologies, and material to sustain the business. Thus, manufacturers need to avoid undesirable effects due to lack of appropriate technologies or processes. On the other hand, formulating a suitable technology to the business which also comply with green manufacturing concept is not easy. This is caused by green manufacturing advance technology requirements.

The last major barrier comes from managerial perspective. Manufacturing is such a complicated system that numerous types of processes, materials, and system patterns are employed. Generic decision tools are difficult to use for the whole manufacturing industry as each manufacturing process or system has its own specificities. Moreover, manufacturing system is closely linked to many other industrial activities and the products from manufacturing impact almost everyone in society. This makes implementing green manufacturing in industry is a complex idea from managerial perspective (Dornfeld, 2012).

2.1.1.3 Principles of Green Manufacturing

For applying green manufacturing in industry, there are several principles that needs to be considered. Those principles are (Dornfeld, 2012):

1. A comprehensive systems approach must be used to evaluate and improve manufacturing processes from a green perspective.
2. The system should be wholly viewed across both the vertical and horizontal directions
3. Harmful inputs and outputs of the system to the environment and humans should be reduced or removed
4. Net resource use should be lowered
5. Temporal effects on the system should always be considered

2.1.1.4 Strategies for Green Manufacturing

Fundamental strategy of green manufacturing discusses mostly about environmental impact reduction which contains environmental emission control and impact remediation. Emissions of manufacturing activities are broadly classified as air emissions, water discharges, and solid waste. Dealing with those emissions, green manufacturing provides three basic treatments that could be done by manufacturer. Those treatments are pollution prevention, end-of-pipe control, and environmental restoration (Dornfeld, 2012).

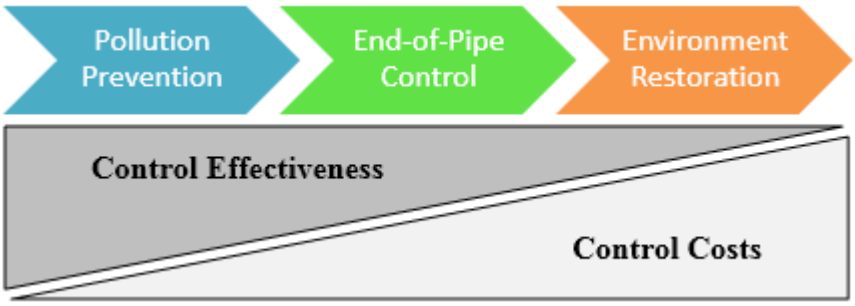

Figure 2.2 Strategies of Green Manufacturing

Pollution prevention means applying the emission control strategies before and during the emission generating process. This treatment is done through some preventive activities such as using less materials and energy and employing environmentally benign materials. Pollution prevention is more effective than two other treatments since it reduces the needs of advance waste treatment.

End-of-pipe treatment enable manufacturers to process the waste and emission that are generated from the manufacturing activities after all activities are done but before it is released to the environment. The techniques that can be used in this method are recycling, collection, and treatment.

Environmental restoration is a treatment for the environmental damage that is caused by the emission releasing done by the industry. Several examples of environmental restoration are hazardous waste management, site restoration, water treatment, airborne emission management. This treatments is costly and usually done due to out of control system or process (Dornfeld, 2012).

2.2 Green Industry Awarding Program

According to Pedoman Penilaian Industri Hijau, (Kementrian Perindustrian Republik Indonesia, 2014) Green Industry Awarding Program is awarding program that is given to industry which has put effort to save resource use and utilize renewable or environmental-friendly resource. This program is derived from Undang-Undang Republik Indonesia Nomor 3 Tahun 2014 pasal 3c Tentang Industri Hijau. This program is one of government strategy to acknowledge awareness level of industry about environmental issue and production efficiency in term of resource saving.

Green Industry Pilot Project is formulated from the vision and mission of Surabaya government period 2011-2015 and the objective of Green Industry Awarding Program. Vision of Surabaya government is "Becoming a better Surabaya as a service and commerce city which is intellect, humane, dignified, and environmentally-insightful". While the mission are:

1. Developing a smarter city life through improvement of human resources which is supported by the increasing of intellectual, mental-spiritual, skills, as well as the health quality of the citizens in an integrated and sustainable.
2. Providing a humane atmosphere of the city through increasing accessibility, capacity, and quality of public services, bureaucracy reforming, as well as the utilization of resources for the greatest city welfare of citizens.
3. Achieving a dignified life of the citizens through community-based economic development that promotes the expansion of access to the economy in order to support the increasing of creativity of all Surabaya citizens in strengthening the local economic structure that is able to compete in regional and international.
4. Creating more-habitable Surabaya city through physically and socially infrastructure development evenly and environmentally-insightful.

Moreover the objective of Green Industry Pilot Project in Surabaya is to encourage the companies in Surabaya to apply the principles of green industry concept. Besides, it is one of the responsibilities of industry as stated in Undang-undang Republik Indonesia Nomor 13 Tahun 2014 tentang Perindustrian pasal 3 ayat c. Participants of this program are classified into two groups. First group is small medium enterprise.

2.2.1 Appraisal Criteria for Large Industry

Large industry is an industry with net assets more than Rp 10,000,000,000 without business site. For large industry, the appraisal depends on three major category which are:

a. Production process

It contains production efficiency program, material input use, energy, water, process technology, human resource, and work environment in production process room.

b. Waste/emission management performance

It contains CO_2e emission reduction, environmental quality standards fulfillment, and waste/emission management facility.

c. Company management

It contains certification, Corporate Social Responsibility, employee health and awards.

Those three criteria are deployed in to several sub-criteria. The criteria and sub-criteria have different weight in term of appraisal scoring. Detail appraisal criteria is shown by the Table 2.1.

Table 2.1 Appraisal Criteria of Green Industry Awarding Program for Large Industry

No.	Scoring Aspect	Aspect's Weight	Sub-aspect	Criteria
1	Production Process	70	Production Efficiency Program	Company regulation in production efficiency program implementation
				Achievement level of company commitment of production efficiency program implementation
			Material Input	Input material ratio to output
				Input Material substitution
				Input material efficiency effort
				Input material licensing/certification and MSDS
			Energy	Energy efficiency effort
				Renewable energy utilization effort
				Periodic energy audit
			Water	Water efficiency effort
				Utilization of reuse water for production process

Table 2.1 Appraisal Criteria of Green Industry Awarding Program for Large Industry (con't)

No.	Scoring Aspect	Aspect's Weight	Sub-aspect	Criteria
1	Production Process	70		Water source conservation effort
				Periodic water use audit
			Process Technology	Reduce, reuse, and recycle program implementation
				Disposal water segregation from production process
				Process technology improvement
				Equipment performance
				Production process, input material handling, and maintenance SOP implementation
				Environmental friendly product innovation
				Reject and defect level of total product
			Human Resource	Improvement program of human resource capacity in term of production efficiency improvement
				Human resource which has competency certification
			Work environment in production shop floor	K3L performance monitoring and evaluation according to Permenaker No. 23 Tahun 2011
2	Waste and Emission Processing Performance	20	CO_2e emission reducing program	CO_2e emission reducing effort
			Environment quality standard fulfillment	Liquid waste
				Gas and dust waste
			Waste/emission processing infrastructure	Waste/emission processing infrastructure operational
3	Company Management	10	Certification	Product certification
				Management system

Table 2.1 Appraisal Criteria of Green Industry Awarding Program for Large Industry (con't)

No.	Scoring Aspect	Aspect 's Weight	Sub-aspect	Criteria
3	Company Management	10	CSR	CSR implementation
				CSR fund allocation
			Awarding	Received awards about production field and production industry management
			Employee health	Employee health checking

2.2.2 Appraisal Criteria for Small-Medium Enterprise

Small-medium enterprise is an industry with net assets of Rp 10,000,000,000 or less without business site. Criteria for small-medium enterprise also deployed into three major perspective which are:

a. Production process

   It contains production efficiency program, material input, energy, water, process technology, and human resource.

b. Environment and work safety management

   It contains waste and work environment.

c. Enterprise management

   It contains certification, Corporate Social Responsibility, and awards.

Those three criteria are deployed in to several sub-criteria. The criteria and sub-criteria have different weight in term of appraisal scoring. Detail appraisal criteria is shown by the Table 2.2.

Table 2.2 Appraisal Criteria of Green Industry Awarding Program for Small-Medium Enterprise

No.	Scoring Aspect	Aspect's Weight	Sub-aspect	Criteria
1	Production Process	70	Production Efficiency Program	Company regulation in production efficiency program implementation
				Achievement level of company commitment of production efficiency program implementation
			Material Input	Input material ratio to output
				Input Material substitution
				Input material handling
				Input material licensing and certification
			Energy	Energy management
				Energy efficiency effort
				Renewable energy utilization effort
			Water	Water efficiency and conservation effort
			Process Technology	Reduce and reuse program implementation
				Process and machine/equipment technology improvement
				Production process SOP implementation
				Reject and defect level of total product
			Human Resource	Improvement program of manufacturing human resource capacity
2	Environment Management and Work Safety	20	Waste	Waste treatment
				Waste utilization
				Waste quality Assessment
				Liquid waste quality standard fulfillment
				Gas and dust waste quality standard fulfillment
			Working Environmental	Occupational and environmental health and safety

Table 2.2 Appraisal Criteria of Green Industry Awarding Program for Small-Medium Enterprise (con't)

No.	Scoring Aspect	Aspect's Weight	Sub-aspect	Criteria
3	Company Management	10	Certification	Product certification
				Management system
			CSR	Social, economic, and surrounded environment concerns
			Awarding	Received awards about production field and production industry management

Based on the criteria above, the participants of green industry program will be classified into five levels of awarding. The awarding levels are shown in the Table 2.3.

Table 2.3 Green Industry Awarding Program Levels

Awarding Classification	Score Interval
Level 5	90.1-100
Level 4	80.1-90
Level 3	70.1-80
Level 2	60.1-70
Level 1	50.0-60

Based on those classification, only companies with the score of 50 or more are considered to have commitment in environment thus awarded with green industry award. Companies with score of 90.1 or more are considered to have implemented green industry concept sustainably.

2.3 Water Efficiency in Industry

Efficiency is the comparison of what is actually produced or performed with what can be achieved with the same consumption of resources (Business Dictionary, 2015). Thus water efficiency could be defined as reducing water wastage by measuring the amount of water required for a particular purpose and the amount of water used or delivered (Vickers, 2002). Water consumption can be a major operating cost for manufacturers. It could cost companies over 1% of business

turnover. Yet by using some simple control measures and inexpensive devices, this can be reduced by as much as 50%. These savings go straight to companies as well as conserving increasingly global resource scarcity.

Many people think water as a free resource, because as individuals society rarely have to account for its use at home. In reality water is a utility that is paid for twice, once on purchase and once on disposal. Freshwater resources in the more densely populated and farmed areas are reaching the point of being optimized. Thus managing water consumption and minimizing water waste are important. The use of water for manufacturing and industry represents 11% of total demand.

The cost of water varies in each region. This includes the suppliers' operating costs, suppliers' maintenance costs, water purchase, and water waste disposal. Disposal costs varies depending on the level of waste water treatment provided by the local sewerage utility. On the other hand, there are additional operating costs of water use and disposal for industry. On site water must be:

- Stored
- Treated
- Pumped around
- Heated and Cooled
- The storage and handling plant must be maintained
- Loss through leakage and spillage may not only increase water costs, they may also waste valuable raw materials and products
- Estimation of the total water cost is around three times of purchase and disposal cost.

2.3.1 Water Utilization in Plastics Industry

In the plastics and chemical sector, the biggest use of water is for cooling and steam production. Water is also a major raw material to make plastic products. Other significant uses include plant and vessel washing, product washing, vacuum pumps and air pollution control (New Zealand's Industry Association, 2015).

Figure 2.3 Coolant Water Making Process

In the prior years, water is often only metered as it comes onto site for billing purposes in general industry, although it has so many varied applications. Following industry increasing awareness to efficiency, many developed sites are now aware the need to meter steam use for energy efficiency programs. However, cooling water flows are still rarely measured.

Having a comprehensive metering system helps to locate leakage. Many plastics or chemical plants that have been developed over a period of year still face leakage problem. The most common problem is underground water mains. Regularly updated distribution network diagram and clear metering need to be applied in any industry in order to enable a full water balance which is constructed and reconciled with the water bill. Without those two, leakage can go undetected for years. Underground leakage can also have much more serious impact, including possible erosion of foundations and roads. If the leak becomes a serious burst pipe, it can result production losses.

In fact, water is the most common solvent used in industry and thus it is extremely valuable to industrial processes. Most water in the plastics or chemical industry is used once only. After being used, water is simply discharged to drain and either to sewer or an on-site treatment plant. Whereas it may be perfectly adequate for re-use in another process or as wash water before discharge.

A "water cascade" can provide opportunities for several cycles of re-use before it becomes too dirty and must be discharged. Every time certain amount of water is re-used, an equivalent volume of clean water does not have to be bought.

By reusing water in the production process, water consumption can be cut by 50%, 70% or even 90%.

2.3.2 Water Efficiency Program

Measuring water is used to establish a baseline water use. This will show how and where water is being used. It will also highlight those area which use the most water and indicate where any leakage may be undetected. To implement water measurement, manufacturers need to ensure that water use calculations include (New Zealand's Industry Association, 2015):

- Pumping costs
- Maintenance costs
- Treatment costs
- The costs of heating or cooling if the waste condition is hot water or cold water
- Disposal costs of resultant waste water (i.e. trade waste charges)

Regarding to this, simple housekeeping programs can be instituted to generate immediate water savings, raise staff awareness of the commercial importance of water savings, and provide a fund for more capital-intensive measures. Simple housekeeping measures which have been used in the plastics or chemical industry include (New Zealand's Industry Association, 2015):

1. Leak Detection Programs

   In industry, there are areas where water use is required but might be decreased. Thus there are several procedures to detect those opportunity, such as:

   - Monitor use over time to detect any leakage. The leakage will show up as rising consumption at times when it is not expected.
   - Leakage can arise from damaged pipeline connections, worn valves, flooded floats on water tanks and corroded pipe work.
   - Check water meters during down-time, e.g. shutdown or the end of a shift.
   - Consider the use of a systematic water minimization program.

- Consider the inclusion of water minimization issues within other training program.
- Triggered hoses

2. Water Use in Cleaning Procedures Reducing Programs

Second use of water in industry is in cleaning field. Since cleaning procedure take a major role, then it needs to be optimized towards reducing water consumption. Several action to optimize water consumption in cleaning procedures are (New Zealand's Industry Association, 2015):

- Eliminate unnecessary wash downs
- If water is used for washing, examine if it can be circulated a number of times, e.g. using dirty water as a pre-wash.
- Some companies utilize water back booth filtration systems which remove solids from the effluent. As a result, booth effluent only needs to be tanked away twice per year rather than once per quarter.
- As water is used in condensers to cool solvent-based metal degreasing plants, attention should be paid to the location of the degreaser, water pipes and water storage tank. The closer this equipment is to sources of heat (e.g. process machinery) the more water and energy will be required for cooling.
- Opening loop water cooling is sometimes employed by using a constant stream of fresh water. Consideration should be given to close this loop using a water tank and cooling tower.
- Valve, pipe and pump maintenance.

3. Monitoring and Evaluating Programs

Once the water balance has been completed, it is important to update it regularly so that the impact of any activities is transparent. This naturally leads to targets setting for production and ancillary use of water utilization monitoring. For that, monitoring and evaluation to the program that has been developed is important.

2.4 Root Cause Analysis (RCA)

According to Bjørn Andersen and Tom Fagerhaug in their book titled Root Cause Analysis: Simplified Tools and Techniques (Andersen & Fagerhaug, 2006), RCA is a structured investigation that aims to identify the true cause of a problem and the action necessary to eliminate it. They stated that RCA is defined as a collective term used to describe a wide range of approaches, tools, and techniques which is used to uncover causes of problem.

Andersen and Fagerhaug stated that RCA tools can be differed based on its purpose. They are problem understanding, problem cause understanding, problem cause data collection, problem cause data analysis, root cause identification, root cause elimination, solution implementation. Each purpose contributes in their own way to the root cause analysis. Some are best applied sequentially, however others can be applied at many different points in the analysis. Deeper explanation of each purpose and the tools that are part of concerned purpose can be explored as follows (Andersen & Fagerhaug, 2006):

1. Tools that are purposed to problem understanding could help the analyst to get to the fundamental of problems. This phase focuses on understanding the nature of the problem. Problem understanding is a first step before starting the analysis. Several tools that are conducted in this purpose are:
    a. Flowchart: chart used to paint a picture of business process
    b. Critical incident: an approach used to explore the most critical issues in a situation
    c. Spider chart: a comparison chart used to benchmark problems
    d. Performance matrix: used to help determine the importance of problem or causes.
2. In term of problem cause brainstorming, RCA tools could be applied at different stages in the analysis. By doing brainstorming the analyst can generate ideas about possible causes. Since the analysis is normally carried out in groups, tools could help the analyst arrive to consensus solutions. Those several tools are:

a. Brainstorming: a formal approach that can be applied throughout the root cause analysis when multiple ideas are required.
b. Brain-writing: in effect, a written brainstorming session
c. Is-is not matrix: a matrix tool to help a group prioritize different alternatives, for example, possible problem causes.
d. Paired comparison: a technique used to reach consensus by allowing participants to choose between pairs of two competing alternatives.

3. In purpose of problem cause data collection, RCA tools could be used to systematically and efficiently collect data related to a problem and its probable cause.
   a. Sampling: used to surmise data on a large population by collecting only a small sample.
   b. Surveys: used to collect data about opinions and attitudes from customers, employees, and so on.
   c. Check sheet: a useful approach that systematically collects data based on predefined sheets that are applied throughout the collection period.
4. Tools that are applied in order to analyze problem cause data imply that RCA tools are used for making the analysis from collected data. When analyzing the same data from different angles, different conclusions might emerge. Some conclusion may not uncover the problem's causes, it is important to have several data analyzing tools available. Several tools in this purpose are:
   a. Histogram: an easy-to-use visual diagram that helps identify patterns or anomalies.
   b. Pareto chart: another visual tool to illustrate which causes generate the most effect
   c. Scatter chart: used to illustrate relationship between two causes or other variables in thee problem situation.
   d. Problem concentration diagram: a visual chart that maps the layout or structure of a site or system and is used to identify where problem occur.

e. Relation diagram: a tool used to identify logical relationships between different ideas or issues in a complex or confusing situation
f. Affinity diagram: a chart that helps correlate seemingly unrelated ideas, causes, or other concepts so they might collectively be explored further.

5. Tools that are purposed to identify root cause are the heart RCA. Root cause analysis is not one single approach, and neither is this group of tools. You can use there tools to more deeply analyze the problem's root cause. Those tools are deployed as follows:
   a. Cause and Effects Chart: an easily applied tool used to analyze possible causes of a problem.
   b. Matrix diagram: a visual technique for spotting relationships between factors and analyzing causal relationships between them. The diagram can thus be used to determine which of different possible causes contribute the most to a problem
   c. Five whys: an approach used to delve ever more deeply in causal relationship.
   d. Fault tree analysis: a tool for looking forward and anticipating what problems can occur in system, product, or business process.
6. Tools that is developed to eliminate the root cause could be used to devise solutions that will remove the root cause and thus eliminate the problem. Those tools are differed as follows:
   a. Six thinking hats: a technique to force people to change their perspective and think according to different roles.
   b. Theory of inventive problem solving (TRIZ): a technique based on breaking down a problem into recognizable standard engineer problems with known solutions.
   c. Systematic inventive thinking (SIT): a tool building further on TRIZ, containing four principles for approaching a problem and its components.

7. In order to implement solution, RCA tool here is the techniques and advice to aid the change process of implementing the solutions. This tool is:
    a. Tree diagram. Used for planning project, for example an improvement implementation.

On the other hand, Rooney and Heuvel (Rooney & Heuvel, 2004) argued in their book that there are several step towards conducting Root Cause Analysis method. These steps must be executed in order to understanding why an event occurred, developing effective recommendations, and at the end achieve the goal of RCA. These several steps are:

1. Data collection.

   Data collection step in the analysis is performed in order to gather data. Without complete information and an understanding of the event, the causal factors and root causes associated with the event cannot be identified. Majority of time spent analyzing an event is spent in gathering data.

2. Causal factor charting.

   This step provides a structure for analyst to organize the gathered information during the investigation and identify gaps or deficiencies in knowledge as the investigation progresses. The causal factor chart is simply a sequence diagram with logic tests that describes the events which lead up to an occurrence and the conditions surrounding these events.

   Data collection continues until the investigators are satisfied with the thoroughness of the chart (and hence are satisfied with the thoroughness of the investigation). When the entire occurrence has been charted out, the investigators are in a good position to identify the major contributors to the incident, called causal factors. Causal factors are those contributors (human errors and component failures) that, if eliminated, would have either prevented the occurrence or reduced its severity.

3. Root cause identification.

   After all the causal factors have been identified, the investigators begin root cause identification. The map structures the reasoning process of the investigators by helping them answer questions about why particular causal factors exist or occurred. The identification of root causes helps the investigator determine the reasons the event occurred so the problems surrounding the occurrence can be addressed.

4. Recommendation generation and implementation.

   The next step is the generation of recommendations. Following identification of the root causes for a particular causal factor, achievable recommendations for preventing its recurrence are then generated.

   The root cause analyst is often not responsible for the implementation of recommendations generated by the analysis. However, if the recommendations are not implemented, the effort expended in performing the analysis is wasted. In addition, the events that triggered the analysis should be expected to recur. Organizations need to ensure that recommendations are tracked to completion.

2.5 Analytical Hierarchy Process (AHP)

Analytic Hierarchy Process (AHP) is a multi-criteria decision-making approach that was introduced by Saaty. AHP has attracted the interest of many researchers mainly due to the nice mathematical properties of the method and the fact that the required input data are rather easy to obtain. AHP is a decision support tool which can be used to solve complex decision problems. It uses a multi-level hierarchical structure of objectives, criteria, sub-criteria and alternatives. The pertinent data are derived by using a set of pairwise comparisons. These comparisons are used to obtain the weights of importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion. If the comparisons are not perfectly consistent, then it provides a mechanism for improving consistency (Triantaphyllou, 1995).

2.5.1 Benefits of AHP Method

AHP is often used in multi criteria decision making problem since it has several advantages in the application. Those advantages more or less are described with these points (Ciptomulyono, 2014):

1. AHP is hierarchical structured. It could conduct comprehensive assessment through deep criteria that build the goal.
2. AHP calculate the validity until the limit of inconsistency tolerance of criteria and alternative that are selected by decision making.
3. AHP considers the output of sensitivity analysis in decision making.
4. AHP is developed depending on the measurement theory that put the qualitative and "intangible" criteria into account.
5. AHP gives attention to steps development process and dialectic of human being in decision making
6. AHP accommodate logic, experience, emotion, intuition, and subjectivity of the assessor systematically.

2.5.2 AHP Steps

In implementing AHP methods, there are several steps that must be conducted. Those several steps are (Ciptomulyono, 2014):

1. Build the hierarchy of decision element. It can be done by defining the problems and listing the decision making hierarchically.
2. Collect preference data by comparing each alternative. This step is employed by implementing pairwise comparison that is developed by Saaty.
3. Determine the priority and importance weight of each criteria in one hierarchical level by using pairwise comparison.
4. Assess the consistency of pairwise comparison that has been done to determine the weight and preference score in previous step.
5. Conduct the calculation for each alternative in all hierarchical level.

To perform the pairwise comparison in obtaining the weight of criteria either the preference value for each alternative according the criteria, certain number are needed. These number represent the expert judgment value of the

experts. The classification of the number can be shown on the Table. 2.4 (Triantaphyllou, 1995)

Table 2.4 Scale of Relative Importance

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	An activity is strongly favored and its dominance demonstrated in practice
9	Absolute importance	The evidence favors one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed

2.6 Net Present Value

Net present value identify the gap between present investment values with future cash flow which is withdrawn to the present value. Before doing the calculation, the relevant interest rate must be determined first as the base. If the net present value of future flow is greater than present investment values, then the investment is considered as feasible. The formulation to acquire the NPV is provided as follows (Pujawan, 2003).

$NPV = FV/(1+i)^1 + ... + FV/(1+i)^n$ .....(Equation 2.1)

FV = inflow or outflow value

i = interest rate

2.7 Brown Gibson Method

Brown–Gibson model is one of many multi-attribute decision making techniques. The method was developed in 1972 by P. Brown and D. Gibson. This

is one of the few models which integrates both objective and subjective factors in decision making (Çankaya University Department of Industrial Engineering, 2012).

For subjective factor a formulation has been developed as follows.

$SFi = \sum Rij * Wj$ ..... (Equation 2.2)

SFi = Subjective Factor recommendation *i*

Rij = The score of recommendation *i* in criteria *j*

Wj = The weight of criteria *j*

On the other hand, objective factor has a formulation as follows.

$OFi = (Pi * \sum 1/Pi)^{-1}$ ..... (Equation 2.3)

OFi = Objective Factor recommendation *i*

Pi = Cost of recommendation *i*

Equation 2.2 assumes that the objective factors are cost-based. If the objective factors are profit-based, then a negative sign has to be multiplied to the previous objective factor and thus Equation 2.2 can still be used (Çankaya University Department of Industrial Engineering, 2012).

In order to combine both objective and subjective factor, preference measure is obtained with the equation below.

$PMi = (k * OFi) + ((1 - k) * SFi)$ ..... (Equation 2.4)

PM = Preference Measure recommendation *i*

k = preference index

2.8 Previous Research in Water Efficiency or RCA

Research about water efficiency have been conducted for several time. Those research could be used as support to manage this research. At least there are three research about water efficiency.

First research is a journal titled A Technical Review of Emerging Technologies for Energy and Water Efficiency and Pollution Reduction in the Textile Industry (Hasanbeigi & Price, 2015). This research was conducted by Ali Hasanbeigi and Lynn Price. Generally this research gave an overview of textile industry processes and compiles available information on the energy savings, environmental and other benefits, costs, commercialization status, and references

for 18 emerging technologies to reduce the industry's energy use and environmental emissions. This paper was intended to be a resource on these emerging technologies for engineers, researchers, investors, textile manufacturers, policy makers, and other interested parties.

Second research titled "Identifying Water Recycling Strategy Using Multivariate Statistical Analysis for High-Tech Industries in Taiwan" by Wen-Shyong Lin et al (Lin, et al., 2015). This research illustrated the usefulness of multivariate analysis fore valuation and interpretation of complex water use related datasets, and in assessment of water recycling and reuse strategies for effective water resource management. Multivariate statistical techniques in this research was divided into cluster analysis (CA) and discriminant analysis (DA). Those two analysis were applied in this study for the evaluation of water resource management strategies in high-tech industries, on the basis of the existing water use data of 70 participating plants in Taiwan since 2011. The existing water use data were collected and transformed into detailed water balance charts to recognize the water use performance. Later, water use performance at individual plants was evaluated by three indices, namely the "processing water recovery rate", the "plant water recovery rate", and the "plant discharge rate".

Results of this research showed that increasing in the ratios of effluent recycled to pure water system (EPWR) and recycled to secondary water system (ESWR) had positive effects on achieving higher water use performance. On the other hand, process water consumption and ESWR were influential factors in discriminating samples with lower water use performance. The results also confirmed that improvement on both EPWR and ESWR contributed to the highest water use performance. From this research it is renowned that opportunities for water recycling in high-tech industries appears to be technically feasible, future efforts could usefully be undertaken to implement further investment on water-use efficiency and novel treatment techniques, and investigation on various reuse purposes.

The last research is titled The Role of Water Auditing in Achieving Water Conservation in The Process Industry which was conducted by Dani Jennifer Barrington et al (Barrington, et al., 2013). This study investigated the use of water

auditing techniques to examine water flows within a petroleum refinery, concurrently identifying practical ways for achieving water conservation. The work illustrated that, even in a refinery with processes considered highly efficient within the industry, many opportunities existed to improve water conservation through technical, cultural and behavioral adaptations. These included the use of alternate water sources such as rainwater runoff, reuse of water within process units, and the introduction of an overarching company policy to minimize water use and effluent discharge. Water auditing was developed by two audit process which were primary level audit and secondary level audit. As the result, this study demonstrated that water auditing could be used to identify both the current weaknesses of site water management and the potential for technical and behavioral improvements, including through aligning corporate strategy with water management goals.

On the other hand**,** previous research with the RCA method have been conducted before. These research could give insight to the author about how apply those methods to certain problems. There is one example of research with RCA method.

This research is titled "A Root Cause Analysis for Arctic Marine Accidents from 1993 to 2011" (Kum & Sahin, 2015). The aim of this paper was to investigate the marine accidents/incidents which were recorded by Marine Accident Investigation Branch (MAIB) as occurring north of 66'33^{o} from 1993 to 2011 to reveal their causes by using root cause analysis. Root Cause Analysis (RCA) was proposed to clarify the causes and prevent the future incidents from happening. As an empirical study, fault trees of collision and grounding for the Arctic Region was constructed. Fuzzy Fault Tree Analysis (FFTA) was applied to this problem in order to propose a recommendation to reduce the occurrence probabilities. Risk levels of each factors were determined by expert consultations. In this study, Accident to Person was found as the most observed incident. Negligence/careless of injured person had the highest priority for root causes of marine accidents. In order to combat this phenomenon, scientific results of this study could open up a dialog between law makers and shipping companies those aim to decline incidents. Furthermore, it was assumed to contribute representatives developing crew training

manuals and competence requirements as well as opening Arctic navigation training centers.

CHAPTER 3
RESEARCH METHODOLOGY

In this chapter, the methodology of the research is determined. This chapter provides explanation on how the research is conducted.

3.1 Flowchart of Methodology

The methodology is a framework that guides the author how to do the research. The flowchart is shown in Figure 3.1.

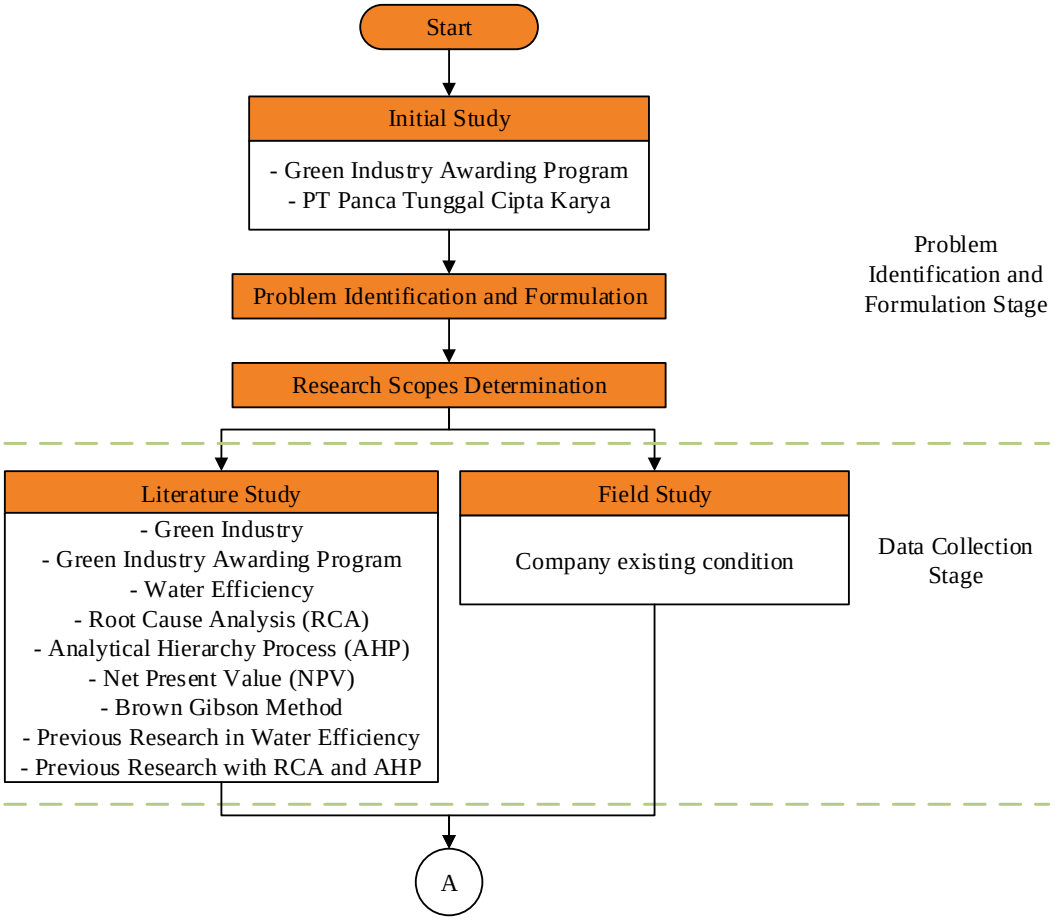

Figure 3.1 Flowchart of Methodology

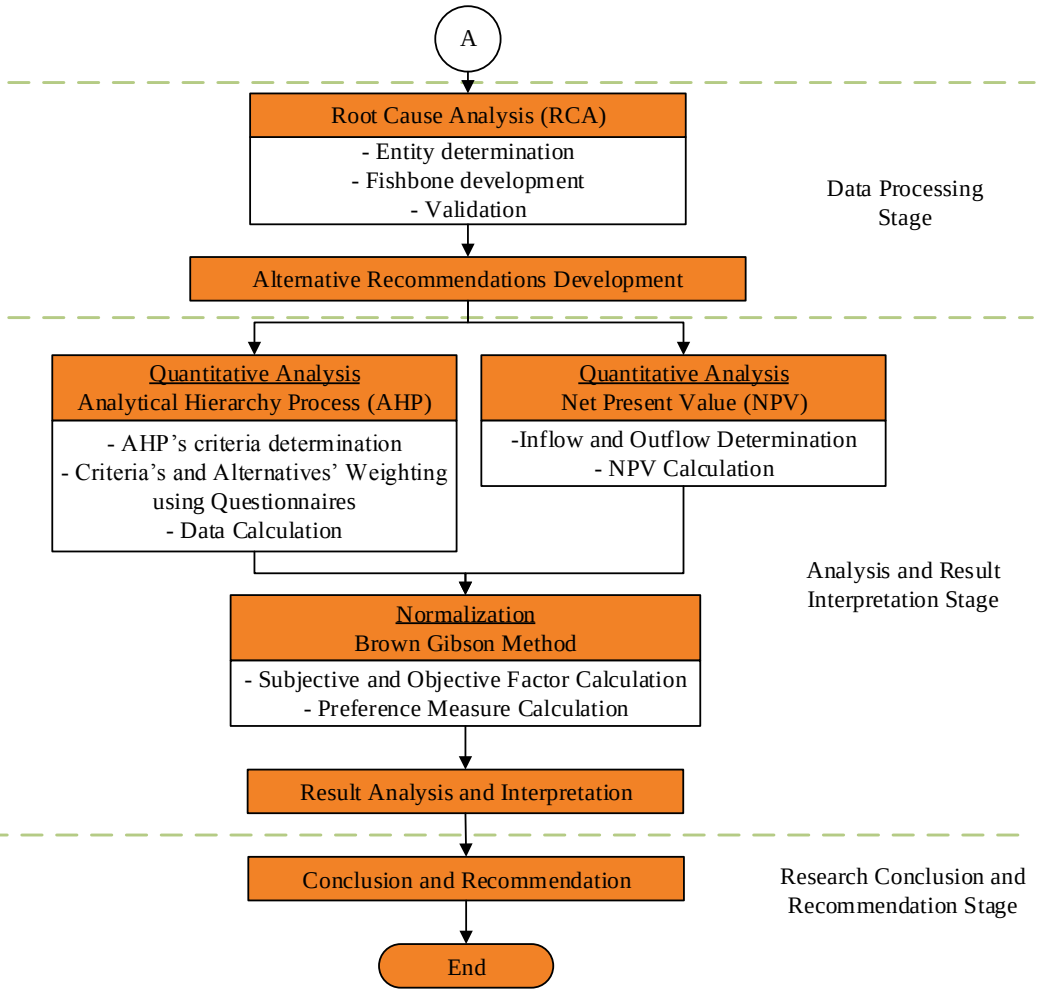

Figure 3.1 Flowchart of Methodology (con't)

To achieve research's goal, the author will break down the root causes of the company activities that conduct inefficiency use of water. The method which is used to obtain root causes is Root Cause Analysis (RCA). This method could figure out the main problems of the activity and the root cause of it (Fouad & Mukattash, 2010). According to the root causes which are found, the recommendation alternatives will be developed. Not all recommendation will be implemented since the company has constraint in investment cost and resource. To obtain the most suitable recommendation to be implemented, Analytical Hierarchy Process (AHP) approach is proposed. AHP approach will assess the recommendation based on the several factors that could influence the implementation process. By doing these steps of research, the author could give a recommendation to the company in how to improve their water use efficiency in the most significant way.

This research is started by problem identification and formulation stage. The second stage is data collection stage. The third stage is data processing stage. Next stage is analysis and result interpretation stage. Moreover the last stage is research conclusion and recommendation stage.

3.2 Flowchart Explanation

From the flowchart above, this research could be deployed to 5 steps which are problem interpretation and formulation, data collection, data processing, analysis and result interpretation, and research conclusion and recommendation step. Deeper explanation would be done in the subchapters below.

3.2.1 Problem Identification and Formulation Stage

In problem identification and formulation stage, there are several steps which are initial study, problem identification and formulation, and research scope formulation. Initial study is a study to understand the basic information about the object. From initial study, it will be derived the problem of the company to reach the standard in term of green industry. After formulating the problem, research scopes of the research are things that are determined.

3.2.1.1 Initial Study

Initial study is done by doing quick research about Green Industry Awarding Program. The research is about the purpose of this program, how this program is conducted, and especially what the criteria expected from the company that is participated in this program. On the other hand, study about the company is also conducted. This study is done by doing direct observation to company's condition and interview to the owner of the company. From this study, it is expected the problems of the company could be recognized.

3.2.1.2 Problem Identification and Formulation

From the previous initial study, it is known the goal that is wanted to be reach from Green Industry Awarding Program and the existing condition from the company from direct observation. By comparing the goal and the existing condition, the researcher could recognize the gap. The gap is matters that want to be erased. Since that the gap could be said as problems.

In PT. Panca Tunggal Cipta Karya Sentosa, there are two problems that are detected. They are water use saving and defect existence. These problems will be solved through two different research which will be done by two different researcher. In this research itself, water use saving will be the main focus. Thus, problem formulation in this research is how to give solution to the company in order to improve water use saving activity through selected recommendation.

3.2.1.3 Research Scopes Determination

After formulating the problem, research scopes need to be determined towards bordering the research. Thus the research is feasible to be done appropriate to the constraints of the research. Research scope is constructed by the limitation and the assumption. Limitations are used in the research to give clear illustrations in how far the research will be conducted. Besides, assumptions are created to affirm the research validity although the data is limited.

3.2.2 Data Collection Stage

Data collection stage is done to gather deeper information about the particular matters that are involved in the research. Data collection is done through two different approach. First is literature study and second is field study.

3.2.2.1 Literature Study

Literature study is done to support the research by enriching the knowledge from theoretical perspective. Literature study is derived from several sources which are journal, previous final project, and any related reliable source. Thus this stage discusses the green industry topics, green industry awarding program, plastics industry in the world and its movement to sustainability, root cause analysis method, and analytical hierarchy process method.

3.2.2.2 Field Study

In this stage, the author observes directly to the company to find needed data. Field study will be done through directly observing the company condition and interviewing the owner, the employee of the company, and other concerned stakeholder. Type of needed data that will be collected from this step is primary data.

3.2.3 Data Processing Stage

Data processing stage is started by mapping the problem of the company in water use with root cause analysis method. The output of RCA method will be fishbone diagrams which is provided to give insight what actual root causes of each problem are. From the root cause that has been determined before, the author will develop several recommendation that is suitable to the problem and the company condition. Those several recommendation will be chosen by using AHP approach considering several factors. The factors itself are determined by the stakeholder involved to the program such as the owner and the employee. The factors assessed is not only quantitative factors but also qualitative factors.

3.2.3.1 Root Cause Analysis (RCA)

RCA method is applied to all activity that involves water in its process. Observation to all activity is used to give comprehensive background to the problem. Then, entities from each problem in each activity are developed in order to capture all possibilities that result causes. According to those entities, the root causes of each problem are determined. RCA method is constructed by the author based on direct observation in the company. After the RCA is developed, it will be validated to the owner of the company to assure that the RCA has represented the actual condition and problem of the company.

3.2.3.2 Alternative Recommendation Development

By considering the main cause of the problem in each activity, recommendation alternatives are developed. These recommendation alternatives are expected to answer the problem itself. The development of recommendation will take theoretical literature and technical application in other company as the main guidance. On the other hand, alternatives recommendations must take existing condition as the main consideration. Thus the recommendations are still feasible to be implemented in the company.

3.2.4 Analysis and Result Interpretation Stage

This stage is a stage to analyze the result of data processing stage. The analysis are taken from qualitative and quantitative perspective. Qualitative perspective is approached by AHP method, while quantitative perspective is

approached by NPV method. Both perspectives will be combined using Brown Gibson method.

3.2.3.3 Qualitative Analysis: Analytical Hierarchy Process (AHP)

AHP is started by developing the criteria that will assess the recommendation alternatives. The criteria are determined from intensive discussion with related stakeholder such as owner and employee. Focus group discussion here will be done in order to have comprehensive criteria of recommendation that is suitable with company condition.

After developing the criteria, the weight of each criteria and the score of each alternative based on each criteria are determined. Both weight of criteria and the score of each alternative will be given by expert through questionnaires. The expert in this case is related stakeholder in decision making which is the owner.

The last step is calculating the score based on the hierarchy which has been developed. The output of this method is ranking of recommendation according to its feasibility of implementation in the company.

3.2.3.4 Quantitative Analysis: Net Present Value (NPV)

NPV is done to all recommendations to see whether the recommendations are economically beneficial. In this research, NPV is started by forecasting the needs and benefits from each recommendation. The needs will be the outflows and the benefits will be the inflows. The outflows and the inflows will be calculated using NPV formulation. As the assumption, the calculation uses 0.075 as the interest according to Indonesia Central Bank. Thus the company could recognize the value of the recommendation in the present.

3.2.3.5 Normalization: Brown Gibson Method

Normalization is done in order to combine both qualitative and quantitative values. The qualitative value which is derived from the AHP score does not to be normalize since the value has been in the standard score. However the quantitative value still needs to be normalized since NPV value is not in the standard score. After that, quantitative and qualitative values are combined with weight for each perspective. The weight will be set in several scenarios to see the sensitivity of the result.

3.2.5 Research Conclusion and Recommendation Stage

This stage is the final stage of the research. Research conclusion stage is done by formulating the conclusion in term to answer the objectives of the research. On the other hand, recommendation is developed towards giving advice of research execution and as the input for next similar research.

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CHAPTER 4
DATA COLLECTION AND PROCESSING

Data processing conducts elaboration about initial study of the company, root cause analysis, and the development of alternative recommendations.

4.1 Initial Study of PT. Panca Tunggal Cipta Karya Sentosa

The initial study elaborates deep description about the company profile, business process, manufacturing process, and water utility in PT. Panca Tunggal Cipta Karya Sentosa

4.1.1 General Description of PT. Panca Tunggal Cipta Karya Sentosa

PT. Panca Tunggal Cipta Karya Sentosa is a plastic manufacturing company which is located in Pergudangan Margomulyo Jaya Blok B.23. This company is established in 2011. In 5 years, the company has developed their business until employing 32 workers and investing 8 injection machines. PT. Panca Tunggal Cipta Karya Sentosa divides their work hours into three shifts which are 07.00 AM - 03.00 PM, 03.00 PM - 11.00 PM, 11.00 PM - 07.00 AM.

PT. Panca Tunggal Cipta Karya Sentosa produces many kind of plastic household and stationery product like plastic jar, hanger, clip board, and bucket. This company distributes their product to the retailer of plastic product. Their main customer are household store, minimarket and stationery store around Surabaya.

Figure 4.1 Example of Product: Plastics Bucket

Currently, PT. Panca Tunggal Cipta Karya Sentosa runs their business based on the requirement of the customer. Hence, the variety of the product produced in the company is large. It has more than 50 different molds of product. The biggest order are for hanger, bucket, maps manager, plastic bowl, and plastic jar. Therefore, to fulfil the demand, PT. Panca Tunggal Cipta Karya Sentosa could produce 5 tons of each product. Besides, this company also rents their mold to other plastic injection manufacturers to earn more income.

On the other hand, the supplier of PT. Panca Tunggal Cipta Karya Sentosa are several uncertain supplier in Surabaya and nearby. Several uncertain suppliers are used because the price of plastic is much fluctuated and thus this company is always looking for supplier that provides lowest price.

PT. Panca Tunggal Cipta Karya Sentosa is built on 30 meters x 20 meters industrial location. Roughly the layout of this company is shown in the Figure 4.2.

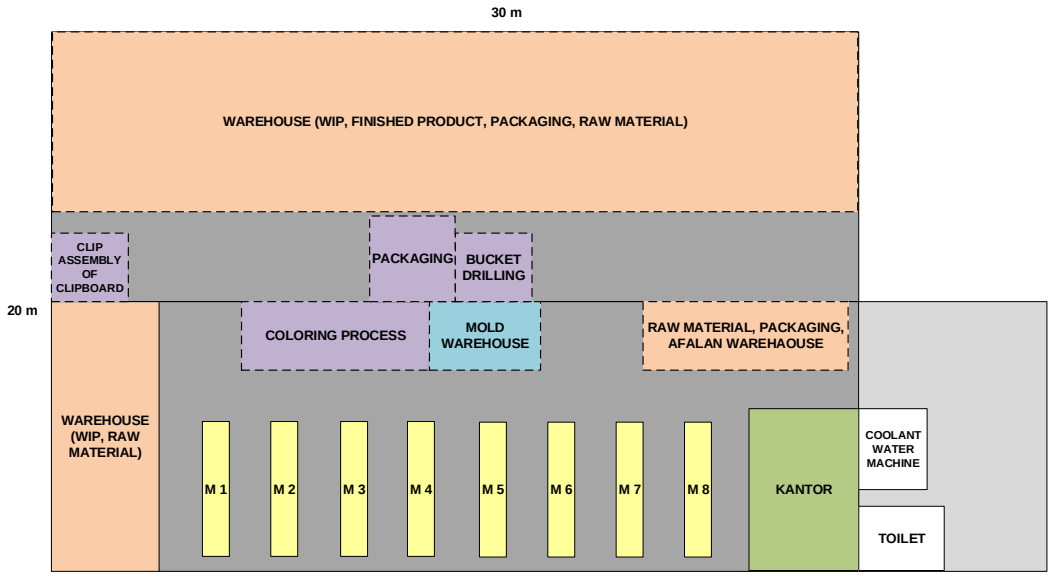


Figure 4.2 PT. Panca Tunggal Cipta Karya Sentosa Layout

Basically this company is divided in two chambers. One is the processing area and the other is the warehouse. The illustration is shown by Figure 4.3 and Figure 4.4.

Figure 4.3 Warehouse Area

Figure 4.4 Processing Area

In term of being environmentally-friendly, PT. Panca Tunggal Cipta Karya Sentosa has done several activities. Firstly, this company has utilized the waste of production as their raw material for the next production process. This waste is called "afalan" material. This strategy will reduce the raw material procurement cost but will add other cost of processing the "afalan" itself.

Figure 4.5 Afalan Raw Material

Secondly, the company has implemented reducing effort in energy use. PT. Panca Tunggal Cipta Karya Sentosa commits to press the use of lamp by changing some part of the shop floor roof with clear glasses. Hence, there is no need to use lighting in daylight. Moreover, the company utilize high efficiency machine as their preference. Thirdly, in term of safety, the company has applied K3L effort such as provide the employee with safety tools and equipment such as gloves. However the matter of this regulation is that not all employee longs to use the safety equipment. Fourthly, in term of water using, the company has regulation that is applied to all employee not to utilize water for bathing.

4.1.2 Manufacturing Process of PT. Panca Tunggal Cipta Karya Sentosa

PT. Panca Tunggal Cipta Karya Sentosa operates their production process through batching methods. This batching method is separated based on the color and type of product. One batch could process 30 kilograms of raw materials of each machine.

Overall steps of production could be described as the Figure 4.6. All process stated in the figure is operated by the company itself including the afalan processing. Moreover, the additional processes are only conducted for clip assembly in clipboard and wire installing in bucket. The scrap that is produced in

drilling process of wire installing will be the afalan also. The afalan later will be processed first become tiny pieces of afalan cutting resembling the plastics ore.

Packaging, cutting, and labeling process is done manually, while injection, additional, and afalan process are done semi-automatically with machine. The additional input other than product such as the label, the wire, the packaging, and the clip are procured from the supplier.

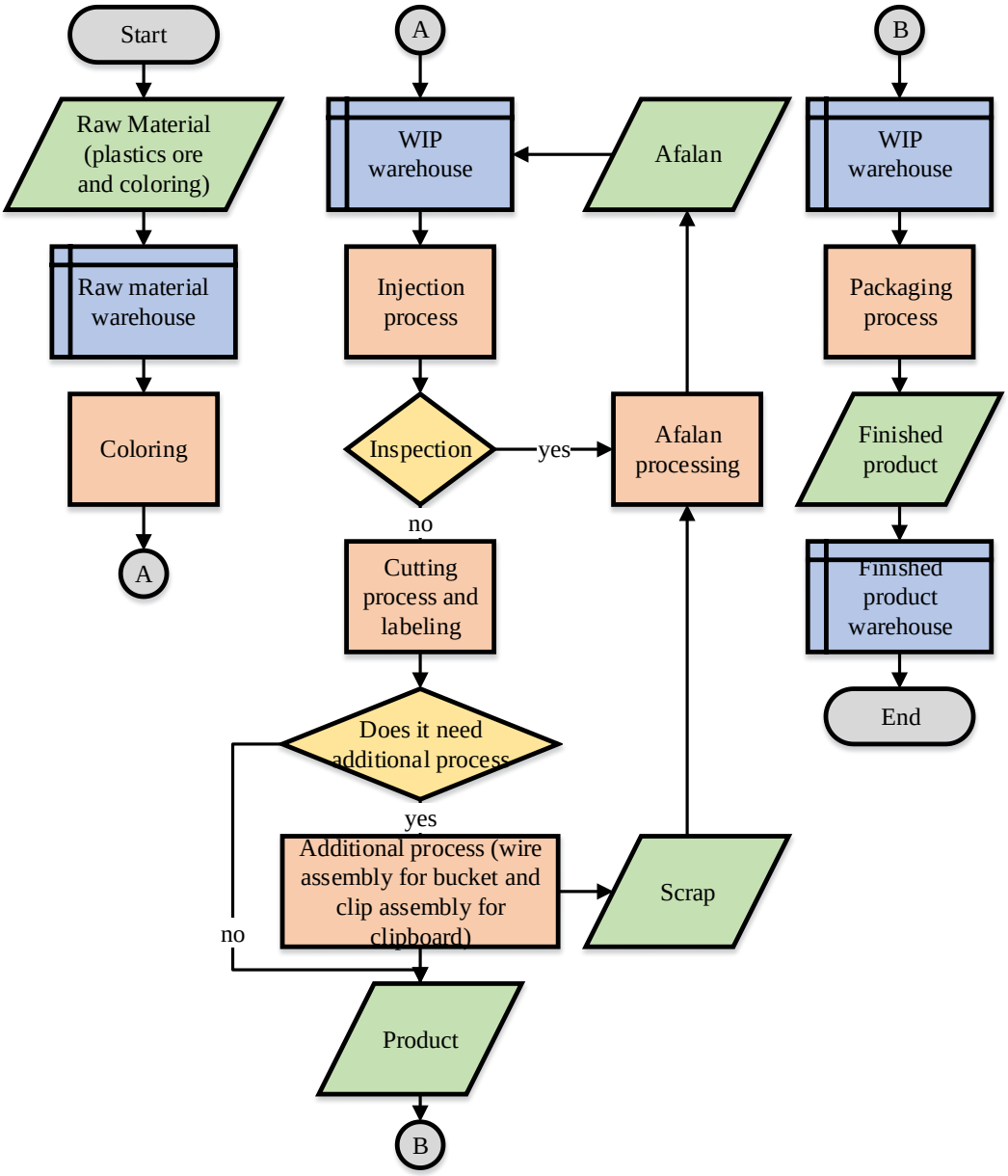


Figure 4.6 PT. Panca Tunggal Cipta Karya Sentosa Production Process Flowchart

Figure 4.7 Coloring Process

Figure 4.8 Injection, Inspection, Cutting, and Labeling Process

4.1.3 Water Utility in PT. Panca Tunggal Cipta Karya Sentosa

Water utilization in this company is purposed for two main activities which are toilet & cleaning activities and production process. In more detail overview, water use flow in this company could be captured as Figure 4.9.

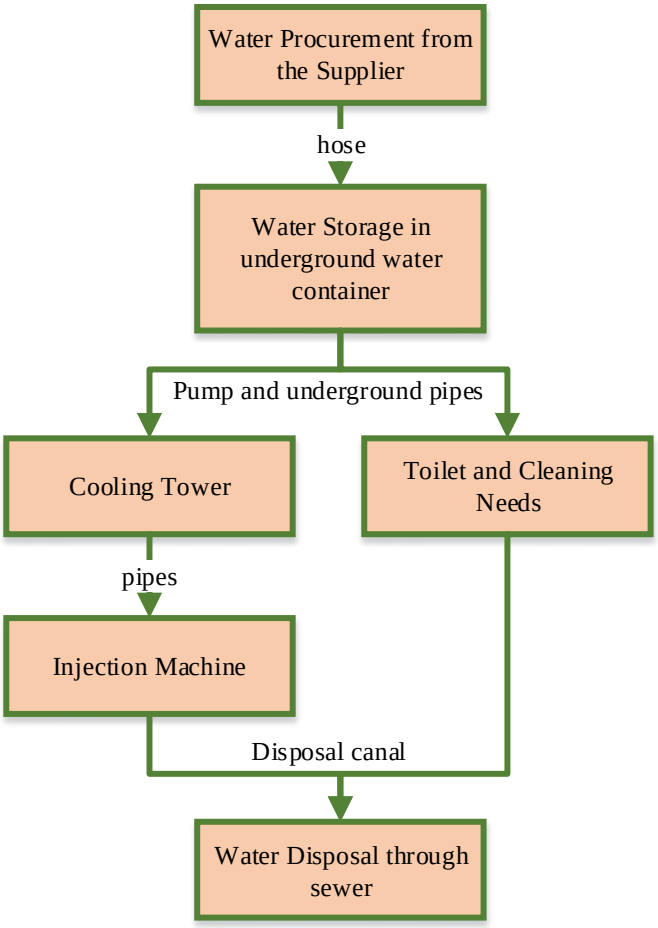


Figure 4.9 Water Use Flow

Each activity in the flowchart would be explained as follows.

4.1.3.1 Water Storage

First phase of water flow in this company is water procurement. The water is not supplied by PDAM because the reconstruction of the PDAM pipes have not reached the location of the company. On the other hand, the company could not use land water since the location of the company is in the coast which is brackish and thus not suitable to metal-formed machine like the company uses. This situation makes the company should buy it from the water supplier outside the plant area. As known, this type of water supply would cause more expensive price. With this supplying method, the company should expend Rp 2.500.000/month, while actually they can expend only about Rp 1.000.000 if PDAM stream could reach their area.

In water procurement process, the water would be delivered by the water supplier with truck. Later the water will be contained in the underground water container. The distribution from the truck to the water container is done using hose.

Water container is purposed as the water back up to all activity in the company. Then, to distribute the water to the next water flow, the company uses pump. The figure of the underground water container and the pump could be seen in the Figure 4.10.

Figure 4.10 Underground Water Container and the Pump

The problem in this process is occurred in the distribution from the water truck to the underground water container. The hose that is used in the process is often discovered leaking. The leakage is caused by improper between-hose connection.

4.1.3.2 Cooling Tower

Cooling tower is used to produce cooling water that will be circulated to the injection machine in the next stage. Basically cooling tower will transfer the heat of water through vapor that will be evaporate to the atmosphere and so a small amount of makeup water is required. Figure 4.11 shows the illustration of cooling tower process as stated before. Figure 4.12 shows the cooling tower picture in the company.

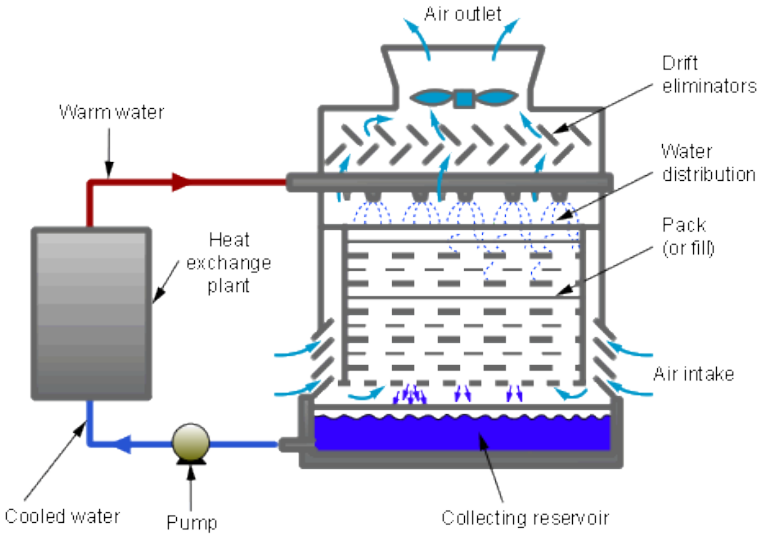


Figure 4.11 Cooling Tower System

(Commonwealth of Australia, 2012)

Figure 4.12 Cooling Towers at PT Panca Tunggal Cipta Karya Sentosa

The company has a type of cooling tower with 2 different sizes. The first machine (left side in the figure) has height of 220 cm and diameter of 162 cm. On the other hand, the second one (right side in the figure) has height of 183 cm and diameter of 142 cm. Whereas, the basin of the first machine is 162 x 324 x 100 cm in dimension and thus could contain about 5,248.8 liters; the basin of the second

machine is 183 x 368 x 100 cm in dimension and thus could contain about 6,734.4 liters

The problem of these two machines is about the water that may be splashed during the cooling process. Actually these splash are recognized as the vapor that needs to be produced in order to transfer the heat of water. The water splash is produced in tiny size but the amount is huge. Moreover the splash is produced as long as the coolant water is produced. The range of splash could reach 3 meters from the machine itself. If all the splash is accumulated, it could reach quite high amount of water. However as described above, the splash is actually the requirement of cooling process.

4.1.3.3 Injection Machine Cooling System

Injection machine cooling system is flowing through the machine with water stream system that has been installed directly in the machine. This system is applied in order to keep the temperature of the injection machine from the inside. The flow of the cooling system comes from the underground water container to all machine through piping. The length of the pipe is about 18 meters along the production floor. Moreover the diameter of the pipe is about 15 centimeters. The illustration of the piping in cooling system is shown by Figure 4.13.

Figure 4.13 Piping in Injection Machine Cooling System

The problem with this cooling system is in the stream. The stream is often discovered leaked in several point. This situation is caused by the clamp between

the hose to the machine is not connected well since the clamp is indeed needs to be opened-closed as the requirement of production process. The leakage could be shown in the Figure 4.14.

Figure 4.14 Leakage nearby the Injection Machine

The leakage causes non-optimized water usage in the system. The other inappropriate water usage is in the system itself. The company insists to use a fresh water in this cooling system. However actually reuse water is actually possible to be applied. It only will require several method to keep the quality of the water and thus the machine would not be rusted.

4.1.3.4 Toilet and Cleaning Activities

Cleaning process in this company is used mostly by the employee of the company. They usually use the toilet to do their personal needs such as urinate, washing hands, ablution, and bathing (for several employee that take overtime). The toilet could be shown as the Figure 4.15.

Figure 4.15 The Toilet

This process is basically connected to the nature of the company, culture and the habit of the employee. The water basin in the toilet is often found empty. It is done in purpose by the owner of the company since the employee still could not take the responsibility of water use. They often left the water basin overflowed and thus cause water loss for the company. For now, the company directs that the water tap in the toilet can only be used in the time of necessity. Containing water in the toilet basin is not allowed.

However this policy of the company leads to other problem. Since the employee does not have water source for cleaning process, the employee use water in the cooling tower basin instead. That makes the cleaning requirements are placed near to the cooling tower such as Figure 4.16 shows.

Figure 4.16 Cleaning Area

4.1.3.5 Water Disposal

Water disposal in this company utilize the sewer that has been built by the executive of the company location. The company flows through all the used water in toilet & cleaning activities and machine cooling system with only one cycle of use. PT. Panca Tunggal Cipta Karya Sentosa currently does not have such reuse or recycling procedure in the water use system.

4.2 Root Cause Analysis

The root cause analysis is developed based on the existing condition of the company. The elaboration of the root cause uses Fishbone Diagram as the tool. The diagram based on the theory is served in Figure 4.17, while the diagram after validation is served in Figure 4.18

Firstly the initial fishbone is developed. This fishbone is developed based on some literature research which has been done before the direct observation. The research is done in all possible fields influencing the inefficiency water. Those possible fields are reporting system, piping system, human factor, facilities factor, and etcetera. At last the findings from the research are summarized into this initial fishbone. Thus, anything stated in this fishbone is still in possibility.

The next is validated fishbone which is developed based on the initial fishbone. The validated fishbone is derived from intensive discussions with the owner of the company and several employees (the report could be seen in the Appendix 4). On the other side this research also observes the activities in the

company directly. Basically, during the discussion and observation, all root causes in the initial fishbone which are not occurred in the existing condition will be wiped out. Moreover, if during discussions and observations the author finds something new, it will be formulated into the validate fishbone also. So that, the validated root cause could be developed comprehensively.

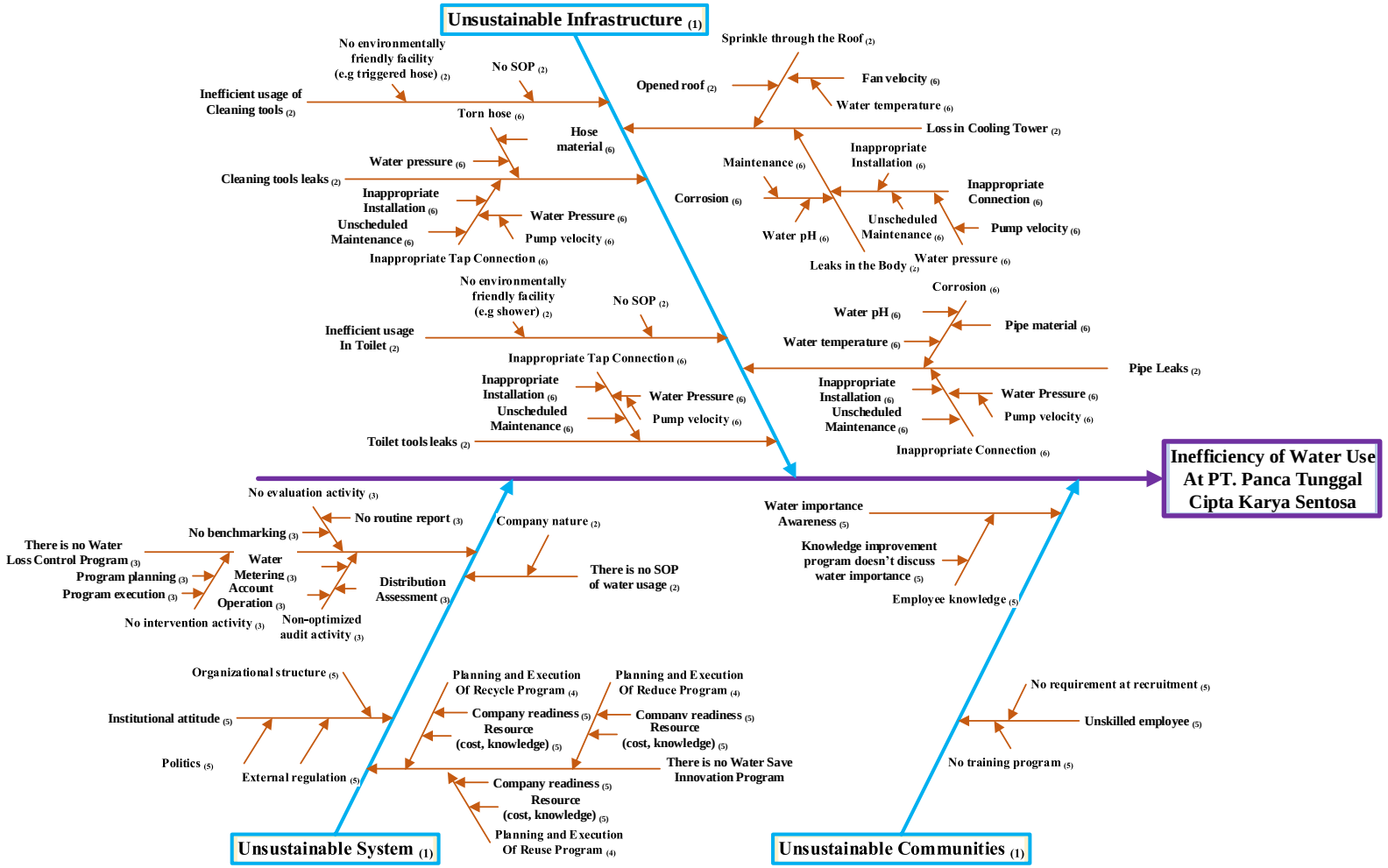


Figure 4.17 Initial Fishbone Diagram of Inefficiency Water Use at PT Panca Tunggal Cipta Karya Sentosa

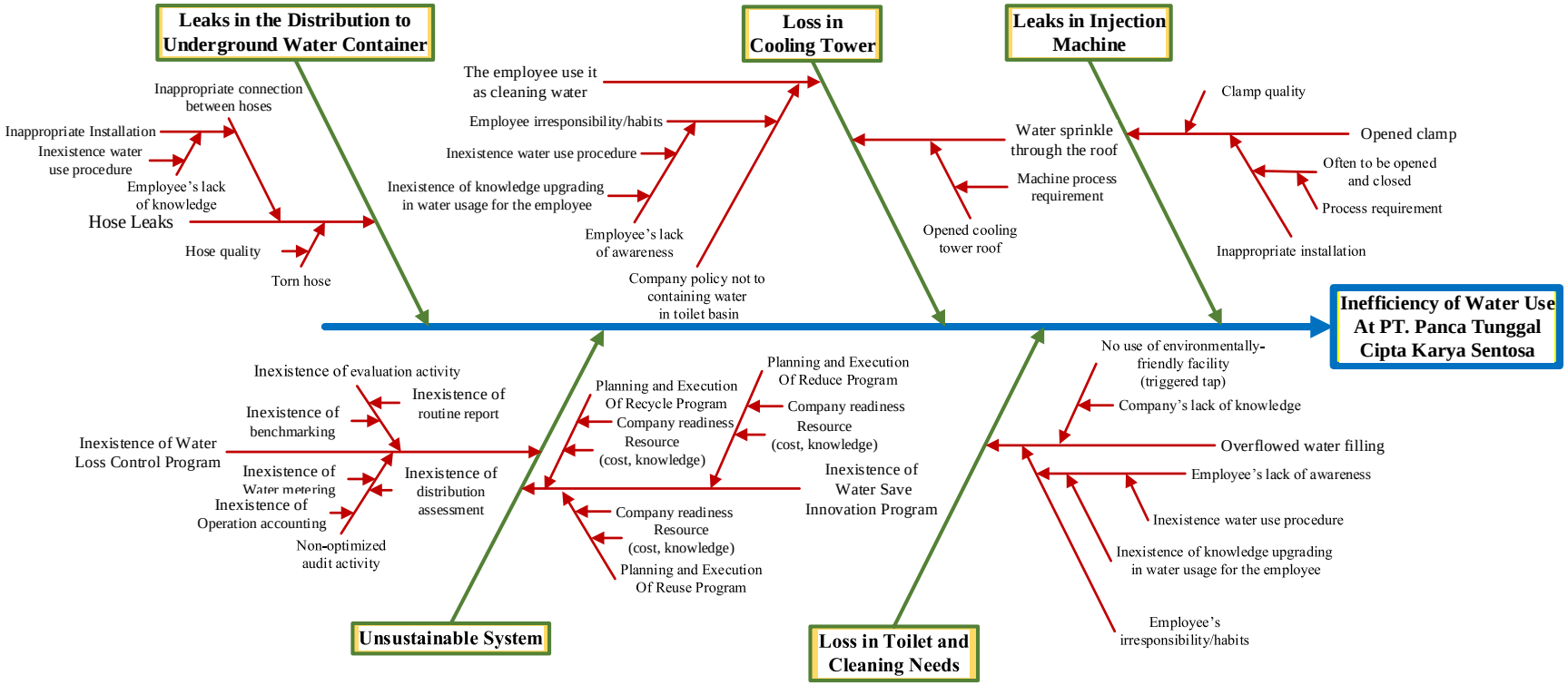


Figure 4.18 Validated Fishbone Diagram of Inefficiency Water Use at PT Panca Tunggal Cipta Karya Sentosa

The index on the Figure 4.17 indicate the sources where the information are taken. The source are as follows.

1: (United States Environmental Protection Agency, 2015)

2: Direct Observation

3: (United States Environmental Protection Agency, 2001)

4: (Black & Veatch, 2015)

5: (Farley, 2001)

6: (Lahlou, 2001)

According to focus group discussion done with the owner and some employees (the report could be seen in the Appendix 4), there are 2 activities that cause the worst effect in water efficiency. The considerations to choose those two activities as the critical problems are the likelihood of each activity and the amount of water that may loss caused by the activity. Those activities are Unsustainable System and Water Loss in Cooling Towers.

Unsustainable System

Sustainable system in water efficiency is defined as any program or water management in company that leads to a better usage of water. Unfortunately, PT Panca Tunggal Cipta Karya Sentosa does not have such a program to manage their water use. This makes the company cannot improve their activity in water use sustainly.

Water management in this case especially is defined into two activities which are water loss control program and the water innovation program. According to US EPA (United States Environmental Protection Agency, 2001), water loss control program is designed to detect the inefficiency or leakage in water use easier and thus find better improvement. It cover several sub-activities which are water audit, intervention, and evaluation. Unfortunately, all those sub-activities has not been implemented in the company. On the next step, water management encourages a company in water save innovation program. This program is usually used to increase the efficiency of water use. The specific activities in this program could be reduce, reuse, and recycle activity. The implementation of these activity is usually driven by the findings of evaluation activity in water loss control

program. After all, inexistence of both water loss control program and water save innovation program make the company in a very stagnant phase and hard to be improved in term of water efficiency.

Loss in Cooling Towers

In this activity, mainly the cause of water loss is caused by the behavior of the workers. They usually use processed water in the cooling towers basin as cleaning water. They use it mostly to wash their hands after working. This habits is done frequently and thus lead to loss in very high number.

It is estimated that each worker will at least do washing hands activity once a day. In one washing hands activity, at least it is used a bowl of water or approximately 750 ml. At the same time, PT Panca Tunggal Cipta Karya Sentosa has 32 workers which operates the business every day. It means the water loss caused by this problem only could approximate 32 x 750 ml = 24,000 ml/day or 24 liter/day or 720 liters/month. In terms of amount this activity causes the largest water loss.

Inexistence of water use procedure and the lack of employee's knowledge or awareness are identified as the main causes of that worker habits. The company does not have such a SOP of water use and thus the employee do not how to treat water. On the other hand, the company also does not give any knowledge to encourage the awareness of the employee. Even in the discussion session that is usually held by the company, water efficiency never becomes the topic.

From the elaboration in each activity above, it is known that the most influencing root causes are inexistence of water loss control program, inexistence of water save innovation program, inexistence of water use procedure, and employee lack of knowledge.

4.3 Alternative Recommendations Development

According to the root cause analysis that has been conducted before, the author proposes 4 alternative recommendations which are deployed as follows

4.3.1 Training and Routine Discussion

Training and routine discussion is done in order to improve the knowledge of the employee. The company does not have to make the new training program. PT Panca Tunggal Cipta Karya Sentosa could give topic about water efficiency in the current training and discussion program. According to the statement of the owner, the company usually held a discussion among employees at the end of the shift. The discussion is done in order to increase the knowledge of the employee about production process. On the other hand, at the beginning of recruitment, the company usually does some brief training about production process also.

4.3.2 Water Use SOP

Water Use SOP is developed in order to solve the problem in inexistence of water use procedure. At the same time, the SOP must be established to standardize the behavior of all employees in terms of water use. The SOP will arrange the attitude in all activities utilizing water such as cleaning activity, water procurement, and cooling system. It will regulate how to treat the water efficiently. With this SOP, all employee cannot treat water as they like, but they have to follow the regulation inside the SOP.

On the other side, it is known that shaping the behavior of employees is not easy. It needs more than a regulation. Therefore several supporting tools are developed in order to penetrate the SOP into employees' attitude. These supporting tools are water metering equipment which is installed to measure the water use, water procurement reporting system which is applied to record all water procurement activities in the company, SOP upgrading which is done to standardize the knowledge of the employees about the SOP, warning posters which are employed to encourage the awareness of the workers, and rewarding mechanism which is done to trigger the employee to obey the new SOP.

4.3.3 Water Loss Control Program

Since water management is an important thing in industry, water loss control program needs to be implemented in this company. Water loss control program will manage all aspect of water management such as audit, intervention,

and the evaluation. This program usually implemented in several companies in purpose to detect water loss that could inflict a financial loss to the company as soon as possible. This program later also enable the company to do a sustain improvement in water use. Innovation could be done as the advance achievement of this program implementation.

4.3.4 Water Reuse Program

Normally, there are three types of water treatment innovation that could be implemented in a company which are reduce, reuse, and recycle. The easiest is to reduce water use. However reducing program is still not suitable to this company. It occurs since the company does not have any water use reporting method until now. Thus the company could not recognize in what sector actually the water use could be reduced.

The second is water reuse program. Water reuse program is possible to be implemented in the company. In several sectors, there are water disposal that is actually still can be utilized for other sector. For example, water that is used for hand-washing activity still can be utilized later for machine cooling system. It is identified as it is because after being used for hand-washing activity, the water is still not containing any hazardous compound that could damage the machine.

The third is water recycle program. Water recycle program is still not necessary to be implemented in the company. It occurs since the required water in the company is not in huge amount. Moreover the company does not produce any water waste that is required to be recycled.

At last water reuse program is the most suitable innovation program to be implemented in the company. With this program, it is expected the need of the company in procuring water could be decreased.

CHAPTER 5
RECOMMENDATIONS ANALYSIS

In order to arrange the priority of the recommendations, this research uses both qualitative and quantitative analyses. Qualitative analysis is needed to consider several factors that could not be numerically counted. On the other hand, quantitative analysis would consider the economical investment and benefit of the recommendation. At the end, both quantitative and qualitative would be normalized using Brown-Gibson method.

5.1 Qualitative Analysis

Qualitative analysis would be done using AHP method. AHP is used since this method is one the simplest ways to prioritize recommendation with several criteria. The criteria in AHP usually give very different result among recommendations. One criteria could be contradictive to other criteria. AHP here is needed to make it clearer. For example in this case, usually easy recommendation rarely results huge impact to the company. However those to criteria are the consideration in recommendation selection. Therefore, AHP is required here.

At the beginning, the experts which are proposed are more than one person. They are the owner and two employees. However, following the research journey, having more than one expert is quietly impossible. It occurs since it is only the owner who follows the research from the beginning till the end. There is no other person who knows as wholly as Pak Bambang. Recruiting other respondents which are not appropriate or not having the same knowledge as Pak Bambang potentially causes higher value of inconsistency. In addition, some research has been conducted to know how many expert that AHP needs. Those research found that there is no minimal number of expert in AHP. As long as that one expert is reliable and comprehensively knows the problems, then it would not cause a matter. Therefore, the research decide to use only one expert to fill in the questionnaire.

First, the criteria of decision should be determined. After that, pairwise comparison should be done to acquire the importance weight of criteria and the

preference score of alternative recommendations. All the values of pairwise comparison would be collected through questionnaire which is addressed to the expert from the company. At the end, hierarchical calculation would be done to emerge the priority of the recommendation in term of qualitative perspective.

5.1.1 Hierarchy of Decision Elements Development

The decision criteria must be several factors which have to be considered on behalf of water efficiency implementation in the company. For that, the criteria of the decision would be as follows:

a. Easiness of implementation

   Easiness of implementation means how simple the implementation of the recommendation. With easy and simple operational, the company expects to implement the recommendation without difficulties.

b. The availability of resource

   This criteria concerns in how far the company could provide the needs of the recommendation. The resource could be the skillful employees, time, or other possible requirements of the recommendation.

c. The quickness of impact occurrence

   This criteria covers how fast the impact of the recommendation could be experienced by the company. Of course, the quicker impact would be more preferable.

d. The magnitude of the impact

   Since the decision considers the result as the main point, then how big the impact of the recommendation also becomes the decision criteria.

Regarding those criteria, it is expected that the first priority is the recommendation which brings the quickest and the biggest impact to the company with the least effort. Thus the hierarchy of decision elements could be shown as the Figure 5.1.

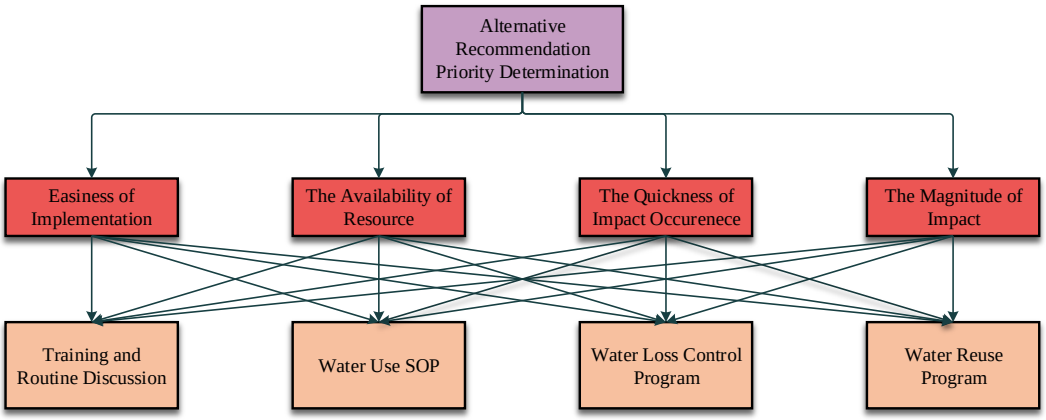


Figure 5.1 Hierarchy of Decision Elements

5.1.2 Pairwise Comparison

The pairwise comparison would be done based on the values which are given by the expert from the company. The expert in this case is the owner of the company itself. The owner is selected as the only respondent since he is still the only person who has wholly knowledge about the company. This occurs because the company is still run in a very simple way. Information and direction flows come from the owner directly to all employees. It makes there is not employee who is expert in certain position in the company.

5.1.2.1 Importance Weight of Criteria Determination

The weight of the criteria shows how important certain criteria in recommendation implementation. Data has been collected and thus could be provided in the Table 5.1.

Table 5.1 Data Recap of Criteria Pairwise Comparison

Criteria Weight										
Easiness of Implementation	9	7	5	3	1	3	5	7	9	The Availability of Resource
Easiness of Implementation	9	7	5	3	1	3	5	7	9	The Quickness of Impact Occurrence
Easiness of Implementation	9	7	5	3	1	3	5	7	9	The Magnitude of Impact
The Availability of Resource	9	7	5	3	1	3	5	7	9	The Quickness of Impact Occurrence

Table 5.1 Data Recap of Criteria Pairwise Comparison (con't)

Criteria Weight										
The Availability of Resource	9	7	5	3	1	3	5	7	9	The Magnitude of Impact
The Quickness of Impact Occurrence	9	7	5	3	1	3	5	7	9	The Magnitude of Impact

After collecting it from the respondent, the data is input to the Expert Choice Software version 2000 to automatically calculate the weight of each criteria. The interface of inputting data in software is shown in the Figure 5.2.

	Easiness c	The Availal	The Quickn	The Magnit
Easiness of Implementation		3.0	3.0	5.0
The Availability of Resource			3.0	5.0
The Quickness of Impact Occurence				3.0
The Magnitude of Impact	Incon: 0.07			

Figure 5.2 Pairwise Comparison among Criteria

According to the inputted data, the result of criteria weight could be provided as in the Figure 5.2

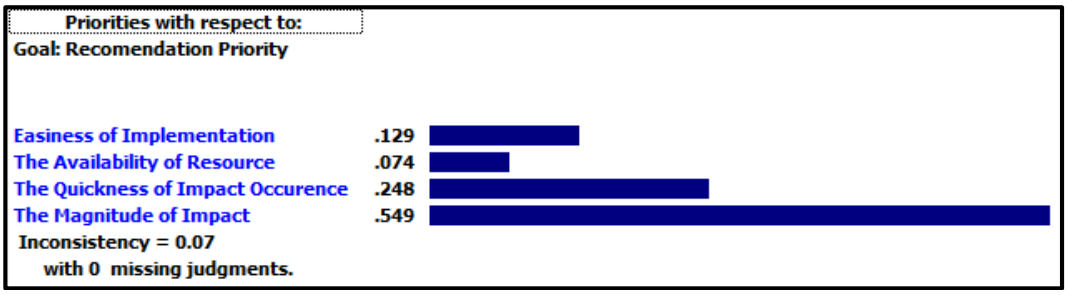


Figure 5.3 Criteria Weight Result

Regarding the result of criteria weight processed by Expert Choice Software, it is known that the most important criteria is the magnitude of impact. This criteria is followed by the quickness of impact occurrence, easiness of implementation, and the availability of resource, respectively. This result indicates that the company expects recommendation that could cause the most significant result to the company. It is shown by the high value of the first criteria, more than twice of the second criteria. On the other hand, the company considers the resource availability the least, since the resource still can be attempted.

5.1.2.2 Preference Score of Alternative Recommendation Determination

Following the criteria pairwise comparison, the pairwise comparison among alternative recommendations are also done. The pairwise comparison among alternative recommendations are applied with respect to a certain criteria. Moreover, the data collected could be shown in the Table 5.2.

Table 5.2 Data Recap of Alternative Recommendation Pairwise Comparison

Easiness of Implementation										
Training and Routine Discussion	9	7	**5**	3	1	3	5	7	9	Water Use SOP
Training and Routine Discussion	9	**7**	5	3	1	3	5	7	9	Water Loss Control Program
Training and Routine Discussion	9	7	**5**	3	1	3	5	7	9	Water Reuse Program
Water Use SOP	9	7	5	**3**	1	3	5	7	9	Water Loss Control Program
Water Use SOP	9	7	5	**3**	1	3	5	7	9	Water Reuse Program
Water Loss Control Program	9	7	5	3	1	**3**	5	7	9	Water Reuse Program
The Availability of Resource										
Training and Routine Discussion	9	7	5	3	1	**3**	5	7	9	Water Use SOP
Training and Routine Discussion	9	7	5	**3**	1	3	5	7	9	Water Loss Control Program
Training and Routine Discussion	9	7	5	**3**	1	3	5	7	9	Water Reuse Program
Water Use SOP	9	7	**5**	3	1	3	5	7	9	Water Loss Control Program
Water Use SOP	9	7	**5**	3	1	3	5	7	9	Water Reuse Program
Water Loss Control Program	9	7	5	3	**1**	3	5	7	9	Water Reuse Program
The Quickness of Impact Occurrence										
Training and Routine Discussion	9	7	5	3	1	**3**	5	7	9	Water Use SOP
Training and Routine Discussion	9	7	5	**3**	1	3	5	7	9	Water Loss Control Program
Training and Routine Discussion	9	7	5	3	**1**	3	5	7	9	Water Reuse Program
Water Use SOP	9	7	5	**3**	1	3	5	7	9	Water Loss Control Program

Table 5.2 Data Recap of Alternative Recommendation Pairwise Comparison (con't)

The Quickness of Impact Occurrence										
Water Use SOP	9	7	5	3	1	3	5	7	9	Water Reuse Program
Water Loss Control Program	9	7	5	3	1	3	5	7	9	Water Reuse Program
The Magnitude of Impact										
Training and Routine Discussion	9	7	5	3	1	3	5	7	9	Water Use SOP
Training and Routine Discussion	9	7	5	3	1	3	5	7	9	Water Loss Control Program
Training and Routine Discussion	9	7	5	3	1	3	5	7	9	Water Reuse Program
Water Use SOP	9	7	5	3	1	3	5	7	9	Water Loss Control Program
Water Use SOP	9	7	5	3	1	3	5	7	9	Water Reuse Program
Water Loss Control Program	9	7	5	3	1	3	5	7	9	Water Reuse Program

All the value on the data are inputted to the Expert Choice Software. This step is done in order to acquire the score which is automatically processed by the software. Figure 5.4, Figure 5.6, Figure 5.8, and Figure 5.10 will show the interface of inputting the score for each criteria. Moreover Figure 5.5, Figure 5.7, Figure 5.9, and Figure 5.11 will show the score of each alternative recommendation with respect to a certain criteria.

	Training ar	Water Use	Water Los	Water Reu
Training and Routine Discussion		5.0	7.0	5.0
Water Use SOP			3.0	3.0
Water Loss Control Program				3.0
Water Reuse Program	Incon: 0.09			

Figure 5.4 Pairwise Comparison among Alternative Recommendations with respect to Easiness of Implementation

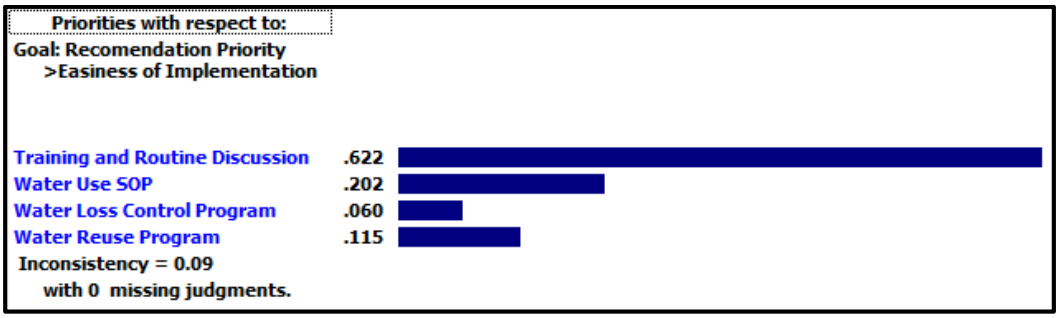


Figure 5.5 Alternative Recommendation Score with respect to Easiness of Implementation

Regarding to the result, it is recognized that training and routine discussion is the easiest recommendation to implement. On the other hand, water loss control program is the most difficult recommendation. This result may occur since training and routine discussion is indeed the simplest recommendation. The company only need to provide time and the material to discuss, while water loss control program needs more complex system about distribution mapping, reporting, and evaluation.

	Training ar	Water Use	Water Los:	Water Reu
Training and Routine Discussion		3.0	3.0	3.0
Water Use SOP			5.0	5.0
Water Loss Control Program				1.0
Water Reuse Program	Incon: 0.02			

Figure 5.6 Pairwise Comparison among Alternative Recommendations with respect to The Availability of Resource

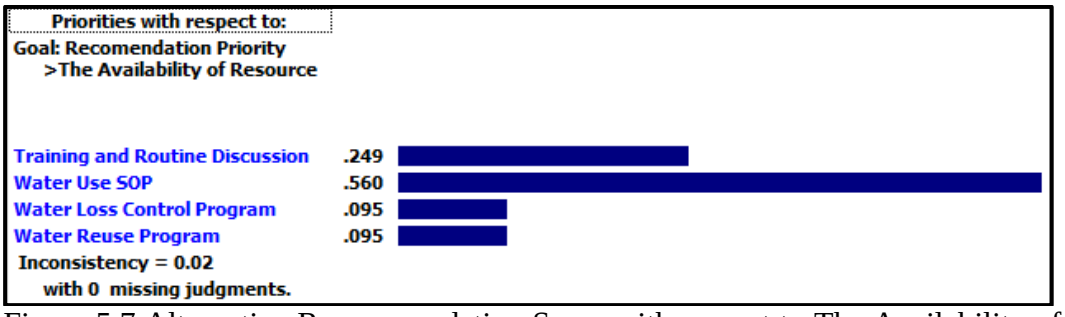


Figure 5.7 Alternative Recommendation Score with respect to The Availability of Resource

From the Expert Choice result in Figure 5.7, it is known that in term of the availability of resource, water use SOP has the highest score. On the other hand, water loss control program and water reuse program are the recommendations with the lowest score. This occurrence is identified in tune with the actual condition.

Water use SOP only requires the available resources in the company and thus the company does not need to provide any other new equipment. Whereas, water loss control program need well-trained employee which are capable to execute the program, while water reuse program need certain new equipment to support the program.

	Training ar	Water Use	Water Los:	Water Reu
Training and Routine Discussion		3.0	3.0	1.0
Water Use SOP			3.0	3.0
Water Loss Control Program				3.0
Water Reuse Program	Incon: 0.06			

Figure 5.8 Pairwise Comparison among Alternative Recommendations with respect to The Quickness of Impact Occurrence

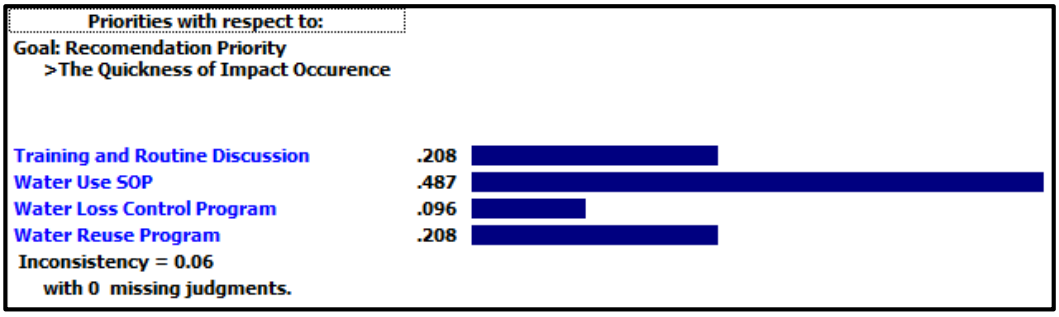


Figure 5.9 Alternative Recommendation Score with respect to The Quickness of Impact Occurrence

The recommendation which has the highest value with respect to the quickness of impact occurrence is water use SOP. Generally, it occurs since water use SOP is a preventive step to avoid unnecessary use of water. By applying this SOP ideally, the result should emerge directly. On the other hand, the least value is owned by water loss control program. It may occur since this program is a complex system. This program is done in purpose to make a well water management system. Implementing this program is not directly give the company the impact because one of the most important thing in this program is historical data which is acquired after at least a month of implementation.

	Training ar	Water Use	Water Loss	Water Reu
Training and Routine Discussion		3.0	5.0	3.0
Water Use SOP			3.0	3.0
Water Loss Control Program				3.0
Water Reuse Program	Incon: 0.07			

Figure 5.10 Pairwise Comparison among Alternative Recommendations with respect to The Magnitude of Impact

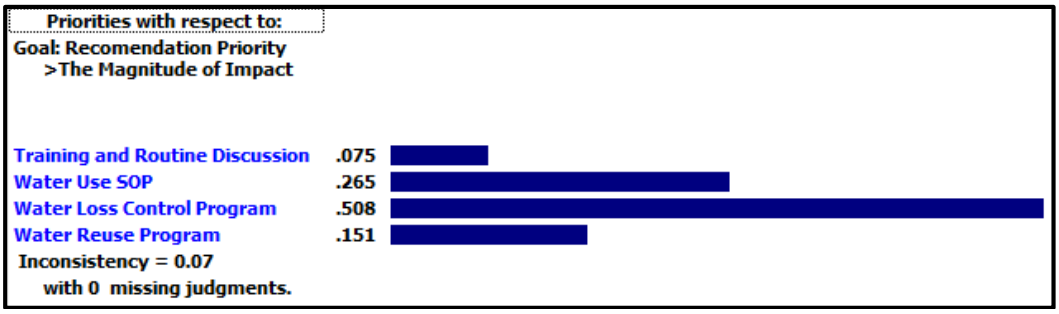


Figure 5.11 Alternative Recommendation Score with respect to The Magnitude of Impact

According to the result shown by Figure 5.11, it is identified that water loss control program is the recommendation which has the highest score. Otherwise, training and routine program is the recommendation with the lowest score. Those occurrences are led by the fact that water loss control program indeed promises well-managed water use. By implementing this program the company would have neat water use and distribution record. At the advance stage, the company could detect water leakage or loss as soon as possible because the company knows the best practice of water use and distribution in detail. Thus this recommendation could bring huge impact to the company. On the other hand, training and routine discussion indeed cannot provide a tangible impact to the company. It merely establishes fundamental knowledge of the employee to treat water efficiently. Hence, training and routine discussion will have insignificant impact in short time.

5.1.3 Total Score Calculation

In order to obtain the priority of alternatives recommendations, the total calculation needs to be done. According to AHP method, then total score could be drawn with the formula:

$Total\ Score\ i = \sum_{i=1}^{n} \sum_{j=1}^{n} Xij\ Yj$ ..... Equation 5.1

Xij = the score of i alternative recommendation in j criteria

Yj = the weight of j criteria

i = 1, 2, 3, 4

j = 1, 2, 3, 4

Example:

Total score training and routine discussion = (0.129x0.622) + (0.074x0.249) + (0.248x0.208) + (0.549x0.075)

= 0.191

According to that formulation, the calculation of the total score of each recommendation could be done as shown by Table 5.3

Table 5.3 Total Calculation of Alternative Recommendation

Alternative Recommen-dations	**Criteria**				**Total Score**
	Easiness of Implemen-tation	**The Availability of Resource**	**The Quickness of Impact Occurrence**	**The Magnitude of Impact**	
	0.129	0.074	0.248	0.549	
Training and Routine Discussion	0.622	0.249	0.208	0.075	0.191

Table 5.3 Total Calculation of Alternative Recommendation (con't)

Alternative Recommen-dations	**Criteria**				**Total Score**
	Easiness of Implemen-tation	**The Availability of Resource**	**The Quickness of Impact Occurrence**	**The Magnitude of Impact**	
	0.129	0.074	0.248	0.549	
Water Use SOP	0.202	0.56	0.487	0.265	0.334
Water Loss Control Program	0.06	0.095	0.096	0.508	0.317
Water Reuse Program	0.115	0.095	0.208	0.151	0.156

The calculation above confirms that the most preferable recommendation from the qualitative perspective is water use SOP. The second most preferable recommendation is water loss control program. Those two are followed by training and routine discussion and water reuse program. Roughly, the value of two top recommendations are twice of the value of the two bottom recommendations. The gap is quiet high and thus indicates that two top recommendations are much more preferable than the two bottom recommendations.

On the other hand, according to the calculation, it is known that the first and the second priority are in very close score. The gap is only 0.017 which is a small number. The gap indicates that might be those two recommendations are actually preferable to be in the first priority.

Water use SOP gets the higher value in the three criteria which are easiness of implementation, the availability of resource, and the quickness of impact occurrence. Whereas, water loss control program gets the higher value in the magnitude of impact. Even water loss control program gets higher value only in one criteria, but this criteria has the highest weight. Thus, this criteria could increase the total score of water loss control program recommendation until close to water use SOP score.

Similarly, the two bottom recommendations, training and routine discussion and water reuse program, are also in very close gap. The gap is only 0.035. It indicates that those recommendations are in one level of preference.

5.2 Quantitative Analysis

Quantitative analysis is done using NPV method. By doing this quantitative analysis, it is expected that the author could recognize how economically profitable a certain recommendation is. Through NPV method, the author will identify the inflow and the outflow caused by the recommendation implementation. The outflow is obtained from the investment done in the beginning and the needed cost among the time horizon. The inflow is obtained from the savings of desired benefits among the time horizon. The NPV is done to all recommendations. In addition, the time horizon of calculation is 10 years. The formulation to calculate NPV is provided as follows:

$NPV = FV/(1+i)^1 + ... + FV/(1+i)^{10}$ .....(Equation 2.1)

FV = inflow or outflow value

i = interest rate = 0.075 (Bank Indonesia, 2015)

Using that formulation, the calculation of the NPV of each recommendation could be delivered as follows.

Training and Routine Discussion

Training and routine discussion implementation could lead several costs and benefits. Those costs and benefits could be shown in the Table 5.4.

Discussion will be held every 3 months. It will take a half hour of working time. Thus the cost is formulated from the production loss along the discussion time.

Discussion cost = (((discussion time/average production time) * machines number) * estimated loss for a product) * discussion frequency in a year

= (((1800/10)*7) * Rp 3,000) * 2

= Rp 7,560,000

Training will be held once in the beginning of implementation. It will be conducted in about 2.5 hours containing the course and necessary practice.

Training cost = ((((discussion time/average production time) * machines number) * estimated loss for a product) * 5) + logistics cost

= (((1800/10)*7) * Rp 3,000) *5 + Rp 1,000,000

= Rp 19,900,000

Savings is assumed by reducing irresponsible activities which are done by the employees. According to the statement of the owner, cost savings could be up to Rp 1,000,000 whenever the employees could perform according to the rules. Thus the savings in a year is Rp 12,000,000

The scheme of cash flow based on the elaboration before could be determined in the Figure 5.12.

Table 5.4 Outflow and Inflow of Training and Routing Discussion

Training and Routine Discussion			
Outflow		Inflow	
Discussion Cost	Rp 7,560,000	Savings	Rp 12,000,000
Training Cost	Rp 19,900,000		

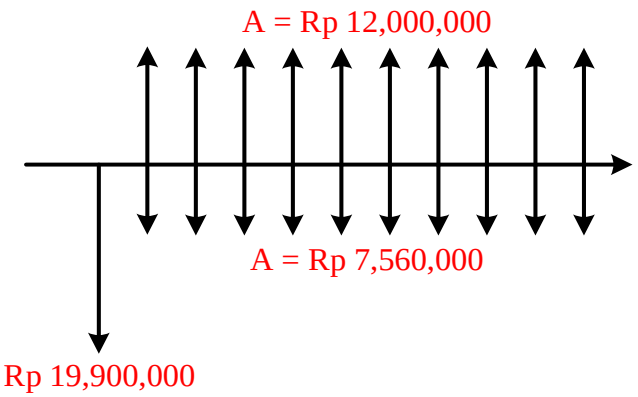


Figure 5.12 Training and Routing Discussion Cash Flow

After that, the NPV of this recommendation could be obtained such as follows.

NPV = - Rp 19,900,000 – (Rp 7,560,000/(1+0.075)^{1}+…..+Rp 7,560,000/(1+0.075)^{10}) + (Rp 12,000,000/(1+0.075)^{1}+…..+Rp 12,000,000/(1+0.075)^{10})

= Rp 10,576,519.44

Water use SOP

Water use SOP implementation could lead several costs and benefits. Those costs and benefits could be shown in the Table 5.5.

Upgrading is expected to be held once in the beginning of time horizon. Upgrading is assumed to be done in a half hour. Hence the cost is the same with discussion cost in the previous recommendation plus logistic cost.

SOP Upgrading = (((discussion time/average production time) * machines number) * estimated loss for a product) + logistic cost

= (((1800/10)*7) * Rp 3,000) + Rp 1,000,000

= Rp 4,780,000

Initial investment containing the procurement of new equipment such as water metering and water hose. Since the economic life of the equipment according to Undang Undang Republik Indonesia Nomor 36 Tahun 2008 tentang Pajak Penghasilan (Republik Indonesia, 2008) are 16 years, then reinvestment is not required.

Equipment Investment = water metering price + 10 meters water hose price
= Rp 675,000 + Rp 945,000 (Alibaba Group, 2015)
= Rp 1,620,000

Rewarding will be done every month for two best employees. Each employee will get Rp 150,000. This is aimed to encourage the employee to do the new regulation.

Rewarding = 12 * 2 * Rp 150,000
= Rp 3,600,000

Savings in this recommendation will be caused by the same reason of previous recommendation. Although the treatment is different, the purpose is the same, which is reducing irresponsible activities. Thus the savings is also the same, Rp 12,000,000.

The scheme of cash flow based on the elaboration before could be determined in the Figure 5.13.

Table 5.5 Outflow and Inflow of Water Use SOP

Water Use SOP			
Outflow		Inflow	
SOP Upgrading	Rp 4,780,000	Savings	Rp 12,000,000
Investment	Rp 1,620,000		
Rewarding	Rp 3,600,000		

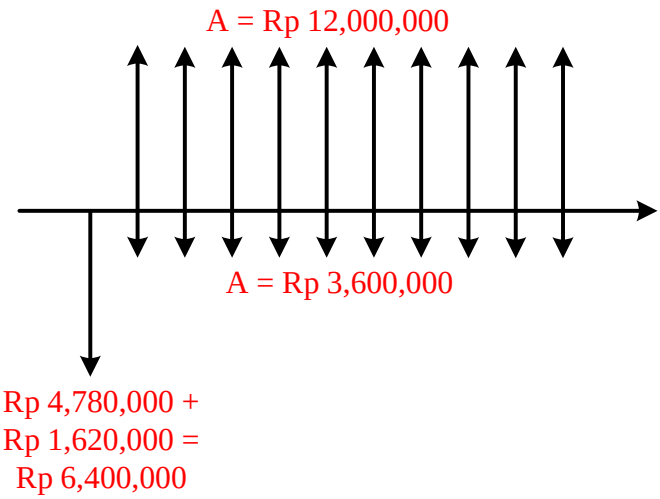


Figure 5.13 Water Use SOP Cash Flow

After that, the NPV of this recommendation could be obtained such as follows.

NPV = - Rp 4,780,000 – Rp, 1,620,000 - + (Rp 12,000,000/(1+0.075)^{1}+…..+Rp 12,000,000/(1+0.075)^{10}) - (Rp 3,600,000/(1+0.075)^{1}+…..+Rp 3,600,000/(1+0.075)^{10})

= Rp 51,258,280.03

Water Loss Control Program

Water loss control program implementation could lead several costs and benefits. Those costs and benefits could be shown in the Table 5.6.

Equipment investment is expected to be done once in the beginning of time horizon. The equipment are 4 water metering, which are installed in every water-based activity, and a leakage detector. Since the economic life of the equipment according to Undang Undang Republik Indonesia Nomor 36 Tahun 2008 tentang Pajak Penghasilan (Republik Indonesia, 2008) are 16 years, then reinvestment is not required.

Equipment investment = (4 * water metering price) + leakage detector price

= (4 * Rp 675,000) + Rp 2,700,000 (Alibaba Group, 2015)

= Rp 5,400,000

System preparation covers the designing process of reporting, performance indicator, manual, and other required system. The whole activity is assumed to cost the company about Rp 1,000,000.

According to US EPA in (United States Environmental Protection Agency, 2001), the implementation of water loss control program could lead to soon leakage detection. They confirmed that in average the program could reduce for 30% of water cost.

Soon Leakage Detection = (water cost in a month * 12) * 0.3

= (Rp 2,500,000 * 12) * 0.3

= Rp 9,000,000

The scheme of cash flow based on the elaboration before could be determined in the Figure 5.14.

Table 5.6 Outflow and Inflow of Water Loss Control Program

Water Loss Control Program			
Outflow		Inflow	
Equipment Investment	Rp 5,400,000	Soon Leakage Detection	Rp 9,000,000
System Preparation	Rp 1,000,000		

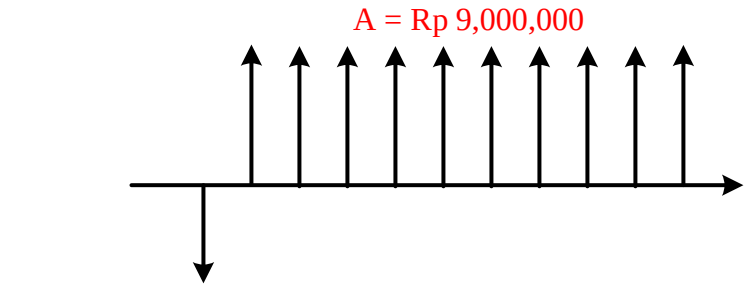


Figure 5.14 Water Loss Control Program Cash Flow

After that, the NPV of this recommendation could be obtained such as follows.

NPV = - Rp 5,400,000 - Rp 1,000,000 + (Rp 9,000,000/$(1+0.075)^1$+…..+ Rp 9,000,000/$(1+0.075)^{10}$)

= Rp 55,376,728.6

Water Reuse Program

Water reuse program implementation could lead several costs and benefits. Those costs and benefits could be shown in the Table 5.7.

Equipment investment is expected to be held once in the beginning of time horizon. The equipment are sink, which is connected to the certain reuse container, and water harvesting container.

Equipment investment = sink price + water harvesting container
= Rp 1,350,000 + Rp 2,025,000 (Alibaba Group, 2015)
= Rp 3,375,000

Equipment maintenance is done twice every year. The price of the pipe technicians in Surabaya is conducted from the website.

Equipment maintenance = 2 * Rp 200,000 (OLX, 2015)
= Rp 400,000

The upgrading of the program is needed. It is used to give comprehensive understanding to all employee. The upgrading here is similar to SOP upgrading cost. Thus the cost is also the same.

Program Upgrading = (((discussion time/average production time) * machines number) * estimated loss for a product) + logistic cost
= (((1800/10)*7) * Rp 3,000) + Rp 1,000,000
= Rp 4,780,000

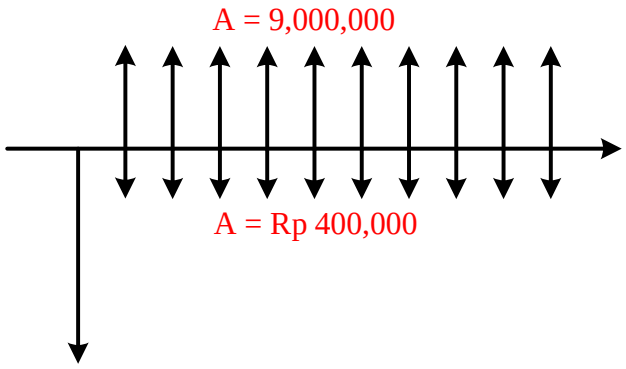
The estimation of water savings in this recommendation is derived from historical data. India government provides data that in average all the company that implement reuse program could save until 20% of water cost (India Government, 2013).

Water Savings = 0.2 * water cost * 12
= 0.2 * Rp 2,500,000 * 12
= Rp 6,000,000

The scheme of cash flow based on the elaboration before could be determined in the Figure 5.15.

Table 5.7 Outflow and Inflow of Water Reuse Program

Water Reuse Program			
Outflow		Inflow	
Equipment Investment	Rp 3,375,000	Water Savings	Rp 6,000,000
Equipment Maintenance	Rp 400,000		
Program Upgrading	Rp 4,780,000		



Rp 3,375,000 + Rp 4,780,000 = Rp 8,150,000

Figure 5.15 Water Reuse Program Cash Flow

NPV = - Rp 3,375,000 - Rp 4,780,000 – (Rp 400,000/$(1+0.075)^{1}$+…..+ Rp 2,000,000/$(1+0.075)^{10}$) + (Rp 6,000,000/$(1+0.075)^{1}$+…..+ Rp 6,000,000/$(1+0.075)^{10}$)

= Rp 30,283,853.35

From the overall calculation it is known that the most profitable recommendation is water use SOP with the NPV value of Rp 55,376,728.6. This recommendation is followed by water loss control program, water reuse program, and training and routine discussion with the NPV value of Rp 51,258,280.03; Rp 30,283,853.35; and Rp 10,576,519.44, respectively.

Generally, in term of inflow, water loss control program could provide the highest number. Furthermore, the initial cost of implementing this recommendation also requires quiet small value. It makes water loss control program could acquire the highest NPV.

5.3 Normalization

Normalization here is done to standardize the value of quantitative and qualitative score. This step is using Brown-Gibson method to combine both score.

First of all, the qualitative score which has been calculated in the sub-chapter before is already in the standardized form. Thus, the qualitative score could be directly converted into subjective factor. To recall the value, the recap of alternative recommendation subjective factor is assisted in the Table 5.8.

Table 5.8 Alternative Recommendations Subjective Factor

Alternative Recommendations	SF
Training and Routine Discussion	0.191
Water Use SOP	0.334
Water Loss Control Program	0.317
Water Reuse Program	0.156

Next step is standardizing the quantitative score into objective factor. Since the quantitative score is in profit-based, not cost-based, then the formulation of normalization is shown as follows.

$$OF = -(Pi * \sum 1/Pi)^{-1}$$ ..... (Equation 5.3)

OF = Objective Factor

Pi = Profit of recommendation *i*

Example:

OF Training and Routine Discussion = - (10,576,519x 1.65137E-07)$^{-1}$

= - 0.573

The calculation is done to all recommendation and the result is presented in the Table 5.9.

Table 5.9 Alternative Recommendations Objective Factor

Alternative Recommendations	Ci	1/Ci	OF
Training and Routine Discussion	Rp 10,576,519	9.45491E-08	-0.573
Water Use SOP	Rp 51,258,280	1.9509E-08	-0.118
Water Loss Control Program	Rp 55,376,729	1.80581E-08	-0.109
Water Reuse Program	Rp 30,283,853	3.30209E-08	-0.200
Total 1/Ci		1.65137E-07	

After having subjective and objective factor value, priority arrangement from both perspectives are recognized having small different. Subjectively, the priority arrangement are water use SOP, water loss control program, training and routine discussion, and water reuse program. On the other hand, objectively, the priority arrangement are water loss control program, water use SOP, water reuse program, and training and routine discussion.

In order to combine the value, Brown Gibson Method provided a formulation which is shown as follows.

$PMi = (k * OF) + ((1 - k) * SF)$ .....(Equation 2.4)

PM = Preference Measure

k = preference index

Example:

PM of Training and Routing Discussion = (-0.354 x 0.35) + (0.191 x 0.65)

= 0.00044

Preference index is acquired from the discussion with the owner from the company. Generally, the company owner prefers the subjective factor as the main consideration. The owner believes that all the problem in water use in the company is mostly caused by inappropriate behavior of the employees. Besides that, the company cannot afford recommendation which is too demanding in terms of resources. This occurs since preparing new resources means more energy for the company. In addition, for the company, economic benefit would be pointless if the recommendation is too complex and makes the company could not implement it optimally. Thus, the company needs recommendations which is feasible to be implemented in the company, in term of resources and the result to change the employee behavior.

Considering those reasons, the owner prefers the subjective factor because this factor could represent the requirements that the company proposes. The company can place profit or savings as the second priority. At last, the feasibility of the recommendation, which is meant by the company, in this research could be

only assessed by subjective factor. This makes the preference index of subjective factor should be higher than objective factor. In this case, the preference index is set in several value to see the sensitivity. The result of calculation is shown in the Table 5.10.

Table 5.10 Alternative Recommendations Preference Measure

Alternative Recommendations	OF	SF	LPM (35:65)	LPM (40:60)	LPM (45:55)
Training and Routine Discussion	-0.354	0.191	0.00044	-0.0268	-0.0541
Water Use SOP	-0.213	0.334	0.1425	0.11517	0.08785
Water Loss Control Program	-0.209	0.317	0.13305	0.1067	0.08035
Water Reuse Program	-0.224	0.156	0.02337	0.00437	-0.0146

According to the final calculation, the recommendation priority are water use SOP, water loss control program, water reuse program, and training and routine discussion. The arrangement is not changing in any scenarios of SF-OF weight. This means the result is not sensitive to the weight.

Although so, the first priority and the second priority have very small gap. The gap is about 0.0075. Whereas the third and the fourth recommendation have small LPM value with quiet far gap to second priority. It may indicate that first and second recommendations could be implemented at the same stage. On the other hand, the third and fourth recommendations could be implemented later.

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CHAPTER 6
SELECTED RECOMMENDATION DESIGN

This chapter gives the design of the selected recommendations. The recommendations are two recommendations with the highest LPM score in the previous chapter. The selected recommendations is water use SOP and water loss control program. This chapter deploys the SOP itself and the supporting system of recommendation implementation.

6.1 Water Use SOP

Water SOP is designed in Bahasa Indonesia. This is done to ease the company in implementation. Thus the company could directly use the SOP.

According to the Figure 4.9, there are several activities which use water. Those activities are water storage, cooling tower, injection machine cooling system, toilet and cleaning activities, and water disposal. Cooling tower, injection machine cooling system, and water disposal are executed automatically. For that, the involvement of human resource is not too required. On behalf of that reason, the SOP are only established for water storage and toilet and cleaning activities.

6.1.1 Water Storage SOP

Water procurement activity is done routinely. In order to depict the process, the flowchart is developed in Figure 6.1. Furthermore, specific SOP is conducted on behalf of giving more detail instructions. The SOP is provided in Table 6.1.

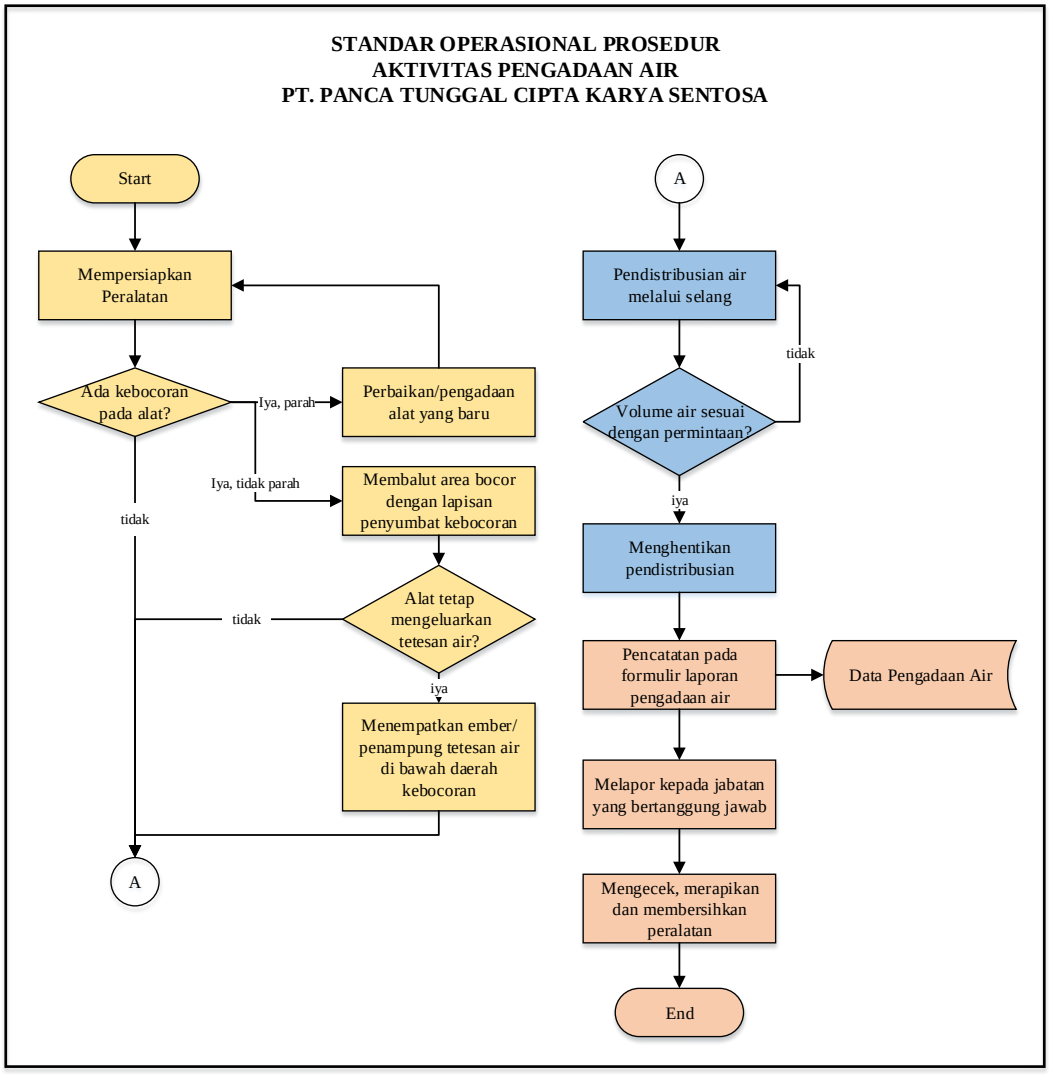


Figure 6.1 Water Storage Activity Flowchart

Table 6.1 Water Storage Activity SOP

PT. PANCA TUNGGAL CIPTA KARYA SENTOSA	Nomor Dokumen :	Tanggal :
	STANDAR OPERASIONAL PROSEDUR	Terbitan :
	Aktivitas Pengadaan Air	Revisi :
	(Penerimaan Air dari Supplier)	Halaman :

I **Tujuan**

Aktivitas pengadaan air dilakukan dengan baik dan benar untuk mengurangi ketidak-efisienan dalam penanganan air.

II **Cakupan**

Karyawan

Table 6.1 Water Storage Activity SOP (con't)

PT. PANCA TUNGGAL CIPTA KARYA SENTOSA	Nomor Dokumen :	Tanggal :
	STANDAR OPERASIONAL PROSEDUR	Terbitan :
	Aktivitas Pengadaan Air	Revisi :
	(Penerimaan Air dari Supplier)	Halaman :

III **Tanggung Jawab**

Petugas Administrasi

- Menyiapkan selang air dan membuka pintu kontainer air
- Mengecek kebocoran selang dan melakukan tindakan yang sesuai
- Mengawasi proses pendistribusian air sampai pada volume yang ditetapkan
- Mencatat formulir hasil aktivitas pengadaan air
- Menyerahkan dan melaporkan formulir

IV **Dokumen Terkait**

Formulir Pencatatan Pengadaan Air

V **Prosedur**

1 Persiapan Alat

1.1 Mempersiapkan selang, membuka pintu kontainer air.

1.2 Melapisi alat dengan penyumbat kebocoran, jika terjadi kebocoran pada alat yang digunakan.

1.3 Menempatkan ember/alat lain di daerah kebocoran untuk menampung, jika masih ada tetesan air yang keluar.

2 Saat Pendistribusian Air

2.1 Mendampingi petugas supplier air selama proses pendistribusian air.

2.2 Mengawasi alat pengukur air sehingga air yang masuk ke dalam kontainer sesuai dengan volume yang diminta.

3 Pasca Pendistribusian Air

3.1 Melakukan pencatatan tentang banyaknya air yang diterima dan uang yang dibayarkan pada formulir laporan.

3.2 Melaporkan proses pendistribusian kepada pihak yang bertanggung jawab.

3.3 Membersihkan peralatan aktivitas pengadaan air.

6.1.2 Cleaning Activities

Cleaning activities are including the activities of employee's self-cleaning and the cleaning activities for production equipment. In order to depict the process, the flowchart is developed in Figure 6.2. Furthermore, specific SOP is conducted on behalf of giving more detail instructions. The SOP is provided in Table 6.2.

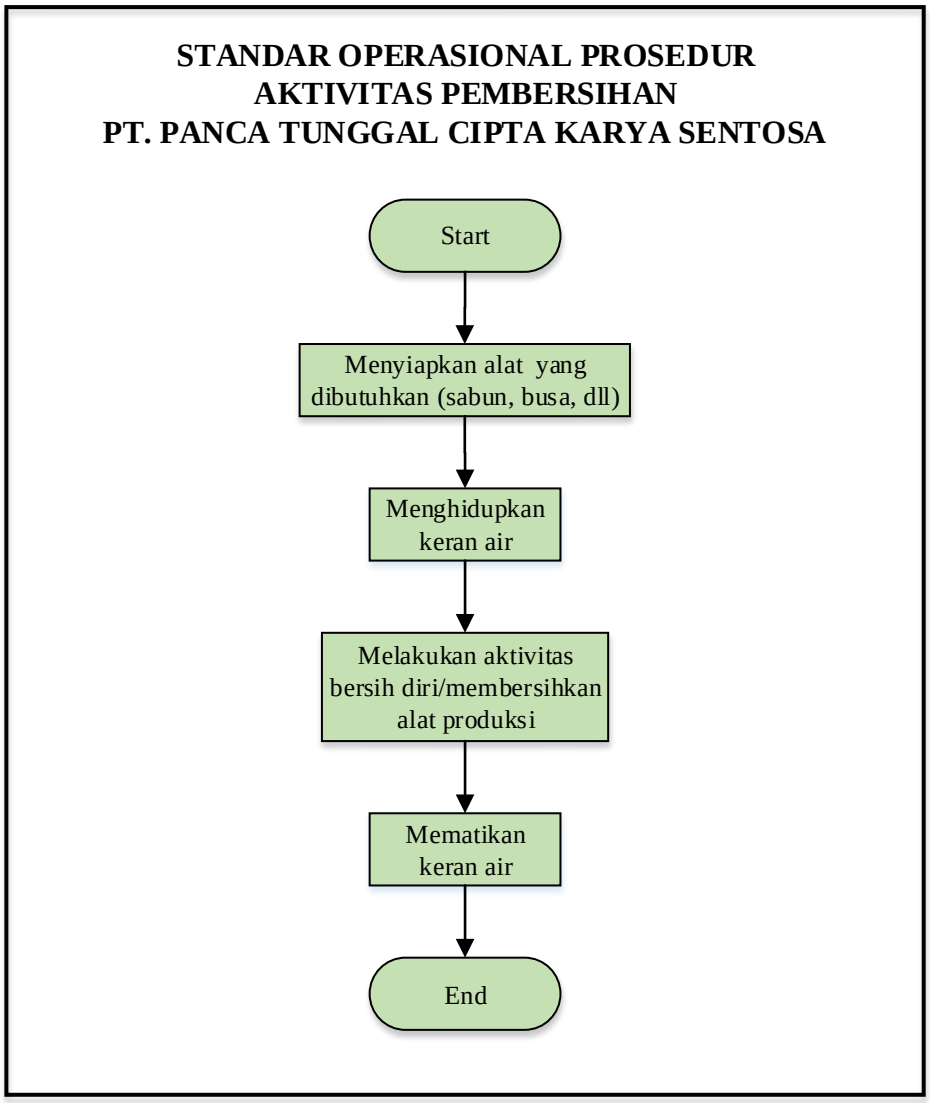


Figure 6.2 Cleaning Activities Flowchart

Table 6.2 Cleaning Activities SOP

PT. PANCA TUNGGAL CIPTA KARYA SENTOSA	Nomor Dokumen :	Tanggal :
	STANDAR OPERASIONAL PROSEDUR	Terbitan :
	Aktivitas Pembersihan	Revisi :
	(Bersih Diri atau Pembersihan Alat Produksi)	Halaman :

I **Tujuan**

Aktivitas pembersihan, bersih diri maupun pembersihan alat produksi, dapat berjalan dengan baik sehingga mengurangi pemakaian air yang tidak sesuai.

II **Cakupan**

Karyawan

III **Tanggung Jawab**

- Menggunakan air seperlunya
- Mematikan keran yang telah dihidupkan
- Menggunakan air hanya untuk keperluan perusahaan
- Menggunakan hanya air di dalam kamar mandi

IV **Dokumen Terkait**

-

V **Prosedur**

1. Mempersiapkan alat pembersih (sabun, busa, dll) yang dibutuhkan.
2. Menghidupkan keran air.
3. Menggunakan air untuk keperluan bersih diri/pembersihan alat produksi secukupnya.
4. Mematikan keran air setelah penggunaan selesai.

6.1.3 Supporting Tools for Water Use SOP Implementation

In term of implementing water use SOP, there are several things to be remembered by the owner. Those several things could support the implementation of the recommendation. They are deployed as follows:

1. Water Metering Equipment

   Water metering equipment is required. It is caused by the indication of the owner that the water received from the supplier maybe less that the water paid by the company. Until now the company cannot control the exact volume of the water that is distributed from the supplier. For that, the company need to set up an equipment to recognize the volume of the distributed water. The equipment could be water volume measurement tool, specific signs inside the container, or any other tools.

2. Water Procurement Reporting System

   In term of having good water management, the company could at least establish such reporting system. This reporting system is aimed to record all the inflow of the water. This reporting later could become the historical data and ease the company to recognize unusual water use. The responsible employee also need to collect the bill from the supplier. The example of the reporting could be like Table 6.3.

Table 6.3 Water Reporting System Example

No.	Hari Pemesanan	Volume Air Dipesan	Hari Kedatangan	Volume Air Diterima	Uang Dibayarkan	Pegawai yang Bertanggung Jawab	Tanda Tangan Supplier	Tanda Tangan Pegawai

3. SOP Upgrading

   Understanding about the SOP for the whole company is important matter. For that the upgrading needs to be held at the beginning of the implementation. This upgrading is done in order to give comprehensive knowledge about new regulation to all employees. Thus, the company could run the SOP well.

4. Warning Posters

   Besides three supporting tools above, warning posters about important part in the SOP are also needed. These posters need to be spread in strategic place of water use such as toilet and cooling tower. For example, the memo could contain cautions such as “Close the tap right after use it!” or “Don’t use water in cooling tower!”, and others. This mechanism is needed to encourage the awareness and establish the habit of the employees. Especially, it will be needed in cleaning activity SOP which is addressed to all employees, not only specific section in the company. The example of the poster could be like the Figure 6.3.

Figure 6.3 Warning Poster Example

5. Rewarding Mechanism

   The last thing to remember in implementing water use SOP is rewarding mechanism. The company needs to aware that implementing new thing is not an easy issue and thus it would be better for the company to appreciate employees which attempt to follow the new rules. In this case, rewarding mechanism may be required. Rewarding mechanism

also can be used as the tool to embed the awareness of water efficiency to all employees.

6.2 Water Loss Control Program

According to United States Environmental Protection Agency in Control and Mitigation of Drinking Water Losses in Distribution Systems (United States Environmental Protection Agency, 2001), Water Loss Control Program has several elements. They are water audit, intervention, and evaluation. This program has been simplified considering the condition of the company.

6.2.1 Water Audit

Water audit provides a system to collect and maintain the water-based activity. For that, these are several things to be prepared:

1. Develop information system

   The effectiveness of water loss control program increases with the type, amount, and detail of information that is collected. Data storage and organization can be as simple as a log book or spreadsheet.

2. Mapping

   Determining size and location of a water system's piping and other assets is the first step in data gathering. Some systems use hardcopy maps, while others use their own Computer Aided Drafting and Design (CADD) system or Geographic Information System (GIS) packages to update the distribution system inventory. Low cost and free CADD and GIS software packages are available for water system managers who want to begin electronic mapping with minimal expense.

3. Employing Performance Indicator

   A proactive water loss control program requires that a water audit is completed and the standard performance indicators are calculated. This guidance document concentrates on performance indicators related to control and mitigation of water loss in the water-based activity.

4. Assessing Losses and Data Gap Analysis

   Once baselines have been established, undertake an analysis to determine where water loss control improvements can and should be made. Start with the obvious problems that can be remedied within budget then examine larger issues that may involve further analysis or a large financial investment.

5. Comparing Loss Control Options

   In addition to the economic level of water loss as a tool to assist in assessing losses, a cost/benefit analysis between options is extremely useful. A cost/benefit analysis allows for direct comparison by converting all aspects of competing options to present values so they can be compared on an equivalent basis.

6.2.2 Intervention

Intervention is formed to follow-up the previous data analysis. The activities in this step could be:

1. Further Information Gathering

   Both water audits and calculated performance indicator values will identify operational areas where more data should be collected. Periodic water audits and tracking of performance indicator values identify the most significant components in terms of loss volume and cost impact.

2. Leakage Detection and Locating

   In order to better understand how water leaks are detected, water managers should look at three major water loss leak detection categories: (1) leak detection through appearance, (2) leak quantification through flow monitoring, and, (3) locating hidden leaks with leak detection equipment (acoustic, thermal, electromagnetic, tracer, etc.).

3. Repairing, Rehabilitation, and Replacement

   A variety of technologies are available to repair leaks depending on their location and size. Many studies have shown that the most

significant portion of leak repair cost and time is attributed to uncovering the leak site and dewatering.

4. Operation and Maintenance Program

   An effective water loss management program is one that incorporates leak prevention techniques over the life cycle of the distribution system. The decision made in the design and construction phase may impact the operations of the system for years to come. Thus operation and maintenance program is required.

6.2.3 Evaluation

After doing the water audit, the company should evaluate the data to determine where improvements can be made or where further information is required. Data gaps in the information should be reviewed and updated as information becomes available. After each intervention the water system manager should evaluate how successful the actions were.

CHAPTER 7
CONCLUSIONS AND RECOMMENDATIONS

This last chapter provides several conclusions and recommendation. Conclusions are obtained to respond to the objective of the research. On the other hand, recommendations are provided to give next research in similar issue better insight.

7.1 Conclusions

The conclusions of the research are:

1. There are two main problems in water-based activity at PT Panca Tunggal Cipta Karya Sentosa. The problems are inexistence of a system supporting the company to evaluate their water management and the water loss in cooling towers. Furthermore, this research found that the root causes of water problem in the company are inexistence of water loss control program, inexistence of water save innovation program, inexistence of water use procedure, and employee lack of knowledge.
2. In order to solve the root causes, several alternative recommendations are developed. Those recommendations are training and routine discussion, water use SOP, water loss control program, and water reuse program.
3. In term of qualitative perspective, water use SOP is the most preferable recommendation which has the highest score. On the other hand, from the quantitative perspective, water loss control program is the most preferable recommendation. At last, the combination between quantitative and qualitative perspective leads to the most preferable recommendations over all. Those recommendations are water use SOP and water loss control program.

7.2 Recommendations

After doing the research, the author could recommend several things, which are:

1. The eagerness of the company to achieve something better needs to be appealed. Thus the recommendation of something new can be approved decently.
2. The involvement of the government in the Green Industry Awarding Program needs to be increased.
3. At the problem identification stage, the author needs to have deeper conversation to several different perspectives, especially the employees, in the company in order to ease the process. The company may provide specific time to support the research.
4. All recommendation could be designed in detail form since the company will need it all in the future.

APPENDIX

Appendix 1. AHP Questionnaire

KUISIONER PRIORITAS REKOMENDASI

NAMA : Sambang.
JABATAN : Pimpinan

Kuisioner ini ditujukan untuk memilih rekomendasi yang paling diinginkan oleh perwakilan perusahaan PT. Panca Tunggal Cipta Karya Sentosa. Rekomendasi yang dimaksud adalah:

1. Pelatihan dan Diskusi Rutin
2. SOP Penggunaan Air
3. *Water Loss Control Program*
4. Program *Reuse* Air

Rekomendasi tersebut akan dipilih berdasarkan beberapa kriteria yaitu:

1. Kemudahan Pelaksanaan
2. Banyaknya Kebutuhan
3. Cepatnya Terjadi Dampak
4. Besarnya Dampak

Lingkari angka sesuai kriteria yang dirasa paling penting.

1 = sama penting
3 = sedikit lebih penting
5 = lebih penting
7 = sangat lebih penting
9 = jauh lebih penting

Contoh:

Kemudahan Pelaksanaan **sedikit lebih penting** daripada banyaknya kebutuhan, maka:

Kemudahan Pelaksanaan	9	7	5	3	1	3	5	7	9	Banyaknya Kebutuhan

Bobot Kriteria

Kemudahan Pelaksanaan	9	7	5	3	1	3	5	7	9	Banyaknya Kebutuhan
Kemudahan Pelaksanaan	9	7	5	3	1	3	5	7	9	Cepatnya Terjadi Dampak
Kemudahan Pelaksanaan	9	7	5	3	1	3	5	7	9	Besarnya Dampak
Banyaknya Kebutuhan	9	7	5	3	1	3	5	7	9	Cepatnya Terjadi Dampak
Banyaknya Kebutuhan	9	7	5	3	1	3	5	7	9	Besarnya Dampak
Cepatnya Terjadi Dampak	9	7	5	3	1	3	5	7	9	Besarnya Dampak

Lingkari angka sesuai nilai alternatif terhadap kriteria yang telah ditentukan.

1 = sama baik
3 = sedikit lebih baik
5 = lebih baik
7 = sangat lebih baik
9 = jauh lebih baik

Appendix 1. AHP Questionnaire (con't)

Contoh:

Pelatihan dan Diskusi Rutin **sedikit lebih mudah** dilaksankan daripada SOP Penggunaan Air, maka:

Kemudahan Pelaksanaan										
Pelatihan dan Diskusi Rutin	9	7	5	**3**	1	3	5	7	9	SOP Penggunaan Air

Skor Rekomendasi Alternatif

Kemudahan Pelaksanaan										
Pelatihan dan Diskusi Rutin	9	7	**5**	3	1	3	5	7	9	SOP Penggunaan Air
Pelatihan dan Diskusi Rutin	9	**7**	5	3	1	3	5	7	9	*Water Loss Control Program*
Pelatihan dan Diskusi Rutin	9	7	**5**	3	1	3	5	7	9	Program *Reuse* Air
SOP Penggunaan Air	9	7	5	**3**	1	3	5	7	9	*Water Loss Control Program*
SOP Penggunaan Air	9	7	5	**3**	1	3	5	7	9	Program *Reuse* Air
Water Loss Control Program	9	7	5	3	1	**3**	5	7	9	Program *Reuse* Air
Banyaknya Kebutuhan										
Pelatihan dan Diskusi Rutin	9	7	5	3	1	**3**	5	7	9	SOP Penggunaan Air
Pelatihan dan Diskusi Rutin	9	7	5	**3**	1	3	5	7	9	*Water Loss Control Program*
Pelatihan dan Diskusi Rutin	9	7	5	**3**	1	3	5	7	9	Program *Reuse* Air
SOP Penggunaan Air	9	7	**5**	3	1	3	5	7	9	*Water Loss Control Program*
SOP Penggunaan Air	9	7	**5**	3	1	3	5	7	9	Program *Reuse* Air
Water Loss Control Program	9	7	5	3	**1**	3	5	7	9	Program *Reuse* Air
Cepatnya Terjadi Dampak										
Pelatihan dan Diskusi Rutin	9	7	5	3	1	**3**	5	7	9	SOP Penggunaan Air
Pelatihan dan Diskusi Rutin	9	7	5	**3**	1	3	5	7	9	*Water Loss Control Program*
Pelatihan dan Diskusi Rutin	9	7	5	3	**1**	3	5	7	9	Program *Reuse* Air
SOP Penggunaan Air	9	7	5	**3**	1	3	5	7	9	*Water Loss Control Program*
SOP Penggunaan Air	9	7	5	**3**	1	3	5	7	9	Program *Reuse* Air
Water Loss Control Program	9	7	5	3	1	**3**	5	7	9	Program *Reuse* Air
Besarnya Dampak										
Pelatihan dan Diskusi Rutin	9	7	5	3	1	**3**	5	7	9	SOP Penggunaan Air
Pelatihan dan Diskusi Rutin	9	7	5	3	1	3	**5**	7	9	*Water Loss Control Program*
Pelatihan dan Diskusi Rutin	9	7	5	3	1	**3**	5	7	9	Program *Reuse* Air
SOP Penggunaan Air	9	7	5	3	1	**3**	5	7	9	*Water Loss Control Program*
SOP Penggunaan Air	9	7	5	**3**	1	3	5	7	9	Program *Reuse* Air
Water Loss Control Program	9	7	5	**3**	1	3	5	7	9	Program *Reuse* Air

Appendix 2. Report of Visitation 1

1.1 Informasi Umum

Tempat Kunjungan	:	Pergudangan Margomulyo Jaya Blok B.2-3, Surabaya
Tanggal Kunjungan	:	Kamis, 8 Januari 2015
Waktu	:	09.00 – 13.00
Tim ITS	:	Linggar Asa Baranti Denisa Melva Napitupulu
Narasumber	:	Pemilik PT. Panca Tunggal Cipta Karya Sentosa dan pegawai.

1.2 Hasil Kunjungan

Kunjungan menghasilkan beberapa informasi terkait gambaran umum perusahaan, kendala yang dihadapi, system produksi, aliran produksi, waktu produksi standard, dan layout perusahan tersebut.

1.2.1 Gambaran Umum

Berikut adalah gambaran umum proses bisnis perusahaan:

- Produknya adalah macam-macam produk berbahan dasar plastik (tempat sabun, mangkok, tempat kertas, termos plastik, hanger, gayung, *clip board*, timba cor, dll).
- Sistem produksi sangat fleksibel, MTO atau MTS sesuai kebutuhan.
- Tidak ada supplier yang pasti, yang terpenting adalah kecocokan harga dan keadaan material. Supplier berada di Surabaya dan sekitarnya.
- Penjadwalan produksi tidak pasti, sangat bergantung pada permintaan yang ada.
- Proses produksi berjalan 24 jam sehari dengan 3 shift kerja, 07.00-15.00, 15.00-11.00, 11.00-07.00.
- Memiliki 30-40 pegawai, 8-10 diantaranya adalah pegawai tetap.

- Ada *sharing session* di saat-saat tertentu untuk menyamakan *skill* pegawai.
- *Warehouse* barang jadi, WIP, dan *raw material* masih bercampur. Pembagian masih belum jelas.
- Memiliki 8 mesin injeksi yang belum tentu bekerja full dalam sehari, tergantung demand. Memiliki sekitar 55 cetakan. Cetakan dan mesin dapat juga disewakan untuk perusahaan lain.
- Tidak ada spesifikasi pegawai secara khusus.
- Ada catatan jumlah produksi, pembelian *raw material*, dan barang keluar tiap hari.

1.2.2 Kendala

Berikut adalah kendala yang disampaikan oleh pemilik tentang perusahaan:

- Mesin sangat bergantung dengan keahlian operator karena mesin memiliki karakteristiknya masing-masing.
- *Skill* pegawai tidak merata.
- *Defect* bisa tergantung dengan cuaca. Jika cuaca sangat panas, bisa jadi *raw material* sangat mudah meleleh sehingga dengan suhu mesin yang ditetapkan biasanya dapat menghasilkan defect yang lebih banyak daripada biasanya.
- Kurang besarnya tempat sehingga membuat gudang, tempat produksi dan *packaging* tidak memiliki *layout* yang tertata dengan baik.

1.2.3 Sistem Produksi

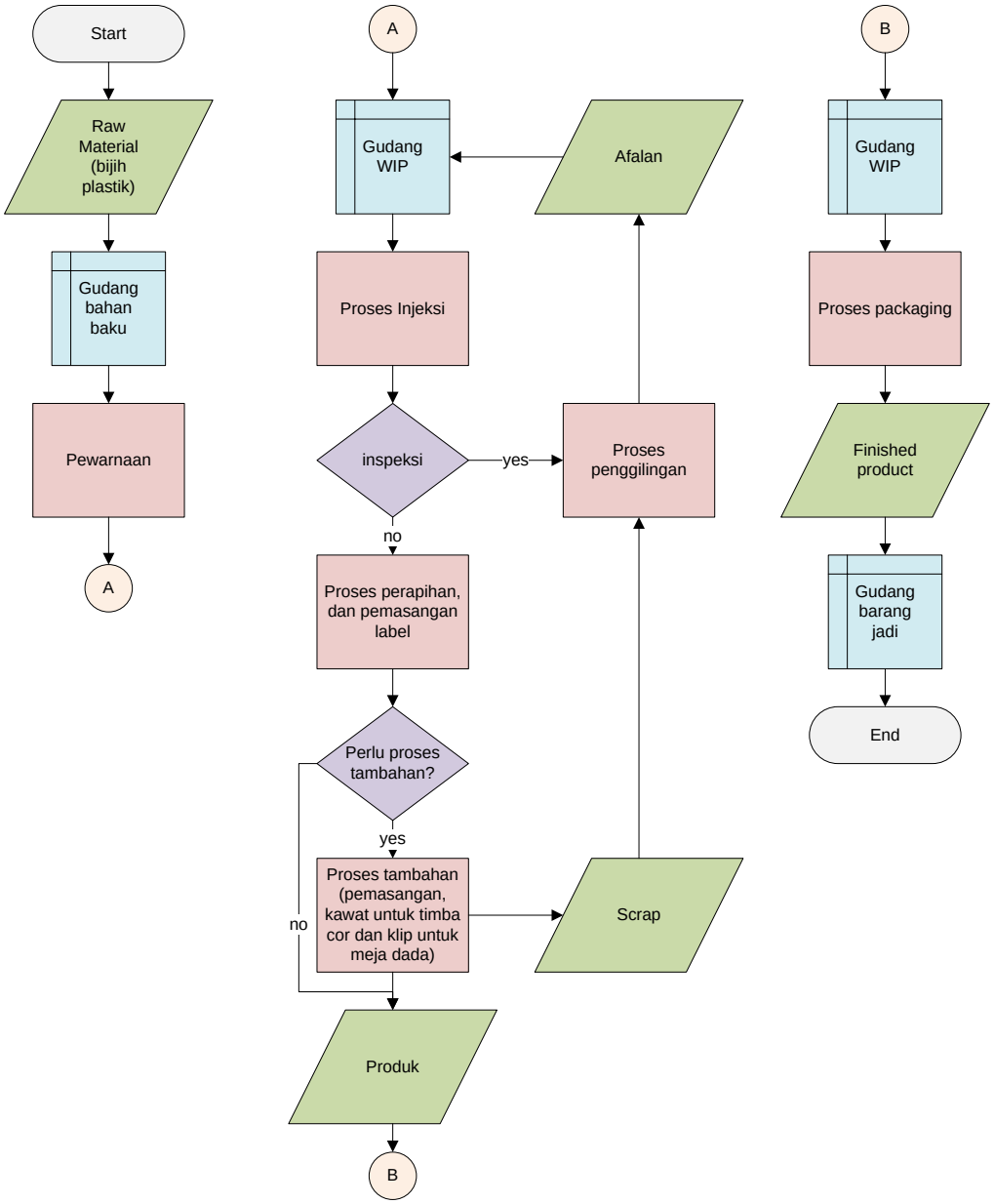
Berikut adalah informasi yang didapatkan mengenai sistem produksi secara keseluruhan:

- Dilakukan dengan metode *batch* setiap 30 kilogram bijih plastik, sesuai dengan kapasitas mesin.
- 1 mesin dapat memproduksi 1 ton dalam sehari.
- *Defect rate* kurang lebih 5%.

- Mesin sering rusak. Jika rusak berat, waktu *maintenance* bisa mencapai 1 hari, sedangkan jika rusak ringan waktu *maintenance* mencapai 1 jam.

1.2.4 Aliran Produksi

Berikut adalah aliran produksi di PT. Panca Tunggal Cipta Karya Sentosa.



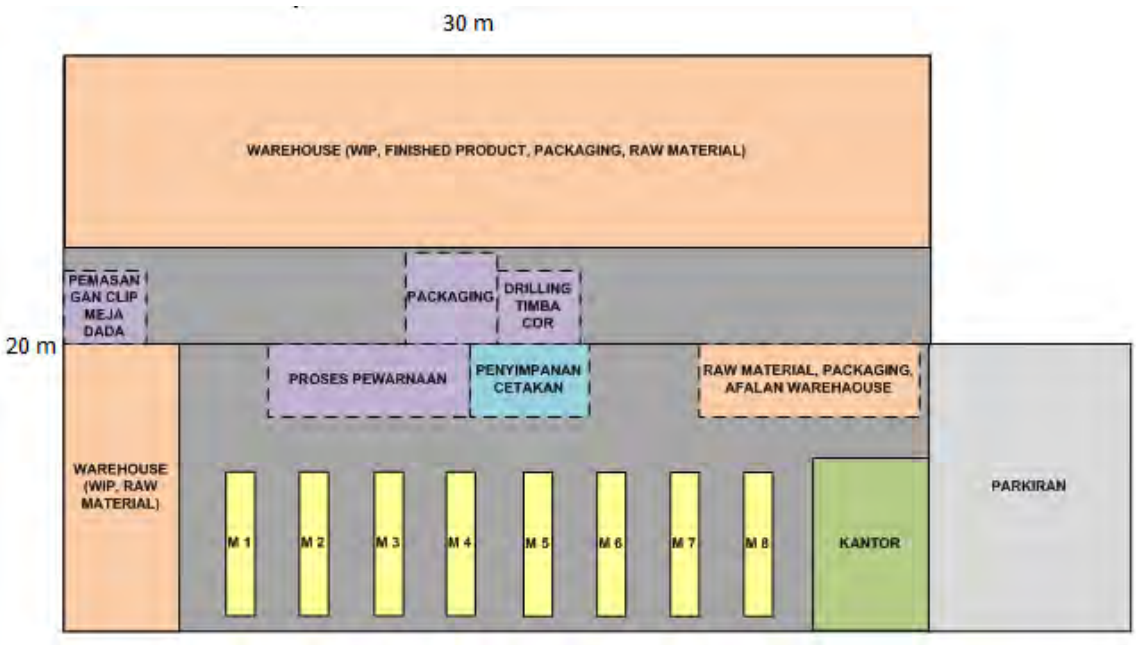
1.2.5 Waktu Produksi

Berikut adalah waktu produksi masing-masing produk

Produk	Waktu Proses Produksi (detik)	Waktu Proses Inspeksi, Perapihan dan Pemasangan Label (detik)	Proses Tambahan (detik)
Tempat Sabun	13	5	
Mangkok	10	5	
Tempat Map	47	7	
Termos Plastik	25	12	
Hanger (2 buah)	23	3	
Gayung	17	5	
Clip Board	26	14	8
Timba Cor	26	24	10

1.2.6 Layout

Berikut adalah layout PT. Panca Tunggal Cipta Karya Sentosa.



1.3 Dokumentasi Kunjungan Perusahaan

Produk Jadi

Cetakan Untuk Mesin

Aplikasi Stiker

Gudang Barang Jadi

Gudang Bahan Baku

Proses *Finishing*

Produk Afalan

Bagian dalam Perusahaan

Tempat Pewarnaan Plastik

Appendix 3. Report of Visitation 2

2.1 Informasi Umum

Tempat Kunjungan	:	Pergudangan Margomulyo Jaya Blok B.2-3, Surabaya
Tanggal Kunjungan	:	Jumat, 16 Januari 2015
Waktu	:	09.00 – 13.00
Tim ITS	:	Linggar Asa Baranti Denisa Melva Napitupulu
Narasumber	:	Pemilik PT. Panca Tunggal Cipta Karya Sentosa dan pegawai.

3.2 Hasil Kunjungan

Kunjungan menghasilkan penilaian PT. Panca Tunggal Cipta Karya Sentosa terhadap buku Industri Hijau. Berdasarkan hasil pengamatan dan *interview* dengan pemillik, dapat disimpulkan bahwa perusahaan ini masih perlu melakukan perbaikan untuk mendapatkan sertifikasi industri hijau.

PENILAIAN PENGHARGAAN INDUSTRI HIJAU

KATEGORI INDUSTRI KECIL DAN MENENGAH

PT. PANCA TUNGGAL CIPTA KARYA SENTOSA

No	Aspek Penilaian	Bobot Aspek	Sub Aspek	Bobot Sub Aspek	Kriteria	Bobot Kriteria	Skor	Skor Kriteria	Nilai Kriteria	Nilai Sub Aspek	Nilai Aspek
1	Proses Produksi	70	Program Efisiensi Produksi	16.67	Kebijakan perusahaan dalam penerapan efisiensi produksi	50	2	0.5	0.25	0.041667	0.223609
					Tingkat capaian penerapan komitmen perusahaan dalam meningkatkan efisiensi produksi	50	0	0	0		
			Material Input	16.67	Rasio material input terhadap output	25	4	1	0.25	0.052083	
					Subsitusi material input	25	0	0	0		

No	Aspek Penilaian	Bobot Aspek	Sub Aspek	Bobot Sub Aspek	Kriteria	Bobot Kriteria	Skor	Skor Kriteria	Nilai Kriteria	Nilai Sub Aspek	Nilai Aspek
					Penanganan material input	25	1	0.25	0.0625		
					Sertifikasi atau ijin material input	25	0	0	0		
			Energi	16.67	Manajemen energi	33.33	2	0.5	0.16665	0.027775	
					Upaya efisiensi energi	33.33	0	0	0		
					Upaya pemanfaatan energi terbaru	33.33	0	0	0		
			Air	16.67	Upaya efisiensi atau konservasi air	100	0	0	0	0	
			Teknologi Proses	16.67	Penerapan program *reduce* dan reuse	25	3	0.75	0.1875	0.03125	
					Peningkatan teknologi proses dan mesin atau peralatan	25	0	0	0		

No	Aspek Penilaian	Bobot Aspek	Sub Aspek	Bobot Sub Aspek	Kriteria	Bobot Kriteria	Skor	Skor Kriteria	Nilai Kriteria	Nilai Sub Aspek	Nilai Aspek
					Penerapan SOP proses produksi	25	0	0	0		
					Tingkat produk reject dan defect terhadap total produk	25	0	0	0		
			Sumber Daya Manusia	16.67	Program peningkatan kapasitas SDM Manufaktur	100	4	1	1	0.166667	
2	Pengelolaan lingkungan dan keselamatan kerja	20	Limbah	50	Pengelolaan Limbah	20	3	0.75	0.15	0.175	0.135
					Pemanfaatan Limbah	20	4	1	0.2		
					Pengujian Kualitas Limbah	20	0	0	0		
					Pemenuhan baku mutu limbah cair	20	0	0	0		

No	Aspek Penilaian	Bobot Aspek	Sub Aspek	Bobot Sub Aspek	Kriteria	Bobot Kriteria	Skor	Skor Kriteria	Nilai Kriteria	Nilai Sub Aspek	Nilai Aspek
					Pemenuhan baku mutu limbah gas dan debu	20	0	0	0		
			Lingku-ngan Kerja	50	Keselamatan Kesehatan Kerja dan Lingkungan	100	4	1	1	0.5	
3	Manajemen Perusahaan	10	Sertifikasi	33.33	Produk	50	0	0	0	0	0
					System Manajemen	50	0	0	0		
			CSR	33.33	Kepedulian terhadap sosial, ekonomi dan lingkungan sekitar	100	0	0	0	0	
			Penghar gaan	33.33	Penghargaan terkait bidang produksi dan pengelolaan bidang industri yang pernah diterima	100	0	0	0	0	

No	Aspek Penilaian	Bobot Aspek	Sub Aspek	Bobot Sub Aspek	Kriteria	Bobot Kriteria	Skor	Skor Kriteria	Nilai Kriteria	Nilai Sub Aspek	Nilai Aspek
Total Nilai											35.86 %

Kesimpulan

Berdasarkan hasil penilaian PT Panca Tunggal Cipta Karya Sentosa terhadap Penghargaan Industri Hijau, dapat disimpulkan bahwa perusahaan tersebut belum memiliki komitmen terhadap lingkungan karena memiliki total nilai di bawah 50% yaitu 35.86%. Diperlukan banyak perbaikan jika ingin meningkatkan efisiensi produksi di perusahaan ini di semua aspek. Namun dari kunjungan yang dilakukan, perusahaan ybs masih belum memiliki keinginan untuk menerapkan konsep *green* pada perusahaannya.

Appendix 4. Report of Visitation 3

3.1 Informasi Umum

Tempat Kunjungan	:	Pergudangan Margomulyo Jaya Blok B.2-3, Surabaya
Tanggal Kunjungan	:	Senin, 2 Maret 2015
Waktu	:	09.00 – 13.00
Tim ITS	:	Linggar Asa Baranti Denisa Melva Napitupulu
Narasumber	:	Pemilik PT. Panca Tunggal Cipta Karya Sentosa dan pegawai.

3.2 Hasil Kunjungan

Kunjungan menghasilkan beberapa informasi tambahan terkait gambaran umum perusahaan.

3.2.1 Fishbone Awal

Kunjungan ini bertujuan untuk mendapatkan permasalahan inti yang sudah tervalidasi. Validasi dilakukan melalui *Focus Group Discussion* dan observasi langsung. Dari pernyataan pemilik dan beberapa pegawai banyak didapatkan fakta-fakta yaitu:

- Perusahaan merasa kerugian paling banyak terjadi di mesin *cooling tower* karena air yang terciprat keluar mesin. Cipratan itu terjadi sepanjang mesin tersebut berjalan. Tapi keadaan ini tidak bisa dibenahi karena memang cipratan air itu adalah kebutuhan mesin untuk menghilang panas dalam air.
- Toilet sering dikosongkan untuk menghindari air meluap, karena pegawai sering lupa mematikan air.
- Selain itu, pegawai akan didenda jika menggunakan air untuk keperluan pribadi seperti mandi, mencuci motor, dll.

- Sudah beberapa kali ditemukan pegawai mandi atau mencuci motor menggunakan air perusahaan.
- Ketidaksadaran pegawai tentang penggunaan mungkin dikarenakan tingkat pendidikan yang rendah dan tidak adanya syarat-syarat khusus saat *recruitment*.
- Secara umum tidak pernah ditemukan pipa bocor. Sehingga karat ataupun suhu air yang terlalu panas dapat dikonfirmasi tidak ada di perusahaan ini.
- Kebocoran sering terjadi di sambungan pipa atau selang.
- Sambungan pipa sering terjadi dan dikarenakan kebutuhan proses untuk melepas-pasang sambungan ketika memulai proses baru.
- Selang bocor hanya disumbat dengan kain sehingga masih merembes keluar dengan jumlah besar.
- Pemilik membiarkan pegawai menggunakan air di *cooling tower* karena tidak terpikirkan alternatif lain dan pada umumnya perusahaan tidak merasa itu sebuah permasalahan.
- Sampai sekarang perusahaan belum memiliki sistem untuk menglola air dengan baik. Sehingga perusahaan tidak tahu penggunaan air secara berkala apakah naik atau turun.

3.2.2 Fasilitas yang Menggunakan Air

PT. Panca Tunggal memiliki beberapa alat-alat yang dioperasikan untuk penggunaan air. Hasilnya didapatkan melalui observasi langsung. Beberapa fasilitas yang diobservasi dalam kunjungan kali ini adalah:

Tangki Air

Tangki Air Bawah Tanah dan Pompa

Air akan didistribusikan dari supplier melalui truk langsung ke tangki ini. Pengisian tangki akan dilakukan jika tangki air sudah terlihat kosong. Pendistribusian dilakukan menggunakan selang. Selang yang digunakan seringkali mengalami kebocoran sehingga membuat air terbuang sia-sia.

Cooling Towers

Cooling Towers di PT Panca Tunggal Cipta Karya Sentosa

Cooling towers di perusahaan ini digunakan untuk memproduksi *cooling water*. Selanjutnya *cooling water* ini dimanfaatkan untuk system pendingin di dalam mesin injeksi.

Ada dua *cooling towers* dalam perusahaan ini, yaitu:

1. Cooling Tower 1 : tinggi = 220 cm, diameter = 162 cm.
2. Cooling Tower 2 : tinggi = 183 cm, diameter = 142 cm.
3. Bak untuk CT1 : 162 x 324 x 100 cm, dapat memuat 5,248.8 liter air
4. Bak untuk CT2 : 183 x 368 x 100 cm, dapat memuat 6,734.4 liter air.

Air hasil produksi sering menyiprat keluar mesin dan tidak ada tempat penampungan. Cipratan ini berupa uap air yang sangat susah ditampung karena jarak cipratan yang jauh dan menyebar.

Sistem Pendingin Mesin Injeksi

Pipa untuk Sistem Pendingin Mesin Injeksi

Pipa-pipa tersebut digunakan untuk menyalurkan *cooling water* dari *cooling towers* ke 8 mesin injeksi.

Kebocoran dekat Mesin Injeksi

Pada sambungan pipa ke mesin sering ditemukan kebocoran. Frekuensinya termasuk sangat sering sesuai pengakuan pegawai. Hal ini terjadi karena setiap penggantian cetakan, maka sambungan ini juga akan dibongkar, sehingga memperbesar kesempatan sambungan untuk bocor.

Toilet dan Kegiatan Pembersihan

Toilet

Toilet seringkali sengaja dikosongkan oleh Pemilik. Hal ini dilakukan karena memang pegawai sering menggunakan air di dalam toilet secara tidak bertanggung jawab. Pemilik menyatakan beberapa pegwai pernah menggunakan air toilet untuk hal-hal pribadi seperti mencuci sepeda motor. Untuk menanggulangi hal tersebut, pemilik memberlakukan aturan denda Rp 5000 untuk pegawai yang menggunakan air tidak sesuai tujuan toilet pada umumnya.

Area Pembersihan

Sebagai konsekuensi seringnya kosong toilet, pegawai akhirnya menggunakan air di dalam bak *cooling towers* sebagai air untuk membersihkan diri. Hal ini tentu saja dapat menyebabkan kerugian bagi perusahaan karena bak tersebut berisi air yang telah diproses. Sehingga *cooling tower* harus memproses ulang *cooling water*.

Appendix 5. Report of Visitation 4

4.1 Informasi Umum

Tempat Kunjungan	:	Pergudangan Margomulyo Jaya Blok B.2-3, Surabaya
Tanggal Kunjungan	:	Kamis, 7 Mei 2015
Waktu	:	13.00 – 17.00
Tim ITS	:	Linggar Asa Baranti Denisa Melva Napitupulu
Narasumber	:	Pemilik PT. Panca Tunggal Cipta Karya Sentosa dan pegawai.

4.2 Hasil Kunjungan

Kunjungan ini bertujuan untuk mendapatkan prioritas rekomendasi. Sebelumnya peneliti menceritakan rekomendasi-rekomendasi yang diusulkan sesuai dengan permasalahan yang ada. Rekomendasi tersebut adalah SOP penggunan air, *water loss control program*, dan program *reuse* air. Pemilihan rekomendasi menggunakan metode AHP. Untuk memilih rekomendasi juga telah disediakan beberapa kriteria. Metode AHP digunakan untuk memilih rekomendasi dari perpektif kualitatif.

Selain itu, pada kunjungan ini juga dilakukan diskusi mengenai rekomendasi dan bobotnya. Hasilnya adalah:

- Pemilik lebih memilih untuk menggunakan perspektif kualitatif sebagai acuan pemilihan. Karena kualitatif menangkap kriteria mungkin-tidaknya rekomendasi itu implementasikan.
- Bagi pemilik, jika rekomendasi itu terlalu susah, maka lebih baik tidak digunakan.
- Mengatur pegawai akan sangat susah, sehingga pemilik pesimis dapat diperbaiki hanya dengan rekomendasi-rekoendasi yang diajukan.

4.3 Dokumentasi Kunjungan

Diskusi dengan Pegawai

Appendix 6. Report of Visitation 5

5.1 Informasi Umum

Tempat Kunjungan : Pergudangan Margomulyo Jaya Blok B.2-3, Surabaya
Tanggal Kunjungan : Senin, 1 Juni 2015
Waktu : 13.00 – 17.00
Tim ITS : Linggar Asa Baranti
Denisa Melva Napitupulu
Narasumber : Pemilik PT. Panca Tunggal Cipta Karya Sentosa dan pegawai.

1.2 Hasil Kunjungan

Kunjungan dilakukan untuk menyampaikan surat undangan untuk presentasi akhir proyek dan menyampaikan rekomendasi untuk meminimalisir penggunaan air. Adapun rekomendasi yang dihasilkan adalah:

1. Pembuatan SOP pada perusahaan

   Pembuatan SOP ini meliputi proses penggunaan air di perusahaan. Tujuannya adalah sebagai petunjuk kepada pegwai untuk megelola air dengan baik. Selain itu juga ada beberapa alat bantu yang butuh disiapkan dalam rangka mendukung pengimplementasian SOP. Alat-alat tersebut seperti form pencatatan air, alat ukur penggunaan air, poster-poster pengingat, dll.
2. Water Loss Control Program

   Program ini berupa system yang lebih menyeluruh dalam pengelolaan air. Aktivitas yang ada di dalamnya adalah pencatatan rutin, deteksi kebocoran, *maintenance*, analisis penggunaan air, dan evaluasi.

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BIOGRAPHY

Linggar Asa Baranti is the first daughter of Mudji Santoso and Dian Edi Wurasti. She was born on Surabaya, December 13th 1993. Now she lives at Bungurasih Timur 25 RT.02 RW.01 Waru, Sidoarjo with her parents and one little brother.

She started her education at SDN Kedung Rejo I Waru, Sidoarjo. Then, she continued her studies at SMPN 1 Sidoarjo and SMAN 1 Sidoarjo. Afterwards, the author forwarded her study at Institut Teknologi Sepuluh Nopember, Surabaya in Industrial Engineering Department.

During her college life, the author was actively following one of student organizations, Himpunan Mahasiswa Teknik Industri ITS. She specifically entered the field of public relation in that organization, as Public Relation Head of Department. On the other side, the author enriched her academic knowledge by becoming one of the assistants in Manufacturing System Laboratory.