FINAL PROJECT – TI 141501

ANALYSIS OF MUNICIPAL WASTE TRANSPORTATION MODE ALTERNATIVES IN SURABAYA

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TUGAS AKHIR – TI 141501

ANALISA PEMILIHAN ALTERNATIF MODA TRANSPORTASI PENGANGKUTAN SAMPAH DI KOTA SURABAYA

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ANALYSIS OF MUNICIPAL WASTE TRANSPORTATION MODE ALTERNATIVES IN SURABAYA

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ABSTRACT

Nowadays, municipal waste management becomes an important issue to be discussed, unexceptionally in Surabaya. It is because the pollutions of waste are getting worse due to its increasing volumes from year to year and indirectly it can give serious impacts to the environment such as global warming. Therefore, local government through one of its entities, *Dinas Kebersihan dan Pertamanan Kota Surabaya*, works hard to conduct better waste collection system through creating an effective and efficient system in an environmental friendly manner.

By conducting this research, hopefully, it will be able to give recommendation or solution to achieve those goals which are by providing two alternatives. Both alternatives related to the way of gaining operational savings by reducing high arm roll trucks rotation numbers through waste volume compression in waste collection points. The best alternative will be selected based on technical, financial, and operations analysis. The technical analysis is used to evaluate the appropriateness of both alternatives in terms of technology, capacity, and managerial in preparing requirements of new waste collection system. The financial indicators used to evaluate the alternatives are Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit Cost Ratio (BCR).

Keyword: Alternatives Selection; Benefit Cost Ratio; Internal Rate of Return; Net Present Value; Waste Collection System.

ANALISIS PEMILIHAN ALTERNATIF MODA TRANSPORTASI PENGANGKUTAN SAMPAH DI KOTA SURABAYA

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ABSTRAK

Pengelolaan sampah perkotaan kini telah menjadi isu yang penting untuk didiskusikan, tanpa terkecuali di Kota Surabaya. Hal ini dikarenakan polusi dari sampah semakin buruk akibat peningkatan volume sampah dari tahun ke tahun dan secara tidak langsung memberikan dampak serius terhadap lingkungan seperti pemanasan global. Oleh karena itu, pemerintah daerah melalui Dinas Kebersihan dan Pertamanan Kota Surabaya bekerja keras untuk melaksanakan sistem pengumpulan sampah yang lebih baik dengan menciptakan sebuah sistem yang lebih efektif, efisien, dan ramah lingkungan.

Melalui penelitian ini, harapannya, dapat memberikan rekomendasi atau solusi untuk DKP demi mencapai tujuan-tujuan itu yaitu dengan mengusulkan dua alternatif. Kedua alternatif sama-sama bertujuan untuk melakukan penghematan biaya operasional dengan mengurangi tingginya jumlah ritase truk *arm roll* melalui penggunaan mesin pengkompres sampah di Lokasi Pembuangan Sementara (LPS). Alternatif terbaik akan dipilih berdasarkan analisis aspek teknis, operasional, dan keuangan. Analisis teknis dan operasional digunakan untuk mengevaluasi kecocokan kedua alternatif dalam hal teknologi, kapasitas, dan manajerial untuk diterapkan sebagai sistem pengumpulan sampah yang baru. Indikator yang digunakan dalam analisis keuangan yaitu *Net Present Value* (NPV), *Internal Rate of Return* (IRR), dan *Benefit Cost Ratio* (BCR).

Kata Kunci: *Benefit Cost Ratio*; *Internal Rate of Return*; *Net Present Value*; Pemilihan Alternatif; Sistem Pengumpulan Sampah.

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During the completion of the study and this research, many parties have involved giving their uncountable supports and prayers to the author. Therefore, in this opportunity, the author would like to express the most sincere and greatest gratitude to the ones mentioned below:

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Author realizes that this final project report is still far from perfection. Accordingly, constructive critics and suggestions are expected to improve this report. Furthermore, author hopes this report would be beneficial for the readers and could be used wisely as needed.

Surabaya, 21 July 2016

Author

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CHAPTER I

INTRODUCTION

This chapter is the beginning of research report in which containing research background, problem formulation, research objectives, research benefits, and research scope. In the end of this chapter, there will be outline of the research report which is provided to describe a big picture of writing sequences done by author in finishing the whole research report.

1.1 Research Background

The growth of population which keeps increasing from year to year, both directly and indirectly, will affect the increasing number of waste production, unexceptionally in Surabaya. As can be seen in Figure 1.1, from 2013 to 2015, there is specific increasing of waste volumes. The data is based on waste volumes collected in Benowo as the only one final landfill from total around of 180 waste collection points in Surabaya.

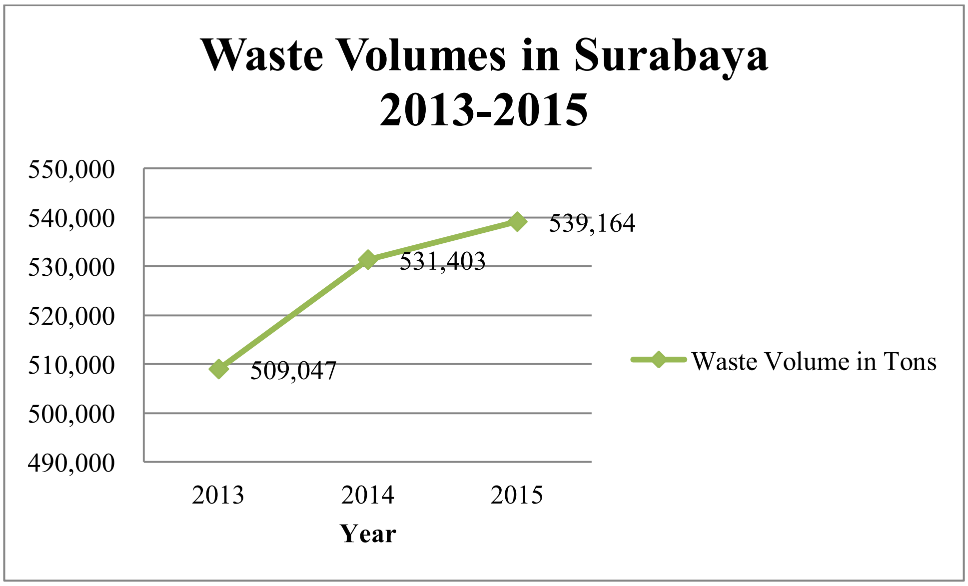

Figure 1.1 Increasing of Waste Volumes in Surabaya (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2012)

The waste management needs specific attention which is if not immediately being managed in proper ways then there will be more serious impact to the environment. Those impacts are such global warming. Associated with all of above reasons, an integrated waste collection system is needed to avoid and minimize municipal waste problems.

Based on *Undang-Undang No. 18 tahun 2008* about waste management, waste management is the joint responsibility of Central Government and Local Government, in which its operational management can be done through cooperation and collaboration with the related business entity, waste management organization, and obviously society. Therefore, in order to guarantee the certainty of waste management's law in Surabaya for the fulfillment of society rights in obtaining proper and environmental friendly waste management, the basic of waste management law as appointed in Local Regulation is necessary. In conducting waste management, DKP is always trying to create an effective waste transportation through operational cost minimization. The existing way to minimize waste collection cost which already implemented by DKP is using compactor truck.

However, compactor truck consumes more diesels because the process of compacting waste in the truck is using diesels therefore the consumption becomes double for running truck's machine and compactor machine. It consumes around 40-50 liters per day compared to arm roll truck which only consumes 25 liters per day. Meanwhile, the usage of arm roll trucks is having rejection from society due to social and resistance reasons. From the operational activities itself, arm roll rotation number per month in totally five areas of Surabaya is very high as shown in Figure 1.2.

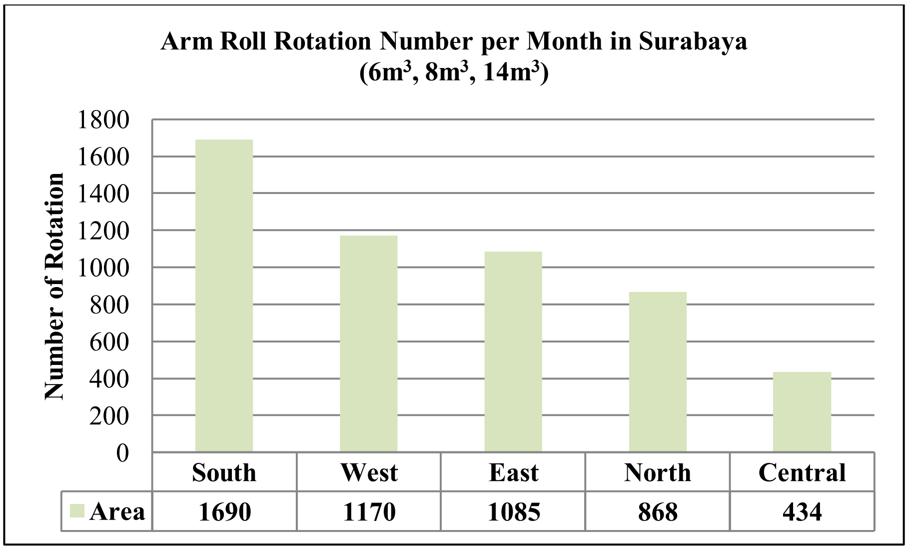

Figure 1.2 Arm Roll Truck Rotation Number (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2012)

The proposed waste collection system which is the procurement of waste compactors in waste collection points is expected to reduce those high arm roll rotation number. Waste compactors are industrial machines which compress waste to make it more cost-efficient and environmental friendly to dispose of. They use weights and pressure to effectively squeeze or compact waste material together so that it takes up less physical space. This makes it easier to store and dispose of waste materials as less storage is required and fewer collections are needed. It also reduces the space taken up in landfill.

The waste compactor is expected to be demountable to make it able to be easily lifted by arm roll trucks to transport the waste to the landfill. Besides compactor’s advantages as mentioned previously, this machine will also help to improve aesthetics value in waste collection points since the waste piles will be compressed inside the machine. It will also improve waste collection system in terms of many aspects.

Figure 1.3 Demountable Waste Compactor (Thetford International, 2008)

Demountable waste compactors are available in various different forms, and key options include flexibility in site location, various size and capacity options, fitted with a range of hoppers, fully reversible in transit, and effective against leakage. Demountable (or roll on/roll off) waste compactors can be can be sited simply in a required area. They have the advantage of being an integral compactor and container which can be manufactured in various sizes. The units can be fitted with a range of hoppers to include fork truck loading. They can be fully enclosed for hand loading, fitted with a bin loader attachment or have the option of being positioned for loading in reverse.

As well as reducing the size of waste materials and cutting down on the storage space costs prior to disposal, a waste compactor can benefit businesses by reducing the cost of waste transportation as well the frequency of collections. Additionally, businesses can gain a smoother and more efficient waste disposal service which is green and energy-efficient. Smaller waste equates to less space taken up in landfill sites and this has far-reaching benefits for all.

Based on first part in ninth clause of Local Regulation of Surabaya City, waste management execution is divided into two main activities, first is waste reduction and second is waste handling. Every person and/or organization is compulsory to conduct both waste reduction and handling in an environmental friendly manner. Since this research is only focusing on waste handling in an environmental friendly manner, then there will be only detail description of waste handling activities. Waste handling activities are including sorting, collecting, transporting, processing, and final disposal of waste in landfill.

The large investment needed to purchase waste compactor and to implement new system in all waste collection points obviously has to be analyzed properly in order to make them realized. Therefore, a comprehensive research is necessary to be conducted about the potencies of waste compactor whether it gives more benefits in terms of cost savings and efficiency improvement in waste collection.

1.2 Problem Formulation

Based on the above background, this research will specifically evaluate the viability of the use of arm roll truck with demountable waste compactor to transport waste from waste collection point to the final landfill. The evaluation will involve technical, operation, and financial aspects.

1.3 Research Objectives

The objectives which want to be reached by author through this research are as follow.

1. Elaborate the weaknesses of existing waste collection system.
2. Identify alternatives of new system.
3. Select the waste collection points in Surabaya which will be the targets to implement new system.
4. Select the alternative of new system which is appropriate and most efficient to be implemented as better waste transportation system in Surabaya.

1.4 Research Benefits

The benefits which want to be gained through this research are as follow.

1. *Dinas Kebersihan dan Pertamanan* (DKP) Surabaya will get recommendation to make decision for proposing new better waste collection system.

2. *Dinas Kebersihan dan Pertamanan* (DKP) Surabaya will know the best financing alternatives for new system.
3. *Dinas Kebersihan dan Pertamanan* (DKP) Surabaya will have more savings in the operational cost since the new system can indirectly reducing number of arm roll rotation.

1.5 Research Scope

This subchapter contains limitations and assumptions used in the making of this research.

1.5.1 Limitations

The limitations set for this research are as follow.

1. The object for this research is the waste transportation mode which is arm roll truck that used to transport waste from waste collection points to final landfill.
2. Data used for this research is data from DKP in the range of 2012 to 2016, including the trucks used in this research are those with production year at least starting from 2012.
3. Conventional container used for one of waste collection system alternatives is closed or sealed container type.
4. Waste collection points in each region which selected to be research's implementation point are those with minimum 2 rotations of arm roll trucks.
5. The hydraulic of arm roll truck is only capable to lift container and the waste in the weight of maximum 20-25 tons.

1.5.2 Assumptions

The assumptions set for this research are as follow.

1. All data given by DKP is valid and verified.
2. All arm roll trucks are in good condition during research.
3. There is no change of both demountable waste compactor and compactor machine cost and specification during research.

4. The additional assumptions will be later added in Chapter IV if necessary.

1.6 Research Report Outline

This subchapter is provided to give big picture of research report, which will be described concisely below.

- CHAPTER I: INTRODUCTION

  This chapter is the beginning of research report in which containing research background, problem formulation, research objectives, research benefits, and research scope. In the end of this chapter, there will be outline of the research report which is provided to describe a big picture of writing sequences done by author in finishing the whole research report.

- CHAPTER II: LITERATURE REVIEW

  This chapter contains all supporting theory and concepts used by author related to this research in order to give easier understanding for reader. The main topics gathered in the literature review are information about the observation object, elements of solid waste management system, comparisons of each waste compactor type, and methodology used in this research.

- CHAPTER III: RESEARCH METHODOLOGY

  This chapter contains detail explanation of methodology's flow used to finish the research which is starting from problem identification until making conclusions and recommendations of this research.

- CHAPTER IV: DATA ANALYSIS

  This chapter discusses the evaluation of existing waste collection system, identification of alternative system collection, and the analysis of new system selected.

- CHAPTER V: CONCLUSION AND SUGGESTION

  This last chapter elaborates the conclusions which can be drawn from this research in the aims of answering all research objectives along with the suggestions which are given regarding this typical future research topic.

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CHAPTER II
LITERATURE REVIEW

This chapter contains all supporting theory and concepts used by author related to this research in order to give easier understanding for reader. The main topics gathered in the literature review are information about the observation object, elements of solid waste management system, comparisons of each waste compactor type, and methodology used in this research.

2.1 Dinas Kebersihan dan Pertamanan Kota Surabaya

DKP or *Dinas Kebersihan dan Pertamanan Kota Surabaya* is one of Local Government institution which is responsible in sanitation and park management. DKP has vision of creating clean, green, beautiful, and sparkling Surabaya.

DKP is responsible in transporting mostly residential and small traditional market waste from waste collection points to final landfill Benowo as can be seen in Figure 2.1. DKP has totally 186 waste collection points to be served which spread in North, South, West, East, and Central Surabaya.

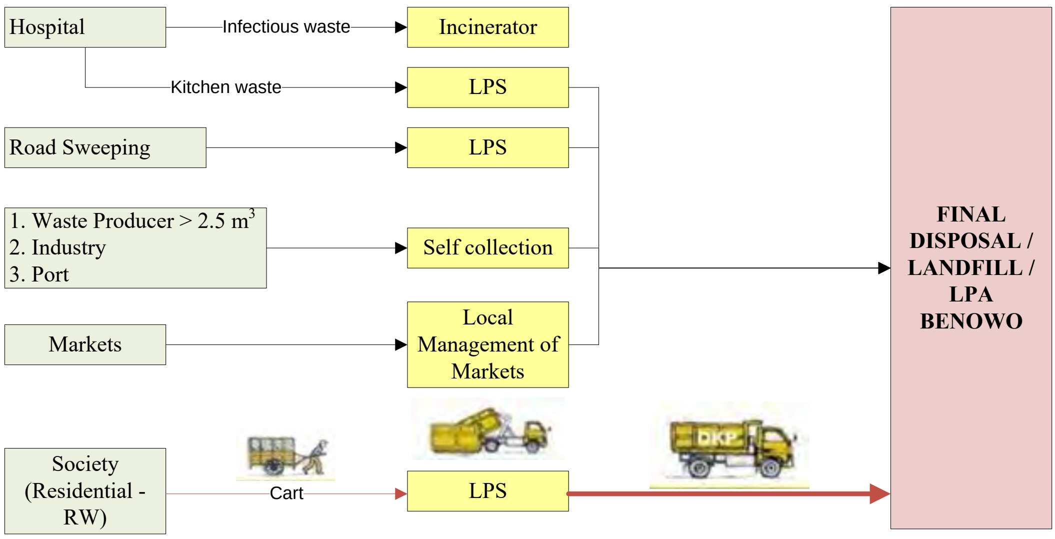

Figure 2.1 Waste Collection System in Surabaya (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2012)

2.2 Elements of Solid Waste Management System

As explained in the research background, the solid waste management system is divided into six specific activities (Tchobanoglous & Kreith, 2002).

2.2.1 Waste Generation

Waste generation encompasses those activities in which materials are identified as no longer being of value and are either thrown away or gathered together for disposal. What is important in waste generation is to note that there is an identification step and that this step varies with each individual. Waste generation is, at present, an activity that is not very controllable.

2.2.2 Waste Handling and Separation, Storage, and Processing at the Source

Waste handling and separation involve the activities associated with managing wastes until they are placed in storage containers for collection. Handling also encompasses the movement of loaded containers to the point of collection. Separation of waste components is an important step in the handling and storage of solid waste at the source. On-site storage is of primary importance because of public health concerns and aesthetic considerations.

2.2.3 Waste Collection

Collection includes both the gathering of solid wastes and recyclable materials and the transport of these materials, after collection, to the location where the collection vehicle is emptied, such as a materials-processing facility, a transfer station, or a landfill.

2.2.4 Waste Transfer and Transport

The functional element of transfer and transport involves two steps: (1) the transfer of wastes from the smaller collection vehicle to the larger transport equipment, and (2) the subsequent transport of the wastes, usually over long distances, to a processing or disposal site. The transfer usually takes place at a transfer station. Although motor vehicle transport is most common, rail cars and barges are also used to transport wastes.

2.2.5 Waste Separation, Processing, and Transformation of Solid Waste

The means and facilities that are now used for the recovery of waste materials that have been separated at the source include curbside collection and drop off and buyback centers. The separation and processing of wastes that have been separated at the source and the separation of commingled wastes usually occurs at materials recovery facilities, transfer stations, combustion facilities, and disposal sites.

Transformation processes are used to reduce the volume and weight of waste requiring disposal and to recover conversion products and energy. The most commonly used chemical transformation process is combustion, used in conjunction with the recovery of energy. The most commonly used biological transformation process is aerobic composting.

2.2.6 Waste Disposal

Today, disposal by land filling or land spreading is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from MRFs, residue from the combustion of solid waste, compost, or other substances from various solid waste processing facilities. A modern sanitary landfill is not a dump. It is a method of disposing of solid wastes on land or within the earth's mantle without creating public health hazards or nuisances.

2.3 Comparisons of Waste Compactor Alternatives

There are many types of waste compactors that can be alternative and there is also waste compression machine which already commonly used in Indonesia.

2.3.1 Waste Compactors

Waste compactors are designed to compress waste material to reduce the amount of space it takes up. Waste compactors are capable of compressing a large volume of waste materials into a relatively small space. Key features of the products include the structural stability of the machinery itself as well as high safety requirements and easy operation. Many waste compactors are easy to load as well as easy to use, and this ensures that businesses are able to take care of their waste with minimal effort. Some compactors will feature loading chutes and many units are constructed from high quality steel to ensure durability. There is a great deal of variance in the power or force used by different waste compactors but most units are low-noise options to avoid causing disruption to workers. Thorough maintenance and servicing are also key features of these machines (Thetford International, 2008).

As well as reducing the size of waste materials and the storage space they take up prior to disposal, a waste compactor can also benefit businesses by reducing the cost of waste transportation. Waste collections at work sites will be required far less frequently when using compactors and this has a knock-on effect on the prices associated with the process. Additionally, businesses gain a smoother and more efficient waste disposal service which is eco-friendly – thus boosting their green credentials. Smaller waste equates to less space taken up in landfill sites and this has far-reaching benefits for all involved. There are many environmental benefits produced by waste compactors but the central idea is that the smaller waste takes up less space in landfill sites. Additionally, fewer waste collections can mean fewer harmful emissions (as there are less vehicles on the road) and equate to a reduction in the consumption of fuels.

Technical analysis is also done by doing benchmarking between compactor types based on several aspects which are mostly about the specifications, as can be seen in Table 2.1.

Table 2.1 Benchmarking of Compactor Types

				
Model	Portable	Static	Demountable	Compactor + Bin Hoist
Total Capacity	10 m^3	8-32 m^3	13.8 m^3	20-22.5 m^3
Compaction Force	380 kN	380 kN	287 kN	340 kN
Cycle Time	43 seconds	47 seconds	28 seconds	38 seconds
Electric Motor	5.5 kW	7.5 kW	5.5 kW	5.5 kW
Weight	3 x 400 V/50 Hz	3 x 400 V/50 Hz	3 x 380 V/50 Hz	3 x 415 V/32 A

Source: (Kenburn Waste Management, 2016, PDE Waste Technologies, 2016)

2.3.2 Waste Compression Station

The existing whole package eco-friendly waste management system is called Waste Compression Station. This is an integrated solution consisting an Indoor Building, Compression Machine and Transfer Vehicle. It makes the waste management system more clean, eco-friendly, low cost operational, effective and efficient (OMNI, 2012). The waste compression machine can be seen in Figure 2.2 and the specifications in Table 2.2.

Figure 2.2 Waste Compression Station (OMNI, 2012)

Table 2.2 Specification of Waste Compression Station

	Description	Specification
Machine	Compression Method	Vertical
	Maximum Compression Strength	100 t
	Waste Disposal Capacity	80 t/d
	Main Motor Power	18.5 kW
	Working Pressure System	21 Mpa
	Waste Block Dimension	1600 x 1850 x 1400 mm
	Junk Block Weight	4 ton
Hydraulic	Hydraulic Maximum Pressure	21 Mpa
Structure Dimension	Length	6250 mm
	Width	3250 mm
	Height	6400 mm
	Compaction Space Volume	5 m^3
	Compaction Weight	19 ton
Power Supply	System	AC
	Voltage	380 volt
	Frequencies	50 Hz

Source: (OMNI, 2012)

2.4 Investment

Investment is one of the most important variables in economics. Because it is so important, economists have studied investment intensely and understand it relatively well (Hassett, 2008).

2.4.1 Investment Definition

In an economic sense, an investment is the purchase of goods that are not consumed today but are used in the future to create wealth. In finance, an investment is a monetary asset purchased with the idea that the asset will provide income in the future or appreciate and be sold at a higher price. Investment is all activities which contain the factors of sacrifices and expenses to reach a goal in the future. For example, a manager buys thousands of shares by using her own money. A business man spends billions rupiah to construct a new plant. A housewife saves money in a bank every month so that someday she can buy a car (Pujawan, 2003).

From above examples, there are two types of investments which are financial investment and real investment. If someone do an investment by saving money or resources he or she has, it is types of financial instruments such as stock, obligation, and others so that it can be said that financial investment occurred. Meanwhile, real investment is embodied in the forms of real assets such as plant, product's equipments, land, and others.

Investment, whether it is done in industrial field or other fields, basically is an effort to implant scarce production factors in a certain project. The project itself can be totally new or improvement of an existing project. There are two factors involved in an investment which are time and risk. In several certain investments, time has more roles, meanwhile in the other types of investment, risk factor is more dominant.

2.4.2 Investment Goals

The main goal of an investment is to get various benefits that sufficiently feasible in the future. Those benefits can be financial rewards, such as profit, and non financial benefits which is the creation of new working field, the increasing of exports, import substitution or utilization of raw materials in a rich and developed country, proud of the area improves, and other benefits (Sutujo, 1982).

Commonly, personal and private corporate tend to place financial benefits as main goal, meanwhile government institution mostly prioritize macro economy benefits, religion, or culture which is all of them not only giving financial benefits.

2.4.3 Interest

The rate of interest measures the percentage reward a lender receives for deferring the consumption of resources until a future date. Correspondingly, it measures the price a borrower pays to have resources now (Malkiel, 2008).

Corporate legislation requires disclosure of interest payable on loans, and companies often show a single interest figure in the income statement while providing details in a note that may also include netting out of interest received or some other adjustments. In cost accounting, interest is normally excluded from cost computations on the grounds that (being a payment for capital) it is equivalent to dividend, and hence is a finance item and not a cost item.

2.4.4 Investment Analysis Variables

In an investment analysis, there are some variables that support the calculation of the investment itself.

2.4.4.1 Investment Cost

Investment cost is an initial cost needed to realize a project and expected to be gained back with additional profit in certain time (Soeharto, 2002). Components of the investment cost are such as land cost, direct cost or construction cost, and indirect cost.

2.4.4.2 Capital

Capital can be come from two sides, private and loan (Riyani, 2006). Private is implanted by the owner of the project itself whether loan is from bank or other financial institution, money and capital markets.

2.4.4.3 Operational and Maintenance (O&M) Costs

Operating expenses are those expenditures that a business incurs to engage in any activities not directly associated with the production of goods or services. These expenditures are the same as selling, general and administrative expenses. Examples of operating expenses include the following: Compensation-related operating expenses (compensation for non-production employees, sales commissions, benefits for non-production employees, pension plan contributions for non-production employees), office-related operating expenses (accounting expenditures, depreciation of fixed assets assigned to non-production areas, insurance costs, legal fees, office supplies, property taxes, rent costs for non-production facilities, repair costs for non-production facilities, utility costs), sales and marketing-related operating expenses (advertising costs, direct mailing costs, entertainment costs, sales material costs, travel costs) (Bragg, 2015).

Repair and maintenance expenses are the costs incurred to bring an asset back to an earlier condition or to keep the asset operating at its present condition (as opposed to improving the asset). For example, if a company truck is damaged, the cost to repair the damage is immediately debited to repairs and maintenance expense. Routine maintenance such as engine tune-ups, oil changes, radiator flushing, etc. is also debited to repairs and maintenance expense. If an expenditure is made to improve the truck, such as adding a hydraulic lift to the truck or if an expenditure is a major repair that extends an asset's useful life, the amount is not expensed immediately; rather, the amount is recorded as an asset and is then depreciated over the truck's remaining useful life (Averkamp, 2003).

2.4.4.4 Tax

An income tax is a government tax on the taxable profit earned by an individual or corporation. The resulting revenue is usually one of the chief sources of cash for a government entity. It is considered one of the more fair forms of taxation, since it is only imposed if a person or business has been successful enough to generate taxable income. Thus, its impact on the poor or unprofitable is minor to nonexistent (Bragg, 2015).

Most tax rates are progressive, which means that the tax rate increases as the level of income increases. The reasoning behind this tax structure is that the poor are less able to pay taxes, while the rich have more excess cash with which to pay taxes.

The amount of income tax paid can be reduced by a number of deductions, which are allowed as the result of legislation by the relevant government entity. These deductions are usually intended to foster certain types of behavior by taxpayers.

The amount of tax depends on a country in certain time. In Indonesia which regulates value-added tax of goods and service is *Undang-Undang No. 8 tahun 1984*. In the article 7, it is mentioned the tax amount for value-added goods and services is 10%.

2.4.4.5 Depreciation

Depreciation is a method of allocating the cost of a tangible asset over its useful life. Businesses depreciate long-term assets for both tax and accounting purposes. Depreciation is commonly caused by one or more factors as followed (Pujawan, 2003):

1. Physical damage because of the usage of that equipment or property.
2. Production or service needs which is newer and bigger.
3. Declining production or service needs.
4. The property or asset becomes obsolete because of technology development.
5. The findings of facilities that can produce better product with lower cost and good safety level.

Table 2.3 Depreciation Value

Group of Tangible Asset	Lifetime	Straight Line (SL)	Double Declining Balance (DDB)
I. Non Building			
Group 1	4 years	25 %	50%
Group 2	8 years	12,5%	25%
Group 3	16 years	6,25%	12,5%
Group 4	20 years	5%	10%
II. Building			
Permanent	20 years	5%	-
Non Permanent	10 years	10%	-

Source: (Undang-Undang No. 17 tahun 2000)

2.4.4.6 Cash Flow

Cash flow is one of the main financial statements (along with the income statement and balance sheet). The cash flow statement reports the sources and uses of cash by operating activities, investing activities, financing activities, and certain supplemental information for the period specified in the heading of the statement (Averkamp, 2003).

2.5 Analysis of Investment Alternatives Selection

In the alternatives selection, qualitative and quantitative criteria must be considered. Below are the systematic steps in making a decision of alternatives selection (Pujawan, 2003):

1. Define several alternatives that will be analyzed.
2. Define planning horizon that will be used as the base of comparing alternatives.
3. Estimate the cash flow of each alternative.

4. Compare the alternatives by using selected measurement or method.
5. Conduct supplementary analysis.
6. Choose best alternative from the analysis.

There are several techniques that can be used to compare alternatives of investment which are some of them as following:

1. Present Worth Analysis
2. Annual Worth Analysis
3. Future Worth Analysis
4. Rate of Return Analysis
5. Benefit Cost Ratio Analysis
6. Payback Period Analysis

In this research, the alternatives selection analysis of the investment is done by using Net Present Value (NPV) method, based on the smallest risk of loss, Benefit Cost Ratio (BCR), and Internal Rate of Return (IRR). By not changing the objectives of the planning of using waste compactor or compression machine, then it will be analyzed all alternatives that may be developed, which is to minimize investment cost and maximize the benefits that will be gained.

To evaluate the various investment projects three criteria are mostly used which take into account the inter-temporal value of money (Marglin, 1967- Watt, 1973 - Mishan, 1975 - Christodoulou, 1989): a) the criterion of Net Present Value (NPV) b) the criterion of Internal Rate of Return (IRR) and c) the criterion of Benefit-Cost Ratio (B/C). The application of these three criteria is based on the analysis of the same economic data. First, estimations of the net periodical revenues of every investment are required as well as determination of the discount rate. The discount rate, in the first and third criterion, is used for discounting the net periodical revenues whereas in the second criterion is used as comparison measure with the rate which the investment is expected to generate IRR.

The alternatives are as followed:

1. Alternative 1, modifying the existing conventional waste container by adding compression machine with the investment and operational activities which managed individually by DKP, managed individually by private waste company, or doing partnership.

2. Alternative 2, purchasing the whole demountable waste compactor from China with the investment and operational activities which managed individually by DKP, managed individually by private waste company, or doing partnership.

Net Present Value (NPV) discounts all of the cash inflows and outflows by a specified interest rate. The net amount of all of the discounted amounts is the net present value. If the net present value is $0, the project is expected to earn exactly the specified rate. If the net present value is a positive amount, the project will be earning more than the specified interest rate. A negative net present value means the project is expected to earn less than the specified interest rate (Averkamp, 2003).

NPV method has advantages as followed (Soeharto, 2002):

1. Input time value of money factor.
2. Consider all project cash flow.
3. Measure absolute and relative measurement, so that can easily follow the contribution to the effort of increasing company's asset or stockholder.
4. Easily to be understood.

The internal rate of return (IRR) is the discount rate that would make the net present value of the benefit stream (incremental benefits minus investment costs) equal to zero. It is the maximum interest rate that can be paid for an investment if the project is to break even. The formal selection criterion for the IRR measure of a project is to accept all independent projects having an internal rate of return equal to or greater than the opportunity cost of capital. The internal rate of return is the measure used by the World Bank and most other international financing agencies for practically all benefit-cost analyses. In Excel, the formula for computing the internal rate of return is =IRR(range, guess) where range is the range of cells that make up the time series and guess is an interest rate that will help the algorithm begin the iterative procedure it uses to find an answer, i.e., an "i" that satisfies the equation (Pearson, 2002).

Practitioners often interpret internal rate of return as the annual equivalent return on a given investment; this easy analogy is the source of its intuitive appeal. But in fact, IRR is a true indication of a project's annual return on investment only when the project generates no interim cash flows, or when those interim cash flows really can be invested at the actual IRR (Kelleher & MacCormack, 2004).

When the calculated IRR is higher than the true reinvestment rate for interim cash flows, the measure will overestimate, sometimes very significantly, the annual equivalent return from the project. The formula assumes that the company has additional projects, with equally attractive prospects, in which to invest the interim cash flows. In this case, the calculation implicitly takes credit for these additional projects. Calculations of net present value (NPV), by contrast, generally assume only that a company can earn its cost of capital on interim cash flows, leaving any future incremental project value with those future projects.

IRR's assumptions about reinvestment can lead to major capital budget distortions. Using IRR as the decision yardstick, an executive would feel confidence in being indifferent toward choosing between the two projects. However, it would be a mistake to select either project without examining the relevant reinvestment rate for interim cash flows. Even if the interim cash flows really could be reinvested at the IRR, very few practitioners would argue that the value of future investments should be commingled with the value of the project being evaluated. Most practitioners would agree that a company's cost of capital, by definition, the return available elsewhere to its shareholders on a similarly risky investment, is a clearer and more logical rate to assume for reinvestments of interim project cash flows

In its simplest form, benefit cost ratio is a figure that is used to define the value of a project versus the money that will be spent in doing the project in the overall assessment of a cost-benefit analysis. This ratio provides a value of benefits and costs that are represented by actual dollars spent and gained. By definition the benefit cost ratio should be expressed using present values that are discounted (Ord, 2011).

Using the benefit cost ratio allows businesses and governments to make decisions on the negatives and positives of investing in different projects. In other words, using benefit cost ratio analysis allows an entity to decide whether or not the benefits of a given project or proposal outweighs the actual costs that go into the creation of the project or proposal.

Benefit cost ratio is simple enough to figure out, however, there are benefit cost ratio calculators available that take into consideration other factors that make the calculation a bit more complex. Factors such as actual employee production or production line breakdowns can cause the benefit cost ratio to change dramatically and so they must be accounted for when delving into the details of a particular proposal or project.

Businesses and governments can benefit greatly by figuring out the cost of a project versus its returns. For this reason alone, the benefit cost ratio is an important formula to be used in the decision making process for any project that might be presented.

2.6 Previous Studies or Researches

There are several previous studies or researches about the analysis of alternatives selection of an object. Table 2.4 briefly elaborates the comparison between previous researches and this research.

Table 2.4 Previous Researches of Alternatives Selection Analysis

No.	Researcher's Name	Year	Research's Title	Methodology
1.	Purwita Sari Pawestri	2006	Selection of Raw Materials Alternatives for Biodiesel Industry in East Java	Financial Analysis
2.	Nur Rakhmah Riyani	2006	Alternatives Selection Analysis of Travel Terminal Development Project Investment at Kambang Putih Tuban	Net Present Value (NPV) and Sensitivity Analysis
3.	Dwi Yogo Bhekti	2013	Alternatives Selection Analysis of Heavy Equipments Investment at *Dinas Pekerjaan Umum Kab. Bangka*	Net Present Value (NPV) and Sensitivity Analysis
4.	Adelia Rizki	2014	Analysis of Road Sweeper Usage in Surabaya and Its Risk Management Study	Technical Analysis, Net Present Value (NPV), Benefit Cost Ratio (BCR), Risk Management
5.	Nurulita Aisyah	2016	Analysis of Municipal Waste Transportation Mode Alternatives in Surabaya	Technical Analysis, Financial Analysis (BCR, NPV)

Source: (Pawestri, 2006, Riyani, 2006, Bhekti, 2013, Rizki, 2014)

CHAPTER III

RESEARCH METHODOLOGY

This chapter contains detail explanation of methodology's flow used to finish the research which is starting from problem identification until analyzing the data collection and processing. All phases or stages of the methodology are illustrated by using flowchart and each of them will be elaborated more systematically in the following subchapters. The flowchart of the whole research can be seen in Figure 3.1.

3.1 Preliminary Study

The preliminary study is the beginning of conducting this research in which field observation is done by the author with the purpose of identifying the real problem of waste management. After the problems have been detected, the literatures are explored and reviewed as used to support theories needed by author in solving the problems through this research. The literature reviews used by author includes books, journals, articles on websites, references used by DKP, and previous final project papers.

3.1.1 Alternatives Identification

This stage can be done after object observation is already conducted. It is because the type of waste compactor required by DKP which is demountable waste compactor is not available in Indonesia, but it can be imported from overseas, such as China. Meanwhile, there are two waste collection points in Surabaya, namely *Tambak Rejo* and *Krembangan*, which already using waste compression station due to their high volume number of waste. This machine seems to be not efficient in terms of size because it is too large so it consumes much fuels and it is static or cannot be lifted to the truck so the operator needs to wait the truck to transport the compressed waste in the machine to final landfill. In order to minimize investment cost and realize demountable waste compactor as required, then the design and making of compression machine on the top of existing waste container being proposed as another alternative. Overall, technology, capacity, and managerial factors are identified to select the best alternative.

3.1.2 Alternatives Determination

As stated in previous subchapter, the combination of existing waste container and principle of waste compression station then is being the first alternative in order to minimize investment cost. It is because DKP does not need to purchase new waste demountable compactor and they also can still minimize arm roll truck operational cost since the waste being compressed which directly decreasing the rotation number and reducing time consumption of waste operational process in the waste collection point. The second alternative will be purchase the whole new mobile or demountable waste compactor from overseas which is obviously having high quality and has been proven successfully in many countries to reduce waste transportation cost.

3.2 Data Collection Phase

This subchapter contains data collection and processing of the research. First, the data required for this research are data of waste collection point under DKP management such as its number and capacity along with the physical condition and waste types. Secondly, data of purchasing price, Operation and Maintenance (O&M) costs of arm roll truck such as driver cost, fuel cost, and arm roll rotation number are also gathered. Third, data of purchasing price, Operation and Maintenance (O&M) costs of selected waste compactor such as operator cost, fuel cost, diesel cost, maintenance cost, and the specifications are also necessary.

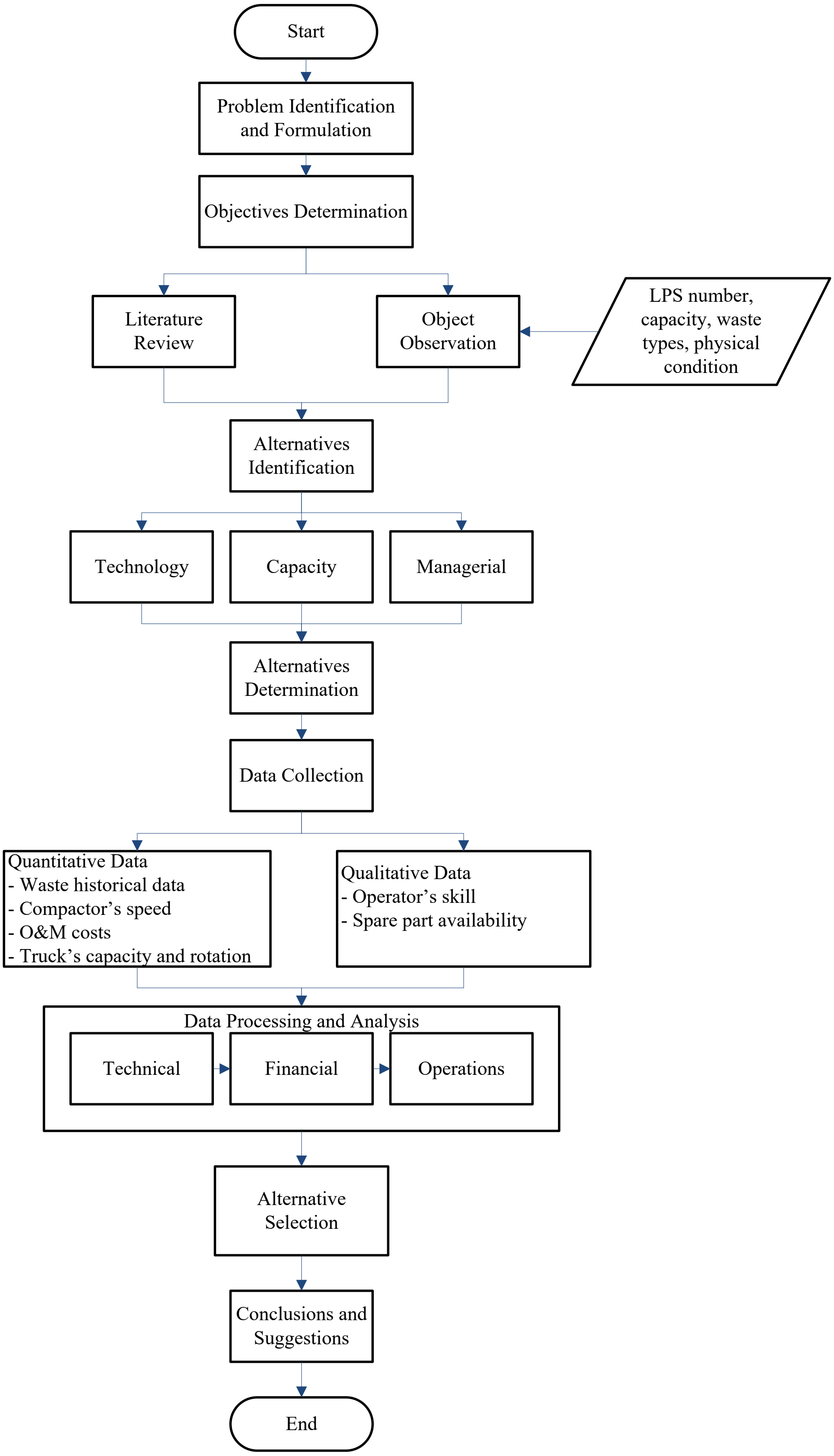

Figure 3.1 Flowchart of Whole Research Methodology

3.3 Data Processing Phase

All data which have been collected from the previous phase are processed in order to obtain parameters which are useful to develop the technical, financial, and operational analysis of waste compactors construction.

3.3.1 Data Analysis

This stage aims to conduct data processing needed to evaluate the selected alternative which will be implemented as new waste collection system. The evaluation includes technical, financial, and operational analysis.

3.3.1.1 Technical Analysis

Technical analysis in this research focuses in the selection of several alternatives of waste compactors. The selection is conducted precisely in which all specifications of waste compactors machine itself must be appropriate with conditions of waste collection points in Surabaya.

3.3.1.2 Financial Analysis

Financial analysis in this research elaborates all costs that involve in the waste compactors alternatives selection which are investment cost, operations and maintenance costs, tax, and depreciation. This analysis will determine whether the new waste transportation mode gives more benefit in terms of cost saving and efficiency improvement in the waste management.

Investment costs are including purchasing cost of new waste compactor and additional arm roll truck, and installment of power supply facilities in waste collection points. Operations and maintenance costs are including operator cost, operations and maintenance cost of both arm roll truck and waste compactor, such as diesel consumption cost. After all of those costs are examined, then there will be Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit Cost Ratio (BCR) analysis used to evaluate the selection result. Then the selected alternative will be analyzed whether the operational management of new waste collection scheme will be only operated by Local Government through DKP or by conducting partnership with private waste management companies in Surabaya.

3.3.1.3 Operational Analysis

The most critical thing that must be analyzed in the operational analysis is the power supply installment which is generator set in waste collection points for running the waste compactors. All compression machines or compactors must exactly need generator set to compress the waste.

3.3.2 Alternative Selection

This subchapter contains decision of selecting alternative which fulfills and meets the requirement of best waste collection system based on all analysis performed previously. From technical analysis, the selected alternative is supposed to appropriate with the terms and conditions applied in waste collection system of Surabaya. From financial analysis, the selected alternative has to fulfill three indicators or criteria of accepting an investment, which are the NPV is more than zero, the IRR is more than cost of capital, and the BCR is more than 1. Cost of capital refers to the opportunity cost of making a specific investment. It is the rate of return that could have been earned by putting the same money into a different investment with equal risk. Thus, the cost of capital is the rate of return required to persuade the investor to make a given investment. If both alternatives meet all of those criteria, then the alternative with higher value among them all is the best alternative.

3.4 Conclusion and Suggestion Phase

This last stage of the research aims to conclude all results obtained from data processing and analysis to answer the research objectives in the beginning of the research. Suggestions are made by author through this research for DKP to help them implementing this study for realizing better municipal waste management.

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CHAPTER IV
DATA ANALYSIS

This chapter discusses the evaluation of existing waste collection system, identification of alternative system collection, and the analysis of new system.

4.1 Evaluation of Existing Waste Collection System

This subchapter will elaborate the existing condition of waste collection system in Surabaya. There are three kinds of existing waste collection system: arm roll truck with conventional container, compactor truck, and dump truck with static waste compression station. Arm roll trucks with conventional containers have the biggest role in transporting waste in which they transport from more than 180 waste collection points to final landfill, meanwhile dump truck with static waste compression machine is only contributing to transport waste from two waste collection points to final landfill.

4.1.1 Arm Roll Truck with Conventional Container

In this section, all data needed related to arm roll truck with conventional container system are provided. As can be seen in Table 4.1, there are data of investment cost needed to provide waste collection system by using arm roll truck together with the container. The truck and container sizes are determined based on waste volumes in waste collection point. DKP totally has 100 trucks with production year starting from 1990 until 2014.

Table 4.1 Arm Roll Trucks and the Containers Investment Cost

Brand	Container Size	Truck (IDR)	Container (IDR)
ISUZU	14 m^3	615,425,000	51,094,090
ISUZU	8 m^3	312,530,000	37,164,630

Source: (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

Even though this system is mostly used by DKP, actually it still has several disadvantages which are:

1. Due to two rotations of arm roll trucks there will be one container left in waste collection point. It affects waste pickers in residential has irregular time in picking the wastes because they know they still can dispose the wastes in the second rotation. Therefore sometimes there are delays in the residential wastes pick up activities that can create a dirty and unhealthy residential environment.
2. The one left container in the waste collection point causes the wastes getting rotten therefore the container becomes easily corroded and waste collection point becomes more smelly.

Those disadvantages are obtained by doing direct observation and also information gathered through interview with one of staffs from operational division. This division is responsible to manage waste transportation system by using both arm roll trucks and compactor trucks.

The data of O&M costs of this system in the selected waste collection points will be shown in subchapter 4.2.

4.1.2 Compactor Truck

The second existing waste collection system is using compactor truck. This system is used by DKP since 2013. This system needs larger investment than arm roll trucks, but it can support the local government vision of conducting green, efficient, and environmentally friendly waste collection system.

Table 4.2 Compactor Truck's Investment Cost

Supplier	Brand	Price + Additional Cost (IDR)	Description	Total (IDR)
PT. Groen Indonesia	HINO	503,000,000	Unit (Truck)	1,255,105,602
		692,898,406	Compactor	
		51,314,784	BBNKB	
		7,697,218	PKB	
		195,194	Administration	

Source: (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

It is stated as efficient system because compactor trucks are able to compact the wastes in the truck therefore it can accommodate more volumes in only one rotation to the final landfill. But actually, the process of compacting wastes itself needs diesel therefore even the rotation is low, the expenses of diesel used is high. DKP has total of 25 compactor trucks which are mostly used to transport waste from central area of Surabaya. This system has several advantages and disadvantages as shown in Table 4.4.

Table 4.3 O&M Costs of One of Compactor Trucks

Compactor Truck with The Highest Workload							
No.	**Waste Collection Point**	**Vol. (m^3)**	**License Number of Vehicle**	**Operational Cost (Diesel Usage) per Year (IDR)**	**Maintenance Cost per Year (IDR)**	**Driver Cost per Year (IDR)**	**Total per Year (IDR)**
1.	SRIKANA	10	L9389NP	110,074,710	209,000	39,000,000	149,283,710
2.	SRIKANA	10	L9384NP	104,180,123	1,721,500	39,000,000	144,901,623

Source: (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

Table 4.4 Advantages and Disadvantages of Using Compactor Truck

No.	Advantages	No.	Disadvantages
1.	High volume of wastes accommodated	1.	High investment cost
2.	The lye buckets are provided	2.	High volumes of diesel used
3.	Good aesthetics value		
4.	More systematic residential wastes pick up activities		

Source: Direct Observation by Author

4.1.3 Waste Compression Station

The last existing waste collection system is using dump truck to transport wastes that already compressed in waste collection point. The compression activities are done by using static compression station. It uses power supply to compress 7-8 tons of wastes per day.

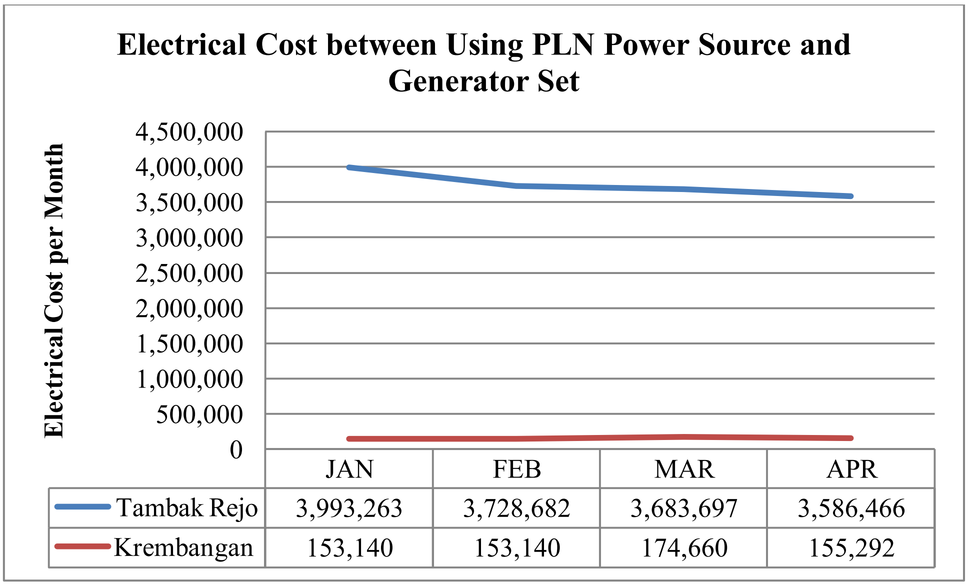


Figure 4.1 Electrical Cost between Using PLN Power Source and Generator Set (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

Based on Figure 4.1, it can be seen that there is huge difference of electrical costs in Tambak Rejo and Krembangan waste collection points. Krembangan uses generator set to produce electrical or power source to run the waste compression machine therefore its electrical cost is small per month.

4.2 Selection of Waste Collection Points for Implementing New System

As already mentioned in the limitation of this research, from total of 180 waste collection points in Surabaya, only those with minimum rotation number of two will be chosen to be implementation place of new system. Based on data given by DKP, 34 waste collection points which spread in five areas of Surabaya that use arm roll trucks are chosen as can be seen in the following tables.

Table 4.5 Number of WCP Rotations per Day at East I Area

No.	Waste Collection Point	Rotation per Day	Number of WCP Operator	Volume (m^3)	License Number of Vehicle
1.	KALIWARON	2	1	14	L 9353 NP
2.	SUTOREJO	2	0	14	L 8012 SP
3.	MOJO ARUM	2	1	14	L 9349 NP
4.	KARANG GAYAM	2	1	14	L 8022 NP
5.	BHAKTI HUSADA	2	1	14	L 8023 NP

Source: (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

Table 4.6 Total Cost Incurred per Year of Using Arm Roll Trucks with Conventional Container at WCP East I Area (in IDR)

Waste Collection Point	Operational Cost (Diesel)	Maintenance Cost	Driver Cost	WCP Operator Cost	Total Cost
KALIWARON	93,538,575	34,013,377	39,000,000	6,660,000	173,211,951
SUTOREJO	84,066,592	43,876,417	39,000,000	0	166,943,008
MOJO ARUM	91,251,151	11,536,725	39,000,000	6,660,000	148,447,875
KARANG GAYAM	78,302,042	105,578,481	39,000,000	6,660,000	229,540,523
BHAKTI HUSADA	92,281,408	42,520,808	39,000,000	6,660,000	180,462,216

Source: (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

Table 4.7 Number of WCP Rotations per Day at East II Area

No.	Waste Collection Point	Rotation per Day	Number of WCP Operator	Volume (m^3)	License Number of Vehicle
1.	RUNGKUT KIDUL	4	1	14	L 9417 NP L 8010 TP
2.	MEDOKAN AYU	2	1	14	L 8061 SP
3.	TULUS HARAPAN	2	1	8	L 9491 NP L 9485 NP

Source: (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

Table 4.8 Total Cost Incurred per Year of Using Arm Roll Trucks with Conventional Container at WCP East II Area (in IDR)

Waste Collection Point	Operational Cost (Diesel)	Maintenance Cost	Driver Cost	WCP Operator Cost	Total Cost
RUNGKUT KIDUL	201,076,085	45,548,197	78,000,000	6,660,000	331,284,282
MEDOKAN AYU	87,102,723	63,047,442	39,000,000	6,660,000	195,810,165
TULUS HARAPAN	193,129,378	8,299,500	78,000,000	6,660,000	286,088,878

Source: (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

Table 4.9 Number of WCP Rotations per Day at Central Area

No.	Waste Collection Point	Rotation per Day	Number of WCP Operator	Volume (m^3)	License Number of Vehicle
1.	KALIBUTUH	2-3	0	14	L 8038 PP
2.	SULUNG KALI	2	1	14	L 8022 PP
3.	MAKAM PENELEH	2	1	8	L 9413 NP

Source: (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

Table 4.10 Total Cost Incurred per Year of Using Arm Roll Trucks with Conventional Container at WCP Central Area (in IDR)

Waste Collection Point	Operational Cost (Diesel)	Maintenance Cost	Driver Cost	WCP Operator Cost	Total Cost
KALIBUTUH	76,036,403	63,655,570	39,000,000	0	178,691,973
SULUNG KALI	67,515,573	20,495,001	39,000,000	6,660,000	133,670,574
MAKAM PENELEH	108,692,759	6,783,050	39,000,000	6,660,000	161,135,809

Source: (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

Table 4.11 Number of WCP Rotations per Day at North Area

No.	Waste Collection Point (WCP)	Rotation per Day	Number of WCP Operator	Volume (m^3)	License Number of Vehicle
1.	KALI KEDINDING	2-3	1	14	L 9425 NP L 8010 RP
2.	MBAH RATU	2	1	14	B 9552 EQ
3.	TANJUNG SADARI	2	1	14	L 8011 SP
4.	SIDOTOPO	2	1	8	L 9411 NP
5.	TAMBAK ASRI	2	1	8	L 9001 YP

Source: (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

Table 4.12 Total Cost Incurred per Year of Using Arm Roll Trucks with Conventional Container at WCP North Area (in IDR)

Waste Collection Point (WCP)	Operational Cost (Diesel)	Maintenance Cost	Driver Cost	WCP Operator Cost	Total Cost
KALI KEDINDING	184,908,433	74,986,682	78,000,000	6,660,000	344,555,115
MBAH RATU	72,341,072	17,165,501	39,000,000	6,660,000	135,166,573
TANJUNG SADARI	62,248,308	77,808,652	39,000,000	6,660,000	185,716,960
SIDOTOPO	75,672,555	6,491,308	39,000,000	6,660,000	127,823,863
TAMBAK ASRI	61,849,389	21,653,551	39,000,000	6,660,000	129,162,940

Source: (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

Table 4.13 Number of WCP Rotations per Day at South Area

No.	Waste Collection Point (WCP)	Rotation per Day	Number of WCP Operator	Volume (m^3)	License Number of Vehicle
1.	MAKAM MATARAM	4	0	14	L 9354 NP L 8023 PP
2.	JOYOBOYO	4	0	14	L 8010 PP L 8010 SP
3.	BUKIT BARISAN	4	1	14	L 8011 NP L 8005 RP
4.	BABATAN PILANG	2	1	14	L 9426 NP
5.	JETIS KULON	2	1	14	L 8011 RP
6.	SIWALAN KERTO	2	1	14	L 8014 TP
7.	KETINTANG WADER	2	1	14	L 9223 NP
8.	PASAR BARU JAGIR	2	0	14	L 9352 NP
9.	PASAR BERAS BENDUL MERISI	2	0	14	L 8029 SP
10.	PASAR WIYUNG	2	1	8	L 9410 NP
11.	WONO KROMO	2	1	8	L 8062 NP
12.	DUKUH MGL	2	1	8	L 9047 VP

Source: (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

Table 4.14 Total Cost Incurred per Year of Using Arm Roll Trucks with Conventional Container at WCP South Area (in IDR)

Waste Collection Point (WCP)	Operational Cost (Diesel)	Maintenance Cost	Driver Cost	WCP Operator Cost	Total Cost
MAKAM MATARAM	153,472,626	95,990,846	78,000,000	0	327,463,473
JOYOBOYO	181,896,506	60,421,115	78,000,000	0	320,317,622
BUKIT BARISAN	140,937,887	137,391,504	78,000,000	6,660,000	362,989,391
BABATAN PILANG	76,238,540	5,013,952	39,000,000	6,660,000	126,912,492
JETIS KULON	68,630,136	44,295,217	39,000,000	6,660,000	158,585,353
SIWALAN KERTO	90,175,624	65,266,893	39,000,000	6,660,000	201,102,518
KETINTANG WADER	100,399,713	9,250,450	39,000,000	6,660,000	155,310,164
PASAR BARU JAGIR	85,463,683	31,828,355	39,000,000	0	156,292,039
PASAR BERAS BENDUL MERISI	73,876,853	66,371,444	39,000,000	0	179,248,297
PASAR WIYUNG	56,456,360	14,158,101	39,000,000	6,660,000	116,274,461

Table 4.14 Total Cost Incurred per Year of Using Arm Roll Trucks with Conventional Container at WCP South Area (in IDR) (Con't)

Waste Collection Point (WCP)	Operational Cost (Diesel)	Maintenance Cost	Driver Cost	WCP Operator Cost	Total Cost
WONO KROMO	31,896,473	67,285,206	39,000,000	6,660,000	144,841,680
DUKUH MGL	59,797,113	24,088,825	39,000,000	6,660,000	129,545,939

Source: (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

Table 4.15 Number of WCP Rotations per Day at West Area

No.	Waste Collection Point (WCP)	Rotation per Day	Number of WCP Operator	Volume (m^3)	License Number of Vehicle
1.	SIMORUKUN	3	1	14	L 8021 TP L 8067 QP
2.	JAYA MIX	2	1	14	L 8072 QP
3.	SONO KWIJENAN	2	1	14	L 8006 NP
4.	MANUKAN KULON	2	1	14	L 8022 SP L 8060 PP
5.	KUWUKAN	2	1	8	L 9019 RP
6.	SIMOHILIR	2	1	8	L 9019 PP

Source: (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

Table 4.16 Total Cost Incurred per Year of Using Arm Roll Trucks with Conventional Container at WCP West Area (in IDR)

Waste Collection Point (WCP)	Operational Cost (Diesel)	Maintenance Cost	Driver Cost	WCP Operator Cost	Total Cost
SIMORUKUN	144,526,098	105,772,218	78,000,000	6,660,000	334,958,316
JAYA MIX	61,590,601	15,672,814	39,000,000	6,660,000	122,923,415
SONO KWIJENAN	46,418,701	61,728,894	39,000,000	6,660,000	153,807,595
MANUKAN KULON	117,950,090	101,005,293	78,000,000	6,660,000	303,615,383
KUWUKAN	52,584,848	19,483,247	39,000,000	6,660,000	117,728,095
SIMOHILIR	65,919,279	25,335,753	39,000,000	6,660,000	136,915,032

Source: (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

4.3 Identification of New Waste Collection System Alternatives

All alternatives proposed for better waste collection system needs detail evaluation which is seen from three criteria: technology, capacity, and managerial. Each of them will be elaborated in detail below.

4.3.1 Technology

As evaluated in previous subchapter, the existing waste collection system still not efficient and effective yet. The government through DKP mostly use arm roll trucks to transport wastes. The high volume of wastes in Surabaya leads this system having high rotation number. This rotation number finally leads to high amount of CO_2 emission released to the air. It can be simply said that this system is not green and environmentally friendly.

Through this research, a new system with advanced technology is expected to improve the existing system becomes more efficient, effective, and environmental friendly. In terms of cost efficiency, the new system is expected to reduce compensation cost of releasing CO_2 emission and transportation cost. In terms of time efficiency, the new equipment also expected to have compressing ability in which the wastes will be compressed in the waste collection point. Therefore it makes the lye contained in the wastes can be filtered before transported to final landfill. The filtered waste with less lye will shorten the time of gasification process in final landfill.

4.3.2 Capacity

The capacity aspect of waste transportation modes are crucial if this issue relates to increasing number of waste volumes in Surabaya from time to time. The mobile waste compactor with its advanced technology as proposed is expected to be able to accommodate double capacity of conventional container. This factor surely has to become concern for local government in improving waste collection system because this will lead to great reduction of waste volume and increase the loading capacity and transportation efficiency, reduce the costs of waste disposal and transportation up to 75%.

4.3.3 Managerial

The new system that will be implemented should also consider about the managerial factor which relates to how this new system can be done in easier, quicker, safer and more practical way than the existing ones. It may be difficult to change some people mindset and train them to use the new system. For some people, they think that they will face several difficulties on how to use new equipment. Those people are for example the operator at waste collection points. Almost all waste collection points have operator in existing condition. If the local government would like to implement the new system, all parts must be managed properly, including operators management. Local government is responsible to give training both to existing waste collection point operator to introduce them to something really new. It may consume cost and time but actually the new system alternatives provided in this research can be realized if all parts ready to implement it.

4.4 Determination of New Waste Collection System Alternatives

As elaborated in previous subchapter about criteria of new system alternatives, in this chapter will be clearly determined about two alternatives proposed for better waste collection system.

4.4.1 Alternative 1

The first alternative is providing new system by modifying the existing conventional containers of arm roll trucks. This alternative provides several advantages if compared to the existing system which is as follow.

1. Residential waste pick up activities becomes more systematic with no delays therefore the environment becomes cleaner and healthier.
2. Higher volume of wastes disposed.
3. Reduce truck's rotation number that makes the waste collection point becomes cleaner and have less smell.
4. Fasten gasification process at final landfill.
5. Reduce possibility of container having corrosion.

4.4.2 Alternative 2

The second alternative is providing new system by purchasing the whole mobile waste compactor from overseas supplier, such as from China. The advantages of this alternative by looking at the equipment's specification (Yutonghi Co., Ltd., 2015) are as follow.

1. Ideal for compacting wet and general waste.
2. Large loading aperture (approx. 1,800 x 1,300 mm).
3. Long life cycle (15 years).
4. Low corrosion due to non-contact between the hydraulic cylinders and the waste.
5. Self-cleaning and thus hygienic (cleaning under and behind the pendulum blade is not required).
6. Low operating noise level.
7. Compression: The S1700M mobile trash compactor adopts horizontal compress mode, whose working pressure can reach 16-18 MPa and maximum compression density can reach nearly 0.9.
8. Fewer Actions and Low Failure Rate: The garbage compression and loading can be achieved through self-contained trash compactor by only two steps. It is both simple and practical. The safety interlock has been established between the actions to prevent any accident due to improper operation and provide safe and reliable operations.
9. Flexible Movement: The S1700M mobile trash compactor can operate just in a truck space and can be moved to anywhere.
10. Easy Maintenance: The S1700M self-contained trash compactor is equipped with a special maintenance window. The hydraulic and electrical parts can be pulled out of the container for easy and safe maintenance.
11. Superior Applicability: S1700M mobile trash compactor is equipped with two control modes: the fixed operating panel and remote control, thus the worker can stand outside the safety operating distance for operation, which is safety, convenient and practical.
12. High mechanization performance: The entire process from garbage collection to garbage compression is fully automatic, while all procedures are controlled by the travel switch and proximity switch, which is characterized by accurate positioning and high degree of mechanical automation. Thereby it is able to improve working efficiency and reduce labor intensity.

13. Safe and Reliable Equipment Operation: S1700M self-contained trash compactor is configured with electrical control with 24V DC safe voltage and the interlocking device to avoid any accident due to improper operation. The hydraulic system is equipped with a single motor, a single pump, and a pressure relay to control the sequence of actions of the cylinder. The hydraulic system can be started at zero pressure. This improves the work efficiency and ensures quick and smooth equipment operation.

4.5 Identification of Technical Aspect of Each Alternative

In this subchapter will be shown the technical aspects which are identified in each alternative.

4.5.1 Alternative 1

In order to modify the existing mobile conventional container to become a mobile waste compactor, there are several components needed as shown in Table 4.17.

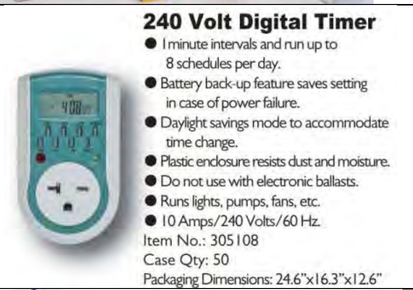
Table 4.17 Components Required to Modify Existing Conventional Container

No.	Component	Picture	Function
1.	Hydraulic Pump		To give compression or compaction forces to wastes from roller into container.
2.	Pendulum blades		To keep the waste pushed into the container.

Table 4.17 Components Required to Modify Existing Conventional Container (Con't)

No.	Component	Picture	Function
3.	Power Take Off (PTO)		To stir the hydraulic pump.
4.	Roller		To roll the wastes disposed from hopper into container.
5.	Hydraulic Seal Cylinder		To prevent diesel leakage from hydraulic pump.
6.	Hydraulic Hose		To provide flexibility for hydraulic pump operation or maintenance.
7.	Lye Bucket		To accommodate lye of wastes after compression.

Table 4.17 Components Required to Modify Existing Conventional Container (Con't)

No.	Component	Picture	Function
8.	Operating Panel		To operate the compactor such as to turn on the roller.
9.	Automatic Timer		To warn if the container is already fulfilled by wastes in the upper limit.
10.	Solenoid Valve		To operate valve on hydraulic pump automatically.
11.	Hopper		To transport waste from cart into the roller.

Source: (Indonesian Alibaba, 2016)

4.5.2 Alternative 2

S1700M movable-type horizontally-compressed garbage transfer equipment combines the refuse unloading, compression and storage functions, integrates compression with storage into one structure. The waste water resulting from compression of garbage will flow into the drain well directly through the blow-off pipe before being discharged into the urban sewage pipe network by the sewage pump. The complete S1700M will only occupy a truck place. It is so maneuverable that it can be moved at any moment. It is a new concept of municipal living garbage collector in line with the state's requirements for living garbage disposal.

It is characterized by small floor area, convenience and flexibility, simple supporting facilities and low operating costs. It can be set up in the open air. It can also be used for long-distance transport. It can be used in a place where it is not convenient to build a fixed compression station in the city, and also can be used as the rural garbage collection equipment. It is especially applicable to metropolitan vegetable markets, concentrated dining areas and residential areas for collection, compression and transfer of garbage (Yutonghi Co., Ltd., 2015).

Figure 4.2 S1700M Horizontally-Compressed Garbage Movable Equipment (Zhengzhou Yutong Heavy Industries Co., Ltd., 2015)

Table 4.18 Technical Aspects Identification of Alternative 2

Item	Parameters
Compressed dustbin	The dustbin volume is 17m³, transfers through arcs at both sides and looks more aesthetic in appearance. The dozer blade is at front of dustbin. Above the dozer blade is hydraulic electrical system with compact structure and 30t compression force
Turning mechanism	The hopper volume is 2m³, the feeding inlet can be completely sealed after turning of hopper
Hydraulic system	Motor, hydraulic pump and solenoid valve all use imported parts, the motor power is 5.5kw
Control system	It can be controlled directly on the control cabinet or using wireless remote controller. The control voltage is the 24V safety voltage.

Source: (Zhengzhou Yutong Heavy Industries Co., Ltd., 2015)

The working methods of both alternatives are actually the same as shown in Figure 4.3. First, the pendulum blade will be in rear position. During the compactor stroke, the entire filling area is still available for continuous filling. In the return stroke, the pendulum blade passes under the material and throws it before container opening. In the pre-stroke, the material is pushed under the break edge in the container.

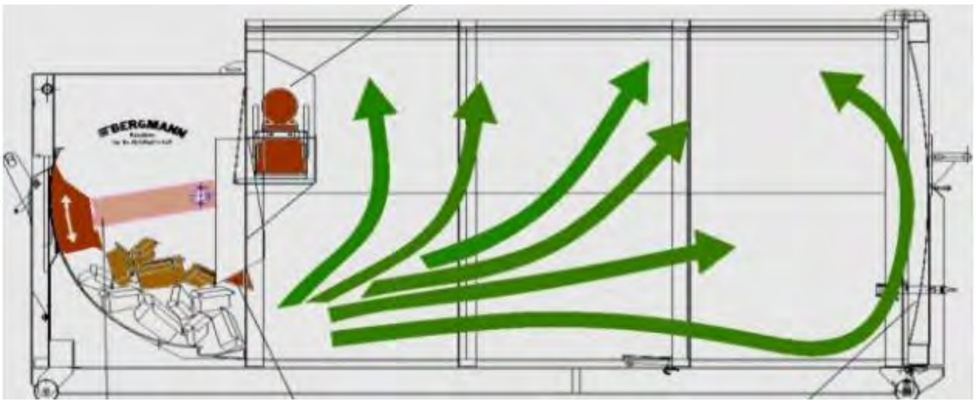


Figure 4.3 Working Method of Movable Waste Compactor (Bergmann, 2015)

4.6 Identification of Financial Aspect of Each Alternative

Financial aspects identification including investment cost, operational (electrical and diesel costs) and maintenance cost, and operator cost.

4.6.1 Alternative 1

The financial aspects identification for this alternative is shown below.

4.6.1.1 Investment Cost

The investment cost for this alternative means the total cost of modifying conventional container.

Table 4.19 Components of Investment Cost for Alternative 1

No.	Components	Quantity (Units)	Price per Unit (IDR)	Total Cost (IDR)
1.	Power Take Off (PTO) + Cable	2	685,200	1,370,400
2.	Roller (front and rear)	2	2,970,000	5,940,000
3.	Hydraulic pump	2	4,050,000	8,100,000

Table 4.19 Components of Investment Cost for Alternative 1 (Con't)

No.	Components	Quantity (Units)	Price per Unit (IDR)	Total Cost (IDR)
4.	Pendulum claws / blade	9	13,500	121,500
5.	Hydraulic seal cylinder	1	6,750,000	6,750,000
6.	Hose	5	9,000	45,000
7.	Lye bucket	4	200,000	800,000
8.	Push buttons / control system	1	627,750	627,750
9.	Autotimer	1	135,000	135,000
10.	Solenoid valve	10	135,000	1,350,000
11.	Hopper	1	6,750,000	6,750,000
12.	Side aperture modification	1	2,500,000	5,000,000
13.	Modification Service		4,000,000	
Total Investment Cost for Alternative I				**38,489,650**

Source: (Indonesian Alibaba, 2016)

4.6.1.2 Operational and Maintenance Cost

Total diesel consumptions by generator set per year is the operational cost.

Table 4.20 Data Required to Calculate Diesel Cost Consumptions for Alternative 1

Electrical cost for generator set per kWh	IDR 57.32
Multiplier factor of diesel consumption for generator set per kWh	0.21
Electrical Data Necessity	380 V
	32 A
	5.5 kW
Capacity of 1x press	0.3 m^3
Total time needed for 1x press	90 secs
Compactor's speed in 1x press (0.5/90)	**0.0033 m^3/sec**
Total time needed to press 16 m^3 of waste per day	4,800 secs
Total time needed to press 28 m^3 of waste per day	8,400 secs
Working hour of compactor per day vol. 8 m^3 (4,800/3600)	**1.3 hours**
Working hour of compactor per day vol. 14 m^3 (8,400/3600)	**2.3 hours**
Total days per year	365
Cost of 1 liter of diesel	IDR 5,150

Diesel consumption (operational cost) per year of alternative 1 (14 m^3)

= kW x multiplier factor x running hour(s) per day x total days per year x cost of 1 liter solar

= 5.5 x 0.21 x 2.3 x 365 x 5,150

= IDR 5,065,926

Diesel consumption (operational cost) per year of alternative 1 (8 m^3)

= kW x multiplier factor x running hour(s) per day x total days per year x cost of 1 liter solar

= 5.5 x 0.21 x 1.3 x 365 x 5,150

= IDR 2,894,815

Maintenance cost details for this alternative is obtained based on maintenance record data of both existing arm roll truck with conventional container and compactor truck. First, the maintenance frequency for hydraulic system is based on compactor truck data with the highest workload which is L 9384 NP and L 9389 NP. Secondly, the maintenance frequency for container is based on conventional container maintenance data in the arm roll truck with the highest workload which are L 9354 NP (14 m^3) and L 9485 NP (8 m^3). Third, the maintenance frequency for generator set is based on existing generator set used to run waste compression station. The vehicles with highest workload are chosen in order to anticipate and know the highest cost of maintenance that will be spent per year.

Table 4.21 Maintenance Cost per Year for Alternative 1 with Size of 8 m^3

Maintenance	Frequency per Year	Quantity per Maintenance	Unit	Price/Unit (IDR)	Total (IDR)
Hydraulic System					
Filtering hydraulic oil	5	2	liter	55,000	550,000
Checking hydraulic pump	2			75,000	150,000
Hydraulic hose	2	1	unit	250,000	500,000
PTO air switching	2			350,000	700,000
Cross joint PTO	2			150,000	300,000
				Sub Total	2,200,000
Container					
Welding wire	6	50	pieces	25,000	7,500,000
UNP Channels (6.5)	6	1	meter	45,000	270,000
UNP Channels (8)	6	1	meter	60,000	360,000
UNP Channels (10)	6	1	meter	75,000	450,000
UNP Channels (12)	6	1	meter	100,000	600,000
Sliding plate (3 mm)	3	5	sheets	10,000	150,000
Sliding plate (4 mm)	3	3	sheets	15,000	135,000
Strip plate	3	1	meter	12,500	37,500
				Sub Total	9,502,500
Generator Set					
Filtering diesel	2	2	units	50,000	200,000
				Sub Total	200,000
Total maintenance cost per year					**11,902,500**

Table 4.22 Maintenance Cost per Year for Alternative 1 with Size of 14 m^3

Maintenance	Frequency per Year	Quantity per Maintenance	Unit	Price/Unit (IDR)	Total (IDR)
Hydraulic System					
Filtering hydraulic oil	5	3	liter	55,000	825,000
Checking hydraulic pump	2			75,000	150,000
Hydraulic hose	2	1	unit	315,000	630,000
PTO air switching	2			425,000	850,000
Cross joint PTO	2			160,000	320,000
				Sub Total	2,775,000
Container					
Welding wire	6	75	pieces	25000	11,250,000
UNP Channels (6.5)	6	1	meter	45000	270,000
UNP Channels (8)	6	1	meter	60000	360,000
UNP Channels (10)	3	1	meter	75000	225,000
UNP Channels (12)	6	1	meter	100000	600,000
Sliding plate (3 mm)	3	5	sheets	10000	150,000
Sliding plate (4 mm)	1	5	sheets	15000	75,000
Strip plate	1	1	meter	12500	12,500
				Sub Total	12,942,500
Generator Set					
Filtering diesel	2	2	units	60,000	240,000
				Sub Total	240,000
Total maintenance cost per year					**15,957,500**

4.6.1.3 Operator Cost

Based on the existing waste collection system, operator cost in the waste collection point is paid IDR 555,000 per month.

4.6.2 Alternative 2

The financial aspects identification for this alternative is as shown below.

4.6.2.1 Investment Cost

The investment cost for this alternative which is using S1700M (ZY022-10) movable-type horizontally-compressed garbage transfer equipment produced by Zhengzhou Yutong Heavy Industries Co., Ltd. China is IDR 63,778,642 including tax.

4.6.2.2 Operational and Maintenance Cost

Total diesel consumptions by generator set per year is the operational cost.

Table 4.23 Data Required to Calculate Diesel Cost Consumptions for Alternative 2

Electrical cost for generator set per kWh	IDR 57.32
Multiplier factor of diesel consumption for generator set per kWh	0.21
Electrical Data Necessity	380 V
	32 A
	5.5 kW
Capacity of 1x press	0.5 m^3
Total time needed for 1x press	68 secs
Compactor's speed in 1x press (0.5/68)	**0.00735 m^3/sec**
Total time needed to press 28 m^3 of waste per day	3,808 secs
100% efficiency	26.47 m^3/hr
Working hour of compactor per day (3,808/3600)	**1.06 hours**
Total days per year	365
Cost of 1 liter of diesel	IDR 5,150

Diesel consumption (operational cost) per year of alternative 2

$= \textbf{kW x multiplier factor x running hour per day x total days per year}$

$\textbf{x cost of 1 liter solar}$

$= 5.5\ x\ 0.21\ x\ 1.06\ x\ 365\ x\ 5{,}150$

$= IDR\ 2{,}296{,}553$

Maintenance cost details for this alternative is obtained based on maintenance record data of both existing arm roll truck with conventional container and compactor truck. First, the maintenance frequency for hydraulic system is based on compactor truck data with the highest workload which is L 9384 NP and L 9389 NP. Secondly, the maintenance frequency for generator set is based on existing generator set used to run waste compression station. The vehicles with highest workload are chosen in order to anticipate and know the highest cost of maintenance that will be spent per year.

Table 4.24 Maintenance Cost per Year for Alternative 2

Maintenance	Frequency per Year	Quantity per Maintenance	Unit	Price/Unit (IDR)	Total (IDR)
Hydraulic System					
Filtering hydraulic oil	5	2	liter	55,000	550,000
Checking hydraulic pump	1			150,000	150,000
Hydraulic hose	1	1	unit	500,000	500,000

Table 4.24 Maintenance Cost per Year for Alternative 2 (Con't)

Maintenance	Frequency per Year	Quantity per Maintenance	Unit	Price/Unit (IDR)	Total (IDR)
Hydraulic System					
PTO air switching	2			847,000	1,694,000
Cross joint PTO	2			192,500	385,000
				Sub Total	3,279,000
Container					
Routine cleaning	3			150,000	450,000
				Sub Total	450,000
Generator Set					
Filtering diesel	2	2	units	60,000	240,000
				Sub Total	240,000
Total maintenance cost per year					**3,969,000**

4.6.2.3 Operator Cost

Based on the existing waste collection system, operator cost in the waste collection point is paid IDR 555,000 per month.

4.7 Calculation of Waste Compactor Needed for a New System

In this subchapter will be given the number of conventional container needed for existing system depends on arm roll trucks rotation numbers and modified container required to be purchased for the first alternative of new system.

Table 4.25 Conventional and Modified Container Required Based on Rotation Number

Rotation Number	Minimum Number of Conventional Container	Minimum Number of Modified Container or Waste Compactor
2	3	1
3	4	2
4	5	2

Source: Direct Observation by Author

Table 4.26 Numbers of Modified Containers and Mobile Compactors of Each Area

Area	Number of Modified Container (8 m3)	Number of Modified Container (14 m3)	Number of Mobile Compactor
East I	0	5	5
East II	1	3	4
Central	1	3	4
North	2	4	6
South	3	12	15
West	2	5	7

4.8 Total Cost Needed for Each Alternative

After the number required for both alternatives have been known, then it is needed to calculate total cost needed for each alternative. The driver cost for both alternatives later will be neglected because it is already covered in the existing system, meanwhile for the operator cost, both alternatives only needs to cover waste collection points that still have no operator yet, which are totally six waste collection points.

4.8.1 Total Cost Needed for Alternative 1

Total cost needed for alternative 1 is shown in Table 4.27 and 4.28.

Table 4.27 Investment Cost, Maintenance Cost, and Diesel Cost for Alternative 1

Area	Number of $8m^3$ Modified Containers	Number of $14m^3$ Modified Containers	Per Unit Per Year		
			Investment Cost	Maintenance Cost	Diesel Cost
East I	0	5	192,448,250	79,787,500	25,329,631
East II	1	3	153,958,600	59,775,000	18,092,594
Central	1	3	153,958,600	59,775,000	18,092,594
North	2	4	230,937,900	87,635,000	26,053,335
South	3	12	577,344,750	227,197,500	69,475,560
West	2	5	269,427,550	103,592,500	31,119,261

Table 4.28 Driver Cost, Operator Cost, and Salvage Value at Year 15 for Alternative 1

Area	Number of $8m^3$ Modified Containers	Number of $14m^3$ Modified Containers	Per Unit Per Year		
			Driver Cost	Operator Cost	Salvage Value at Year 15
East I	0	5	195,000,000	33,300,000	9,622,413
East II	1	3	195,000,000	26,640,000	7,697,930
Central	1	3	156,000,000	26,640,000	7,697,930
North	2	4	273,000,000	39,960,000	11,546,895
South	3	12	702,000,000	99,900,000	28,867,238
West	2	5	312,000,000	46,620,000	13,471,378

4.8.2 Total Cost Needed for Alternative 2

Total cost needed for alternative 2 is shown in Table 4.29 and 4.30.

Table 4.29 Investment Cost, Maintenance Cost, and Diesel Cost for Alternative 2

Area	Number of Mobile Compactors	Per Unit Per Year		
		Investment Cost	Maintenance Cost	Diesel Cost
East I	5	318,893,212	19,845,000	11,482,766
East II	4	255,114,570	15,876,000	9,186,213
Central	4	255,114,570	15,876,000	9,186,213
North	6	382,671,854	23,814,000	13,779,319
South	15	956,679,636	59,535,000	34,448,299
West	7	446,450,497	27,783,000	16,075,873

Table 4.30 Driver Cost, Operator Cost, and Salvage Value at Year 15 for Alternative 2

Area	Number of $8m^3$ Modified Containers	Per Unit Per Year		
		Driver Cost	Operator Cost	Salvage Value at Year 15
East I	5	195,000,000	33,300,000	15,944,661
East II	4	195,000,000	26,640,000	12,755,728
Central	4	156,000,000	26,640,000	12,755,728
North	6	273,000,000	39,960,000	19,133,593
South	15	702,000,000	99,900,000	47,833,982
West	7	312,000,000	46,620,000	22,322,525

4.9 Benefit Cost Ratio (BCR)

The first indicator to select best alternative for new waste collection system is by looking at the Benefit Cost Ratio of each alternative. In BCR, if the value of the ratio (BCR>1) means that the alternative is feasible and vice versa.

Table 4.31 Lists of Benefits, Disadvantages, and Costs of Alternative 1

No.	Benefit	Disadvantages	Cost
1.	Savings on reduction of CO_2 emission by truck	Cost for power supply installment	Investment cost for conventional container modification along with its operational and maintenance costs
2.	Operational savings on diesel expenses by truck	Cost for operator trainings	
3.		Cost for CO_2 emission production from generator set	

Table 4.32 Lists of Benefits, Disadvantages, and Costs of Alternative 2

No.	Benefit	Disadvantages	Cost
1.	Savings on reduction of CO_2 emission by truck	Cost for power supply installment	Investment cost for purchasing mobile waste compactor along with its operational and maintenance costs
2.	Operational savings on diesel expenses by truck	Cost for operator trainings	
3.		Cost for CO_2 emission production from generator set	

4.9.1 Calculation of Each BCR Components

As listed in previous tables, each benefit, disadvantage, and cost has to be calculated precisely to get expected BCR.

- Benefits

1. Savings on reduction of CO_2 emission by truck

Table 4.33 CO_2 Emission Rate Based on Vehicle's Type

Categories	CO	HC	NO_X	PM_{10}	CO_2	SO_2
	(g/km)	(g/km)	(g/km)	(g/km)	(g/kg Fuel)	(g/km)
Motorcycle	14	5.9	0.29	0.24	3,180	0.008
Car (Fuel)	40	4	2	0.01	3,180	0.026
Car (Diesel)	2.8	0.2	3.5	0.53	**3,172**	0.44
Bus	11	1.3	11.9	1.4	3,172	0.93
Truck	8.4	1.8	17.7	1.4	3,172	0.82

Source: (Ismayanti & Boedisantoso, 2012)

Table 4.34 Data to Calculate Truck Savings on CO_2 Emission

Components	Quantity	Unit
CO_2 emission factor for car (diesel)	3,172	g/kg diesel
1 liter of diesel	0.8	kg
1 year of usage	314,392.58	liter
UU No.13 Year 2011 about compensation due to pollution and environmental damage	Per 400 kg	IDR 24,750
Total number of compactors	41	units

From the data above, it can be known that:

$$\textbf{Diesel usage per year (kg)}$$

$$= \textbf{314,392.58 liter x 0.8} = \textbf{251,514 kg diesel}$$

$$\textbf{Amount of } CO_2 \textbf{ produced (g)} = CO_2 \textbf{ emission factor x diesel usage per year}$$

$$\textbf{Amount of } CO_2 \textbf{ produced (g)}$$

$$= \textbf{3,172 x 251,514} = \textbf{797,802,611 gram} = \textbf{797,803 kg}$$

$$\textbf{Total cost savings of } CO_2 \textbf{ produced}$$

$$= \frac{797,803}{400} \textbf{ x IDR 24,750 x 41} = \textbf{IDR 2,023,925,499}$$

2. Operational savings on diesel expenses by truck

Table 4.35 Existing Operational Cost Savings of Each Area

Area	Existing Operational Cost Savings (IDR)
East I	219,719,883
East II	240,654,093
Central	126,122,367
North	228.509,878
South	559,620,759
West	244,494,808
Total	**1,619,121,787**

Total benefits for alternative 1 and 2

$$= \textbf{IDR 2,023,925,499} + \textbf{IDR 1,619,121,787}$$

$$= \textbf{IDR 3,643,047,286}$$

$$\textbf{PV (6.75\%, 15 years) by using Microsoft Excel}$$

$$= \textbf{IDR 33,710,915,135}$$

- **Disadvantages**

1. Cost for generator set and power supply installment

Table 4.36 Cost Components of Power Supply Installment

Cost Components per Unit	Cost (IDR)
Generator set + installment	13,800,000
Panel installment (MCB box)	240,000
Total	**14,040,000**

$$\textbf{Total cost for generator set and power supply installment}$$

$$= \textbf{IDR 14,040,000 x 41} = \textbf{IDR 575,640,000}$$

2. Cost for CO_2 emission production from generator set

Table 4.37 Data to Calculate Generator Set Compensation Cost on CO_2 Emission

Components	Quantity	Unit
CO_2 emission factor for generator set (diesel)	10,151	g/kg diesel
1 liter of diesel	0.8	kg
1 year of usage	983,53	liter
UU No.13 Year 2011 about compensation due to pollution and environmental damage	Per 400 kg	IDR 24,750
Total number of compactors	41	units

The CO_2 emission rate based on U.S. Energy Information Administration is actually 22.8 pounds for diesel generator set. It is then converted to grams into 10,151 grams per kg diesel used per year.

Alternative 1

From the data in Table 4.37, it can be known that:

$$\textbf{Diesel usage per year (kg)} = \textbf{983.53 liter x 0.8} = \textbf{786.83 kg diesel}$$

$$\textbf{Amount of } \mathbf{CO_2} \textbf{ produced (g)} = \mathbf{CO_2} \textbf{ emission factor x diesel usage per year}$$

$$\textbf{Amount of } \mathbf{CO_2} \textbf{ produced} = \mathbf{10,151 \text{ x } 786.83} = \textbf{7,987,399 gram} = \textbf{7,987 kg}$$

$$\textbf{Total compensation of } \mathbf{CO_2} \textbf{ produced}$$

$$= \mathbf{\frac{7,987}{400}} \textbf{ x IDR 24,750 x 41} = \textbf{IDR 20,263,033}$$

Total disadvantages for alternative 1

$$= \textbf{IDR 575,640,000} + \textbf{IDR 20,263,033}$$

$$= \textbf{IDR 595,903,033}$$

$$\textbf{PV (6.75\%, 15 years) by using Microsoft Excel}$$

$$= \textbf{IDR 5,514,184,968}$$

Alternative 2

From the data in Table 4.37, it can be known that:

$$\textbf{Diesel usage per year (kg)} = \textbf{446.87 liter x 0.8} = \textbf{357.5 kg diesel}$$

$$\textbf{Amount of } \mathbf{CO_2} \textbf{ produced (g)} = \mathbf{CO_2} \textbf{ emission factor x diesel usage per year}$$

$$\textbf{Amount of } CO_2 \textbf{ produced} = 10,151 \text{ x } 357.5 = 3,629,079 \text{ gram} = 3,629 \text{ kg}$$

$$\textbf{Total compensation of } CO_2 \textbf{ produced}$$

$$= \frac{3,629}{400} \text{ x IDR } 24,750 \text{ x } 41 = \text{IDR } 9,206,522$$

Total disadvantages for alternative 2

$$= \text{IDR } 575,640,000 + \text{IDR } 9,206,522$$

$$= \text{IDR } 584,846,522$$

$$\textbf{PV } (6.75\%, 15 \text{ years}) \textbf{ by using Microsoft Excel}$$

$$= \text{IDR } 5,411,873,603$$

- **Costs**

The total costs incurred for alternative 1 is shown in Table 4.38.

Table 4.38 Total Costs Incurred for Alternative 1

Components	Total per Year (IDR)
Investment Cost	1,578,075,650
Maintenance Cost	617,762,500
Diesel Cost	188,162,975
Operator Cost	39,960,000
Salvage Value	78,903,783

$$\textbf{PV } (6.75\%, 15 \text{ years}) \textbf{ by using Microsoft Excel}$$

$$\textbf{Investment cost} +$$

$$\textbf{PV } (6.75\%, 15, -(\textbf{Maintenance cost} + \textbf{diesel cost} + \textbf{operator cost}), \textbf{salvage value})$$

$$= \text{IDR } 9,375,851,944$$

$$\textbf{Benefit Cost Ratio} = \frac{\textbf{Benefits} - \textbf{Disadvantages}}{\textbf{Cost}}$$

$$\textbf{BCR Alternative 1} = \frac{\text{IDR } 28,196,730,167}{\text{IDR } 9,375,851,944} = 3.01$$

$$(\textbf{BCR} > 1 \textbf{ means that alternative 1 is acceptable or feasible})$$

The total costs incurred for alternative 1 is shown in Table 4.39.

Table 4.39 Total Costs Incurred for Alternative 2

Components	Total per Year (IDR)
Investment Cost	2,614,924,339
Maintenance Cost	162,729,000
Diesel Cost	94,158,683
Operator Cost	39,960,000
Salvage Value	130,746,217

$\mathbf{PV\ (6.75\%, 15\ years)\ by\ using\ Microsoft\ Excel}$

$\mathbf{Investment\ cost} +$

$\mathbf{PV\ (6.75\%, 15, -(Maintenance\ cost + diesel\ cost + operator\ cost), salvage\ value)}$

$= \mathbf{IDR\ 4,942,952,178}$

$$\mathbf{Benefit\ Cost\ Ratio} = \frac{\mathbf{Benefits - Disadvantages}}{\mathbf{Cost}}$$

$$\mathbf{BCR\ Alternative\ 2} = \frac{\mathbf{IDR\ 28,299,041,526}}{\mathbf{IDR\ 4,942,952,178}} = \mathbf{5.73}$$

$(\mathbf{BCR} > 1\ \mathbf{means\ that\ alternative\ 2\ is\ acceptable\ or\ feasible})$

4.10 Net Present Value and Internal Rate of Return of Each Alternative

The second and third indicator to select best alternative for new waste collection system is by looking at the Net Present Value and Internal Rate of Return of each alternative. In NPV, if the value is more than 0 (NPV>0) means that the alternative is acceptable and vice versa. Meanwhile, the larger result of IRR means the best alternative. The term internal refers to the fact that its calculation does not incorporate environmental factors (e.g., the interest rate or inflation). Internal rates of return are commonly used to evaluate the desirability of investments or projects. The higher a project's internal rate of return, the more desirable it is to undertake the project. Assuming all projects require the same amount of up-front investment, the project with the highest IRR would be considered the best and undertaken first.

4.10.1 Alternative 1

The NPV and IRR values for alternative 1 are shown in Table 4.40.

Table 4.40 Net Present Value (in IDR) and Internal Rate of Return for Alternative 1

Year	Savings	Expenses	Cash Flow Before Tax	Depreciation	Taxable Income	Tax (10 %)	Cash Flow After Tax
0		1,578,075,650	(1,578,075,650)				(1,578,075,650)
1	1,619,121,787	845,885,475	773,236,312	99,944,791	673,291,521	67,329,152	705,907,160
2	1,619,121,787	845,885,475	773,236,312	99,944,791	673,291,521	67,329,152	705,907,160
3	1,619,121,787	845,885,475	773,236,312	99,944,791	673,291,521	67,329,152	705,907,160
4	1,619,121,787	845,885,475	773,236,312	99,944,791	673,291,521	67,329,152	705,907,160
5	1,619,121,787	845,885,475	773,236,312	99,944,791	673,291,521	67,329,152	705,907,160
6	1,619,121,787	845,885,475	773,236,312	99,944,791	673,291,521	67,329,152	705,907,160
7	1,619,121,787	845,885,475	773,236,312	99,944,791	673,291,521	67,329,152	705,907,160
8	1,619,121,787	845,885,475	773,236,312	99,944,791	673,291,521	67,329,152	705,907,160
9	1,619,121,787	845,885,475	773,236,312	99,944,791	673,291,521	67,329,152	705,907,160
10	1,619,121,787	845,885,475	773,236,312	99,944,791	673,291,521	67,329,152	705,907,160
11	1,619,121,787	845,885,475	773,236,312	99,944,791	673,291,521	67,329,152	705,907,160
12	1,619,121,787	845,885,475	773,236,312	99,944,791	673,291,521	67,329,152	705,907,160
13	1,619,121,787	845,885,475	773,236,312	99,944,791	673,291,521	67,329,152	705,907,160
14	1,619,121,787	845,885,475	773,236,312	99,944,791	673,291,521	67,329,152	705,907,160
15	1,796,500,197	845,885,475	950,614,722	99,944,791	850,669,931	85,066,993	865,547,729
NPV							**5,013,959,154**
IRR							**45%**

The BI rate per 19 May 2016 is 6.75%, so the Net Present Value (NPV) can simply be calculated by using Microsoft Excel using NPV formula:

=NPV (6.75%, ∑ Net Period Cash Flow or Cash Flow After Tax) + Initial Investment

Value-added tax rate as mentioned in *Undang-Undang Dasar No. 42 tahun 2009 pasal 7* is 10%. The salvage value which is 5% from purchasing price is determined based on similar existing mobile compactor with brand of Bergmann. After its useful life which is 15 years, it still can be sold with price of 5% from initial purchasing price.

Depreciation is the allocation of an asset's cost over its useful life. These two alternatives will be used as an asset at an equal amount each period continually throughout its useful life. Therefore, the straight-line depreciation method is chosen, which allocates an equal portion of an asset's cost to depreciation expense each period. The calculation of depreciation value is done by using Straight Line method as can be seen below.

$$D = \frac{\text{Investment Cost} - \text{Salvage Value}}{\text{Useful Life}}$$

$$D = \frac{1{,}578{,}075{,}650 - 78{,}903{,}783}{15}$$

$$\mathbf{D = IDR\ 99,944,791}$$

4.10.2 Alternative 2

The NPV and IRR values for alternative 2 are shown in Table 4.41.

Table 4.41 Net Present Value (in IDR) and Internal Rate of Return for Alternative 2

Year	Savings	Expenses	Cash Flow Before Tax	Depreciation	Taxable Income	Tax (10 %)	Cash Flow After Tax
0		2,614,924,339	(2,614,924,339)				(2,614,924,339)
1	1,619,121,787	296,847,683	1,322,274,104	165,611,875	1,156,662,230	115,666,223	1,206,607,881
2	1,619,121,787	296,847,683	1,322,274,104	165,611,875	1,156,662,230	115,666,223	1,206,607,881
3	1,619,121,787	296,847,683	1,322,274,104	165,611,875	1,156,662,230	115,666,223	1,206,607,881
4	1,619,121,787	296,847,683	1,322,274,104	165,611,875	1,156,662,230	115,666,223	1,206,607,881
5	1,619,121,787	296,847,683	1,322,274,104	165,611,875	1,156,662,230	115,666,223	1,206,607,881
6	1,619,121,787	296,847,683	1,322,274,104	165,611,875	1,156,662,230	115,666,223	1,206,607,881
7	1,619,121,787	296,847,683	1,322,274,104	165,611,875	1,156,662,230	115,666,223	1,206,607,881
8	1,619,121,787	296,847,683	1,322,274,104	165,611,875	1,156,662,230	115,666,223	1,206,607,881
9	1,619,121,787	296,847,683	1,322,274,104	165,611,875	1,156,662,230	115,666,223	1,206,607,881
10	1,619,121,787	296,847,683	1,322,274,104	165,611,875	1,156,662,230	115,666,223	1,206,607,881
11	1,619,121,787	296,847,683	1,322,274,104	165,611,875	1,156,662,230	115,666,223	1,206,607,881
12	1,619,121,787	296,847,683	1,322,274,104	165,611,875	1,156,662,230	115,666,223	1,206,607,881
13	1,619,121,787	296,847,683	1,322,274,104	165,611,875	1,156,662,230	115,666,223	1,206,607,881
14	1,619,121,787	296,847,683	1,322,274,104	165,611,875	1,156,662,230	115,666,223	1,206,607,881
15	1,749,868,004	296,847,683	1,453,020,321	165,611,875	1,287,408,447	128,740,845	1,324,279,477
NPV							8,594,586,743
IRR							46%

The calculation of depreciation value is done by using Straight Line method as can be seen below.

$$D = \frac{\text{Investment Cost} - \text{Salvage Value}}{\text{Useful Life}}$$

$$D = \frac{2{,}614{,}924{,}339 - 130{,}746{,}217}{15}$$

$$\mathbf{D = IDR\ 165,611,875}$$

4.11 Analysis of Alternative Selection for New Waste Collection System

As can be seen previously, from three different financial indicators, which are BCR, NPV, and IRR, all results show that second alternative is the best alternative for new waste collection system. However, from investment cost perspective, first alternative gives much lower value than selected alternative. But, investment cost is only in the beginning of the operation. From Table 4.41, it can be seen that in the first year of implementation, the savings can already cover the investment costs along with the operational and maintenance costs.

The most affecting factor that makes alternative 2 is chosen is the low operational and maintenance costs. The whole mobile compactor which is designed to compact huge volume of wastes in an efficient way with environmental friendly concept will consider the social and cost effects of releasing CO_2 to the environment. It is designed to compact waste in quick time so that the diesel volume used by generator set can be low. Therefore the diesel consumption cost of this alternative is smaller than first alternative. As can be seen in subchapter 4.4.2, there are many advantages provided by alternative 2 related to maintenance of the equipment. The easy and practical maintenance affects low maintenance cost. Different with first alternative which needs to frequently replacing the wire, channels and sliding plate of container, this alternative only needs routine cleaning since the container is already designed to have low corrosion rate.

It also can be seen from the technical aspect evaluation that mobile compactor S1700M gives many benefits which can cover the needs of DKP. The capability and reliability of this equipment are already proven in many countries. Lastly, from operations aspect evaluation, this equipment is proven to be easy and safe in operation and maintenance with high safety consideration for the operator.

Besides the first alternative is not chosen from the financial aspects evaluation, local government will also need several considerations if they would like to take this alternative. Even though the investment cost has small value, but it may consume much time to modify total of 41 containers. Meanwhile, the rotations of arm roll trucks to dispose waste will not change. There will be shortage of containers to accommodate waste volumes and it leads to cause another problem such as more delays of waste pick up activities.

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APPENDIX

Appendix 1: Recapitulation of DKP Waste Transportation Modes

No	Modes	Brand and Type	Year	No. Plate	Diesel Usage		Maintenance 1Year (IDR)	Description
					Type	Liter/Year		
Compactor Truck								
1	Compactor	Hino FF172LA	1986	L8048SP	diesel	-	9,767,120	Severely damaged
2	Compactor	Hino FF172LA	1986	L8044RP	diesel	-	14,403,190	Severely damaged
3	Compactor	Hino FF172LA	1987	L8044TP	diesel	-	3,146,220	Severely damaged
4	Compactor	Hino FF172LA	1987	L8045PP	diesel	7,786.67	16,463,150	
5	Compactor	Toyota Ryno BY42/68	1988	L8045NP	diesel	8,319.36	28,413,582	
6	Compactor	Isuzu NKR 66	2005	L8064QP	diesel	7,162.58	14,311,975	
7	Compactor	Isuzu NKR 71 STD	2006	L9002WP	diesel	9,149.83	9,302,075	
8	Compactor	HINO WU342R DUTRO130HD	2009	L9054NP	diesel	8,136.33	17,796,900	
9	Compactor	HINO WU342R DUTRO130HD	2009	L9053NP	diesel	8,397.61	34,632,860	
10	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2013	L9384NP	diesel	20,229.15	1,721,500	
11	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2013	L9385NP	diesel	16,865.55	940,500	
12	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2013	L9386NP	diesel	18,305.48	-	
13	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2013	L9388NP	diesel	6,957.08	-	
14	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2013	L9389NP	diesel	21,373.73	209,000	

No	Modes	Brand and Type	Year	No. Plate	Diesel Usage		Maintenance 1Year (IDR)	Description
					Type	Liter/Year		
15	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2014	L9452NP	diesel	15,715.33	11,770,000	
16	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2014	L9448NP	diesel	17,351.40	1,155,000	
17	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2014	L9451NP	diesel	16,123.33	7,199,500	
18	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2014	L9453NP	diesel	8,953.63	13,985,400	
19	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2014	L9455NP	diesel	10,771.31	-	
20	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2014	L9454NP	diesel	17,474.45	-	
21	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2015	L9553NP	diesel	17,763.33	-	
22	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2015	L9554NP	diesel	15,165.23	-	
23	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2015	L9555NP	diesel	10,487.40	-	
24	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2015	L9556NP	diesel	8,490.16	-	
25	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2015	L9557NP	diesel	16,741.65	-	
26	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2015	L9560NP	diesel	14,933.33	-	
27	Compactor	HINO/FG8JJKB GGJ (FG235JJ)	2015	L9561NP	diesel	17,294.60	-	
28	Compactor	HINO/FG8JJ1D BGJ	2015	L9627NP	diesel	-	-	
Truk Hyd. Cont. / Arm Roll 6M3								
1	Hyd. Cont. / Arm Roll 6M3	Mitsubishi F82RH	1990	L8047SP	diesel NS	200.00	-	

No	Modes	Brand and Type	Year	No. Plate	Diesel Usage		Maintenance 1Year (IDR)	Description
					Type	Liter/Year		
2	Hyd. Cont. / Arm Roll 6M3	Isuzu NKR 71 STD	2007	L9001XP	diesel	10,393.68	25,868,253	
3	Hyd. Cont. / Arm Roll 6M3	Isuzu NKR 71 STD	2007	L9001YP	diesel	12,009.59	21,653,551	
4	Hyd. Cont. / Arm Roll 6M3	Isuzu NKR 71 E2	2010	L9047VP	diesel	11,611.09	24,088,825	
5	Hyd. Cont. / Arm Roll 6M3	Isuzu NKR 71 E2	2010	L9048VP	diesel	9,264.02	10,619,601	
6	Hyd. Cont. / Arm Roll 6M3	Isuzu NKR 71 E2	2010	L9049VP	diesel	8,711.98	16,345,534	
7	Hyd. Cont. / Arm Roll 6M3	Isuzu NKR 71 E2	2013	L9410NP	diesel	10,962.40	14,158,101	
8	Hyd. Cont. / Arm Roll 6M3	Isuzu NKR 71 E2	2013	L9411NP	diesel	14,693.70	6,491,308	
9	Hyd. Cont. / Arm Roll 6M3	Isuzu NKR 71 E2	2013	L9412NP	diesel	11,732.19	12,915,910	
10	Hyd. Cont. / Arm Roll 6M3	Isuzu NKR 71 E2	2013	L9413NP	diesel	21,105.39	6,783,050	
11	Hyd. Cont. / Arm Roll 6M3	Isuzu NKR 71 E2	2013	L9415NP	diesel	14,357.15	6,279,000	
Truk Hyd. Cont. / Arm Roll 8M3								
1	Hyd. Cont. / Arm Roll 6M3	Hino /WU342R DUTRO130HD	2014	L9487NP	diesel	13,005.13	2,491,500	
2	Hyd. Cont. / Arm Roll 6M3	Hino /WU342R DUTRO130HD	2014	L9488NP	diesel	12,946.85	9,270,800	
3	Hyd. Cont. / Arm Roll 6M3	Hino /WU342R DUTRO130HD	2014	L9489NP	diesel	13,245.24	3,687,750	
4	Hyd. Cont. / Arm Roll 6M3	Hino /WU342R DUTRO130HD	2014	L9485NP	diesel	23,505.96	8,299,500	
5	Hyd. Cont. / Arm	Hino /WU342R	2014	L9491NP	diesel	13,994.89	-	

No	Modes	Brand and Type	Year	No. Plate	Diesel Usage		Maintenance 1Year (IDR)	Description
					Type	Liter/Year		
	Roll 6M3	DUTRO130HD						
6	Hyd. Cont. / Arm Roll 8M3	Isuzu TLD 58	1995	L8063PP	diesel	7,567.77	48,449,491	
7	Hyd. Cont. / Arm Roll 8M3	Isuzu TLD 58	1995	L8062RP	diesel	897.02	5,685,550	
8	Hyd. Cont. / Arm Roll 8M3	Isuzu TLD 58	1995	L8062NP	diesel	6,193.49	67,285,206	
9	Hyd. Cont. / Arm Roll 8M3	Isuzu TLD 58	1995	L8062PP	diesel	6,592.81	67,219,878	
10	Hyd. Cont. / Arm Roll 8M3	Isuzu TLD 58	1995	L8063SP	diesel	6,425.30	96,299,040	
11	Hyd. Cont. / Arm Roll 8M3	Toyota Dyna RBY 43	1995	L8085QP	diesel	10,016.93	24,132,349	
12	Hyd. Cont. / Arm Roll 8M3	Toyota Dyna RBY 43	1995	L8077QP	diesel	9,922.72	18,360,646	
13	Hyd. Cont. / Arm Roll 8M3	Toyota Dyna RBY 43	1995	L8078QP	diesel	8,736.47	36,808,807	
14	Hyd. Cont. / Arm Roll 8M3	Toyota Dyna RBY 43	1995	L8071QP	diesel	8,976.76	30,258,843	
15	Hyd. Cont. / Arm Roll 8M3	Toyota Dyna RBY 43	1996	L8005NP	diesel	2,178.97	58,825,189	
16	Hyd. Cont. / Arm Roll 8M3	Toyota Dyna RBY 43	1996	L8005TP	diesel	6,669.01	41,576,016	
17	Hyd. Cont. / Arm Roll 8M3	Toyota Dyna RBY 43	1996	L8004RP	diesel	965.00	13,398,964	
18	Hyd. Cont. / Arm Roll 8M3	Toyota Dyna RBY 43	1996	L8004TP	diesel	6,803.33	6,677,676	
19	Hyd. Cont. / Arm Roll 8M3	Toyota Dyna RBY 43	1997	L8033NP	diesel	8,314.30	19,291,533	
20	Hyd. Cont. / Arm	Toyota Dyna RBY 43	1997	L8032TP	diesel	11,502.01	19,821,948	

No	Modes	Brand and Type	Year	No. Plate	Diesel Usage		Maintenance 1Year (IDR)	Description
					Type	Liter/Year		
	Roll 8M3							
21	Hyd. Cont. / Arm Roll 8M3	Toyota Dyna RBY 43	1997	L8032SP	diesel	650.00	29,826,576	
22	Hyd. Cont. / Arm Roll 8M3	Isuzu NKR 71 HD E2	2007	L9019PP	diesel	12,799.86	25,335,753	
23	Hyd. Cont. / Arm Roll 8M3	Isuzu NKR 71 HD E2	2007	L9019RP	diesel	10,210.65	19,483,247	
Truk Hyd. Cont. / Arm Roll 14M3								
1	Hyd. Cont. / Arm Roll 14M3	Hino FF173MA	1993	L8037NP	diesel	6,574.09	32,197,000	
2	Hyd. Cont. / Arm Roll 14M3	Hino FF173MA	1993	L8038PP	diesel	14,764.35	63,655,570	
3	Hyd. Cont. / Arm Roll 14M3	Hino FF173MA	1993	L8038RP	diesel	14,423.75	44,496,870	
4	Hyd. Cont. / Arm Roll 14M3	Hino FF173MA	1993	L8042RP	diesel	8,647.27	37,193,449	
5	Hyd. Cont. / Arm Roll 14M3	Hino FF173MA	1993	L8038NP	diesel	7,867.99	42,171,350	
6	Hyd. Cont. / Arm Roll 14M3	Hino FF173MA	1993	L8037PP	diesel	10,052.58	101,018,197	
7	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1995	L8061SP	diesel	16,913.15	63,047,442	
8	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1995	L8060NP	diesel	3,570.99	37,624,840	
9	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1995	L8004QP	diesel	16,918.23	23,741,499	
10	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1995	L8060TP	diesel	5,832.46	21,804,711	
11	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1995	L8061NP	diesel	6,783.33	12,219,281	

No	Modes	Brand and Type	Year	No. Plate	Diesel Usage		Maintenance 1Year (IDR)	Description
					Type	Liter/Year		
12	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1995	L8060PP	diesel	8,795.81	62,227,275	
13	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1995	L8060RP	diesel	8,090.63	44,353,507	
14	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1995	L8084QP	diesel	8,544.77	89,212,315	
15	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1995	L8074QP	diesel	10,612.39	52,879,158	
16	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1995	L8072QP	diesel	11,959.34	15,672,814	
17	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1995	L8067QP	diesel	11,914.01	47,839,321	
18	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1995	L8080QP	diesel	5,108.33	21,148,701	
19	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1995	L8075QP	diesel	11,013.33	46,209,654	
20	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1996	L8005RP	diesel	11,553.33	68,028,227	
21	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1996	L8005SP	diesel	11,967.90	54,771,808	
22	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1996	L8005PP	diesel	2,222.33	48,812,144	
23	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1996	L8006NP	diesel	9,013.34	61,728,894	
24	Hyd. Cont. / Arm Roll 14M3	Nissan CKA12E/H	1997	L8029SP	diesel	14,345.02	66,371,444	
25	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8014TP	diesel	17,509.83	65,266,893	
26	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8010PP	diesel	20,963.58	23,728,302	

No	Modes	Brand and Type	Year	No. Plate	Diesel Usage		Maintenance 1Year (IDR)	Description
					Type	Liter/Year		
27	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8011TP	diesel	15,078.33	54,724,626	
28	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8012SP	diesel	16,323.61	43,876,417	
29	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8012RP	diesel	13,338.33	45,388,831	
30	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8010RP	diesel	16,426.67	64,949,341	
31	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8010SP	diesel	14,356.13	36,692,813	
32	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8011RP	diesel	13,326.24	44,295,217	
33	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8011SP	diesel	12,087.05	77,808,652	
34	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8011NP	diesel	15,813.25	69,363,277	
35	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8011PP	diesel	18,428.53	25,324,597	
36	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8010TP	diesel	20,049.95	37,417,122	
37	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8023PP	diesel	13,799.19	53,576,940	
38	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8022RP	diesel	16,265.00	43,786,747	
39	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8021SP	diesel	14,831.91	55,873,894	
40	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8022TP	diesel	14,325.42	45,388,803	
41	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8023SP	diesel	13,685.00	16,519,588	

No	Modes	Brand and Type	Year	No. Plate	Diesel Usage		Maintenance 1Year (IDR)	Description
					Type	Liter/Year		
42	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8022PP	diesel	13,109.82	20,495,001	
43	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8022SP	diesel	14,107.12	38,778,018	
44	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8021TP	diesel	16,149.31	57,932,897	
45	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8022NP	diesel	15,204.28	105,578,481	
46	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2002	L8023NP	diesel	17,918.72	42,520,808	
47	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2005	L8054QP	diesel	14,485.51	30,427,100	
48	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2005	L8055QP	diesel	14,944.84	36,949,954	
49	Hyd. Cont. / Arm Roll 14M3	Isuzu FTR33F	2005	L8057QP	diesel	14,152.17	32,781,354	
50	Hyd. Cont. / Arm Roll 14M3	Hino FG8JKKB GGJ	2007	L9018RP	diesel	16,288.03	13,429,680	
51	Hyd. Cont. / Arm Roll 14M3	Hino FG8JKKB GGJ	2012	L9223NP	diesel	19,495.09	9,250,450	
52	Hyd. Cont. / Arm Roll 14M3	Isuzu / FTR 90 L	2013	L9349NP	diesel	17,718.67	11,536,725	
53	Hyd. Cont. / Arm Roll 14M3	Isuzu / FTR 90 L	2013	L9350NP	diesel	16,635.86	5,901,175	
54	Hyd. Cont. / Arm Roll 14M3	Isuzu / FTR 90 L	2013	L9352NP	diesel	16,594.89	31,828,355	
55	Hyd. Cont. / Arm Roll 14M3	Isuzu / FTR 90 L	2013	L9353NP	diesel	18,162.83	34,013,377	
56	Hyd. Cont. / Arm Roll 14M3	Isuzu / FTR 90 L	2013	L9354NP	diesel	16,001.32	42,413,906	

No	Modes	Brand and Type	Year	No. Plate	Diesel Usage		Maintenance 1Year (IDR)	Description
					Type	Liter/Year		
57	Hyd. Cont. / Arm Roll 14M3	Isuzu / FTR 90 L	2013	L9416NP	diesel	13,842.23	3,415,099	
58	Hyd. Cont. / Arm Roll 14M3	Isuzu / FTR 90 L	2013	L9417NP	diesel	18,993.95	8,131,075	
59	Hyd. Cont. / Arm Roll 14M3	Isuzu / FTR 90 L	2013	L9418NP	diesel	17,045.57	21,463,688	
60	Hyd. Cont. / Arm Roll 14M3	Isuzu / FTR 90 L	2013	L9419NP	diesel	19,798.26	11,667,450	
61	Hyd. Cont. / Arm Roll 14M3	Isuzu / FTR 90 L	2013	L9420NP	diesel	18,254.15	13,775,650	
62	Hyd. Cont. / Arm Roll 14M3	Isuzu / FTR 90 L	2013	L9421NP	diesel	19,139.16	16,737,750	
63	Hyd. Cont. / Arm Roll 14M3	Isuzu / FTR 90 L	2013	L9422NP	diesel	20,498.66	19,300,147	
64	Hyd. Cont. / Arm Roll 14M3	Isuzu / FTR 90 L	2013	L9424NP	diesel	16,304.27	22,572,214	
65	Hyd. Cont. / Arm Roll 14M3	Isuzu / FTR 90 L	2013	L9425NP	diesel	19,477.88	10,037,341	
66	Hyd. Cont. / Arm Roll 14M3	Isuzu / FTR 90 L	2013	L9426NP	diesel	14,803.60	5,013,952	

Appendix 2: Recapitulation of DKP Waste Collection Rotations by Arm Roll Trucks

No.	No. PLATE	Arm Roll	WASTE COLLECTION POINT	ROTATION/DAY	DRIVER	DESCRIPTION
AREA: EAST I						
1	L 9353 NP	14	LPS KALIWARON	2 rotations	IMAM SUJITO	
2	L 9420 NP	14	LPS MERR KALIJUDAN	1 rotation	FATKUR	
3	L 9420 NP	14	LPS PACAR KELING	1 rotation	FATKUR	
4	L 8012 SP	14	LPS SUTOREJO	1 -2 rotations	SUWANDI	

No.	No. PLATE	Arm Roll	WASTE COLLECTION POINT	ROTATION/DAY	DRIVER	DESCRIPTION
5	L 9384 NP (2) / L 9389 NP (2)	10	LPS SRIKANA	4 rotations	L 9384 NP DARMAWAN L 9389 NP DJUNARIN	COMPACTOR
6	L 9415 NP	8	LPS GUBENG MASJID	1 rotation	SANUT	
7	L 9415 NP	8	LPS PASAR GUBENG MASJID	2 days 1x	SANUT	
8	L 8037 PP	14	LPS KALIBOKOR	2 rotations	SUPARTO	
9	L 9453 NP	10	LPS BOKTONG	1 rotation	SAMUJI	COMPACTOR
10	L 8057 QP	14 /14	LPS ITS	1 - 2 rotations	MULYO	
11	L 8012 SP	14	LPS KEPUTIH TINJA	3 days 1x	SUWANDI	
12	L 8067 QP	14	LPS KEJAWAN PUTIH	2 days 1x	HERI E	
13	L 9425 NP	14	LPS WISMA PERMAI	1 rotation	SUNARI	
14			LPS PASAR PUCANG			PD PASAR
15	L 9349 NP	14	LPS MOJO ARUM	2 rotations	LAIMAN	
16	L 8022 NP	14	LPS KARANG GAYAM	2 rotations	EFENDY	
17	L 8011 TP	14	LPS BOGEN TAMBAKSARI	1 - 2 rotations	AS BUDIONO	
18	L 9488 NP	8	LPS MEDOKAN SEMAMPIR	1 rotation	MUNARI	
19	L 8075 QP	14	LPS SEMOLOWARU BADAYS	2 days 1x	SUPAR	
20	L 9415 NP	8	LPS PETOJO	2 days 1x	SANUT	
21	L 9561 NP	10	LPS CANDIPURO	1 rotations	ARIF	COMPACTOR
22	L 8084 QP	14	LPS BARATA JAYA	1-2 rotations	WIDARMANTO	
23	L 9047 VP	8	LPS ASRAMA BRIMOB NGINDEN	4 days 1x	M.KHOIRUL HUDA	
24	L 8023 NP	14	BHAKTI HUSADA	2 rotations	MANSUR	
25	L 9412 NP	8	KOMPOS SUTOREJO	1 rotation	KARMIN	
26	L 9485 NP	8	DARMA HUSADA INDAH	1 rotation	ROJIUN	
AREA: EAST II						
1	L 9416 NP	14	TENGGILIS UTARA	1 -2 rotations	SUJI	
2	L 8012 RP	14	LPS PRAPEN	2 days 1x	SUFENDY	
3	L 9001 XP	8	LPS SMA 16	3 days 1x	SUKADI	
4	~~L 9018 RP~~	~~14~~	~~LPS KEDUNG BARUK~~	~~1 -2 rotations~~	~~M. KHOIRUDIN~~	Not printed
5	L 9491 NP (1) /	8	LPS TULUS HARAPAN	2 rotations	SRIYONO/SLAMET	

No.	No. PLATE	Arm Roll	WASTE COLLECTION POINT	ROTATION/DAY	DRIVER	DESCRIPTION
	L9485 NP (1)					
6	L 8061 SP	14	LPS MEDOKAN AYU	2 rotations	DANI S	
7	L 9018 RP	8	LPS KENDALSARI	1-2 rotations	M.KOIRUDIN E	
8	L 8021 SP	14	LPS WONOREJO	1 rotation	M. AMIN	
9	L 9048 VP	8	LPS METRO	2 days 1x	AGUS S	
10	L 9491 NP	8	LPS RUNGKUT ASRI	3 days 1x	SRIYONO	
11	L 9417 NP / L 8010 TP	14 /14	LPS RUNGKUT KIDUL	4 rotations	SYAIFUDIN ZAKRI / JOKO PRASETYO	
~~12~~	~~L 9349 NP~~	~~14~~	~~LPS KUTISARI~~	~~1 rotations~~	~~LAIMAN~~	Not printed
12	L 8004 QP	14	LPS WIGUNA TIMUR	1 rotation	M. RIYANTO	
13	L 8005 PP	14	LPS PURIMAS	2 days 1x	SUTRISNO	
14		6	LPS BP2IP	3 days 1x		DUMP TRUK RAYON
AREA: CENTRAL						
1	L 8022 PP	14	LPS SULUNG	2 rotations	M. SAFUAN	
2	L 9448 NP	10	LPS PECINDILAN	1 -2 rotations		COMPACTOR
3	L 8005 PP	14	LPS PASAR GENTENG	2 days 1x	SUTRISNO	
4		10	LPS SIMPANG DUKUH	2 rotations		COMPACTOR
5	L 8012 QP	14	LPS PIRNGADI	1-2 rotations	SUFENDY	
6	L 9421 NP (1-2) / L 8061 SP (2days 1x)	14	LPS DUPAK PRAHU	1 -2 rotations	L 9421 NP L 8061 SP	
7	L 8038 PP	14	LPS KALIBUTUH	2 - 3 rotations	MUSTOIT	
8		10	LPS PANDEGILING	3 -4 rotations		COMPACTOR
9		10	LPS TAMAN KETAMPON	1 -2 rotations		COMPACTOR
10	L 8021 SP	14	LPS PASAR KEPUTRAN SELATAN	1 rotation	M. AMIN	
11	L 8075 QP	14	LPS PASAR KAPASAN	2 days 1x	SUPAR	
12	L 9413 NP	8	LPS MAKAM PENELEH	2 rotations	ASAN	
13	L 8012 RP	14	LPS THR	3 days 1x	SUFENDY	
14	L 8060 RP	14	LPS JL.SEMUT KALI	1 -2 rotations	SUKAMTO	
15	L 8006 NP	14	LPS PASAR BUAH PENELEH	2 days 1x	YUNUS	

No.	No. PLATE	Arm Roll	WASTE COLLECTION POINT	ROTATION/DAY	DRIVER	DESCRIPTION
16		10	LPS PASAR BUNGA KAYUN	1 rotations		COMPACTOR
AREA: NORTH						
1	B 9552 EQ	14	LPS MBAH RATU	2 rotations	SUPRIANTO	
2	L 8011 SP	14	LPS TANJUNG SADARI	2 rotations	SUWOTO	
3	L 8023 SP	14	LPS PESAPEN POMPA	1 rotation	ANAS	
4	L 9048 VP	8	LPS KODIKAL	3 days 1x	AGUS S	
5	L 9487 NP	8	LPS AMPEL MAKAM	7 days 1x	SUGIANTO	
6	L 8022 NP	14	LPS AMPEL PARIWISATA	2 days 1x	EFENDY	
7	L 8005 TP	8	LPS DUKUH BULAK BANTENG	1-2 rotations	TEGUH P	
8	L 8010 PP	14	LPS MENTARI	7 days 1x	SAMADJI	
9	L 8063 PP	8	LPS ASRAMA BRIMOB PPI	2 days 1x	AHC. ZAENAL	
10	L 8063 PP	8	LPS JATIPURWO	1 rotation	AHC. ZAENAL	
11	L 9489 NP	8	LPS PASAR DUPAK BANDAREJO	1-2 rotations	SUYANTO	
12	L 9418 NP	14	LPS BULAK BANTENG	1 rotation	KARNAWI	
13	L 9418 NP	14	LPS MRUTU KALIANYAR	1 rotation	KARNAWI	
14	L 9413 NP	14	LPS PASAR BUAH WONOKUSUMO	1 rotation	SOKOR	
15	L 9421 NP	14	LPS PLATUK DONOMULYO	1 rotation	BUDI UTOMO	
16	L 9487 NP	8	LPS BULAK BANTENG TIMUR	1 rotation	SUGIANTO	
17	L 8042 RP	14	LPS TAMBAK DERES	1-2 rotations	TEGUH W	
18	L 9487 NP	8	LPS TAMBAKWEDI	1 rotation	SUGIANTO	
19	L 9425 NP(1)/L 8010 RP(2 rotations)	14 /14	LPS KALIKEDINDING	2- 3 rotations	SUNARI/JUNIANTO	
20	L 9412 NP	8	LPS THP KENJERAN	1 rotation	KARMIN	
21	L 8023 SP	14	LPS MEMET	1 rotation	M. ANAS	
22	L 9411 NP	8	LPS SIDOTOPO WETAN	2 rotations	SUKIR	
23	L 8075 QP	14	LPS KAMPUNG SERATUS	7 days 1x	SUPAR	
24	L 9001 YP	8	LPS TAMBAK ASRI	2 rotations	ABD. MANAF	
~~25~~	~~L 8063 SP~~	~~8~~	~~LPS LANTAMAL~~	~~7 days 1x~~	~~JOKO SUSILO~~	Not printed
26	L 9485 NP	8	LPS JATISRONO	2 days 1x	SLAMET	

No.	No. PLATE	Arm Roll	WASTE COLLECTION POINT	ROTATION/DAY	DRIVER	DESCRIPTION
27	L 8037 PP	14	PASMAR MARINIR	4x /bulan		
28	L 9489 NP	8	MOROKREMBANGAN	2 days 1x	SUYANTO	
28	L 8032 SP	8	LARANGAN	3 days 1x	MURTADLO	
AREA: SOUTH						
1	L 8063 SP	8	LPS SIMOKATRUNGAN	1 rotation	JOKO SUSILO	
2	L 8063 SP	8	LPS PETEMON KUBURAN	2 days 1x	JOKO SUSILO	
3	L 9354 NP(2) / L 8023 PP(3)	14 / 14	LPS MAKAM MATARAM	4-5 rotations	L 9354 NP L 8023 PP	
4	L 8011NP QP (3) / L 8005 RP (1)	14 / 14	LPS BUKIT BARISAN	3 rotations	L 8080 QP GUNAWAN L 8005 RP M. SAMSUL	
5	L 8005 RP	14	LPS MERAPI	1 rotation	M. SAMSUL	
6	L 8011 PP	14	LPS BUKIT MAS	2 days 1x	M. ARIPIN	
7	L 9018 RP	14	LPS WONOBOYO	1 rotation	M. KHOIRUDIN	
8	L 8085 QP	8	LPS JOGOLOYO	1 rotation	DAYSYOKO	
9	L 8085 QP	8	LPS YANI GOLF	2 days 1x	DAYSYOKO	
10	L 9048 VP	8	LPS RUSUNAWA GUNUNGSARI	7 days 1x	AGUS S	
11	L 9410 NP	8	LPS PASAR WIYUNG	2 rotations	SUWADJI	
12	L 9426 NP	14	LPS BABATAN PILANG	2 rotations	SULIS	
13	L 9485 NP	8	LPS KRAMAT	4 days 1x	RODJIUN	
14	L 8085 QP	8	LPS TPI WIYUNG	5 days 1x	DAYSYOKO	
15	L 8060 PP	14	LPS PASAR KEDURUS	1 rotation	M.RISKA M	
16	L 9048 VP	8	LPS WARUGUNUNG	2 days 1x	AGUS S	
17	L 9350 NP	14	LPS BALAS KLUMPRIK	1 rotation	AMIR	
~~18~~	~~L 9489 NP~~	~~8~~	~~LPS RUSUN WARUGUNUNG~~	~~4 days 1x~~	~~SUYANTO~~	
19	L 8062 NP	8	LPS WONOKROMO	2 rotations	PRABOWO	
20	L 8011 RP	14	LPS JL. JETIS KULON	2 rotations	MARTAM	
21	L 9422 NP	14	LPS JAMBANGAN	1 rotation	ALI FAUZI	
22	L 9419 NP	14	LPS KARAH	1 rotation	YUSMAN HADI	
23	L 9419 NP	14	LPS BUNGURASIH	1 rotation	YUSMAN HADI	
24	L 8014 TP	14	LPS SIWALANKERTO	2 rotations	ANTOK	

No.	No. PLATE	Arm Roll	WASTE COLLECTION POINT	ROTATION/DAY	DRIVER	DESCRIPTION
			LANDASAN		MULYONO	
25	L 8077 QP	8	JL. A. YANI	7days 1x	SUYANTO	
26		10	LPS JEMUR NGAWINAN	2 rotations		COMPACTOR
27	L 9223 NP	14	LPS KETINTANG WADER BARU SELATAN	2 rotations	SUTARNO	
28	L 8005 NP	8	LPS GAYUNG KEBONSARI	1 rotation	ABD. MANAF	
29	L 8077 QP	8	LPS GAYUNG PRING	1 - 2 rotations	SUYANTO	
30	L 8033 NP	8	LPS KEBONSARI MAKAM	2 days 1x	KARIDIN	
31		10	LPS JEMUR WONOSARI	1 rotations		COMPACTOR
32		10	LPS NGAGEL	2 rotations		COMPACTOR
33	L 8011 PP	14	LPS PRAPEN DKK	2 days 1x	M. ARIPIN	
34	L 8011 PP	14	LPS NGAGEL DADI	1-2 rotations	M. ARIPIN	
35	L 9422 NP	14	LPS BRATANG LAPANGAN	1 rotation	ALI FAUZI	
36	L 8004 QP	14	LPS RAYA PRAPEN	1 rotation	M. RIYANTO	
37	L 8084 QP	14	LPS PANJANG JIWO	1 rotation	WIDARMANTO	
38	L 9416 NP	14	LPS PRAPEN 88	2 days 1x	SUJI	
39	L 8005 SP	14	LPS JAJAR TUNGGAL	1 rotation	HERU P	
40	L 9350 NP	14	LPS POLDA JATIM	2 days 1x	AMIR MUZAKI	
41	L 9424 NP	14	LPS JAGIR	1 rotation	MARGONO	
42	L 9352 NP	14	LPS PASAR BARU JAGIR	2 rotations	CHIRUL AMIN	
43	L 8029 SP	14	LPS PASAR BERAS BENDUL MERISI	2 rotations	ADI TRI UTOMO	
44	L 9049 VP	8	LPS RSAL	1 rotation	SUPRIONO	
45	L 9001 YP	8	SITI KHATIJAH	2 days 1x	ABD. MANAF	
46	L 8062 PP	8	LPS MATARAM UTARA	1-2 rotations	TAUFIK S	
47	L 8054 QP	14	LPS MENANGGAL	1 rotation	JONI P	
48	L 9049 VP	8	LPS KODAM 516	3 days 1x	SUPRIONO	
49	L 9049 VP	8	LPS KODAM 517	3 days 1x	SUPRIONO	
50	L 9485 NP	8	LPS PONDOK MANGGALA	2 days 1x	RODJIUN	
51	L 8078 QP	8	LPS TELKOM KETINTANG	2 days 1x	EDY SETYONO	
52	L 9350 NP	14	LPS GAYUNGSARI	1 rotation	AMIR MUZAKI	

No.	No. PLATE	Arm Roll	WASTE COLLECTION POINT	ROTATION/DAY	DRIVER	DESCRIPTION
53	L 8078 QP	8	LPS PONDOK INDAH WIYUNG	1 rotation	EDY SETYONO	
54	L 8085 QP	8	KODAM	3 days 1x	DAYSYOKO	
55	L 9413 NP	8	KODAM	4 days 1x	ASAN	
56	L 8063 SP	8	MARINIR GUNUNG SARI	3 days 1x	JOKO SUSILO	
57	L 9047 VP	8	DUKUH MENANGGAL	2 rotations	M.KHOIRUL H	
58	L 9489 NP	8	KODIKAL	7 days 1x	SUYANTO	
59	L 8010 PP (2) / L 8010 SP (2)	14	JOYOBOYO	4 rotations	L 8010 PP L 8010 SP	
AREA: WEST						
1	L 8072 QP	14	LPS JAYAMIX	2 rotations	BUDIONO	
2	L 8021 TP(2) / L 8067 QP(1)	14 /14	LPS SIMORUKUN	3 rotations	L 8021 TP MUSRAB L 8067 QP HERI EKA SUSANDI	
3	L 8022 TP	14	LPS SUKOMANUNGGAL	1 - 2 rotations	MUSTOFA	
4	L 8006 NP	14	LPS SONO KWIJENAN	2 rotations	YUNUS	
5	L 8062 PP	8	LPS PASAR ASEMROWO	2 days 1x	TAUFIK S	
6	L 9491 NP	8	LPS GENTING	1 rotation	SRIYONO	
7	L 9487 NP	8	LPS KALIANAK	3 days 1x	SUGIANTO	
8	L 8075 QP	14	LPS JL.GREGES	3 days 1x	SUPAR	
9	L 9488 NP	8	LPS ROMOKALISARI	2 days 1x	MUNARI	
10	L 8005 NP	8	LPS TAMBAK OSOWILANGUN	2 days 1x	ABD. MANAF	
11	L 9048 VP	8	LPS BOEZEM MOROKREMBANGAN	7 days 1x	AGUS SETIAWAN	
12	L 9485 NP	8	LPS SUMBEREJO	7 days 1x	RODJIUN	
13	L 9048 VP	8	LPS GRAHA SURYANATA	2 days 1x	AGUS S	
14	L 9491 NP	8	LPS JAWAR	7 days 1x	SRIYONO	
15	L 8005 NP	8	LPS JURANG KUPING	3 days 1x	ABD. MANAF	
16	L 8006 NP	14	LPS PASAR BENOWO	2 days 1x	YUNUS	
17	L 8005 TP	8	LPS PAKAL MADYA	2 days 1x	TEGUH P	
18	L 9019PP	8	LPS LANGKIR	3 days 1x	SYAIFUL M	
19	L 8005 PP	14	LPS BABAT JERAWAT	2 days 1x	SUTRISNO	
20	L 8055 QP	14	LPS KENDUNG	2 days 1x	SURIYANTO	

No.	No. PLATE	Arm Roll	WASTE COLLECTION POINT	ROTATION/DAY	DRIVER	DESCRIPTION
21	L 9424 NP	14	LPS KENDUNG MAKAM	1 rotation	MARGONO	
22	L 8022 SP (1) / L 8060 PP(1)	14 /14	LPS MANUKAN KULON	2 rotations	L 8022 SP L 8060 PP	
23	L 8071 QP	8	LPS PASAR MANUKAN WETAN	1 rotation	NUR CAHYONO	
24	L 8071 QP	8	LPS MANUKAN TLOGO	1 rotation	NUR CAHYONO	
25	L 8022 TP	14	LPS CANDI LONTAR	1 rotation	MUSTOFA	
26	L 9019 RP	8	LPS KUWUKAN	2 rotation	SAIFUL MUHIBI	
27	L 8054 QP	14	LPS BALONGSARI	1 rotation	JONI P	
28	L 8010 PP	14	LPS KARANGPOH	1 rotation	JOKO RIONO	
29	L 9488 NP	8	LPS LAKARSANTRI	2days 1x	MUNARI	
30	L 8005 SP	14	LPS LIDAH KULON	2days 1x	HERU P	
31	L 9485 NP	8	LPS PURI LIDAH KULON	2 days 1x	RODJIUN	
32	L 8071 QP	8	TAMBAK OSO WILANGON	2 days 1x	NUR CAHYONO	
33	L 8005 NP	8	LPS BANGKINGAN ASPOL	3 days 1x	ABD. MANAF	
34	L 8078 QP	8	LPS BANGKINGAN	2 days 1x	EDDY S	
35	L 8074 QP	14	LPS TENGGER KANDANGAN	1 rotation	DEDI CANDRA	
36	L 8011 SP	14	LPS BRINGIN	2 days 1x	SUWOTO	
37	L 8063 SP	8	LPS BUNTARAN	3 days 1x	JOKO SUSILO	
38	L 8063 PP	8	LPS ALAS MALANG	3 days 1x	ACH. ZAENAL	
39	L 9001 XP	8	LPS LIDAH WETAN	1 rotation	SUKADI	
40	L 8038 RP	14	LPS TUBANAN	1-2 rotations	PAIMAN	
41	L 9019 PP	8	LPS SIMOHILIR	2 rotations	M. SOLEH	
42	L 9019 PP	8	LPS PASAR SIMO	2days 1x	M. SOLEH	
43	L 8005 SP	8	LPS MAKAM LIDAH KULON	2 days 1x	HERU P	
44	L 8033 NP	8	LPS KLAKAH REJO	1 rotation	KARIDIN	
45	L 9001 XP	8	LPS PASAR SEMEMI	1 rotation	SUKADI	
46	L 8085 QP	8	LPS SEMEMI	4 days 1x	DAYSYOKO	
47	L 8055 QP	14	LPS KANDANGAN	2 days 1x	SURIYANTO	
48	L 8055 QP	14	LPS PUTAT GEDE	1-2 rotations	SURIYANTO	
49	L 8022 SP	14	LPS PONDOK INDAH BENOWO	1 rotation	YULIANTO	
50	L 9489 NP	8	LPS GRIYA CITRA ASRI CGA	2 days 1x	SUYANTO	

No.	No. PLATE	Arm Roll	WASTE COLLECTION POINT	ROTATION/DAY	DRIVER	DESCRIPTION
51	L 9001 YP	8	LPS KEJARI (KEJAKSAAN SUKOMANUNGGAL)	7 days 1x	ABD. MANAF	
~~52~~	~~L 8085 QP~~	~~8~~	~~LPS KRAMAT~~	~~2 days 1x~~	~~DAYSYOKO~~	
53	L 8010 PP	14	DARMO INDAH	1 rotation	JOKO RIONO	
54	L 9426 NP	14	MADE	7 days 1x	SULIS	
55	L 8060 PP	14	PRADAH KALI KENDAL	1 rotation	M.RISKA M	

Appendix 3: Recapitulation of DKP Waste Collection Rotations by Compactor Trucks

No.	No. PLATE	M^3	WASTE COLLECTION POINT	ROTATION/DAY	DRIVER	DESCRIPTION
1	L9561NP	10	LPS SIMPANG DUKUH - LPS CANDIPURO-TAMAN APSARI		ARIF	
2	L9386NP	10	LPS PANDEGILING		SATRAWI	
3	L9385NP	10	JL. PANDEGILING-URIP SUMOHARJO-EMBONG MALANG		AJI	
4	L9388NP	10	TAMAN BUNGKUL-TAMAN SULAWESI-TAMAN LANSIA-KANTOR PMI(EMBONG PLOSO)-TAMAN PRESTASI-BALAI PEMUDA-KANTOR DPRD-JOGGING TRACK PUSURA-ST.GUBENG-PDAM		SAGUN P	
5	L9553NP	10	LPS KAYOON		AWANG	
6	L9455NP	10	LPS KETAMPON-RS BHAYANGKARA-MONUMEN POLISI ISTIMEWA		AGUS EFENDI	
7	L9452NP	10	JL. KARET-KEMAYORAN BARU-JMP-LPS PECINDILAN		ERIK	
8	L9454NP	10	LPS JEMUR WONOSARI		WANDIK	
9	L9453NP	10	LPS BOKTONG-TAMAN FLORA-		SAMUJI	

No.	No. PLATE	Arm Roll	WASTE COLLECTION POINT	ROTATION/DAY	DRIVER	DESCRIPTION
			KALISUMO			
10	L9451NP	10	LPS NGAGEL		SETIADI	
11	L9448NP	10	LPS PECINDILAN		ERWINSYAH	
12	L9554NP	10	LPS TAMBAK REJO		DANU	
13	L9560NP	10	LPS TAMBAK REJO		AGUNG	
14	L9384NP	10	LPS SRIKANA		DARMAWAN	
15	L9389NP	10	LPS SRIKANA		DJUNARIN	
16	L9557NP	10	LPS PANDEGILING		KISWANTO	
17	L9556NP	10	SALURAN DINOYO-SALURAN DARMOKALI-PS. BUNGA KAYOON		HAMID	
18	L9555NP	10	PS. KEPUTRAN		FATKHUROHMAN	
19	L9627NP	10	CADANGAN			

CHAPTER V
CONCLUSION AND SUGGESTION

This last chapter elaborates the conclusions which can be drawn from this research in the aims of answering all research objectives along with the suggestions which are given regarding the typical future research topic.

5.1 Conclusions

There are four conclusions that can be obtained as the answers to the objectives of this research as follows:

1. There are three transportation modes of existing waste collection system. First is by using arm roll trucks with conventional sealed container (sizes of $8m^3$ and $14m^3$), secondly is by using compactor truck which only can lift bin hoist, and the last is by using dump truck to accommodate compacted waste from static waste compression machine in the waste collection point.

Table 5.1 Conclusions of Existing System Weaknesses

No.	Existing System	Weaknesses
1.	Arm roll truck with conventional container	High rotations affect high operational cost through diesel consumptions and maintenance cost of both trucks and containers.
2.	Compactor truck	• This system has high investment which is per compactor truck costs more than IDR 1.2 billion per unit. • High diesel consumptions that use for running truck's machine and compressing waste by hydraulic pump which also using diesel as its fuel.
3.	Waste Compression Station	• High investment cost to purchase the waste compression machine and also operational cost through electrical and diesel costs used to running that machine with power of 18.5 kW. • Needs quite large space to accommodate it. Meanwhile, most of waste collection points in Surabaya have small spaces.

2. The first existing system that mostly covering waste collection points in Surabaya is being the concern of DKP in order to make this system be able to create operational and maintenance savings from reducing the number of rotation numbers. There are two alternatives of new system given in this research to improve the existing system. First is modifying conventional container of arm roll truck by adding compactor machine and secondly is using the whole new demountable or mobile waste compactor.
3. As can be seen in Table 4.5-4.16, there are 34 waste collection points which will be used as location for the implementation of new waste collection system. From total of 34 waste collection points, 27 points have 2 rotations of waste pickings per day, 3 points have 3 rotations of waste pickings per day, and the remaining 4 points have 4 rotations per day.
4. It is obtained that alternative 2 gives higher value of NPV of IDR 8,594,586,743 and IRR of 46%. Besides looking for savings on operational and maintenance costs, DKP must also conduct a green and environmentally friendly system as commanded by local government. In order to select the best alternative that covers this factor, Benefit Cost Ratio is used as the indicator. From the ratio, alternative 2 gives higher ratio which is 5.73. It is because this alternative has more benefits from CO_2 emission consumption savings rather than total costs incurred to conduct the system.

5.2 Suggestions

The suggestion that can be given from this research is in order to implement new system, DKP has to make sure that all things needed for the operations, including operator, are prepared. The operators in selected waste collection points must be trained properly to avoid any disoperation that can lead to cause any accident.

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