Promoting Waste-to-Energy Program for BRT Project based on Participatory Research Approach: A Case of Used Cooking Oil in Bogor City, Indonesia

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Abstract

The rapid increase in population has directly resulted into increased energy demand, especially in transportation sector. To survive with the growth of energy consumption, transit has become key alternative to alleviate mobility problem in the country. However, to cope with the increasing fuel price and limited resources in this coming near future, the important consideration for transit agencies is to guide on how to successfully implement BRT in the changing political, institutional, and operational setting. The alternative of energy sources from biomass productions has received much attention, which could be obtained from the agriculture crop or from domestic waste materials. To enhance fuel diversification, in the same time also to eliminate the environmental pollution through efficient Bus Rapid Transit (BRT), this paper discusses the possibilities of utilizing used-

cooking oil for BRT in Bogor as a case study. With an objective of understanding the underlying factors governing the utilization of used-cooking oil as biodiesel, the policy interventions required for better dissemination of renewable energy are also discussed. Thus, to increase the availability, use of alternative energy and maintain the amount of raw material to produce sufficient fuel as an alternative energy, the incentive programs and campaigns are the must. Participatory Approach (PA) was adopted to encourage all stakeholders to participate in the process of bio-diesel material collection. Finally, the use of used-cooking oil for BRT could be a key solution for current problem faced by the study area i.e., traffic congestion that demands efficient BRT, and meeting demand of the waste used-cooking oil for its proper utilization in BRT as a biodiesel fuel. Thus, this proposed program will help to tackle these twin objectives of smoothing traffic in the city and reduce emission from the city transportation system.
Keyword; Bogor city, BRT, Bio-diesel material

1. Introduction

Indonesia represents as the fourth largest country in term of population (230 million of 2009) in the world. As a densely populated country (i.e. population density: 119.83 people/km^2; total area: 1,919,317 km^2), it has resulted to the high energy consumption with the consequence of high pressure on natural resource utilization in order to drive for the economic growth. It can be seen that there is continuously increasing rate of energy consumption that reached up to 136,121 in year 1999 as seen in Figure 1. In the same time, Indonesia has also created and generated excessive amount of waste, which is unable to be used as input into further process, would potentially pollute the environment. Since currently there are severe environmental problems occurred in big cities as well as medium size cities of the country, particularly related to transportation sector such as air pollution and noise pollution, environment problem has become a major concern in the country, especially, air quality condition which is gradually degrading due to the human activities. The high demand with the limited supply of energy provided in transportation sector plays a key role as a driving force to search for other energy alternative to be utilized. For instance a variety of processed human wastes can be used as biofuel for reducing significant operational cost while maintaining clean air and environment in general. Furthermore, increasing levels of urban congestion create the need of an alternative approach for new transportation solutions. A creative, emerging public transit solution is Bus Rapid Transit (BRT) which was introduced in Indonesia since 2004.

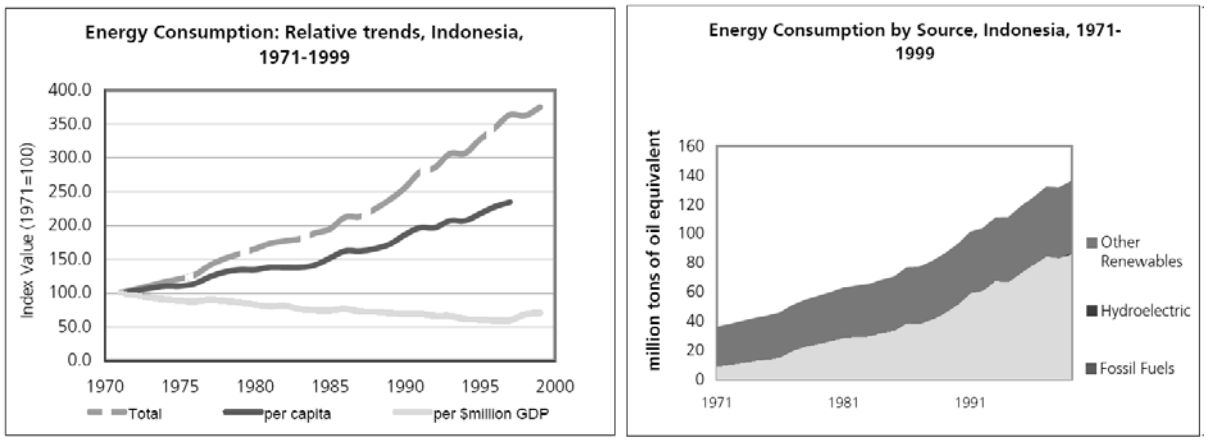


Figure 1. Trend of energy consumption in Indonesia
Source: Earth Trends 2003.

The system similar to BRT is applied in several cities of Indonesia (Batam, Riau-Sumatera; Bogor, West Java; Yogyakarta and etc.) in order to cope with the traffic congestion problem of the countries. Bogor is one of the cities which have adopted this system as an alternative public transit mode since April 2007. This is due to the high potential of the system to be at a minimum investment, faster than traditional "local bus" service and that, at a maximum, include grade separated bus operations. The essential features of BRT systems are some form of bus priority, faster passenger boarding, faster fare collection, and a system image that is uniquely identifiable. BRT represents as an alternative mode in Indonesia to improve mobility at relatively low cost through incremental investment in a combination of bus infrastructure, equipment, operational improvements, and technology.

Despite the potential cost and mobility benefits, however, the transportation profession lacks a consolidated and generally accepted set of principles for planning, designing, and operating BRT vehicles and facilities. Transit agencies need guidance on how to successfully implement BRT in the changing political, institutional, and operational setting. The goal of promoting this type of public transport is faced with the difficulties to cope with the increasing fuel price and limited resources in this coming near future. This is also one of the significant problems for operating BRT system at the cities due to the operating and investment allocation, thus, effective solution is required to be addressed in order to introduce BRT in more sustainable way. One effective solution to increase the availability and use of alternative energy, such as blended bio-diesel or blended gasoline fuels for motor vehicles, is to establish blended bio-diesel or blended gasoline blending facilities. Here, it is necessary to maintain the amount of collected bio-diesel raw material to produce sufficient fuel as an alternative energy. Thus, Participatory Approach (PA) was introduced to encourage the participation of the local need in response to the environmental concern. Therefore, the incentive programs and campaigns should be considered to encourage all stakeholders to participate in the process of bio-diesel material collection. This indicates the two distinct problems currently faced by the medium size cities such as Bogor, Indonesia, to achieve the efficient BRT to meet the demand of the waste for its proper utilization in BRT as biodiesel fuel. Thus, this proposed program will help to tackle these twin objectives of smoothing traffic in city and reduce emission from the city transportation system in the city.

2. Literature Review

This study applied the concept of Participatory Approach (PA) to involve in collaborative support from all concerned stakeholders and also to sustain the cycle of supply and demand of alternative energy. Furthermore, the cooking energy concept was adopted in order to alleviate the shortage and investment cost of the energy input into the transportation system in the study area. The detail of the concepts and their applications were reviewed in the following details:

2.1 Concept of Participatory Research

Participatory Approach (PA) and methods have become recent interest in the social and environmental sciences. PA involves collaborative research, education and action which are oriented towards social change, representing a major epistemological challenge to mainstream research traditions. It has recently been the subject of heated critique and debate and rapid theoretical and methodological development. PA captures these developments, exploring the justification, theorization, practice and implications of PA. PA offers different social, spatial and institutional contexts for mass induced problem solving. In spite of PA's radical potential, while maintaining a critical awareness, its challenges and dangers should be counted for. This study first explores the intellectual, ethical and pragmatic contexts of PA; the development and diversity of approaches to PA in bioenergy utilization and development. The principles, dilemmas and strategies associated with participatory approaches and methods including diagramming, cartographies, art, theatre, photo voice, video and geographical information systems are also discussed.

In this case we should also consider how effective PA will be, including the analysis of its products and processes, participatory learning, representation and dissemination, institutional benefits and challenges, and working between research, action, activism and change. Spatial perspective and an attention to scale provide helpful means of negotiating the potentials and paradoxes of PA. This approach responds to critiques of PA by highlighting how the spatial politics of practicing participation can be mobilized to create more effective and just research processes and outcomes. It could consider the significant weight to the recent critical reappraisal of PA, suggesting why, when, where and how to take forward PA commitment to enabling collaborative social transformation. The key to a participatory approach is that stakeholders and other external parties must join as active participants in defining and developing the target issues. This requires the relationship between organization and stake holders to be one of trust, respect and authenticity (Kindon, 2008).

FAO and CIFOR (2006) in Kindon (2008) pointed out about the example of adapt and adaptation of PA programs in disseminating low cost charcoal stove. This method offers rural community around campus to participate in the program of bioenergy implementation. The stove was designed in collaboration with Physics Department in Bogor Agricultural University and after 5 years operations have led to a wider community involvement around peasant and farmers around the campus. This program provides the evidence to support PA is one of the sufficiency solution for major improvement in combining low cost charcoal stove with the low carbon society initiated by The Ministry of Environmental Life and Ministry of National Education (Ind and Bjerke, 2007). Thus, to apply PA for sustaining the energy demand to run the BRT project in the study area, the consideration of different roles of stakeholder need to be assessed. Then, the method to raise the awareness and the knowledge disseminate will be provided in accordance with the distinctive characteristics of different groups.

2.2 Concept of waste to energy

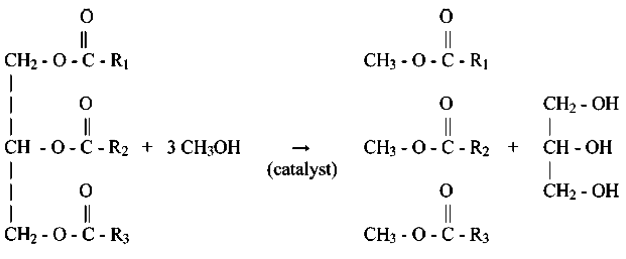
Typical definition of waste is garbage or refuse that no longer has use or value. Utilization of such waste for the purpose of generating energy is the basic concept of waste to energy. To reduce the cost of raw material of waste together with the purpose of minimizing by recycling option, this study use the waste cooking oil instead of other waste from crop product. This will help to reduce the problem of waste oil disposal (Wiltsee, 1998). This is due to the reason that cooking oil is one of the alternative solutions of renewable energy since it is easily available from either commercial or non-commercial source at low-cost or free of cost (Pohekar et al., 2005; Ouedraogo, 2006). Furthermore, it is more economic source as a raw material for bio production when it was compared to the other type of oil crop (Zhang *et al*., 2003; Kulkarni and Dalai, 2006). This competitive alternative also benefit in many merits. It is biodegradable and non-toxic compared to other petroleum based diesel and more favorable than the conversion on the basis of food production. With these appealing points of advantage from the cooking oil, it has become an alternative renewable energy to minimizing the impact on greenhouse effect. By using the waste of cooking oil or used cooking oil, it could then convert into methane, biodiesel or thermal energy (Shumate and Olsen, 1994). However, the quantity and quality of waste cooking oil will be varying by site specific of waste collection (Kulkarni and Dalai, 2006). As well as the sufficiency amount of cooking oil to be convert for the specific purpose of biodiesel will be normally categorized by the free fatty acids (FFA) which is important component during cooking oil treatment process. The waste cooking oil or waste fryer grease (WFG) is categorized by its free fatty acid (FFA) content. For the FFA content of waste cooking oil is <15%, then it is called “yellow grease”; otherwise, it is called “brown grease”. Due to the production of large quantities of waste cooking oil, the quality of raw material plays a key factor for consideration due to the capital cost for the plant of pretreatment equipment (Kulkarni and Dalai, 2006). Peiró et al. (2010) study the feasibility of process to obtain the biodiesel from different source as depicted in Table 1. In the transesterification, the system would be limited by the energy inputs into the system. Thus, to derive the amount of cooking oil for 100 liter, it requires 120 liter of used cooking oil.

Table 1. Inputs and outputs of the production of biodiesel from Used Cooking Oil

Compounds	Inputs	Outputs	Units
Used Cooking Oil	1.1741	-	Tons
Water	0.0916	0.1557	Tons
Methanol	0.2587	0.1475	Tons
Sulphuric Acid	0.0125	-	Tons
Potassium Hydroxide	0.0151	-	Tons
Biodiesel	-	1.000	Tons
Process Glycerol	-	0.0981	Tons
Potassium Sulphate	-	0.0222	Tons
Organic Waste	-	0.0854	Tons
Emissions		0.0632	Tons
Diesel	0.0201	-	Tons
Electricity	516.08	-	MJex
Steam (from natural gas)	642.00		MJex

Source: Peiró et al., 2010

For more understanding of the transesterification process, the equation 1 will be used to explain the transesterification reaction in detail. This is to explain how the collection of cooking oil from various sources could be transferred to the biodiesel. Peiró et al., 2010 explained that the collection of cooking oil will be first treated to the lower content of solid wastes and water to increase the yield of glycerides and free fatty acids (FFA). Then, it will be delivered to the pre-esterification and transesterification process with excess methanol. The using of an acid catalyst is to obtain methyl ester which will be used in the two step of reaction for the derivation of biodiesel.



Equation 1. **Triglyceride** **Methanol** **Mixture of fatty esters** **Glycerin**

Based on the equation, it was found that the triglyceride have the direct influence to the number of fatty esters or biodiesel. Thus, the exact determination of the expect quantity of biodiesel plays an important role to estimate the required amount of resources to input into the process, especially, in the cooking oil material. This is due to several considerations need to be paid for the reaction of free fatty acid (FFA) such as the required amount of the catalyst. Kulkarni and Dalai (2006) suggested that for the case of the high degree of FFA, the catalyst in the group of Acid-Catalyzed should be applied rather than Alkali-Catalyzed. Since, the Acid-Catalyzed cannot have direct reaction with FFA and forms soap. The soap formed during the reaction prevents the glycerol separation, which drastically reduces the ester yield. Furthermore, Wang *et al*. (2007) also recommended that the process of biodiesel could be done into 2 steps; first the used cooking oil should be input into the esterification process before input into the transesterification process based on alkali catalyzed. This process could be ensured the amount of final product of biodiesel.

For our study we consider conversion of used cooking oil into biodiesel in order to replace fossil fuel in city BRT. The process of making biodiesel from vegetable oil either it could be used or non-used is known as transesterification. This can be achieved by adding methanol to vegetable oil. This process requires the catalyst to increase the rate of the chemical reaction between methanol and vegetable oil which could be seen in Figure 2. Alkaline either Sodium Hydroxide or Potassium Hydroxide is commonly used catalyst in the process of making bio-diesel from vegetable oil. However, in the case of used cooking oil slightly different steps should be undertaken. A reheating of cooking oil for several times causes some of the fatty acids, bonded to the glycerol, to break away and gloat freely in the vegetable oil. Therefore it is named as Free Fatty Acid (FFA). There are two ways of dealing with these FFA. First one is esterification of the FFA before starting transesterification, and second one is increasing the amount of catalyst in the single transesterification process. In this process, the additional catalyst neutralizes the FFAs in creating soap as an additional by-product. An additional amount of catalyst needed could be calculated through a titration of sample of used cooking oil. The first process is common in the commercial production, while later one is better option for smaller scale production, which also produces soap as by product.

3. Used Cooking Oil Project in Bogor

One of the human wastes is cooking oil, a potential resource to produce Bio Diesel Fuel (BDF). The Bogor Government has initiated Program of Bus Rapid Transit (BRT) since 2007 for three proposed achievements, namely replacing small public vehicles, improving city transportation services as well as reducing Green House Gas (GHG) emissions. The process of used cooking oil could be demonstrated in Figure 2. Cooking oil utilization could be used as input fuel for all of the buses driven by

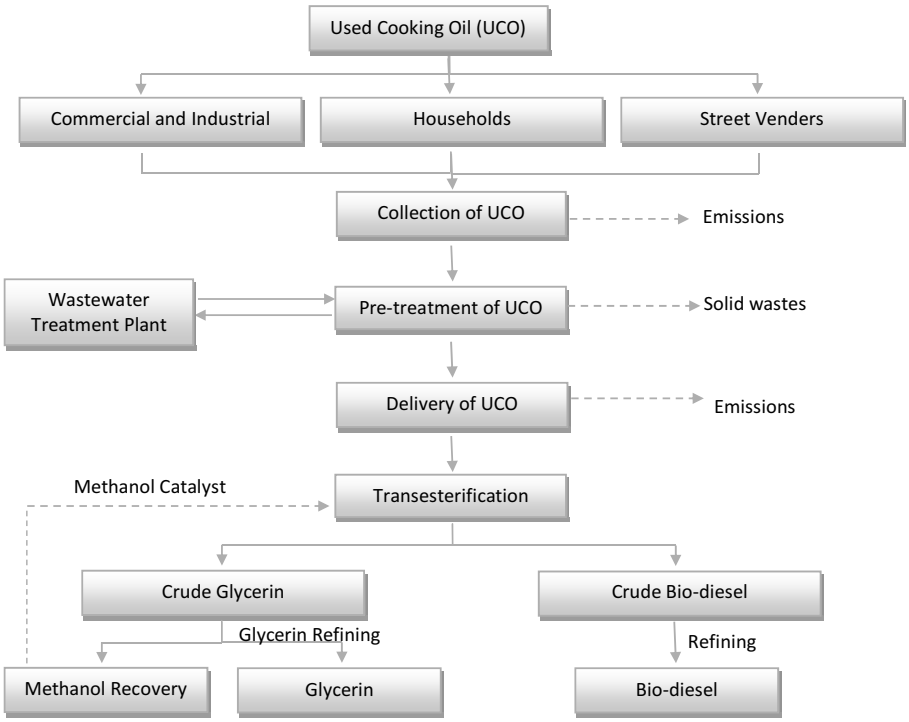


Figure 2. Processing of used cooking oil into bio-diesel fuel

mixed fuel with composition of 1 liter BDF and 4 liters diesel. It means around 20 % of fuel consumption can be replaced by the use of BDF (used cooking oil). Therefore, the application of biofuel (used cooking oil) is very significantly useful for mitigating some human negative impacts on the environment. The biofuel consumption can replace demand of fuel consumption due to the potential of its economic value and the waste utilization. It is generally agreed that used cooking oil can be reused for waste reduction and maximize its utilization for having clean air.

Bogor, as shown in Figure 3, is one city in "megapolitan" called JABODETABEKJUR (Jakarta Bogor Depok Tangerang Bekasi Cianjur), which consists of 2 provinces, 4 cities, and 3 regencies populated by roughly 20 million inhabitants. It can be found 8 entrances in transit city around 412,000 vehicle movements per day as well as residential city with about 13.3 % commuters. The transportation system is supported by 10,401 small minibus, 46,034 private cars, and 73,145 motorcycles, which utilize total length of road 833,855 km.

The operational system of minibus is operated by using 1 regional bus terminal and 3 sub terminals. The existing condition of our focused system, BRT in Bogor, the BRT system, is supported by 30 buses since it is initially operated in 2007. The fuel consumption is 100 liter per day for each bus, thus all the buses would consume energy around 3,000 liter per day. The amount of 3,000 liter consists of 80 % of fossil fuel and 20 % of BDF (waste cooking oil). Thus, the BRT system needs availability of cooking oil as many as 600 liters per day (18,000 liter per month). Currently, it is only supplied as many as 8,000 liter per month, thus it faces the situation of the supply deficit of 10,000 liters of waste cooking oil per month.

Main problems of the project to promote waste to energy of BRT are two folds: (1) BRT management and (2) waste cooking oil supply. The first is important because waste cooking oil project mainly serves BRT. On BRT management, the problems are how to encourage people to use BRT, make users' friendly environment for BRT, collaborative/participate with the existing small public vehicle (SPV) owners, and promote policy instrument for increasing BRT ridership, e.g. transit planning, parking policy. About waste of cooking oil, the problems are how to increase amount of cooking oil collection, certify the collectors to have more hub for cooking oil collection, provide encouragement or incentive for local and individual collectors, and prepare for future alternative clean energy for BRT system.

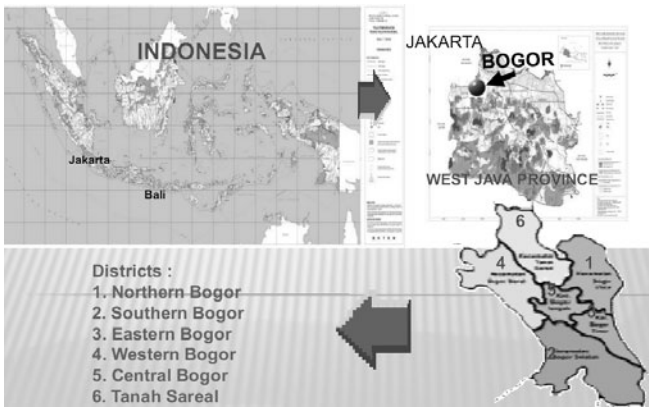


Figure 3. Map of Bogor City
Source: Roesli, 2010.

4. Stakeholders

Due to the increasing in number of vehicles in Bogor, the BRT system has been introduced in order to cope with this increasing in demand since April 2007 with 50 km of service. This new system provides the service with 10 buses for only one corridor. Then, in the early of 2008, the additional 20 buses was granted by Ministry of Transportation (MOT) to strengthen the service with opening new corridor (Sinaga, 2008) to cope with increasing demand as they are more comfortable (air conditioned buses), and have scheduled services, smart card ticketing system and new professional management. This increasing in demand put the pressure on the energy need in term of energy or fuel input into the process. Thus, it called for the local solution since the urgent and effective solution could be described as a bottom up approach for sufficient solution. One of the challenges is to enhance voluntary collaboration with restaurants, hotels and households to supply waste cooking oil. Further promotion of BRT and making it financially sustainable system is big a challenge. Therefore, in order to be successful, the program should involve many stakeholders participation, from households, industries and commerce, and government agencies as depicted in Figure 4. The following paragraph explains the roles of each stakeholder and potential conflicts of interests among them.

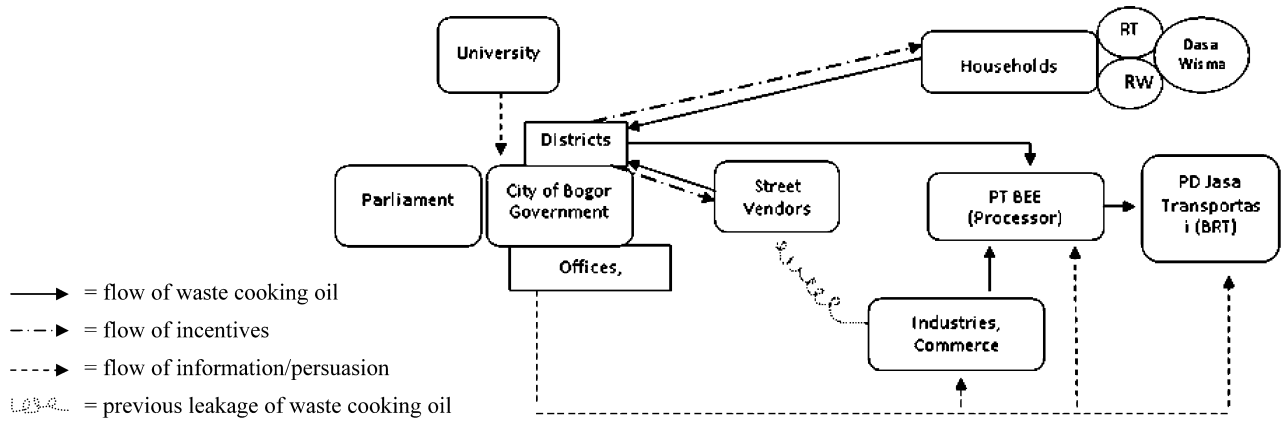


Figure 4. Stakeholder's interactions.

4.1 Households

Number of households in Bogor City in 2008 is 206,112 units or 876,292 persons (with average of 4.25 persons per households). Households are important source for the collection of waste cooking oil, but it has been facing problem of shortage in collection. To tackle the problem, Bogor City launched the plan to ensure households submit the waste to district offices for 3,000 rupiah per liter. Beside this, an intensive program on awareness about adverse effect of reusing cooking oil on human health as well as positive effect of using used cooking oil as biofuel in environment was initiated. This program provides a helpful in persuading households to participate in the waste to energy project of city BRT. To sustain the program, it is necessary to make them realize the importance of BRT in Bogor city.

4.2 School and University

Surfactant and Bioenergy Research Center (SBRC), Bogor Agricultural University is involved in development of the bio-diesel fuel (BDF) from the beginning of 2007. The university will provide qualified research output that aid to improve use efficiency of used cooking oil as well the city BRT system. Roles of various stakeholders including the role of schools and university are presented in Table 2.

Table 2. Stakeholders' roles

Stakeholders	Roles
School and universities	Knowledge and technical transfer
Street food vendors	Incentives, certification
Industry and commercial	Certification, incentives, collection mechanism
City government	Facilitation, certification, set target
Residential	Awareness raising, collection mechanism, incentive mechanism

4.3 Industries and Commerce

In order to secure the number of cooking oil, there is several stakeholders concern with the waste collection. The detail of each group is explained as follows:

(1) Hotels

Hotels are important source of waste cooking oil. They agree voluntarily to submit waste cooking oil to processing facility in Bogor. Number of hotels and accommodations in Bogor City in 2008 is 43 which have 1,374 rooms and 2,041 beds (BPS Jawa Barat 2008). As seen in Table 3, most hotels are non-star hotels.

Table 3. Number of hotels & other accommodations in Bogor City (2008)

Star Hotels		Total of Rooms									
		<10		10-24		25-40		41-100		>100	
Unit	Room	Unit	Room	Unit	Room	Unit	Room	Unit	Room	Unit	Room
6	499	7	47	18	318	7	233	5	277	--	--

Source: BPS Jawa Barat

(2) Restaurants

There are 27 restaurants in Bogor City, which could play an important role as one of sources of waste cooking oil. For example, Saung Kuring Restaurant voluntarily provides around 5 liters of waste cooking oil per day. Furthermore, Bogor City also receives waste cooking oil from sources locate out of Bogor City. For example, PT Pangan Sari Utama, kitchen unit of PT Chevron Geothemal Salak, a geothermal power plant located in Sukabumi Regency also give the used cooking oil to Bogor City. However, the potential contributors such as KFC, McDonald and other restaurants are still reluctant to supply their used cooking oil to the project. Formulation of regulation that enforces them to contribute minimum proportion of their used cooking oil could be done through the discussion with business communities and other civil societies of the city.

(3) Food Processing Industries

In 2003, there are only 6 medium/large scale food industries in Bogor City, left behind. However, the numbers of small food industries are about 1,083 units. They could also be important contributors of used cooking oil to the project. Assessment requires to be done about the potential of such food processing industries in providing used cooking oil to the project

(4) PT Bumi Engeri Equatorial (PT BEE)

PT BEE is a *private company* responsible for processing used cooking oil to biodiesel. PT BEE then supplies biodiesel oil to PD Jasa Transportasi. Capacity building of the processing company in order to meet the future demand of biodiesel is very crucial. It can be done through the increasing the capacity of processing plant to meet the supply of used cooking oil and demand of biodiesel.

4.4 Street Vendors

Street vendors cited here are people who sell fried snacks (*gorengan*), whether mobile or stationary. This informal job is important to absorb unemployment in City of Bogor or surrounding areas. However, there is not available data for number of street vendors in Bogor City, although they can be seen almost everywhere in the City. Therefore, assessment of the number of street vendors should be conducted to help for assess the exact amount of used cooking oil acquired from them.

Furthermore, it is important to gain participation from street vendors for two reasons. First, they are of the main users of used cooking oil. Most likely these small business with minimal capital uses used cooking oil several times as a business strategy to lower selling price. If they use fresh cooking oil, they tend to use it several times. Second, they usually have long working hours. Therefore they face some difficulties to submit used cooking oil to a collection point if they are far from their place of living and/or selling. Also, it is very important to note that their customers are mainly low income communities who are price sensitive. Thus, forcing street vendors not to use used cooking oil may put the negative impact to their sales and profit. This is the reason to proper incentive to food vendors are very essential to make them participate in the project.

4.5 Government Agencies

In Bogor City, there are eleven departments (*dinas*), four agencies (*badan*), and four offices (*kantor*). Among these government agencies, the government agency responsible for the program is Environment Office (*Kantor Lingkungan Hidup*). Since the nature of the program is cross sectors, other government agencies may also take their parts, for example Department of Transportation, Communication, and Informatics; Department of Culture and Tourism; Department of Industry, and also Trade, and Cooperative. Furthermore, there are four city owned enterprises. Among them, PD Jasa Transportasi is one of the operators of Bus Rapid Transport as main user of biodiesel produced from used cooking oil.

5. Relevance and Goal of Participatory Approach

In the decision making process, Bogor City officials gained influence from success story of using used cooking oil in Kyoto, Japan. In addition, there is capacity development of Bogor Agricultural University to do research in used cooking oil as biodiesel source. Furthermore, there is the promotion of residents' awareness in the implementation of the used cooking oil project in Bogor city. It is not an easy process, mainly due to the differences in the cultural and may also socio-economic difference between developed and developing city (Kyoto and Bogor). In Kyoto, all of the residents are usually aware of health issue, therefore there is high tendency of using cooking oil only twice and then throw it away. In contrast, common people in Bogor use cooking oil more than two times. For example, many restaurants add fresh cooking oil to used one; and at the end there is no waste to throw away. While common people awareness is low, many big restaurants are reluctant to contribute in used cooking oil project. For example, franchise restaurants collect their used cooking oil; send it to Jakarta. Those used

cooking oil is eventually supplied to street vendors. Therefore, participatory approach (PA) plays a key solution to bring all stakeholders in relevant for increasing awareness of all the stakeholders including general mass, street vendor, and big hotels and restaurants in the city. The goal of participatory approach is to enhance people ownership of BRT project in general and collection of used cooking oil in particular.

5.1 Proposed Application of Participatory Approach

(1) Decision Making

In supply chain of used cooking oil, the chains starts from community used cooking oil, collected by collection unit/point (dasa wisma/RT/RW, school, market, restaurant, hotel, industry). Then pooled at pre-processor or mixture at PT BEE, and final product is used by BRT (as depicted in Figure 5). A decision making of implementing participatory approach is mainly at collection unit or collection point. This is about the selection of the most feasible approach in term of resource amount (to make sure enough quantity collected), location (to ensure sustainability) and which stakeholders at what costs.

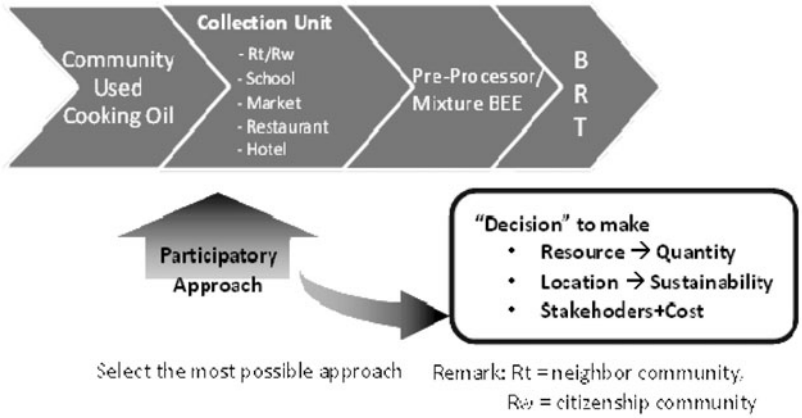


Figure 5. Supply chain

(2) Implementation

a) Residential

The awareness on the danger of consuming used cooking oil among residential is relatively low. Therefore, Bogor City should organize workshop on health risk associated with reuse of cooking oil for local leader to disseminate the knowledge among the local people, and training for housewife called "Dasa Wisma" (group of ten households) for the process of collecting used cooking oil. The housewife is important in the collection process as they are the one who is involved in cooking. Besides Bogor city should run campaign for collecting used cooking oil. In the campaign, the government may distribute a container/jar to store used cooking oil before they are collected by the authority. In the campaign process, government should also inform people about incentives that will be given to the people, such as cash back for each liter of used cooking oil provided or incentive in term of special privileges in the city Bus Rapid Transit (BRT) system for certified used cooking oil contributors. In the collection of used cooking oil from household, "Dasa Wisma" or "Rukun Tetangga" (Rukun Tetangga, literally means group of neighbors) handover the collection to "Rukun Warga" (RW, literally means group of residents) then to collection centers in each designated location. A flow of the collection in this chain should be coordinated by sub district heads.

b) Universities and Schools

Universities and schools in the city could play a very crucial role in the successful implementation as well as to achieve sustainability goal of the project. Therefore, the roles of these institutions are described as follows;

- set up the community training center among multi stakeholders and create networks to other school to link with other regions,
- initiate the new collection center by incorporating the knowledge among the researchers/staff of universities for sustainable plan,
- get participation for student involvement, include in lectures or special activities for students in special events,
- promote new technology for medium and long term for sustainable transportation system, and
- promote more attractive dissemination of knowledge in different kind of media or cooperation with the media.

Thus, in nutshell, universities and schools can contribute in dissemination of the knowledge as well as contribute in

research and development aspects of the project.

c) Industrial and Commercial sectors

Industrial and commercial sector must participate in public campaign for community health problem associated with used cooking oil and better environment as part of Corporate Social Responsibility in converting used cooking oil into green energy. Furthermore, they also should contribute in collection process. They can contribute logistics for collection and distribution of used cooking oil. In return, the industry or commercial organization contributing the project may get benefit for transportation service to their employee by BRT to commute from home to office and vice versa. This will serve as the win-win situation for the project as well as the industry/commerce.

d) Street Vendors

Street vendors are among the important actors for successful project implementation. Therefore, awareness rising about the danger of consuming used cooking oil and importance of bio-diesel fuel (BDF) is mandatory. In order to encourage their participation in the project, they should be provided with used cooking oil container for the collection of the used cooking oil. In addition, some incentives, such as monetary incentives and also special privileges in the Bus Rapid Transit (BRT) system of the city are necessary. It should be offered for them based on the contribution they made in terms of supplying used cooking oil to the project. Furthermore, designation of special zone for street vendors, with their participation in finding the most suitable place, will help to solve the problem of street vendors in the city. The operation of street vendors is identified as the problem of the city government as it disturbs the movement of traffic as well pedestrians. Allocation of free spaces in such designated area for the food vendors could also be one option to motivate them in the project.

e) Government Agency

Apart from socialization and campaign, government agency may set up regulation/s by means of setting guidelines/laws for newly established processing industry that used cooking oil. In addition, the agency must establish a system to certify the contributors. For residents, the system must assure that the certified contributors have right to use BRT for free for some distance based on the contribution they made in term of quantity of used cooking oil to the project. For street food vendors, the system is important for allocation of free space in specially designated areas for food vendors, concession in using BRT for certified contributors, and cash benefits if contributed extra amount of used cooking oil. For commercial and industrial organizations, apart from transportation benefit for workers, they may also get certification of their contribution in Corporate Social Responsibility (CSR). In long term, the government must be proactive in facilitation of collection process, for example by providing enough transportation means for collection together with setting up collection centers in designated areas. The government must also cooperate with university to prepare future alternative clean energy for BRT other than used cooking oil (Figure 6).

(3) Demand of used cooking oil (UCO)

Planned number of operational Bus Rapid Transit (BRT) in the Bogor city will determine the demand of diesel fuel. Together with this, blending target groups will be the main driving force for the demand of used cooking oil to be used as biodiesel. As mentioned in earlier part of this paper, we set short, medium and long term target of blending proportion as well as replacement of Small Public Vehicle (SPV) in order to reduce GHGs (CO_2, N_2O, etc.), as well as reduce the road congestion. Based on the target set for blending proportion and number of SPV replacement the demand of used cooking oil is presented in Table 4. The calculation shows that for the short term a monthly demand of UCO is 19,800 liters (L), which will increase to 413,300 L in the long term. This action will result in the substantial reduction in the GHGs emission from transportation sector in the city as well as traffic congestion in long run (Roesli, 2010).

Table 4. Projection of used cooking oil demand.

Period	Blending proportion (a)	Number of SPV to be replaced (b)	Number of BRT needed (c=b/3)	Demand of fuel L/BRT/ month (d*)	Demand of diesel L/month (e=c*d)	Demand of Biodiesel L/ month (e*a)	Demand of UCO/month kilo liter (kL)
Short term	0.20	150	50	1,825	91,250	18,250	19.8
Medium term	0.30	500	167	1,825	304,167	91,250	99.1
Long term	0.50	1,250	417	1,825	760,417	380,208	413.3

(4) Supply of used cooking oil

Per capita consumption of used cooking oil among the 0.8 million residents in the city define the supply of used cooking

oil from Bogor city. At present, per capita consumption of cooking oil is 14.08 liters, which is growing at the rate or 11.7% per annum (Statistics Central Bureau, 2002). This growth rate is quite high and could be the source of several cardio-vascular related health problems. Therefore, during the campaign, the information on adverse effect of excessive oily food should be disseminated. With this target in term of per capita consumption of vegetable oil should be set to 10%, 5%, and 1% for short, long, and medium term, respectively (Table 5).

Population growth rate in Bogor city is 1.65% per annum, which will assumed to be remain constant throughout the planned period. Due to the reason that out of the total cooking oil consumed by the resident of the city, in short run we assume that 15% will be disposed as the wastage. This proportion can be increased up to 30% through making them aware of the health hazards of reusing the cooking oil. Similarly, it is rational to assume that out of these used cooking oil, 20% can be collected through the voluntary participation of big food industries, as well as participation of street food vendors and local residents. Through incentives to all the contributors, we target up to 50% of these used cooking oil in long term will be available for the project. With this condition, the supply of cooking oil will be able to meet the demand in short and medium term but unable to meet the demand in the long run. Therefore, it is essential to improve the efficiency of used cooking oil collection in term of the reduction of FFA. Table 6 gives the different target set for short, medium, and long term. This is the case of 80% of collection of cooking which will be able to meet the demand of used cooking oil in long run (Figure 6). Therefore, contribution of the all the concerned stakeholders in promote the collection of quality cooking oil collection is crucial to meet the objective of green city with smooth flow of traffic.

Table 5. Projection of used cooking oil supply.

Period	Per capita consumption of CO (L)	Average per capita growth in consumption	Populat-ion (million)	Total consum-ption (kL)	Conver-sion rate (Oil to waste)	Collecti-on rate (Target)	Collected UCO (kL)/month
Short term	15.5	10%	0.89	13838	15%	20%	34.6
Medium term	20.7	5%	0.95	19701	20%	30%	98.5
Long term	24.1	1%	1.08	25909	30%	50%	324

Table 6. Different target rate for collection under different plan period.

Period	Target 1	Target 2	Target 3
Short term	20	25	25
Medium term	30	35	40
Long term	50	60	80

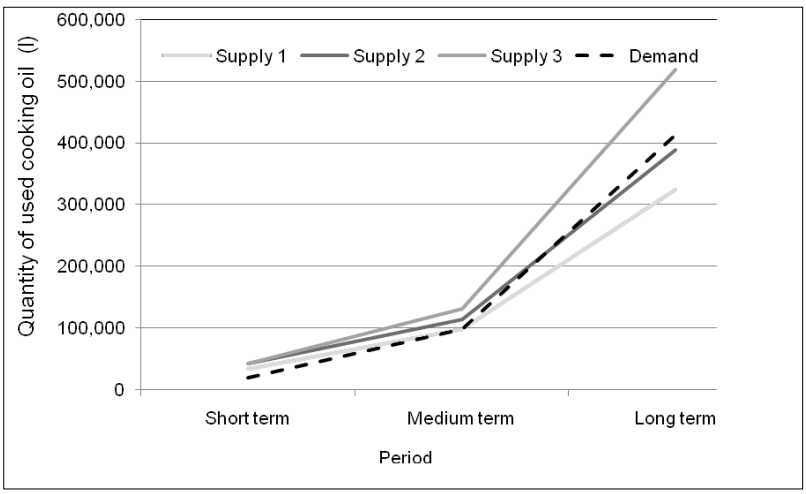


Figure 6. Demand of Used Cooking Oil and supply under different assumptions.

5.2. External Factors

The external factors which can significantly affect to this proposed project are able to be identified among multi-stakeholders, e.g., community, local government owned enterprise, and government itself, both in the city and national level.

The influencing factors can be seen in the detail of Table 7.

Table 7. The external factors to the proposed project.

External Factors	Supportive	Hindering
Personal Level ● Lifestyle change ● Participatory response	● Higher consumption of cooking oil ● Increasing in popularity to participate program	● More considering about the healthy food without cooking oil ● Ignore/lower involvement ● Compete with other local sectors ● Require the technology/ knowledge to deal with extra collection
Site Level (BRT Project) ● BRT service system ● Technology adaptation ● Collaboration among BRT and existing minibus	● More ridership of BRT usage (convenient, safety & comfort) ● Employ the suitable technology for BRT ● More involvement from minibus driver's household and alleviate the social conflict	● Maintain their private mode of utilization ● More electric car usage ● The availability of minibus will exist and difficult to be replaced by BRT
City Level ● Competition among other stakeholders ● Quality control of monitoring system	● More awareness to participate the program ● Achieve the plan of low carbon city	● Compete with other stakeholders ● Require more maintenance cost for technology & human resources to resolve the problem
National Level ● Macroeconomic of the country ● Clean energy campaign	● Rely on the good status of the economic ● Supportive from government	● Bad status of the economic will reduce the amount of cooking oil ● Other sources of biodiesel may be the other alternative

6. Concluding Remarks

Cooking oil plays an important role as an alternative energy for sustaining the transportation energy management in Bogor City. BRT is one of the main modes of its potential cost and mobility benefits, however, transit agencies need guidance on how to successfully implement BRT in the political, institutional, and operational. The goal of this promoting public transport is seems with the difficulties to cope with the increasing fuel price and limited resources in this coming near future. The utilization of used cooking oil is a powerful renewable energy option which could support the clean environment with less pollution of its implementation for BRT. However, the differences of cultural and socio-economic might influence on the number of using cooking oil more than twice. Therefore, participatory approach (PA) is relevant for increasing health awareness, increase the availability, use of alternative energy and maintain the amount of raw material to produce sufficient fuel among all the stakeholders including general mass, street vendor, and big hotels and restaurants in the city. Thus, the goal of participatory approach (PA) is to enhance people ownership of BRT project in general and collection of used cooking oil in particular. Participatory approach is an appropriate tool to guarantee success of used cooking oil program. To achieve the success of participatory approach, it requires sustainable coordination among multi-stakeholders to raise their awareness and participate the program e.g., residential, schools and universities, commercial and industrial and government agencies. Furthermore, it is also necessary to pay attention on the approach of sustainable waste to energy program from physical to social approach by short term, medium term and long term.

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