Applicable waste to energy technology for urban society

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Abstract. This paper presents an analysis on waste to energy technology application for an urban area that has a reasonable impact for the society. There are many technology to convert waste to become energy, however, the selection of each technology depends on the local condition such as the waste itself, the site condition and also the society that will deploy the technology. Therefore, this study was conducted to categorize the technology with its relation to the society condition. The study method was a literature review, and the review included the type of technology, the type of society and the typical neighbourhood of the society. The result of this study is an interrelationship between society, neighbourhood and the potential application of waste to energy technology.

1. Introduction

The According to Jakarta Statistic report [1], Bantar Gerbang as the last garbage dump in Jakarta (TPST) will be full and cannot accommodate any more in the next 5 years. This is because the area and capacity of the TPST are limited to accommodate waste from Jakarta, which reached 7.4 thousand tons per day in 2018. This number has even increased by 12 percent from the average amount of waste per day in 2017 (6.7 thousand tons). Therefore, the DKI Jakarta Provincial Government, through the Environment Agency, continues to make efforts to solve the waste problem in Jakarta.

The increasing rate of development, population growth, as well as the activities and socio-economic levels of the people in Indonesia have triggered an increase in the amount of waste generation. Furthermore, the old paradigm of waste management which relies on collection, transportation and disposal, cause the amount of waste even worst. All of these activities require a larger budget from time to time, if they are not available it will cause many operational problems such as waste that is not transported, facilities that do not meet the requirements and the operation of the facilities that do not follow the technical requirements [2].

Currently, one of the regional strategic activities carried out is the construction of an Intermediate Treatment Facility (ITF) to reduce waste at the source, and the optimization of the Bantar Gebang TPST. Apart from that, other strategic activities include involving the local community and regional officials by activating the community’s Waste Bank activities. These programs are considered quite successful in efforts to reduce the waste that enters the Bantar Gebang TPST. The average amount of waste entering the TPST in 2019 is around 6.7 thousand tons per day, or down about 11 percent from 2018. If the regional strategic activities that have been carried out by the DKI Jakarta Environment Agency continue to be encouraged and coupled with issuing local policies related to waste reduction, the amount of waste will continue to decline every year [3].
Cities will always be in touch closely related to the good land development within the city itself and the adjacent or the surrounding area. Besides, the land is also closely related to humans and the environment [4]. Explanation about population theory states that the population should be in equilibrium where the environment can support and the boundary between these equilibrium points is the carrying capacity of the environment [5]. Hence the development and good urban growth is a city that can balance between environmental conditions with population density which will be accommodated in the city.

Current theories of urban planning, such as Urban and Principles of Intelligent Urbanism and New Urbanism, have the objective to develop communities that can serve their own needs and to control the urban sprawl for improving the urban quality life. These theories also aims to prevent the environmental degradation, also to fix the existing urban areas. One of the objective of these theories that relate to the waste management is to provide appropriate ways to control and manage wastes [6].

Today, there are several types of technology that can convert waste to energy. They are: (1) Combustion processes are classified as mass burn combustion, where waste is not pre-sorted, or RDF combustion, a more costly process where recyclable materials are sorted from the rest of the waste. This process is also known as the Solid Recovered Fuel (SRF) combustion process, (2) Another thermal treatment process is gasification, which is effective in minimizing air polluants. Gasification occurs in the presence of limited oxygen and generates a synthetic gas to be used in a heat and electricity producing gas turbine, (3) A third process, pyrolysis, is now reaching market maturity - it is a thermochemical process that produces syngas, and most recently cellulosic ethanol, (4) Anaerobic digestion is a form of biological treatment where organic material is treated and the output biogas is rich in methane. The biogas can be cleaned and used, turned into heat and electricity, or used for methane [7].

This paper presents an interrelationship between a society, neighbourhood and the potential application of waste to energy technology. The interrelationship will link the aspect of hierarchy level of neighbourhood and the aspect of the waste to energy technology. The aspect of the hierarchy level of neighbourhood will see the physical condition, socio economic and informal network. In terms of the technology, the aspects that are studied are the fittest of the method and the initial cost to the society.

In order to know the applicable technology of waste to energy for urban society, the study was conducted through (1) to study the aspect of socio economic in the hierarchy level of neighbourhood, and (2) to investigate the waste to energy that can meet the environment aspect, human health and economics. The all steps were done using literature review.

2. Literature review

2.1. Type of society in the hierarchy level of neighbourhood

From the structural point of view, society is the total social heritage of folkways, mores and institutions; of habits, sentiments and ideals. The following two definitions view society from its functional and structural aspects respectively. Types of Societies: a) Professional Societies: These societies are promoted by the professionals to enhance their profession and bring out a common code of conduct. These societies are also termed as associations. They also include information societies, knowledge societies, academic societies and scientific societies, viz., Indian Management Association, Indian Society of Chartered Accountants, Association of Indian Universities, Indian Medical Association, etc. (b) Charitable Societies: These are non-profit organizations to help the needy persons of the societies. Sometimes, they are also known as Non-Government Organizations, financially supported by corporate and other philanthropists. (c) Economic Cooperative Societies: Many societies like housing, agro-processing, credit, marketing etc., help their members in the particular trade, either through their own resources or from the Government. Examples are cooperative housing societies, cooperative banks, district marketing co-operative societies, each helping in marketing specific product like tea, coffee, jute, plantation, etc. (d) Religious and Cultural Societies: These societies are formed to revive and maintain specific cultures, traditions and religious foundations. Examples are ISKON, Swaminarayan Temple Trust, Church associations, etc.
Summarized from MacIver et al., [8], society is a unit of people that interact one another has mutual or equal relationship. The typo of society, then, it can be based on professionalism, organization, and economic level or cultural. The context in this paper is a society that based on mutual relationship in a neighbourhood. Additionally, a society occurs since there is similar likeness and differences. Therefore, a neighbourhood should be planned based on the local society characteristics.

According to Conyers et al., [9] Planning is an attempt by a public institution to make direction development policies that must be carried out in a region both country and in regions based on the strengths and weaknesses of the region. This means that in a planning process for an urban area, planning agencies must pay attention on social, cultural, economic, security, physical conditions, in terms of financing and quality existing resources in the region and planning is a continuous process that includes decisions or choices of various alternative uses of resources to achieve certain goals in the future. Furthermore, based on Ardeshiri [10], development is considered as a main change in the structure of the society such as, development affect a production capacities and living condition.

In the urban planning and development, an urban hierarchy is closely related to the hierarchy of the means of public interest exist in each city or it can be said it is related to the existing society. The urban hierarchy can help define the means what should necessary or need to be built in each city. Urban means not it only concerns the type, but also the service capacity and quality. Cities provide a variety of goods and services to the surrounding area by forming a hierarchy. To serve the requests of small places widespread, provided low-level goods and services. Cities that serve of both low and high level goods and services, the number is definitely less. The higher the level of goods and services, the greater the range of the population in a small place; in big cities there are large markets [11]. The bigger a city, the more various facilities it provides, so that more the area of influence.

According to Park and Rogers [12] the hierarchy is also based on the characteristic of its physical condition, social and economic composition such as the income and the ethnicity. There are four level for a neighborhood hierarchy and they are as follows (from the lowest level): (1) A face-block, (2) a residential neighborhood that is composed of several face blocks, (3) an institutional neighborhood and (4) a community. The first level is the smallest unit that can be called a neighborhood. It refers to a cluster of several houses nearby that develops the closest bond. Informal and personal relationship is critical, but face-block is too small to organize a political voice. Thus, face-block is not usually an appropriate unit for physical planning. The second level, Residential neighborhoods are relatively homogeneous physical and socioeconomic places. They are designed primarily as residential areas with similar street design and architecture. They often share similar housing values that serve people with similar incomes and life cycles creating relatively homogeneous ambience. The level 3 is an area that is comprised of several residential neighborhoods. It includes quite a range of functions like schools, health centers, recreational and social facilities, and shopping centers. It is often called by its own name and may have an official or an administrative boundary. And the community is a cluster of districts of a city such as townships or suburbs, which cover relatively large areas; sometimes the area extends to the whole city. It is likely to have cultural centers, administrative centers, or colleges available to quite a large number of the population including residents and visitors.

The hierarchy of neighborhood according to the Indonesian public ministry, start from a single house. A house is a building working building as a place to live livable, a means of guidance family, a reflection of dignity and the dignity of its inhabitants, as well as assets for their owners. The second layer is a residential or a cluster of houses. This is as part of the settlement, either urban as well as rural area, which is equipped with infrastructure, facilities, and public utilities as results of compliance efforts livable house. The third level is settlements. Settlements are part of the environment occupancy consisting of more than one unit housing that has infrastructure, facilities, utilities general, as well as having supporting function activities others in urban areas or rural areas. The Residential environment is part of the area settlements consisting of more than one unit settlement. The last level is a city which comprises several residential environments with more facilities, infrastructure and transportation.
Based on the definition above about a hierarchy of neighbourhood, it can be taken some points: at the lower level, the socio-economic is essentially similar. The next level is a neighbourhood that slightly heterogenic, and has several infrastructures. The higher level can be defined as a city. This level has more heterogenic population and has an administrative boundary and has more complex infrastructure and more facilities (Table 1).

**Table 1. The hierarchy of neighbourhood with the characteristics of society.**

| Characteristics of society | The hierarchy of neighborhood |
|----------------------------|-------------------------------|
| **Lower level** | A cluster of several houses that can be named as a residential area | An area that consist of several residential areas with several facilities to support the need of the inhabitant particularly food and low level education. | A city and it consist of several function such as residential, office, and services |
| **Typical neighbourhood** | homogenous | Slightly heterogenic | Heterogeneous, from low to high class |
| **Socio economic** | similar | Slightly differ | Divergent, from low to high income |
| **Level of income** | similar | Slightly differ | Divergent, from low to high income |
| **Culture and life view** | similar | Slightly differ | Heterogeneous |

### 2.2. Type of waste to energy technology and its impact

A summary of a study conducted by Park and Rogers [12] reported that the most cost effective, safe for environment and human health are (1) Hydrothermal carbonization, (2) Ethanol fermentation, (3) Pyrolysis/gasification, (4) Incineration and (5) Anaerobic digestion. The environment aspects are greenhouse effect, odor problem and air or water pollution. As for the health aspect is the human health. The economic aspects are process speed, energy production yield and relative cost. In detail, the technology that meets all the three aspects is the Hydrothermal carbonization. The Ethanol fermentation has drawbacks on odor problem and the cost. The pyrolysis is good in odor problem and process speed, however, the significant drawback is that this technology is not good for human health. Therefore, this three technology are selected to be analysed in the interrelationship to know which technology match with a particular society in a particular neighbourhood (Table 2).

Hydrothermal carbonization is Hydrothermal carbonization (HTC) is a process of converting food waste to energy that using autogenous pressure and temperature between 180 and 350 °C. The end result is a solid fuel which similar to low grade sub-bituminous coal. Ethanol fermentation is a biological process that convert food waste to energy, which resulted in biogas. Pyrolysis and gasification are using thermal processes. Pyrolysis converts food waste, in an oxygen-free environment, into bio-oil as the major product along with syngas (CO + H2) and solid bio-char [13].

**Table 2. The technology and its relation to environment impact, health and economic [11].**

| Aspect                        | Hydrothermal Carbonization | Ethanol fermentation | Pyrolysis |
|-------------------------------|---------------------------|----------------------|-----------|
| Greenhouse effect             | Very good                 | Good                 | moderate  |
| Odor problem                  | Very good                 | Moderate             | very good |
| Air/water pollution           | Very good                 | Very good            | moderate  |
| Human health                  | Very good                 | Good                 | very poor |
| Process speed                 | Very good                 | moderate             | good      |
| energy production yield       | Very good                 | moderate             | moderate  |
| Cost                          | Moderate                  | poor                 | moderate  |

### 3. Concluding remarks and the recommendation

A literature study has been conducted to investigate an initial study on investigating an applicable waste to energy technology for an urban society. There are some concluding remarks that can be made in order to apply a waste to energy technology for an urban society.
A level or a hierarchy of a neighbourhood is based on the physical condition and the socio economic composition. At the lower level, the socio economic and culture as well as the income level are similar. This aspect creates a homogeneous environment in the neighbourhood. Then at the next level, the neighbourhood become slightly differ since it consists of lower level neighbourhood, whereas each lower level neighbourhood has its own characteristics in the income level, socio culture and economics. This slightly differentiation can be also caused by the location and physical condition. The highest level is generally called as a city. This neighbourhood is heterogeneous and consist lots of facilities, building function and services.

At the lower level, since the area is limited and homogenous, the application of the waste to energy depends on its community and the placement can be provided by the community. For the next level, the scope of area is bigger and it might consist different kind of lower level neighbourhood. Therefore, the application or the choice of the technology should be based on voting and the voting can be done by the local authority. As for the placement, the local authority should provide the suitable area in this level of neighbourhood. At the city level, the decision of the application and the placement is fully made by the local government.

The current waste to energy technologies are varied and also has its specification, impact and cost. These aspects influence the application and the placement of the equipment. The HTC could be fit for all the level of neighbourhood. The Ethanol fermentation is suitable for the mid and higher level of neighbourhood since this technology is expensive and has the odor problem. The odor problem has to be overcome to avoid complaints from the inhabitants. The pyrolysis technology seems only fit for the higher level of neighbourhood or city. This technology not only a bit expensive but also has some problem in human health and air or water pollution, even though the process speed is good.

Indeed, the application of waste to energy technology should be supported by the local government, in order to fulfil the needs of the society in terms of reducing local waste, so that the society would gratify with their place or neighbourhood. As stated by Pacione a liveable neighbourhood or a residential setting is affected by attributes of the management system, such as the standard of garbage collection and other local services [14].

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