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# Renewable Energy Developments in Indonesia; Opportunities for Improving Local Production Energy for Local Consumption

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**Abstract**

Replacing consumption of fossil fuel with renewable energy is an important way in reducing carbon emission and one of effective solution facing issues of electricity in Indonesia. In light of the perspective of promoting the renewable energy, we plan to use palm oil as biofuels for power generation activities that will help to supply electricity for local community in Indonesia. This paper is a preliminary study that aims to overview the current progress of renewable energy development in Indonesia, also to introducing background of our planning as one of solution in dealing with Indonesia`s current renewable energy usage. Based on expected outputs of our planning, this study attempts to discuss our concept which is to promote of Local Production Energy for Local Consumption and its application which will lead to development of one Smart Energy Community, as one of the key points to developing Smart City.

*Keywords:* Local production energy; palm oil; renewable energy; smart energy

## 1. Introduction

Indonesia's economy is the largest in Southeast Asia and one of world fastest growing countries in terms of energy consumption. Data Report by IRENA (International Renewable Energy Agency) in 2017 shows that between 2000 and 2014, consumption increased by nearly 65% and it is predicted grow up to 80% by 2030, mainly transport and industry sector shown the fastest growth [1]. Based on Annual Energy Forecast from Indonesia`s Agency for the Assessment and Application of Technology (BPPT), transport fuel consumption will increase on average 5% per year through 2050, as shown in Fig.1 [2].

Nowadays, although there is a trend of decreasing, the majority demand of energy is still covered by fossil fuels which is about 42% of Indonesia's total energy consumption based on oil. Unfortunately, the domestic production oil is only around 825,000 barrel per day on the other hand, oil demand reaches 1,200,000 barrel per days, as shown in Fig.2. Therefore, deficit is covered by import and makes Indonesia is one of net oil importing countries [3].

Based on data Indonesia's Ministry of Energy and Mineral Resources (MEMR), Indonesia has coal resources at around 120.5 billion tons, proven oil resources at around 3.69 billion barrels, and proven natural gas reserves at around 101.54 trillion cubic feet. This translates into about 12 remaining years of oil reserves, 39 years of gas, and 146 years of coal at current production rates. Indonesia's renewable energy sources are also considerable. The country is endowed with significant potential for hydropower (75,000 MW), micro and mini hydropower (1,013 MW), solar (4.80 kilowatt-hours per square meter per day), biomass (32,654 MW), and wind (3 to 6 meters per second), and holds 40% of the world's geothermal reserves (28,000 MW) [4].

Therefore, nowadays Indonesia have been promoting renewable energy to secure stable sources of energy. The goal is not only to reduce the country's dependence on oil imports, but also to increase concern of the global warming aspect. In here, renewable energy having significant role and positive trend of usage by significantly, as shown in Fig. 3.

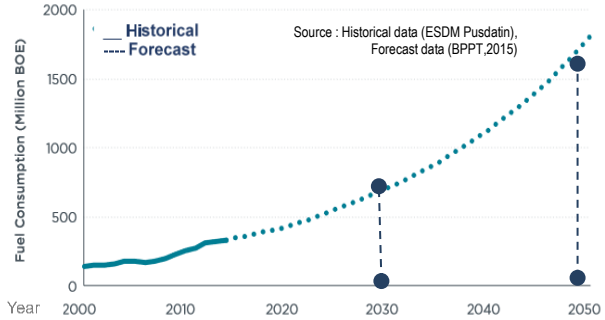


Figure 1. Indonesia transport fuel consumption [2]

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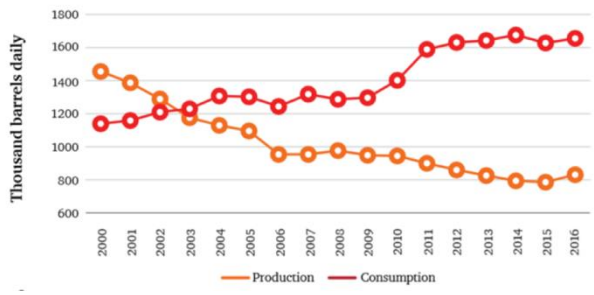
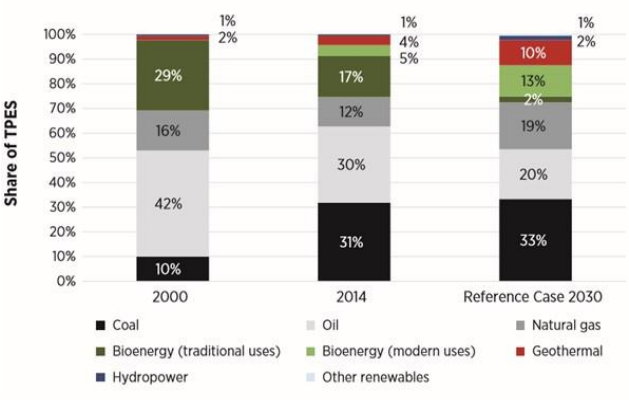



Source :
* Oil Production and Consumption 2000-2005: BP Statistical Review 2015.
* Oil Production 2006-2015: SKK Migas, MoEMR, Oil Production 2016 : Press Release of MoEMR
* Oil Consumption 2016 : EIA/BMI

Figure 2. Oil production versus consumption in Indonesia [3]




TPES : Total Primary Energy Supply

Figure 3. Fuel mix in primary energy supply in 2000, 2014 and in the Reference Case for 2030 [1]

Geothermal is predicted will be increased to 10% in 2030, from 4% in 2014. Bioenergy modern is predicted will be increased from 5% in 2014 to be 13% in 2030. Bioenergy in here refers to the renewable energy of biomass for electricity and heat or to produce liquid for fuels (e.g. bioethanol or biodiesel) for transport use. One interesting to note that bioenergy in term of traditional also has significant usage in Indonesia especially in rural areas which used by 24.5 million households in 2014 [1]. Traditional uses in here in term of using fuel wood or other bioenergy for home cooking and it plays important role in rural areas.

The target of Government of Indonesia for biofuels in 2025 is reach 30% to be mixed with fossil fuels in the transport's energy supply, so level of fossil fuels consumption can be reduced. However, because the slow growth of biofuels development, almost 40% of diesel fuels is still imported [2]. This condition make Government of Indonesia still continue to support palm oil as biodiesel, which this source having highest potential sources in Indonesia especially on the Kalimantan and Sumatera Island.

## 2. Purpose and Method

This study aims to discuss opportunities to improve renewable energy development in Indonesia. There are three focus for this study; *Firstly*, the study will begin with a review the progress of renewable energy development in Indonesia for identifying existing condition of energy issues in the country. *Secondly*, this study will try to discuss our thinking way through overview plan for develop power generation that promoting the usage of palm oil as biofuels for power generation in Indonesia. *Thirdly*, based on expected output from the plan, this study introducing our concepts for developing a more sustainable energy community which can improve and strengthen the concept for "Local energy production for local consumption" which based on local potential sources of energy.

To deal with expected purposes above, we also conduct of literature review as a method through reviewing the previous studies and published research which come from some sources such as Report of Indonesia`s Ministry of Energy and Mineral Resources Ministry, Report of Indonesia Energy by Asian Development Bank, report by The International Renewable Energy Agency (IRENA) and some published research related with the study.

This paper is a preliminary study of a comprehensive planning for promoting one of solutions for sustainable development that can be applied in Indonesia. Therefore, the results also can be integrated with the concept of smart city with based on improving a smart energy community.

## 3. Results and Discussion

### *3.1. Overview of electrification and Indonesia`s national renewable energy initiatives*

Indonesia has many islands, rural areas, unique demography, geographical and diverse social culture with difference level of economy and living standard. This is will be related to the characteristic of level of electrification as shown in Fig.4. Despite being a growing global economic power, Indonesia's energy consumption is considered low. Electricity consumption in 2017 was 1.02 MWh per capita, which was relatively lower than neighboring economies [5]. Electrification ratio in the western part of the country is as high as 99.99% (DKI Jakarta, Jabar, Banten, DIY Kaltim and Babel). Electrification ratio is defined as the ratio of the number of households with access to electricity to the total number of households.

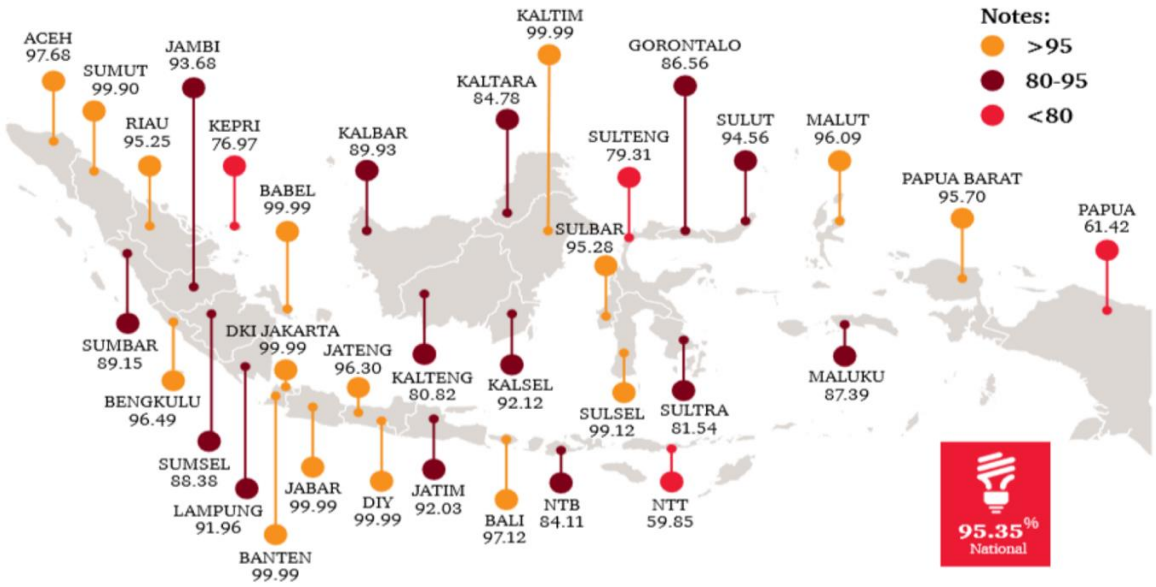



Figure 4. Ratio electrification of Indonesia [5]
(Source: 2017 Performance Report of MoEMR)

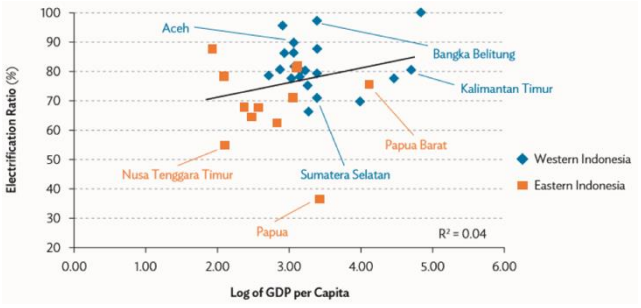
(1) Based on data by the Minister of Energy and Mineral Resources 2017, current national electrification rate in Indonesia is 95,35 % is as shown in Fig. 4 [5]. Electrification ratio herein is a measure of the prevalence of households with electricity access in a country. In general, electrification ratio is defined as the ratio of the number of households with access to electricity to the total number of households. Province of Papua and Nusa Tenggara Timur which identified has the lowest level of ratio of 50 – 70%.

(2) Analysis of survey by Asian Development Bank based on Electrification ratio 2013 by Directorate General of Electricity shows that the level of electrification ratios is not related with level per capita GDP of area in Indonesia [6]. As shown in Fig.5, Kalimantan Timur (East Kalimantan) has the second-highest per capita GDP in Indonesia, but an electrification ratio below the national average.

(3). Analysis of survey also shows that Electrification has not lagged in eastern Indonesia due to lower population densities [6]. Based on this analysis, changes in population density account for only 18% of the differences in electrification ratios. For example, though West Nusa Tenggara (Nusa Tenggara Barat) has higher population density than most provinces in Indonesia, it has one of the lowest electrification ratios.

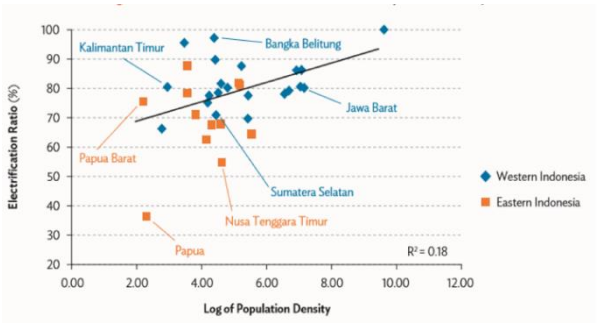
(4) Within next 5 years, the growth demand of electricity will be predicted about 8,6% per year, therefore Government of Indonesia already set target of electrification ratio to 97,4% in 2019 and 100% in 2020. In order to achieve all those targets, Government of Indonesia recognize that government budget will not be sufficient to cover all the cost in rural areas. The cost of electrification in rural area will be more expensive, especially in some islands that having less infrastructure. Therefore, smaller scale of hydropower, wind, solar and bioenergy projects provided by private sector investment on renewable energy is expected to play a much greater role for the future.

(5) Government of Indonesia also identified renewable energy as one of solutions to cover the growth of electricity demand which access to electricity in rural areas where the national electricity grid is not yet available. The government's strategy is outlined in the Presidential Decree No. 5/2006 on National Energy Policy (KEN) which emphasized diversification, environmental sustainability, and maximum use of domestic energy resources. KEN set a compatible target energy mix of oil 25%, coal 30%, gas 22% and renewable energy 23% by 2025, as shown in Fig.7. For Electricity Generation Mix, Draft RUKN 2015 sets a target of renewable energy as 25 % in 2025 [7].




Note: "Eastern Indonesia" here refers to the islands of Sulawesi, Maluku, Papua, and Nusa Tenggara

Figure 5. Electrification ratio and per capita GDP [6]




Note: "Eastern Indonesia" here refers to the islands of Sulawesi, Maluku, Papua, and Nusa Tenggara.

Figure 6. Electrification and population density [6]

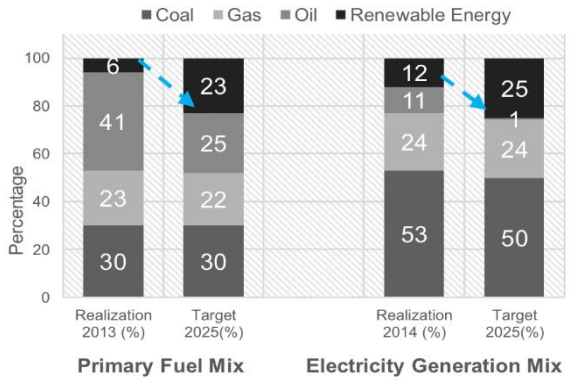



Figure 7. Primary fuel mix and electricity generation mix (2014 and Target 2025)

To achieve the target, the country also issues regulations that recommend that all diesel fuel used for land vehicles must have 20% of bio content by 2018, and then the mandate will increase to be 30% of bio content by 2020 [7]. The biodiesel Indonesia uses to meet its mandate comes exclusively from palm oil sources. Base on this mandate, it is predicted that Bioenergy will continue to play significant role in the renewable energy development in Indonesia for the future.

### *3.2. Highlight of our activities on bioenergy development in Japan and Indonesia*

Government of Indonesia also issued several key strategies to maximize the usage of renewable energy sources such as for electricity generation and biodiesel for transportation. However, because the slow growth of biofuels development, almost still 40% of diesel fuels is still imported. This condition makes government continuing to support research and projects related with biofuels, which include palm oil which having high potential resources in Indonesia.

The fuel for the diesel engine generated from the plant etc. is called biodiesel. It is necessary to do chemical processing and reforming processing to use biodiesel for the diesel engine for transportation. Figure 8 shows process for biodiesel made of waste cooking oil. Thus, it is necessary to turn on a large amount of energy and the cost to manufacture biodiesel. It is necessary to consider the cost that requires it to process the by-product in additionally.

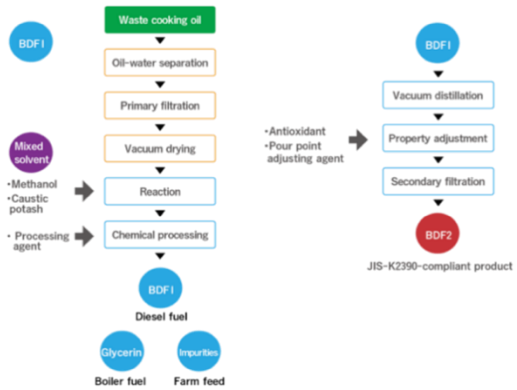



Figure 8. Process for biofuel from waste oil from cooking

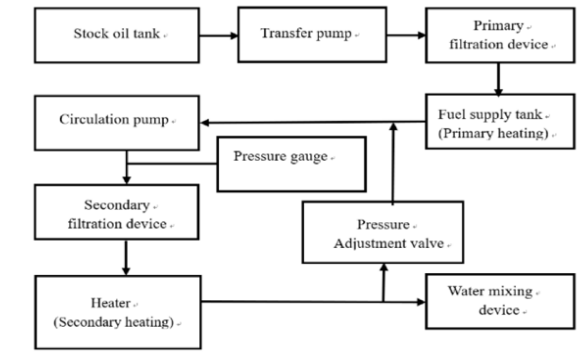



Figure 9. Block diagram of a biofuel production device

(1) Recently, we have conducted research and developed biomass fuel (biofuel) in province of Aichi, Japan. The fuel is a resource recycling type fuel which based on reuses waste cooking oil. This is an alternative fuel to gas oil. Our research using process used oil from tempura fried food (waste cooking oil) into fuel for diesel engines and generator of electricity. Figure 9 shows the concept for block diagram of a biofuel production device. Because it doesn't need chemical processing and reforming processing in the process of manufacturing the fuel as shown in this figure, energy and the cost can be greatly reduced. This is based on our joint research with the National Fisheries University of National Research and Development Agency, Japan Fisheries Research and Education Agency.

As the output of the research, we developed New Clean Fuels for generator of electricity. The developed fuel also has impact on reducing emission such as $CO_2$, NOx and BC.

(2) As next work to renewable energy development, based on the research in Japan, we plan for develop power generation in Indonesia. For this project, we use palm oil as biofuels for power generation activities that will help to supply electricity for the local community consumption in Indonesia. The planned location for plant projects is South Kalimantan, a province of Indonesia located in Kalimantan island. The planned areas have possible connections to palm oil production regarding considering that South Kalimantan has long history of oil palm plantation area.

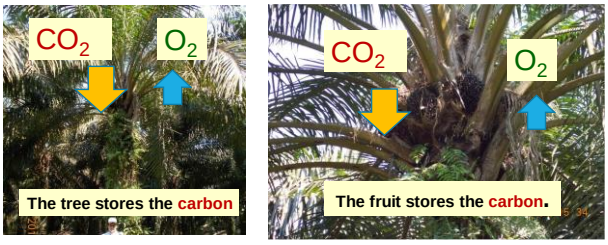



Figure 10. Process of carbon stored in palm oil

3.3 *Expected output and exploring the concept of local production energy for local consumption*

(1) Promoting biofuels from palm oil sources to reducing negative Impact of emission

The study having three reasons using palm oil as fuel. *Firstly*, one of the important problems faced by Indonesia and the world today is global warming. Palm oil tree is sources of low emission carbon in the growth process as shown in Fig.10 [8]. Since the vegetable fuel is renewable energy as carbon neutral, CO2 emissions will be zero in essentially. However, harvest fruits from palm oil and carry it to the factory, energy required to manufacture fuel from palm oil at the factory are added.

*Secondly*, it is realistic to restrain the use of fossil fuels by using Biofuels for diesel engine in order to reducing the effect of emission. Results of study by S. Nishio, et al [9]. which conducted experiment on combustion and exhaust characteristics of 4 stroke cycle medium speed marine diesel engine using gas oil and biofuel (used vegetable oil and palm oil) have been shown that the CO emissions of biofuels without esterification are lower than that of gas oil or MDO at high load condition, as shown in Fig. 11 [9].

*Thirdly*, In the rate of heat release on the 75% load, ignition time of FAME is the earliest and next is that of gas oil. Though MDO, rapeseed oil, palm oil, UVO are the same ignition time mostly, the difference appears at the peak of the premixed combustion. That of MDO is the highest, and those of rapeseed oil and UVO are high next and overlap, as shown in Fig.12 [9]. For relation between Thermal Efficiency and Engine load, the result is shown in Fig.13 [9].

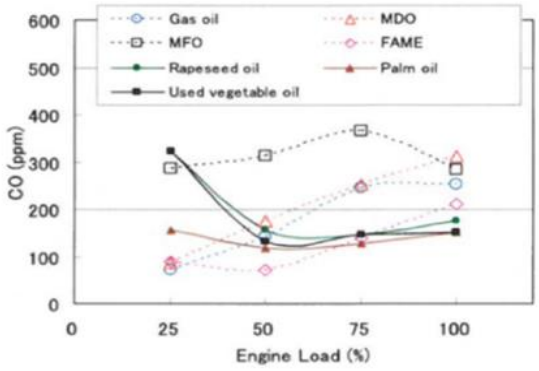



Figure 11. Relation between CO and engine load for palm oil [9]

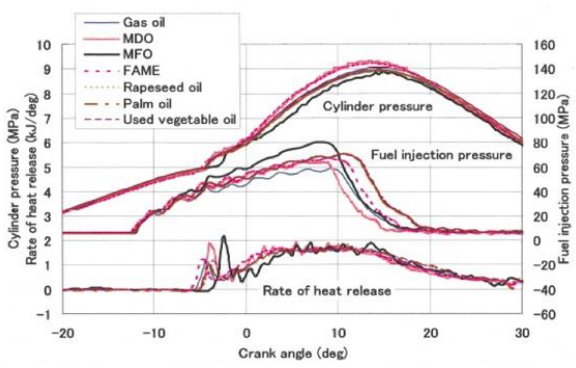



Figure 12. Comparison of cylinder pressure, fuel injection and rate of heat release (75% engine load) [9]

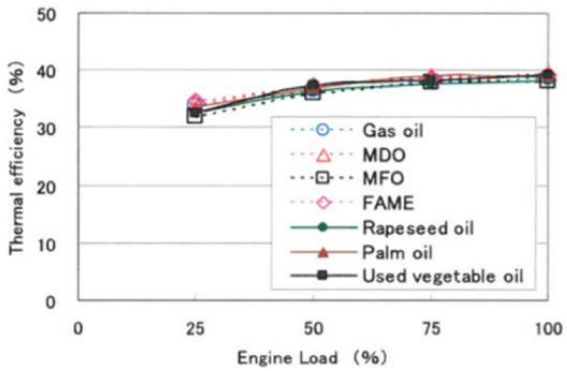



Figure 13. Relation between thermal efficiency and engine load [9]

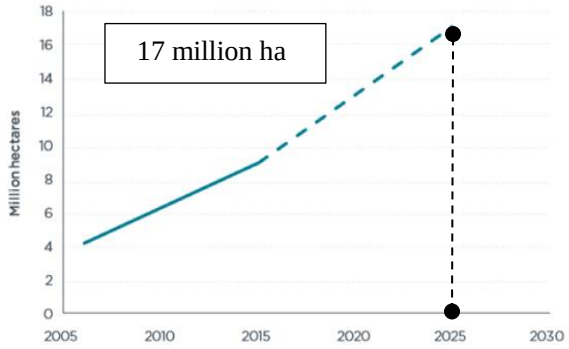



Figure 14. History and projection of palm oil plantation in Indonesia [2]

(2) Promoting energy system through using local potential natural resources

Indonesia is one of most potential supplier countries of biofuels, especially oil palm biodiesel. In 2015 the country is contributed 46% of world total palm oil plantation. Total harvested oil palm area in Indonesia 8.9 million ha in 2015 and is projected to reach 17 million ha by 2025 as shown in Fig. 14 [2].

Majority of Indonesia's population is located in rural areas which agriculture having significant in rural employment. Significant growth in the palm oil industry becoming component of economic and reducing level of poverty. Through maximize natural resources palm as energy, will provides many people with a sustainable income, especially in Sumatera and Kalimantan which having a significant percent of rural poor. In here, new energy system requires rethinking the energy management by maximize the potential sources. The solutions for the new smart energy system are sustainable, stable for supply demand, cost-effective and should having significant impact on reduction of rural poverty.

(3) Promoting local education on maintain renewable energy for people of community.

We will provide training for local engineers to ensure the process of maintenance of power generation, through transfer techniques which accumulated in the local area. It will create new jobs and transfer of knowledge for local human resource.

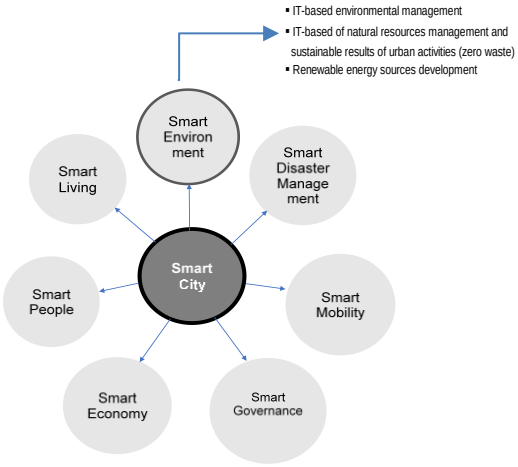



Figure 15. Smart City Components
(National Urban Development Policies and Strategies) [10].

### *3.4. Enhancing the value of local renewable energy and opportunities to develop smart energy community based on our PR-AZ Smart City Concept*

Smart city is an urban concept that can provide a high quality of life through sustainable resource management by implementation technologies to transform the urban existing systems, operations and services through participatory of resident and governance. Indonesia government having the concept for enhancing Smart City Components through BAPPENAS National Urban Development Policies and Strategies, as shown in Fig.15 [10]. Renewable Energy sources development is key urgent point to develop platform of Smart Environment.

In relation to the energy management concepts, there are four of our PR-AZ concepts in order to reach possibility of developing smart city, i.e. Low Carbon Society, Regional Recycling based on agriculture society, Local Production for Local Consumption and Stable Supply of Electricity, as shown in Fig. 16.

A smart city must have comprehensive solution to develop an energy system to be smarter and efficient on cost. The platforms to reach for Smart Energy City can be achieved by several ways and one of the important key points is enhancing local production energy for sustainable local energy system. Therefore, the implementation of the smart energy system which using local potential sources and transform it into energy is needed, to fulfill energy demand and stable supply for the area on the overall. Concept of Smart City is to construct the power generating system that doesn't rely on a large-scale power plant. Therefore, it will be achieved by generating electricity by solar, wind power, and biomass for the community at the town [8].

Based on expected results which as stated before, this study promotes the concepts to break away from current condition of energy consumption which to depend on fossil fuels and shift to the local production energy of biofuels palm oil for local energy consumption. The current system needs the changes from traditional energy form which energy and fuels are supplied from out of region, shift to be the new energy system where the demand and supply are balanced, and sources of fuels come from local renewable sources in the regions. The system will promote many values benefits that will be circulated in the local community.

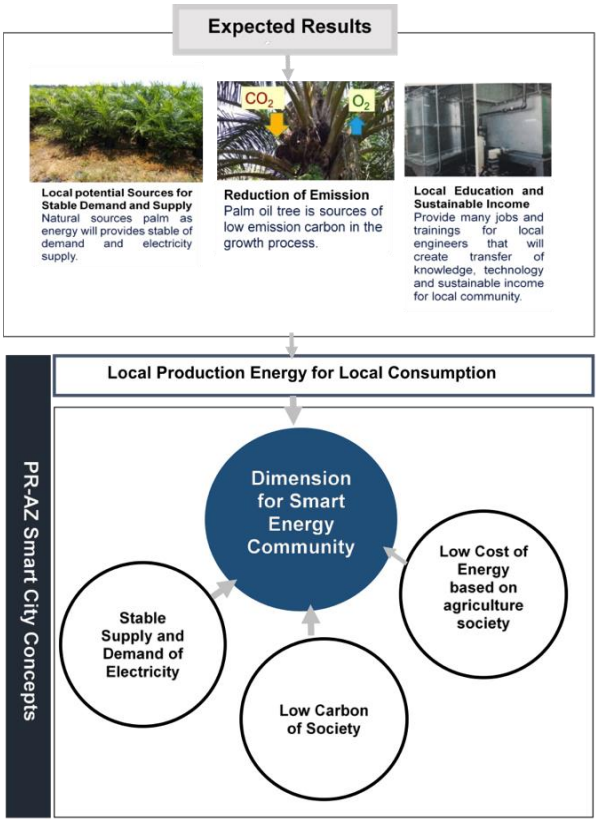



Figure 16. Opportunities to develop smart energy community based on expected results of project

## 4. Conclusion and Further Steps

There are three urgent points which are highlighted in this study, as follows:

1) Recently Indonesia has been improving the use of renewable energy as one of alternative sources of energy in order to reduce the country's dependence on imported fuel fossil, also to reduce environmental impact of carbon emission. In here, this study tries to develop a planning for comprehensive renewable energy program with more enhancing the local potential sources.
2) This study gives an overview of the concepts for `Local Production Energy for Local Consumption' which addressed its application to develop more smart energy community that related with key points development of Smart City. To reach this, based on our research in Japan, we introducing our planning for the usage of palm oil as biofuels for power generation activities which produced energy will be allocated for local community in the region.
3) Based on expected results of the planning, the study promotes our comprehensive concepts to break away from current condition of energy consumption which depending on fossil fuels shift to be the new energy system where the demand and supply are balanced, and fuels come from local renewable sources. The system

also will promote low carbon society, sustainable income and many values benefits that will be circulated in the local community.

The purpose of this paper is the preliminary study to discuss the highlight and background of our activity on renewable development. As further steps, this study will continue to explore various condition related to technical steps and details process of implementation. As the final goal, this study aims to provide a comprehensive concept of how it can be implemented in order to promote the 'Local Production Energy for Local Consumption' which is urgently need to be applied in Indonesia.

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