# Solar and biomass potential of renewable energy in selected ASEAN countries and Japan

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**Abstract.** ASEAN region is believed to have a great potential for biomass and solar energy generation due to its abundance of sunlight, rain, and fertile land. However, these resources are still underutilized as the current rate of renewable energy is relatively low, whereby most countries are still highly emphasizing fossil fuels. The use of fuel without replenishing the fuel source will ultimately deplete the resource in very much the same as fossil fuels currently utilized. While the concept of fuel replenishment seemed simple, the implementation posed a challenge to meet. This is where free energy in the form of solar, wind, wave, underground thermal, and biomass is being harnessed. Therefore, these forms of energy also have certain limitations depending on the geographical and the availability of the sources throughout the region. This study aims to analyze the current potential renewable energy scenario and future prospect of renewable energy resource for biomass and solar energy in selected ASEAN countries and Japan.

## 1. Introduction

Energy resources are essential for livings, where the energy demand is expected to rise annually to fulfil the rapid growth of the economy and industrialization. However, the dependence on non-renewable energy sources, including fossil fuels, will be depleted over time. The transition from non-renewable energy to renewable energy resources could significantly impact the common environmental effect and attenuate the energy shortages. ASEAN countries benefited from a geographical advantage in terms of natural resource ability for renewable energy production. Current potential renewable energy in this

region varies from geothermal, hydropower, biomass, solar, and wind energy, depending on the geographic condition of the region. However, some countries are not associated with geothermal and wind energy where there is no substantial amount of that resource.

Most of the areas in ASEAN countries are covered with 15% of the world's tropical forests [1]. The abundance of biomass resources from forestry, agricultural residues, industrial, animal, and municipal solid waste could potentially contribute to biomass energy in ASEAN countries. ASEAN is known as the most productive agricultural in the world. Moreover, the ASEAN region is covered with an average of 12 hours of sunlight due to its location that lies astride the equator, which is substantial for solar energy generation [2]. The state of the art of this region's geographic condition brings solar and biomass renewable energy as the most promising resource for electricity generation, which was selected in this study to be the potential solution as a long-term energy supply in the ASEAN region.

ASEAN energy ministers have agreed to set a target of the total primary supply of renewable energy share in the region by 23%, and ASEAN installed power capacity of 35% by 2025 [3]. On the other hand, Japan targeted on renewable energy is 22 to 24% of its energy mix by 2030 as gazetted on its 5$^{th}$ Strategic Energy Plan. With the tremendous amount of renewable energy potential, there are a relatively large amount of resources still underutilized by these countries. Towards achieving the goal, Malaysia, Indonesia, Vietnam, and Japan have taken the initiative to adopt the Feed-in Tariff (FiT) for the past few years to enhance the growth of renewable energy generation percentage. In this policy mechanism, the renewable energy electricity generated is purchased by electric power companies at a fixed rate per kWh for a certain period of time. The country's renewable resource generation will govern the variation of FiT rate and duration. Therefore, the objective of this study is to compare the percentages of renewable energy and compare the energy mix of solar and biomass energy installed capacity for respected countries.

## 2. Methodology

This study is based on descriptive statistics, and graphical analysis comparing Japan and selected ASEAN countries of Malaysia, Indonesia, and Vietnam energy generation. These data are generated based on secondary data from each country's government reports with yearly trends from 2003 to 2020. This variation is due to the insufficient accessibility of the latest reports released by the countries. The data represent the total energy installed capacity by mixed fuels and the total installed capacity of renewable energy. The trend is then analyzed and compared in terms of availability, utilization, and potential of solar and biomass renewable energy generation.

## 3. Result & Discussion

Malaysia, Indonesia, Vietnam, and Japan are highly dependent on fossil fuels. Japan had the highest total energy installed capacity of 305.5 GW, followed by Indonesia with 64.5 GW, Vietnam with 48.6 GW, and Malaysia with 34.0 GW. The report from the government of the ASEAN countries and Japan for power generation installed capacity by fuel type as for 2018 is illustrated in figure 1. Therefore, large-scale hydropower is excluded from renewable energy percentage in this report.

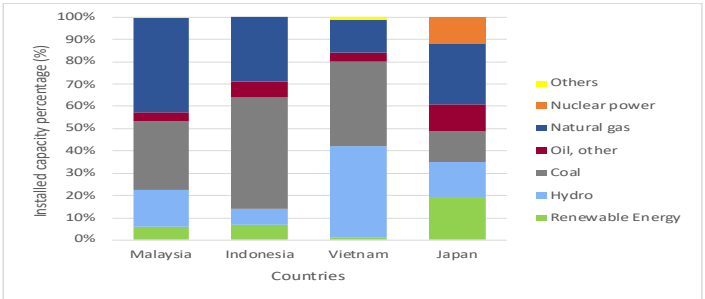


**Figure 1.** Comparison of renewable energy percentages of total installed capacity generation 2018 [4] [5] [6] [7].

In recent years, the government is interested in initiating and promoting renewable energy development to cater to the growth of energy demand without depending on fossil fuels. According to Malaysia Energy Commissions [4], Malaysia's total renewable energy capacity is 6% (2.1 GW), 2.2% biomass, and solar with 2.1%. Whereby, as referred to Secretariat General of National Energy Council [5], Indonesia resulted in 7% (4.5 GW) of installed renewable energy with the majority of 3% is contributed by geothermal followed with biomass of 2.7% Therefore, based on the data from National Load Dispact Center [6], Vietnam has recorded a minimum value of total renewable energy with less than 1% (0.4 GW). The installed renewable energy generated by Japan constitutes 19% (58.0 GW) of its total power generation capacity, according to Japan Electric Power Information Center, INC (JEPIC) [7]. This consisted a large number of solar by 16% and followed by wind 1%. Therefore, the utilization of renewable energy resources in the ASEAN region up until 2018 is relatively low compared to Japan which recorded the highest amount of renewable energy capacity generation. Thus, Japan has high potential in achieving its renewable energy target by 2030 of its energy mix.

### *3.1. Malaysia potential of solar and biomass energy*

Malaysia currently has limited renewable energy resource types compared to other countries. There is no substantial amount of wind and geothermal energy in this region that could be extensively harvested. Therefore, Malaysia could fully utilize its abundance potential of solar and biomass energy. Figure 2 shows the pattern of the renewable energy installed capacity generation from the year 2012 to 2018.

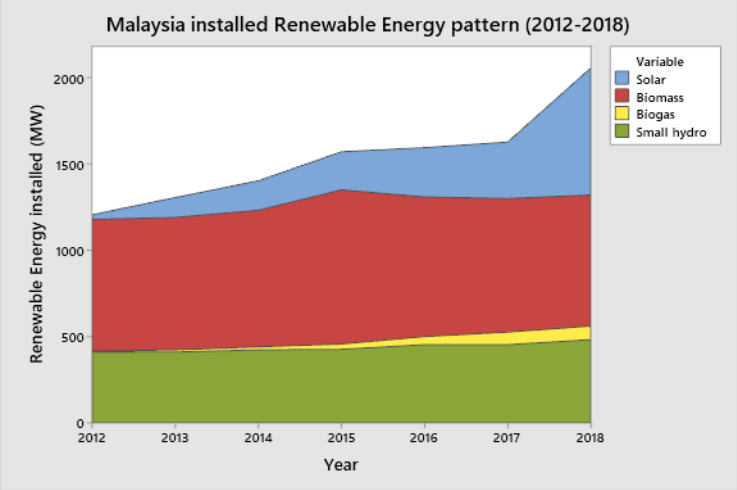


**Figure 2.** Malaysia renewable energy installed capacity generation changes from year 2012-2018 [4] [8] [9] [10] [11] [12] [13].

Feed-in Tariff (FiT) scheme for Malaysia obliges Distribution Licensees (DLs). The contracts for solar PV are set for 21 years with FiT rate between 0.087 to 0.140 USD per kWh. The implementation of FiT resulted to the increase of renewable energy capacity for solar energy over the years. Recently, the Malaysia government, however, is pushing for rooftop solar using a Net Energy Metering (NEM) aimed at self-consumption together with the implementation of Large Scale Solar (LSS) [14]. In 2016, Malaysia's Energy Commission started the bidding process for LSS. The total capacity allocation for LSS is 1000 MW and a levelized tariff for the auction ranging from 0.096 to 0.110 USD per kWh [15]. According to year 2017 to 2018, solar energy recorded a drastic changed by 125% increased on installed capacity of solar resource. The implementation of LSS has contributed in 42% with approximately 310 MW of the total solar capacity on 2018. The estimated potential for solar generation can reach up to 6500 MW [16].

The forest area in Malaysia has covered around 62% of the total land area, and its agriculture covers approximately 4,890,000 hectares of the region [17]. The capacity of biomass energy in Malaysia is

reducing from year 2016 to 2018 by 15%. Therefore, biomass has an advantage over other types of renewable energy in terms of availability, cheaper cost, and sustainability. Malaysia's available biomass resources are from the oil palm, empty fruit bunches, palm kernel shells, sugarcane, and rice husk. In addition, Malaysia is the second-largest palm oil producer globally, which accounted a large amount of oil palm waste to be processed into biomass energy production. With the abundance of biomass resources in Malaysia, agricultural and forestry resource utilization is relatively low. The FiT rate for biomass energy is between 0.064 to 0.074 USD per kWh which covers a period of 16 years [15]. According to the National strategy, from a supply-side perspective, by 2020, Malaysia's palm oil industry is expected to generate about 100 million dry tonnes of solid biomass [18].

*3.2. Indonesia potential of solar and biomass energy*

Indonesia is the largest country by geographical area compared to Malaysia, Vietnam, and Japan. This country has the most renewable energy resource due to its location as the country spans the longest equator line. solar, biomass, small or medium hydropower, wind, geothermal, and biogas are the available renewable energy resource discovered in Indonesia. Figure 3 shows the Indonesia renewable energy installed capacity generation changes from the year 2009 to 2019.

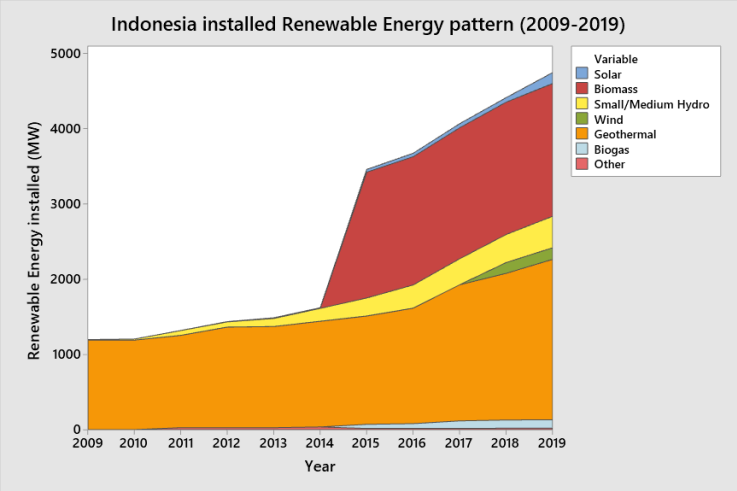


**Figure 3.** Indonesia renewable energy installed capacity generation changes from year 2009-2019 [5].

The trend for solar energy in Indonesia is relatively low compared to other resources. Indonesia's initiatives for solar are mainly focused on residential usage. Therefore, the estimated potential of solar energy is reported around 4.8 kWh/m2 in the entire region [19]. According to the National Energy Plan, the potential capacity for solar power plants is 207,898 MW [20]. Meanwhile, the share of the solar resource in renewable energy installed capacity generation for Indonesia constituted only 145.8 MW in 2019. The FiT in Indonesia for solar PV initially introduced in 2012, ranging from 0.25 to 0.30 USD per kWh. The FiT rate started to reduce in 2016 due to the rapid development of solar power technology [21]. To extend, the Indonesian government had initiated the Rooftop Photovoltaic Solar Systems (RPVSS) policy in 2018 to promote the solar energy system. However, this policy is constrained by both consumer and institutional barriers.

Biomass had recently produced a high capacity of installed renewable energy, approximately around 1.8 GW, the second-largest renewable energy contributed in Indonesia next to geothermal energy. Indonesia is known for its abundance of agriculture, and the forest area covered 94,432,000 hectares in the region [22]. Indonesia's significant biomass sources available are from the agricultural, which is the oil palm residues, bagasse, rice husk, rice straw, and corn cob. Furthermore, the country had explored

using bamboo as biomass energy to generate electricity in rural areas. Indonesia's potential biomass as renewable energy is estimated to reach 146.7 million tons of biomass per year, approximately 50 GW [23].

*3.3. Vietnam potential of solar and biomass energy*

Apart from other countries, Vietnam biomass energy is currently treated as a non-commercial energy resource which used locally. Figure 4 shows the pattern of installed renewable energy in Vietnam from the year 2018 to 2020. Vietnam recorded a large installed capacity for large hydropower and coal. Therefore, renewable energy is relatively minimal in the last decade.

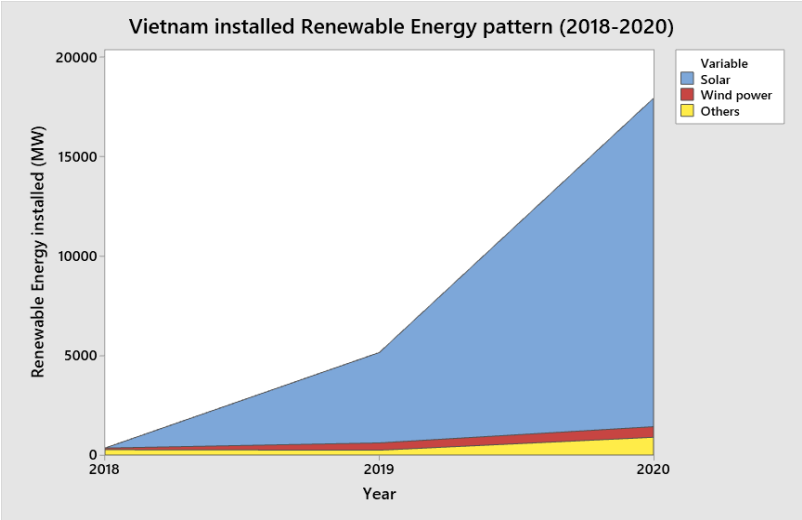


**Figure 4.** Vietnam renewable energy installed capacity generation changes from year 2018-2020 [6].

Renewable energy in Vietnam is increased dramatically from less than 1% in 2018 with a total installed renewable energy of 0.4 GW to more than 25% in 2020 with 18.0 GW. Solar PV is the last resource that is introduced to FiT in 2017 with the enacted tariff of 0.0935 USD per kWh. Prior to the expiration of the solar promotion in the middle of the year 2019, the pattern of solar energy capacity in Vietnam has drastically changed recorded a 12% of renewable energy increment. The progress continues to the year 2020, where the implementation of solar PV rooftop installation recorded growth by 12%, resulting in more than 25% renewable energy achieved by the country on 2020. This achievement has made Vietnam the world's third-largest solar market in 2020 and eventually lead the ASEAN to reach its renewable energy target.

Biomass energy in Vietnam recorded a slow growth. The country has abundance of biomass energy resources from agriculture and forestry, such as bagasse, rice husk, coffee husk, bamboo, and wood chip The total installed capacity for biomass is 560 MW up to 2020. Therefore, the FiT for biomass has increased from 0.058 USD per kWh to 0.0703 USD per kWh for combine heat production (CHP), while Non-CHP with 0.0728 USD per kWh. Electricity of Vietnam (EVN) purchases all renewable energy generated from powerplants with a validation of purchase agreement for 20 years. The policies also include the incentives on investment capital and taxes, as well as land incentives. Forecast for installed capacity for 2030 is 3384 MW, and 2040 is 4509 MW. Vietnam has forecasted the 2030 installed capacity for biomass to be around 3384 MW, and 2040 with 4509 MW [24]. These numbers are large compared to current capacity recorded, thus Vietnam is predicted to have a great future in renewable energy and has the possibilities to make renewable energy as the country main energy with greater generation compared to fossil fuels.

*3.4. Japan potential of solar and biomass energy*

Japan is one of the most advanced countries in the world with remarkable technologies in energy production. Japan is ahead of ASEAN countries by introducing its first nuclear power reactor. Therefore, Japan's government had the pledge to increase the renewable energy resource, especially solar. Figure 5 illustrated the changes in Japan's renewable energy installed capacity from the year 2003 to 2019. Japan's renewable energy resource availability is solar, wind, geothermal, biomass, and small or medium hydropower.

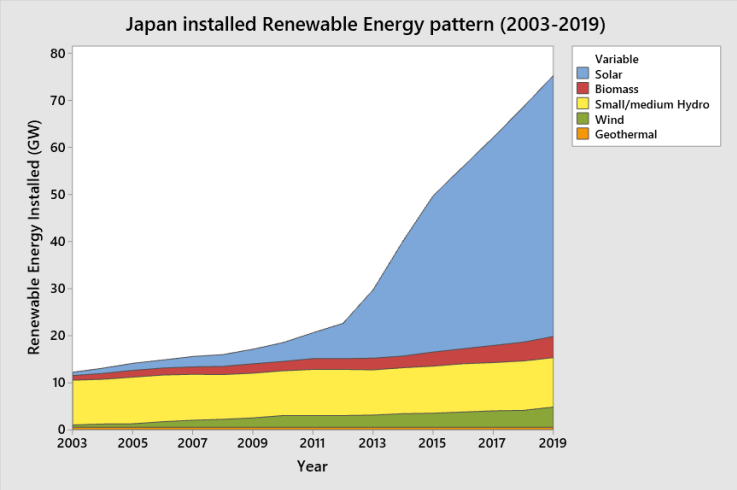


**Figure 5.** Japan renewable energy installed capacity generation changes from year 2003-2019 [7].

Regarding Japan's catastrophic nuclear energy power plant, the government has become more environmentally conscious. The installed renewable energy capacity is proliferating with the introduction of FiT in the year 2012. Japan has recorded a rapid inclined growth on the average of 18% annually of renewable energy installed capacity generation starting from 2012 to 2019. The average yearly irradiance for Japan region ranges from 125 to 162 W/m2 [25], which is sufficient for solar generation. Solar energy recorded the largest share among other renewable energy resources. Japan planned to invest more than 100 billion USD from 2020 to 2030 in solar and wind generation which expected to drive the renewables share of generation mix to 27% by 2030, exceeding the country's target [26]. Thus, solar energy is considered the most promising potential for renewable energy generation.

Japan's land is covered by almost 70% of forests. Biomass renewable energy is increasing over the years but relatively low in the renewable energy percentage compared to other resources. The agricultural residue from the domestic resource can only contribute to a small amount of energy. Japan has set a target for biomass energy of 4% in the energy mix by 2030. There is a significant potential for biomass energy production from waste wood. However, the crop potential in this region is limited due to the climate in northern and southern Japan and it has to be imported [27].

## 4. Conclusion

The potential of renewable energy in ASEAN countries is enormous, whereby the utilized renewable energy is relatively low. Solar energy and biomass have rich potential across all ASEAN countries and Japan. These replenished resources could significantly impact the economic growth, environmental, and socioeconomic of the regional communities. Despite the fact that the generated large scale hydropower leads the renewable energy resources in ASEAN countries, this renewable energy source is dealing with issues related to environmental and social threats. Due to the concern, the countries began to exploit the underutilized potential in other renewable energy resources, especially solar and biomass energy, for future electricity generation. This paper has discussed the current potential renewable energy scenario

and future prospect of renewable energy resource for biomass and solar energy in selected ASEAN countries and Japan. Based on the findings, the potential renewable energy for these four countries has been determined. Malaysia, Indonesia and Vietnam has abundance potential on solar and biomass energy, whereby Japan has large potential on solar energy, but low potential on biomass. The scheme and policies as a driving force in promoting renewable energy has successfully implemented on these regions with a remarkable turn of renewable energy percentage. Vietnam and Japan could become the role model for other ASEAN countries to follow as these countries recorded a drastic development in renewable energy and reached country's target. The future of biomass and solar energy is expected to increase with solar PV and biomass potential acceleration and cost reduction.

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