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Article

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Monitoring Indonesia's Energy Mix Achievement Using Simple Linear Regression

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ABSTRACT

The energy crisis has become a global issue. It can be seen in various countries worldwide experiencing an energy crisis. The energy crisis and global warming encourage countries to use renewable energy sources significantly from time to time. Based on historical data of installed capacity, it can be calculated the installed capacity in 2025 using a simple linear regression method. Renewable energy generating capacity is obtained from this installed capacity, meeting 23%. The results of a simple linear regression show that in 2025, the installed capacity of renewable energy plants is 22.66%. It means that there is a deviation of 0.34% from the target. Meanwhile, for 2050, the achievement of the energy mix is 28.47%, which means that it is 2.53% lower than the target of 31%. Conformity between the general national energy plan and the regional one is essential.

Keywords: Energy, Crisis, Mixed, Renewable, Simple Linear Regression
JEL Classifications: C2, C25, K290

1. INTRODUCTION

The energy crisis has become a global issue. It can be seen in various countries worldwide experiencing an energy crisis. Several situations that describe the energy crisis occur in developing countries and occur in major countries worldwide. The energy crisis and global warming encourage countries to significantly use renewable energy sources (RES). Besides the energy crisis, the issue of environmental pollution such as air pollution caused by burning fossil fuels and concerns about climate change and global warming, coupled with high oil prices (Shahin et al., 2015), encourages countries to make significant use of renewable energy sources. Increasing threats such as global warming, carbon emissions, and their relationship to energy consumption are among the most cited fields in environmental economics (Lilis et al., 2021). The problem of climate change is a significant challenge in sustainable development programs (Lilis et al., 2021). The increase in energy consumption and greenhouse gas emissions has damaged the social and economic life of the community (Lilis et al., 2021), (Jorgenson and Clark, 2016), (Kim and Jeong, 2016), (Ming et al., 2016). Besides the energy crisis, global warming and emission problems are also international issues.

Meanwhile, the operation of fossil fuel power plants has emissions that are harmful to the environment (Guvenc et al., 2012). Various efforts to reduce emissions have also been widely published (Hrvoje et al., 2013), reducing CO2 Emissions in the Cement Industry. Efforts to reduce CO2 emissions through Biogas, Wind, and solar energy have been published (Lilis et al., 2020). Climate change has also become an increasingly pressing issue on political agendas around the world, and this is not only because of environmental sustainability issues; but also because sustainability has an economic and financial impact (Joao, 2021).

The utilization of unlimited natural energy sources from the environment to be converted into electrical energy, while considering environmental aspects, provides many advantages for RES in their use, especially environmental protection (Dario, 2021). Using RES to substitute fossil energy sources requires consistency and coordination between central and regional

governments. Mohtasham (Javid, 2015) shows that applying any renewable energy (RE) requires a sustainability analysis, which depends on three main components, namely environmental impacts, externality costs, and economics and financing. Ellabban (Omar et al., 2014) shows the global benefits of RE production where they categorize them into environmental, economic, technological, social, and political aspects. In addition, they propose a RE market development process and describe the barriers to the deployment of RE technologies. In addition, (Peidong et al., 2009) presented the weaknesses of the RE development policy in China, which could be the lack of coordination and consistency of policies, the weakness, and incompleteness of the driving system, the lack of innovation in regional policies, the incomplete financing system for RE projects or low investment in research and technical development of RE. Sri Fadilah (Sri et al., 2020) explained the impact of RE consumption on the economic growth of ASEAN countries, where RE consumption and non-RE consumption, labor force growth, and capital stock have a positive relationship with the economic growth of ASEAN countries.

With more than 275 million people and the fourth largest population globally, Indonesia requires a vast electrical energy supply. On the other hand, Indonesia is blessed with RE sources with enormous potential and has not been fully utilized. The Indonesian Government is very active in promoting RE and reducing the resulting emissions. It is evidenced by the various policies that have been issued related to RE, both in government regulations, presidential regulations, and ministerial regulations. The government regulations include The Government Regulation No. 79 of 2014 concerning National Energy Policy and Government Regulation No. 70 of 2009 concerning Energy Conservation. The Presidential Regulations include Presidential Regulation No. 4 of 2016 concerning the Acceleration of Electricity Infrastructure Development, Presidential Regulation No. 22 of 2017 concerning the General Plan of National Energy, Presidential Regulation No. 61 of 2011 concerning the National Action Plan for Reducing Greenhouse Gas Emissions, Presidential Regulation No. 1 of 2014 concerning Guidelines for the preparation of the National General Energy Plan, and Presidential Regulation No, 26 of 2008 concerning the Establishment of the National Energy Council. The Ministerial Regulations referred to above include the Ministerial Regulation of Energy and Mineral Resources No. 38 of 2016 concerning Acceleration of Electrification in Undeveloped Rural Areas, Remote Areas, Borders, and Small Inhabited Islands Through the Implementation of Small-Scale Electricity Supply Businesses, and Minister of Energy and Mineral Resources Regulation No. 39 of 2017 concerning the Implementation of Physical Activities Utilizing NRE and Energy Conservation, Minister of Energy and Mineral Resources No. 49 of 2018 concerning the Use of Rooftop Solar Power Generation Systems by Consumers of PT. PLN, The State Electricity Company, and the Minister of Environment No. P15 of 2019 concerning Quality Standards for Thermal Power Generation.

Based on historical data of installed capacity, it can be calculated the installed capacity in 2025 using a simple linear regression method. RE generating capacity is obtained from this installed capacity, meeting 23% of the total. This paper discusses the Indonesian Government's breakthrough in meeting the target of using RE in the 2025 energy mix.

The potential of RE sources in Indonesia is vast, but various challenges inequitable access to RE also need to be resolved. Some of the challenges referred to include production costs that are still relatively high, so they cannot compete with conventional energy, and some components of RE plants cannot be developed in Indonesia, so they still have to be imported so that it affects their maintenance. Besides the issue of production costs and components, policies to encourage investor interest are very much needed.

This paper consists of four main sections where the first section discusses the condition of power demand and supply in Indonesia, the second section discusses the methodology for meeting the targets, the third section presents the results and discussion, and the last section presents the conclusion.

2. RESEARCH METHOD

2.1. Problem Formulation

Currently, the energy crisis and the greenhouse effect are international issues. Reserves of energy sources from fossil fuels are dwindling, while RES has enormous potential, and only a tiny part has been utilized. Based on 2018 Electricity Statistics, Directorate General of Electricity, Ministry of Energy and Mineral Resources, Indonesia, the production of electrical energy from all power plants in Indonesia in 2018 was 188698.46 GWh, of which 173952.42 GWh or 92.19% was supplied from thermal generators and the remaining 14746.05 or 7.81% supplied from RE generation. Thermal energy generators still dominate the fulfillment of electrical energy needs. Meanwhile, according to the 2019 Indonesia Clean Energy Status Report, Indonesia has 432 GW of RE potential, of which only 7 GW have been used commercially.

As a tropical country, Indonesia has enormous potential for RES. The potential of RES in Indonesia is shown in Table 1. The utilization of new and renewable energy (NRE) in 2015 was only 1.9% of the potential of NRE in Indonesia. Meanwhile, the installed PV capacity was 78.5 MW from 207,898 MW or 0.0378% solar potential in the same year. The installed PV capacity is only 0.9555% of the total installed RE in the same year, which is 8215.5 MW, while the government targets that in 2025, NRE is at least 23% of the total primary energy mixed 31% in 2025. 2050. Given the sizeable solar potential, the Government plans to develop PV of 6.5 GW in 2025 and 45 GW in 2050.

The energy crisis and emission problems encourage countries to use renewable energy significantly from time to time. Likewise with Indonesia, various policies encourage RE to substitute fossil fuels. Based on Presidential Regulation No. 22 of 2017, Indonesia has targeted the percentage of RE to be 23% in the energy mix in 2025 and 31% in 2017. These targets must be monitored to see the gaps that occur so that if there are gaps, the necessary strategic steps can be taken immediately. The installed capacity of electrical energy generation and the installed capacity of RE plants in Indonesia from 2003 to 2020 are shown in Figure 1.

2.2. Simple Linear Regression

The Simple Linear Regression (SLR) Analysis is used to obtain a mathematical relationship in an equation between the dependent variable and a single independent variable. A SLR equation is an equation model that describes the relationship of one independent variable/predictor (X) with one dependent variable/response (Y), which is usually depicted by a straight line, as shown in Figure 2.

The SLR equation is expressed mathematically by,

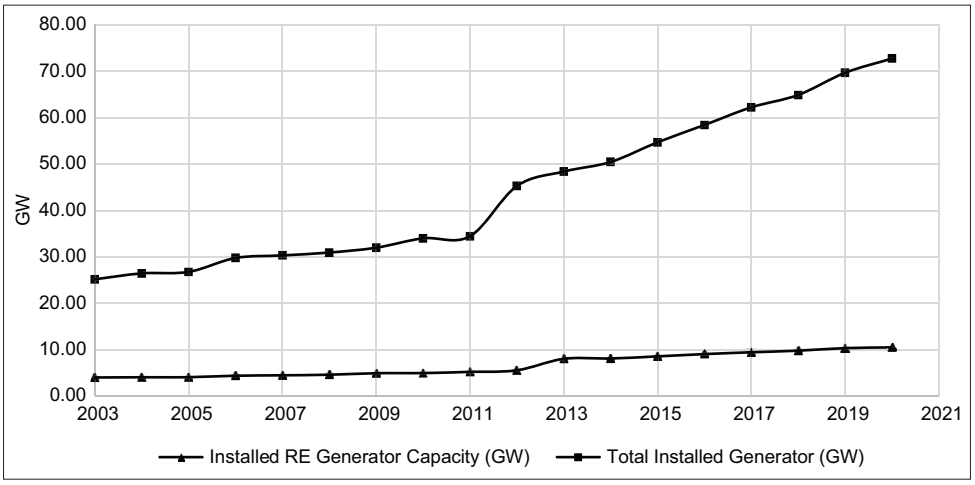
$$Y=a+b.X \quad (1)$$

Where Y is the regression line (response variable), X is the

Table 1: The potential of RES for each province (MW)

Province	Geo-thermal	Wind	Hydro	Ocean	PV	Bio-energy	Micro & Mini Hydro	Waste	Total
Aceh	332	894	5062	0	7881	1174	1538	1	16882
Sumatera Utara	2316	356	3808	0	11851	2912	1204	31	22478
Riau	0	22	1804	0	6307	4195	284	8	12620
Kepulauan Riau	0	922	0	6027	753	16	0	17	7735
Sumatera Barat	1035	428	1804	0	5898	958	1353	7	11483
Jambi	621	37	776	0	8847	1840	447	2	12570
Sumatera Selatan	964	301	776	0	17233	2133	448	12	21867
Bengkulu	780	1513	776	0	3475	645	108	0	7297
Lampung	1339	1137	776	2273	7763	1492	352	5	15137
Kep. Bangka Belitung	0	1787	0	0	2810	223	0	0	4820
Banten	365	1753	0	0	2461	465	72	13	5129
DKI Jakarta	0	4	0	0	225	127	0	0	356
Jawa Barat	3765	7036	2861	0	9099	2554	647	228	26190
Jawa Tengah	1344	5213	813	0	8753	2233	1044	50	19450
Yogyakarta	10	1079	0	0	996	224	5	13	2327
Jawa Timur	1012	907	525	0	10335	3421	1142	78	24420
Bali	262	1019	208	320	1254	192	15	24	3294
Nusa Tenggara Barat	169	2605	208	8644	3036	394	31	9	15096
Nusa Tenggara Timur	763	10188	208	333	9931	241	95	1	21760
Kalimantan Barat	0	554	4737	0	20113	1308	124	5	26841
Kalimantan Tengah	0	681	5615	0	8459	1499	3313	2	19569
Kalimantan Selatan	0	1006	5615	0	6031	1290	158	3	14103
Kalimantan Timur	0	212	5615	0	13479	964	3562	9	23841
Kalimantan Utara	0	73	0	0	4643	0	943	0	5659
Sulawesi Selatan	163	4193	3170	0	7588	959	762	12	16847
Sulawesi Tenggara	98	1414	3170	0	3917	151	301	0	9051
Sulawesi Barat	162	514	0	0	1677	206	7	0	2566
Sulawesi Tengah	368	908	1984	0	6187	327	370	0	10144
Gorontalo	110	137	0	0	1218	131	117	1	1714
Sulawesi Utara	768	1214	1984	0	2113	164	111	4	6358
Maluku	220	3188	430	0	2238	33	190	0	6299
Maluku Utara	580	504	0	0	2020	35	24	0	3163
Papua Barat	0	437	0	391	2035	55	3	1	2922
Papua	0	1411	22371	0	7272	97	615	0	31766
Total	17546	60647	75096	17988	207898	32658	19385	536	431754

Figure 1: Indonesia's power generator capacity



independent variable/predictor, a is the constant, the intersection with the vertical axis, and *b* is the regression constant (slope). The constants a and b, are determined using equations (2) and (3) respectively,

$$a = \frac{\left(\sum Y_i\right)\left(\sum X_i^2\right) - \left(\sum X_i\right)\left(X_i Y_i\right)}{N\sum X_i^2 - \left(\sum X_i\right)^2} \quad (2)$$

$$b = \frac{N\left(\sum X_i Y_i\right) - \left(\sum X_i\right)\left(\sum Y_i\right)}{N\sum X_i^2 - \left(\sum X_i\right)^2} \quad (3)$$

where *N* is the number of data.

3. RESULTS AND DISCUSSION

3.1. Energy Mixed 2025

From equations (1), (2), and (3) it can be written the SLR formulation for the case of electric energy generation in Indonesia and RE generators, involving government policies that plan the construction of RE plants in 2019-2028. The calculation of SLR uses historical data from 2003 to 2020 plus 2025 and 2028. The total installed capacity and RE installed capacity formulations are shown in equations (4) and (5), respectively.

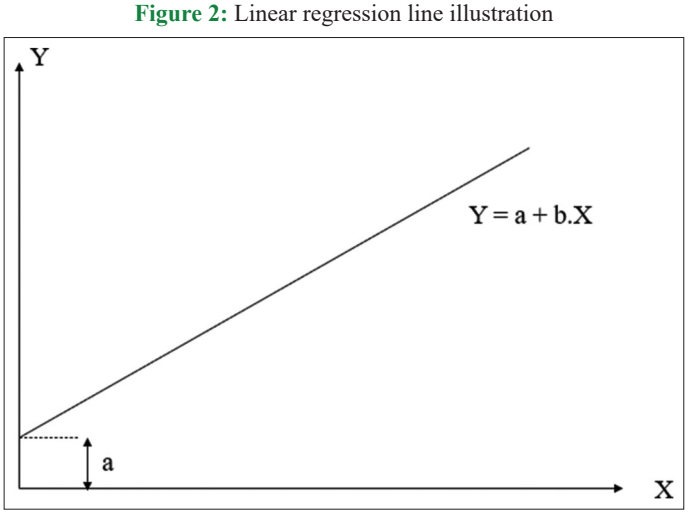
$$KAP_{TOT}=16.03543+2.969355.t \quad (4)$$

$$KAP_{RE}=2.433349+0.442359.t \quad (5)$$

where KAP_{TOT} is the total installed capacity of the generator, KAP_{RE} is the RE generation capacity, and t is the review time. So that the capacity for generating electricity and RE will be obtained as shown in Figure 3.

Figure 1 shows that in 2020 the composition of installed RES is 14.373%. Meanwhile, from Figure 3, it can be seen that for 2025, the plant's installed capacity is 91.4384 GW, with 20,2713 GW of which comes from RES.

Figure 2: Linear regression line illustration



Meanwhile, to achieve the 2025 energy mixed target that has been set, through the Indonesia Clean Energy Status Report, March 2019, the Government plans to build RE plants from 2019 to 2028, amounting to 28847.4 MW. Meanwhile, based on Presidential Regulation No. 22 of 2017, the Government plans to build a total installed power plant target of 115 GW in 2025. Thus, government policies in the plan to build whole power plants and renewable energy plants must be involved in the calculation of the SLR, which of course, will affect the calculation results. The results are shown in Table 2, where the SLR calculation for the installed capacity in 2025 shows 91.4384 GW, and the RE power plant capacity is 20.7213. From Table 2, it can be seen that the RE generation capacity in the energy mix in 2025 is 22.66%, close to the Government's target, or a deviation of 0.34% from the target. In other words, the target for utilizing RES is still less at 0.3095 GW.

The Indonesian government plans to build 28847.4 MW renewable energy power plants in 2019-2028 as stated in the Regional Energy General Plan of each province to achieve the energy mix target. The renewable energy in question includes Geothermal Power Plants, Wind Power Plants, Hydro Power Plants, Ocean Power Plants, Solar Power Plants, Bioenergy Power Plants, Small-scale Hydro Power Plants such as Mini Hydro Power Plants and Micro Hydro Power Plants, and Waste Power Plants. These policies are shown in Figure 4. Figure 4 shows the synergies and synchronization of policies between the central government and local governments, which are an absolute necessity in achieving the energy mixed targets that have been announced.

3.2. Energy Mixed 2050

Based on the existing data of the total installed capacity from 2003 to 2020, equation (4) will show that the total generating capacity in 2050 is 158.56 GW. It is certainly not objective considering that it does not involve government policies. To calculate installed

Table 2: Energy generator capacity 2021-2025

Year	RE Generator Capacity (GW)	Total Generator Capacity (GW)
2021	16.7593	78.0840
2022	17.7498	81.4226
2023	18.7403	84.7612
2024	19.7308	88.0998
2025	20.7213	91.4384

Figure 3: Total power generator capacity

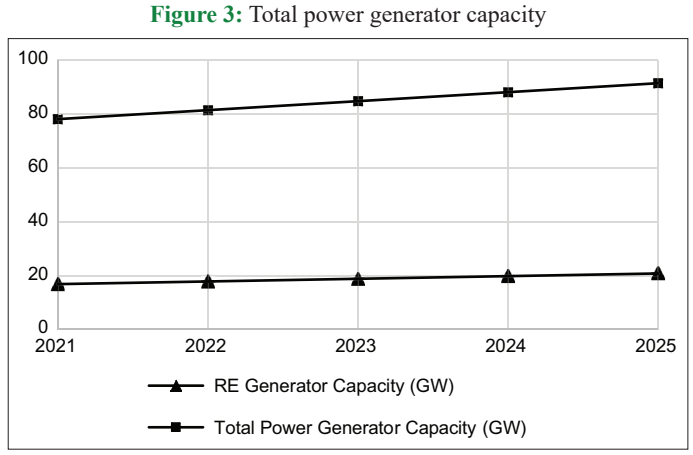
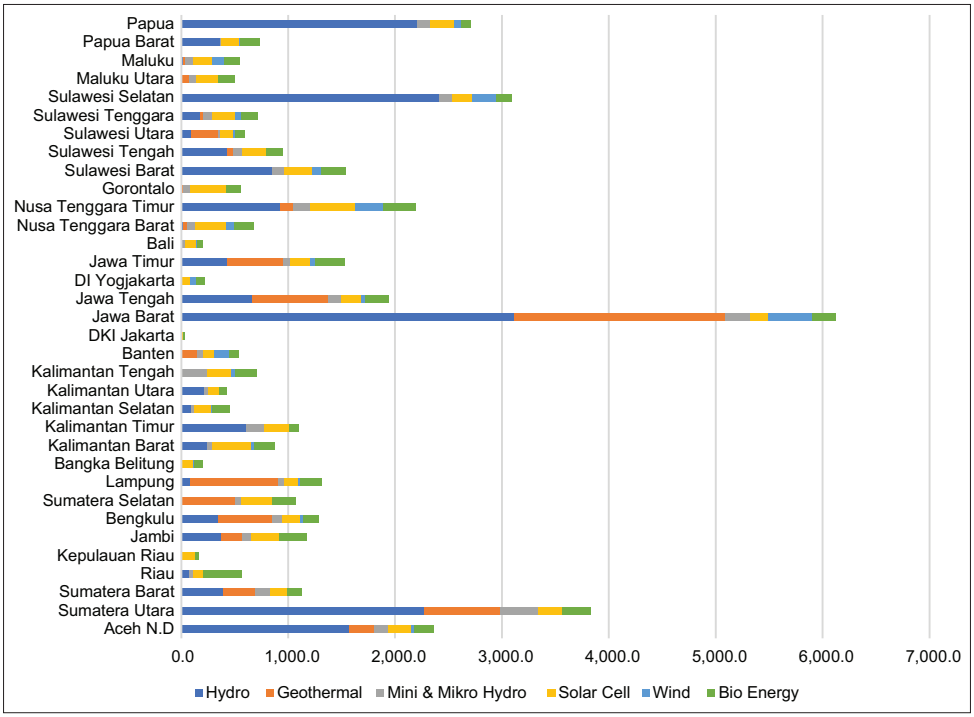


Figure 4: Renewable energy generator development plan 2019-2028 (MW)



capacity in 2050 using SLR, the results in Table 2 are used and involve government policies, namely the target installed capacity in 2050 is 430 GW, Eq. (4) changes to Eq.(6).

$$KAP_{TOT}=-29.0534+7.846706.t \quad (6)$$

The installed capacity is 347.588 GW in 2050 (that is, the 48th year from the 2003 base year). This result is not in line with the government›s target of 430 GW. While the SLR calculation for the installed capacity of RE involves government policies, namely the total power plant development target of 430 GW, the target for developing renewable energy plants until 2028, and the SLR results in 2025 where the installed capacity is the response point, then Eq. (5) turns into Eq. (7),

$$KAP_{RE}=-15.5962+2.386517.t \quad (7)$$

In 2050, the installed capacity of RE will be 98.566 GW. Thus, the RE mixed to energy sources totals 28.4695% in 2050. There is a deviation of 2.5305% from the 31% target. In other words, the utilization of RES is still 8.73368 GW less than the target. In 2050, the installed capacity of RE will be 98.566 GW. Thus, the mix of ER to energy sources totals 28.4695%.

4. CONCLUSION

This paper aims to monitor the achievement of the energy mixed targets in 2025 and 2050. The SLR calculation results show that Indonesia's installed generating capacity in 2025 is 91.4384 GW from the target of 115 GW and the installed capacity of RES is 20.7213 GW or a mixed of RES of 22.6615% of the target of 23%. So, there is a lack of utilization of RES of 0.3095 GW. Meanwhile, in 2050, the total installed capacity of power plants is 347.588 GW from the target of 430 GW, and the installed capacity of RES is 98.9566 GW or a mixed of RES 28.4695%. So, there is a lack of utilization of RES of 8.73368 GW.

REFERENCES

Dario, M. (2021), Advantages and disadvantages of renewable energy source utilization. International Journal of Energy Economics and Policy, 11(3), 176-183.

Guvenc, U., Sonmez, Y.U., Duman, S., Yorukeren, N. (2012), Combined economic and emission dispatch solution using gravitational search algorithm. Scientia Iranica, 19(6), 1754-1762.

Hrvoje, M., Vujanovica, M., Markovskab, N., Filkoskic, R.V., Bana, M., Duica, N. (2013), CO_2 emission reduction in cement industry. Chemical Engineering Transaction, 35, 703-708.

Javid, M. (2015), Review article-renewable energies. Energy Procedia, 74, 1289-1297.

Joao, E. (2021), Toward the Paris agreement implementation impact on electricity sector: The emerging reality. International Journal of Energy Economics and Policy, 11(1), 1-8.

Jorgenson, A.K., Clark, B. (2016), The temporal stability and development differences in the environmental impacts of militarism: The treadmill of destruction and consumption-based carbon emission. Sustainability Science, 11(3), 505-514.

Kim, D., Jeong, J. (2016), Electricity restructuring, greenhouse gas emission efficiency and employment reallocation. Energy Policy, 92, 568-476.

Lilis, Y., Febrianti, R.A.F., Kamran, H.W. (2020), Reducing CO_2 emission through biogas, wind and solar energy production: Evidence from Indonesia. International Journal of Energy Economics and Policy, 10(6), 684-689.

Lilis, Y., Febrianti, R.A.F., Kamran, H.W. (2021), Climate change and energy consumption pattern in Thailand: Time trends during 1988-2013. International Journal of Energy Economics and Policy, 11(1), 571-576.

Ming, T., Shen, S., Caillol, S. (2016), Fighting global warming by greenhouse gas removal: Destroying atmospheric nitrous oxide

thanks to synergies between two breakthrough technologies. Environmental Science and Pollution Research, 23(7), 6119-6138.

Omar, E., Abu-Rub, H., Blaabjerg, F. (2014), Renewable energy resources: Current status, future prospects and their enabling technology. Renewable and Sustainable Energy Reviews, 39, 748-764.

Peidong, Z., Yanli, Y., Yonghong, Z., Lisheng, W., Xinrong, L. (2009), Opportunities and challenges for renewable energy policy in China. Renewable and Sustainable Energy Reviews, 13(2), 439-449.

Shahin, A., Quazi, T.Z., Siddique, F. (2015), Assessment renewable energy source. International Journal of Scientific and Engineering Research, 6(12), 206-211.

Sri, F., Lestari, R., Sahdan, M.H., Abdul Khalid, A.Z. (2020), The impact of renewable energy consumption on the economic growth of the ASEAN countries. International Journal of Energy Economics and Policy, 10(6), 602-608.