

Hydroelectricity consumption, power losses and economic performance in Indonesia

Cite as: AIP Conference Proceedings 2097, 030024 (2019); <https://doi.org/10.1063/1.5098199>
Published Online: 23 April 2019

Yusri Syam Akil, Andi Abdul Halik Lateko, and Amran Rahim



View Online



Export Citation

ARTICLES YOU MAY BE INTERESTED IN

[Recent progress of biogas produced from the waste of natural indigo dyes for electricity generation](#)

AIP Conference Proceedings 2097, 030025 (2019); <https://doi.org/10.1063/1.5098200>

[Dimensional analysis of horizontal axis wind turbine scaling design](#)

AIP Conference Proceedings 2097, 030027 (2019); <https://doi.org/10.1063/1.5098202>

[Effect of immersion on the impact properties of Zalacca midrib fiber/rHDPE by compression molding](#)

AIP Conference Proceedings 2097, 030026 (2019); <https://doi.org/10.1063/1.5098201>

AIP | Conference Proceedings

Get **30% off** all
print proceedings!

Enter Promotion Code **PDF30** at checkout



Hydroelectricity Consumption, Power Losses and Economic Performance in Indonesia

Yusri Syam Akil^{1,a)}, Andi Abdul Halik Lateko^{2,b)}, and Amran Rahim^{3,c)}

¹*Department of Electrical Engineering, Hasanuddin University, Gowa, Indonesia*

²*Department of Electrical Engineering, Muhammadiyah University of Makassar, Indonesia*

³*Department of Mathematics, Hasanuddin University, Makassar, Indonesia*

^{a)}Corresponding author: yusakil@unhas.ac.id

^{b)}halik@unismuh.ac.id

^{c)}amran@science.unhas.ac.id

Abstract. In general, the usage of renewable power plants for electric systems is expected not only increased over the year to meet electricity demand but also can support economic condition in a related place. In this paper, causality relationship between electricity consumption particularly from hydropower plant (HEC), losses of the power system (PLOSS), and economic growth (GDP) in Indonesia was investigated using statistical method. Yearly data from year 1985 to 2014 were used in this study. From results of unit root test, examined variables (HEC, PLOSS, and GDP) were stationary at first difference as indicated by their values which have significance at 5% level. Co-integration results using Johansen test to identify long-run relationship between observed variables confirmed that there is 1 co-integration equation in the model. This indicated HEC, PLOSS, and GDP have long-run relationship. Next determining causality direction using Granger test shown that HEC and PLOSS have only unidirectional Granger causality running from HEC to PLOSS. A similar finding for causality direction between GDP and PLOSS. For HEC and GDP, they have bidirectional causality which means HEC influenced GDP condition and vice versa. Resulted information assisted in making electricity energy policy from hydropower plant (HPP) which is potential in Indonesia as an indicator to get high economic performance.

INTRODUCTION

The usage of renewable power plants for electric systems in the world including in Indonesia is expected can increase over the year to meet electricity demand. It is caused some issues such as resulted CO₂ emissions which contribute to climate change, and increasing fuel price by time (energy production cost) due to the usage of fossil fuel for thermal plant in electric systems can be reduced. With regards to this, one of renewable energy resources which is robust to produce electricity energy is hydropower. A system of hydropower has many advantages included environmental friendly, low operating cost, long lives, low maintenance, and high reliability [1,2]. Moreover, hydropower plant is possibly built in many scales for electricity production (in terms of small, medium or large scale) and existing technology is relatively mature. Therefore for hydropower development plan in one place, it is important to analyze the usage level of hydroelectricity energy and its influence including its impact to electric system condition such as power losses value for effectiveness. Some studies regarding hydroelectricity consumption and its relationship with other variables such as economic growth for several countries which conducted using different methods, steps of analysis, period and kinds of variables data can be seen in [1-4]. For example, in [1] for case of Malaysia, in [2] for case of 7 countries in Latin America, in [3] for case of 6 OECD countries which have high income, and in [4] for case of 10 different countries which consumed highest hydroelectricity energy.

In Indonesia, to follow electricity demand growth and to stimulate the usage of renewable energy, government declares to add renewable energy based power generation unit including from hydropower up to 22.5% in 2025 [5]. As a country which have thousands of islands, Indonesia has quite big hydropower resources with total technical potential is around 75,000 MW. The hydropower resources are scattered in various regions namely in Sumatra (20.8%); Java (5.6%); Kalimantan (28.8%); Sulawesi (13.6%); Bali, NTT, NTB (0.8%); Maluku (0.6%); and in Papua (29.8%) [6]. However, utilization of the hydro energy is still low until year 2014 namely around 10% of total potential [6]. To handle the situation, studies in this area are needed as an effort to increase the usage level of hydropower for fulfillment national electricity energy needs.

This research focus to analyze causality relationship between electricity consumption from hydropower plant (HEC), power losses (PLOSS), and economic performance (GDP) in Indonesia. Some similar studies for Indonesian context using different variables have been done as in [7-14]. However, none of them have analysed hydroelectricity consumption and power losses variables. Therefore besides to fill the gap, presented information is expected can become a reference to support hydropower development strategy in Indonesia.

Structure of this paper has four parts. Part 2 shows typical used variables data and applied approach (analysis procedure). Part 3 explains the result of statistical test for each step and their analyses, meanwhile in the last part is concluding remark including implication of study regarding the development of hydropower utilization in Indonesia.

DATA INPUT AND APPLIED APPROACH

Three annual variables data used in this study namely HEC defined in terawatt hours (TWh), PLOSS (% of total) and GDP (billion of USD) are taken from World Bank database [15] as graphically shown in Figure 1. Period of the data are between year 1984 and 2014. As an initial analysis, both yearly hydroelectricity consumption and GDP values tend to increase, meanwhile for PLOSS due to penetration of hydropower plants in electric systems although increased but tends to have same values in six last years under observed period as in the Figure 1. The electricity consumption volume from hydropower plant is around 2.8 TWh in year 1985 and become 15.1 TWh in year 2014. Meanwhile for GDP is 85.289 billion USD in year 1985 and become 890.487 billion USD in year 2014. Next, PLOSS value in 1985 is 6.66% and increasing over the year until 2009 and after that the losses values are almost

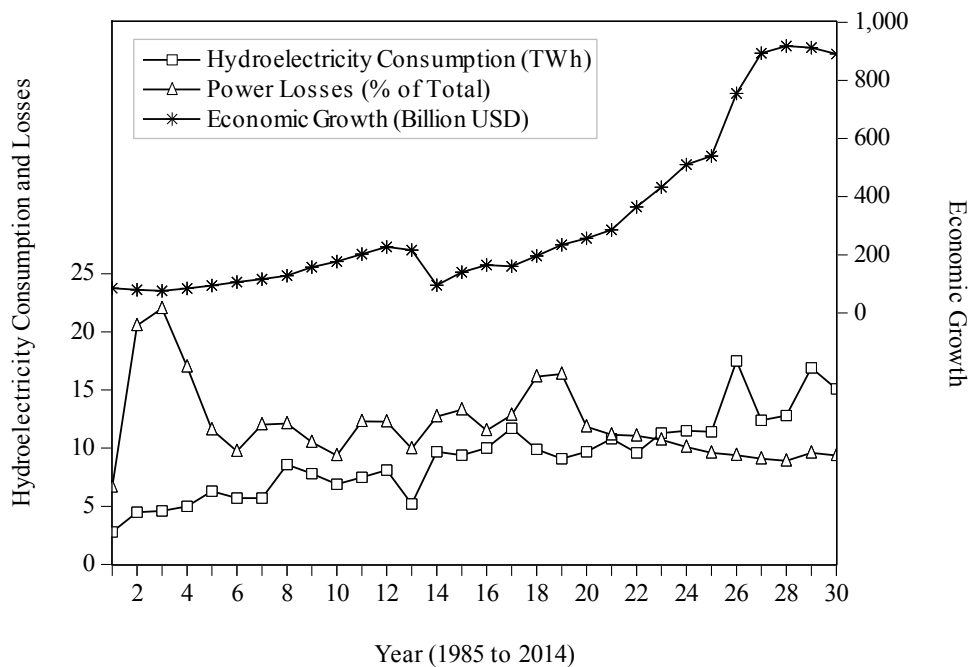


FIGURE 1. Variation of hydroelectricity consumption, power losses, and economic growth values in Indonesia under studied period.

same until 2014 (around 9%). To analyze further the relationship between HEC, PLOSS, and GDP, various common statistical tests in the composed model were applied with four steps. Here, unit root test to determine stationary condition for data is firstly done and followed by lag selection to find optimal lag length to get better model. Next, to identify long run relationship for variables, Johansen co-integration test is done. Finally, Granger causality test is performed to determine causality direction between the analyzed variables.

RESULTS

Unit Root and Lag Selection Analysis

As stated before, unit root analysis is firstly performed for HEC, PLOSS and GDP variables using common ADF and PP test which is needed to get integration order for data analysis. From the testing, all observed variables have p-values under 0.05 at first differences as seen in Table 1 which indicated non-stationary data variables are rejected at 5% significance level. This means that the three variables are stationary at first differences. The stationary data are needed in the part of causality testing to prevent misleading results [16]. Next, lag length selection to get better model using Schwarz Criterion is done. From results, optimal lag is found at lag 1 as indicated by the lowest value obtained at the lag.

TABLE 1. Unit root testing results for each variable

Variable	Levels			
	ADF value	p-value	PP value	p-value
HEC	-0.2112	0.9275	-1.5552	0.4917
PLOSS	-2.4658	0.1346	-3.2451	0.0274
GDP	1.2959	0.9980	1.2959	0.9980
Variable	First Differences			
	ADF value	p-value	PP value	p-value
HEC	-8.1816	0.0000	-11.5125	0.0000
PLOSS	-6.9804	0.0000	-7.6318	0.0000
GDP	-3.3487	0.0220	-3.3487	0.0220

Notes: ADF is Augmented Dickey Fuller; PP is Phillips-Peron

Johansen Co-integration Analysis

The third step is examined long-term relationship among variables using Johansen co-integration test. Results of co-integration test with optimal lag length for model are provided in Table 2. By using 5% significance level for TS and MEV p-values, the NH is rejected which means no co-integration relation at $R = 0$. The results for

TABLE 2. Co-integration test result

Null Hypothesis (NH)	Trace Statistics (TS)		Max. Eigen Value (MEV)	
	t-statistics	p-value	Max. eigen statistics	p-value
CN is 0 ($R = 0$)	41.9677	0.0013	30.6728	0.0017
CN is at most 1 ($R \leq 1$)	11.2949	0.1940	10.9254	0.1580
CN is at most 2 ($R \leq 2$)	0.3945	0.5433	0.3694	0.5433

Note: CN is co-integration number

cointegration relation at $R \leq 1$ and $R \leq 2$ shown NH can not rejected at the same significance level. In other words, the composed model has co-integration equation at 5% level. This means the moving of three observed variables (HEC, PLOSS, and GDP) in long time period in Indonesia have same tendency, or it can be said they have long-run relationship.

Granger Causality Analysis

Based on the previous steps, causality tes with differenced data for model is performed in this fourth step. At 5% significance level, results shown HEC and PLOSS variable has unidirectional Granger causality relationship. Variable of HEC influence PLOSS as confirmed by obtained F-Statistic value is 0.0110 (under 0.05, rejection of null hypothesis). It means the increasing volume of electricity consumption from hydropower plant will affect total power losses in electric systems eventhough its impact tends to better in the view of electric system operation (PLOSS percentage values are almost same in the six last years under observed period as in the Figure 1). For GDP and PLOSS, it has unidirectional causality as well which is running from GDP to PLOSS. Meanwhile for HEC and GDP, they have bidirectional causality which means HEC influenced GDP condition and vice versa. From obtained results, the role of electricity energy consumption from hydropower plant as a key elements to increase economic development is confirmed, and at the same time economic growth influence electricity consumption from hydropower plant. For losses, it is affected by economic growth. Considering undeveloped hydropower potential is still high and ratio of electrification in year 2015 in Indonesia is still around 88.3%, energy policy to stimulate further the using of hydropower is needed as a strategy not only to replace or to reduce the using of thermal power plant (fossil fuel) but also to overcome the condition.

TABLE 3. Summary of Granger causality test result

No	Null Hypothesis (NH)	F-Statistic	Prob.
1	HEC does not Granger cause PLOSS	7.49292	0.0110 ^a
2	PLOSS does not Granger cause HEC	1.80010	0.1913
3	GDP does not Granger cause PLOSS	4.81470	0.0374 ^a
4	PLOSS does not Granger cause GDP	0.00181	0.9664
5	GDP does not Granger cause HEC	6.68931	0.0157 ^a
6	HEC does not Granger cause GDP	5.64978	0.0251 ^a

Note: ^aDenotes significant at 5% level

CONCLUSIONS

Through statistical approach, it is found that hydroelectricity consumption (HEC), power losses (PLOSS) and economic growth (GDP) in Indonesia have long-run relationship. Examining causality direction shown that HEC and PLOSS have unidirectional Granger causality running from HEC to PLOSS and similar finding for causality direction between GDP and PLOSS. For HEC and GDP, they have bidirectional causality which means HEC affected GDP condition and vice versa. Based on this, development hydropower plant is a key to handle some issues related to providing electricity energy and its usage. This caused besides environmental friendly, hydroelectricity can increase economic performance with suitable impact to the electric systems in terms of line losses values tends not to increase in several last years under studied period. As undeveloped hydropower potential is still high in Indonesia, therefore, policies for development plan such as giving more access and priority in using of hydropower energy particularly for electricity needs is important.

REFERENCES

1. E. Lau, C. Tan, and C. Tang, *Energy Sources, Part B: Economics, Planning, and Policy*, **11**(11), 1042–1049 (2016).
2. S. A. Solarin, and I. Ozturk, *Renewable and Sustainable Energy Reviews*, **52**, 1857–1868 (2015).
3. M. Bildirici, *Procedia Economics and Finance*, **38**, 264-270 (2016).
4. N. Apergis, T. Chang, R.Gupta, and E. Ziramba, *Renewable and Sustainable Energy Reviews*, **62**, 318–325 (2016).
5. Dirjen EBTKE. Strategy to achieve electricity based new and renewable energy target 22.5% in year 2025 (in Indonesian). <http://ebtke.esdm.go.id>, accessed 31 July 2018.
6. Dirjen EBTKE, Policy for development of hydropower (in Indonesian). <http://ebtke.esdm.go.id>, accessed 31 July 2018.
7. G. sasongko, and A. D. Huruta. *Indonesia* **19**, 80–87 (2018).
8. H.-K. Kim, and S.-H. Yoo, *Energy Sources, Part B: Economics, Planning, and Policy*, **11**(6), 547–552 (2016).
9. I. Yuliadi, *International Journal of Management and Applied Science*, **4**(6), 26-30 (2018).
10. J.-H. Hwang, and S.-H. Yoo, *Quality and Quantity*, **48**(1), 63-73 (2012).
11. J. A. Soares, Y. K. Kim, and E. Heo, *Geosystem Engineering*, **17**(1), 58-62 (2014).
12. M. Shahbaz, Q. M. Adnan, A. K. Tiwari, and N. C. Leita, *Renewable and Sustainable Energy Reviews*, **25**, 109-121 (2013).
13. M. Akter, and Md N. Bulbul, *International Journal of Economics, Finance and Management Sciences*, **5**(4), 204-212 (2017).
14. M, B. Yusoff, and I. Febrina, *Margin—The Journal of Applied Economic Research*, **8**(1), 1–13 (2014).
15. The World Bank. World development indicators (Indonesian data), accessed year 2018.
16. C.W.J. Granger, and P. Newbold, *Journal of Econometrics*, **2**(2), 111-120 (1974).