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The Impact of Electricity Production Sources and GDP on CO_2 Emission in Bangladesh: A Short-run Dynamic

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Abstract: This study aims to measure the short-run dynamics of electricity production sources and GDP on CO_2 emission in Bangladesh. As a developing nation, Bangladesh needs to generate more electricity to cater to the demands of households and firms. However, environmental degradation due to energy utilization, industrialization, and economic expansion has negative consequences. The current study applies the Autoregressive Distributed Lag (ARDL) approach by considering the time series data from 1972 to 2018. The findings showed that the short-run association with ECT is 25% and 1% increase in electricity production raises the CO_2 emission by 0.63%. The GDP has no significant impact on CO_2 emission in the short run. The current study recommends that modern technologies like small power producers (SPP), solar panels, recommends that other renewable technologies can be used as alternatives to electricity production. Through small power producers, the country can meet the electricity demand for households and small firms. This study will create awareness on the need for sustainable electricity production by considering lesser environmental damages.

Keywords: ARDL, CO_2 emission, electricity, GDP, short-run dynamics.

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INTRODUCTION

Since her independence in 1971, Bangladesh has encountered a potential shortage in energy sector. The total reserve of energy does not increase significantly with its demand (Khan & Rasel, 2018). Coal, gas, fossil have been commonly used in power generation in this country. Utilization of coal, gas, fuel, and other energy have caused environmental degradation and CO_2 emission. CO_2 emission is a crucial concern for Bangladesh due to the power generation by coal burning and fossil consumption. Natural gas has also been used in the power generation sector where it is badly needed in industrializations. Besides, coal, gas, and fuel consumption are the issues for environmental problems and economic issues (Lu, 2017), (Veysset et al., 2014). Global warming, GHG, and CO_2 emission have risen day by day where the deduction of ambient quality created natural disorders like floods, drought, cyclones, etc.

The major factors for the accomplishment of higher standards of living and socio-economic development as well as the major pillars of any workable economy are energy production and consumption. It is sure that the fabrication and expenditure of power are related to producing carbon dioxide (CO_2) emission. There is a activist relationship between economic augmentation and energy utilization (Dogan & Turkekul, 2016). The development of an economy essentially relies upon inexhaustible and non-sustainable power utilization. The creation of these sorts of energy delivers the Carbon dioxide. There is a tradeoff for ecological quality. As the expansion in power utilization expands carbon dioxide discharges. Energy arrangement of Bangladesh is expected to broaden for cleaner and ecologically benevolent fuel sources which makes overall mindfulness for the exploitation of cleaner energy. There is exists a constructive relationship between power supply and CO_2 emissions while increased CO_2 emissions is associated with economic growth (Nnaji et al., 2013; Egbunike & Emudainohwo, 2017; Zamil & Hassan, 2019). (Samu et al., 2019) state that GDP per capita, electricity utilization and carbon dioxide emanations have existed a long-run equilibrium connections and positive liaison with electricity utilization and real income.

When considering environmental degradation and Bangladesh, the vast majority would presumably cast a ballot the country "Destined to endure the side-effects of ocean level ascent and greater tropical storms." Bangladesh does unquestionably confront genuine effects hastened by environmental change: propelling oceans could swallow a significant part of the seaside region, compelling mass relocation inland. Bangladesh very weak to lessen the ozone harming substances being heaved by more created nations, nor would they be able to expect to switch what's been finished. The nation has rather become a hotbed for variation procedures and experimentation, where some new models are being created and investigated. Through everywhere on Bangladesh, they cause environmental change by catching warmth, and they likewise add to respiratory illness from smog and air contamination. Outrageous climate, food supply disturbances, and expanded out of control fires are different impacts of environmental change brought about by ozone harming substances.

Oil, coal and natural gas are the main sources of electricity production. Renewable energy sources, nuclear energy, and fossil fuels (coal, natural gas, and petroleum) are three main categories of energy for electricity generation. Solar thermal energy, geothermal, nuclear, biomass and fossil fuels are used to generate electricity with steam turbines in most of the time. In addition, energy demand is expanding yearly due to economic expansion, electricity production, industrial activities, and other development activities; the age of power has expanded by 12.5%–14.5% yearly (Khatun & Ahamad, 2015). Although, Bangladesh contributes just 0.56% of CO_2 outflows internationally, the public authority affects the lower atmosphere, by utilizing elective procedures and in this way decreasing GHGs.

Moreover, the Bangladesh Petroleum Corporation (BPC) has planned for focusing on renewable energy utilization in Bangladesh. The identifiable renewable sources are important in this process (Baul et al., 2018). Alterative use of electricity like solar panels and other small power producers (SPP) can support reducing the CO_2 emission in place of coal, gas, fuel consumption. The key objective of this cram is to estimate the impact of electricity production sources and GDP on CO_2 emission in Bangladesh. This study will lend a hand to mitigate the gap of prior research by scheming model for electricity production sources, GDP, and carbon emission. It investigates the self-contribution of GDP and electricity production sources as oil, gas, and coal in the direction of CO_2 emission which is deficient in accessible literature for Bangladesh. This examination will be viable to infer arrangements for lessening carbon outflow in Bangladesh just as expanding financial development and recommend taking some basic methodology which is conceivable to address energy issues of the nation by guaranteeing feasible turn of events and simultaneously decrease CO_2 discharge by creating options in contrast to petroleum derivative utilization, the primary wellspring of CO_2 release. Overall this study will create attentiveness in case of sustainable electricity productions by considering less environmental damages.

According to Akimoto et al. (2006), coal burning, gas consumption, and fossil consumption are the primary manmade sources of CO_2 discharge and climate change. Global emission has largely increased by fossil consumption and manufacturing activities (Ke et al., 2017), (Boden et al., 2009), (Nejata et al., 2015). Amri (2019) finds that energy consumption increases CO_2 emission. Natural gas and oil consumption increase CO_2 gas in BRICS countries with the long-run association (Dong et al., 2017), (Pao et al., 2012). There is a long-run association between industrialization and energy discharge where electricity production enhances CO_2 discharge, and EKC exists between industrialization and CO_2 emission. Shahbaz et al., (2014) It finds that the production of electricity and economic development contribute to increased Carbon footprint and shows that the use of electricity induces economic expansion, industrial growth, and pollution. As a key determinant for developing, emerging and developed economies, electricity spending plays a crucial role in economic development. Asumadu-Sarkodie & Owusu (2016) stated that in the long-run causality between oil consumption and CO_2 secretion in Pakistan. A study on European state presents, GDP cause to oil utilization in developed countries and oil has cause to GDP in transition countries (Žiković & Vlahinic-Dizdarević, 2011). The long-term replacement coefficient is in the range of minus 0.4–1.0 depending on the model definition, which is substantially greater in absolute value than the short-term (static) coefficients observed in other studies in OECD countries (Dyrstad et al., 2019). GDP, energy outlay and CO_2 have long-run association but this result does not accept the EKC hypothesis in China through 2004-2009 (Pao et al., 2012). Setiawan & Iswati (2019), Egbunike & Emudainohwo (2017) also investigate the CO_2 management issues in Indonesia. Energy consumption boost the industrial development in Bangladesh which result examined by (Rahman & Kashem, 2017). (Baul et al., 2018) assert that household biomass fuel exploitation increases carbon emission in Bangladesh. In a panel study on Asian countries, Lean & Smyth (2009) state that electricity production increases the CO_2 where GDP accelerates the CO_2 discharge. There is a long-run association between energy use and economic enhancement. Energy utilization also increases industrialization in Kuwait (Salahuddin et al., 2018). The energy utilization and manufacturing sector cause environmental vulnerability (Vatopoulos & Tzimas, 2012). According to Adom (2011), electricity consumption accelerates economic growth and industrial development in the studied country. (Rahman et al., 2020) have found the energy consumption and GDP growth has increased the CO_2 discharge in Bangladesh. They further state that forestation and agricultural cultivation increase the ambient quality and recommend the use of renewable energy generation. (Islam et al., 2017) found that industrialization and expansion of GDP accelerate CO_2 in Bangladesh.

However, the current study intends to measure the impact of electricity production sources and GDP enhancement on CO_2 emission. This is the initial attempt to measure the environmental impact of oil, gas, and coal consumption in the purpose of electricity production. The inspiration and commitment of our study are laid out as seeking after as follows: first, the examination has decided energy-related discharges in Bangladesh by investigating data from 1972 to 2018 that was up to this point unstudied; second, Mondal et al. (2010); Mondal & Islam (2012); Shahbaz et al. (2014) by further examining existing examinations in regards to CO_2 outflows from Bangladesh, and Sakamoto et al. (2019) utilize the EKC theory. Nonetheless, in this examination, we have at last chosen to depend upon the ARDL strategy. This technique is commonly used to depict the impact on CO_2 emission from a different lag structure of independent variables. ARDL bound testing technique has been deployed in this study to estimate the cointegration. ARDL model is applicable in case when variables are stationary at the level and 1st difference. Through this study current literature would be beneficiaries in field of environmental economics, energy economics and pollution issues by policy coordination and recommendation to the authorities and specialist in relevant field.

METHODS

In this study, annual basis time series data has been assigned to examine the impact of electricity production sources and GDP on CO_2 discharge in Bangladesh. The research considered data from 1972 to 2018. World Development Indicators (WDI) and International Energy Statistics (IES) are the foremost data sources of this cram. Oil, gas, and coal are the main sources of power generation in Bangladesh where hydraulic and renewable sources have tiny contributions to accelerating electricity production. The term ES presents electricity fabrication from oil, coal, and gas sources (% of total). The current study used a combination of oil, gas, and coal sources to measure the impact on CO_2 emission in the studied country. As per our study limitation we have used the combination of electricity production source because of availability of data from data collection source (WDI), another reason is time series estimation. Moreover, CO_2 presents CO_2 emissions (metric tons per capita) and GDP presents gross domestic product (constant 2010 US$). The current study deals with the ARDL model with ECM short-run dynamics. ARDL has been derived, based on the ADF unit root test of the data series where some of the data series has stationary at level I(0) and some are stationary at first differences I(1).

Current study takes CO_2 as a dependent variable and GDP and ES as the independent variables. Emission of CO_2 is a function of electricity production source and gross domestic products. The estimated function has been presented in equation 1.

$$CO_2 = f(ES, GDP) \quad (1)$$

Now, the constructed econometric model is that:

$$CO_{2\,t} = \omega_0 + \beta_1 ES_t + \beta_2 GDP_t + \varepsilon_t \quad (2)$$

The log revolution has been presented in equation 3.

$$LnCO_2 = \omega_0 + \beta_1 LnES_t + \beta_2 LnGDP_t + \varepsilon_t \quad (3)$$

Where, ω_0 is the intercept term and coefficient are presented by β_1 and β_2.
The term ε presents the residuals of estimations where t means time.

The trouble-free unit root stochastic process tag on the practices

$$\varphi_t = \theta\varphi_{t-1} + \mu_t \text{ where, } -1 \le \theta \le 1 \quad (4)$$

$$\varphi_t - \varphi_{t-1} = \theta\, \varphi_{t-1} - \varphi_{t-1} + \varepsilon_t \quad (5)$$

$$\varphi_t - \varphi_{t-1} = (\theta-1)\, \varphi_{t-1} + \varepsilon_t \quad (6)$$

$$\delta\varphi_t = \partial(\varphi_{t-1}) + \varepsilon_t \quad (7)$$

Where, $\partial = (\theta-1)$ and the first diffrence machinist is δ.
if $\partial = 0$ then $\vartheta = 1$ meaning that the series have unit root as the condition of H_o.

$$\text{if } \partial = 0 \text{ then; } \delta Y_t = Y_t - Y_{t-1} = \varepsilon_t \quad (8)$$

Since, ε_t is an error term, it is described as stationary after enchanting the first difference. Now, ADF test has the subsequent forms:

$$\delta\varphi_t = \tau_1 + \tau_{2t} + \partial(\varphi_{t-1}) + \alpha_t \sum_{i=1}^{f} \delta\varphi_{t-1} + \varepsilon_t \quad (9)$$

Where, ε_t is an error module and ADF $\delta\varphi_{t-1}$ is the lagged assortment principle.

The co-integration analysis of this study has been derived from the ARDL bounds testing approach which indicates the short-run dynamics and long-run association by (Pesaran et al., 1999). The model assortment criteria have the mixed order integration as some variables are stationary at level I(0) and others are stationary at first difference I(1). The ARDL framework is present in equation 10.

$$\Delta(CO_2)_t = \omega_0 + \sum_{i=0}^{b} \varphi_1 \Delta(LnCO_2)_{t-1} + \sum_{i=0}^{c} \varphi_2 \Delta LnES_{t-1} + \sum_{i=0}^{d} \varphi_3 \Delta LnGDP_{t-1} + \varepsilon_t \quad (10)$$

Where, change or first difference operator presented by Δ, t presents time and ε represents the residuals or error term. To estimate the short-run dynamics error correction mechanism (ECT) has been assigned in the form of equation 11.

$$\Delta(CO_2)_t = \omega_0 + \sum_{i=0}^{b} \partial_1 \Delta(LnCO_2)_{t-1} + \sum_{i=0}^{c} \partial_2 \Delta(LnES)_{t-1} + \sum_{i=0}^{d} \partial_3 \Delta(LnGDP)_{t-1} + \gamma(ECT)_{t-1} + \varepsilon_t \quad (11)$$

Where, ω_1 is used as an intercept term. The ∂_1, ∂_2 and ∂_3 present the short-run dynamics and ECT is correction mechanism with ECT measurement term γ. The desired value of ECT is 0 to 1. The result should be to carry a pessimistic sign and significance.

RESULTS AND DISCUSSION

The unit root test result has been presented in Table 1. The required null hypothesis states that, the data series have unit root which means the data series are not stationary. Through the ADF test, the variable $LnCO_2$ has unit root at level I(0) with intercept but $LnCO_2$ has no unit root at level I(0) with trent and intercept which means stationary at level I(0) and this variable is also stationary after taking first difference I(1). Similarly, LnES has non stationary at level I(0) but stationary at first difference I(1). Whatever, LnGDP is stationary at first difference I(1). The estimated results are stationary in mixed order I(0) , and I(1) that is why, the current study applies the ARDL model with cointegration analysis supported by ARDL bound testing approach. Vector Autoregressive (VAR) has been assigned to determine the optimum lag selection in this process. The optimum lag length criteria have been presented in Table 2 with considering the special criteria as the minimum value of AIC, SIC, HQ statistics. The current study considers that the optimum lag is 2 which is selected based on SIC and HQ criteria.

Table 1 Unit Root Test Results

Variable	At level		At 1st Differences	
	Intercept	Trend and Intercept	Intercept	Trend and Intercept
$LnCO_2$	-0.65	-3.61**	-6.10***	-6.06***
LnGDP	2.21	-1.18	-8.18	-10.11***
LnES	-1.80	-0.94	-6.74***	-6.86***
Note: *, **, *** presented 10%, 5%, 1% significance level.				

Table 2 Optimum Lag Selection for the ARDL Model

Lag	LogL	LR	FPE	AIC	SC	HQ
0.000	93.627	NA	0.000	-4.648	-4.520	-4.602
1.000	272.964	321.887	0.000	-13.383	-12.870	-13.199
2.000	287.525	23.894	0.000	-13.668	-12.772*	-13.346*
3.000	292.461	7.341	0.000	-13.460	-12.180	-13.000
4.000	309.75	23.064*	2.03e-1*	-13.885*	-12.222	-13.288
Note: * presents 5%, significance level.						

Table 3 has presented the estimated results of the ARDL bound testing. The results demonstrate there is no long-run association flanked by dependent and independent variables. F statistics is considered for measuring the relations (Pesaran et al., 1999), (Narayan, 2005). The anticipated F statistic is 1.38 which is less than the upper bound also the lower bound statistics at the level of significance 10%. A critical value for upper bound at 10% level is 4.14 and lower bound 3.17 respectively. Whatever the result clarifies is that there is a short-run association between dependent and independent variables where long run association doesn't exist.

The results of short-run dynamics have been presented in Table 4. The coefficient of Error Correction Term (ECT) is negative (-0.25) and the result is significant at a 5% level. Moreover, the dependent variable is $LNCO_2$ and the explanatory variables are LNES and LNGDP To measure the impact of electricity production sources (ES) and GDP on carbon dioxide emission, the Coefficient of D(LNES) is 0.63, meaning that 1 % increase in electricity production will increases by 0.63% in CO_2 emission and in the case of D(LNES(–1)), the coefficient is 0.35%. Similar kinds of impact also founded to measure impact of electricity production on CO_2 emission (Tiwari, 2011; Bento & Moutinho, 2016; Jones et al., 2017; Wang et al., 2017; Xie et al., 209; Rahman et al., 2021). Electricity production sources indicate a significant effect on the field of the environment in Bangladesh. An Increasing rate of electricity utilization in developing countries takes place due to the amplifying of economic and noneconomic activities. In the case of short-run dynamics, GDP has no significant impact on increasing the CO_2 emission. Estimated results of coefficient D(LNGDP) and D(LNGDP(–1)) is -0.74 and -0.55 respectively. Were the results being insignificant to explain CO_2 emission. The estimated ECT is (-0.25) which indicates the speed of adjustment 25% moves together in equilibrium from disequilibrium in the long run.

Table 3 Bound Test Result

Test Stat.	Value	K
F-stat.	1.397	2
Cri. Va. Bounds	L. Bound	U. Bound
Significance	I0 Bound	I1 Bound
10.00%	3.17	4.14
5%	3.79	4.85
2.50%	4.41	5.52
1%	5.15	6.36

Table 4 ARDL Short-run Dynamics ($LNCO_2$ Dependent Variable)

Variable	*Coeff.*	*Std. Er*	*t-Stat*	*Prob.*
D(LNCO2(-1))	*-0.28***	*0.14*	*-2.01*	*0.05*
D(LNES)	*0.63***	*0.28*	*2.25*	*0.03*
D(LNES(-1))	*-0.35*	*0.23*	*-1.55*	*0.13*
D(LNGDP)	*-0.74*	*0.53*	*-1.39*	*0.18*
D(LNGDP(-1))	*-0.55*	*0.54*	*-1.00*	*0.32*
CointEq(-1)	*-0.25***	*0.13*	*-2.01*	*0.05*

*Note: *, **, *** presented 10%, 5%, 1% significance level.*

Residual diagnostics of short-run dynamics have been presented in Table 5 and the stability test in Figure 1. The diagnostics test declares that the residual has been normally distributed with J-B statistics 0.54 and the estimated probability 0.94. The heteroscedasticity test states that residual is homoscedastic in nature with observe R^2 and probability value is 4.34 and 0.89 respectively. The autocorrelation test suggests that there are no serial correlations. To stability diagnostics, CUSUM test shows the stability of this estimation. Moreover, CUSUM squares test also indicate the stability of estimated model in Figure 1 and 2 respectively.

Table 5 Residual Diagnostics Test

Normality Test		Heteroskedasticity Test		Serial Correlation	
J-B stat	Prob	Obj R^2	Pro.	Obj R^2	Pro.
0.54	0.92	4.34	0.89	2.81	0.24

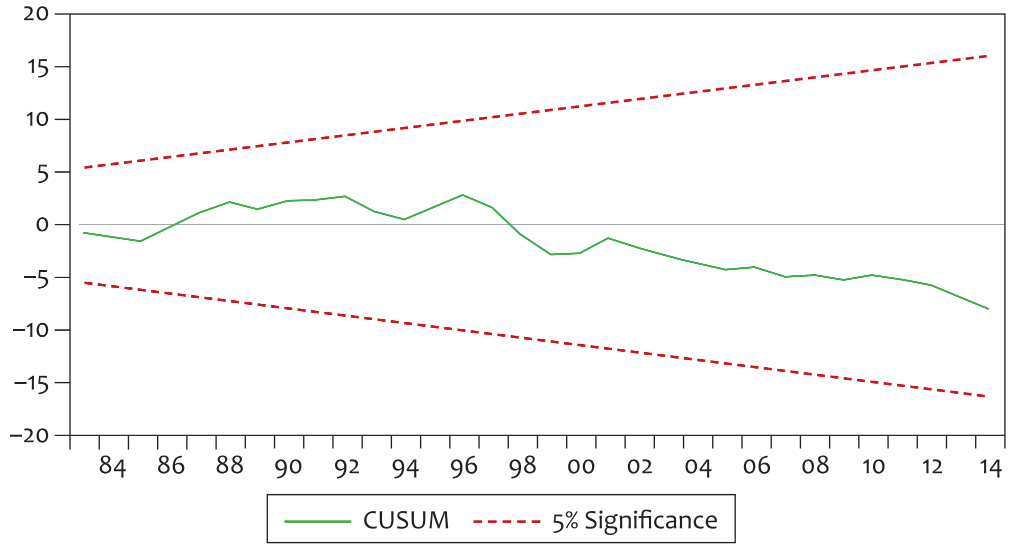

Figure 1 Stability Diagnostic Test Result (CUSUM Test)

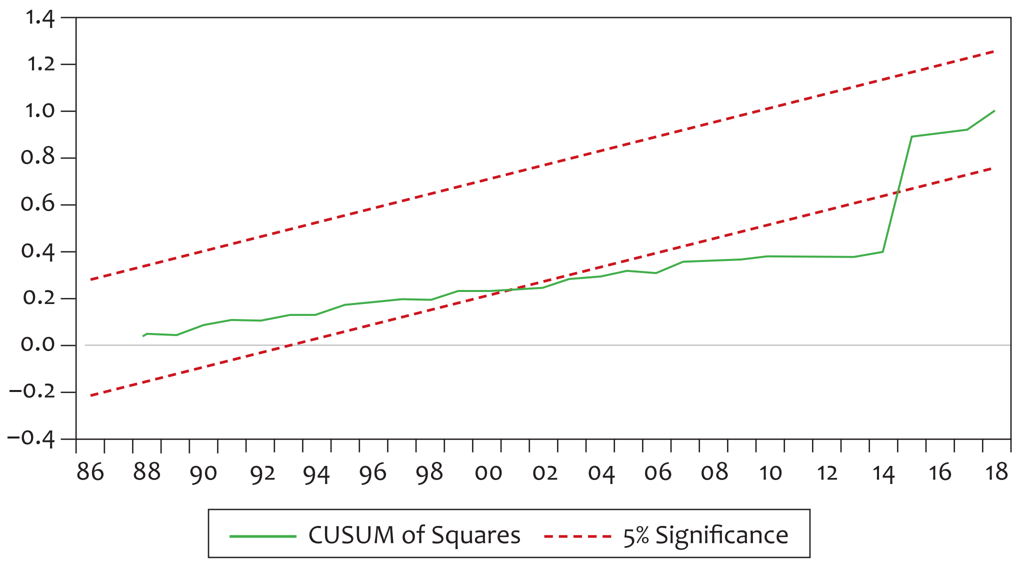

Figure 2 Stability Diagnostic Test Result (CUSUM Squares Test)

CONCLUSION

The current study has examined the impact of electricity production source and GDP on CO_2 emission in Bangladesh by using the ARDL approach. The considerable variables are ES (electricity production from oil, gas, and coal sources), CO_2 and GDP. ADF unit root suggests the mixed order in nature which helps to move in the ARDL approach. The estimated bound test suggests the short-run dynamics. GDP has no noteworthy impact on CO_2 emission in the short run. The electricity production sources have a momentous impact on the acceleration of CO_2 discharge in the short run. Oil, coal, and gas are vital sources of electricity production in Bangladesh (Hossain & Badr, 2007). Coal and oil-burning has an impact on CO_2 discharge in worldwide (Rahman & Kashem, 2017); (Dogan & Turkekul, 2016). In the case of developing countries like Bangladesh, energy consumption is the cause of ecological dilapidation because those kinds of countries are utilizing non-renewable energy resources for industrial expansion and other production activities that heighten CO_2 releases in nature. Natural gas is largely used in industrial sectors, but a large portion of natural gas is used in power generation in Bangladesh. The current study suggests the alternative use of energy sources. Sequential reserves of energy are largely needed to maintain a balance between energy demand and supply. As indicated by results, electricity production has emphatically swayed on CO_2 discharges where the result explains that, 1% increase in electricity production will increases by 0.63% in CO_2 emission and lag of electricity production D(LNES(–1)) shows the coefficient is 0.35%. This indicates that, 1% increase in electricity production with lag period will increases by 0.35% in CO_2 emission. The results recommend that the less energy proficient innovation which delivers less perfect energy as well as to expand CO_2 discharges. For this situation, selection of energy preservation strategy can be utilized as apparatus to improve the natural quality to upgrade expectations for everyday comforts. The input impact between power creation and CO_2 emanations additionally shows that Bangladesh is developing at the expense of climate for example ascend in power creation block natural quality. Based on its findings, this study recommends that renewable energy can create a new door to increase energy reserve. Tree plantation should be increased for maintaining ambient quality. Modern technologies like small power producers (SPP), solar panels, and other technologies can be used as alternatives to electricity production. Sufficient private investments should be ensured in power and solar panels business because of poor electricity pricing policies and other bottlenecks. These are suggested for reducing the CO_2 emission and increase in electricity generation since the massive utilization of solar resources will improve the environmental quality due to less emission in atmosphere. Through the usage of small power producers, the electricity demand for households and small firms can be supplied. Government should take the initiative in purpose of increasing the access of renewable resources with less consumption of non-renewable energy resources. Subsidies on renewable energy resources can ensure less environmental damage. The current study assists the short-run energy sustainability and the importance of safe electricity production. Future research should focus on long run estimation between electricity production sources and CO_2 emission in Bangladesh.

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