The Development of Renewable Energy in Bangladesh

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Now in Bangladesh almost 80% people have the access of electricity. The electricity consumption percentage is increasing sharply along with the economic development of Bangladesh. This research has shown the effect of energy consumption and population growth on economic development and the effect of GDP growth on energy consumption as well. This research has collected historical data and have done unit root test by Augmented Dicky Fuller model, then used multiple regression analysis to analyze data, and have given some suggestions for future sustainable economic development.

1. Introduction

Energy is one of the key elements of modern civilization. The demand is always increasing and to fulfill this big amount of energy supply mankind is using fossil fuels every day, which is one of the biggest reasons of global warming. But in some recent years, some countries took initiative to use unlimited sources of renewable energy. In this way, it's possible to reduce the global warming as well as can save the fossil fuels which is limited. The electricity consumption is increasing rapidly in Bangladesh with the sustained GDP growth rate. In 2016-17 fiscal year the per capita consumption of electricity was 308.22 (kWh) which was 9.6% higher than the previous year (Annual Report of BPDB, 2017). Government took several initiatives to encourage investment in this sector, so in the last year Bangladesh got some FDI specially from China in energy sector, which will boost up the energy productions and supply capacity (Acaravci and Ozturk, 2010; Akinlo, 2008).

Bangladesh got the status to mid-income level country from the less developed county recently. So, Bangladesh is moving forward to the industrial based economy from the agriculture-based economy. For this developing process Bangladesh needs huge energy to fulfill the demand. To supply that big amount of electricity according to the developing demand, so after 2012 government encouraged private sectors to contribute on this, the government and private sectors altogether produced 11405 MW which is less than the current demand. Furthermore, according to the estimation of World Bank the total power demand would be 17,304 MW in 2020. So, to face the future challenge some private and international NGO encouraged to go for renewable energy which will minimize the cost and produce electricity sustainably (Apergis and Payne, 2010).

Right now, Bangladesh has proven reserved of natural gas of 385,100 M3, according to the estimation of January 1, 2016, but it is limited. And some others fossil fuels are mostly depending on import. So, the unstable global market price can natively effect on the price of energy in Bangladesh. Burning fossil fuel is not unlimited, but for long time sustainable solution is not that, we need to think something about renewable, sustainable and environment friendly. According to the BPDB report 2017 government setup a plan to produce 2000 MW from renewable sector (BPDB, 2017). On the other hand, Bangladesh has only 2.87% share of renewable energy in the total generation of energy (BPDB, 2017). So, in this situation further study is needed to determine the best sustainable way of energy production (Chontanawat et al., 2008; Eggoh et al., 2011).

2. Overview of energy sector of Bangladesh

2.1 Current scenario of energy sector of Bangladesh

Bangladesh is considered as a potential renewable energy source. There are total 21 natural gas field and five coalfields in Bangladesh. As a developing country right now the electricity demand in Bangladesh is growing day by day, in the fiscal year of 2015-16 the total electricity production amount in Bangladesh was 9,479 MW which was 4.9% higher than the previous year. But the demand was much higher compared to production

which was 12,644 MW and 10.87% higher than the previous year (Islam et al., 2014; Khatun and Ahamad, 2015; Stern, 1997; Stock et al., 1996; Palma et al., 2018).

Table 1: Brief outlook of Bangladesh energy sector

Fiscal Year	Installed Capacity MW	Present Capacity MW	Maximum Demand MW	Maximum Generation MW	PeakMaximum Load Shedding MW
2012-01	9151	8537	8349	6434	1048
2013-02	10416	9821	9268	7356	932
2014-03	11534	10929	10283	7817	307
2015-04	12365	11770	11405	9036	250
2016-05	13555	12771	12644	9479	250

2.2 SWOT analysis of Bangladesh energy sector

Taking the reference from Bangladesh Power Development Board (BPDB) strategic plan the SWOT analysis of the current situation in Bangladesh energy sector presented as follows.

Bangladesh has a huge source of natural gas, right now the 8,810 MW of electricity come from natural gas operated power plant which is 64.99% of total yearly production (BPDB, 2017). 2 ongoing nuclear generated power plants which will start their work from 2021 and 2022 respectively, both of them will contribute 1200+1200= 2400 MW power to the national grid. Diversified infrastructure and the national network for transporting gas, oil, petroleum, materials import facility by sea. Taking initiative for renewable energy, government give priority to solar power plant and wind based power plant and some power plants construction works are going on. The buyer of electricity is government, so any private organization can produce power and sell that to the government.

But there are also some weaknesses. The 64.99% of produced power come from gas generated power plant, but natural gas is non-renewable (BPDB, 2017). There are very low numbers of nuclear energy scientist are in Bangladesh as well as some other energy sectors experts are also very few. Some power plants in Bangladesh depends on imported raw materials, so the increasing the price in international market can directly affect the unit price of power. The power generation technology and transportation systems are used in Bangladesh are quite old, so those are decreasing the efficiency of power production and the power transportation. Very few research spending on this power sector, so the modern, effective and efficient way of power production in Bangladesh is almost absent.

As for opportunities, Bangladesh has more than 7000 Giga Watt hours (GWH) of potentiality of produce renewable energy**.** Bangladesh is a new member with developing country status, so there are huge industrialization going on, that means in some recent future the electricity demand will go up. Bangladesh government is welcoming for any kind of foreign investment, and they have special policy for especially power plant investment. After finishing the construction of transportation system, the overall work efficiency will be improved.

Also, threats exist. Operating the first 2 major uranium power plant without having own expert is kind of security concern. The main problem of present world is global warming, the height of the Bangladeshi land is not very high from the sea level. Load shedding is very often. The first nuclear power plant in Bangladesh will be started in 2021 and the second one in 2022, but the uranium price in world market is increasing sharply.

2.3 Current scenario of renewable energy sector of Bangladesh

In this modern world the whole modern ecosystem is depending on fossil fuel energy, which is not renewable and results global warming. To skip this issue, renewable energy can be the alternative solution. But it is not always sustainable, because sometimes the biomass energy production can create deforestation, or hydroelectricity production can change the natural water flow system. So, paying more attention about our renewable energy which should be not only renewable but also sustainable is needed.

The renewable energy generations still now hold a very small portion of total power generation. The current installed RE capacity is currently 437 MW, which includes 230 MW Kaptai hydropower plant being the only grid-connected RE resource. To fulfill the future demand Bangladesh government has taken initiative to invest in RE sector, domestic private companies and some international organizations are jointly working for the renewable energy sector. According to the planning and SREDA data the future implementation model is like what showed in Table 2.

The potentiality of renewable energy is very high. There are total 7010 GWH of potentiality is existing in Bangladesh, if government can implement their planning properly then in 2022 all private and public sectors altogether can produce 3666 MW renewable energy. But for some kind of renewable energy plant such as photovoltaic plant need more land which is quite difficult to manage because of high density of population.

Table 2: New planning for implementation of wind and solar plant (in MW)

		2018	2019	2020	2021	Total
Govt. on Govt. land	Solar	50	30	40	45	273
	Wind	150	150	100	100	600
IPP on Govt. land	Solar	50	50	50	50	338
	Wind	100	100	50	50	350
Private on Private land	Solar	100	100	100	100	600
	Wind	100	100	50	50	420
Total		550	530	390	395	2581

Table 3: Renewable energy potentiality and capacity in Bangladesh

RE system	Resources	Capacity (MW)	Annual Generation (GWh)
Solar Park	Solar	1400	2000
Solar Rooftop	Solar	635	860
Solar Home	Solar	100	115
Solar irrigation	Solar	545	735
Wind Parks	Wind	637	1250
Biomass	Rice husk	275	1800
Biogas	Animal waste	10	40
Waste to Waste	Waste	1	6
Small Hydropower	Hydropower	60	200
Mini & micro grid	Hybrid	3	4
Total		3666	7010

3. Methodology and analysis

3.1 Sampling and data collection

For data collection we have used the source of World Bank Database, United Nations Database, Bangladesh Power Development Board report, Global Economic Data from CEIC database. We have collected 17 years of time series data for our research from 2001 to 2017.

Table 4: Data Source

Variable Name	Data Source
GDP	CEIC Database & Word bank Database
Population Growth	CEIC Database & Word bank Database
Energy Consumption	Bangladesh Power Development Board

3.2 Descriptive statistics of data

Table 5: Descriptive statistical table for time series data (2001-2017)

	GDP	PG	PCEC
Mean	6.124117647	1.578823529	180.6664706
Standard Error	0.180479465	0.131663236	14.24891686
Median	6.19	1.35	165.32
Mode	4.8	1.16	#N/A
Standard Deviation	0.744135898	0.542861427	58.74978925
Sample Variance	0.553738235	0.294698529	3451.537737
Kurtosis	-0.303925071	0.071543037	-0.060957282
Skewness	-0.432156267	1.064662833	0.850759182
Range	2.5	1.68	202.14
Minimum	4.8	1.05	106.08
Maximum	7.3	2.73	308.22
Sum	104.11	26.84	3071.33
Count	17	17	17

We used Microsoft excel to generate descriptive statistics of our collected data, in some recent years Bangladesh gained a stable GDP growth rate with GDP 6.12 mean value of the last 17 years GDP, which indicated the developing scenario of domestic economy. With the developing process of economy, the electricity consumption is also increasing, the mean per capita electricity consumption of the last 17 years is 180.66 kWh.

3.3 Unit root test on time series data

First of all we have done ADF test and check the data is stationary or non-stationary. For doing unit root test we used Eviews statistical package software.
Null Hypothesis H0: Variable has unit root; Alternative Hypothesis H1: Variable is stationary

Table 6: ADF Unit Root test result

Variable Time-series	P-Value	Test Statistics	1% Value	5% Value	10% Value
GDP (1st D)	0.0048	3.06	2.72	1.96	1.60
PG (1st D)	0.0017	3.52	2.72	1.96	1.60
PCEC (1st D)	0.0000	5.26	2.72	1.96	1.60

The Unit Root result table shows that the P value is less than 0.05 which means it rejected null hypothesis and accepted alternate hypothesis. If we see the Test Statistics value then we can also see that GDP, Population Growth (PG) and Per Capita Energy Consumption (PCEC) critical value in all levels is less than Test Statistics value, which means its rejected null hypothesis and accepted alternate hypothesis.

3.4 Multiple Regression analysis

For our research we used multivariate regression model to see the relationship between GDP growth and Energy Consumption. The statistical regression model as follows:

$$y_i = a_i + \sum_{i=o} \beta_i X_i + \varepsilon_i \tag{1}$$

Where, $y_i = Dependent\ Variable$, $a_i = Intercept\ of$ the $Equatio$, $\beta_i = coefficient\ of\ Xi\ varables$
$X_i = Different\ Independent\ variables$, $\varepsilon i = error\ terms$
After implementation of the variables into the model it would be like this

$$GDP_t = \alpha + \beta_1 PCEC_t + \beta_2 PG_t + \mu_t \tag{2}$$

$$PCEC_t = \alpha + \beta_1 GDP_t + \mu_t \tag{3}$$

Where, GDP_t=Gross Domestic Production at time t, $PCEC_t$= Per Capita Energy Consumption at time t PG_t=Population Growth at time t, μ_t=Error terms at time t. In this stage, researcher used statistical data analysis package to analyze collected data and got the result like as below.

Table 7: Basic econometric result of (Eq1)

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	5.9992149	0.740850175	8.097743782	1.18859E-06	4.410249306	7.588180493
PG	-0.599115433	0.261905134	-2.287528406	0.038243437	-1.160846077	-0.037384789
PCEC	0.005926945	0.002420063	2.449087135	0.028093122	0.000736426	-0.037384789

Table 8: Regression statistics and ANOVA table of (Eq1)

Regression Statistics	
Multiple R	0.777527014
R Square	0.604548257
Adjusted R Square	0.548055151
Standard Error	0.500259076
Observations	17

ANOVA				
	df	SS	F	Significance F
Regression	2	5.35618376	10.70127487	0.001512357
Residual	14	3.503628005		
Total	16	8.859811765		

In table 7 (Eq1) the beta coefficients of PCEC is 0.0059, the P value is 0.028 which is less than 0.05, that mean PCEC is positively correlated with GDP with confidence level of 95%. On the other hand, the beta coefficient of PG is -0.599, the P value is 0.038 which is less than 0.05, that means PG is negatively correlated with GDP with the confidence level of 95%. From the ANOVA table 4.5 we can see that the Adjusted R square is 0.548 which means the independent variables can explain 54% of the dependent variable, which is statistically significant and a good econometric model.

Now by the second equitation (Eq2) we will see the effect of GDP growth on PCEC, and the result has been generated as below.

Table 9: Basic Econometric Result of (Eq2)

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	4.577588651	0.456650666	10.02426798	4.84001E-08	3.604260795	5.550916506
GDP	0.008560133	0.002410483	3.551210056	0.002902018	0.003422309	0.013697957

Table 10: Regression Statistics and ANOVA table of (Eq2)

Regression Statistics				
Multiple R	0.675825483			
R Square	0.456740084			
Adjusted R Square	0.420522756			
Standard Error	0.566461567			
Observations	17			
ANOVA				
	df	SS	MS	F
Regression	1	4.046631166	4.046631166	12.6110928
Residual	15	4.813180598	0.320878707	
Total	16	8.859811765		

In table 9 (Eq2) the beta coefficients of GDP is 0.008, the P value is 0.002 which is less than 0.05, that mean GDP is positively correlated with PCEC with the confidence level of 95%. And from the regression statistics and ANOVA table 4.7 we can see the adjusted R square is 0.42 which means that the independent variable GDP can explain 45% of the dependent variable, that means this model is statistically significant and a good econometric model.

4. Recommendations for Bangladesh Renewable Energy Sector

First, increase social awareness. The population must be educated on the availability and benefits of renewable energy, especially at the remote and rural areas. The availability of an accessible information system will help to increase general awareness, acceptance and interest on renewable energy. The media can play a significant role in this sector as well. In areas lacking access to such media outlets awareness can be spread through demonstration projects which actively involve members of that area.

Second, invest renewable energy projects. Investing more on sustainable energy means it will decrease the load of non-renewable energy and fossil fuels and burning less fossil fuels means that huge amount of equivalent money can be invested on other development projects. It is important that sufficient renewable energy financing is made available to stimulate and encourage project development in Bangladesh. Financing arrangements to support investment in renewable energy must be developed at the local, national and international level in order to encourage technology adoption. Apart from government funding, innovative funding programs should be developed.

And last, a developing country like Bangladesh need more access to energy while at the same time the world as a whole need to rely on less polluting forms of energy. Energy services have a critical role in achieving the Millennium Development Goals (MDGs). International cooperation in the area of renewable energy is needed to help fill the gap and improve energy equity. For renewable energy development there are many countries and international organizations are willing to help, so Bangladesh can take help from some other countries and organizations to make a strong basement of renewable energy.

5. Conclusions

After analyzing time series data of the last 17 years, in this research we have seen that there is a positive correlation between energy consumption and economic growth. That means, increasing the amount of energy use will increase the speed of economic growth, because when increase the renewable energy use that will reduce the use of fossil fuel at the same time. Saving the money of less fossil fuel use will increase the amount of investment in other development sectors, which will increase the standard of lifestyle and economic growth of Bangladesh. So in future renewable energy would be a great environment friendly and sustainable development. If Bangladesh can't increase the ratio of renewable energy in future that would be dangerous for environment and also will have negative influence on the economic growth. In our research we have used the data of per capita electricity consumption which included both renewable and non-renewable data, if the time series data was available for renewable energy we would use that, but unfortunately there are no data available regarding renewable energy sector for our research, in the report published from Bangladesh Power Development Board (BPDB, 2017) we know that the renewable energy share of energy production is only 2.87% which is really very low, and the data of renewable energy from the last 17 years is absent. It's clear that if one country gives more concentration on renewable energy then that would be eco-friendlier and efficient as well as sustainable for economic growth. And it's also clear that renewable energy has the advantages from all side compared to non-renewable energy sector. So in the future research we will try to find out and categorize the most efficient way of renewable energy production for Bangladesh and vice-versa.

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