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ENERGY DEMAND PERSPECTIVES IN BANGLADESH (1992/93-2019/20)

by

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Energy Demand Perspectives in Bangladesh, (1992/93-2019/20)

Abstract

The present paper attempted to forecast the demand for primary energy broadly categorized into: (a) commercial (coal, petroleum, natural gas, and hydropower), and (b) non-commercial energy (rice hull and straw, jute stick, firewoods, crop wastes, etc.) for the period 1992/93-2019/20 AD to facilitate in the energy sector planning and development. The demand forecast, based on past time series data (1972/73-1991/92), is made by utilizing two methods: (a) "Market Penetration Theory" that uses trend extrapolation and inter-fuel substitution priniciples, and (b) "Trend Extrapolation Model" taking into account the the exogenous variables, e.g., GDP and energy/GDP ratio.

Results reveal that the fractional share of commercial energy in total energy consumption will increase from the 1991/92 level of 51 percent to 85 percent by 2019/20 AD. The total energy demand for 2019/20 AD, by using the "Market Penetration" model, is estimated at 1,465 Peta Joules. The share of commercial and non-commercial energy constitutes 1,239 and 226 Peta Joules, respectively. The annual compound growth rates for total energy, commercial energy and non-commercial energy for the period 1992/93-2019/20 AD, are estimated at 3.23%, 4.89% and -0.01%, respectively. This implies that, the commercial energy demand would increase by a factor of four from the 1991/92 consumption level of 300 Peta Joules, while the demand for non-commercial energy being substituted by the commercial energy over time would decrease slightly instead. Within the commercial energy sector, the demand for natural gas would dramatically increase by a factor of six from the 1991/92 consumption level of 206 to 1,202 Peta Joules by 2019/20 AD thereby covering 97 percent of total commercial energy demand. Therefore, special attention is required to plan for the commercial energy sector as it relates to direct depletion of a non-renewable natural resource stock, i.e., the natural gas. The energy demand forecasts made by utilizing the "Trend Extrapolation" model also yielded a close estimate of total energy demand of 1,655 Peta Joules by 2019/20 AD (a 12 percent variation from the estimate of "Market Penetration" model).

1. Introduction

Energy, both commercial and non-commercial, serves as the major vehicle for development in Bangladesh as elsewhere in the world. For the past two decades, since the birth of Bangladesh, lopsided development efforts without proper concerns for the environment as well as productivity levels of the resource bases has lead to unprecedented crisis in various sectors of the economy. The energy sector also faces severe crisis in meeting the increasing demands for domestic, industrial, transportation and other uses (GOB, 1991).

In the energy consumption scenario of Bangladesh, non-commercial energy plays a dominant role. The domestic sector alone consumes about 65 percent of the total energy and 91.5 percent of this energy is provided by biomass fuels (GOB, 1991). The immense pressure on biomass fuels without proper measure for replenishment has resulted in massive deforestation, decline in soil fertility and/or reduced productivity in lands. Agricultural residues and animal wastes, that are supposed to be utilized for soil fertility management, are used as energy for domestic uses, agro-based industries as well as other uses. About 64 percent of total non-commercial energy come from agricultural residues whose future availability is dependent on the future agricultural development plans. Also, such diversion of agricultural residues for energy use has raised concerns for the policy planners as yields of major crops (e.g., rice, wheat, jute) are showing a declining trend owing to declining soil fertility and disparate access to required rural infrastructure.

However, observation of past energy consumption data revealed that the share of non-commercial energy in the total energy consumption has been declining steadily allowing for substitution by the commercial energy. The reasons for such phenomenal change can be largely attributed to past and present policy thrusts for developing the commercial energy sector, particularly the natural gas. For example, the sectoral allocation for energy in the Five Year Development Plans increased consistently from only 11 percent in the First Five Year Plan (1973-78) to 21 percent in the Fourth Five Year Plan (1990-95) (Planning Commission, 1973; 1980; 1985;

and 1990). Also, the supply constraints in rapid growth of biomass energy without proper development measures for replenishment could be another reason for declining share of non-commercial energy[1].

The present study based on past time series data, defers from other studies conducted so far in that, the phenomenol changes of observed inter-fuel substitution (i.e., the shift from non-commercial energy to commercial energy), has been taken into account while estimating the primary energy demand upto 2019/20 AD. Also, within the commercial energy sector, the change in composition of primary energy source, e.g., natural gas, petroleum, coal and hydropower is analyzed.

2. Analytical Framework

2.1 Market Penetration Theory

The theory postulates that, a product newly intoduced into the market usually is less advanced, both operationally and economically, as compared with the older product already existing in the market with which it is competing. Over time, the new product will be developed further to increase its efficiency and reduce its cost. Also, once the new product gets a foothold in the market with a nominal share revealing its commercial feasibility, it is likely to gain an advantage over the older one and the substitution process continues. The extent of such substitution, however, depends on the parameters of the market, the competing products and other externalities (Khanna, 1991). As the substitution process continues, the competition intensifies and the fractional rate of substitution

[1] The Task Force Report (TFR, 1991) apprehends that though there will be some increase in the supply of biomass fuel, the per capita availability of biomass fuel will decrease substantially in future due to: (a) diminishing forest resources; (b) stagnated jute and livestock production; (c) shift to HYV rice which produces less straw for fuel; and (d) increasing pressure on residues for allocation to other end uses, such as fodder, building materials etc.

of the older product tends to diminish. Eventually, a saturation point will be reached in the market, where the fractional rate of substitution of the older product will decline to zero.

Khanna (1991) notes that, this fundamental dynamics of substitution proceeds following a logistic curve, characterised by slow initial rise, followed by a period of more rapid growth and then levelling off towards a saturation value, the final level of adoption of the new product. For the two competing products, the fraction always adds upto unity.

Figure 1 presents the fractional shares of commercial (coal, petroleum, natural gas, and hydro-power) and non-commercial (cow-dung, jute straw, rice straw, rice hull, bagasse, firewoods, twigs, and crop wastes) energy. and their trend values. The share of the commercial energy increased from 29 to 51 percent during the period 1972/3-1991/92. On the other hand, the share of non-commercial energy declined from 71 to 49 percent during the same period. Within the commercial energy sector, petroleum and coal had a declining share, while natural gas showed sharply increasing share (Figure 2). The hydropower share remained stable at less than 5 percent with annual variations. The petroleum share declined from 57 to 26 percent, the coal share declined from 8 to 2 percent, while the share of natural gas more than doubled from 30 to 69 percent. Within the non-commercial energy components, cowdung had a declining share from 26 to 19 percent, while the rest of the components remained stable within a variation range of 2-3 percent only (Figure 3). This phenomenon on changes in the energy consumption pattern, between non-commercial and commercial energy, can be viewed as the penetration or substitution of the latter in the total energy market.

2.2 Models Utilizing Market Penetration Theory

The common models describing the penetration of one product over the other in a market are (Khanna, 1991):

$$Fischer - Pr\ yModel : \ln\left(\frac{f}{1-f}\right) = c_1 + c_2(t) .....(1)$$

$$BlackmanModel : \ln\left(\frac{f}{F-f}\right) = c_1 + c_2(t), ...(2)$$

$$FfloydModel : \ln\left(\frac{f}{F-f}\right) + \left(\frac{f}{F-f}\right) = c_1 + c_2(t), ...(3)$$

Where, f = market share of the new product at time t;

F = upper limit of the market share,

c_1 and c_2 = constants.

A simulated version of the above models into a single equation is given by (Khanna, 1991)

$$\ln\left(\frac{f}{F-f}\right) + \partial\left(\frac{f}{F-f}\right) = c_1 + c_2(t), ...(4)$$

Where, ∂ = a constant termed as delay coefficient;

Substituting $\partial = 0$ results in *Blackman Model*

and $\partial = 0$, $F = 1$ results in *Fischer-Pry Model*

and $\partial = 1$ results in *Ffloyd Model*

2.3 Multi-Level Substitution: An Extension of the Two Product Substitution Model

The aforementioned models competing between two products can be further extended for more than two products. Assuming that a market contains *n* products, named as x_1 , x_2 , x_3 , ... x_n, where x_1 is the oldest product and x_n is the newest product (Khanna, 1991). The basic assumption is that over time the older product x_1 being technologically weak will lose its market share to all other products (x_2 , x_3 , x_4 , ... x_n) and x_n being technologically advanced will take over market share of all other products (x_1 , x_2 , x_3 , ... x_{n-1}).

In the present study, the "substitution" principal is used to estimate the total energy demand while the "multi-level substitution" principal is used to estimate the demand for energy components within the commercial energy sector.

3. Application of the Market Penetration Theory to Estimate Energy Demand for Bangladesh

3.1 Demand for Total Energy (Commercial and Non-Commercial Energy)

The demand for total energy, utilizing the time series data of the period 1972/3-1991/92, has been computed by fitting a logistic curve as it provided the minimum standard error of regression with highest Adj.R-squared.

$$Energy\ (t) = \left(\frac{1}{1/u + (b_0 \times b_1^t)} \right),.....(5)$$

$$= \left(\frac{1}{1/5{,}000 + (0.003333 \times 0.960539^t)} \right)$$

Where, Energy (t) = total energy demand during the period t, (t = 1 for the year 1972/73 upto 20 for the year 1991/92),

b_0 , b_1 and u are constants. The values for constants are: u = 5,000, b_0 = 0.003333, and b_1 = 0.960539. "u" denotes the upper boundary value, and its value is selected such that the predicted value fits the observed values with minimum error,

Adj. R-squared = 0.982, $F_{(1,18)}$ = 1010.927, and S.E. (Regression) = 0.0327.

As evident from the equation, the fit is remarkably well. The time variable alone explained about 98 percent of variation in the total energy demand with this specification. Figure 4 shows the energy consumption curve for the period 1972/73-1991/92.

3.2 Fractional Share Estimations of Commercial and Non-Commercial Energy

The fractional shares of the commercial and non-commercial energy displayed in Figure 1 has been utilized to estimate the parameter of the Equation (4) by assuming various values of the delay factor. The model[2] that fits the time-series data (1973-91) with minimum error is given by:

$$\ln\left(\frac{f(t)}{F - f(t)}\right) = -1.04763 + 0.05725\ (t), \ldots..(6)$$

where, *f(t)* = fractional share of the commercial energy during the period t (t=1 for the year 1972/73 and upto 20 for the year 199192),

c_1 = -1.04763, c_2 = 0.05725, ∂ = 0.01, S.E. c_1 = 0.05376, c_2 = 0.00440,

Adj. R-squared = 0.957, S.E. (regression) = 0.0748,

$F_{(1,18)}$ = 423.34070. D.W. Statistic = 1.89 (after correction for autocorrelation using Prais-Winsten method).

[2] Coefficients on the R.H.S. of the Equation (6) is obtained by utilizing Equation (4) assuming various values of the delay factor. For future projection of the fractional share, Equation (6) is used as the delay coefficient assumes zero value.

The result of the estimation is presented in Table 1 which shows the actual and predicted values of the fractional shares of commercial and non-commercial energy for the period 1972/73-1991/92 is almost negligible.

Equation (6) is then used to estimate the fractional shares of the commercial and non-commercial energy from 1992/93 upto 2019/20 and the result is provided in Table 2. The future total energy demand and the corresponding shares of commercial and non-commercial energy were computed by using Equations (5) and (6) and is presented in Table 3 and Figure 4. The result reveals that the increase in total energy demand is largely due to the growth in commercial energy, while the non-commercial energy being substituted by the commercial energy over time, will slighly decrease. The annual compound growth rates for the different time periods within the forecasting horizon is presented in Table 4. The overall annual compound growth rates for total energy, commercial energy and non-commercial energy for the period 1992/93-2019/20 AD is estimated at 3.32, 4.89 and -0.84 percent, respectively. The growth rates for energy are highest for the first eight year block (1992/93-1999/2000), while for the last ten year block (2011/12-2019/20), the rates are lowest. This finding is consistent with the assumption of the model, where at the initial stage of penetration, the substitution takes place at a faster rate and gradually slows down, eventually levelling off towards a certain value[3].

3.3 Fractional Share Estimations of Commercial Energy Components

The "multi-level substitution" principal is utilized in estimating fractional shares of natural gas,

[3] Perhaps the stage of saturation point for Bangladesh is much beyond the planning horizon utilized in this study. However, the trend is visible within the projected period.

petroleum, coal and hydropower comprising the commercial energy sector. The following methods are used for the purpose.

3.3.1 Frational Share Estimation of Natural Gas

The fractional share of natural gas against the sum of the fractional shares of petroleum, coal, and hydropower is modelled using Equation (5). The resulting specification is given by:

$$\ln\left(\frac{f_g(t)}{1-f_g(t)}\right) = -1.13937 + 0.09647(t), \ldots\ldots(7)$$

Where: $f_g(t)$ = fractional share of natural gas during t

c_1 = -1.13937, c_2 = 0.09647, ∂ = 0.01. S.E. c_1 = 0.09309. S.E. c_2 = 0.00768.

Adj. R-squared = 0.937. $F_{(1, 18)}$ = 282.16562. S.E. (Regression) = 0.15003.

D.W. Statistic = 2.45 (after correction for autocorrelated disturbances using Prais-Winsten Method).

3.3.2 Fractional Share of Petroleum

Equation (5) is again applied to the sum of fractional shares of natural gas and petroleum against the fractional shares of coal and hydropower. The resulting equation is given by:

$$\ln\left(\frac{f_{gp}(t)}{1-f_{gp}(t)}\right) = 1.67532 + 0.05979(t), \ldots\ldots(8)$$

Where: $f_{gp}(t)$ = sum of fractional shares of natural gas and petroleum during t

c_1 = 1.67532, c_2 = 0.05979, ∂ = 0.00. S.E. c_1 = 0.12870. S.E. c_2 = 0.01064.

Adj. R-squared = 0.728. $F_{(1, 18)}$ = 51.90868. S.E. (Regression) = 0.21737.

D.W. Statistic = 2.14 (after correction for autocorrelated disturbances using Prais-Winsten Method).

The fractional share of petroleum is then obtained by deducting the resulting estimation from the fractional share of natural gas obtained from Equation (7).

3.3.3 Fractional Shares of Coal and Hydropower

The fractional shares of coal and hydropower are grouped in one (as these represents very small share in total commercial energy demand in later years) and is obtained from the following Equation:

$$f_{ch}(t) = 1 - f_{gp}(t), \ldots\ldots. (9)$$

where: $f_{ch}(t)$ = is the combined fractional shares of coal and hydropower.

Table 5 presents the result of using Equations (7), (8) and (9) on past data of fractional shares of natural gas, petroleum, and coal and hydropower. The difference in the estimates and the actual fractional shares are almost negligible.

Table 6 provides the forecasted fractional shares of natural gas, petroleum, and coal and hydropower over the forecasting horizon. It seems that, the natural gas demand will sharply increase covering 97 percent of all commercial energy demand by 2019/20 AD leaving practically no role for other types of commercial energy. The estimated demand for natural gas, petroleum, and coal and hydropower is presented in Table 7. Figure 5 presents the total energy demand scenario from 1992/93 to 2019/20 AD.

Trend Extrapolation Model

For an alternative estimation, "Trend Extrapolation" model (based on time series data) assuming energy demand as a function of exogenous variables, e.g., GDP and energy/GDP ratio, has been utilized to forecast the demand for energy upto 2019/20 AD. The GDP is included as exogenous variable as it was found to be highly correlated with energy consumption (Pearson's correlation coefficient: $r = 0.983$; $P < 0.01$).

The model used is:

$$ln\ (e_t) = ln\ (egr_t) + ln\ (GDPC_t) \quad .... \quad (10)$$

where, e = commercial energy consumption (PJ/year)

egr = energy/GDP ratio (PJ/Mill. US$)

GDPC = Real GDP (at constant 1985 prices in Mill. US$/year)

t = time period.

The model in Equation (10) is estimated by Ordinary Least Squares (OLS) method. No multi-collinearity and autocorrelated disturbances were detected. The estimated result is:

$\ln (e_t)$	$= -7.92477$	$+ 0.01563 \ln (egr_t)$	$+1.10022 \ln (GDPC_t)$
S.E.	(1.209)	(0.03743)	(0.00419)

Adj. R-squared = 0.985, $F_{(2,17)} = 642.362$.

S.E. (Regression) = 0.02652. D.W. Statistic = 1.56.

The fit is remarkable, as both the variables are statistically significant and R-squared accounts for 99 percent of the total variation in the dependent variable.

The energy demand forecasts made from two different approaches, the "Market Penetration Theory" and the "Trend Extrapolation" yielded a close estimate with only 12 percent variation

(Table 9). However, the dynamics of inter-fuel substitution, not captured in the “Trend Extrapolation” model reduces its usefullness in comparison to the “Market Penetration” model. Therefore, when one wants to analyze the inter-fuel demand, it is advisable to utilize the latter approach.

Conclusion

Demand forecasts for the period 1992/93-2019/20 AD reveal that the primary energy demand will more than double by the end of 2020 AD. Within this period, the commercial energy demand will increase by a factor of four, indicating that special attention is required to develop commercial energy sector. Within the commercial energy sector, natural gas alone will cover 97 percent of all commercial energy demand. This finding particularly raises the concern for the adverse environmental impacts associated with use of non-renewable fossil fuel, particularly, the natural gas and must receive due consideration. Despite the thrust in the past plan allocations for the commercial energy sector, requisite development has not been achieved. There remains ample scope for introducing energy efficient technologies and energy conservation measures in both the commercial and non-commercial energy sectors. Therefore, effective energy planning and policy prescription is vital for Bangladesh as the country is entering into 21st century.

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Table 1. Commercial and Non-commercial Energy Fractional Shares and Their Trend Values (1972/73-1990/91)

Year	Commercial Energy	Trend Values	Non-commercial Energy	Trend Values
1972/73	0.2860	0.2697	0.7140	0.7303
1973/74	0.2810	0.2796	0.7190	0.7204
1974/75	0.2718	0.2895	0.7282	0.7105
1975/76	0.2791	0.2994	0.7209	0.7006
1976/77	0.2858	0.3092	0.7142	0.6907
1977/78	0.3034	0.3191	0.6966	0.6809
1978/79	0.3001	0.3290	0.6999	0.6710
1979/80	0.3547	0.3389	0.6453	0.6611
1980/81	0.3615	0.3488	0.6385	0.6512
1981/82	0.3881	0.3587	0.6119	0.6413
1982/83	0.3659	0.3686	0.6341	0.6314
1983/84	0.3906	0.3785	0.6094	0.6215
1984/85	0.4114	0.3883	0.5886	0.6117
1985/86	0.4286	0.3982	0.5714	0.6018
1986/87	0.4770	0.4081	0.5230	0.5919
1987/88	0.4306	0.4180	0.5694	0.5820
1988/89	0.3997	0.4279	0.6003	0.5721
1989/90	0.4115	0.4378	0.5885	0.5622
1990/91	0.3883	0.4477	0.6117	0.5523

Note: Trend value: $Y = \alpha + \beta t$ where α and β are constant and t denotes time
Source:Computed from Statistical Yearbook of Bangladesh (Various Issues).

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Table 2. Fractional Shares of Commercial Energy (1972/73-1990/91)

Year	Oil	Natural Gas	Electricity	Coal
1972/73	0.5880	0.3034	0.0262	0.0824
1973/74	0.5487	0.3480	0.0333	0.0700
1974/75	0.6148	0.2615	0.0357	0.0880
1975/76	0.5398	0.3449	0.0369	0.0784
1976/77	0.5111	0.3697	0.0401	0.0791
1977/78	0.5519	0.3362	0.0447	0.0671
1978/79	0.5396	0.3691	0.0438	0.0475
1979/80	0.5484	0.3792	0.0391	0.0333
1980/81	0.5031	0.3928	0.0413	0.0638
1981/82	0.4544	0.4490	0.0435	0.0531
1982/83	0.3944	0.5185	0.0585	0.0285
1983/84	0.3959	0.5341	0.0591	0.0109
1984/85	0.3755	0.5513	0.0574	0.0159
1985/86	0.3755	0.5443	0.0589	0.0213
1986/87	0.3324	0.5811	0.0563	0.0303
1987/88	0.3595	0.5601	0.0575	0.0229
1988/89	0.4165	0.4827	0.0922	0.0086
1989/90	0.3738	0.4061	0.0840	0.0814
1990/91	0.3856	0.4908	0.0950	0.0286

Source:Computed from Statistical Yearbook of Bangladesh (Various Issues).

Table 3.Fractional Shares of Non-Commercial Energy (1972/73-1990/91)

Year	Cow-dung	Jute stick	Rice straw	Rice hulls	Bagasse	Firewood	Twigs	Crop wastes
1972/73	NA	NA	NA	NA	NA	NA	NA	NA
1973/74	0.2553	0.0603	0.1810	0.2274	0.0557	0.0325	0.1021	0.0856
1974/75	0.2652	0.0362	0.1857	0.2195	0.0576	0.0362	0.1090	0.0905
1975/76	0.2501	0.0388	0.1844	0.2421	0.0477	0.0366	0.1103	0.0897
1976/77	0.2513	0.0468	0.1782	0.2299	0.0521	0.0369	0.1118	0.0927
1977/78	0.2494	0.0495	0.1702	0.2295	0.0529	0.0381	0.1151	0.0952
1978/79	0.2737	0.0567	0.1610	0.2165	0.0479	0.0371	0.1130	0.0939
1979/80	0.1887	0.0527	0.1847	0.2111	0.0716	0.0487	0.1324	0.1100
1980/81	0.1855	0.0464	0.1816	0.2228	0.0685	0.0455	0.1365	0.1131
1981/82	0.1872	0.0431	0.1825	0.2178	0.0738	0.0452	0.1367	0.1134
1982/83	0.1794	0.0432	0.1757	0.2123	0.0720	0.0481	0.1448	0.1242
1983/84	0.1845	0.0465	0.1623	0.2393	0.0684	0.0461	0.1384	0.1145
1984/85	0.1867	0.0409	0.1572	0.2404	0.0676	0.0471	0.1421	0.1179
1985/86	0.1805	0.0582	0.1527	0.2336	0.0621	0.0480	0.1449	0.1199
1986/87	0.1992	0.0642	0.1824	0.1673	0.0716	0.0504	0.1448	0.1198
1987/88	0.1968	0.0573	0.1576	0.2149	0.0683	0.0517	0.1383	0.1149
1988/89	0.2037	0.0602	0.1626	0.2136	0.0614	0.0502	0.1342	0.1139
1989/90	0.1887	0.0400	0.1553	0.2621	0.0661	0.0429	0.1339	0.1108
1990/91	0.1899	0.0439	0.1492	0.2593	0.0679	0.0475	0.1325	0.1096

Source:Computed from Statistical Yearbook of Bangladesh (Various Issues).

Table 4. Actual and Estimated Fractional Shares of Commercial and Non-commercial Energy (1972/73-1990/91)

Year	Commercial Energy		Non-commercial Energy	
	Actual	Estimated	Actual	Estimated
1972/73	0.2860	0.2767	0.7140	0.7233
1973/74	0.2810	0.2839	0.7190	0.7161
1974/75	0.2718	0.2912	0.7282	0.7088
1975/76	0.2791	0.2987	0.7209	0.7013
1976/77	0.2858	0.3062	0.7142	0.6938
1977/78	0.3034	0.3139	0.6966	0.6861
1978/79	0.3001	0.3217	0.6999	0.6783
1979/80	0.3547	0.3295	0.6453	0.6705
1980/81	0.3615	0.3375	0.6385	0.6625
1981/82	0.3881	0.3456	0.6119	0.6544
1982/83	0.3659	0.3537	0.6341	0.6463
1983/84	0.3906	0.3619	0.6094	0.6381
1984/85	0.4114	0.3703	0.5886	0.6297
1985/86	0.4286	0.3787	0.5714	0.6213
1986/87	0.4770	0.3871	0.5230	0.6129
1987/88	0.4306	0.3957	0.5694	0.6043
1988/89	0.3997	0.4043	0.6003	0.5957
1989/90	0.4115	0.4129	0.5885	0.5871
1990/91	0.3883	0.4216	0.6117	0.5784

Source:Computed from Statistical Yearbook of Bangladesh (Various Issues).

Table 5. Actual and Estimated Fractional Shares of Commercial and Non-commercial Energy (1991/92-2019/20)

Year	Commercial Energy	Non-commercial Energy
1991/1992	0.4304	0.5696
1994/1995	0.4569	0.5431
1999/2000	0.5016	0.4984
2004/2005	0.5463	0.4537
2009/2010	0.5902	0.4098
2014/2015	0.6328	0.3672
2019/2020	0.6733	0.3267

Source: Estimated

Table 6. Estimated Future Demand for Commercial and Non-commercial Energy (1991/92-2019/20)

Year	Commercial Energy (PJ)	Non-commercial Energy (PJ)	Total Energy (PJ)
1991/1992	228.45	302.33	530.78
1994/1995	264.30	314.12	578.42
1999/2000	334.51	332.33	666.84
2004/2005	419.42	348.34	767.76
2009/2010	520.91	361.66	882.57
2014/2015	640.84	371.93	1012.78
2019/2020	780.98	378.91	1159.89

Source: Estimated

Table 7. Compound Growth Rate of Demand for Commercial and Non-commercial Energy (1991/92-2019/20)

Year	Commercial Energy	Non-commercial Energy	Total Energy
1991/1992 to 1999/2000	4.77	1.18	2.85
1991/1992 to 2009/2010	4.58	1.00	2.83
1991/1992 to 2019/2020	**4.39**	**0.81**	**2.79**
2000/2001 to 2009/2010	4.41	0.83	2.80
2000/2001 to 2019/2020	4.22	0.64	2.77
2010/2011 to 2019/2020	4.03	0.45	2.72

Note: Growth rates are computed by fitting semi-log trend function: $\ln Y = \alpha + \beta t$, where α and β are constant and t denotes time

Source: Estimated

Table 8. Actual and Predicted Values of Real GNP, Nominal GNP and Energy Consumption (1972/73-1990/91)

Year	Real GNP at 1987 Prices (m US$)		Nominal GNP (m US$)		Energy Consumption (PJ)	
	Actual	Predicted	Actual	Predicted	Actual	Predicted
1972/73	282.16	290.24	46.38	68.34	295.53	302.91
1973/74	319.43	303.03	73.34	78.96	316.16	311.74
1974/75	315.04	316.38	126.85	91.24	304.29	320.84
1975/76	328.87	330.32	110.32	105.43	327.71	330.19
1976/77	331.22	344.87	109.28	121.83	331.51	339.82
1977/78	355.87	360.06	147.15	140.77	357.78	349.74
1978/79	377.92	375.92	173.83	162.66	377.30	359.94
1979/80	383.92	392.49	200.65	187.95	365.59	370.43
1980/81	419.22	409.78	233.72	217.18	381.21	381.24
1981/82	432.54	427.83	258.39	250.95	399.67	392.36
1982/83	452.01	446.68	290.86	289.97	404.31	403.80
1983/84	475.38	466.35	350.91	335.06	420.35	415.58
1984/85	493.43	486.90	404.60	387.16	437.76	427.70
1985/86	513.83	508.35	462.46	447.36	472.68	440.17
1986/87	535.48	530.75	535.48	516.92	467.83	453.01
1987/88	550.63	554.13	592.98	597.30	468.99	466.22
1988/89	565.19	578.54	656.12	690.18	458.23	479.82
1989/90	602.71	604.03	733.52	797.50	488.41	493.81
1990/91	623.36	630.64	830.74	921.52	475.01	508.21

Source:Computed from World Tables (1994) and Statistical Yearbook of Bangladesh (Various Issues).

Table 9. Estimated Future Demand for Total Energy (1991/92-2019/20)

Year	Energy Demand Forecast by		Average of Two Methods (PJ)
	Market Penetration Theory (PJ)	Trend Extra-polation (PJ)	
1991/1992	530.78	515.59	523.19
1994/1995	578.42	560.67	569.55
1999/2000	666.84	645.23	656.04
2004/2005	767.76	742.56	755.16
2009/2010	882.57	854.56	868.57
2014/2015	1012.78	983.45	998.12
2019/2020	1159.89	1131.78	1145.84

Source: Computed