Indicators of Energy Use and Efficiency in Bangladesh

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Abstract

The paper analyses the pattern of demand for both commercial and non-commercial energy across difficult sectors of the Bangladesh economy. It examines the energy intensity of agriculture and industry sectors as well as the transport sub-sector, which is the largest component of the services sector. The paper attempts a regression exercise, with time series data, to establish the relationship between energy demand (dependent variable) and real GDP and population (explanatory variables). The estimated elasticities are then used to reach some pertirent policy conclusions. Given the growing demand for energy but the limited availability of indigenous gas and coal resources, the paper recommends for a proper use of the country's gas and coal supplies through formulation and adoption of an appropriate energy policy.

Section I: Introduction

Bangladesh, occupying a very small area of the world map is densely populated and it is well known as a poor country in terms of both low per capita income and low energy consumption. The use of commercial and noncommercial energy in different economic sectors of Bangladesh plays an important role in the development of these sectors. About 100 percent of the rural and about 70 percent of the urban people in Bangladesh depend on bio-mass fuel for cooking and it will remain the principal source of energy supply up to a foreseeable future. The greater use of noncommercial energy for cooking purpose and brick burning industries reduces the direct use of commercial energy. On the other hand, commercial energy like coal, petroleum products, natural gas and electricity has been used for a long time and their demand is increasing day by day. The increasing use of petroleum products and electricity in the agricultural sector indicates development of farming processes. The growing use of petroleum

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products in transport sector makes it possible for the agricultural and industrial products to reach the furthest corner of the country. The use of sufficient commercial energy especially use of electricity has developed work-culture among the people and enhance their efficiency. The unplanned way of using fuel wood for the purpose of brick burning poses a threat to the ecological balance. On the other hand, the extensive use of commercial energy in industry and transport sectors create air pollution and the pollution levels are rising due to the absence of advanced technologies. In such a situation, it is necessary to formulate a right policy towards energy and environment management. Towards formulation of an appropriate energy policy it is also necessary to have a clear idea about the demand for energy and the sources of its supply. This will indicate how growth can be sustained through a non-energy intensive path, and fuel-wise supply and consumption analysis can help in policy formulation towards an efficient use of energy.

Section II: Energy Consumption Pattern in Bangladesh

2. Consumption of Commercial and Noncommercial Energy

Table-1 shows the final consumption of commercial and noncommercial energy and their relative shares in Bangladesh. It is observed from this table that in 1976-77 the commercial and noncommercial energy consumption were, respectively 1374 and 5562 TTOE. After 24 years i. e., in 1999-2000 the respective consumption rose to 3642 and 7394 TTOE. Within this period of 24 years the average growth rates of these two kinds of energies were 5.37% and 1.51% respectively. The sum of commercial and noncommercial energy consumption gives the total energy consumption. In the financial year 1976-77 it was 6936 TTOE and it rose to 11041 TTOE in 1999-2000. This means that within this period of 24 years the total energy consumption increased by 4105 TTOE and the average growth rate was 2.57% in this period. The relative shares of both energies were, respectively, 19.8% and 80.2% in 1976-77. Both types of energy consumption increased as the use of commercial energy increased in economic activities and the use of noncommercial energy spread from rural to urban areas. But the relative share of commercial energy consumption increased with a simultaneous fall in the relative share of noncommercial energy consumption. As a result of that the respective relative shares of these energies changed to 33.03% and 66.97% in 1999-2000.

Table 1 : Consumption of commercial and non-commercial energy in Bangladesh

Unit: Thousand Tons of Oil Equivalent (TTOE)

Years	Commercial energy	Noncommercial energy	Total energy
1976-77	1374 (19.80)	5562 (80.20)	6936 (100)
1977-78	1588 (21.50)	5954 (78.95)	7542 (100)
1978-79	1620 (20.43)	6309 (79.57)	7929 (100)
1979-80	1844 (24.65)	5635 (75.35)	7479 (100)
1980-81	1869 (24.32)	5817 (75.68)	7646 (100)
1981-82	1958 (25.10)	5842 (74.90)	7800(100)
1982-83	1687 (21.60)	6124 (78.40)	7811(100)
1983-84	1747 (22.20)	6119 (77.80)	7866 (100)
1984-85	1962 (24.10)	6176 (75.90)	4138 (100)
1985-86	2158 (25.08)	6447 (74.92)	8605 (100)
1986-87	2382 (28.95)	5895 (71.05)	8227 (100)
1987-88	2544 (24.51)	6378 (71.49)	8922 (100)
1988-89	2456 (30.30)	6570 (69.70)	9424 (100)
1989-90	3251 (32.13)	6866 (67.87)	10117 (100)
1990-91	2870 (29.25)	6942 (70.75)	9812 (100)
1991-92	2996 (30.0)	6994 (70.0)	9990 (100)
1992-93	3107 (30.45)	7093 (69.55)	10200 (100)
1993-94	3358 (31.40)	7201 (64.20)	10559 (100)
1994-95	3974 (35.50)	7222 (64.50)	11196 (100)
1995-96	3501 (32.78)	7179 (67.22)	10680 (100)
1996-97	3621 (33.45)	7203 (66.55)	10824 (100)
1997-98	3742 (33.86)	7309 (66.14)	11051 (100)
1998-99	3720 (33.24)	7472 (66.76)	11192 (100)
1999-2000	3647 (33.03)	7394 (66.97)	11041 (100)

Note: Figures in bracket indicate % share.

Source: (1) Bangladesh Bureau of Statistics: "Statistical Yearbook of Bangladesh", various issues.

2.1 Fuel-wise Final Consumption of Commercial Energy

The fuel-wise final consumption of commercial energy in original commodity unit and the percentage share of each fuel are shown in table-2. In 1976-77, the consumption of coal, petroleum products, natural gas and electricity were 259 thousand metric tons, 989 thousand metric tons, 125 million cubic metres and 1047 Gwh, respectively, and their respective percentage share was 13.09, 71.97, 8.38 and 6.56%. It is clearly observed that the consumption of coal declined over time with the increase of consumption of petroleum products, natural gas and

electricity. After the span of 20 years, in 1996-97, the respective consumption of these four categories of energy came to be 646 thousand metric tons, 1039 thousand metric tons, 1584 million cubic metres and 7422 Gwh, and their respective shares were 12.39, 28.7, 40.33 and 18.54%. It is observed that in original commodity unit the consumption of each type of fuel was increasing every year except the consumption of coal and petroleum products, which recorded a study decline.

Table 2 : Fuel-wise final consumption of commercial energy in Bangladesh

(Unit: in original commodity account)

Year	**Coal** (000'Metric Ton)	**Petroleum Products** (000'Metric Ton)	**Natural Gas** (Million Cubic Metre)	**Electricity** (Gwh)
1976-77	259 (13.09)	989 (71.97)	125 (8.38)	1047 (6.56)
1977-78	250 (10.93)	1140 (71.80)	172 (9.98)	1345 (7.29)
1978-79	186 (7.97)	1179 (72.76)	210 (11.94)	1381 (7.33)
1979-80	235 (8.85)	1331 (72.20)	248 (12.40)	1405 (6.55)
1980-81	246 (9.14)	1283 (68.63)	302 (14.90)	1595 (7.33)
1981-82	300 (10.64)	1239 (63.27)	365 (17.18)	2028 (8.91)
1982-83	163 (6.71)	1004 (59.53)	394 (21.53)	2399 (12.23)
1983-84	62 (2.46)	1979 (61.76)	426 (22.47)	2703 (13.31)
1984-85	98 (3.47)	1176 (59.94)	512 (24.05)	2860 (12.54)
1985-86	148 (4.76)	1215 (56.30)	603 (25.75)	3307 (13.19)
1986-87	233 (6.79)	1297 (54.44)	671 (26.19)	3484 (12.58)
1987-88	202 (5.51)	1479 (58.14)	651 (23.58)	3772 (12.77)
1988-89	54 (1.31)	1699 (59.48)	777 (25.07)	4695 (14.14)
1989-90	563 (12.02)	1702 (52.35)	817 (23.16)	4705 (12.47)
1990-91	180 (4.53)	1576 (54.91)	814 (26.14)	4870 (14.60)
1991-92	169 (3.92)	1605 (53.57)	820 (25.23)	6021 (17.28)
1992-93	63 (1.40)	1730 (55.68)	909 (26.96)	5760 (15.96)
1993-94	59 (1.22)	1787 (53.22)	1086 (29.81)	6149 (15.75)
1994-95	0 (0.0)	2174 (54.69)	1307 (30.30)	6934 (15.01)
1995-96	354 (7.10)	1280 (36.56)	1445 (38.03)	7454 (18.31)
1996-97	646 (12.39)	1039 (28.70)	1584 (40.38)	7822 (18.58)

Note: Figures in bracket indicate % share of total commercial energy consumption and used conversion factor (1 thousand ton of coal = 0.6944 TTOE, 1 million cubic metre of natural gas = 0.921678 TTOE and 1 Gwh electricity = 0.086 TTOE).

Sources: (1) Bangladesh Bureau of Statistics: "Statistical Yearbook of Bangladesh", various issues.

(2) Govt. of India (1979): " Report of the Working Group on Energy Policy", Planning Commission, New-Delhi.

2.2 Fuel-wise Final Consumption of Noncommercial Energy

The use of noncommercial energy has a significant role in Bangladesh economy and in 1976-77 more than 80% of the total energy was supplied from these sources. The percentage share of noncommercial energy decreased continuously with the increase in the use of commercial energy because of the income effect, and in 1996-97 noncommercial energy consumption came down to two-thirds of the total energy consumption (Table 1). The use of animal-dung was, however, an exemption. In 1976-77, the consumption of animal-dung, agricultural residues and fire-wood were respectively, 6.9, 14.5 and 0.6 million metric tons and their respective percentage shares were 25.2%, 71.1% and 3.7% (table-3). With the decline in the use of animal-dung and the increase in the use of agricultural residues and fire-wood, their respective consumption in 1981-2000 came to be 8.1, 22.22 and 2.2 million metric tons with their percentage shares of 19.0%, 75.5% and 5.5%, respectively.

Table 3 : Fuel-wise final consumption of noncommercial energy in Bangladesh

Unit: in million metric ton.

Year	Animal dung	Agricultural residues	Fire-wood
1976-77	6.9 (25.2)	14.5 (71.1)	0.6 (3.7)
1977-78	7.2 (24.9)	14.6 (71.3)	0.6 (3.8)
1978-79	8.4 (27.4)	14.9 (68.9)	0.7 (3.7)
1979-80	5.2 (18.6)	15.1 (76.7)	0.7 (4.4)
1980-81	5.2 (18.6)	15.4 (76.9)	0.7 (4.5)
1981-82	5.3 (18.7)	15.4 (76.8)	0.7 (4.5)
1982-83	5.3 (17.9)	16.4 (77.3)	0.8 (4.8)
1983-84	5.5 (18.4)	16.1 (77.0)	0.8 (4.6)
1984-85	5.6 (18.8)	16.0 (76.3)	0.8 (4.9)
1985-86	5.7 (18.1)	16.9 (77.2)	0.9 (4.7)
1986-87	5.7 (19.9)	14.8 (75.1)	0.8 (5.0)
1987-88	6.0 (19.7)	16.2 (72.2)	0.9 (8.1)
1988-89	6.4 (20.4)	16.5 (74.6)	0.9 (5.0)
1989-90	6.2 (18.9)	17.8 (76.8)	0.8 (4.3)
1990-91	6.3 (19.0)	17.3 (76.3)	0.9 (4.7)
1991-92	6.6 (19.7)	17.7 (75.1)	1.0 (5.2)
1992-93	6.7 (19.8)	18.2 (74.9)	1.0 (5.3)
1993-94	6.6 (19.2)	18.2 (75.2)	2.0 (5.6)
1994-95	6.7 (19.4)	18.3 (75.5)	2.1 (5.1)
1995-96	6.7 (19.3)	18.1 (75.4)	0.7 (5.3)
1996-97	6.7 (19.3)	18.2 (75.4)	0.7 (5.3)
1997-98	7.7 (19.24)	18.68 (75.3)	2.2 (5.46)
1998-99	7.9 (19.0)	19.32 (75.4)	2.1 (5.6)
1999-2000	8.1 (19.0)	22.22 (75.5)	2.2 (5.5)

Note: Figures in bracket indicate fuel-wise % share of total noncommercial energy consumption, and used conversion factor (1 million ton of jute-stick = 304.84 TTOE, 1 million ton of rice-straw = 297.75 TTOE, 1 million ton of rice-hulls = 302.34 TTOE, 1 million ton of bagasse = 181.35 TTOE, 1 million ton of twigs and leaves = 368 TTOE, 1 million ton of other wastes = 304.42 TTOE, 1 million ton of cow-dung = 207.1 TTOE and 1 million ton of fire-wood = 567.33 TTOE).

Sources: *(1) Govt. of India (1979): "Report of the Working Group on Energy Policy", Planning Commission, New-Delhi.*

(2) Bangladesh Bureau of Statistics (2000): "Statistical Yearbook of Bangladesh".

Section III: Energy Supply Scenario in Bangladesh

3.1 Commercial Energy Supply Scenario in Bangladesh

Bangladesh is not rich in mineral resources excepting natural gas. Yet the North-Eastern region of Bangladesh (adjacent to the Asam Basin in India) which is situated at the foothills of the Himalayan range formed out of ancient crush is well placed in the world map as a hydro-carbon rich country with its reserve of coal and natural gas.

3.1.1 Coal

Till date five coal fields have been discovered in Bangladesh. Among these the coal field of Jamalgonj in Joypurhut district is the biggest with an estimated reserve of 1053 million metric tons. The estimated coal reserves in the coal mines of Khalaspur at Rangpur district and Barapukuria at Dinajpur district are respectively, 685 and 389 million metric tons. The other two discovered coal fields are at Phulbaria and Dighipara in Dinajpur district, but at these coal mines the inside reserve of coal has not been estimated. The total amount of coal reserve estimated inside the three coal mines of the country is 2127 million metric tons which constitute only 0.2% of the world' bituminous coal reserves.

3.1.2 Natural gas

In modern world natural gas is considered to be the most important after petroleum products as primary fuel. It is replacing petroleum as a commercial energy. The use of natural gas has been increasing day by day with the development of the new scientific technologies throughout the world and also in Bangladesh. Consequently it has already become an important fuel resource in this country. Up to January 2005, the total number of gas fields explored in Bangladesh is twenty four. The total proven plus probable reserve of 20 gas fields is 23.099 TCF, of which recoverable reserve is 13.790 TCF (BBS, 2000). The new reserve of the last discovered four gas fields has not been estimated yet.

3.1.3 Petroleum Products

Bangladesh is not rich in petroleum products. The only oil field of the country discovered at Horipur in Sylhet can not produce petroleum significantly. This explains the total dependence of Bangladesh on imported oil and other petroleum products. The crude oil from Horipur oil field in past and at present the condensate obtained from the natural gas fields can meet a very small part of the total demand.

3.1.4 Hydro power

As delta plains feature the land pattern of most part of the country, the scope of hydel power generation is very limited in Bangladesh. The only hydel-power plant of the country on "Karnafulli" river at Kaptai in Chittagong Hill tracts contributes a lot to the economic development of Bangladesh. The installed capacity of this hydel-power plant is 230 Mwh. But depending on the water flow rate, the maximum annual generation of hydroelectricity from this plant is 900 Gwh. The potential of hydro power generation from the Sangu and Matamuhuri rivers in Chittagong Hill Tract is low, and they are not economically viable owing to the low rate of water flow in the said rivers.

3.2 Noncommercial Energy Supply Scenario in Bangladesh

Noncommercial energy is derived from traditional sources, such as agricultural residues, fire-wood and cow-dung. Agricultural residues are a sum of jute-stick, rice-hulls, rice-straw, bagasse, twigs and leaves. Almost 60% of the total energy consumption in Bangladesh is supplied directly or indirectly by crop residues of rice-straw, jute-stick, rice-hulls and bagasse (Russell, 1982). On the other side, forest supplies the basic need of the rural and the town people in the form of fuel and it is extensively used in both areas. Bangladesh possessed about 15.35 % forest area of the total geographical area in 1973-74 and it came down to about 13.16 % in 1999-2000.The total availability of firewood as of 1999-2000 is 9481 thousand cubic feet from these forest, which cannot meet even a half of the cooking requirements of the poor people. Homestead forests are also a source of fire-wood supply for the rural people. Dried dung of animal is extensively used as fuel in rural areas and also in towns. In 1999-2000, out of the total estimated production of 6.7 million metric tons of animal-dung to be burnt for energy about 30% is used for cooking purposes. About 22 million cattle and buffaloes are the source of animal dung (Table-4).

Table 4 : Main sources of noncommercial energy in Bangladesh

Name of fuels	Sources
Rice-straw and Rice-hulls	Rice cultivated area———26064 thousand in acres.
Jute-stick	Jute cultivated area———1701 thousand in acres.
Bagasse	Sugarcane cultivated area———412 thousand in acres.
Fire-wood	Forest area 19915 square kilometer.
Animal-dung	The cattle and buffaloes———21633 thousand in head.

Source: (1) Bangladesh Bureau of Statistics (2000): "Statistical Yearbook of Bangladesh".

3.3 Break up demand-supply gap for commercial energy

It is beyond any doubt that both commercial and noncommercial energy have significant positive contribution towards the economic development of a country. However, to enhance the pace of development more and more commercial energy has to be made use of. This is because, the demand for commercial energy is observed to be significantly high for almost all sectors of production in this populous country. In the past, noncommercial energy was used as fuel for cooking purpose to a large extent. However, recently a demand-supply gap is emerging in this respect (Shamim & Salahuddin, 1994 and Rahaman, 1998). On the other hand, resorting to noncommercial energy as a substitute to commercial energy by the industrial sector is putting gradually more pressure on the ecological balance. Indigenous supply of petroleum products is lacking while domestic natural gas and coal production is crippled by the complex web of restrictions imposed by foreign companies. This coupled with financial constraints, lack of proper technology and topological features of this country with its vast network of streams and rivers, is making the task of transmission and distribution of gas to its cities and towns next to difficult. It is making the use of natural gas very difficult in industries and as fuel in power plants as a substitute of imported petroleum products. Planning and implementation regarding the use of CNG in lieu of petroleum products in vehicles in transport sector did not see much progress. Though domestic coal production picked up in recent times, it had been largely an import item in earlier days. All these reasons explain why traditionally there has been a significant demand-supply gap in the commercial energy sector. We can see that, from 1976-77 to 1994-95, there was 100% demand-supply gap for each of the years as all the required coal was imported (table-5). An opposite picture is revealed in the case of natural gas where all the requirements were fulfilled from indigenous production and consequently there has been no demand-supply gap. In case of petroleum products, barring the condensate obtained from domestic gas fields, everything has been imported.

Table 5 : Fuel-wise demand-supply gap of commercial energy in Bangladesh

Year	Coal (000'Metric Ton)	Petroleum products (000'Metric Ton)	Natural gas (Million Cubic Metre)
1976-77	-259 (100)	-1050.63 (88.48)	0 (0)
1977-78	-250 (100)	-1282.52 (97.05)	0 (0)
1978-79	-186 (100)	-1331.80 (96.35)	0 (0)
1979-80	-235 (100)	-1485.90 (93.96)	0 (0)
1980-81	-246 (100)	-1483.60 (97.20)	0 (0)
1981-82	-300 (100)	-1466.00 (97.60)	0 (0)
1982-83	-163 (100)	-1173.40 (91.92)	0 (0)
1983-84	-62 (100)	-1346.37 (94.25)	0 (0)
1984-85	-98 (100)	-1457.09 (95.80)	0 (0)
1985-86	-148 (100)	-1641.00 (96.36)	0 (0)
1986-87	-233 (100)	-1578.00 (97.05)	0 (0)
1987-88	-202 (100)	-1602.50 (88.56)	0 (0)
1988-89	-54 (100)	-1761.16 (90.0)	0 (0)
1989-90	-563 (100)	-1678.29 (86.83)	0 (0)
1990-91	-180 (100)	-1479.76 (82.94)	0 (0)
1991-92	-169 (100)	-1552.70 (85.63)	0 (0)
1992-93	-63 (100)	-1754.20 (84.26)	0 (0)
1993-94	-59 (100)	-1913.09 (92.47)	0 (0)
1994-95	0 (0)	-2347.57 (93.41)	0 (0)

Note: Figures in bracket indicate percentage.

Section IV: Energy Intensities in Bangladesh

4.0 Overall Energy Intensity in Bangladesh

Overall Energy intensity (= Commercial Energy Consumption / GDP) in Bangladesh has been increasing in real terms. In the financial year 1976-77, total GDP was 301.67 billion taka and total commercial energy consumption was 1374 TTOE. In this situation the energy intensity was 4.55. Overtime energy intensity of Bangladesh economy increased and in 1999-2000, overall energy intensity was 4.63 (Table-6)

4.1 Energy Intensity in Agriculture Sector in Bangladesh

Agriculture Sector holds the major share in GDP, although its percentage share in GDP has been declining overtime.

The energy intensity of agriculture sector is much lower compared to other sector in Bangladesh as shown in table 7. Energy intensity of this sector increased from 0.357 in 1996-99 to 1.711 in 1999-2000. In some years a big change occurred in energy intensity in this sector. For example in 1987-88, energy intensity was 1.871 which was double of this previous years and it was 2.136 in 1988-89. Flood, cyclone, flow-tide, and drought are the reason for the big change in energy consumption in those two years. Specially the cyclone and flow-tide of 29.11.1988 was most destructive (Bangladesh Compendium of Environment Statistics, 1797).

Table 6 : Trend in energy intensity in Bangladesh

Years	E/Q	Years	E/Q	Years	E/Q
1976-77	4.55	1984-85	4.82	1992-93	5.54
1977-78	4.91	1985-86	5.08	1993-94	5.75
1978-79	4.78	1986-87	5.38	1994-95	6.52
1979-80	5.40	1987-88	5.58	1995-96	5.45
1980-81	5.30	1988-89	6.12	1996-97	5.33
1981-82	5.48	1989-90	6.53	1997-98	5.32
1982-83	5.50	1990-91	5.58	1998-99	5.06
1983-84	4.42	1991-92	5.58	1999-2000	4.63

Note: Energy in TTOE and GDP in Billion taka at constant (1984-85) price

Table 7: Sector wise energy intensity and share of total GDP

	Agriculture		Commerce & Services		Industry		Transport	
Years	E/Q	%share of total GDP	E/Q	% share of total GDP	E/Q	% share of total GDP	E/Q	% share of total GDP
1976-77	0.357	46.3	0.836	31.3	15.88	11.1	10.242	11.1
1977-78	0.607	46.6	0.886	31.8	17.76	10.5	11.009	10.8
1978-79	0.369	44.2	0.957	33.6	15.99	11.1	10.968	10.8
1979-80	0.632	43.9	0.913	33.8	18.38	11.2	11.964	10.8
1980-81	0.561	44.2	0.983	34.4	19.24	10.5	11.841	10.6
1981-82	0.642	43.8	1.000	34.5	21.56	10.4	10.708	10.9
1982-83	0.750	43.5	0.925	34.8	16.62	10.1	8.488	11.1
1983-84	0.717	42.7	0.933	35.4	14.94	10.3	9.117	11.6
1984-85	0.998	41.8	0.915	36.6	17.28	9.8	9.675	11.2
1985-86	1.166	41.3	1.123	37.3	17.89	9.7	9.041	11.1

Years	Agriculture		Commerce & Services		Industry		Transport	
	E/Q	%share of total GDP	E/Q	% share of total GDP	E/Q	% share of total GDP	E/Q	% share of total GDP
1986-87	0.987	34.9	0.991	37.5	21.35	10.1	9.159	11.8
1987-88	1.871	38.4	1.127	39.1	18.75	9.8	9.379	11.9
1988-89	2.136	37.1	0.931	40.0	19.74	9.8	10.432	12.1
1989-90	1.555	38.3	0.775	38.8	25.89	9.9	10.573	11.9
1990-91	1.403	37.6	0.584	39.5	18.18	9.8	12.553	11.8
1991-92	1.529	36.9	0.525	39.7	18.93	10.1	12.249	11.8
1992-93	1.339	35.9	0.596	40.1	14.15	10.5	14.264	11.9
1993-94	1.574	34.6	0.531	40.7	14.53	10.9	13.780	12.0
1994-95	2.435	32.8	0.594	42.0	14.96	11.3	15.451	12.1
1995-96	1.926	32.2	0.585	42.4	13.69	11.3	13.337	12.1
1996-97	1.846	32.4	0.506	42.4	13.08	11.1	12.800	12.2
1997-98	1.932	31.6	0.478	44.6	12.37	11.5	12.592	12.3
1998-99	1.858	31.6	0.447	45.3	11.88	11.3	12.028	12.4
1999-2000	1.711	32.3	0.427	44.3	11.36	11.1	10.389	12.3

Source: Dersived from BBS, Statistical yearbook of Bangladesh, various issues.

4.2 Energy Intensity in Commerce and Services Sector in Bangladesh

The energy intensity in this sector is much lower than that in other sectors. Among the 24 years (1974-75 to 1999-2000) of our discussion, in the first 12 years (from 1974-75 to 1987-88), this sector was second to agriculture with respect to energy intensity but in the next 12 years this sector overtook the agriculture sector in this respect.

4.3 Energy Intensity in Industry Sector in Bangladesh

This sector is a highly energy intensive sector. Energy consumption by this sector is relatively higher than other sectors but its share in GDP is much lower than other sector. In 1976-77 this sector's energy intensity was 15.88 and share in GDP was 11.1%. The gradually increasing price of oil in the world market, political instability of the country such as strikes and hartal, the gradually decreasing demand for jute products of Bangladesh in foreign market and the political conflict among oil-rich countries of the Middle East affected the energy intensive sectors of Bangladesh economy. Energy intensity of this sector fluctuated during the period 1976-77 to 1989-90 and it reached the maximum value of 25.89 in 1989-90. After that the energy intensity started decreasing in this sector and reached 11.36 in 1999-2000. The reason behind this was a vast change in the

structure of the industrial sector, for example the decline of the energy-intensive jute industry on the one hand and the rise of low energy intensity readymade garments industry on the other. The low energy intensity of export-oriented, ready-made garments and other agro-based industries strengthens the case for their further expansion.

4.4 Energy Intensity in Transport Sector in Bangladesh

The Transport sector of Bangladesh is greatly dependent upon petroleum products. Recently some vehicles in Dhaka city have been transformed to CNG and this process is continuing resulting in the use of natural gas to some extent in the transport sector. However, in the financial year 1976-77 this sector used 343TTOE commercial energy with energy intensity amounting 10.242 and contributing about 11.1% of the total GDP. As the sub-sectors of this sector, the contribution of Bangladesh Railways and Bangladesh Biman to GDP is rather small. In 1976-77, the Bangladesh Railways used 129.16 TTOE energy while it could add only 0.271 billion taka and to GDP the airline added only 0.275 billion taka. The energy consumption by the latter in relation to its value addition is however, very low.

The energy consumption in this sector has been increasing although the energy intensity during 1982-83 to 1987-88 was a little bit low. The increasing use of bus and trucks and the use of old vehicles in road transport are partly responsible for the rise in energy intensity in this sector. The growth rate of motorized vehicles of road transport was 1302% over the period 1972 to 2000. However, although the transport sector is highly energy intensive, it is no less important than other sectors. In this sector, the use of fuels can be minimized if a proper conservation policy is adopted.

Section V: Indicators of Energy Use in Bangladesh

5.1 Indicators of Energy Use in Agricultural Sector

The purpose of this section is to analyze the pattern and trend in commercial energy usage in the agriculture sector in Bangladesh and to forecast its future demand. An analysis of commercial energy consumption pattern in this sector indicates that some commercial energy is used directly and some indirectly. Among direct usage, mention can be made of power tiller and tractor in harvesting and thrashing, irrigation by deep tube well, shallow tube well and low lift pump, drainage of surplus water and use of pesticides by mechanical instruments etc. On

the other hand, the use of fertilizers can be considered the primary source of indirect usage (fertilizes that require natural gas as one of the main inputs in the production process). Fuels that are used directly are mainly petroleum products and electricity. However, petroleum products in this type of usage mainly comprise of diesel oil and a small part of High Speed Kerosene Oil (HSKO). The major portion of the equipment used is privately owned. The flood control project run by the Bangladesh Water Development Board is run totally by electric power. In addition electric power is also used to run a small number of tube well and low fit pumps. However, though the agriculture sector often gets the benefits of irrigation through natural means, it becomes counter-productive at times. To compensate the effect of a devastating flood, often additional efforts are made to raise the productivity in the following dry season. This entails additional energy as a result of which we see considerable fluctuation in the annual commercial energy consumption.

We can now consider, under the overall perspective, that the commercial energy usage depends on the area cultivated by modern methods. If we consider the commercial energy usage in agriculture as the dependent variable (Y) and the irrigated area under modern method as the independent variable (X), then the true relationship among the variables can be given as:

$$Y = a + bx$$

In this analysis we use time series data for 18 years from 1982-83 to 1999-2000, where commercial energy consumption is expressed in physical units (TTOE) and the unit of cultivated area under modern method has been in thousand acres (Table 8)

Table 8 : Cropping intensity and area irrigated by modern method in Bangladesh

Years	**Intensity of Cropping** (in thousand acres)	**Area Irrigated by modern method** (in thousand acres)	Years	**Intensity of Cropping** (in thousand acres)	**Area Irrigated by modern method** (in thousand acres)
1982-83	155.04	2330	1991-92	173.06	5357
1983-84	153.96	2681	1992-93	174.35	5745
1984-85	152.18	3026	1993-94	174.51	5523
1985-86	154.47	3080	1994-95	174.63	6618
1986-87	150.72	3318	1995-96	173.18	7690
1987-88	166.75	3706	1996-97	175.71	7917
1988-89	168.19	4458	1997-98	176.79	8074
1989-90	168.41	4708	1998-99	174.73	8617
1990-91	171.70	4836	1999-2000	175.45	9135

Source: Bangladesh Bureau of Statistics (2000): "Statistical Yearbook of Bangladesh".

Now we try linear regression for relating dependent variable (Y) and explanatory variable (X) and we calculated correlation between the both variables using log values.

$$\text{Log } Y_t = \text{Log a} + b \text{ Log } X_{t,} \qquad [\ t = 1, 2, 3,\text{……..T}\ ]$$

Assuming a Stochastic behavior,

$$\text{Log } Y_t = A + b \text{ Log } X_t + U_t$$

We apply Ordinary Least Square (OLS) to derive estimates A and b. b gives us direct estimates of energy elasticity with respect to modern method irrigated area. The results of the complete model are given in Table 9.

Table 9 : Estimated Result of Agriculture Energy - Irrigated Area Elasticity

Dependent Variable	**A**	**B**	**t**	**R^2**	**D-W**
Agricultural Energy (Commercial)	-2.2020	0.9230	0.8550	0.820	0.3420

In table 8, a simple agricultural commercial energy consumption function has been estimated with modern method irrigated area. The result shows that there is a close association between the two variables. This implies that a 1% increase in area cultivated by modern method will lead to 0.923% increased in commercial energy consumption in the agricultural sector in Bangladesh. The negative value of the intercept term implies very low consumption level in the base period. During the period under consideration, there is a sharp increase of commercial energy use in the agricultural sector in Bangladesh. The value of R^2 is quite high (0.82), which implies that the modern method irrigated area has power in explaining commercial energy consumption in this sector.

Table 10 : Commercial Energy Consumption in the Manufacturing Industries of Bangladesh

Years	Commercial Energy consumption (TTOE)	Years	Commercial Energy consumption (TTOE)
1981-82	294.57	1991-92	1430.86
1983-84	394.77	1993-94	1624.45
1985-86	291.53	1995-96	1729.26
1987-88	731.35	1997-98	1593.01
1989-90	1577.05		

Table 11 : Overall Energy Industry for CMI

Years	E/Q	Years	E/Q
1981-82	0.0061	1991-92	0.0064
1983-84	0.0063	1993-94	0.0049
1985-86	0.0039	1995-96	0.0034
1987-88	0.0082	1997-98	0.0027
1989-90	0.0078		

5.2 Energy Demand Analysis in the manufacturing Industries of Bangladesh

Bangladesh has a narrow industrial base but demand for industrial goods has increased due to sharp increase in demand for domestic consumption and export of specific industrial goods. This sub section enquires into the nature and pattern of the demand for commercial energy consumption in manufacturing industries.

5.2.1 Overall Energy Intensity for Manufacturing Industries

Energy intensity is defined as the ratio of total commercial energy consumption to total output in a particular year. Table 10 represents commercial energy consumption for manufacturing industries in Bangladesh, and Table 11 shows the overall energy intensity in industries. In 1987-88, energy intensity increased to 0.0082. In the following years energy intensity steadily declined and reached 0.0027 in the year 1997-98.

5.2.2 Selected Energy Intensive Industries for CMI Group

We have identified nine industries as highly energy intensive industries. These industries are Food Manufacturing Industries (CMI code no. 311-312), Wood and Cork Products Industries (CMI code no. 331), Paper and its Products Industries (CMI code no. 341), Industrial Chemical Industries (CMI code no. 352), Petroleum refineries and its Products Industries (CMI code no. 354-355), Glass and its Products Industries (CMI code no. 362), Non metallic minerals Industries (CMI code no. 369), Fabricated metal Industries (CMI code no. 381-382), and Scientific Precision etc. Industries (CMI code no.386).

5.2.3 Share of Energy intensive and Energy Non-Intensive Industry Group

In the manufacturing sector in Bangladesh, we have classified industries as energy intensive and energy non intensive industries, and we calculated the share of energy intensive industries (S_1) and the share of energy non-intensive industries (S_2) in the total number of manufacturing industries separately (Table-12).

Table 12 : % share of Energy intensive and Energy non intensive Industry Groups in total manufacturing output

Years	S_1(Energy intensive)	S_2(Energy non intensive)
1981-82	0.152	0.848
1983-84	0.171	0.829
1985-86	0.182	0.818
1987-88	0.223	0.777
1989-90	0.299	0.701
1991-92	0.282	0.718
1993-94	0.140	0.860
1995-96	0.148	0.852
1997-98	0.569	0.431

The classification between energy intensive and energy non intensive has been done based on an assumption as follows:

For S_1, e_i(energy intensity) > Overall energy intensity, and

S_2, e_i < Overall energy intensity

Table 13 : Energy use in Transport Sector

Years	Energy (TTOE)	Years	Energy (TTOE)
1976-77	399	1988-89	590
1977-78	435	1989-90	626
1978-79	437	1990-91	763
1979-80	463	1991-92	776
1980-81	460	1992-93	952
1981-82	433	1993-94	966
1982-83	364	1994-95	1140
1983-84	407	1995-96	1039
1984-85	451	1996-97	1062
1985-86	429	1997-98	1088
1986-87	479	1998-99	1097
1987-88	509	1999-2000	1132

Source: Bangladesh Bureau of Statistics (2000): "Statistical Yearbook of Bangladesh".

In other words, those industries will be considered to be energy intensive whose energy intensity is greater than the overall energy intensity, and those industries whose energy intensity is less than overall energy intensity are considered as energy non- intensive industries.

5.3 Energy Demand Analysis in Transport Sector of Bangladesh

Petroleum products are the major source of fuel in the transport sector of Bangladesh. With the rapid growth of population and the increase in the number of vehicles in road sub-sector, commercial energy consumption is increasing in the transport sector. In 1994-95 the use of petroleum products stood at 1140 thousand metric tons which was 28.7% of the total commercial energy of the country. In 1999-2000 the amount of commercial energy consumption in this sector was 1132 TTOE which was 31.04% of total commercial energy consumption. The overall growth of energy consumption was 6.48% during the period 1976-77 to 1999-2000.

5.3.1 General Feature of Bangladesh Transport Network and Growth of Different Modes

The transport system of Bangladesh consists of roadways, railways, inland waterways, two sea-pots and civil aviation in both domestic and international traffic. In 2000, there are about 21174 km. of paved road, 2768 route-km. of railways, 3600 km. of perennial waterways which increases to 5968 km. during the monsoon, two sea ports, and three international and eight domestic air ports.

Bangladesh witnessed rapid growth of transport since independence. The overall growth rate is nearly 6.05% freight carried and 8.4% for passenger carried. As both freight carried and passenger carried by the Bangladesh Biman are negligible, Bangladesh railways, Bangladesh roadways and Bangladesh inland waterways are our main concern.

5.3.2 Energy used in Bangladesh railway

Bangladesh Railway consumes about 33.49% of transportation energy in which the share of coal and petroleum products is, respectively, 38.6% and 61.4%. Energy consumption of Bangladesh Railway is decreasing. In 1976/77 total energy consumption of Bangladesh Railway was 33.49% of total transport energy but in 1997-98 it was only about 3.66%.

5.3.3 Energy used in Bangladesh roadway and Bangladesh waterway

As there are no separate documents on fuel consumption of Bangladesh road transport and Bangladesh water transport, we may get the fuel consumption of road and water transport by deducting the fuel consumption used in railway sub sector from total transport energy. Though there is the question at air transport, it is insignificant. The fuel consumption was 265 thousand metric ton in 1976-77, which was 66.5% of total transport energy consumption (Table 14).

Trucks and buses use two-thirds of fuel used by the road sub-sector and the amount is increasing rapidly. The use of fuel rose to 1048 TTOE in 1997-98, which was 96.3% of transport energy, and overall growth rate was 7.26%.

Table 14 : Sub-sector wise Energy Consumption in transport sector

Years	Railway (TTOE)	Roadway & Waterway (TTOE)	Total Transport Energy (TTOE)
1976-77	134	265	399
1977-78	133	302	435
1978-79	129	308	437
1979-80	118	345	463
1980-81	102	358	460
1981-82	94	339	433
1982-83	69	295	364
1983-84	62	345	407
1984-85	61	390	451
1985-86	56	373	429
1986-87	53	426	479
1987-88	52	457	509
1988-89	52	538	590
1989-90	52	574	626
1990-91	47	716	763
1991-92	47	729	776
1992-93	42	910	952
1993-94	40	927	966
1994-95	41	1099	1140
1995-96	38	1001	1034
1996-97	40	1022	1062
1997-98	40	1048	1088
1998-99	NA	NA	1097
1999-2000	NA	NA	1132

5.4 Indicators of Energy Use in Bangladesh Residential Sector

Generally in domestic sector commercial, non commercial renewable and non-conventional energy are used. More and less commercial energy is used in the urban area. In recent times renewable and non conventional energy have been added to commercial energy with the help of Government and non-government organizations, and these are increasingly being used in both urban and rural areas. However the quantum of energy used differs across households depending on their income, numbers of members in the family and housing conditions of the household, which influence their energy demand.

In this context, it is to be mentioned that 18% of population in Bangladesh use electricity for lighting purpose. Among them 76.43% are urban and 13.91% are rural. Insufficient supply and improper transmission of electricity generation remain a major problem. The generation of electricity, its transmission and distribution all remain very feeble in the western region compared to the eastern part. On the other hand, the eastern part being rich in gas field, people can use gas for cooking purpose. The poor in urban areas who can not afford to buy fuel sometimes have to take ill cooked or semi cooked food, and the rural people use kerosene for lighting purposes.

Table 15 : Fuel-wise energy in residential sector

Years	Coal (000, M.ton)	Petroleum (000, M.ton)	Natural gas (mn.cum.)	Electricity (GWH)	Convert TTOE
1976-77	0	342	18	147	371.23
1980-81	0	388	84	268	488.47
1984-85	0	335	184	543	518.11
1988-89	0	443	262	1044	774.26
1992-93	0	370	370	2093	891.02
1996-97	N.A	N.A	N.A	N.A	1060
1999-2000	N.A	N.A	N.A	N.A	1064

According to the 1991 population census, 72% of urban households and 99% of the rural households use biomass fuel for cooking purposes. Household-wise use of kerosene, gas and electricity for cooking is 2.32%, 20.43% and 5.12%, respectively, in urban areas, and 0.36%, 0.20% and 0.38%, respectively, in rural areas. Sixty three percent households in urban areas and 8.59% households in rural areas use electricity for illuminating purpose. Kerosene is used in 37% urban households and 91% rural households for lighting. This scenario is not at all

promising for the economic development of the country. Innumerable families are plugged in darkness. The result is excessive dependence on fire wood, cow dung and agricultural residues leading to deforestation and pollution at a large scale.

Demand for commercial energy has been growing at a rapid rate in the residential sector. For example average annual growth rate of commercial energy was 5.08% during 1977-78 to 1999-2000. Large section of the population of the country can not get these (gas and electricity) facility but demand is very high. The main drivers of energy demand in this sector are population growth and their income.

A log-linear regression model has been tried to relate residential energy consumption (Dependent variable) and real GDP and population (the two explanatory variables). The elasticity estimates have been derived.

For estimation, annual time series data from 1976-77 to 1999-2000 for residential energy consumption in physical unit (TTOE) and GDP at constant 1984/85 prices, and population in million have been used.

The a log-linear relationship estimated between consumption of Domestic Energy, Real GDP and Population is as follows:

$$\text{Log } G_t = \text{Log } a + b_1 \text{Log } Y_t + b_2 \text{ Log } P_t, \quad [t = 1, 2, 3, \ldots\ldots\ldots\ldots T]$$

where, G_t is the commercial energy consumption in residential sector; Y_t, the real GDP in billion taka in 1984/85 prices; and P_t, the population in million of Bangladesh at time t.

Assuming a stochastic behavior,

$$\text{Log } G_t = A + b_1 \text{Log } Y_t + b_2 \text{ Log } P_t + U_t$$

OLS method has been applied to derive estimates for A, b_1, and b_2. b_1 and b_2 give the direct estimates of residential energy elasticity with respect to GDP and population.

The estimates are shown in table-16.

The long run population elasticity of domestic energy (b_2) has been found in this table to be quite high, 2.651, indicating that a significant increase of domestic energy demand can be expected the increase in population in Bangladesh. The GDP elasticity (b_1) is 1.5335 which is also high but from less than population elasticity (b_2).

Table 16 : Results of Regression

Independent variable	Residential energy consumption
Constant	- 5.768
GDP	1.5335
Population	2.651
R^2 adj.	0.947
adj. R^2	0.942
D-W	0.737

Section VI: Analytical Framework for Energy Demand

It is crucial that we accurately identify the determinant of energy consumption. Most studies have isolated GDP, population, and index of industrial production as broad determining factors. However, it is Energy-GDP relationship, which is the most interesting and which has attracted a lot of attention. Most studies have postulated a positive relationship between these two variables. Darmstader et. Al. (1971) has studied in great detail the correlation between energy consumption and nation income. The important conclusion was that a positive relation between GDP and energy holds both cross-sectionally and historically. However, even though this connection between energy consumption and GDP may be quite obvious, the chain of causation between these two factors is not very clear. This is so because it has been observed that causality between energy and GDP is not necessarily unidirectional. Nevertheless, energy-GDP elasticity has an important policy implication. For the period of 24 years from 1976-77 to 1999-2000 we analyze the energy-GDP relationship for Bangladesh economy. The different elasticity estimates are defined as:

(i) Total Energy – GDP elasticity.

(ii) Commercial Energy – GDP elasticity.

(iii) Noncommercial Energy – GDP elasticity.

For estimation, annual time series data an annual basis for total energy consumption, commercial energy consumption and noncommercial energy consumption in physical unit (tons of oil equivalents) and GDP at constant prices (base year 1984-85 and prices in billion taka) have been used. Data have been complied from the Statistical Yearbook of Bangladesh, various issues, published by Bangladesh Bureau of Statistics.

We take a hypothetical a log linear relationship between energy consumption and real GDP.

$$\text{Log Energy} = \text{Log a} + b \text{ Log GDP}_t \qquad [t = 1, 2, 3, \ldots\ldots\ldots T]$$

where i= total energy consumption, commercial energy consumption, noncommercial energy consumption.

Assuming a stochastic behaviour,

$$\text{Log Energy} = A + b \text{ Log GDP}_t + U_t$$

We apply OLS to derive estimates for A and b. b gives us a direct estimate for energy –GDP elasticity. The estimated results are shown in table-17. The estimated coefficients represent long run income elastic ties of total energy, commercial energy and noncommercial energy consumption. The long run income elastic ties of energy consumption have been found to be quite high for commercial energy, at 1.3781, indicating that a significant increase in commercial energy demand can be expected as GDP in Bangladesh increases, and the long run noncommercial energy elasticity is 0.3654 , indicating relatively less significant increase in demand than commercial energy.

Table 17 : estimate results of energy-GDP elasticity

Dependent variable	B	T	R2	D-W
Total energy	0.6352	18.008	0.936	0.926
Commercial energy	1.3781	14.972	0.911	0.775
Noncommercial energy	0.3654	12.690	0.880	1.638

Section VII: Summary and Conclusion

The findings of this study can be summarized as follows: (a) There has been a shift in energy consumption from noncommercial energy sources to commercial energy sources; (b) The growth of commercial energy consumption has been very fast; (c) Indigenous natural gas is the main mineral resource in Bangladesh; (d) Agriculture and commerce & service sectors are less energy intensive sectors; (e) Industry and Transport sector are highly energy intensive; (f) GDP is the main driver to the consumption of commercial energy; (g) Irrigation by modern method

is the main driver to the consumption of commercial energy in agriculture; (h) Nine industries are highly energy intensive, but the number of energy intensive industries is increasing; (i) Passenger-km. and ton-km. are the main drivers for transportation energy consumption; (j) Socio-economic factors, viz. population and income growth are drivers to commercial energy consumption in the residential sector; and (k) there is the need for efficient energy planning to fulfill the country's growing energy requirement. Given that about 82% of the population of this country can not get electricity facility, about 92% of the population can not get gas facility for cooking in domestic sector, agriculture and industrial sectors often face energy crisis, and the transport sector is heavily dependent on imported petroleum products, a proper use of our indigenous natural gas and coal resources through formulation and adoption of appropriate policies can provide the right answer.

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