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Towards a Carbon Tax in Bangladesh

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Development Context

Bangladesh is a strong actor in the effort to reduce global carbon emission. This is appropriate as it faces a major adverse burden from global climate change. Although per capita carbon emission is low, total carbon emission in Bangladesh is growing. Consequently, as a good global team player, Bangladesh committed to reducing its carbon footprint in its Intended Nationally Determined Contributions (INDC) submissions in 2015.

The main source of CO2 emission is the use of fossil fuel in both combustible and non-combustible forms. On a long–term basis, CO2 emissions in Bangladesh grew at an annual average rate of 7.2% over 1970-2016. The CO2 trend for the more recent years (2004-2016) shows an even faster growth at 9.2% annually owing to the growing influence of urbanization and associated industrialization and use of electricity. From a sectoral perspective, the power sector is dominant CO2 emitter, with emission growing at an annual average rate of 8.8% per year, which is significantly faster than the average rate of growth of CO2 for the economy. As a result, its share in CO2 emission surged from 22% in 1970 to 44% in 2016. Transport sector emission also grew faster than total CO2, as a result of which its share in total CO2 emission nearly doubled from 7.9% in lower 1970 to 14% in 2016. Both also show emission growth spikes in the more recent years of 2004-2016. The growing contribution of these two rapid emitters is the primary reason for the spike in total CO2 emission in the recent years. Emissions from buildings and industrial sector grew somewhat slower, causing their shares in total CO2 emission to fall substantially. However, there is a similar spike in emission growth from industrial sector during 2004-2016.

This pattern of sectoral contributions to CO2 emission has major implication for future outlook for CO2 emission. Under the business as usual (BAU) policy framework of the present time, the outlook for further growth of CO2 emission is highly unfavorable. As Bangladesh grows faster with concomitant increases in industrialization and urban development, the demand for power will surge. Industrialization and urbanization will also lead to faster demand for transport services. Both these fast-growing CO2 emitters along with the spike in industrial emission in recent years will increase the overall growth of CO2 from the 9.2% in recent years (2004-2016) to 10% plus. Indeed, the observed GDP elasticity of carbon emission during 2004-2016 of 1.4 suggests that CO2 emission will likely grow by 11.2% under a GDP growth scenario of 8%.

However, international experience suggests that the CO2 elasticity of GDP tends to fall as income grows. Energy intensity of production typically tends to rise at low levels of income and then falls and stabilizes at below one. Under these assumptions, the projected path of CO2 emission is flatter than in the BAU case. Even with moderated growth in CO2 emission over 2025-2041 periods, CO2 is projected to grow at around 10% per year. This rapid rate of CO2 emission will be inconsistent with Bangladesh's global commitment to reduce the growth of CO2 emission and must be addressed speedily through a major reform of carbon reduction policies including reform of fuel prices and the introduction of carbon taxes.

The Case for a Carbon Tax

A review of the environmental policies shows that the overall environmental management including control of air pollution relies heavily on command and control type instruments comprising of laws, regulations and standards. There is very little use of incentive policies especially taxes and pricing policies. Indeed, by providing heavy subsidy on natural gas and fuel oil, Bangladesh provides an incentive for excessive consumption of fossil fuel. Therefore, fossil fuel pricing policies are inconsistent with CO2 reduction objective. This is a fundamental contradiction in environmental management in Bangladesh that must be addressed soon.

International experience shows that environmentally sensitive countries have taken several measures to reduce the rate of growth of CO2 emission. One major policy initiative is the adoption of renewable energy for power generation. Globally, the share of renewable energy in power production has increased from 20% in 1990 to 25% in 2017. The EU countries have moved much faster than the rest of the world. Thus, its relative share of renewable energy for power production has expanded from 13% in 1990 to 30% in 2017. Germany and United Kingdom provided leadership to this transformation. As compared to these, the relative share of Bangladesh has gone down from 9.79% in 1990 to a mere 1.6% in 2017. The main reason for this decline is that almost all additional power generation since 1990 rely on use of fossil fuel. In Bangladesh, there is only one hydropower station linked to the Kaptai dam. The installed capacity of 230MW reached in 1988 has remained fixed at that level since then. Progress with other renewable energy has not happened in any significant way. At the national grid level, solar and wind account for only 3MW of installed capacity (0.02% of total installed capacity). There is better progress at the non-grid sources particularly at the household level where solar housing project and solar irrigation promoted through IDCOL has achieved better success. Nevertheless, as a source of power, wind and solar energy account for a mere 1% of total electricity generated in Bangladesh.

The government has put considerable emphasis to promoting non-hydro renewable energy. A Renewable Energy Policy was adopted in 2008. The policy set a target of 5% share of renewable energy for power generation for 2015 and 10% share for 2020. Both targets will be missed. Apart from excessive focus on mega power projects based on fossil fuels including LNG and coal, the policy framework for Renewable Energy is not conducive to the adoption of clean energy. A major contradiction is the continued subsidization of fossil fuel. In countries that have moved ahead successfully with renewable energy the incentive policies were set properly. Use of fossil fuel has been taxed considerably to discourage its use. These taxes are as high as 70% in many European countries, especially the UK even though the UK is a major oil producer. India and China have also introduced a carbon tax to discourage the use of carbon emitting fossil fuel. If Bangladesh wants to promote wind and solar energy in power and other uses, it must set the policy framework for renewable energy accordingly. A key policy priority is to reform the fuel prices. It must eliminate the fuel subsidy and instead adopt a well-defined carbon tax to discourage the consumption of fossil fuel and promote the expansion of renewable energy.

Since use of fossil fuels is a major source of carbon emission, several countries have adopted a carbon tax. Simply defined a carbon tax is levied on the carbon content of fuels. An alternative instrument to carbon tax is the use of emission trading systems (ETS) whereby the government fixes the total volume of emission for each type of polluting industry and allocates these pollution rights to industries through an auction system. Conceptually the two instruments are equivalent. Global experience shows that while some countries have adopted either a carbon tax or an ETS, some countries have used both. The choice of instrument is based on a number of factors including administrative capabilities, pollution measurement and monitoring readiness and political economy considerations. The limitations of developing countries in the first two areas suggest a preference for carbon taxes on inputs.

Although only a limited number of countries have introduced a proper carbon tax or adopted an ETS scheme because of political opposition to the potential cost-cascading effects of a full-blown carbon tax, most oil importing countries impose a tax on gasoline over and above the normal VAT or sales tax. This is a special levy in the form of an excise tax that is usually set in relation to the carbon content of the liquid fuel. The cost cascading effects are moderated by either levying the tax at the gas pump only or by exempting sensitive sectors. Thus, a gasoline tax (petrol and diesel) at the pump gate raises the cost of transport but does not directly affect electricity and manufacturing production. Also, in this case other primary fuels such as natural gas, furnace oil, kerosene and coal are outside the tax net. While gasoline taxes are often conceived as a road user charge earmarked for road maintenance (as in the USA), these taxes are increasingly being used as an environmental tax to reduce consumption of fuel oil in transport. It is not surprising therefore that tax rates are very high in OECD countries except USA, including countries that have not introduced a carbon tax. The UK for example imposes a tax rate of about 71% on gasoline as compared with only 23% in USA. India's tax rate of 42% exceeds rates in Australia, Canada and USA showing its growing commitment to reducing carbon emission.

Approach to Carbon Tax in Bangladesh

The gasoline tax can be conceived as a part of a longer-term plan to introduce a proper carbon tax at a later stage. This is how it has progressed in some countries that have introduced a carbon tax. For example, in India the carbon tax emerged first in 2010 as a tax on domestic coal but was later broadened to include petrol and then diesel. So, essentially, the carbon tax in India emerged over a 5-year period in different stages. The tax rates have also been adjusted gradually.

This pragmatic approach is best suited to the current political economy environment of Bangladesh. The pricing reform for natural gas is off the table and the government will not accept taxation of fuel oil or coal for electricity generation to avoid electricity cost escalation. Similarly, the government will oppose the taxation of kerosene to avoid pass through effects on the poor. Consequently, the taxation of petrol and diesel presents the most promising option for introducing a carbon tax. The elimination of fuel oil subsidy at the pump gate through proper pricing policy is a first step in a sequential program to reducing carbon emission from the use of fuel oil. This reform can be combined with the imposition of an excise duty on petrol and diesel that is in addition to the normal applicable VAT. The initial rate of the carbon tax can be determined based on expected carbon reduction, the amount of resources mobilized and the level of political comfort. The tax rate can also be varied in relation to international prices. Thus, the tax rate can be increased when oil prices are low and reduced when international oil prices go up. A similar approach is used in India.

Simulation Results

To illustrate the importance of a carbon tax as an instrument for CO2 reduction, this paper provides a quantitative example of how a specific carbon tax on gasoline might work. The simulations use two models: a model that estimates the revenue and CO2 reduction effects of a carbon tax on gasoline and a second model that incorporates the general equilibrium effects of this carbon tax for output and prices. Two Policy Scenarios are considered. A Low Policy Case (LPC), where the tax is imposed only on gasoline (petrol, octane and diesel); and a High Policy Case (HPC), where the tax is also imposed on furnace oil and kerosene.

In both cases the carbon tax has a strong effect on both CO2 reduction and revenue generation. Much of the effect comes from the diesel component as it dominates the volume of consumption in the transport sector and is also used in agriculture for irrigation purposes. For both Scenarios the CO2 reduction effects strengthen over the years as substitution of clean energy for diesel happens and there is a cumulative build up in the reduction in the use of diesel and gasoline. There are also efficiency gains from better technology and energy conservation in transportation and irrigation. The revenue effects are large even in the first year with a collection of Taka 43 billion in the LPC, growing to Taka 137 billion in FY2031. Revenues are higher in the HPC. Clearly, as far as carbon reduction and revenue gains are concerned, the proposed carbon tax is a win-win.

The output and employment effects depend upon the ease of substitution of clean energy for fossil fuel. In the short term, defined as 2-3 years, there is a decrease in GDP with the largest reduction in transport services, which in turn causes declines in industry and agriculture. It is assumed that efficiency improvements and substitution of clean energy /technology takes effect from FY2022 onwards. This is a reasonable assumption. Although presently Bangladesh is lagging behind on substitution prospects especially for renewable energy, globally the technology is out there and with proper pricing policies for fuel oil along with the carbon tax, private investment will help facilitate substitution prospects as well as create incentive for more efficient energy use and adoption of clean fuel technology. For example, solar power has already become popular in rural housing and irrigation. Availability of electricity has also caused a massive reduction in the use of kerosene. In transportation CNG has become popular that has lowered the demand for gasoline. Investments in electricity based light rail for mass transit are underway that will lower the use of diesel and gasoline for urban transportation.

As can be expected, the output loss and price increase effects are larger for HPC. However, once the substitution effects are underway, the output and employment losses are offset on average for both cases. Simulations also show that output loses can be offset by government investment in infrastructure using the revenues generated by the carbon tax. Importantly, increased government spending on social protection can help offset the adverse effects on real incomes of the poor due to the carbon tax.

Although the CO2 reduction and revenue impact are stronger in the HPC, the differences are not dramatic. For both cases, diesel consumption dominates and is the most potent source of CO2 reduction and revenue mobilization for the carbon tax on fuel oil. In terms of product mix, furnace oil consumption is the second largest product after diesel. Regarding kerosene, the rapid decline of the past several years due to substitution to cleaner energy has made this a relatively insignificant source of CO2 emission for Bangladesh. The revenue impact is also not large. Since kerosene tax is politically very sensitive, continued focus on providing rural electrification and LPG for cooking might be the better policy alternatives than a carbon tax on kerosene.

Summary and Conclusions

The use of carbon tax can be a major way to reduce carbon emission. Simulation analysis shows that with reasonable assumptions about demand elasticities of income and prices for oil products a carbon tax would bring about substantial reduction in CO2 emission. This reduction need not hurt GDP growth or adversely affect the income of the poor. The carbon tax not only lowers CO2 it also yields revenues. These revenues can be used to invest in clean fuel, clean technology and infrastructure projects that will help offset the loss of output from carbon taxes. Bangladesh is way behind the rest of the world in clean energy and clean technology. Proper pricing of fossil fuel along with the carbon tax will provide the incentives to reduce the consumption of these fuels and also motivate private investment in clean energy and clean technology. The carbon tax incidence is progressive in the sense that the cost of living increases is highest for the top ten percentile and lowest for the bottom ten percentile. Furthermore, the increase in cost of living for the poor can be offset through income transfers from additional social protection spending based on carbon tax revenues. Thus, a proper combination of fossil fuel pricing, carbon tax and investments can make carbon tax a win-win policy package.

Towards a Carbon Tax in Bangladesh

I. Background and Development Context

Bangladesh is a strong actor in the effort to reduce global carbon emission. This is appropriate as it faces a major adverse burden from global climate change. Although per capita carbon emission is low, total carbon emissions in Bangladesh are growing. Consequently, as a good global team player, Bangladesh has committed to reducing its carbon footprint in its Intended Nationally Determined Contributions (INDC) submissions in 2015 (Government of Bangladesh 2015).

The strategy for reducing carbon emission relies almost entirely on regulations, investments and technology. There is hardly any use of incentive policies. A recent paper showed the great potential for using incentives, especially fiscal policy, to improve environmental management in Bangladesh also mobilizing revenues while (Ahmed 2018). The paper notes that a balanced carbon emission reduction strategy will need to combine regulations with fiscal incentives to reduce air pollution and adopt clean energy. In that context, it advocates the use of a carbon tax as a fiscal policy instrument to curb the use of fossil fuel and thereby lower carbon emission.

The objective of this paper is to examine the use of a carbon tax for lowering carbon emission while raising public revenues in Bangladesh. Both are important development objectives and are inter-related. The heavy reliance on fossil fuel for energy is partly driven by the virtual absence of clean energy. This is to a substantial extent owing to the shortage of resources. Similarly, choices of clean technology are constrained by the lack of research and adaptation spending for clean technology. More broadly, poor environmental outcomes in Bangladesh are partly due to inadequacy of policies and institutions including the virtual absence of the use of fiscal policy instruments, but they are also owing to inadequate public spending on environmental programmes and institutions.

The paper is organized as follows: after the introductory statement in Section I above, Section II provides an analysis of the carbon emission challenge in Bangladesh. The distinction between greenhouse gases and carbon emission is clarified in this Section, as these two concepts are used confusingly in Bangladesh. Section III contains a review of Bangladesh's INDC commitment and the approach being used to secure those commitments. The absence of fiscal policy instruments as a constraint to lowering carbon emission is brought out to provide the case for introduction of a carbon tax. Section IV then develops the carbon tax policy based on global experience and the Bangladesh political economy context. In Section V, the simulation results of the proposed carbon tax are discussed. A business as usual (BAU) scenario is first established that defines the status quo as presently with no carbon tax. This is then compared with two policy scenarios: the most likely and politically feasible scenario that constitutes the Low Policy Case (LPC) and a more unlikely but desirable High Policy Case (HPC) that yields stronger CO2 reduction outcomes but would likely be politically challenging for implementation. Section VI concludes the paper with a brief summary and concluding remarks. Annex A provides details of the analytical framework and models used for the policy simulations.

II. Measuring Green House Gases (GHG) in Bangladesh

Concept of Green House Gases (GHG)

Green House Gas (GHG) emission is often used synonymously with Carbon (CO_2) emission. This is misleading. GHG emission is a broader term than CO_2 emission. As a matter of fact, CO_2 emission is a subset of GHG emission. There is a total of 24 GHG that are globally acknowledged to be harmful for Ozone layer and are held responsible for global warming phenomenon. The United Nations Framework Convention on Climate Change (UNFCCC) has developed methodologies to calculate and mitigate the emission of these gases by various active global mechanisms and frameworks. The three most commonly used sources of GHG are: carbon (CO_2), nitrous oxide (N_2O) and methane (CH_4). The N_2O and CH_4 molecules are far more harmful for Ozone layer than CO_2. For analytical purposes, the emission of all sources of GHG is converted into CO_2 equivalent. For example, one kg of methane emission is measured as 72 kg of carbon emission over 20 years (1 kg CH_4 = 72 kg CO_2 e).

Trend of GHG in Bangladesh

The main source of CO_2 emission is the use of fossil fuel in both combustible and non-combustible forms. The primary sources of N_2O from human interactions are agriculture, wastewater management, industrial processes and fuel combustion. The main human activities contributing to CH_4 are rice agriculture, biomass burning, landfills and wastes, livestock farming, fossil fuel production, distribution and use and biofuels. The two measures of GHG emission (CO_2+N_2O +CH_4) and CO_2 only for Bangladesh are shown in Table 1. A third measure, which is an intermediate measure and falls between the narrow CO_2 only measure and the broader CO_2 + N_2O + CH_4 measure, is derived by combining the narrow CO_2 only measure with GHG emissions by the agriculture sector. It accounts for a substantial part of N_2O and CH_4 but not all of it (Table 1).

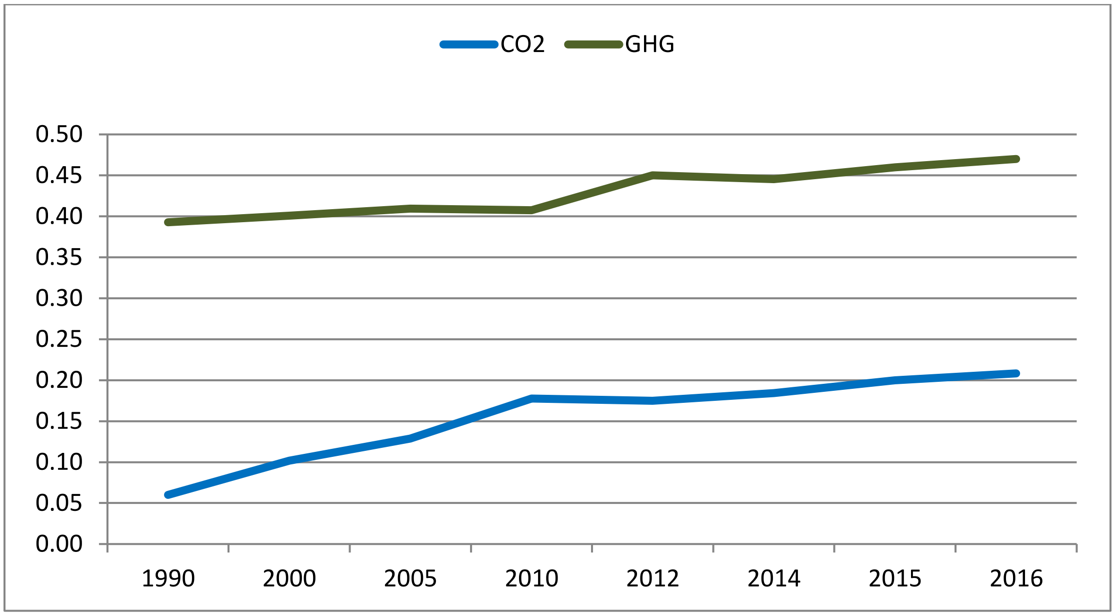
The broad GHG measure of carbon equivalent emission for Bangladesh is almost three times higher than the narrow CO_2 only measure. For example, as compared with estimated carbon emission of 74.5 million tons by the narrow CO_2 measure, total carbon equivalent emission amounted to 219 million tons by the broader measure (CO_2, N_2O and CH_4). The total GHG emission estimate falls to 150 million tons by the intermediate measure including CO_2 and N_2O and CH_4 from agriculture only. When compared globally, Bangladesh remains a small polluter of GHG by both narrow and broad measures (Figure 1). Its emission contribution is even lower when GHG is measured in per capita terms. Yet, as a good global citizen it makes sense to focus on the broad measure of GHG emission and the environmental country strategy and policy framework should be to reduce emission based on this measure. However, for the present study, we look only at the CO_2 since the main objective of this study is to establish the case for a carbon tax as a means to reduce carbon emission from the use of fossil fuel.

Table 1: Alternative Measures of GHG Emissions for Bangladesh (000 tons CO2 e)

Year	CO2	CO2+N2O+CH4	CO2+Agriculture
1970	3111	117351	49817
1971	3099	111079	50342
1972	3249	113599	51035
1973	3867	115297	52203
1974	4135	114415	53027
1975	4917	118807	54371
1976	5276	116496	55298
1977	5399	118169	55997
1978	5807	121107	56987
1979	6473	123273	58241
1980	7300	117100	59664
1981	7105	117875	60070
1982	7718	120018	61293
1983	7261	113561	61452
1984	7574	116874	62388
1985	8845	119645	64289
1986	9818	122518	65900
1987	11063	121763	67790
1988	11659	122559	69039
1989	12727	126327	70766
1990	13475	126575	72182
1991	12654	125054	71970
1992	14225	126925	74079
1993	15058	126458	75094
1994	16297	128497	77412
1995	19984	133684	82877
1996	20290	134790	83293
1997	22065	136465	84858
1998	22525	135425	84812
1999	24030	141330	89025
2000	26070	143970	91556
2001	30732	149532	96457
2002	32451	154551	99407
2003	33976	157476	100630
2004	34946	157046	100967
2005	38286	163686	105961
2006	40573	168373	109750
2007	44185	175185	113768
2008	50245	185845	123763
2009	54588	192088	128041
2010	59676	199976	134399
2011	59687	203287	135768
2012	60882	202582	136375
2013	63633	206041	139358
2014	65735	208856	142415
2015	71266	215102	148903
2016	74476	219032	152362

Source: EU Edgar 2017; FAO Stats 2017 (for agriculture); Missing data interpolated based on long-term trend.

Figure 1: Bangladesh Global Shares of GHG Emissions (%)



Source: EU Edgar 2017

GHG Long-Term Trend

The trend growth rates for the three measures of GHG are summarized in Table 2. On a long – term basis, CO_2 emissions exhibit the fastest growth, rising at an annual average rate of 7.2% over 1970-2016. The intermediate measure of GHG (CO_2 plus agriculture emission) shows a trend growth of only 2.5% per year, which is much slower than CO_2 emission growth owing to a slowdown in emission growth from agriculture. The most comprehensive measure of GHG (CO_2+N_2O+CH_4) shows the slowest growth rate of 1.4% per year owing to the slowdown in the growth of emission from N_2O and CH_4, especially CH_4. These slow rates of growth of N_2O and CH_4 are a positive development for Bangladesh, although the rapid growth of carbon is a concern. Indeed, the CO_2 trend for the more recent years (2004-2016) shows an even faster growth at 9.2%, reflecting the growing influence of urbanization and associated industrialization and use of electricity. There is a much smaller spike in the growth of emission in recent years when the two broader measures are considered. The reduction in emission from CO_2 is indeed the main challenge for containing the growth of GHG emissions in Bangladesh.

Table 2: Trend growth rates in GHG emissions

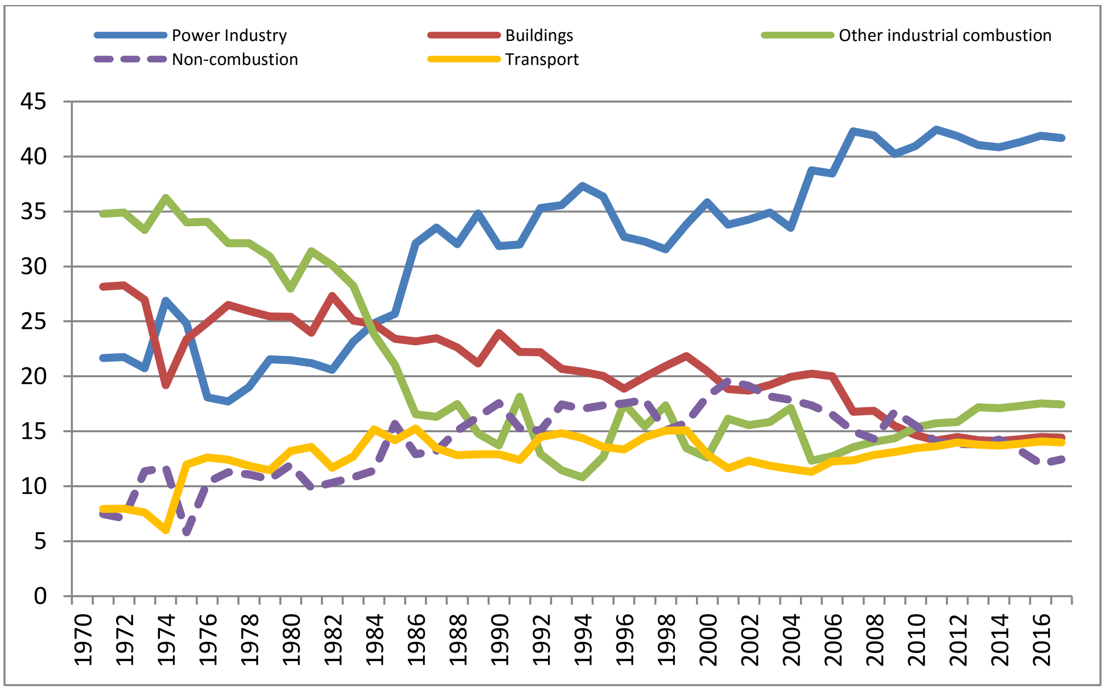
Source of Emission	1970-2016 (% p.a.)	2004-2016 (% p.a.)
CO2	7.07	9.22
N2O	2.45	
CH4	0.31	
Agriculture	1.15 (1990-2016)	
N2O + CH4	0.05 (1970-2012)	
CO2 + Agriculture	2.47	3.49
CO2+ N2O + CH4	1.44	2.81

Source: Table 1 and author estimates

Sectoral Shares of GHG

Detailed data on the sectoral breakdown is only available for CO2. Since the reduction in CO2 is the main emission challenge and the focus of this study is on CO2, this is not a major constraint. The pattern of sectoral CO2 emission is shown in Figure 2. Data on trend growth rates by main sectors is shown in Table 3.

Figure 2: Bangladesh Sectoral Composition of CO2



Source: EU Edgar 2017

The Figure 2 shows a clear pattern of the dominant role of CO2 emission from the power sector. CO2 emission from the power sector grew at an annual average rate of 8.8. % per year, which is significantly faster than the average rate of growth of CO2 for the economy. As a result, its share in CO2 emission surged from 22% in 1970 to 44% in 2016. Transport emission also grew faster than total CO2, as a result of which its share in total CO2 emission nearly doubled from 7.9% in lower 1970 to 14% in 2016. Both also show emission growth spikes in the more recent years of 2004-2016. Indeed, the growing contribution of these two rapid emitters is the primary reason for the spike in total CO2 emission in the recent years. Emissions from buildings and industrial sector grew somewhat slower, causing their shares in total CO2 emission to fall substantially. However, there is a similar spike in emission growth from industrial sector during 2004-2016.

Table 3: Bangladesh Sources of CO2 Emission (%)

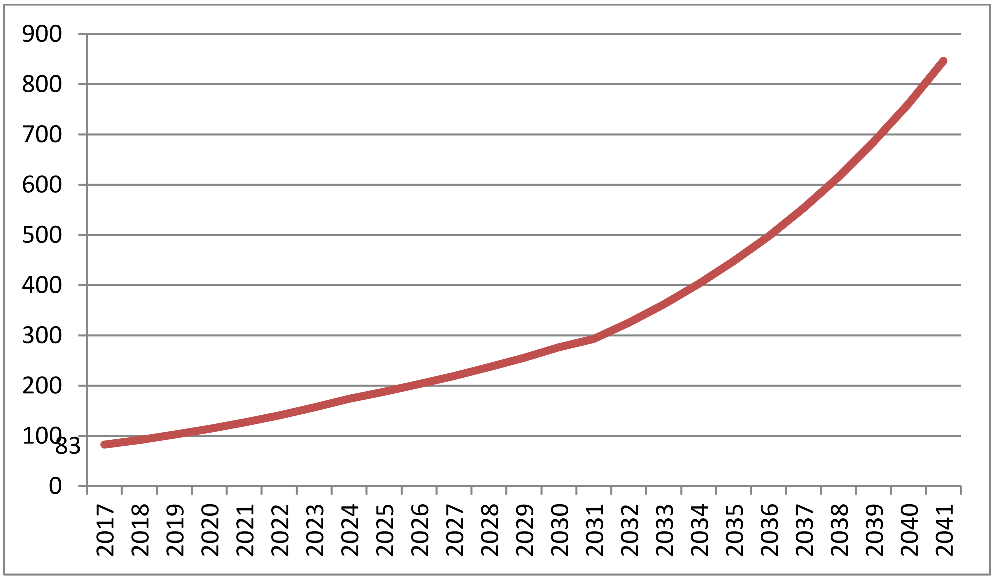
Sector	Rate of growth (% p.a. 1970-2016)	Share in 1970	Share in 2016
Power	8.8	21.66	41.69
Buildings	5.7	28.16	14.41
Other Industrial Combustion		34.78	17.46
Non-Combustion		7.46	12.44
Total Industrial	5.1	39.82	29.90
Transport	7.7	7.94	14.00
Total	7.0	100.0	100.0

Source: EU Edgar 2017

CO2 Emission Outlook for the Future under Business as Usual (BAU) Scenario

This pattern of sectoral contributions to CO2 emission has major implication for the future outlook for CO2 emission. Under the business as usual (BAU) policy framework of the present time, the outlook for further growth of CO2 emission is highly unfavorable. As Bangladesh grows faster based on a growing pattern of industrialization and urban development, the demand for power will surge. Industrialization and urbanization will also lead to faster demand for transport services. Both these fast-growing CO2 emitters along with the spike in industrial emission in recent years will increase the overall growth of CO2 from the 9.2% in recent years (2004-2016) to 10% plus. Indeed, the observed GDP elasticity of carbon emission during 2004-2016 of 1.4 suggests that CO2 emission will likely grow by 11.2% under a GDP growth scenario of 8%. However, international experience suggests that the CO2 elasticity of GDP tends to fall as income grows. Energy intensity of production typically tends to rise at low levels of income and then falls and stabilizes at below one. Under these assumptions, the projected path of CO2 emission under BAU is illustrated in Figure 3. Even with moderated growth in CO2 emissions over 2025-2041 periods (10% per year), this rapid rate of CO2 emission will be inconsistent with Bangladesh's global commitment to reduce the growth of CO2 emission and must be addressed speedily through a major reform of carbon reduction policies including reform of fuel prices and the introduction of carbon taxes.

Figure 3: Projected CO2 Emission under BAU (million tons)



Source: Author projections

III. Bangladesh Global Commitment to Fight Climate Change

INDC Commitments: Bangladesh faces major downside risks from the adverse effects of climate change. Many of these risks are already happening as reflected in erratic weather patterns, frequency of flooding and sea level rise. While several adaptation and mitigation measures are underway to reduce the impact of climate change, Bangladesh has joined forces with other global partners to lower the GHG and CO2 emissions. Under the latest Paris Accord of 2015, Bangladesh has made several commitments to reduce CO2 under its INDC. Specifically, the INDC 2015 makes the following commitments regarding its efforts to reduce CO2 emissions (Box 1).

Box 1: Mitigation Contributions of Bangladesh under INDC 2015

- An unconditional contribution to reduce GHG emissions by 5% from Business as Usual (BAU) levels by 2030 in the power, transport and industry sectors, based on existing resources.

- A conditional 15% reduction in GHG emissions from BAU levels by 2030 in the power, transport, and industry sectors, subject to appropriate international support in the form of finance, investment, technology development and transfer, and capacity building.

- A number of further mitigation actions in other sectors which it intends to achieve subject to the provision of additional international resources.

(Government of Bangladesh 2015)

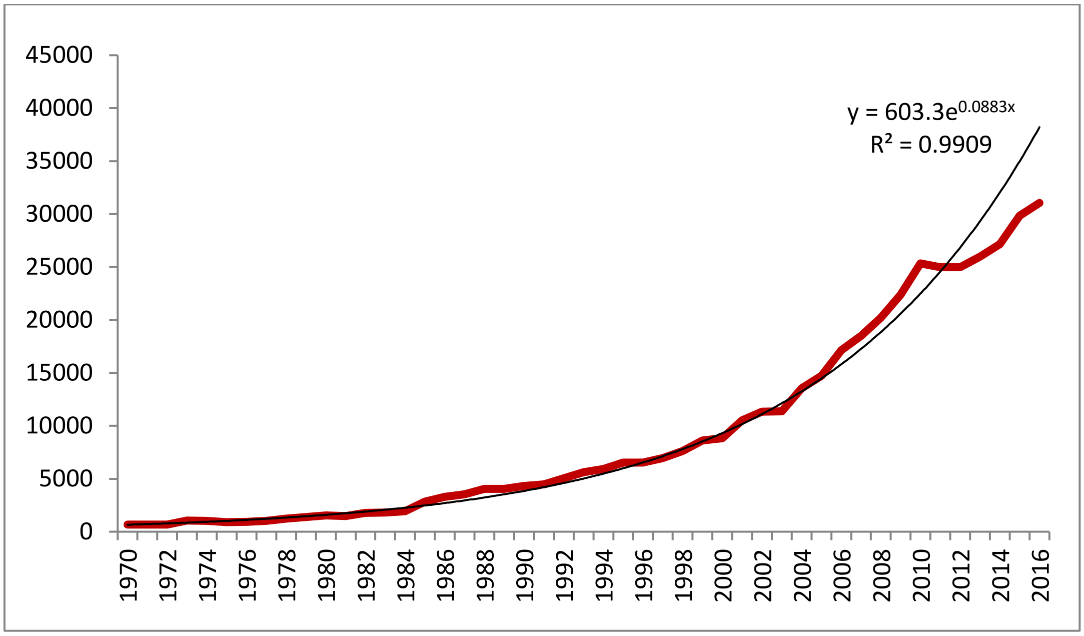
The CO2 reduction pledge is made cautiously and with several caveats including the availability of international financing. Although the commitments are couched in terms of GHG, which is a much broader commitment, these are to be interpreted as commitment to reduce CO_2. Another issue is that the CO_2 levels under BAU are not specified which makes it unclear about how much actual reduction is pledged because BAU projections depend upon what assumptions are made about income elasticity of CO_2. Notwithstanding these caveats, the government's commitment to contain carbon emission is clear. The main policy question is whether the strategy to reduce CO_2 is balanced with adequate policy instruments.

Consistency of Policies with CO_2 Reduction: The policy framework for environmental management including control of air pollution was reviewed extensively in a recent policy paper (Ahmed 2018). The main conclusion is that overall environmental management including control of air pollution relies heavily on command and control type instruments comprising of laws, regulations and standards. There is very little use of incentive policies especially taxes and pricing policies. Indeed, by providing heavy subsidy on natural gas and fuel oil, Bangladesh provides an incentive for excessive consumption of fossil fuel (Ahmed, Alam and Sattar 2016). Therefore, fossil fuel pricing policies are inconsistent with CO_2 reduction objective. This is a fundamental contradiction in environmental management in Bangladesh that must be addressed soon.

Use of fossil fuel is a primary determinant of carbon (CO_2) emission. Much of the fossil fuel is used for production of electricity. As the Bangladesh economy has grown, the demand for power has increased. Alongside, CO_2 emission has also increased. Evidence shows that emission from power has grown at a long-term trend of 8.8% per year between 1970 and 2016 (Figure 4). As a result, the share of power sector in total CO_2 emissions has accelerated from 22% to 42% over the same periods. Although improved technology has slightly lowered the growth rate of carbon expansion from power, this pattern could go up as natural gas supply shrinks and fuel-oil and coal use increases.

Bangladesh GDP growth is on an increasing trend growing presently in the 7% plus range and could reach 8% in the coming years. The government's Perspective Plan 2041 seeks to achieve upper middle-income status in FY2031 and higher income status by FY2041. Indicative projections show that to achieve these targets GDP will need to grow at around 8-9% from FY2020-FY2041. The demand for electricity will increase commensurately. Presently some 98.6% of electricity is produced by using fossil fuel. The share of renewable energy is a mere 1.4%. This suggests that the CO_2 emission from power will continue to increase at a rapid rate unless corrective actions are taken soon.

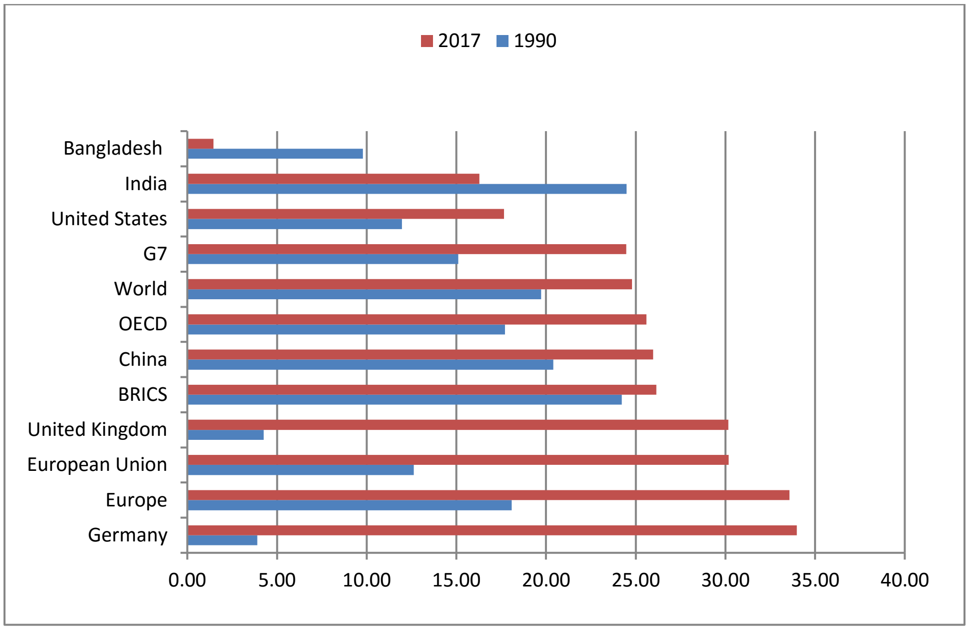
Figure 4: Bangladesh Power Sector CO2 Emission (000 tons)



Source: EU Edgar 2017

International experience shows that environmentally sensitive countries have taken large number of measures to reduce the rate of growth of CO2 emission. One major policy initiative is the adoption of renewable energy for power generation. The global progress relative to Bangladesh in adopting clean energy for power generation is illustrated in Figure 5. Globally, the share of renewable energy in power production has increased from 20% in 1990 to 25% in 2017. The EU countries have moved much faster than the rest of the world. Thus, its relative share of renewable energy for power production has expanded from 13% in 1990 to 30% in 2017. Germany and United Kingdom provided leadership to this transformation. As compared to these, the relative share of Bangladesh has gone down substantially from 9.79% in 1990 to a mere 1.6% in 2017. The main reason for this decline is that almost all additional power generation since 1990 rely on use of fossil fuel. In Bangladesh, there is only one hydropower station linked to the Kaptai dam. The installed capacity of 230MW reached in 1988 has remained fixed at that level since then. Progress with other renewable energy has not happened in any significant way. Contrary to the global trend, much of power production shifted to carbon polluting fossil fuel.

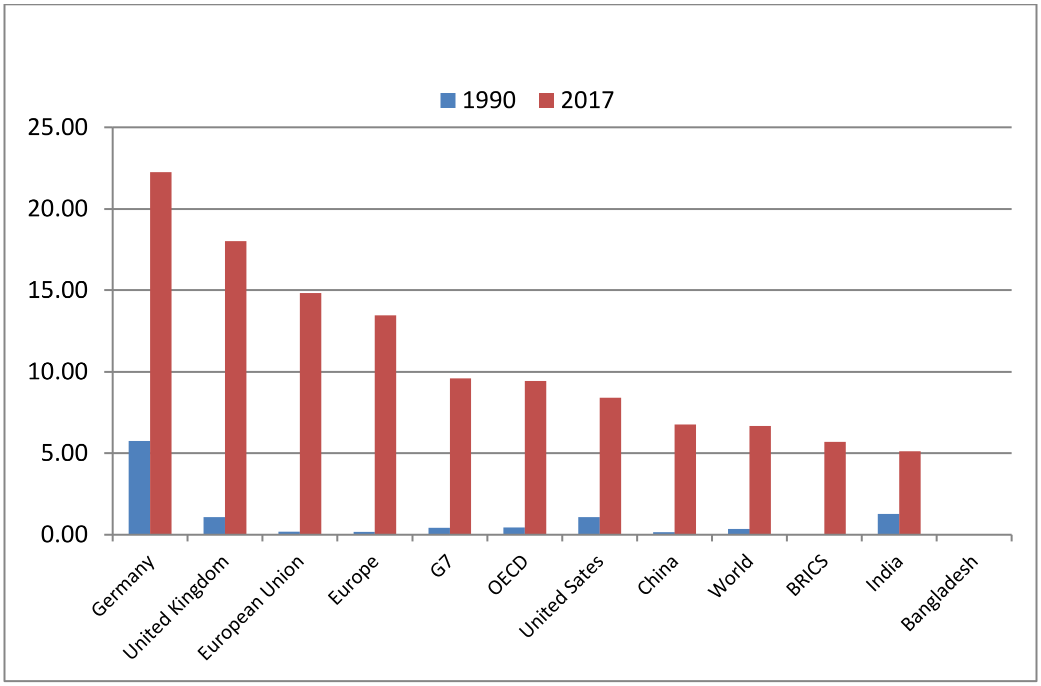
Figure 5: Share of renewables in electricity production (%)



Source: Ener data 2018

In addition to hydro power, there are several sources of renewable energy. These include: wind, biomass (wood, landfill gas, municipal solid waste, other biomass waste), solar and geothermal. Wind and solar power are fast emerging as major sources of renewable and clean energy. The global trend in the use of wind and solar energy for electricity is shown in Figure 6. Globally, the use of these clean energy sources for power has increased from 0.35% in 1990 to 6.68% in 2017, which is a significant development. Importantly, EU has marched ahead rapidly with new technological breaks showing the way for developing countries including Bangladesh. Thus, the share of wind and solar energy in power production has soared from a mere 0.18% in 1990 to 14.82% in 2017. Germany and United Kingdom have led the way in adopting wind and solar energy for power production. In Germany, the share of wind and solar based electricity has soared from 5.74% in 1990 to 22.25%. In the UK, the corresponding shares are 1.07% and 18.01%. These reflect remarkable progress in technology that bodes well for the growth of renewable energy and lower CO_2 emission. India and China are also moving more aggressively in adopting clean energy in recent years. Wind and solar energy now account for 5.11% and 6.77% of power supply respectively.

Figure 6: Share of wind and solar in electricity generation (%)



Source: Ener data 2018

The progress in Bangladesh unfortunately has been minimal so far. At the national grid level, solar and wind account for only 3MW of installed capacity (0.02% of total installed capacity). There is better progress at the non-grid sources particularly at the household level where solar housing project and solar irrigation promoted through IDCOL has achieved better success. Nevertheless, as a source of power, wind and solar energy account for a mere 1% of total electricity generated in Bangladesh.

The government has put considerable emphasis to promoting non-hydro renewable energy. A Renewable Energy Policy was adopted in 2008. The policy set a target of 5% share of renewable energy in power generation for 2015 and 10% share for 2020. Both targets will be missed. Apart from excessive focus on mega power projects based on fossil fuels including LNG and coal, the policy framework for Renewable Energy is not conducive to the adoption of clean energy. A major contradiction is the continued subsidization of fossil fuel. In countries that have moved ahead successfully with renewable energy the incentive policies were set properly. Use of fossil fuel has been taxed considerably to discourage its use. These taxes are as high as 70% in many European countries, especially the UK even though the UK is a major oil producer. India and China have also introduced a carbon tax to discourage the use of carbon emitting fossil fuel. If Bangladesh wants to promote wind and solar energy in power and other uses, it must set the policy framework for renewable energy accordingly. A key policy priority is to reform the fuel prices. It must eliminate the fuel subsidy and instead adopt a well-defined carbon tax to discourage the consumption of fossil fuel and promote the expansion of renewable energy.

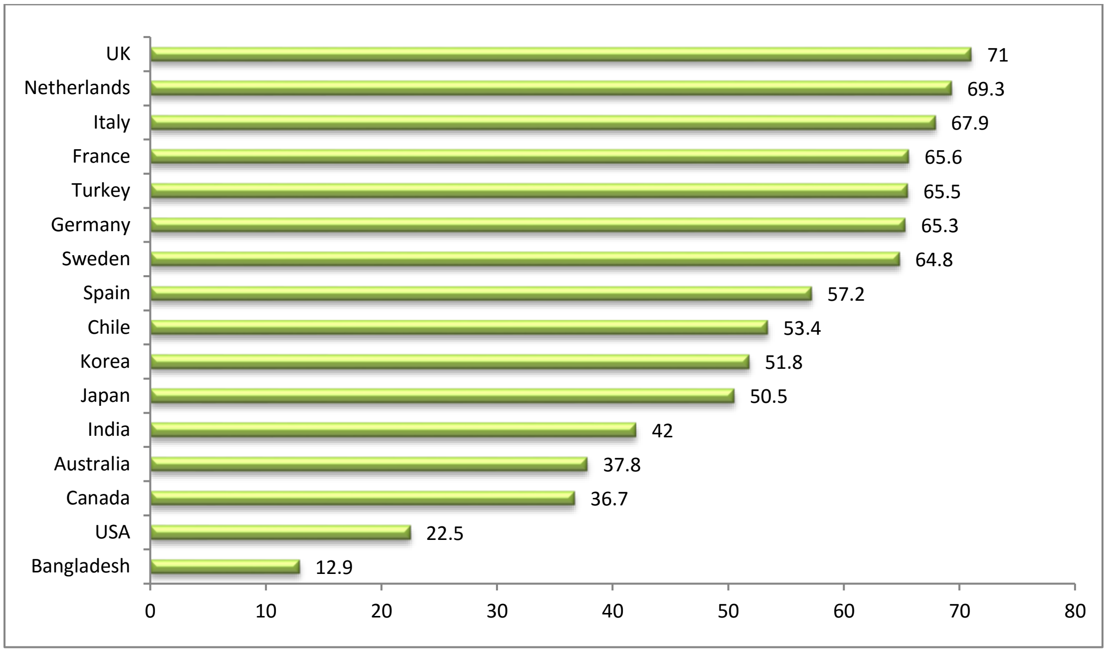
IV. International Experience with Carbon Tax

Since use of fossil fuel is the main source of carbon emission, a number of countries have adopted a carbon tax. Simply defined a carbon tax is levied on the carbon content of fuels. As of 2015, some 16 countries had introduced a carbon tax including two developing countries (India and Mexico) and 2 other developing countries were in the process of implementing a carbon tax (South Africa and Chile) (World Bank 2016). A proper carbon tax should be levied on all fossil fuel and at the upstream stage (the point where the possession of the carbon fuel passes the producer).

An alternative EFR instrument to carbon tax is the use of emission trading systems (ETS) whereby the government fixes the total volume of emission for each type of polluting industry and allocates these pollution rights to industries through an auction system. Conceptually the two instruments are equivalent. A carbon tax sets a price and the volume of pollution emerges as an outcome. An ETS sets the total quantity of carbon emission and lets the market set the price of carbon through an auction and internal trading. Both instruments are used in several OECD countries and a number of developing countries are in the process of adopting ETS schemes (World Bank 2016). As of 2015 ETS schemes were valued at $34 billion and carbon tax schemes at $14 billion (World Bank 2016). Global experience shows that while some countries have adopted either a carbon tax or an ETS, some countries have used both. The choice of instrument is based on a number of factors including administrative capabilities, pollution measurement and monitoring readiness and political economy considerations. The limitations of developing countries in the first two areas suggest a preference for pollution taxes on inputs.

Although only a limited number of countries and territories (estimated at 40 as of 2015 by the World Bank) have introduced a proper carbon tax or adopted an ETS scheme because of political opposition to the potential cost-cascading effects of a full-blown carbon tax, most oil importing countries impose a tax on gasoline over and above the normal VAT or sales tax. This is a special levy in the form of an excise tax that is usually set in relation to the carbon content of the liquid fuel. The cost cascading effects are moderated by either levying the tax at the gas pump only or by exempting sensitive sectors. Thus, a gasoline tax (petrol and diesel) at the pump gate raises the cost of transport but does not directly affect electricity and manufacturing production. Also, in this case other primary fuels such as natural gas, furnace oil, kerosene and coal are outside the tax net. While gasoline taxes are often conceived as a road user charge earmarked for road maintenance (as in the USA), these taxes are increasingly being used as an environmental tax to reduce consumption of fuel oil in transport. It is not surprising therefore that tax rates are very high in OECD countries except USA, including countries that have not introduced a carbon tax. The UK for example imposes a tax rate of about 71% on gasoline as compared with only 23% in USA (Figure 7). India’s tax rate of 42% exceeds rates in Australia, Canada and USA showing its growing commitment to reducing carbon emission.

Figure 7: Tax Rate on Premium Gasoline (percent of selling price)



Source: OECD Database; Ministry of Finance (India); Ministry of Energy and Mineral Resources (Bangladesh)

V. Towards a Carbon Tax in Bangladesh

Imposition of a carbon tax requires as a first step a proper mechanism for setting energy prices. Many countries have implemented reforms only to see subsidies reappear when international oil prices increase. Establishing a proper oil pricing system is important to ensure the sustainability of reforms. The reform of oil subsidy and pricing policy was analyzed in detail in a previous study (Ahmed, Alam and Sattar 2016). A summary of the main points is presented here.

Reform of fuel subsidy and pricing policy: GIZ (2015) suggests a set of four principles to guide the development of a sustainable oil pricing policy: pricing principles; price regulation principles; transparency principles; and enforcement principles.

a) *Pricing principles:* These comprise of three elements: cost coverage; applying fuel taxes; and internalizing the external effects of the transport sector. The idea behind cost coverage is that prices should at least cover all costs of production (import, refining, transport and depreciation. The next consideration in price setting is the use of taxes (i.e. value added taxes, excise duties) to develop the transport sector (cost recovery of road infrastructure including maintenance) or more broadly to generate revenues for the government. A third consideration is to internalize the external costs from use of fossil fuel (i.e. the tax on carbon emission). Most countries are moving towards this broad-based pricing policy.

b) *Price regulations principles:* This principle advocates that price adjustments must reflect the changes in cost of production, exchange rate changes and general inflation. The rationale for this principle is to avoid subsidy by allowing full pass through of all factors that affect the cost of production.

c) *Transparency principles:* The idea here is that stakeholders have full information about how prices are set. Information about the main components of pricing (costs and taxes), how prices are set, who sets the prices, the frequency of price changes and the reason for changes must be communicated to the general public through a website and mass media so that there is common understanding for the oil price behavior.

d) *Enforcement principles*: The proper implementation of defined pricing principles requires that they are properly monitored, supervised and enforced. Enforcement must also pay attention to issues of smuggling, black-markets, adulteration and quality assurance for oil products as per specification.

The current Bangladesh oil pricing system does not meet any of the above principles, suggesting that a thorough overhaul of the pricing system is needed. Two policy questions emerge: Should government continue to regulate oil prices by instituting an automatic pricing formula or should it deregulate the prices and leave pricing to the market? This is a political economy choice. For example, India and Philippines have completely deregulated oil prices, except for kerosene in the case of India. The advantage of a market-based pricing is the complete de-politicization of oil pricing. However, this requires adequate competition in the domestic oil market and proper administrative and regulatory capacities to monitor the performance of the oil companies and prevent cartelization.

Since Bangladesh does not yet have a competitive oil market, full deregulation of oil prices may be pre-mature at this time. So, in the first phase of the reforms the adoption of an automatic pricing formula that reflects the above principles may be the way to go along with deregulation of the oil market to allow private sector participation in all areas of the oil industry. This pricing policy should be administered by the Bangladesh Energy Regulatory Commission (BERC) without any government intervention. This requires that the BERC should be strengthened with greater autonomy and quality staffing to do its assigned job with proper competence. BERC will also be responsible to provide all necessary information to the public at large to meet fully the transparency criteria for oil pricing. The government's main role will be to decide the taxation policy for oil as appropriate.

Over the longer term, subsidy reforms for petroleum products should aim to fully liberalize pricing. More liberalized regimes—where prices are determined by private sector suppliers and move freely with international prices—tend to be more robust to the reintroduction of subsidies than automatic pricing mechanisms. Under a liberalized regime, the role of the government is to develop prudential regulations to ensure that fuel markets are competitive and there is free entry and exit from the sector. Successful implementation of an automatic pricing mechanism can facilitate the transition to a liberalized pricing regime by getting the public used to frequent changes in domestic oil prices. It can also build up the confidence of private suppliers that the government will not return to subsidized pricing.

Introduction of a carbon tax on gasoline: As noted from global experience, political economy constraints, especially opposition from business and consumers, have limited the full use of a carbon tax in many countries including in the USA. On the other hand, experience also suggests that countries that have not adopted a full-fledged carbon tax have used the gasoline tax quite successfully to introduce a limited carbon tax. Indeed, the gasoline tax can be conceived as a part of a longer-term plan to introduce a proper carbon tax at a later stage. This is how it has progressed in some countries that have introduced a carbon tax. For example, in India the carbon tax emerged first in 2010 as a tax on domestic coal but was later broadened to include petrol and then diesel. So, essentially, the carbon tax in India emerged over a 5-year period in different stages. The tax rates have also been adjusted gradually.

This pragmatic approach is best suited to the current political economy environment of Bangladesh. The pricing reform for natural gas is off the table and the government will not accept taxation of fuel oil or coal for electricity generation to avoid electricity cost escalation. Similarly, the government will oppose the taxation of kerosene to avoid pass through effects on the poor. Consequently, the taxation of petrol and diesel presents the most promising option for introducing a carbon tax. The elimination of fuel oil subsidy at the pump gate through proper pricing policy is a first step in a sequential program to reducing carbon emission from the use of fuel oil. This reform can be combined with the imposition of an excise duty on petrol and diesel that is in addition to the normal applicable VAT. The tax rate can be set in proportion to the carbon content of petrol and diesel, whereby the carbon content of diesel (kg/liter) is about 14% higher than for petrol. However, since petrol is lighter, per metric ton (MT) the CO_2 emissions are roughly similar. The initial rate of the carbon tax can be determined based on expected carbon reduction, the amount of resources mobilized and the level of political comfort. The tax rate can also be varied in relation to international prices. Thus, the tax rate can be increased when oil prices are low and reduced when international oil prices go up. A similar approach is used in India.

VI. Illustrative Simulation Results of a Carbon Tax on Gasoline

To illustrate the importance of a carbon tax as an instrument for CO_2 reduction, this section provides a quantitative example of how a specific carbon tax on gasoline might work. The simulations use two models: a model that estimates the revenue and CO_2 reduction effects of a carbon tax on gasoline and a second model that incorporates the general equilibrium effects of this carbon tax for output and income distribution. The details of the two models are provided in Annex A. The main simulation results are provided here. Two Policy Scenarios are considered. A Low Policy Case where the tax is imposed only on gasoline (petrol and diesel); and a High Policy Case where the tax is also imposed on furnace oil and kerosene.

Low Policy Case Revenue and CO2 Reduction Effects of a Gasoline Tax

Policy changes and assumptions: The revenue generation and CO2 reduction effects are simulated on the basis of imposing a 10% carbon tax on the current prices of petrol, octane and diesel starting in FY2019 and gradually increasing to 25% by FY2041. To simplify analysis, the tax is imposed on the current price in 2019. Prices after that are held constant in real terms and the tax is imposed on those real prices. This is simplified from two angles. First, in real life, international prices of oil will fluctuate. Second, a prerequisite for the carbon tax is to set up an automatic pricing mechanism that institutes a full pass-through of all domestic price components of oil products. However, this simplification does not affect the fundamental results of the introduction of the carbon tax. Additionally, presently, there is no subsidy on gasoline and diesel and the carbon tax rate could be used to stabilize the fluctuations in international prices.

Since petrol and octane are near perfect substitutes and their prices are very similar, these two are lumped together under petrol. Since Bangladesh is a net importer of petroleum product and is a tiny player in the global market, it essentially faces an unlimited supply of petroleum product at the world prices. Domestic pricing and taxation do not influence the supply curve. Since Bangladesh is a net importer of petroleum product and is a tiny player in the global market, it essentially faces an unlimited supply of petroleum product at the world prices. Domestic pricing and taxation do not influence the supply curve. So, the CO2 reduction and revenue effects depend upon the demand for petrol (including octane) and diesel. The demand pattern in turn depends upon price and income elasticities. In the base case (BAU), real price of petrol and diesel are held constant. So, demand grows in line with real income growth and associated income elasticity. For the policy case, demand depends upon both real income and real post-tax prices. Growth in real income will tend to increase demand for petrol and diesel but increase in real prices will tend to reduce demand. For income and inflation projections, the macroeconomic framework developed for the Perspective Plan 2041 (PP2041) are used. The PP2041 projections contain the government's growth and inflation targets.

Unfortunately, data constraints have made it difficult to obtain reliable direct estimates of income and price elasticities of petrol and diesel from Bangladesh. But there is plenty of evidence from other countries, especially India, where the demand pattern is very similar to Bangladesh[1]. Importantly, a recent research paper provides a useful summary of evidence from a large number of developing and industrial countries that can be used for this research. There are several important findings of international experience with estimating demand functions for gasoline that have a bearing for this research. These are:

[1] See for example Agrawal 2012.

1) Short-term and long-term income and price elasticities differ substantially. Typically, full adjustments to price and income changes take several years.
2) Price elasticities tend to be below one for both short and long term.
3) While long-term price elasticities are higher because of substitution possibilities that open up over the longer term, price elasticities tend to fall once substitution possibilities narrow down and become more expensive. Gasoline becomes a necessity and insensitive to price increases.
4) Income elasticities tend to be higher at the early stages of development. These elasticities can exceed one at low per capita income levels and then taper off at upper middle income and high-income levels.
5) A summary of income and price elasticities for developing and developed countries is shown in Table 4.

Table 4: Average Income and Price Elasticities of Demand for Gasoline

Economy Type	Price		Income	
	Short-term	**Long-term**	**Short-term**	**Long term**
LDC	-0.33	-0.61	0.64	0.94
Advanced Economies	-0.13	-0.61	0.25	0.69
India: Gasoline	NA	-0.85	NA	1.39
India: Diesel	NA	-0.56	NA	1.02

Source: *Huntington, Barrios and Arora 2017; Agrawal 2012 (for India)*

Impact on CO2 reduction and government revenues: The effect of the gasoline tax on CO2 reduction and government revenues is illustrated in Table 5.

Table 5: Impact of Carbon Tax on CO2 Reduction and Revenue Increases

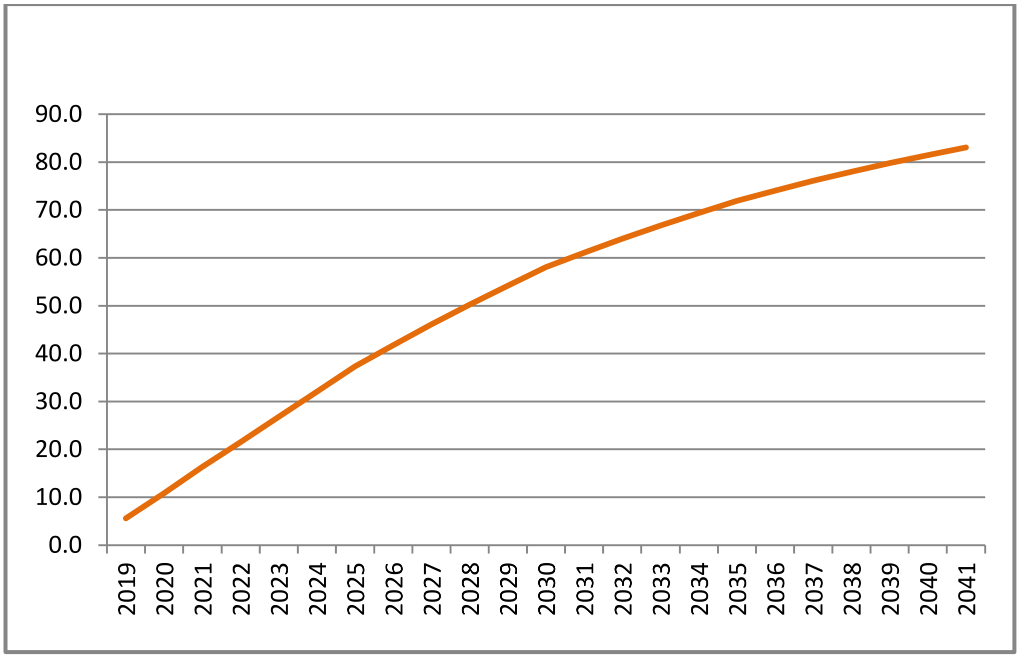
Description	FY2018	FY2019	FY2020	FY2021	FY2022	FY2025	FY2031	FY2035	FY2041
Carbon tax (%)		10	10	11	11	14	19	22	25
GDP growth rate		8.1	8.2	8.2	8.3	8.5	9.0	9.4	9.9
Inflation rate (%)		5.5	5.5	5.3	5.2	5.0	4.6	4.5	4.4
Income elasticity		0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.6
Price elasticity		-0.6	-0.6	-0.6	-0.6	-0.6	-0.4	-0.4	-0.4
BAU Scenario									
Diesel consumption (ml. MT)	4.5	4.8	5.1	5.5	5.9	7.4	11.0	14.1	19.8
Diesel CO2 emission (ml. MT)	14.39	15.26	16.37	17.58	18.89	23.53	35.11	45.13	63.40
Diesel price (Tk/ liter) (inflation adjusted)	66	69	72	76	80	93	123	146	190

Description	FY2018	FY2019	FY2020	FY2021	FY2022	FY2025	FY2031	FY2035	FY2041
Gasoline consumption (Octane plus petrol) (ml. MT)	0.46	0.49	0.53	0.57	0.61	0.76	1.14	1.46	1.93
Gasoline CO2 emission (ml. MT)	1.47	1.57	1.69	1.81	1.95	2.42	3.62	4.65	6.53
Gasoline price (TK/ liter) Inflation adjusted	86	91	96	101	106	123	162	194	241
Policy Case (with carbon tax)									
Diesel price increase (Tk/liter)		7	7	8	9	13	23	32	48
Diesel consumption (ml. MT)		4.50	4.56	4.60	4.64	4.61	4.28	3.96	3.36
Diesel CO2 emission (ml. MT)		14.4	14.59	14.70	14.83	14.74	13.67	12.68	11.08
Diesel consumption (ml. liters)		5368.05	5437.30	5479.71	5527.39	5494.94	5096.81	4725.12	4003.99
Diesel tax revenue (Tk bl)		36.81	39.34	45.92	48.73	71.58	118.63	152.08	190.54
Gasoline price increase		9	10	11	12	17	31	43	63
Gasoline consumption (ml MT)		0.466	0.472	0.475	0.479	0.477	0.442	0.410	0.347
Gasoline CO2 emission (ml. MT)		1.48	1.50	1.51	1.53	1.52	1.41	1.31	1.11
Gasoline CO2 consumption (ml. liters)		628.92	637.03	642.00	647.58	643.78	597.14	553.59	469.11
Gasoline tax revenue (Tk. bi)		5.71	6.10	7.12	7.55	11.09	18.30	23.57	29.54
Net Policy Impact of CO2 Tax									
Reduction in Diesel CO2 (ml. MT)		0.85	1.78	2.87	4.06	8.79	21.44	32.45	52.65
Reduction in gasoline CO2 (ml. MT)		0.09	0.18	0.30	0.42	0.91	2.21	3.34	5.42
Total CO2 reduction (ml. MT)		0.94	1.96	3.17	4.48	9.70	23.65	35.80	58.08
Total CO2 revenues (Tk. bl)		**43**	**45**	**53**	**56**	**83**	**137**	**176**	**220**

Source: Model Projections, Annex A.

The CO2 tax has a strong effect on both CO2 reduction and revenues. Much of the effect comes from the diesel component as it dominates the volume of consumption in the transport sector and is also used in agriculture for irrigation purposes. The CO2 reduction effects strengthen over the years as substitution of clean energy for diesel happens and there is a cumulative build up in the reduction in the use of diesel and gasoline (Figure 8). There are also efficiency gains from better technology and energy conservation in transportation and irrigation. The revenue effects are significant even in the first year with a collection of Taka 43 billion, growing to Taka 137 billion in FY2031. Clearly, as far as carbon reduction and revenue gains are concerned, the proposed carbon tax is a win-win.

Figure 8: Impact of CO2 Reduction of a Gasoline and Diesel Tax
(% CO2 Reduction over BAU level)



Source: Model Projections

Economy Wide Effects of the Low Case

While the partial equilibrium effects on CO2 reduction and increases in revenues are strongly positive, an important policy question is the feedback effects of the tax on output, inflation and employment. To look at the economy wide effects, we use an environmentally sensitive augmented input-output model (EIOM). The details are contained in Annex A. Basically, the results of the low case in terms of the effects on the prices and consumption of petroleum products are plugged in the EIOM to get the effects on wholesale prices, cost of living index and production of goods and services that use petroleum.

The first-round effects are on prices and inputs of land and water transport services that tend to raise prices of these services and reduce their outputs. The feedback effects on the rest of the economy are captured through the input-output coefficients in other production/consumption sectors that use transport services. In the short run, there is an increase in the prices of goods and services that use gasoline and diesel relatively intensively (Table 6). The cost of living index (CPI) increases depending upon the relative weights of gasoline and diesel and other products that use gasoline and diesel relatively intensively. Importantly, the CPI increases suggest that the carbon tax is progressive; the cost of living increases most for the top tenth percentile of the population and least for the bottom tenth. Also, the overall magnitude of cost of living increase is modest.

The output and employment effects depend upon the ease of substitution of clean energy for fossil fuel. In the short term, defined as 2-3 years, there is a decrease in GDP with the largest reduction in transport services, which in turn causes declines in industry and agriculture. It is assumed that efficiency improvements and substitution of clean energy /technology takes effect from FY2022 onwards. This is a reasonable assumption. Although presently Bangladesh is lagging behind on substitution prospects especially for renewable energy, globally the technology is out there and with proper pricing policies for fuel oil along with the carbon tax, private investment will help facilitate substitution effects as well as create incentive for more efficient energy use and adoption of clean fuel technology. For example, solar power has already become popular in rural housing and irrigation. Availability of electricity has also caused a massive reduction in the use of kerosene. In transportation CNG has become popular that has lowered the demand for gasoline. Investments in electricity based light rail for mass transit are underway that will lower the use of diesel and gasoline for urban transportation.

Table 6: Economy Wide Effects of Carbon Tax in Bangladesh: Low Case

	2019	2020	2021	2025		2031		2035		2041	
				NSE	WSE	NSE	WSE	NSE	WSE	NSE	WSE
Price and Cost of Living Index											
General Price Increase (%)	0.324	0.324	0.336	0.417		0.429		0.437		0.494	
Cost of Living Index (%)	0.804	0.804	0.835	1.036		1.066		1.086		1.227	
Income Group 1	0.613	0.613	0.636	0.789		0.812		0.827		0.934	
Income Group 2	0.612	0.612	0.635	0.788		0.811		0.827		0.934	
Income Group 3	0.657	0.657	0.681	0.845		0.870		0.886		1.001	
Income Group 4	0.768	0.768	0.797	0.989		1.018		1.037		1.171	
Income Group 5	0.969	0.969	1.005	1.247		1.284		1.308		1.477	
GDP loss/gain (Billion BDT)											
Agriculture	-0.04	-0.05	-0.04	0.00	0.1	0.00	0.10	-0.10	0.00	-0.10	0.0
Industry	-0.70	-0.8-	-0.8-	-1.30	16.5	-2.00	24.8	-3.0	30.6	-5.50	46.2
Construction	-0.00	-0.00	-0.00	-0.0-	-0.10	-0.10	0.00	-0.10	0.00	-0.10	0.1
Services	-20.6	-22.5	-23.1	-31.5	-16.8	-40.1	-24.7	-48.6	-30.4	-73.3	-45.9
All	-21.4	-23.3	-23.9	-32.8	-0.1	-42.2	0.2	-51.7	0.3	-79.0	0.4
Loss (gain) as % of PP projected GDP	-0.01	-0.01	-0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Employment loss/gain (Million Persons)											
Agriculture	-0.004	-0.004	-0.004	-0.003	0.009	-0.003	0.002	-0.002	0.001	-0.001	0.001
Industry	0.000	0.000	0.000	0.000	0.005	0.000	0.003	0.000	0.002	0.000	0.001
Construction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Services	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	0.000	-0.001	0.000	-0.001	0.000
All	-0.002	-0.002	-0.002	-0.009	0.013	-0.009	0.014	-0.011	0.014	-0.014	0.015
Loss (gain) as % of PP projected employment	-0.009	-0.009	-0.008	-0.013	0.040	-0.013	0.038	-0.014	0.036	-0.016	0.035

Source: EIOT Projections

Once substitution effects are underway, the output and employment losses are offset on average. Simulations also show that output loses can be offset by government investment in infrastructure and clean energy using the revenues generated by the carbon tax. Importantly, increased government spending on social protection can help offset the adverse effects on real incomes of the poor due to the carbon tax.

High Policy Case CO2 Reduction and Revenue Effects

The HPC is built on similar assumptions as the LPC except that it assumes that the carbon tax is also imposed on fuel oil and on kerosene. Fuel oil is used in both power and industrial sector. Kerosene is mostly used in rural areas for lighting and in both urban and rural areas for cooking. The consumption of kerosene has come down in recent years, declining by 12.7% per year during FY2013-FY2018. This has happened because of the growth in rural electrification and also owing to the growth in the supply of low-cost LPG in cylinder form for cooking. This is a good outcome for health and environmental improvement. It also suggests that kerosene is an inferior good and its consumption will continue to decline as income grows. The trend in use of fuel oil shows a sharp reduction during FY2014-FY2016. But the trend has picked up to positive since then and increased by 7.6% per year during FY2016-FY2018, reflecting the growing shortage of natural gas for use in power and industrial units. This is a negative development for both long-term growth and CO2 emission that needs to be countered through incentive and other policies, especially greater efforts to increase the production of renewable energy and energy trade with neighbors including Nepal and Bhutan.

The CO2 reduction and revenue effects of the HPC are summarized in Table 7. Prices of both fuel oil and kerosene increase by the same tax rate as applied to diesel and gasoline. The price and income elasticity assumptions for fuel oil are the same as in the case of diesel and gasoline (Table 4) but for kerosene the projections assume a steady decline of 5% every year. This is in line with the tapering off in the fall in kerosene consumption in FY2018 over FY 2017 (6.4% reduction). Using price and income elasticities are not very meaningful and these estimates are not available in any case. Importantly, since kerosene volume is a tiny part of fossil fuel use in Bangladesh, the results are not sensitive to underlying demand assumptions. Results of Table 7 show this clearly. Details are contained in Annex A.

Table 7: CO2 Reduction and Revenue Impact of the High Case

	2019	2020	2021	2022	2025	2031	2935	2041
CO2 Reduction and Revenue Impact High Case								
Reduction in CO2 from Diesel (MT)	0.85	1.78	2.87	4.06	8.79	21.44	32.45	52.65
Reduction in CO2 from Gasoline (MT)	0.09	0.18	0.30	0.42	0.91	2.21	3.34	5.42
Reduction in CO2 from Fuel Oil (MT)	0.16	0.33	0.53	0.75	1.63	3.97	6.02	9.76
Reduction in CO2 from Kerosene (MT)	0.01	0.01	0.02	0.02	0.05	0.08	0.08	0.08
Total Reduction in CO2	**1.11**	**2.30**	**3.72**	**5.25**	**11.38**	**27.70**	**41.90**	**67.92**
Tax Revenue Diesel (Tk billion)	36.81	39.34	45.92	48.73	71.58	118.63	152.08	190.54
Tax Revenue Gasoline (TK. billion)	5.71	6.10	7.12	7.55	11.09	18.39	23.57	29.54
Tax Revenue Fuel Oil (Tk billion)	4.41	4.71	5.50	5.84	8.57	14.21	18.22	22.83
Tax Revenue Kerosene (TK billion)	1.23	1.22	1.32	1.29	1.50	1.60	1.56	1.34
Total Revenue (TK billion)	**48.16**	**51.36**	**59.86**	**63.41**	**92.74**	**152.83**	**195.43**	**244.24**

Source: Model Projections High Case

As expected, the CO2 reduction and revenue impact of the HPC are stronger than the LPC. But the changes are not dramatic. Tax on fuel oil makes significant difference for both reductions in CO2 emissions and for higher revenues. In terms of product mix, fuel oil consumption is the second largest product after diesel. Nevertheless, diesel consumption dominates and is the most potent source of CO2 reduction and revenue mobilization for the carbon tax on fuel oil. Regarding kerosene, the rapid decline of the past several years due to substitution to cleaner energy has made this a relatively insignificant source of CO2 emission for Bangladesh. The revenue impact is also not large. Since kerosene tax is politically very sensitive, continued focus on providing rural electrification and LPG for cooking might be the better policy alternatives than a carbon tax on kerosene.

The Economy Wide Effects of the High Case

The economy wide effects of the HPC are broadly similar to the LPC, although the magnitude of sectoral price and CPI increases are higher and output reduction effects are larger. Substitution of fossil fuel with clean energy will offset these output losses. Government investment in infrastructure and clean energy and on social protection spending using the higher revenues will also offset these output losses and remove the adverse effects on the poor.

Table 8: Economy Wide Effects of Carbon Tax in Bangladesh: High Case

High Case	**2019**	**2020**	**2021**	**2025**		**2031**		**2035**		**2041**	
				NSE	**WSE**	**NSE**	**WSE**	**NSE**	**WSE**	**NSE**	**WSE**
Price and Cost of Living Index											
General Price Increase (%)	0.537	0.537	0.588	0.733		0.749		0.771		0.849	
Cost of Living Index (%)	0.945	0.945	1.001	1.244		1.277		1.306		1.461	
Income Group 1	0.780	0.780	0.834	1.037		1.063		1.089		1.213	
Income Group 2	0.773	0.773	0.825	1.027		1.052		1.078		1.201	
Income Group 3	0.811	0.811	0.864	1.075		1.102		1.129		1.259	
Income Group 4	0.911	0.911	0.966	1.201		1.233		1.261		1.410	
Income Group 5	1.092	1.092	1.151	1.430		1.469		1.501		1.683	
GDP loss/gain (Billion BDT)											
Agriculture	-0.05	-0.05	-0.06	-0.10	0.20	-0.10	0.10	-0.1	0.10	-0.10	0.10
Industry	-4.30	-5.00	-5.90	-6.90	14.2	-8.20	17.9	-9.5	24.10	-11.20	33.6
Construction	-0.10	-0.10	-0.10	-0.10	0.00	-0.10	0.00	-0.1	0.0	-0.20	0.00
Services	-20.9	-22.8	-23.4	-31.8	-14.5	-40.4	-18.1	-48.9	-24.1	-73.5	-33.70
All	-25.3	-28.0	-29.5	-38.9	-0.10	-48.8	-0.10	-58.6	0.00	-85.0	0.00
Loss (gain) as % of PP projected GDP	*-0.02*	*-0.02*	*-0.02*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Employment loss/gain (Million Persons)											
Agriculture	-0.005	-0.005	-0.005	-0.004	0.010	-0.002	0.003	-0.002	0.002	-0.001	0.001
Industry	-0.003	-0.003	-0.003	-0.002	0.004	-0.001	0.002	0.000	0.001	0.000	0.001
Construction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Services	-0.001	-0.001	-0.001	-0.001	0.000	-0.001	0.000	-0.001	0.000	-0.001	0.000
All	-0.004	-0.004	-0.004	0.008	0.013	0.011	0.013	0.012	0.014	0.014	0.015
Loss (gain) as % of PP projected employment	-0.013	-0.013	-0.012	0.026	0.039	0.029	0.037	0.031	0.036	0.032	0.035

Source: EOIT Projections

VII. Summary and Conclusions

The use of carbon tax can be a major way to reduce carbon emission. Simulation analysis shows that with reasonable assumptions about demand elasticities of income and prices for oil products a carbon tax would bring about substantial reduction in CO2 emission. This reduction need not hurt GDP growth or adversely affect the income of the poor. The carbon tax not only lowers CO2 it also yields revenues. These revenues can be used for investment in clean fuel, clean technology and infrastructure projects that will help offset the loss of output from carbon taxes. Bangladesh is way behind the rest of the world in clean energy and clean technology. Proper pricing of fossil fuel along with the carbon tax will provide the incentives to reduce the consumption of these fuels and also motivate private investment in clean energy and clean technology. The carbon tax incidence is progressive in the sense that the cost of living increases is highest for the top ten percentile and lowest for the bottom ten percentile. Additionally, the increase in cost of living for the poor can be offset through income transfers from additional social protection spending from carbon taxes. Thus, a proper combination of fossil fuel pricing, carbon tax and investments can make carbon tax a win-win policy package.

ANNEX A

Analytical Framework for Assessing Impact of Carbon Tax in Bangladesh

Like any other tax, imposition of carbon taxes (CT) on petroleum products (i.e. petrol, octane, diesel, furnace oil and kerosene) in Bangladesh may have impact on price and consumption (or sale) of these products directly, and indirectly on the sectors and households who use them as input in their production activities or as final consumption. Imposition of carbon taxes will reduce carbon (Co2) emissions compared to a pre-taxed situation due to lower consumption from CT inclusive higher prices. Furthermore, because of interdependence of the economic system, any effect on particular commodities (or sectors) of the economy is likely to have implications on the prices of other commodities as well as outputs of other activities. For analytical purposes, a two-step process is used. In step 1, the effect of a carbon tax on Co2 emissions and revenues is calculated. In step 2, the results of the introduction of a carbon tax is incorporated in an environmentally inclusive input-output model to assess the general equilibrium effects of the carbon tax.

A. Assessment of Impact of Carbon Tax on Co2 Emissions and Revenues

The model is based on a simple demand and supply framework. Since Bangladesh is a net importer of petroleum product and is a tiny player in the global market, it essentially faces an unlimited supply of petroleum product at the world prices. Domestic pricing and taxation do not influence the supply curve. Demand on the other hand is influenced by changes in income (i.e. due to the overall economic expansion) and prices (i.e. essentially of the commodities targeted for carbon tax). Co2 emissions are function of consumption and production – and hence are also affected by the changes in incomes (outputs) and prices.

Data, parameters and equations of the Bangladesh carbon tax model are presented below.

A. Data and Parameters

Set Description	Description
i = 1..5	Sector: Petrol, Octane, Diesel, Furnace Oil and Kerosene
t = 2018..2041	Year: Data: 2018 and projections: 2019-2041 from Perspective Plan
Variable Description	
CN	Consumption of petroleum products
PR	Sale price of products
Yg	GDP growth rates
CPI	CPI inflation rate
Co2	Co2 emission rate per MT: petrol/octane– 3.187; diesel, furnace oil, kerosene – 3.198
Co2mt	Co2 emission metric ton
R	Revenue from products (BDT)
Parameters	
Ω	With carbon tax

T	Carbon tax rates
Β	MT to Liter conversion
Δ	Change
∂	Price elasticity
Ψ	Income elasticity
Data and Projections	
CN_t^i	Consumption of Sector i in year t ***without carbon tax***; projection from 2019 to 2030
PR_t^i	*Per liter* sale price of sector i in year t ***without carbon tax***; projection from 2019 based on CPI inflation rate in t
CPI_t	CPI inflation rate from 2019 to 2030 used in perspective plan 2041

B. Specification:

	Equation	Explanation
	Sale Price	
1	$PR\omega\, CT_t^i = PR_t^i + T_t^i$	CT inclusive prices
2	$\Delta PR_t^i = PR\omega\, CT_t^i - PR_t^i$	Change in prices in i with CT in year t
	Consumption (Sale) and Revenue	
3	$CN\omega\, CT_t^i = CN_t^i$ x $[(1 + PR\omega\, CT_t^i)^{\delta^i} + (1 + Yg_t)^{\Psi^i}]$	Consumption/sale of product i with carbon tax
4	$\Delta CN_t^i = CN_t^i - CN\omega\, CT_t^i$	Change in consumption/sale of product i with carbon tax
5	$\Delta CO2mt_t^i = CO2_t^i$ x ΔCN_t^i	Change in CO2 emission levels due to carbon tax
6	$R\,\omega CT_t^i = (CN\omega\, CT_t^i$ x $\beta)$ x ΔPR_t^i	Revenue from carbon tax (BDT)

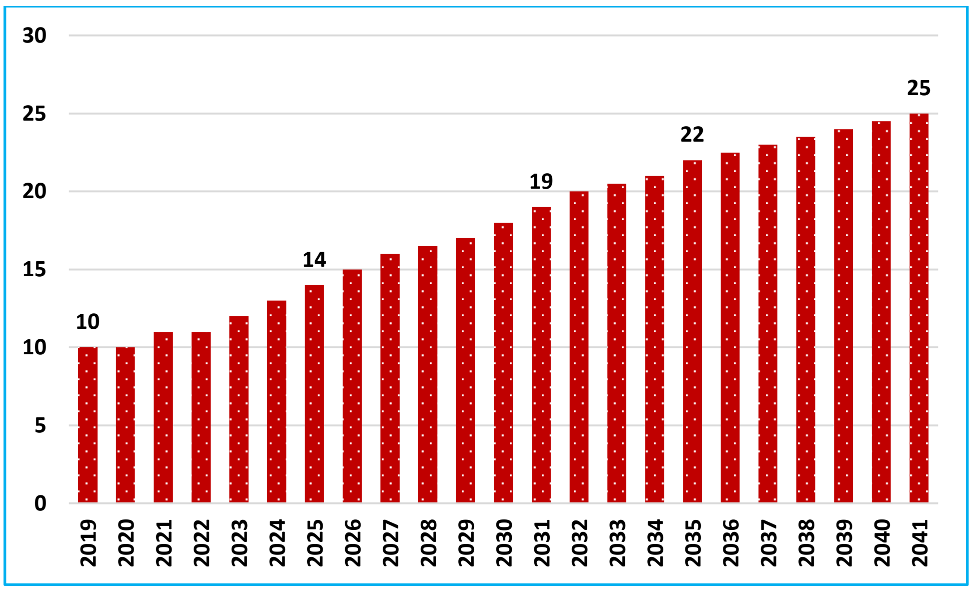
The time period for the projection is 2018 to 2041 – closely conforming to the time period of the perspective plan (i.e. 2021-2041). The carbon tax model considers two situations: (i) pre-carbon tax situation and (ii) carbon tax situation. Data for 2018 has been used to projects values for 2019 to 2041 period. Data on consumption (sale) of petroleum products along with their retail prices for 2018 have been obtained from Bangladesh petroleum corporation (BPC). *In the pre-carbon tax situation*, sale projections of petroleum products for 2019 to 2041 are based on GDP growth rates projections reported in the economic model of the Bangladesh Perspective Plan 2041 (PP2041). The prices of the petroleum products for 2019 to 2041 are index to CPI inflation rates over the 2019 to 2041 period obtained from the macroeconomic framework of the PP2041. The Co2 emission levels from these petroleum products have been calculated using the standard Co2 emission rates for petroleum products.

Imposition of CT on petroleum products will increase the price of product by the same percentage amount (i.e. there is a one to one association between tax rate and price increase). Price increase will lead to fall in demand for these products. The extent of demand decline depends on the percentage price increase and the price elasticity of demand. However, in a growing economy with expansion of income, demand for product increases (i.e. normal goods). The extent demand increase due to income growth depends on the income elasticity of these products. Thus, the net effect on demand for petroleum products depend on the tax rate; income growth; and the price and income elasticities of demand for petroleum products.

Two scenarios are considered. *First* scenario is a *low case scenario* where CT is imposed on three petroleum products: Petrol, Octane and Diesel. In the second scenario CT has been levied on five petroleum products: Petrol, Octane, Diesel, Furnace oil and Kerosene[2]. This scenario is labelled as the *high case scenario*.

Carbon Tax: Carbon tax rates are proposed to increase from 10% in 2019 to 25% in 2041. The trends in proposed carbon tax rates between 2019 and 2041 period is shown in Figure A.1. The proposed rate and time path are illustrative. They affect only the magnitude but do not influence the direction or the policy implications.

Figure A.1: Proposed Carton Tax (%)



C. Impacts of a Carbon Tax on CO2 Emission and Revenues

Low Case: Impacts of imposition of carbon taxes on Petrol, Octane and Diesel are reported in Table A1. below. For simplification purpose, petrol and octane are combined as they are virtually near-perfect substitutes and prices are almost similar. The price and income elasticity assumptions are explained in detail in the main report (Section V). The impacts have been captured in terms of demand for the products; Co2 emissions; and revenue from carbon taxes. The outcomes are reported both for before tax and after-tax situation. The impacts on demand and Co2 emissions are

[2] Kerosene is an inferior good. Following the features of an inferior good, kerosene demand has been projected to decline by 5% every year between 2019 and 2041, which is similar to the pattern observed in the recent past.

significant. Revenue from CT, which is estimated at 43 billion BDT in the first year, increases to 220 billion BDT in 2041.

Table A1: Effects of Carbon tax in Bangladesh: Low Case

	2019	2020	2021	2025	2031	2035	2041
Before Tax							
Diesel demand (MT)	4,770,400	5,118,162	5,495,883	7,359,054	10,979,893	14,111,989	19,823,988
Diesel demand (Million liter)	5,686	6,101	6,551	8,772	13,088	16,821	23,630
Co2 emission @ 3.198/per MT (million MT)	15.3	16.4	17.6	23.5	35.1	45.1	63.4
Petrol/Octane demand (MT)	493,120	529,068	568,114	760,711	1,135,000	1,458,767	2,049,221
Petrol/Octane demand (Million liter)	629	637	642	644	597	554	469
Co2 emission @ 3.187/per MT (million MT)	1.6	1.7	1.8	2.4	3.6	4.6	6.5
After Tax							
Diesel demand (MT)	4,503,400	4,561,494	4,597,074	4,609,852	4,275,847	3,964,026	3,359,054
Diesel price increase per liter	7	7	8	13	23	32	48
Diesel demand (Million liter)	5,368	5,437	5,480	5,495	5,097	4,725	4,004
Diesel revenue (Billion BDT)	37	39	46	72	119	152	191
Co2 emission @ 3.198/per MT (million MT)	14.4	14.6	14.7	14.7	13.7	12.7	10.7
Petro/Octane demand (MT)	465,520	471,525	475,203	476,524	441,998	409,764	347,228
Price increase per liter	9	10	11	17	31	43	63
Petro/Octane demand (Million liter)	629	637	642	644	597	554	469
Petro/Octane revenue (Billion BDT)	6	6	7	11	18	24	30
Co2 emission @ 3.187/per MT (million MT)	1.48	1.50	1.51	1.52	1.41	1.31	1.11
CT Revenue (Billion BDT)	43	45	53	83	137	176	220
Co2 emission (million MT)	15.9	16.1	16.2	16.3	15.1	14.0	11.8

Source: Bangladesh carbon tax model

High Case: In the high case, the impacts on demand and Co2 emissions are more pronounced than the low case. Much of the additional reduction in CO2 and increase in revenue over the low case comes from the inclusion of furnace oil. Kerosene carbon tax makes a negligible impact because it is a tiny share of total petroleum consumption. Indeed, the overall CO2 reduction and revenue increases differences between the high case and the low case is small because of the dominant role of diesel consumption in total petroleum basket, which is included in both cases (Figure A.2.). Furnace oil comes a distant second, followed by octane and petrol. So, a meaningful carbon tax must be imposed on diesel; otherwise, the effects will be negligible. The exclusion of kerosene from carbon tax to avoid political sensitivity is not very sensitive to the results relating to carbon reduction and higher revenues.

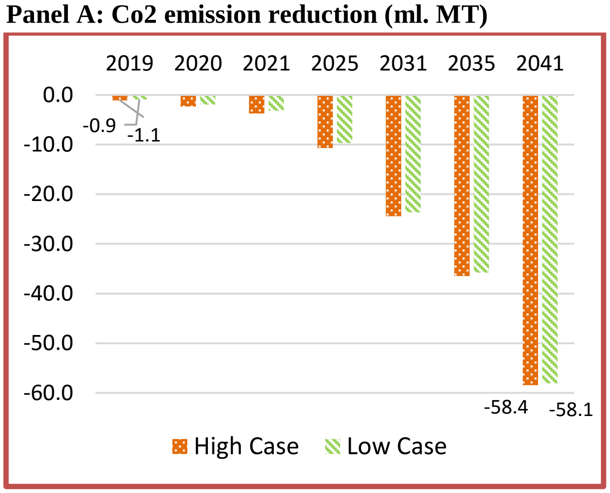
Table A.2: Effects of Carbon tax in Bangladesh: High Case

	2019	2020	2021	2025	2031	2035	2041
Before Tax							
Diesel demand (MT)	4,770,400	5,118,162	5,495,883	7,359,054	10,979,893	14,111,989	19,823,988
Diesel demand (Million liter)	5,686	6,101	6,551	8,772	13,088	16,821	23,630
Co2 emission @ 3.198/per MT (million MT)	15.26	16.37	17.58	23.53	35.11	45.13	63.40
Petrol/Octane demand (MT)	493,120	529,068	568,114	760,711	1,135,000	1,458,767	2,049,221
Petrol/Octane demand (Million liter)	152,000	144,400	137,180	111,734	82,135	66,899	49,177
Co2 emission @ 3.187/per MT (million MT)	181.2	172.1	163.5	133.2	97.9	79.7	58.6
Furnace Oil demand (MT)	884,400	948,873	1,018,900	1,364,319	2,035,598	2,616,268	3,675,234
FO demand (Million liter)	1,054	1,131	1,215	1,626	2,426	3,119	4,381
Co2 emission @ 3.198/per MT (million MT)	2.8	3.0	3.3	4.4	6.5	8.4	11.8
Kerosene demand (MT)	152,000	144,400	137,180	111,734	82,135	66,899	49,177
Kerosene demand (Million liter)	181	172	164	133	98	80	59
Co2 emission @ 3.198/per MT (million MT)	0.49	0.46	0.44	0.36	0.26	0.21	0.16
After Tax							
Diesel demand (MT)	4,503,400	4,561,494	4,597,074	4,609,852	4,275,847	3,964,026	3,359,054
Diesel price increase per liter	7	7	8	13	23	32	48
Diesel demand (Million liter)	5,368	5,437	5,480	5,495	5,097	4,725	4,004
Diesel revenue (Billion BDT)	37	39	46	72	119	152	191
Co2 emission @ 3.198/per MT (million MT)	14.4	14.6	14.7	14.7	13.7	12.7	10.7
Petro/Octane demand (MT)	465,520	471,525	475,203	476,524	441,998	409,764	347,228
Price increase per liter	9	10	11	17	31	43	63
Petro/Octane demand (Million liter)	629	637	642	644	597	554	469
Petro/Octane revenue (Billion BDT)	5.7	6.1	7.1	11.1	18.4	23.6	29.5
Co2 emission @ 3.187/per MT (million MT)	1.5	1.5	1.5	1.5	1.4	1.3	1.1
Furnace Oil demand (MT)	834,900	845,670	852,266	854,635	792,713	734,904	622,746
FO per liter	4	5	5	8	15	21	31
FO demand (Million liter)	995	1,008	1,016	1,019	945	876	742
FO revenue (Billion BDT)	4	5	6	9	14	18	23
Co2 emission @ 3.198/per MT (million MT)	2.7	2.7	2.7	2.7	2.5	2.4	2.0
Kerosene demand (MT)	150,320	141,226	131,834	96,296	57,658	40,591	23,664
Kerosene per liter	7	7	8	13	23	32	48
Kerosene demand (Million liter)	179	168	157	115	69	48	28
Kerosene revenue (Billion BDT)	1	1	1	1	2	2	1
Co2 emission @ 3.198/per MT (million MT)	0.48	0.45	0.42	0.31	0.18	0.13	0.08
CT Revenue (Billion BDT)	48	51	60	93	153	195	244
Co2 emission (million MT)	19.0	19.2	19.4	19.3	17.8	16.5	13.9

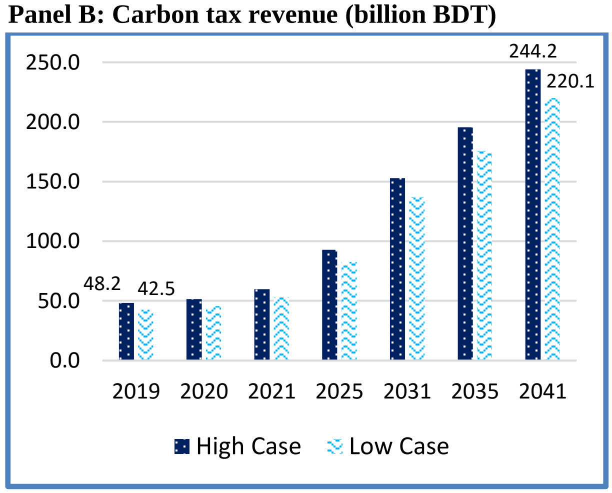
Source: Bangladesh carbon tax model

Figure A.2: CT Revenue and Impact on Co2 Emission Levels

Panel A: Co2 emission reduction (ml. MT)



Panel B: Carbon tax revenue (billion BDT)

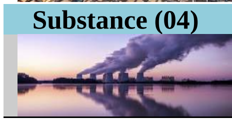


Source: Bangladesh carbon tax model

D. Environment Extended Input-Output Table (EIOT)

Bangladesh Input-output table (IOT) prepared for 2012 under the aegis of Planning Commission to assist projection of macro-economic variables for the 7th FYP is used to capture the general equilibrium effects of the changes in fuel oil prices owing to carbon tax on production, prices and employment. Two satellite matrices namely (i) an employment satellite matrix; and (ii) a substance matrix (i.e. energy use, Co2 emissions) have also been prepared to allow assessment of employment effect and environment effect due to changes in policies. Employment and environment extended input-output table (EIOT) has 57 activities and commodities following GTAP sector classification. Moreover, to model substitution effect (i.e. switch from traditional fossil fuel to a cleaner energy source) a renewable sector has been incorporated into the EIOT.

Table A.3: Description of Bangladesh EIOT 2012

Accounts	Detailed sector classification
Activities/commodities (57)	
	Paddy rice; Wheat; Cereal grains nec; Vegetables, fruit, nuts; Oil seeds; Sugar cane, sugar beet; Plant-based fibers; Crops nec; Bovine cattle, sheep and goats, horses; Animal products nec; Raw milk; Wool, silk-worm cocoons; Forestry; and Fishing (14)
	Coal; Crude Oil; Gas; and Minerals nec (04)
	Bovine meat products; Meat products nec; Vegetable oils and fats; Dairy products; Processed rice; Sugar; Food products nec; Beverages and tobacco products; Textiles; Wearing apparel; Leather products; Wood products; Paper products, publishing; Petroleum, coal products; Chemical, rubber, plastic products; Mineral products nec; Ferrous metals; Metals nec; Metal products; Motor vehicles and parts; Transport equipment nec; Electronic equipment; Machinery and equipment nec; Manufactures nec; and Construction (25)
	Transport nec; Water transport; Air transport (03)
	Electricity; Gas manufacture, distribution; Renewable (03)
	Trade; Communication; Financial services nec; Insurance; Business services nec; Recreational and other services; Public Administration, Defense, Education, Health; and Dwellings (08)
Satellite Employment (04)	
	Labour by skill category: Skilled and Unskilled
	Labour by Gender: Female and Male
Substance (04)	
	Energy use: Domestic energy use and imported energy use
	CO2 emissions: CO2emissions in domestic fuels and CO2emissions in foreign fuels

Source: EIOT

The Input-Output Model (IOM): The move from an IOT data framework to an IO model (also known as multiplier framework) requires decomposing the IOT accounts into 'exogenous' and 'endogenous'. Generally, accounts intended to be used as policy instruments (for example, government expenditure, investment and exports) are made exogenous and accounts specified as objectives or targets must be made endogenous (for example, output). For any given injection into the exogenous accounts of the IOM, influence is transmitted through the interdependent IOM system among the endogenous accounts. The interwoven nature of the system implies that the incomes of producing activities are all derived from exogenous injections into the economy via a multiplier process. The multiplier process is developed here on the assumption that when an endogenous income account receives an exogenous expenditure injection, it spends it in the same proportions as shown in the matrix of average propensities to spend (APS). The elements of the APS matrix are calculated by dividing each cell by the sum total of its corresponding column.

Table A.4: Description of the endogenous and exogenous accounts and multiplier effect

Endogenous (x)	*Exogenous (y)*
The activity (output multipliers), indicates the total effect on the sectoral gross output of a unit-income increase in a given account, *i* in the IOT, and is obtained via the association with the commodity production activity account *i*.	Intervention into through activities (y = c + g + i + e); Where, i= GFC + ST (GFCF) Consumption (c) Government Expenditure (g) Exports (e) Investment Demand (i)

The multiplier analysis using the EIOT framework helps to understand further the linkages between the different sectors and the institutional agents at work within the economy. Accounting multipliers have been calculated according to the standard formula for accounting (impact) multipliers, as follows:

$$x = A\,x + y = (I - A)^{-1}\,y = L\,y$$

Where:

x is a vector of endogenous variables (*which is 57 according to EIOT with all accounts showing non-zero numbers*);

y is a vector of exogenous variables (*which is also 57 according to EIOT with lots of zeros suggesting that policy options are not large*);

A is the matrix of average expenditures propensities for endogenous accounts, and

$L = (I - A)^{-1}$ is a matrix of aggregate accounting multipliers (generalized Leontief inverse).

The present multiplier framework has one endogenous account with 57 activities, and hence we can calculate multiplier measures for 57 activities due to changes in any one of the various exogenous accounts. More specifically, the elements of exogenous account (i.e. Δy) are manipulated to estimate their effects on output of all 57 activities (i.e. Δx).

$\Delta x = L\ \Delta y$ (i)

Impacts on CO2 emission levels by 57 activities (i.e. $\Delta CO2$) are assessed by the following specification:

$\Delta CO2 = RL\ \Delta y$ (ii)

Where, R refers to CO2 intensities by the 57 activities

Employment effects by 57 activities (i.e. Δn) have been calculated by the following specification:

$\Delta n = \text{Ŋ}L\ \Delta y$ (iii)

Where, Ŋ denotes employment intensities by the 57 activities

Price effects by 57 activities (i.e. ΔP) have been determined by the following specification:

$\Delta \mathbf{P}' = \Delta \mathbf{v}'\mathbf{L}$ ***(iv)***

Where, $\Delta \mathbf{v}'$ is the transposed vector of changes in the primary input cost coefficients (i.e. including carbon tax) and $\Delta \mathbf{P}'$ is the transposed vector of consequent price changes.

A relevant issue related to carbon tax is its impact on the final consumer. More specifically will it be regressive, progressive or neutral? Input–output analysis of the impact on commodity prices can provide one input to a quantitative analysis of this question. The other necessary input is data on the expenditure patterns of households at different positions in the income distribution which is, or can be made, compatible with the input–output data in terms of its commodity classification. Where such data are available, the change in the cost of living for a household is given by

$\Delta CP_{Ih} = \Sigma_j \beta h_j \Delta P_j, \quad h = 1, . . . , m$ (v)

Where CPI stands for consumer price index, h indexes households, and β_{hj} is the 2010 budget share of commodity j for the h^{th} household.

E. Economy Wide Impacts

Economy wide impacts of carbon tax are presented under two scenarios or simulations: (i) low case and (ii) high case. The simulation set ups are carefully designed. Estimated changes in prices and demands for the petroleum products have been incorporated into the EIOM to assess economy wide impacts of carbon tax in Bangladesh. The static economywide output and employment outcomes derived from the EIOM are then used to assess effects on output and employment projected for 2019 to 2041 period under the macroeconomic framework of PP2041.

Simulations have also been conducted to invoke substitution effects and their implications on the output and employment. It is assumed that during the initial three years (i.e. 2019-2021), no substitution to renewable energy sector is possible. One to one substitution between the petroleum products and renewable energy product is commenced from 2022. This is a reasonable assumption. Although presently Bangladesh is lagging behind on substitution prospects especially for renewable energy, globally the technology is put there and with correct pricing policies for fuel oil along with the carbon tax private investment will help facilitate substitution effects as well as create incentive for more efficient energy use. For example, solar power has already become popular in rural housing and irrigation. Availability of electricity has also caused a massive reduction in the use of kerosene. In transportation CNG has become popular that has lowered the demand for gasoline. Investments in electricity-based mass transit light rail are underway that will lower the use of diesel and gasoline for urban transportation.

Furthermore, simulations are also carried out to examine impact of investing carbon tax revenues into the economy. It is assumed that CT revenues are invested in infrastructure project and the simulations have been conducted through the construction sector of the EIOM.

Low Case Simulation Set Up: In the low case, price increases and demand reduction of Petrol, Octane and Diesel products found in the BCM are injected to the EIOM via the road and water transport sectors considering that these petroleum products are mainly used in these two sectors as inputs.

High Case Simulation Set Up: High case simulation is on top of the low case simulation set up. Accordingly, price increases and demand reduction of Furnace oil and Kerosene products found in the BCM are injected to the EIOM via the electricity sector considering that Furnace Oil is mainly used in electricity generation.

The simulated results are shown in tables below. Key observations:

- Overall increase in the general price level is moderate. In the low case, it increases between 0.324% in 2019 to 0.494% in 2041. The increase is slightly higher under the high case and varies between 0.537% in 2019 to 0.849% in 2041.

- Increase in cost of living index is higher, from 0.804% in FY2019 to 1.227% in FY2041 but it clearly shows a progressive pattern. The price increases are highest for the top 10% and lowest for the bottom 20%. The pattern is similar for the high case although the magnitude of price increases is higher. Compensations through social protection schemes to poorer households (group 1 and 2) will dampen the income loss from cost escalation faced by them.
- For both low and high cases, the initial output losses are small and almost fully recouped when substitution to renewable energy sectors is considered.

The main conclusion is that the introduction of a carbon tax lowers CO_2 substantially and raises considerable revenues. There is an initial small negative output and employment effects that can be offset with fast transition to clean energy environment. Additionally, the adverse output effects can be compensated with additional public investments in clean energy and infrastructure and social protection spending facilitated by higher revenues from the carbon tax.

Table A.5: Economy Wide Effects of the Carbon Tax in Bangladesh: Low Case

	2019	2020	2021	2025		2031		2035		2041	
				NSE	WSE	NSE	WSE	NSE	WSE	NSE	WSE
Price and Cost of Living Index											
General Price Increase (%)	0.324	0.324	0.336	0.417		0.429		0.437		0.494	
Cost of Living Index (%)	0.804	0.804	0.835	1.036		1.066		1.086		1.227	
Income Group 1	0.613	0.613	0.636	0.789		0.812		0.827		0.934	
Income Group 2	0.612	0.612	0.635	0.788		0.811		0.827		0.934	
Income Group 3	0.657	0.657	0.681	0.845		0.870		0.886		1.001	
Income Group 4	0.768	0.768	0.797	0.989		1.018		1.037		1.171	
Income Group 5	0.969	0.969	1.005	1.247		1.284		1.308		1.477	
GDP loss/gain (Billion BDT)											
Agriculture	-0.04	-0.05	-0.04	0.00	0.1	0.00	0.10	-0.10	0.00	-0.10	0.0
Industry	-0.70	-0.8-	-0.8-	-1.30	16.5	-2.00	24.8	-3.0	30.6	-5.50	46.2
Construction	-0.00	-0.00	-0.00	-0.0-	-0.10	-0.10	0.00	-0.10	0.00	-0.10	0.1
Services	-20.6	-22.5	-23.1	-31.5	-16.8	-40.1	-24.7	-48.6	-30.4	-73.3	-45.9
All	-21.4	-23.3	-23.9	-32.8	-0.1	-42.2	0.2	-51.7	0.3	-79.0	0.4
Loss (gain) as % of PP projected GDP	-0.01	-0.01	-0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Employment loss/gain (Million Persons)											
Agriculture	-0.004	-0.004	-0.004	-0.003	0.009	-0.003	0.002	-0.002	0.001	-0.001	0.001
Industry	0.000	0.000	0.000	0.000	0.005	0.000	0.003	0.000	0.002	0.000	0.001
Construction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Services	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	0.000	-0.001	0.000	-0.001	0.000
All	-0.002	-0.002	-0.002	-0.009	0.013	-0.009	0.014	-0.011	0.014	-0.014	0.015
Loss (gain) as % of PP projected employment	-0.009	-0.009	-0.008	-0.013	0.040	-0.013	0.038	-0.014	0.036	-0.016	0.035

Source: EIOT Projections

Note: NSE: No substitution effect; WSE: With substitution effect. PP: Perspective Plan 2041.

Table A.6: Economy Wide Effects of Carbon Tax in Bangladesh: High Case

High Case	2019	2020	2021	2025		2031		2035		2041	
				NSE	WSE	NSE	WSE	NSE	WSE	NSE	WSE
Price and Cost of Living Index											
General Price Increase (%)	0.537	0.537	0.588	0.733		0.749		0.771		0.849	
Cost of Living Index (%)	0.945	0.945	1.001	1.244		1.277		1.306		1.461	
Income Group 1	0.780	0.780	0.834	1.037		1.063		1.089		1.213	
Income Group 2	0.773	0.773	0.825	1.027		1.052		1.078		1.201	
Income Group 3	0.811	0.811	0.864	1.075		1.102		1.129		1.259	
Income Group 4	0.911	0.911	0.966	1.201		1.233		1.261		1.410	
Income Group 5	1.092	1.092	1.151	1.430		1.469		1.501		1.683	
GDP loss/gain (Billion BDT)											
Agriculture	-0.05	-0.05	-0.06	-0.10	0.20	-0.10	0.10	-0.1	0.10	-0.10	0.10
Industry	-4.30	-5.00	-5.90	-6.90	14.2	-8.20	17.9	-9.5	24.10	-11.20	33.6
Construction	-0.10	-0.10	-0.10	-0.10	0.00	-0.10	0.00	-0.1	0.0	-0.20	0.00
Services	-20.9	-22.8	-23.4	-31.8	-14.5	-40.4	-18.1	-48.9	-24.1	-73.5	-33.70
All	-25.3	-28.0	-29.5	-38.9	-0.10	-48.8	-0.10	-58.6	0.00	-85.0	0.00
Loss (gain) as % of PP projected GDP	*-0.02*	*-0.02*	*-0.02*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Employment loss/gain (Million Persons)											
Agriculture	-0.005	-0.005	-0.005	-0.004	0.010	-0.002	0.003	-0.002	0.002	-0.001	0.001
Industry	-0.003	-0.003	-0.003	-0.002	0.004	-0.001	0.002	0.000	0.001	0.000	0.001
Construction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Services	-0.001	-0.001	-0.001	-0.001	0.000	-0.001	0.000	-0.001	0.000	-0.001	0.000
All	-0.004	-0.004	-0.004	0.008	0.013	0.011	0.013	0.012	0.014	0.014	0.015
Loss (gain) as % of PP projected employment	-0.013	-0.013	-0.012	0.026	0.039	0.029	0.037	0.031	0.036	0.032	0.035

Source: EOIT Projection

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