ESTIMATING THE COST OF REDUCING CO2 EMISSIONS BY 17 PERCENT BY US IN 2020

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Abstract

Recent climate threats forced major greenhouse gases (GHGs) emitter countries i.e. China, USA, India and Brazil to think seriously on reducing GHGs emissions as Europe has already taken serious measures under Kyoto Protocol. These big countries have made different commitments to reduce GHGs emissions in Copenhagen Accord. The US Government made a commitment of reducing GHGs emissions by 17 percent in 2020 subject to the level of 2005 levels. This paper has attempted to estimate the cost of implementing such commitment by US Government using input-output analysis techniques and by assuming improvements in carbon intensity in few key sectors in three policy scenarios developed in this study. The results show very huge cost of enforcing such policy that is around 6.5 trillion dollars when compared with projection of Bureau of Labor Statistics for 2020 considering the price level of 2005. This study suggests that US government needs to put serious attention to address this issue and resolve it by producing environmental friendly and energy efficient technology without having huge tradeoff between other economic and social goals.

Key words: Input-output Model, US Commitment, & GHGs Emissions

1. Introduction

US is facing serious climate problems i.e. extreme weather, hurricanes, storms and floods and their frequency has increased in recent years which caused huge economic and social loss (WRI, 2013). The unsustainable human production and consumption patterns have brought about these problems that have posed serious threats to biodiversity, ecosystem, and global mean temperature. Every country will have to face these issues (Onishi, 2007). Although most of climate problems are global in nature but all these problems are very important to be addressed seriously and carefully.

Human activities have contributed greenhouse gases (GHGs) emissions in atmosphere significantly since industrial revolution (Raman et al., 2012). Increase in anthropogenic emissions of GHGs caused global warming that causes chain of climatic problems to human and other living beings on planet earth. According to Fan et al., GHGs effect will put an end to environment, humans and every other living thing (Fan et al., 2007). Fossil fuel is the main source of energy production and GHGs emissions. In order to get rid of serious climate issues, nations of the world have to reduce consumption of fossil fuel significantly (IPCC, 2007).

Growing awareness regarding the current and future implications of global warming brought together both developed and developing countries to cooperate in forming platforms to address and solve this serious issue. For this, in Kyoto Japan in 1997 about 160 countries reached on common agreement that resulted in Kyoto Protocol. According to this agreement, Annex I countries have to reduce GHGs emissions by average 5 percent below to 1990s level in 2008-2012 and Kyoto Protocol became effective after ratified by Russia in 2004 (Lixon et al., 2008).

On the one hand Europe was attempting to reduce GHGs emissions with compliance to the targets set under Kyoto Protocol and on the other hand, US had no interest to address climate change issues seriously and Kyoto Protocol seemed to be a dirty thing for Bush Administration (Black, 2001), whereas US was emitting more CO2 per capita than any other OECD country (Byrne et al., 2006). Bush Administration also opposed Kyoto Protocol on the grounds of it exempts 80 percent of world population mainly China and India from reducing GHGs emissions and this would damage US economy seriously (Byrne et al., 2007). The withdrawal of US from

Kyoto Protocol created uncertainty and division among the countries to proceed further as the world's largest GHGs emitter deviated from its earlier promise (European Commission, 2001).

US showed great support and interest in 15th Conference of the Parties for United Nations Framework Convention on Climate Change (UNFCCC) held at Copenhagen in 2009. New reductions targets were given to the members of Annex I countries with respect to 1990 or 2005 levels emissions. This conference also focused on methods and principles that determine climate change targets (Turner et al., 2012). As conference was supported by new players like President Obama who made commitment to reduce GHGs emissions by 17 percent compared to the level of 2005 emissions (WRI, 2013) but this conference was not more than a promise and discussion (Suranovic, 2013).

Nonetheless, US commitment was a great step towards reducing GHGs emissions globally. The purpose of this paper is to estimate the cost of implementing the commitment made by President Obama in Copenhagen conference that is reducing GHGs emissions by 17 percent by 2020. The opportunity cost will be measured in terms of GDP/final demand in 2005 year prices. This paper focuses only CO2 emissions[1] as the international scientific community has consensus that carbon dioxide gas (CO2) is the key GHGs that has significant impact on global warming (Solomon et al., 2007). The study further uses policy scenarios i.e. improvement CO2 per dollar intensity in few important sectors of the US economy developed on the basis of recommendations given in WRI report 2013.

The structure of rest of the paper is as follows: second section discusses about data and methodology used in this study. Third sections deals with policy analysis with three scenarios. Fourth section concludes the paper with some recommendations.

[1] Data on other GHGs are not available on sectoral basis.

2. Data & Methodology

A great deal of literature exists on energy and environmental issues for the last few decades. The pioneer work on input-output analysis was done by Leontief (1936 & 1941). He further extended it by adding environmental discharges and abatement activities (Leontief, 1970).

Input-output models are very useful in finding the magnitude of direct and indirect change in total output that results from change in final demand. The basic equation of input-output equation is:

$$X = Ax + Y \tag{1}$$

here X represents total output vector of all sectors, Ax is the intermediate demand matrix of all sectors and Y final demand vector of all sectors. A shows technical coefficients matrix $[a_{ij}]$ which can be obtained by:

$$a_{ij} = \frac{x_{ij}}{X_j} \tag{2}$$

here x_{ij} represents the sale of ith sector to sector j and X_j is the total outlay of sector j.

Putting intermediate demand term to the left of equation (1)

$$\boldsymbol{X - Ax = Y} \tag{3}$$

and simplifying the equation (3)

$$\boldsymbol{X(I - A) = Y} \tag{4}$$

In order to extend the model for addressing the environmental issues into input-output analysis, following equation is added

$$E_i = \hat{R}_i X \tag{5}$$

here E_i shows the vector of total environmental effects of type *i*, $\hat{R}_i$ a diagonal matrix of environmental discharges of type *i*, per monetary unit of sector's output. By playing with equation 5

$$X = \frac{E_i}{\hat{R}_i} \tag{6}$$

Insert the value of *X* in equation (4)

$$Y = (I - A)\hat{R}_i^{-1} E_i \tag{7}$$

Equation (7) can be used to solve for *Y* given the exogenous environmental discharges of type *i*.

Input-output table of US and sectoral emissions of CO_2 for 2005 are taken from World Input-Output Database (WIOD)[2]. The rationale of using IO table for 2005 is to analyze the impact analysis of US commitment to reduce CO_2 emissions by 17 percent subject to the level of 2005 emissions. The IO table taken from WIOD has 36 sectors. But we have added last four sectors i.e. Health and Social Work; Other Community, Social and Personal Services; Private Households with Employed Persons & Extra-territorial organizations and bodies sectors as some of these sectors have no sectoral emissions.

3. Policy Analysis

This policy analysis has three scenarios that are P1, P & P3. We have assumed 17 percent proportional reductions of CO_2 emissions of all 33 sectors[3] compared to the level of 2005 emissions. In these three policy scenarios, we have further assumed improvement in carbon intensity per dollar in few key sectors that results from substitution of natural gas for coal, fuel efficiency and energy efficiency through state and federal actions which are also discussed in WRI report 2013. The purpose of this policy is to analyze the impact of 17 percent reduction of

2 Timmer (ed) (2012) describes methods and sources of data preparation for WIOD. This data is free of cost and can be downloaded at: www.wiod.org.

3 Details of sectors are given in appendices.

CO_2 on the final demand of all 33 sectors in the year 2020. Table 1 shows three scenarios of improvement in carbon intensity per dollar in few key sectors.

Table. 1 Improvement in Carbon Intensity per Dollar in Percent

Sectors	P1	P2	P3
Electricity, Gas and Water Supply	5	10	15
Inland Transport	2	5	7
Air Transport	1	2	3
Coke, Refined Petroleum and Nuclear Fuel	2.5	5	7.5

Source: Author's calculations

Under scenario P1, results show that over all final demand (GDP) will decrease by 16.85 percent subject to the final demand 2005 year.[4] If we see sectoral basis, the highest decline comes in Mining and Quarrying sector that is 23.04 percent which is followed by Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies sector that is 18.22 percent. The least decline comes in Electricity, Gas and Water Supply which is 7.7 percent. Nevertheless, Coke, Refined Petroleum and Nuclear Fuel, Inland Transport, and Air Transport have shown 11. 71, 13.56 & 15.94 percent decline respectively.

Under scenario P2, situation is not very unlikely; trend of decline is seen in all sectors except Electricity, Gas and Water Supply sector which has shown increase in final demand by 2.63 percent. The highest decline in final demand again comes in Mining and Quarrying sector which is nearly 30 percent and Other Supporting and Auxiliary Transport Activities, Activities of Travel Agencies sector has retained its 2nd position in terms of decline. The minimum decline comes in Coke, Refined Petroleum and Nuclear Fuel which is 6.32 percent whereas Inland Transport sector has shown decline of 7.83 percent. Despite positive change in one of the key sectors could not rescue the overall decline of 16.67 percent. In scenario P3, we see lesser decline in overall final demand than under P2 and P1. The Electricity, Gas and Water Supply sector has shown tremendous improvement, its final demand has been increased by 6 times than under P2 scenario. This is the only sector among 33 sectors which has shown positive change whereas all other sectors have shown decrease in final demand. The Coke, Refined Petroleum and Nuclear Fuel sector has shown 7 times improvement in bringing decline in final demand to

[4] The sectoral results of final demands of these three Ps are given in Appendix 1 to 7.

0.45 percent. Meanwhile, Mining and Quarrying sector has shown highest decline in final demand to 36.7 percent which is 50 percent higher than decline of final demand under P1 scenario. The total final demand under this scenario goes down by 16.48 percent than the final demand of year of 2005. US Bureau of Labor Statistics[5] has projected final demand of 195 sectors for the year 2020 using the price of 2005 year and accordingly, total final demand is 18.02 trillion dollars. If we compare the results developed under three Ps with the projections of Bureau of Labor Statistics, we find a very huge cost of reducing CO2 emissions by 17 percent. The final demand has decreased by 36.62, 36.48 & 36.34 percent when compared with the results of P1, P2 and P3 scenarios respectively.

4. Conclusion and Recommendations

Climate change has emerged as one of the biggest challenges that human race has ever encountered. Some climatic issues have affected world uniformly but some of them have affected some regions severely and some less based on their geographic positions. Similarly, United States has also faced severe climatic problems for the last few decades that have caused huge socio-economic cost. The occurrence of extreme weather events, average temperature increase, flooding, hurricanes, and unusual rain have already cost more than $ 1 trillion since 1980 (NCDC)[6]. The cost and severity of such events would be higher and higher in coming years. This changing climatic phenomenon is the result of human production and consumption activities. Besides the attainment of rapid growth and development throughout the globe, the economic liberalization policies resulted intensification of greenhouse gases (GHGs) emissions in the atmosphere. These gases are considered as the root cause of environmental problems of today. The socio-economic cost of climate change impacts is reached at such level where it is imperative to design the policy framework that could curb the increase of GHG emission.

Energy is the life line of economic development and its emission aspect has put the policy makers and scientific researchers at crossroads. At the one side of picture, the energy economist projects higher energy demands and on the other side, the climate change scientists calculate the future socio-economic cost of such higher energy demands that will result in further climate damage. Which side of coin is going to prevail? The question yet to answer. However, the

[5] Data available at: http://www.bls.gov/emp/ep_data_input_output_matrix.htm
[6] National Climate Data Center (NCDC) calculated the cost of 151 natural disasters in US since 1980.

scientific communities of both the sides are extensively engaged in advocating their own agenda. They need to join hands together for addressing this very much serious issue.

This study has tried to estimate the opportunity cost of implementing the 17 percent reduction of CO2 emissions in 2020 subject to the level of 2005 policy of US Government as committed in Copenhagen Accord. Although, it has also assumed improvement in carbon intensity per dollar for few key sectors but results show that even low carbon intensity in few sectors cannot help US from incurring the huge cost of final demand equivalently GDP which also means loss of jobs.

US needs to focus more on development of energy efficient technology, more production of renewable energy and natural gas extraction as natural gas has very less carbon factor as well as it is very economical. This may help US to have less tradeoff between the environmental, economic and social goals.

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Appendix 1. Estimated Final Demand for the Year 2020 under P1

Sectors	Final Demand
Agriculture, Hunting, Forestry and Fishing	61820.22
Mining and Quarrying	71228.08
Food, Beverages and Tobacco	340936.53
Textiles and Textile Products	42415.22
Leather, Leather and Footwear	3122.56
Wood and Products of Wood and Cork	13298.62
Pulp, Paper, Paper , Printing and Publishing	124505.92
Coke, Refined Petroleum and Nuclear Fuel	141490.52
Chemicals and Chemical Products	196874.98
Rubber and Plastics	33373.62
Other Non-Metallic Mineral	12407.66
Basic Metals and Fabricated Metal	60742.49
Machinery, Nec	181292.20
Electrical and Optical Equipment	287192.57
Transport Equipment	386529.30
Manufacturing, Nec; Recycling	96258.83
Electricity, Gas and Water Supply	167873.95
Construction	959365.94
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	134399.00
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	486364.82
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	827334.84
Hotels and Restaurants	432023.29
Inland Transport	122610.94
Water Transport	23736.93
Air Transport	84809.38
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	27401.52
Post and Telecommunications	193059.82
Financial Intermediation	684448.60
Real Estate Activities	1185012.34
Renting of M&Eq and Other Business Activities	473921.63
Public Admin and Defence; Compulsory Social Security	1902442.84
Education	129137.21
Health and other community sectors	1534726.77
Total	11422159.18

Source: Author's Calculations

Appendix 2. Estimated Final Demand for the Year 2020 under P2

Sectors	Final Demand
Agriculture, Hunting, Forestry and Fishing	61820.05
Mining and Quarrying	65156.62
Food, Beverages and Tobacco	340935.24
Textiles and Textile Products	42413.11
Leather, Leather and Footwear	3122.55
Wood and Products of Wood and Cork	13271.50
Pulp, Paper, Paper , Printing and Publishing	124427.10
Coke, Refined Petroleum and Nuclear Fuel	150125.65
Chemicals and Chemical Products	196782.13
Rubber and Plastics	33309.24
Other Non-Metallic Mineral	12380.00
Basic Metals and Fabricated Metal	60602.65
Machinery, Nec	181253.86
Electrical and Optical Equipment	287159.09
Transport Equipment	386346.63
Manufacturing, Nec; Recycling	96254.15
Electricity, Gas and Water Supply	186661.65
Construction	958830.02
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	134371.93
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	485932.08
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	827185.78
Hotels and Restaurants	431813.03
Inland Transport	130732.36
Water Transport	23731.10
Air Transport	85890.66
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	26816.53
Post and Telecommunications	192701.80
Financial Intermediation	683639.54
Real Estate Activities	1184791.53
Renting of M&Eq and Other Business Activities	472366.94
Public Admin and Defence; Compulsory Social Security	1902340.55
Education	129132.36
health and other community sectors	1534569.89
Total	11446867.30

Source: Author's Calculations

Appendix 3. Estimated Final Demand for the Year 2020 under P3

Sectors	Final Demand
Agriculture, Hunting, Forestry and Fishing	61819.89
Mining and Quarrying	58588.27
Food, Beverages and Tobacco	340933.93
Textiles and Textile Products	42411.25
Leather, Leather and Footwear	3122.55
Wood and Products of Wood and Cork	13250.08
Pulp, Paper, Paper , Printing and Publishing	124353.50
Coke, Refined Petroleum and Nuclear Fuel	159533.80
Chemicals and Chemical Products	196697.10
Rubber and Plastics	33257.19
Other Non-Metallic Mineral	12350.37
Basic Metals and Fabricated Metal	60485.80
Machinery, Nec	181222.06
Electrical and Optical Equipment	287127.34
Transport Equipment	386211.67
Manufacturing, Nec; Recycling	96249.58
Electricity, Gas and Water Supply	207673.62
Construction	958278.86
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	134350.51
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	485534.98
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	827069.43
Hotels and Restaurants	431583.38
Inland Transport	136045.15
Water Transport	23725.62
Air Transport	86998.58
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	26360.73
Post and Telecommunications	192415.07
Financial Intermediation	682943.75
Real Estate Activities	1184603.41
Renting of M&Eq and Other Business Activities	470951.41
Public Admin and Defence; Compulsory Social Security	1902248.37
Education	129127.31
health and other community sectors	1534429.51
Total	11471954.09

Source: Author's Calculations

Appendix 4. Final Demand for the Year 2005

Sectors	Final Demand
Agriculture, Hunting, Forestry and Fishing	74482.36
Mining and Quarrying	92557.35
Food, Beverages and Tobacco	410768.4
Textiles and Textile Products	51104.66
Leather, Leather and Footwear	3762.122
Wood and Products of Wood and Cork	16044.97
Pulp, Paper, Paper , Printing and Publishing	150083
Coke, Refined Petroleum and Nuclear Fuel	160248.6
Chemicals and Chemical Products	237290.2
Rubber and Plastics	40263.85
Other Non-Metallic Mineral	14978.65
Basic Metals and Fabricated Metal	73306.25
Machinery, Nec	218457.5
Electrical and Optical Equipment	346047.4
Transport Equipment	465844.2
Manufacturing, Nec; Recycling	115979.1
Electricity, Gas and Water Supply	181880
Construction	1156408
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	161949.2
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	586407.2
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	996913
Hotels and Restaurants	520738.2
Inland Transport	141842.6
Water Transport	28604.42
Air Transport	100895.5
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	33507.27
Post and Telecommunications	232910.6
Financial Intermediation	825359.9
Real Estate Activities	1427923
Renting of M&Eq and Other Business Activities	572460.3
Public Admin and Defence; Compulsory Social Security	2292196
Education	155592
health and other community sectors	1849214
Total	13736020

Appendix 5. % Change in Final Demand for the Year 2020 under P1 in Comparison with 2005

Sectors	Final Demand
Agriculture, Hunting, Forestry and Fishing	-17.00
Mining and Quarrying	-23.04
Food, Beverages and Tobacco	-17.00
Textiles and Textile Products	-17.00
Leather, Leather and Footwear	-17.00
Wood and Products of Wood and Cork	-17.12
Pulp, Paper, Paper , Printing and Publishing	-17.04
Coke, Refined Petroleum and Nuclear Fuel	-11.71
Chemicals and Chemical Products	-17.03
Rubber and Plastics	-17.11
Other Non-Metallic Mineral	-17.16
Basic Metals and Fabricated Metal	-17.14
Machinery, Nec	-17.01
Electrical and Optical Equipment	-17.01
Transport Equipment	-17.03
Manufacturing, Nec; Recycling	-17.00
Electricity, Gas and Water Supply	-7.70
Construction	-17.04
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	-17.01
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	-17.06
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	-17.01
Hotels and Restaurants	-17.04
Inland Transport	-13.56
Water Transport	-17.02
Air Transport	-15.94
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	-18.22
Post and Telecommunications	-17.11
Financial Intermediation	-17.07
Real Estate Activities	-17.01
Renting of M&Eq and Other Business Activities	-17.21
Public Admin and Defence; Compulsory Social Security	-17.00
Education	-17.00
health and other community sectors	-17.01
Total	-16.85

Source: Author's Calculations

Appendix 6. % Change in Final Demand for the Year 2020 under P2 in Comparison with 2005

Sectors	Final Demand
Agriculture, Hunting, Forestry and Fishing	-17.00
Mining and Quarrying	-29.60
Food, Beverages and Tobacco	-17.00
Textiles and Textile Products	-17.01
Leather, Leather and Footwear	-17.00
Wood and Products of Wood and Cork	-17.29
Pulp, Paper, Paper , Printing and Publishing	-17.09
Coke, Refined Petroleum and Nuclear Fuel	-6.32
Chemicals and Chemical Products	-17.07
Rubber and Plastics	-17.27
Other Non-Metallic Mineral	-17.35
Basic Metals and Fabricated Metal	-17.33
Machinery, Nec	-17.03
Electrical and Optical Equipment	-17.02
Transport Equipment	-17.07
Manufacturing, Nec; Recycling	-17.01
Electricity, Gas and Water Supply	2.63
Construction	-17.09
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	-17.03
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	-17.13
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	-17.03
Hotels and Restaurants	-17.08
Inland Transport	-7.83
Water Transport	-17.04
Air Transport	-14.87
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	-19.97
Post and Telecommunications	-17.26
Financial Intermediation	-17.17
Real Estate Activities	-17.03
Renting of M&Eq and Other Business Activities	-17.48
Public Admin and Defence; Compulsory Social Security	-17.01
Education	-17.01
health and other community sectors	-17.02
Total	-16.67

Source: Author's Calculations

Appendix 7. % Change in Final Demand for the Year 2020 under P3 in Comparison with 2005

Sectors	Final Demand
Agriculture, Hunting, Forestry and Fishing	-17.00
Mining and Quarrying	-36.70
Food, Beverages and Tobacco	-17.00
Textiles and Textile Products	-17.01
Leather, Leather and Footwear	-17.00
Wood and Products of Wood and Cork	-17.42
Pulp, Paper, Paper , Printing and Publishing	-17.14
Coke, Refined Petroleum and Nuclear Fuel	-0.45
Chemicals and Chemical Products	-17.11
Rubber and Plastics	-17.40
Other Non-Metallic Mineral	-17.55
Basic Metals and Fabricated Metal	-17.49
Machinery, Nec	-17.04
Electrical and Optical Equipment	-17.03
Transport Equipment	-17.09
Manufacturing, Nec; Recycling	-17.01
Electricity, Gas and Water Supply	14.18
Construction	-17.13
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	-17.04
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	-17.20
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	-17.04
Hotels and Restaurants	-17.12
Inland Transport	-4.09
Water Transport	-17.06
Air Transport	-13.77
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	-21.33
Post and Telecommunications	-17.39
Financial Intermediation	-17.26
Real Estate Activities	-17.04
Renting of M&Eq and Other Business Activities	-17.73
Public Admin and Defence; Compulsory Social Security	-17.01
Education	-17.01
health and other community sectors	-17.02
Total	-16.48

Source: Author's Calculations