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The Copenhagen Dilemma: Carbon Emissions and Economic Development

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There is great hope that a new emissions regime, Copenhagen replacing Kyoto, against the global carbon equivalent emissions would start the walk towards a green economy with cleaner energy and stable climate. But the making of such a global ecology policy must overcome the contradiction between two entirely different measures of country emissions: per capita emissions and total country emissions. Reductions in the huge emissions in the Asia-Pacific region would significantly curb the progression of the greenhouse gases. The Copenhagen dilemma is: environment or economic development, as the non-OECD world will not accept a global environmental policy that reduces economic growth for them. Carbon emissions are intimately linked with energy consumption. There is a risk for policy confusion in relation to reducing greenhouse gases, namely to confound the per capita emissions with the total country emissions. The paper analyses these two variations in the emission of greenhouse gases. When there is talk about the curtailment of greenhouse gases, then it is interesting to know which countries emit how much. This paper suggests a double answer to this question, first showing the variation in total emissions and second analysing the per capita variation.

JEL Codes: Q1, Q2, Q3, Q4, Q5

Keywords: Greenhouse gases, per capita emission – total emissions, energy consumption, country variations, carbon equivalents emissions, economic development, global climate change policy, catch-up

Introduction: The Problem

There is still uncertainty about the impact of climate change upon the economies of the world, as cost estimations differ considerably. Similarly, there are wide differences in what the costs of reducing the emission of greenhouse gases would be (NORDHAUS, 2007; WEITZMAN, 2007). Yet, a consensus among the major governments of the world appears to be forthcoming that something has to be done to reduce the economic risks from large scale climate change with raising sea levels and more of floodings, ocean acidity as well as aridity and drought. If one agrees with the STERN 2006 Report that climate change induced by the emission of greenhouse gases constitutes the

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major market failure of our time, then it is appropriate to search for an international regime to counteract the steady rise in emissions.

It is a well-known fact that total emissions of greenhouse gases have increased sharply over the last twenty years. In 1990 21.2 billion metric tons were released, which figure had increased to 28 in year 2005, and is projected to reach 31.5 in 2010. If the present trend continues with or without a new global policy, then in 2030 the total emissions are predicted to reach 42.3 billion metric tons. The trend for emissions follows closely the projection for energy consumption. This close connection between energy use and carbons emissions entails that a green economy can only be promoted by new ways of generating energy, employed massively. Evidently, the Kyoto regime has had little impact upon halting the emission of greenhouse gases. How, then, can the progression in carbon equivalent emissions be curbed, if not reversed?

The Policy Dilemma: Total Emissions or Per Capita Emissions

There is now strong agreement among natural scientists that these carbon equivalent emissions lead to global warming and climate change, although a small minority raises doubts (LOMBORG, 2009). Some politicians have called for a drastic reduction in the emissions, a few even suggesting an 80 per cent cut up to 2080. Economists have started to enquire into the various policy measures to be used for reducing emissions, as few now take the cornucopian view of late Julian Simon that only adaptation and resilience works (STERN, 2007; HELM and HEPBURN, 2009).

In global environmental policy-making, it is not only important to overcome collective action difficulties, like free riding, transactions costs and the so-called tragedy of the commons. Devising an effective program based upon correct causal information about means and ends is equally relevant as overcoming myopia and opportunism from the involved players. The Kyoto regime was flawed not just because the United States finally reneged like Australia, but also because it did not require emissions reduction from some of the most polluting countries, i.e. China and India. A carbon tax could only contribute to the transformation towards a green economy, if it leads to substantial reductions in the *total* emissions of greenhouse gases, either halting their progression or contributing to real decreases.

As the governments of the countries of the world are in agreement on the need to reduce emissions, the fundamental issue is how to distribute the necessary reductions. Either one targets the per capita variation in emissions or one focuses upon total country emissions. Already in pre-meetings to Copenhagen, this issue has pitted the NON-OECD world against the OECD world. The policy implications of these two alternatives are very different. The crux of the matter is that the regional variation in per capita numbers for carbon equivalent emissions is almost completely different from the regional variation in total emissions. This sets up a difficult *policy dilemma* for the Copenhagen meeting: equality in emissions per capita or efficiency in reducing total emissions? It should be pointed out that the emission of greenhouse gases is closely linked with energy consumption, which in turn depends upon economic development.

Climate Change, Energy Consumption and Economic Development

The argument that a new global emissions regime must NOT hurt economic development in the poor countries in the world posits a link between carbon emissions and economic growth. The link between carbon emissions and economic development is the consumption of energy. Countries that industrialise need lots of energy, which is also true of the post-industrial economies. Table 1 shows the close link between total carbon equivalent emissions and energy consumption, where total emissions in the NON-OECD set of countries are shown to sharply overtake those of the set of OECD countries in predictions based upon present trends.

Table 1: Predicted Energy Related Emissions (billion metric tons)

	OECD	NON-OECD
2010	13.4	17.6
2015	13.6	19.5
2020	13.9	21.5
2025	14.2	23.7
2030	14.6	25.8

Source: Energy Information Administration: <http://www.eia.doe.gov/environment.html>.

As economic development proceeds at a very high rate in the Asia-Pacific region, these countries need energy, especially as their populations keep growing. Only fossil fuels – increasingly coal – can deliver cheap energy today on a massive scale in these countries. To cut back on energy related emissions, an entirely new energy technology must be innovated in a short

period of time. Otherwise, rates of economic growth in China, India and other newly industrializing countries must go down pushing the development gap between rich and poor countries wider.

When governments take a stand on the global warming issue, then they act upon information about its country emissions as well as those of other countries: total emissions or per capita emissions. I will use data from Energy Information Administration (EIA) to show that it is essential not to confound these two decision parameters. I will use most recent available data from the EIA on *emissions in metric tons*¹. The method of analysis is the ANOVA. The data is presented on the basis of country statistics, given that the policy-makers are the governments of these countries. These numbers are slightly higher today as the average yearly increase is about 2 per cent a year. The country emissions data – total emissions and per capita emissions – are grouped according to a division of the globe into seven major regions.

Country Variation in Total Emissions

A total of 214 countries in the world produced some 29, 2 billion metric tons of greenhouse gases in 2006. The average country emission was 0,136 billion metric tons. Appendix 1 has the overall distribution of emissions with countries placed in seven major regions of the globe from 1990. Appendix 1 indicates that the emissions vary tremendously between the major regions of the globe.

Total emissions are a function of the total size of the country economy in terms of population and the level of economic development. Populous countries with an advanced or rapidly industrializing economy have huge emissions, like the US, China, Japan and India. The major finding in Appendix 1 is that the Asia-Oceania region is responsible for 40 per cent of global total emissions, or about double the size of the North American emissions, or thrice as much as those of the EU countries. The total emissions in each of

1 Emissions data are reported in metric units. Emissions of carbon dioxide and other greenhouse gases are measured in carbon dioxide equivalents. Carbon dioxide equivalent data are to carbon equivalents by multiplying by 12/44. Emissions of other greenhouse gases (such as methane) are measured in carbon dioxide equivalent units by multiplying their emissions (in metric tons) by their global warming potentials (GWPs). Carbon dioxide equivalents stand for the amount of carbon dioxide by weight emitted into the atmosphere that would produce the same estimated radiative forcing as a given weight of another radiatively active gas. Carbon dioxide equivalents are calculated by multiplying the weight of the gas being measured (for example, methane) by its estimated GWP (which is 25 for methane) (EIA, Internet: <http://www.eia.doe.gov/oiaf/1605/ggrpt/#units> as of December 18, 2009).

the other regions – Africa, Latin America, Eurasia or the Middle East – are merely about 1/10th of what the Asia-Oceania region emits.

The Asia-Oceania region has such huge emissions, because the average country emission is almost double that of the average country in the world on the one hand and many of these countries have immense populations on the other hand. However, in the global debate on reducing greenhouse gases the governments in this region have been little active or hardly positive to curbing them, at least until lately.

One finds the same pattern of country variations in all the regions. Countries with large population and medium or high levels of economic development emit the most of greenhouse gases. Small countries population wise with an emphasis upon a rural economy emit the least. It is especially population size that counts. There is no specific region effect in the data, as the eta scores indicates. Let me mention a few countries in each region – see Table 2.

Table 2: Country total emissions: in million metric tons of carbon dioxide

Africa:

South Africa 443, Nigeria 101, Congo (Kinshasa) 3, Namibia 3.

Asia-Oceania:

China 6'017, Japan 1'247, India 1'293, South Korea 515, Australia 417, Indonesia 280, Bangladesh 43, North Korea 78.

Central and South America:

Brazil 377, Argentina 162, Chile 65, Bolivia 12, Peru 30, and Haiti 1.8.

Eurasia:

Russia 1'704, Ukraine 329, Kazakhstan 214, Turkmenistan 50.

Europe:

Germany 858, France 418, UK 586, Norway 45, Bulgaria 49.

Middle East:

Saudi Arabia 424, UAE 150, Oman 35, Israel 67, Jordan 20.

North America:

USA 5'903, Canada 614, Mexico 436, Greenland 0.61.

The policy implications of the findings in Table 2 are that only reductions of emissions by the largest polluters would have a clear effect upon the goal of reducing the risk of climate change. The US, China, Japan, India, Germany, the UK and France and Russia as well as Canada and Australia and

South Korea as well as Mexico and Brazil – basically the G20 countries – are responsible for some 80 per cent of all greenhouse gases. The emissions in small and poor countries simply do not matter in a global ecology policy, whether they have high or low emissions per capita. Handling the problem of greenhouse gases by means of a global emissions policy is a question for a small group of big countries. Thus, collective action difficulties as well as transaction costs should therefore be manageable. However, if one looks at the variation from the per capita perspective, then a completely different picture emerges, with other policy implications.

Country Variation in Per Capita Emissions

When governments meet in order to embark upon a global carbon emissions policy, then they will certainly adduce data about per capita emissions in the countries of the world. This very much seems to be in accordance with the requirement of *global justice* in the distribution of resources and economic opportunities. Since advanced countries have much higher per capita emissions, they should take the global cuts, as they can afford it. For development reason, Third World countries must put economics before environment. Let us first look at the variation in per capita emissions on the regional level and the country level.

Appendix 2 shows the immense difference in per capita emissions between the seven regions of the world. The Middle East has, surprisingly, the highest figure, but the per capita figure for the Asia-Oceania region is low, much lower than the number for Eurasia and Europe. Per capita emissions are extremely low in Africa, whereas for Latin America there is a middle-level figure with a higher score for North America. Looking at the individual country scores, one may note the following extreme per capita scores for 2006 in Table 3.

Table 3: The per capita variation in carbon emissions
(metric tons of carbon dioxide)**Africa:**

South Africa 10, Libya 9, Nigeria 0.8, Egypt 1.9, Kenya 0.3, Zambia 0.2, Botswana 2.4, Niger 0.1.

Asia-Oceania:

Australia 21, Hong Kong 12, New Zealand 9, Japan 10, China 5, India 1, Indonesia 1.2, Bangladesh 0.2.

Central and South America:

Trinidad and Tobago 44, Puerto Rico 11, Cuba 2.5, Brazil 2, Argentina 4, Venezuela 6, Peru 1.

Europe:

Luxembourg 26, The Netherlands 16, The UK 10, Germany 10, France 7, Norway 10, Albania 1.

Eurasia:

Estonia 14, Russia 12, Ukraine 7, Kazakhstan 14, Georgia 1.

Middle East:

Qatar 61, UAE 35, Kuwait 31, Bahrain 38, Saudi Arabia 16, Israel 10.

North America:

The US 20, Canada 19, Mexico 4, Greenland 11.

What explains the variation in per capita emission is the GDP per capita. Large populous countries with considerable total emissions have a low per capita figure, if the country is poor. Or a rich small country may have a huge per capita emission number, simply because it is small in population. Thus, the scores for the Gulf States are by far the highest in the world, expressing not only their huge per capita affluence but also their oil and gas extraction activities, at least to some extent. The US displays high per capita figures like Australia and Canada. But the numbers for the large European countries are intermediate. Concerning Brazil, one finds a per capita figure that is surprisingly low, reflecting perhaps that its economy is based on ethanol rather than oil, although the burning of the *Amazonas* increases the emissions considerably. The per capita figure for China is low, although its total emissions are the largest in the world besides the US. The same is true of India.

The economic growth argument for cutting per capita emissions in advanced countries instead of total emissions in all countries bypasses the Asia-Pacific environmental deficit. The rapidly developing countries in the Asia-Pacific region have own reasons for introducing environmental policies that move

their dynamic economies off the heavy reliance upon fossil fuels, causing immense emission of greenhouse gases. The same need for greener economy holds for rapidly industrialising giants like Brazil, Mexico, Nigeria and South Africa. The NON-OECD countries themselves should care for their ecological predicament, the costs of which are not for the OECD world to subsidize.

Ecological Deficits

The Global Footprint Network has developed a method for calculating pollution on the one hand and absorptive capacity on the other hand. It starts from a distinction between footprint and biocapacity as the two fundamental dimensions in environmental pressure, summing these two components to an overall assessment of a surplus or a deficit. Both footprint and biocapacity include a variety of different factors, allowing for a nuanced empirical assessment of various types of pollution on the one hand and different forms of biocapacity on the other hand.

The NGO Global Footprint Network has delivered a huge data set on a large number of countries' use of nature and its biological capacity, respectively. Below the data from 2006 will be employed for a small comparative analysis. The idea is to use some 4 000 data points per year and compress this information into macro scores that are comparable both cross-sectionally and longitudinally. To quote:

The footprints of nations and their biological capacity can be directly compared because resource flows are translated into a common unit of biologically productive area, "global hectares" (or "global acres"). A global hectare is the average per hectare regenerative capacity of all the planet's biologically productive surfaces.

(*Footprintnetwork*, Internet: http://www.footprintnetwork.org/gfn_sub.php?content=national_footprints as of December 18, 2009).

Thus, the common measure of both pollution and capacity to take pollution is "hectares" or "acres" per person. First, one calculates how many hectares an average person in a country needs for fulfilling his/her life-style – the footprint:

- a) *Consumption Footprint*: it is the area used to support a defined population's consumption. The consumption footprint (in gha) includes the

area needed to produce the materials consumed and the area needed to absorb the waste;

- b) *Carbon Footprint*: When used in Ecological Footprint studies, this term is synonymous with demand on CO₂ area. Since both these footprints are calculated in hectares/person, they can added together in a total footprint measure = *demand* for pollution or environmental resources. Second, there is the general absorptive capacity: *Biocapacity*: The capacity of ecosystems to produce useful biological materials and to absorb waste materials generated by humans, using current management schemes and extraction technologies. It is the *supply* of environmental resources.

It goes without saying that these three concepts are based on several assumptions and require much information to be applied. Thus, it is said about biocapacity that "The biocapacity of an area is calculated by multiplying the actual physical area by the yield factor and the appropriate equivalence factor." But it still holds that "Biocapacity is usually expressed in units of global hectares." Trade has also been added to the country scores: "The Ecological Footprint is usually measured in *global hectares*. Because trade is global, an individual or country's Footprint includes land or sea from all over in the world." Pollution in one country C1 has been added to the pollution in another country C2, because C1 export goods produced with pollution to C2.

Table 4 shows the global situation with most recently available data on the major regions of the world.

Table 4: Ecological Deficits or Surpluses 2005 per region

Africa	+ 361
Middle East and Central Asia	- 366
Asia-Pacific	- 2'866
Latin America and the Carribean	+ 1'328
North America	- 892
Europe EU	- 1'170
Europe NON-EU	+ 545

Source: Living Planet Report 2008: 32-39, http://www.footprintnetwork.org/en/index.php/GFN/page/footprint_for_nations

When total ecological imprint is estimated, taking population size into account, then it is no longer tenable to argue that pollution goes with afflu-

ence. On the contrary, poor or medium income countries with large population may have more ecological impact than super affluent countries, especially when biocapacity is taken into account. Industrialising China and India are big polluters in the Asia-Pacific region together with post-industrial Japan and South Korea. Given the fact that the Asia-Pacific region in world has the largest ecological deficit, including the carbon footprint, in combination with overall weak biocapacity, it is in the self-interests of China and India to support a new global ecology regime. Japan and South Korea seems finally to have understood that economic development can be accomplished without massive greenhouse gases emissions from the burning of fossil fuels and cement constructions. Time has come for rapidly developing countries to invest in environmental friendly technology and start combating pollution in their own backyards.

Catch-up and Emission Reductions

What is strictly measurable is the amount of human induced greenhouses gases that enter the atmosphere (CO_2 , CH_4 , $FKCW$, N_2O and O_3). The carbon dioxide emissions amount to some 60 per cent of all the greenhouse gases, where the burning of fossil fuels is 75 per cent and the burning of forests and wood another 25 per cent (WITTIG and STREIT, 2004). What is not fully known with certainty is the amount of climate change that the successive build-up of huge quantities of greenhouses gases leads to. Whereas one group of Third World countries point at the imminent risks for them of climate change, calling for large reductions in total emissions, another groups of Third World countries are prepared to accept a halt in the increase in yearly emissions only if their economic ambition to catch-up with the First World is not seriously impaired. They thus call for large reductions in emissions by countries with high per capita emissions, meaning rich countries in order to support the catch-up effect in global economic development.

In reality, economic development is intimately connected with the consumption of energy from fossil fuels – see Table 5 predicting the growth of energy production for the next twenty years on the basis of present trends. Behind the increase in energy demand is the spectacular industrialization in the Asia-Pacific region. Thus, there will be a clear shift in the regional consumption of energy.

Table 5: Regional (actual and projected) Demand for Energy (Quadrillion BTU)

	China & India	United States	Rest of World	Total
1990	34.9	84.7	228.1	347.7
2000	50.6	99.0	248.3	397.9
2006	91.5	100.0	280.9	472.4
2010	109.6	99.9	298.8	508.3
2020	150.9	105.4	339.5	595.7
2030	188.1	113.6	376.6	678.3

Source: Energy Information Administration: <http://www.eia.doe.gov/environment.html>.

The two economic growth giants, China and India, will soon surpass the United States in energy consumption. How, then, is the global increase in energy demand, necessary for reducing alleviating poverty and accommodating population growth, to be met? Table 6 shows the mix of various energy sources today as well as the projections for the future.

Table 6: Energy Supply 1980–2030 (projections on present trends) (Quadrillion BTU)

	Liquids	Natural Gas	Coal	Nuclear	Renewable
1980	131.0	53.8	70.0	7.6	20.9
1985	123.1	63.5	82.4	15.3	24.4
1990	136.4	75.3	89.2	20.4	26.3
1995	142.6	81.2	88.5	23.3	30.2
2000	155.5	91.0	93.6	25.7	32.3
2005	170.4	107.1	121.7	27.5	35.5
2010	174.7	118.5	140.6	29.0	45.6
2015	183.3	131.0	150.7	31.9	54.6
2020	194.2	141.7	161.7	35.4	62.8
2025	204.6	151.3	175.2	38.2	68.1

Source: Energy Information Administration: <http://www.eia.doe.gov/environment.html>

The extreme reliance upon fossil fuels is obvious in Table 6, both for the present situation and in the projections up until 2030. One observes these stylized projections of a sharp rise in coal generated energy, which is believed to be higher than that of energy from renewable sources. The only way to reduce the amount of greenhouse gases while safeguarding economic development is to initiate the major transformation of the global economy towards a *green economy*. It can only be done by the market economy with its myriad of innovations and micro incentives, but an international regime

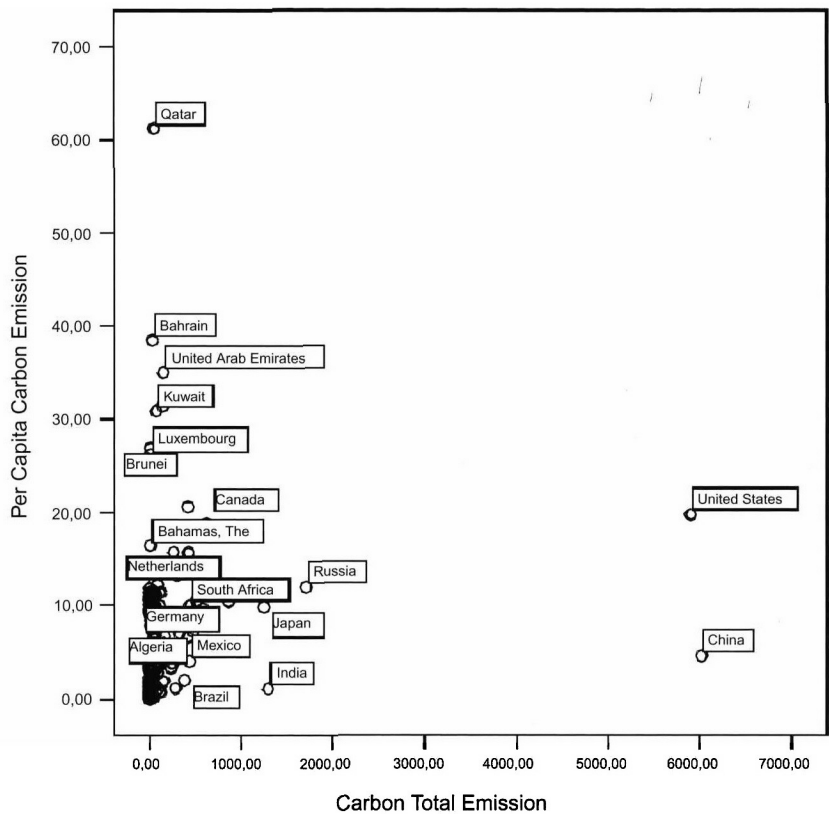
based on an *encompassing carbon tax* or an *inclusive global trading emissions scheme* would be significant policy contributions to that goal. What is most urgent today is to help countries like Brazil and other Amazon Basin countries, Malaysia and Indonesia as well as Russia and Central African countries to halt deforestation, which is often in reality a *double negative*.

Conclusion

A global ecology policy aiming at reducing the emission of greenhouse gases must target total country emissions. Since the governments are responsible for the total emissions numbers, they should be able to overcome collective action difficulties and arrive at a comprehensive policy – a Copenhagen treaty or a Kyoto II regime. Looking at per capita numbers may be an interesting exercise, but these numbers cannot be employed in an effective global policy, stemming the yearly rises in emissions or perhaps curtailing the total amount of emissions. Total emissions go with the size of the country in terms of population as well as with level of economic development. Thus, the G20 group should face up to its responsibility for global warming, emitting almost 80 per cent of the total greenhouse gases.

One can use a simple Figure 1 that portrays the basic problem that the Copenhagen meeting faces: per capita emissions against total country emissions. It would seem just that countries with high per capita emissions take most of the burden of a future cap on the emission of greenhouse gases. However, the crux of the matter is that only the United States has both high per capita emissions and huge *total* emissions. Only by cutting total emissions can a global regime be effective. The ecological deficit is highest in the Asia-Pacific region where several countries have huge total carbon equivalent emissions. Whether industrial or post-industrial, the Asian growth giants need to endorse environmental policies to combat pollution in their countries, which would fit well into a new global policy organization for ecology and development.

Figure 1: Per Capita Emissions against Total Country Emissions



Source: Energy Information Administration: <http://www.eia.doe.gov/environment.html>.

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Appendix 1: Total Carbon Emissions in Countries (EIA)

Region		1980	1990	2000	2006
Africa	Mean	10.15	13.24	15.93	18.87
	Sum	537.76	728.00	892.07	1056.55
	N	53	55	56	56
Asia & Oceania	Mean	79.08	120.44	167.40	254.99
	Sum	3558.55	5299.37	7365.81	11219.56
	N	45	44	44	44
Central and South America	Mean	14.60	16.29	22.56	25.30
	Sum	627.76	716.95	992.81	1138.49
	N	43	44	44	45
Eurasia	Mean	3092.69	3834.05	157.07	173.38
	Sum	3092.69	3834.05	2355.98	2600.65
	N	1	1	15	15
Europe	Mean	156.92	152.27	128.57	134.88
	Sum	4707.50	4568.17	4500.07	4720.85
	N	30	30	35	35
Middle East	Mean	37.75	56.16	84.13	115.79
	Sum	490.76	730.05	1093.74	1505.30
	N	13	13	13	13
North America	Mean	914.68	1161.31	1135.03	1159.01
	Sum	5488.11	5806.56	6810.19	6954.03
	N	6	5	6	6
Total	Mean	96.87	112.93	112.73	136.43
	Sum	18503.12	21683.16	24010.66	29195.42
	N	191	192	213	214

Source: Energy Information Administration: <http://www.eia.doe.gov/environment.html>

Note: Two means are calculated above: (1) total regional emissions divided by total number of countries in a region; (2) total global emissions divided by the total number of countries. The Eta squared scores (between region – within region variation) indicate that the country variation within each region is larger than the between region variation in these means: .382 (1980), .437 (1990), .150 (2000) and .106 (2006). Total emissions are linked with population size that varies between countries in any region.

Appendix 2: Mean Per Capita Emissions in Countries (EIA)

Region	1980	1990	2000	2006
Africa	1.08	1.14	1.23	1.40
Asia & Oceania	4.37	4.28	4.66	5.47
Central and South America	9.02	6.18	7.52	8.74
Eurasia	11.63	13.29	4.95	5.98
Europe	9.17	10.40	15.64	13.14
Middle East	13.61	12.89	15.05	17.22
North America	12.92	18.55	12.01	12.57
Total Mean	6.14	5.75	7.05	7.31

Note: The means above are calculated as the mean of country means, first on a regional basis and then on a global level. The Eta squared scores are low, indicating considerable country variation within the regions: .073 (1980), .186 (1990), .067 (2000) and .094 (2006). Per capita emissions vary with the economic development of the country that also varies in any region.

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