

Carbon Dioxide Emissions: 17 Years and Still Talking...

By Christoph Meyer

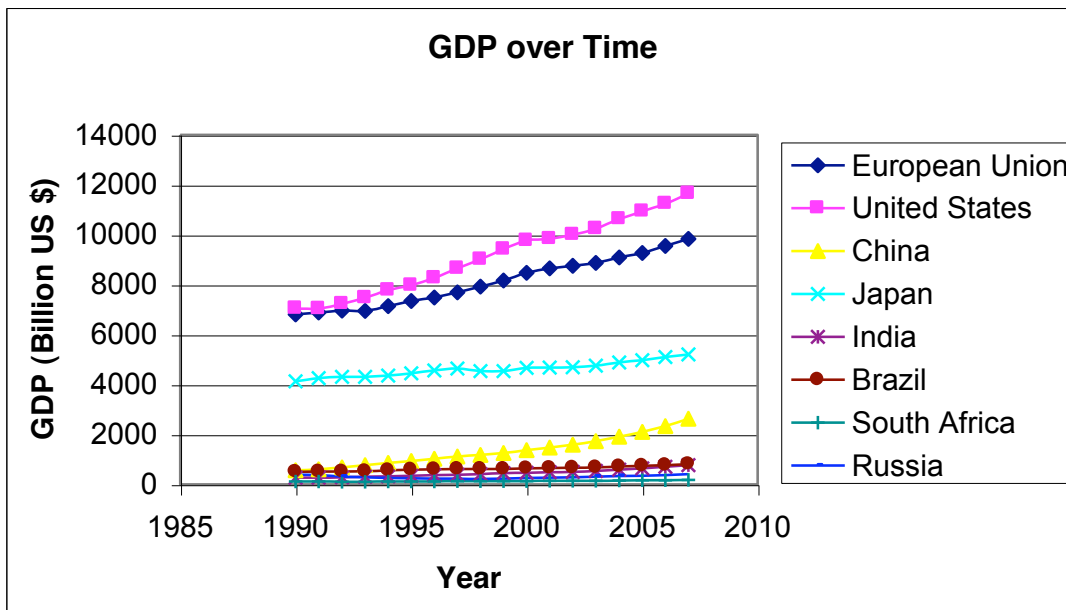
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The 15th annual Conference of the Parties in Copenhagen last year saw delegations from 192 countries come together in an attempt to establish a global climate agreement for 2012 before the end of the first commitment period of the Kyoto protocol (2008-2012). This paper will examine how these figures have changed since Kyoto base year 1990, before looking at certain countries' proposals for the future of their carbon dioxide emissions.

To understand the various trends that have taken place, it is important to view not only the countries' emissions changes, but also the developments in regards to the economy and energy use. Therefore, we present below changes in CO₂ emissions, changes in the gross domestic product of a country, its CO₂ emissions per capita, its energy intensity and its carbon intensity of energy use as well as population change. Energy intensity is the ratio of energy use to the monetary value of GDP. Carbon intensity of energy use is the ratio of CO₂ emissions to energy use. Analyzing these characteristics of the eight chosen countries in the table below allows us to view these countries in several dimensions and relative to each other while keeping the focus on overall CO₂ emissions and climate change.

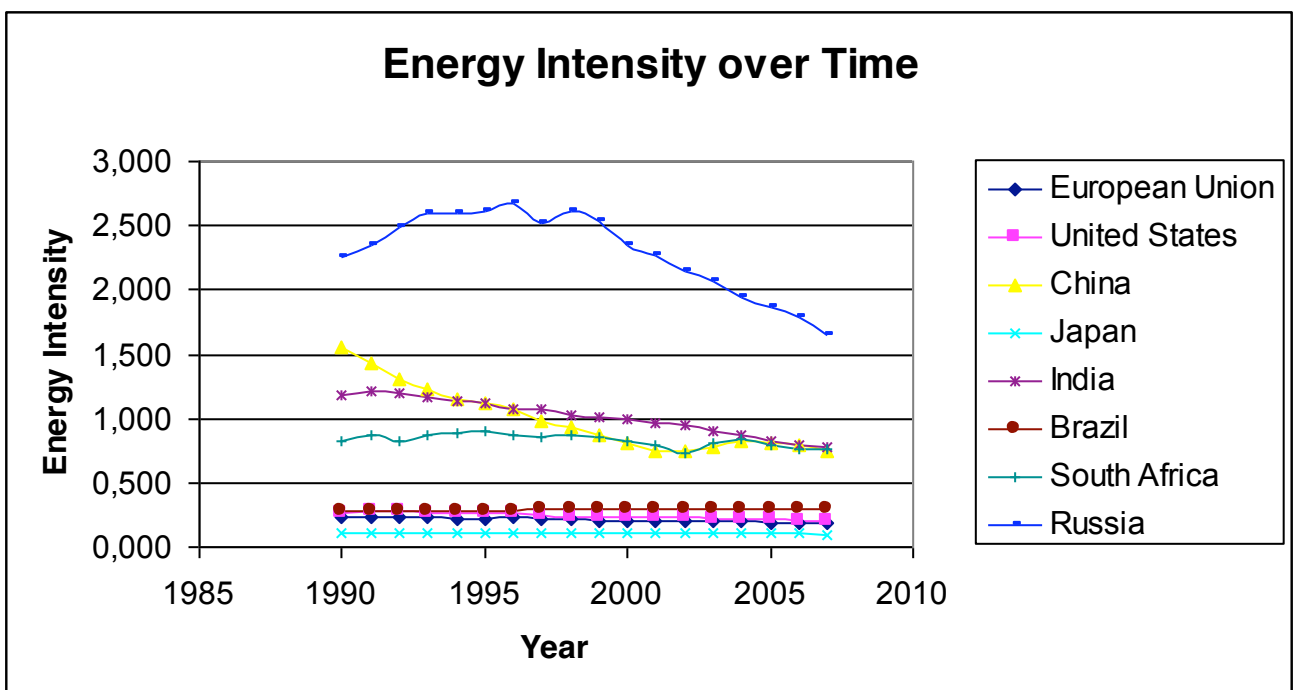
1990-2007	GDP change (%)	Average Annual GDP Growth Rate (%)	Energy intensity change (%)	Carbon intensity of energy use change (%)	CO2 emissions change (%)	CO2 emission per capita change (%)	Population Change (%)
United States	65%	2.99	-26%	-3%	19%	-2%	21%
European Union	44%	2.18	-26%	-10%	-3%	-8%	5%
China	368%	9.51	-52%	20%	171%	134%	16%
Japan	26%	1.38	-7%	-1%	16%	12%	3%
India	185%	6.36	-34%	20%	125%	70%	32%
Brazil	61%	2.85	5%	6%	80%	40%	28%
South Africa	60%	2.82	-8%	-8%	36%	0%	35%
Russia	5%	0.30	-27%	-6%	-27%	-24%	-4%

Gross Domestic Product



Over the period 1990-2007, the countries in the table above have all enjoyed economic expansion, as seen by the positive growth in their gross domestic products. Especially noteworthy changes in GDP are seen in China and India who have both at least doubled their GDP (China's GDP has grown by an average of 9.51% per year and India's GDP has grown by an average of 6.36% per year). Meanwhile, the other countries have also shown considerable economic growth. Russia's GDP change seems particularly small as a result of the collapse of the Soviet Union which occurred during this period.

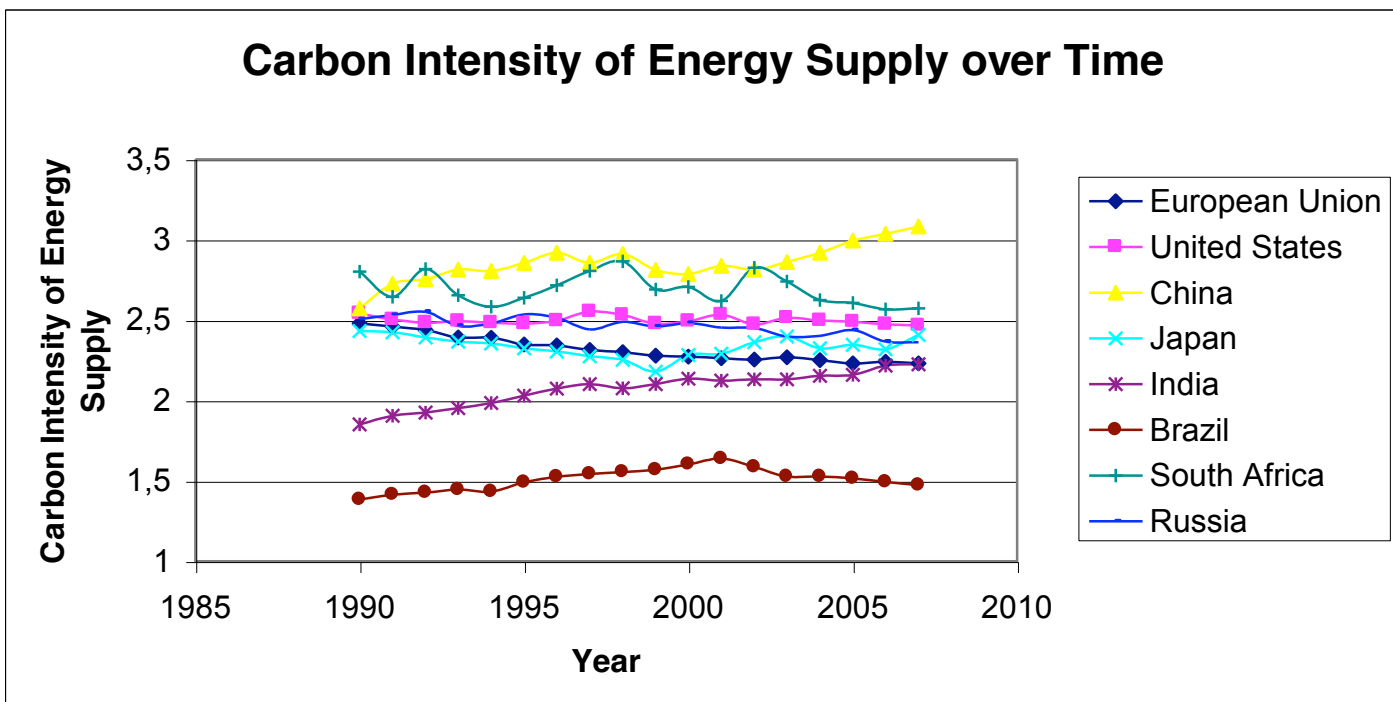
Energy Intensity



Energy intensity is a way of measuring how efficiently energy is used to generate GDP. The

change in this figure is indicative of the way in which an economy is developing and how energy efficiency in the country is changing. Mature industrialized nations tend to have decreasing energy intensities as growing service sectors require less energy to generate GDP. As seen by most of the energy intensity changes, these countries are using less energy to generate additional GDP. China and Brazil have significantly decreased their energy intensities, with faster growth in their GDP than in their energy use. The European Union and United States have similarly large decreases in energy intensity, a trend expected for industrialized countries that tend to having increasingly large service sectors in their economy. Japan has also managed to reduce this number, albeit not quite as much as other developed countries. In the 1970s, the Japanese government was already imposing norms and regulations regarding energy efficiency as a response to pollution concerns and the oil shocks¹. Since Japan had already initially taken measures that improved efficiency most significantly, further measures are more costly and do not yield as important benefits. As a result, Japan did not reduce its energy intensity quite as much as before. South Africa is a country with high energy intensity due the inefficient use of coal for electricity and liquid fuels for energy. South Africa's processes to convert these sources into energy remain fairly inefficient². However, as South Africa transitions to a service economy it has and will continue to improve its energy efficiency³. Brazil, the only country in this list with an energy intensity that has increased from 1990 to 2007, has seen its energy intensity value stagnate. Its GDP and energy use seem to be growing at similar rates, causing very little change to the energy intensity.

Carbon Intensity of Energy Use



The carbon intensity of energy use, in contrast to the carbon intensity of the economy, is the

¹ « Japan's Ambivalent Diplomacy on Climate Change », Céline Pajon, *Health and Environment Reports* n° 5, May 2010, <ifri.org/?page=detail-contribution&id=6073&id_provenance=88&provenance_context_id=3>.

² "White Paper on the Energy Policy of the Republic of South Africa", Department of Minerals and Energy, December 1998, www.dme.gov.za/pdfs/energy/planning/wp_energy_policy_1998.pdf.

³ « Energy Efficiency Strategy of the Republic of South Africa », Department of Minerals and Energy, March 2005, <www.dme.gov.za/pdfs/energy/efficiency/ee_strategy_05.pdf>.

ratio of carbon dioxide emissions to the amount of energy used in a country's economy. In looking at changes in this figure, it is possible to see how the energy sources of a country have evolved and whether the country is pursuing a less carbon-intensive energy mix. There is a significant disparity in the countries' values as certain have positive changes, while others have negative changes in their carbon intensity of energy use values. The United States, European Union, Japan, South Africa and Russia have all decreased their values. For the European Union, the decrease in this number is likely due to several factors. Eastern Europe, similarly to Russia has managed to decrease this number drastically by improving efficiency in its economy and energy sector and by a massive loss of energy intensive manufacturing. Europe has had made considerable investment in renewable energy sources and has witnessed a dash to gas in its power sector. Russia has seen a large increase in the amount of natural gas in its energy mix while the percentage of oil has decreased. South Africa's decrease comes as a result of a transition from a heavily coal dominated energy mix to one that is more diverse and thus less carbon-heavy. This is notably the case in the electricity production, where South Africa has attempted to diversify its production sources. Furthermore, as the country has developed, it has begun using an increasingly large percentage of oil in its energy mix. The United States and Japan have had small decreases as well, most likely linked to increase in efficiency, as their energy mixes have not drastically changed.

On the other side of the spectrum lie mostly the large developing economies of the future: Brazil, China and India. All three of these countries have had increases in the carbon intensity of their energy mixes, meaning that as that increase the use of energy in their economies is achieved through the use of carbon-rich fuels. Out of the three emerging economies, Brazil has had the smallest decrease in its carbon intensity. The change in this figure can be seen by the progression of the country's electricity mix over this period. Brazil traditionally relied heavily on hydropower for the generation of its electricity (93% of Brazil's electricity in 1990 was generated through hydro sources). However, due to an electricity crisis in 2001 due to insufficient amounts of water, the Brazilian government launched a program to develop other electricity production sources, notably natural gas power plants⁴. As a result of this program to reduce its over dependence on hydroelectricity and discovered natural gas reserves, natural gas consumption has increased significantly (16% per year)⁵. From 1990-2007, Brazil has managed to diversify its energy sources, thus achieving less dependence and vulnerability on a particular resource. By having more significant amounts of natural gas in the electricity mix, Brazil has increased the carbon intensity of its energy sources.

India, having had a significant economic expansion over the 1990-2007 period has also had a 20% increase in its carbon intensity of energy use. This result is evident from the changes in both India's energy and electricity mixes. In its electricity mix, India has decreased the share of production from hydro to diversify more, recently increasing the use of natural gas. In regards to the energy mix, India has decreased its use of biomass and waste significantly and used a larger amount of oil in 2007. This trend of an increased use of commercial fuels seems to go hand in hand with the rapid economic growth that India has had in recent years⁶.

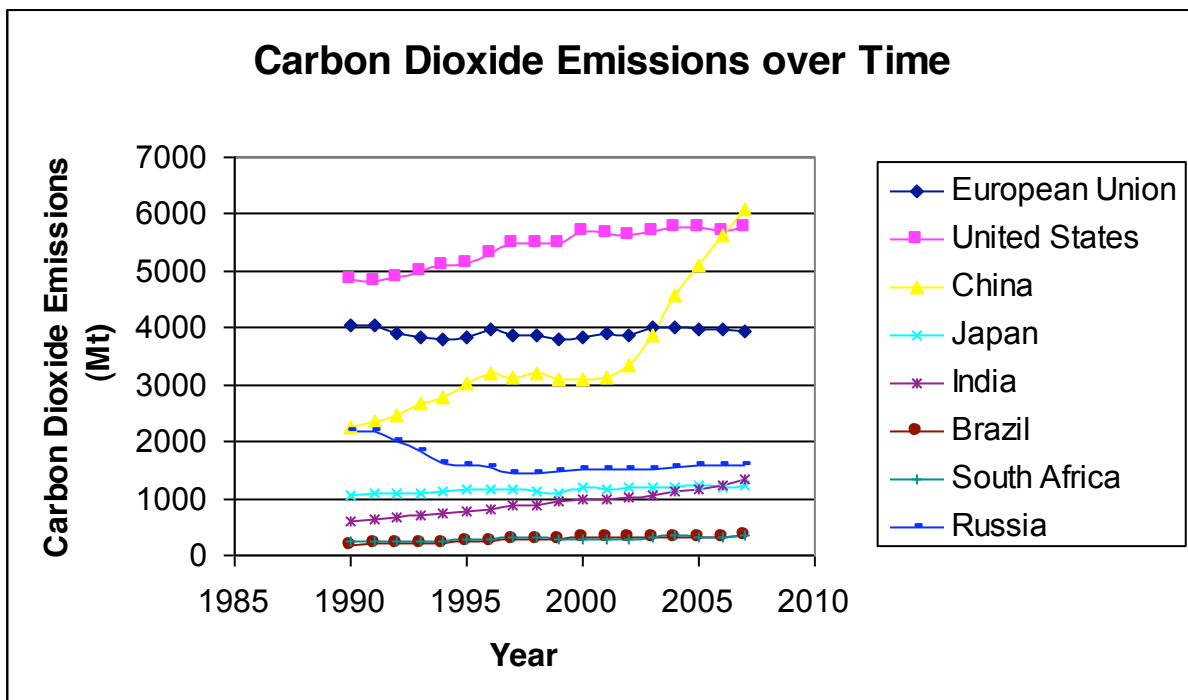
⁴ "Natural-gas-powered thermoelectricity as a reliability factor in the Brazilian electric sector", E. Fernandes, J.C.S. de Oliveira et al., Elsevier Energy Policy 26, December 2007, <www.sciencedirect.com.ezproxy.rice.edu/science?_ob=MIimg&_imagekey=B6V2W-4RFD6DK-1-1N&_cdi=5713&_user=963248&_pii=S0301421507004363&_orig=search&_coverDate=03%2F31%2F2008&_sk=999639996&view=c&wchp=dGLzVzb-zSkzS&md5=dbe4659cebcefe993c4813b2fa39105e&ie=/sdarticle.pdf>.

⁵ "Natural Gas, Energy Policy, and Regional Development: Brazil and the Southern Cone", Peter DeShazo et al., CSIS Policy Papers on the Americas Volume XVIII, Study 1, April 2007, <csis.org/files/media/csis/pubs/070430_conference_report.pdf>.

⁶ « Energy and Emissions : Local and Global Effects of the Rise of India and China », Zmarak Shalizi, World Bank Policy Research Working Paper 4209, April 2007, <www-

China, having had an even greater economic expansion than India over the same period has had the same 20% increase in its carbon intensity of energy use. The result is also apparent in both China's energy and electricity mixes. Similarly to India, China has a predominance of coal and biomass in its energy mix. As a developing economy it also decreased this (Which amount coal still dominates) amount (from 23% in 1990 to 10% in 2007) and began increasing its use of oil in transport. The increase in the use of coal is evident in China's electricity mix. In 2007, China relied on coal to supply 81% of its electricity, up from 72% in 1990. As a result of the use of carbon heavy fuel sources, China's carbon intensity of energy use has seen a significant increase over the 1990-2007 period.

CO₂ emissions



Having looked at countries' GDP, energy intensity and carbon intensity of energy uses, the remaining statistic is perhaps the most important one, CO₂ emissions. In a global environment which is stressing the need to reduce absolute carbon dioxide emissions, it is essential to look at the major emitters' previous tendencies to anticipate and project how their ultimate goals, such as those proposed for 2020, can be achieved. As a general trend, the CO₂ emissions of the above countries have increased, some even very significantly. Emissions from the United States and Japan have increased less than 20% but this still represents a considerable increase. The steady but continued economic growth as well as the lack of significant change in electricity and energy mixes yields this result. South Africa, a developing economy has had a large increase in its emissions, as might be expected from a country in its position. Brazil has had a similar experience to South Africa, however increasing its emissions even more, almost doubling them in this period. The extremity of the developing countries sees China and India once again as those who have seen the most significant changes. Both economies have more than doubled their carbon dioxide emissions over this period, as a result of the vast economic expansion, generated through the use of fossil fuels.

Two regions which have not had the same increase in CO₂ emissions are Russia and the European Union. The decrease in Russia's emissions is not a result of clear policies and actions taken by the government but rather a result of the economic collapse of the Soviet Union. The European Union was also able to benefit from this situation, as it now includes countries previously part of the Soviet Union⁷. These countries along with East Germany had economies that collapsed after the end of the Soviet Union, resulting in significant CO₂ emissions reductions. The integration of these countries into the European Union has allowed them to develop and improve their emissions as well as to pursue an EU wide policy to fight climate change. While the reduction in CO₂ of these two regions looks promising, the dismantling of the Soviet Union and Europe's shift to gas for power remain significant cause of these results.

Another statistic, CO₂ emissions per capita, offers additional information on the evolution of the countries listed above. For instance, the United States, shows an increase in overall CO₂ emissions during the period 1990-2007, yet has decreasing per capita emissions. This may be explained in part by a rapid population growth. In Europe, CO₂ emissions per capita have decreased both as a result of the effects of economic collapse in East and Central Europe, UK's dash to gas and a sharply lower population growth. China, on the other hand has seen a large increase in per capita CO₂ emissions, but not as large as its overall CO₂ emissions. Here, population growth is not the cause. Japan, with its very low population growth – probably diminishing now, has an increased CO₂ per capita value reflecting the structural momentum of its economy. Another interesting country is South Africa, where an equal increase in CO₂ emissions and population has resulted in very little to no change in the CO₂ emissions per capita of this country.

In looking at the indicators above, certain clear trends appear over the last seventeen years. Overall, economic activity has continued to increase, as seen by the positive GDP change. However, these results must be viewed with some skepticism as growth rates of developing countries are often slightly inflated in order to show more economic growth than really took place. Assuming these GDP values are accurate, there is a clear trend in the energy intensity change, namely a decrease. As these countries have become industrialized, it now requires them less energy to earn additional GDP. When looking at the carbon intensity energy use change, we find two different patterns, with the energy mix of some countries becoming more carbon intense while that of others becoming less so. This indicator is of particular interest as it evidences how an economy is fueling its growth and whether it will do so with consideration of CO₂ emissions.

Finally, the most important statistic in relation to climate change shows somewhat of a disappointing reality. CO₂ emissions have, for the most part, been steadily to even rapidly increasing in these countries. Countries such as Brazil, India and China are of particular interest as they are the projected economic growth centers and largest emitters of the future. These countries have also experienced very significant increases in CO₂ emissions per capita. While energy intensity has seen improvements, the matter of absolute CO₂ emissions remains the most important and, unfortunately, most unchanged statistic. More will need to be done in terms of the carbon intensity of energy use if these emissions are to change considerably. If significant reductions are to be made in the future, the next seventeen years cannot unfold as have the last seventeen.

⁷ "Getting Carbon Out: Tougher Than It Looks", Maïté Jauréguy-Naudin, Note de l'Ifri, February 2010, <ifri.org/?page=detail-contribution&id=5864&id_provenance=103&provenance_context_id=16>.