China's Greenhouse Gas Emissions and Mitigation Policies

Jane A. Leggett
Specialist in Energy and Environmental Policy

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Summary

The 112th Congress continues to debate whether and how the United States should address climate change. Most often, this debate includes concerns about the effects of U.S. greenhouse gas (GHG) emissions controls if China and other major countries were not to take comparable actions. China recently surpassed the United States to become the largest emitter of human-related GHG globally, and together, the two nations emit about 40% of the global total (with shares of 21% and 19% respectively).

China's GHG emissions are growing rapidly and, even with policies adopted by China, are expected to rise until at least 2030. The emissions growth is driven by China's rapid economic and industrial growth and its reliance on fossil fuels despite measures to raise the shares of non-fossil energy sources. China requires 50% more energy to produce one billion dollars of GDP (its "energy intensity") compared with the United States. Over the past two decades, strong government directives and investments have dramatically reduced the energy and GHG intensities of China's economy, though the rates of improvement leveled off in the 2000s, and even reversed in subsequent years. A renewed emphasis on improving energy and GHG intensity emerged in the 11th 5-Year Plan, from 2006-2010, and the government says the nation nearly achieved its aggressive goal to reduce by 20% the energy required to produce GDP. In the context of China's 12th 5-Year Plan, from 2011-2015, leaders have set targets to further reduce energy intensity by 16% by 2015. Along with measures to reduce pollution and increase the shares of non-fossil fuels in the energy sector, China has set goals to improve its CO_2 intensity by 40-45% by 2020, with an interim target in the 12th 5-Year Plan of 17% by 2015. Even if these targets are achieved, China's GHG emissions are expected to rise in absolute terms. In addition, the frequency, transparency, and data quality of China's reporting of its GHG emissions and mitigation actions (including underlying energy and other data) have been a challenging diplomatic issue between the United States and China and in the climate change negotiations. China has resisted reporting and reviews comparable to what other industrialized nations or what many developing countries accept. While technical bilateral cooperation on data has been productive and China has moved politically toward better information sharing, the continuing lack of transparency is apparent in uncertain emissions estimates and projections.

Chinese negotiators adhere to the principle of "common but differentiated" responsibilities, agreed in the United Nations Framework Convention on Climate Change (1992). They argue that emissions per person in China are low, that raising incomes must be their highest priority, and that industrialized countries bear primary responsibility for the historical buildup of GHGs in the atmosphere; therefore the industrialized countries should lead in mitigating emissions domestically. Industrialized countries also, they say, should assist developing countries with financial and technological support to mitigate emissions and adapt to coming change.

Debate on potential climate change legislation in the United States has been influenced by China's surging GHG emissions, and uncertainty over whether, how, and when China might alter that trend. There is concern that strong U.S. domestic action taken without Chinese reciprocity would unfairly advantage China in global trade, and fail to slow significantly the growth of atmospheric concentrations of GHGs. The governments of both China and the United States have indicated some closure of their gap on future actions to address climate change by agreeing on national pledges to GHG targets and mitigation actions rather than binding international obligations. China is also engaged with many other countries in bilateral programs to build its governance and technological capacities to abate its GHG emissions.

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Why China's Greenhouse Gas Emissions May Matter

China's greenhouse gas (GHG) emissions have drawn attention in the United States because of their environmental and economic implications. China's actions to address climate change also hold implications for broader economic and security concerns in the United States.

Scientific evidence that the Earth's climate is changing, and that human-related GHG emissions are a major driver of that change, has led to debate over whether and how to control GHG emissions. Once emitted, GHG persist in the atmosphere for years to centuries (and for some gases, millennia). They allow solar radiation to enter the Earth' system, but prevent much of the absorbed energy from escaping back out to space. Scientists agree that the Earth's atmosphere serves as a "blanket" that warms the Earth's surface and that a certain concentration of GHG is essential to maintain the planet at habitable temperatures. There is less agreement on how much warming would result from the higher atmospheric GHG concentrations expected if emissions from fossil fuel use, deforestation, and some agricultural and industrial processes continue. Scientific concerns in the 1980s led to initiation of inter-governmental discussions in 1989 to stabilize GHG concentrations and avoid potentially "dangerous" global temperature rise. These concerns led to negotiation of the United Nations Framework Convention on Climate Change (UNFCCC).

In the late 1980s, climate experts broadly understood that climate change driven by human-related GHG emissions was a global challenge: all major emitting countries would need to engage in slowing then reducing their emissions of GHG as well as increasing GHG removals by "sinks" (e.g., growing forests). When the UNFCCC was opened for signature in 1992,[1] the already industrialized countries[2] emitted almost 80% of the global carbon dioxide (CO_2) from energy and industry.[3,4] The CO_2 emissions of the United States and the European Union were about 23% and 20%, respectively, of the global total. China's were about 11%. All the "developing" countries at the time contributed about one-third. Low income countries saw GHG-driven climate change as a problem made by the industrialized countries. Considering low income countries' challenged financial, technological, and governance capacities, they were not included in the UNFCCC's Annex I, which lists countries with quantitative GHG control targets for the 1990s. Nonetheless, the UNFCCC contained a principle of "common but differentiated responsibilities" among its Parties, with consensus that the already industrialized countries should lead in controlling their emissions and that all countries have obligations to address climate change. Annex I established a

[1] For more information on international negotiations on climate change, see CRS Report R40001, *A U.S.-Centric Chronology of the International Climate Change Negotiations*, by Jane A. Leggett.

[2] The industrialized countries in 1990 included the Members of the Organization for Economic Cooperation and Development (OECD: the United States, Canada, Japan, Australia, New Zealand, the European Union, the Nordic Countries, and Turkey), the former Soviet Union, and Eastern European countries.

[3] World Resources Institute, *Climate Analysis Indicators Tool (CAIT)*, at http://cait.wri.org/. Data extracted July 11, 2011.

[4] Carbon dioxide (CO_2) is, by far, the most important human-related GHG (though water vapor, which is believed not to be directly related to human activities is the most important GHG in the atmosphere), and (CO_2) emissions from fossil fuel-related production, transmission, storage, and use represents in 2010 about three-quarters of all human-related GHG emissions. Estimates of most other human-related GHG are less available and less reliable than estimates for CO_2 emissions. This report will report total human-related GHG emissions when possible, but frequently will use CO_2 emissions when data for all GHG are not reliable (in CRS' judgment).

bifurcation between the Parties listed in Annex I and the Non-Annex I Parties. (Countries are frequently referred to as "developed" versus "developing," although the distinction is undefined and arguably a misleading simplification of the spectrum of differences among countries).

Scientific analyses have concluded that rising GHG concentrations in the atmosphere cannot be stabilized unless all major emitting countries abate their net emissions to near zero.[5] Despite efforts of many countries to reduce their GHG emissions, the continued and rapid growth of emissions from such large emitters as China and the United States has called into question the efficacy of the UNFCCC in meeting its objective of stabilizing concentrations of GHG in the atmosphere. As China's share of global GHG emissions has grown from about 11% in 1990 to about 21% today, and continues to grow, a broad set of observers have concluded that effectively slowing human-induced climate change depends on Chinese reductions of its emissions, as well as reductions from the United States and all other large emitters.

Issues for Congress

U.S. congressional debate on potential climate change policies in the United States frequently invokes China's (and other emerging economies') surging greenhouse gas (GHG) emissions as well as skepticism over whether, how, and when China might alter that trend. Some are concerned that U.S. investment in GHG controls without comparable Chinese actions would unfairly advantage China in global trade, and fail to slow human-induced climate change. In contrast, others point to China's announced aggressive actions to reduce GHG emissions by deploying efficient and non-fossil fuel technologies, and warn that U.S. businesses could fall technologically and competitively behind China in the energy sector and international trade. Moreover, some suggest that Chinese policies may help buffer their production from rising and volatile fossil fuel prices, while the United States' production costs could remain subject to fluctuating world energy prices.

Some experts point to the connections of China's GHG control policies to broader congressional concerns: China's role in world markets for energy, forest products, rare earth metals, and other strategic resources. Some analysts have noted that potential impacts of climate change on China's ecosystems, agriculture, water resources, and coastal zones[6] could affect that nation's economic and political prospects, with both economic and security risks for the United States.[7]

This report lays a groundwork for congressional consideration of China's GHG policies. It describes the underlying economic and environmental context for China's GHG emissions then provides the magnitude and uncertainties of available estimates. It discusses the factors driving

[5] Ultimately, stabilizing atmospheric GHG concentrations means stopping their accumulation in the atmosphere. This requires, essentially, that net GHG emissions must fall to about zero. Although some countries might achieve "negative emissions" by enhancing removals (e.g., growing more forests), this could not compensate for growing emissions in other countries. All countries on average would have to bring their net emissions down to net zero. A recent example of related analysis is found in H. David Matthews and Ken Caldeira, "Stabilizing climate requires near-zero emissions" *Geophysical Research Letters* Vol. 35, L04705, doi:10.1029/2007GL032388 (2008) at http://www.precaution.org/lib/zero_emissions_required.080227.pdf.

[6] Lin Erda; Xu Yinlong; Wu Shaohong; Ju Hui; Ma Shiming, "Synopsis of China National Climate Change Assessment Report (II): Climate Change Impacts and Adaptation." *Advances in Climate Change Research*. (February 2006). original at http://en.cnki.com.cn/Article_en/CJFDTOTAL-QHBH200602001.htm.

[7] See, for example, Joanna I. Lewis, "Climate change and security: examining China's challenges in a warming world" *International Affairs* 85: 6 (2009) 1195–1213 at http://www.chathamhouse.org.uk/files/15111_85_6lewis.pdf.

China's emissions and summarizes some of the best described elements of China's strategy to mitigate its GHG emissions. A brief section identifies key points on China's status in international cooperation.

China's Economic and Environmental Context

Over the past decade, the Chinese people and its leadership have come to view the country's economic well-being and its environmental quality as inextricably correlated. Figures for Gross Domestic Product without accounting for losses to air and water quality, human health, etc. exaggerated actual improvements in living standards. This has resulted in a shift to "harmonious growth" that tries to balance GDP growth with improving living standards.

Between 1980 and 2009 the Chinese economy grew at an average annual rate of 10% (growing by factor of 16 over the period).[8] In the past decade, China's annual growth rates varied between 8% and 14%, over which time its economy has tripled in size. China is now the second largest economy in the world, behind the United States. The country held $3.2 trillion in foreign exchange reserves by the June 2011.[9,10] Hundreds of millions of Chinese have improved their standards of living. These facts lead some to contend that China is no longer a developing country.

Still, a recent World Bank report estimates that up to 200 million people (out of 1.3 billion) in China continue in poverty, living on less than $1.25 a day in 2005.[11] The Chinese government perceives that its legitimacy depends on continuing to improve the living standards of its population. Its economic policies are stated to be strongly aimed at eliminating poverty and raising average incomes. China's achievements so far are reflected in Gross Domestic Product (GDP) per capita in 2009 of $6,800 in international dollars (int$),[12] up 22% from 2007 and up 289% from 2000, according to the World Bank's World Development Indicators. Still, per capita incomes in China were about one-eighth those of Americans levels (respectively, int$5,594 and int$46,628).[13]

Table 1 provides selected economic, energy, and greenhouse gas statistics for China and the United States. In 2009, China's population was more than four times that of the United States, while its economy, as measured using "purchasing power parities,"[14] was just over half as large. Even with relatively slow population growth (0.5% annually) and high projected economic

[8] See CRS Report RL33534, *China's Economic Conditions*, by Wayne M. Morrison.

[9] Using data from the International Monetary Fund at IMF.org.

[10] See CRS Report RL34314, *China's Holdings of U.S. Securities: Implications for the U.S. Economy*, by Wayne M. Morrison and Marc Labonte.

[11] S. Chen and M. Ravallion, "China is Poorer Than We Thought, but No Less Successful in the Fight Against Poverty," Policy Research Working Paper, WPS-4621, World Bank, May 2008, Table 2.

[12] Purchasing Power Parities (PPPs) compare financial data across countries using indices of relative costs rather than market currency exchange rates. "International dollars" are a hypothetical currency that uses PPPs equalizing the US$ and the international $ (int$) at a specific point in time.

[13] World Bank, World dataBank, data extracted July 11, 2011, at http://databank.worldbank.org/ddp/home.do?Step=1&id=4.

[14] See footnote 12.

growth rates of at least 7% annually, it likely would take many years for the living standards of average Chinese to reach those of average Americans.

Table 1. Selected Statistics for China and the United States

(data are for 2009 unless otherwise noted)

	China	United States
Population (millions)[a]	1,331	307
Population Growth (annual %)	0.5	0.9
Gross Domestic Product using Purchasing Power Parities[a] **(GDP_{ppp} in billion international $)**	9,091	14,119
GDP per capita (using international $)	6,828	45,989
GDP growth (%)	14.2	1.9
Primary energy consumption (million tons oil equivalent MTOE)	2,188	2,204
Energy Use per Capita (MTOE oil equivalent per capita)[c]	1.6	7.2
Energy Intensity (MTOE used per int$ millions of GDP_{ppp})	235	156
Electricity Consumption per Capita (kWh per capita)	2,791	13,506
Carbon Dioxide Emissions (1,000 metric tons CO_2) in 2009	7,547	5,904
Greenhouse Gas Emissions (1,000 metric tons CO_2e)[b] **in 2005**	7,527	7,282
Greenhouse Gas Emissions per Capita (metric tons CO_2e per capita) in 2005[d]	6	25
Greenhouse Gas Emissions Intensity in 2005 (tons CO_2e per int$1000 of Gross National Product, using PPPs)	1.4	0.6

Sources and Notes: Most economic data are available from the World Bank, *World Development Indicators*, for both China and the United States. BP provides energy data for 2009 for both countries. Non-CO_2 emissions data are available from the IEA most recently for 2005, and are unofficial for China. Therefore, indicators using six GHG are provided for the year 2005.

a. World Bank Group, *World Development Indicators*, data extracted July 5, 2011.

b. The term "CO_2e," or "carbon dioxide equivalents," quantifies six greenhouse gases (CO_2, CH_4, N_2O, SF_6, HFC and PFC) according to a "Global Warming Potential" (GWP) index of their relative estimated effects on global warming over a 100-year period.

c. British Petroleum (BP), Statistical Review of World Energy 2011 at http://www.bp.com/sectionbodycopy.do?categoryId=7500&contentId=7068481.

d. International Energy Agency (IEA) greenhouse gas database (extracted January 8, 2008).

China's national plans call for structural shifts in its economy. Much of China's recent growth occurred in industrial production, especially of goods for export. In the past few years, China's policies have attempted to shift from emphasizing heavy industry (such as steel) and production for export to stimulating domestic consumption and meeting domestic demands for improved quality of life. China has reduced its incentives for export-oriented production and increased incentives for investments in higher value-added goods and services. These policies, combined with increasing economic integration in Southeast Asia, could decrease the share of heavy manufacturing in China's economy, although preliminary data from early 2011 show that heavy manufacturing remains strong.

Historically, China's promotion of monetary economic growth has led to severe environmental degradation. Many Chinese policymakers appear now to realize, however, that they cannot sustain an "unbalanced" approach that emphasizes industrialization at any cost, especially not in the developed regions of the country. Environmental pollution has become so bad in places that social and political stability are at risk. Officially recognized "public order disturbances" grew from 58,000 in 2003 to 87,000 in 2005, many due to environmental pollution and land-takings stemming from government corruption.[15] Chinese officials have indicated that they seek a "harmonious society" that would entail slower GDP growth with less environmental degradation.

In 2007, the World Bank, working with the Chinese government, estimated that the cost of outdoor air and water pollution to China's economy totaled around US$100 billion annually, or 5.8% of China's GDP.[16] In other words, if non-monetized losses to China's resource assets (e.g., clean water, etc.) were netted from the current (financial) accounts, GDP would have been 5.8% lower. Related to such findings, the Chinese government raised the stated priority of environmental protection in its 11th Five Year Plan (2006-2010). Chinese central government officials have over the past decade pursued a combination of measures to control air, water, and soil pollution, and state that they are striving to build a "recycling" industrialized economy[17] to ease environmental pressures. Their efforts have met with mixed success. Even when national officials genuinely want to encourage environmental improvement, local officials may seek to avoid enforcement of environmental regulations (and may not report accurate data) in order to maximize industrial growth and employment. As will be reflected later in this report, the degree to which national goals and measures will be achieved remains an important question.

Controlling local and regional pollutants like oxides of sulfur and nitrogen, particulates, and mercury has been difficult because of the difference in priorities of local and central government officials, as well as insufficient monitoring data and enforcement of national requirements. Controlling GHG emissions in China is even harder. For conventional pollutants (e.g., particulate matter or water contamination), both mitigation costs and impacts are local or regional; averaged nationally, polluting nations will largely pay the costs of that pollution either financially or in lower well-being. But with GHG emissions, mitigation costs may be local, while climate impacts are global. Without *shared* international action, this can lead to a "tragedy of the commons" phenomenon[18] where the shared resource is not adequately stewarded, or where some people take responsibility while others, who do not control their emissions, become "free riders" on the efforts of those who do.[19]

Over the past three years, China's leadership has demonstrated an increasing realization that it has ownership in the outcomes of a warming world. Increasingly, it recognizes that it too would bear potential climate change costs—of increasing storm intensity, rising sea levels, shifting water

[15] See CRS Report RL33416, *Social Unrest in China*, by Thomas Lum.

[16] World Bank. 2007. *Cost of Pollution in China: Economic Estimates of Physical Damages*. Washington DC.

[17] By a "recycling" economy, the Chinese mean that they would move away from an economic system of resource extraction, processing, and disposal of materials as waste, toward reuse and recycling of materials already existent in the economy.

[18] Garrett Hardin, "The Tragedy of the Commons," *Science* 162:1243-1248, 1968.

[19] There are many ways in which efforts may be divided up internationally, through market systems that set a price on "use" of the resource (i.e., emitting pollution being equivalent to using the atmosphere for waste disposal) or by agreement to emission quotas or "caps" or other means.

availability, challenged agricultural productivity, changing disease patterns, as well as other anticipated impacts.[20]

China's recently announced 12th 5-Year Plan, covering 2011-2015, says the nation should act to balance economic growth with environmental protection. How China reconciles domestic politics with international relations, and "fairness" arguments with pledges of actions to suppress its GHG emissions (to be discussed later) remains to be seen.

China's Greenhouse Gas Emissions

Transparency Concerns

Data from China are equivocal. No one knows precisely the scale of China's GHG emissions or its removals of CO_2 from the atmosphere by vegetation. China has not reported its emissions estimates for any year later than 1994[21,22] although an unofficial estimate for 2004 was released (**Figure 1**).[23] (By comparison, the United States and most industrialized countries have been reporting officially and annually according to internationally agreed guidance since 1995.) The lack of China's reporting, transparency, and acceptance of international review of GHG emissions estimates (and underlying data) has been a major point of contention between China and the United States (and other countries) in the UNFCCC negotiations. While China may not have reliable information at this time, its insistence that reporting should be a point of "differentiation" among countries has not helped China convince others of its sincerity in undertaking domestic actions to slow its GHG emissions growth. China has alleged that international review of its emissions estimates could be "intrusive"; other countries, including the United States, already engage in such reviews, including in-country reviews and discussions with independent third-parties. Since the Copenhagen Accord in 2009, China has agreed to biannual reporting and "consultations," though the terms of those agreements are yet to be defined.

Available Estimates of China's GHG Emissions

The government is currently preparing its second ever GHG emissions inventory, expected to be released in 2012. Based on activity data of varying quality, estimated GHG emissions in China in

[20] The *National Climate Change Program*, released by the Chinese government in 2007, identifies many potential impacts of climate change on China. Additional examples of recent publications outlining such costs include A. Thomson, R. Izaurralde, N. Rosenberg, and X. He, "Climate Change Impacts on Agriculture and Soil Carbon Sequestration Potential in the Huang-Hai Plain of China," *Agriculture Ecosystems & Environment* 114 (2-4): 195-209, 2006; X. Wang, F. Chen, and Z. Dong, "The Relative Role of Climatic and Human Factors in Desertification in Semiarid China," *Global Environmental Change—Human and Policy Dimensions* 16 (1): 48-57, 2006; X. Zhang, and W. Liu, "Simulating Potential Response of Hydrology, Soil Erosion, and Crop Productivity to Climate Change in Changwu Tablel and Region on the Loess Plateau of China," *Agricultural and Forest Meteorology* 131 (3-4): 127-142, 2005.

[21] *The People's Republic of China Initial National Communications on Climate Change*, Office of National Coordination Committee on Climate Change, 2007, available at http://www.ccchina.gov.cn/en/index.asp.

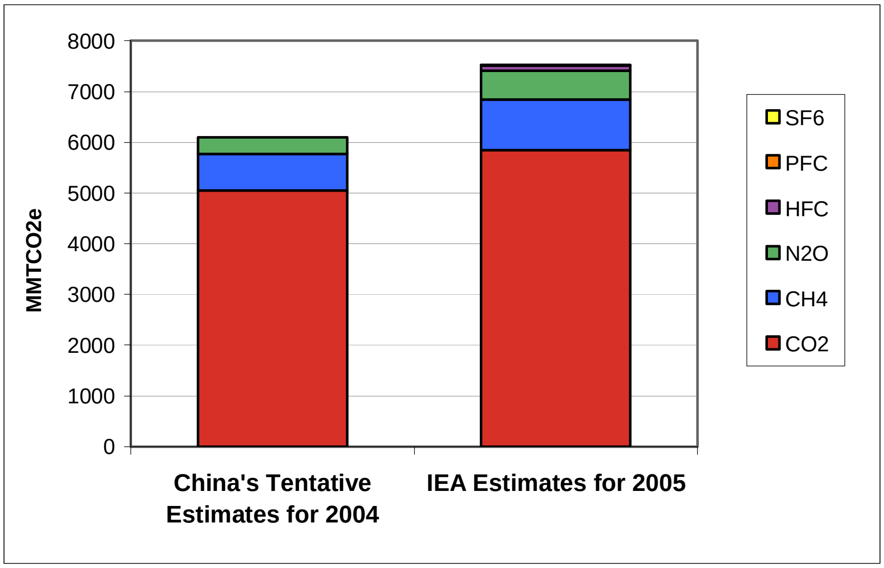
[22] Like some other developing countries, China has resisted proposals in international negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) that developing countries submit annual GHG inventories to the Conference of the Parties.

[23] "China: Backgrounder: Current GHG Emissions in China, Xinhua, June 4, 2007, http://www.chinaview.cn.

2005 were around 7-7.5 billion metric tons of CO2-equivalent,[24] with CO_2 constituting 78-84% of the total. Methane (CH_4) emissions were around 11-13%, nitrous oxide (N_2O) about 1%, and the synthetic gases (sulfur hexafluoride—SF_6, perfluorocarbons—PFC, and hydrofluorocarbons—HFC) together less than 1%. (These are the six GHG covered by the Kyoto Protocol.)

Figure 1. Two Estimates of Recent Chinese GHG Emissions

(by gas, where data were available)



Source: CRS figure with estimates from Xinhua (June 4, 2008); IEA greenhouse gas database (extracted Jan. 8, 2008); World Resources Institute, Climate Analysis Indicators Tool (data extracted July 11, 2011); G.Q. Chen and Bo Zhang, "Greenhouse Gas Emissions in China 2007" *Energy Policy* Vol 38:10 pp. 6180-6193 (October 2010).

Notes: Few estimates of non-CO_2 GHG emissions in China are available, and those that exist use varying years of analysis, scopes, and methods. This figure shows two available estimates for different years, illustrating the similarities and uncertainties regarding China's GHG emissions. Even carbon dioxide emissions, which are straightforward to calculate from energy and cement data, are no better than the quality of the underlying energy data. Though the IEA estimates include emissions of PFC and SF_6, the percentages are too small to appear in this figure.

The Chinese government estimates[25] that the country offset a portion of its GHG emissions with removals (sequestration) by forests: "from 1980 to 2005, a total of 3.0 billion tons of CO_2 were absorbed by afforestation, a total of 1.6 million tons of CO_2 were absorbed by forest management, and 0.430 million tons of CO_2 from deforestation were saved."[26] Removals of CO_2 from the atmosphere by land use, land use change and forestry are much more difficult to quantify in all countries than emissions by other human activities.

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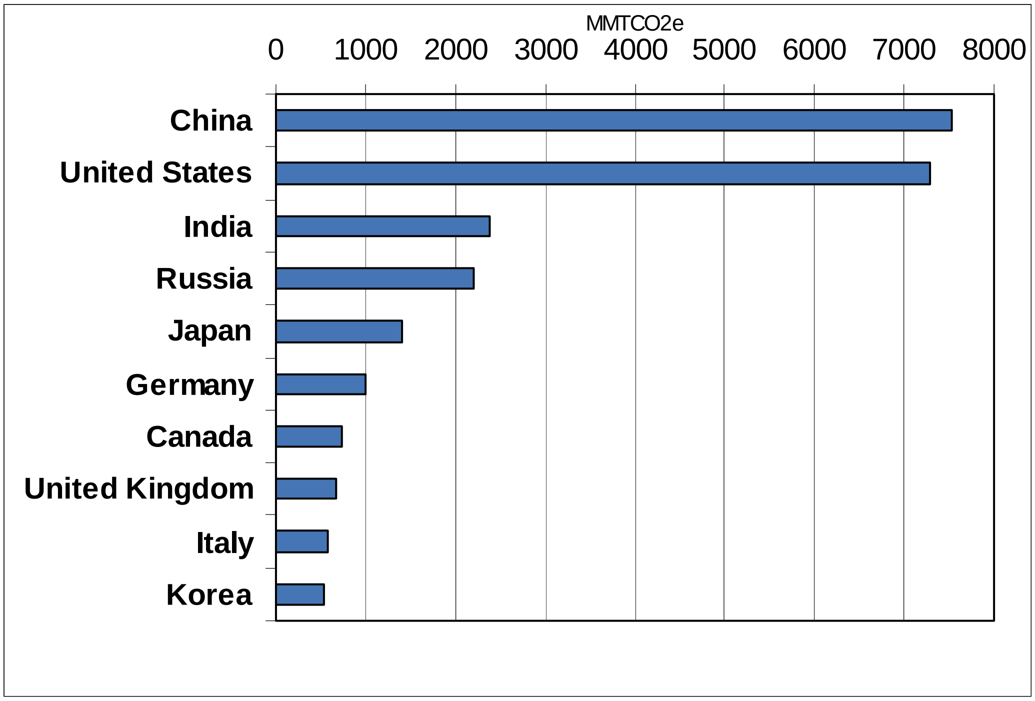
[24] CO_2e means "carbon dioxide equivalent," which is an aggregate of all greenhouse gases with each gas weighted by its effect on temperature change compared to CO_2.

[25] China published this document in June 2007 to outline its plan to address climate change and show its determination to mitigate emissions. The official document is available at http://english.gov.cn/2007-06/04/content_635624.htm.

[26] National Development and Reform Commission (NDRC), "China's National Climate Change Program," p. 10. Note, afforestation is the establishment of a forest on lands not previously forested, as opposed reforestation.

Figure 2 ranks the the IEA's estimates of the world's leading GHG emitters in 2005, the latest year for which non-CO_2 GHG data are available for many countries, including China. According to IEA's estimates for the six GHG, China and the United States were each responsible for about 17% of global GHG emissions in 2005. Using data for energy and cement CO_2 only, China and the United States in 2009 emitted about 21% and 19%, respectively, of the global total.[27]

Figure 2. Top GHG Emitters in 2005



Source: CRS graphic from IEA estimates (extracted January 8, 2008).

[27] BP, op. cit.

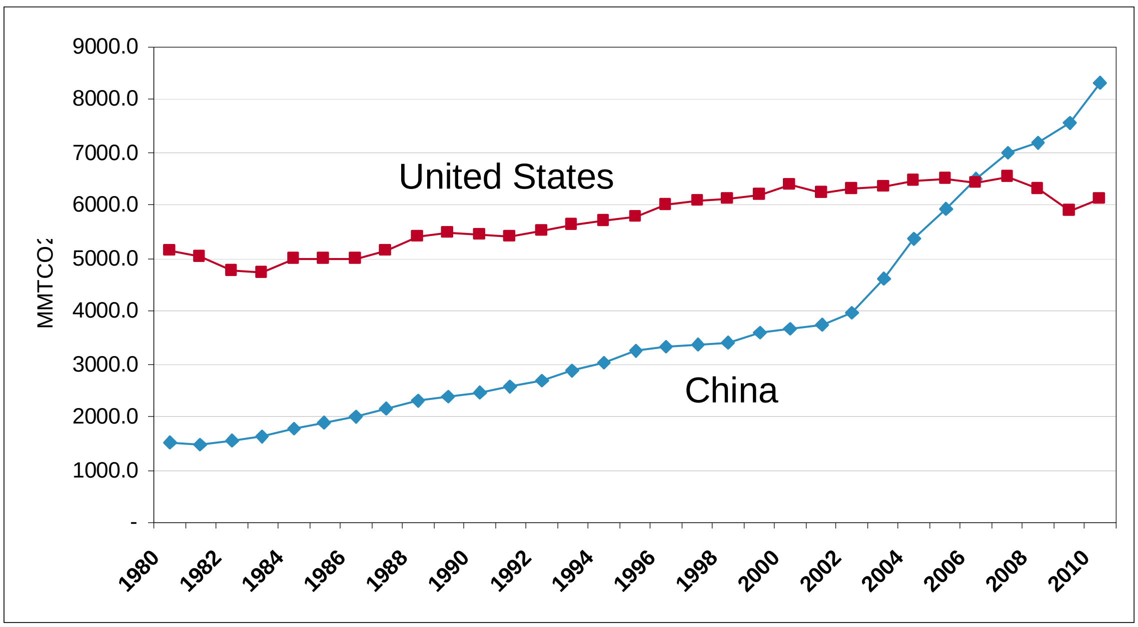
Recent Rates of Growth of China's GHG Emissions

Chinese GHG emissions have grown rapidly. According to unofficial GHG estimates from China, from 1994 to 2004, China's annual average GHG growth rate was around 4%.[28] In this period, the share of carbon dioxide in total GHG emissions increased from 76% to 83%.[29]

The most recent estimates come from BP are somewhat higher than IEA's, globally and for China. According to BP's estimates for 2010, China's and the United States' CO_2 emissions were 8,333 and 6,145 MMT CO_2, respectively. BP estimates that China's CO_2 emissions grew 339% from 1990 to 2010 (**Figure 3**). (This compares with U.S. CO_2 emissions growth of 13% from 1990 to 2010.)

Figure 3. Growth of Estimated CO_2 Emissions from the United States and China

(1980–2010)



Source: BP, Statistical Review of World Energy 2011 at http://www.bp.com/sectiongenericarticle800.do?categoryId=9037188&contentId=7068766

[28] The Climate Change Group, "China Briefing," Issue 1, September 2007.

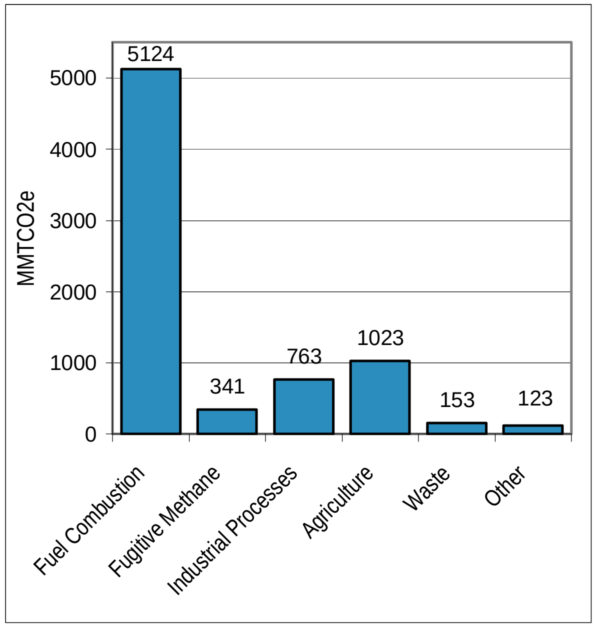
[29] Xinhua, op. cit., June 4, 2007.

GHG Emissions by Sector

Since China has not officially released a GHG inventory since 1994, it is difficult to know how sectors contribute to national emissions. The Pew Center on Global Climate Change estimated that, in 2003, electricity and heat made up 42% of China's GHG emissions,[30] industry[31] 21%, agriculture 20%, households and services 9%, transportation 5%, and waste 3%.[32]

According to IEA estimates, of China's 2005 GHG emissions, about 68% came from fuel combustion in all sectors (**Figure 4**). About 5% evaporated as methane from energy related systems. Another 10% came from industrial processes, and about 14% came from agriculture. Waste and miscellaneous sources accounted for the remaining 4% of China's GHG emissions that year.

Figure 4. GHG Emissions By Source Types in China in 2005



Source: CRS graph from IEA estimates, extracted July 8, 2008.

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[30] Most the electricity demand in China is for its industrial sector.

[31] Not associated with electricity and heat.

[32] Pew Center on Global Climate Change, "Climate Change Mitigation Measures in the People's Republic of China," p. 1, April 2007.

The Drivers of China's GHG Emissions

China's GHG emissions are the highest in the world because of its very large economy, the high share of the economy generated by energy-intensive (and GHG emitting) industry, and the high share of coal in China's energy mix.

The Growing Economy

China's GHG emissions are the highest in the world primarily because of the size of its economy, which is, in turn, due in large part to its vast population of 1.3 billion people. (Per capita, production is much smaller than that of the United States. But multiplying China's low per capita production by its large population makes the China's economy is the second largest globally.) China exercises strong policies to slow population growth; the growth of population in 2005 was approximately 0.6%, down from an average rate of about 1.1% in the 1990s and 1.4% in the 1980s.[33] The relatively slow rate of population growth helps to diminish the corresponding growth of national GHG emissions. China's population policies are clearly not aimed at mitigating GHG emissions, but observers note that without them emissions would have increased substantially.[34]

Though China's population has been growing relatively slowly, production per capita has grown rapidly. China's economy has experienced annual growth rates from 8 to 14% over the past decade. The Chinese economy is now the second largest economy in the world: int$9.1 trillion in 2009—two-thirds as large as the int$14.1 trillion U.S. economy (compared using Purchasing Power Parities), and more than twice the size of Japan's (the third largest economy).

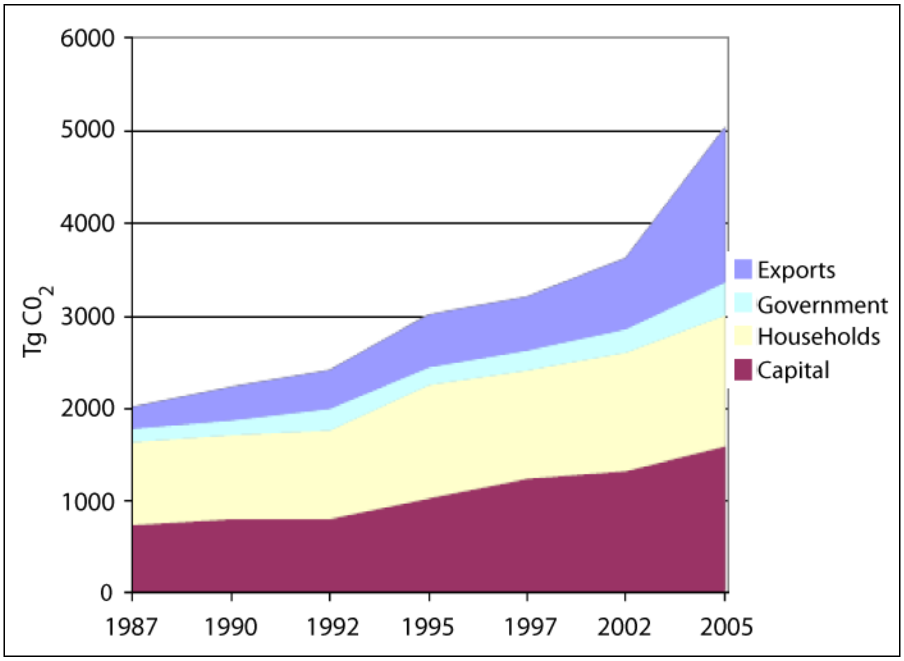
Figure 5 provides one estimate of the economic activities that have driven recent growth of Chinese GHG emissions. It concludes that the emissions associated with exports have grown rapidly in the past few years, as well as capital investment (construction of buildings, roads, etc.) and increasing consumption by the population and their rising incomes.[35]

[33] Population growth rates taken from United Nations, *World Population Prospects: The 2006 Revision*, 2007; and Central Intelligence Agency, *The World Factbook: China*, July 2008, https://www.cia.gov/library/publications/the-world-factbook/geos/ch.html.

[34] According to Gao Guangsheng of the NDRC, Chinese carbon dioxide emissions would have been 1.3 billion tons higher in 2005 had the country not implemented family planning policies in the 1970s, http://www.pewclimate.org/docUploads/Gao%20Guangsheng.pdf. Some people find family planning and other methods of birth control immoral. Regardless of moral viewpoints on China's family planning policies, slowing population growth is likely to contribute to GHG mitigation.

[35] Weber, Christopher L., Glen P. Peters, Dabo Guan, and Klaus Hubacek. 2008. "The Contribution of Chinese Exports to Climate Change." *Energy Policy*. doi:10.1016/j.enpol.2008.06.009.

Figure 5. One Estimate of Factors Driving Recent Growth of GHG Emissions in China



Source: Weber et al., op. cit.

Note: China's total domestic CO_2 emissions, divided by driving demands: exports, governmental consumption, household consumption, and capital investment

China's Energy Sector

Energy production and use emit roughly three-quarters of all GHG in China, as in most other countries (**Figure 4**). China's rising GHG emissions have been primarily due to expansion of energy-intensive[36] industrial activity—largely in manufacturing for export and in construction of new infrastructure (**Figure 5**).[37] China's continuing heavy reliance on coal also results in high CO_2 intensity of its economy.

Energy Intensity

Chinese energy demand has surged since 1990, growing at a rate sometimes faster than the economy (**Figure 6**).[38] Years of government control over the energy sector, as well as incremental moves to decentralize the system, led to important distortions and inefficiencies. In the early 2000s, a decades-long reduction in energy intensity of the economy halted and reversed (**Figure**

[36] Energy intensity is the amount of energy consumed per unit of production in an economy. In **Table 1**, energy intensity is measured as thousands of tons of oil-equivalent used per unit of Gross Domestic Product (GDP). As economies develop, they frequently shift from an agricultural base to resource extraction and manufacturing, which increases their energy intensities. With further growth, the shares of higher value-added production and services grow, resulting typically in a decline of energy intensity.

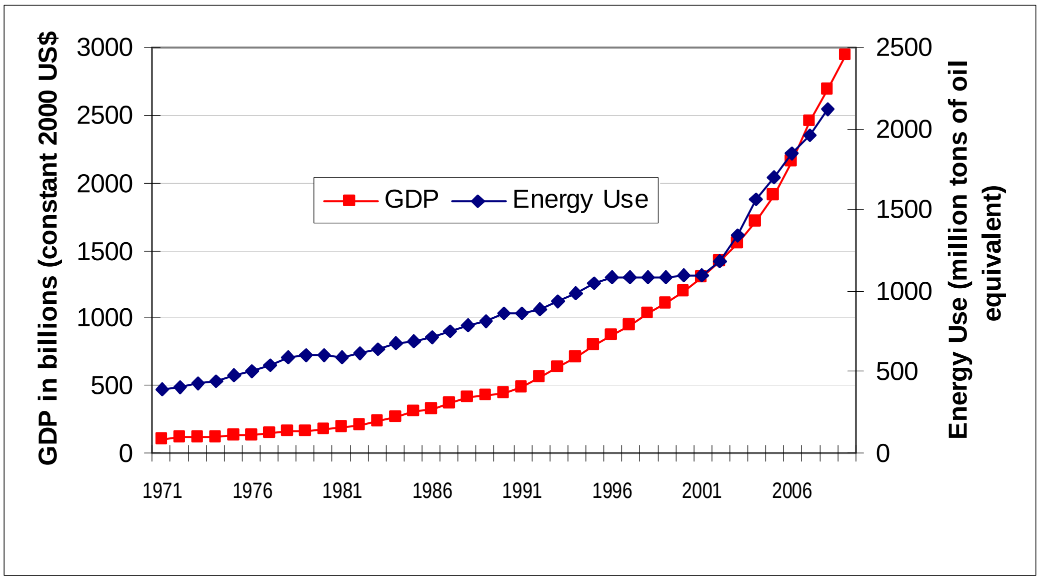
[37] D. Rosen and T. Houser, op. cit.

[38] For a discussion of China's surging energy use, see D. Rosen and T. Houser, *China Energy: A Guide for the Perplexed*, China Balance Sheet, May 2007, http://www.iie.com/publications/papers/rosen0507.pdf.

7), increasing China's dependence on energy to fuel its economic growth. Simultaneously, energy shortages forced stoppages at some enterprises. Though demand for oil for electricity production peaked[39] then declined, demand by vehicle use soared, aggravating concerns about access to supplies from the Middle East and Russia, and about vulnerabilities to price fluctuations. By 2007, China became a net importer of coal. Also, choking levels of pollution, much from the energy sector, triggered public protests, while international pressure increased on China to control its related emissions of air pollutants and GHG. Though reforms were promoted from the 1990s, weak implementation, unreliable data and monitoring, and a predominant emphasis on economic expansion limited their effectiveness. These factors focused the attention of the central government on revising national energy policies in China's 11th and 12th (current) 5-year plans. (Policies will be discussed in "China's GHG Abatement Policies and Programs".)

Figure 6. Growth of the Economy and Energy Use in China

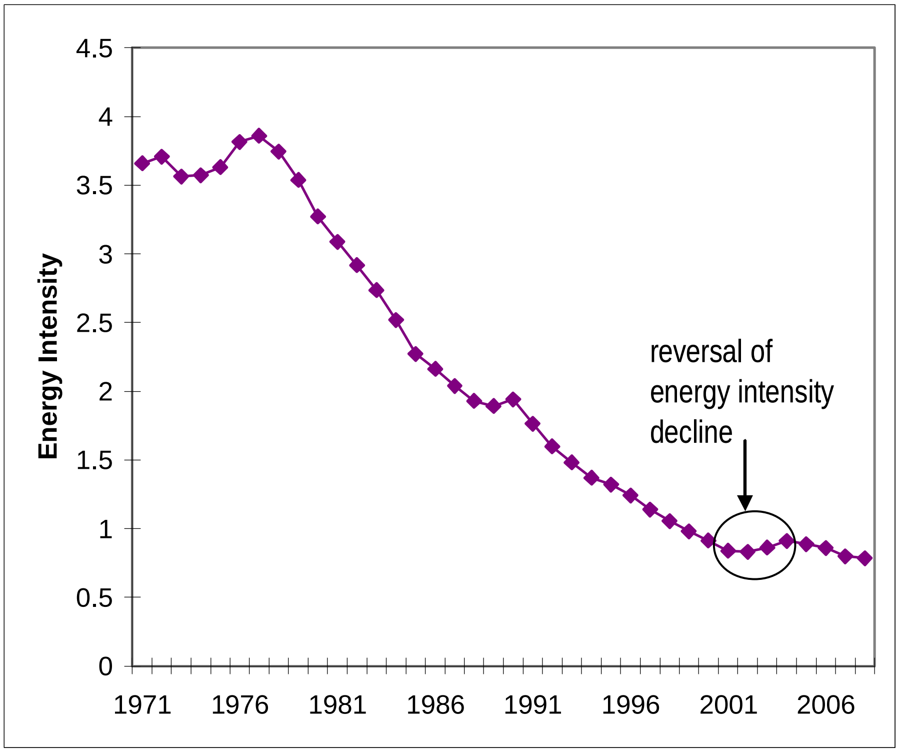
(1971–2009)



Source: CRS figure using data from World dataBank, *World Development Indicators*, extracted July 6, 2011.

[39] With shortages in electrical power from large installations, demand for diesel fuel for small scale electricity generation soared in the early 2000s, peaking in 2004. Rapid construction of electric power plants along with other government policies has alleviated that demand for oil for electricity and its share has fallen to less than 1%.

Figure 7. China's Energy Intensity
(1971–2009)



Source: CRS figure using data from World Development Indicators, extracted July 7, 2011.

Notes: Energy intensity measured as kilotons of oil equivalent per billions of constant 2000 US$.

Reliance on Coal in the Fuel Mix

China uses a high portion of coal in its fuel mix (**Figure 8**)—another reason that its CO_2 emissions are high relative to the size of its economy (its CO_2 intensity).

Coal emits far more CO_2 for the amount of energy it provides than other fossil fuels. Coal's "emission factor" is about 30% higher than that of crude oil, and about 70% more than natural gas, on average. So the high use of coal, and of fossil fuels more generally, in the Chinese economy explains why China's GHG emissions are proportionately high.

Compare the United States and China: In 2009, the United States' fuel mix comprised about 23% coal and 37% petroleum. Nuclear, hydroelectric, and other renewable sources contributed another 13%. In China, however, coal provided 70% of total energy, with petroleum contributing 18%, gas 4%, and nuclear, hydroelectric, and renewables providing the remaining 8%.[40,41] China now

[40] These data are from the *BP Statistical Review of World Energy 2011*, available at http://www.bp.com.

[41] Estimates of GHG emissions in China are uncertain, in part because of underlying uncertainties in official energy and economic data. Such data issues are more pronounced when considering data over time (for example, regarding changes in coal data over the past decade) or in comparison to other countries, where levels of uncertainty may be less.

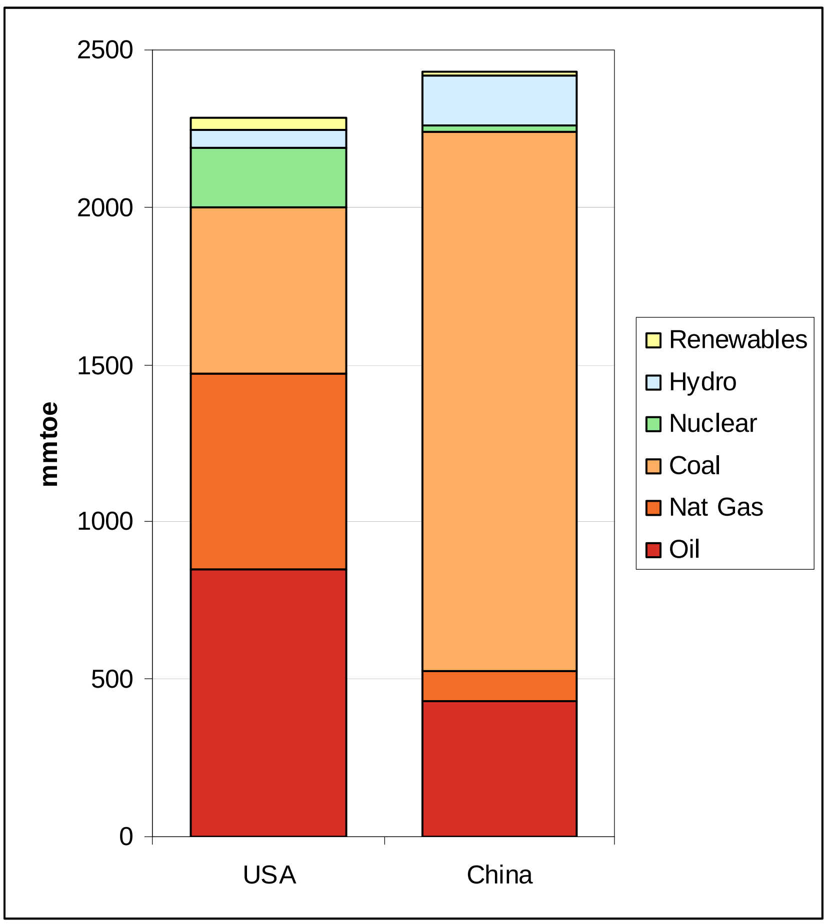
consumes about three times as much coal each year as the United States, even though its total energy demand in 2009 was about 6% higher, according to BP data.

The next biggest difference between China and the United States after China's greater reliance on coal is China's limited quantities of domestic natural gas, and its lower use of petroleum. (However, while oil is being backed out of electricity generation in China, demand for oil for transportation is surging with automobile use.) China also has many fewer nuclear power plants.

Although not reflected in China's CO_2 emissions estimates, the energy sector also emits a large portion of methane (CH_4) from coal production. Due to the dangers of uncontrolled methane leaks in mines, the government has tried to force capture and abatement of those methane emissions, but rates are thought to remain high (based, in part, on continuing frequency of coal mine explosions).

Figure 8. Primary Energy Consumption by Energy Types, United States and China

(2009)



Source: CRS figured using data from BP, *Statistical Review of World Energy* (June 2011) at http://www.bp.com/sectionbodycopy.do?categoryId=7500&contentId=7068481.

Other Sectors Emitting GHG

Agriculture is the next most significant sector for GHG emissions, although recent estimates are not available. In 1994, China's agriculture sector contributed 17% of all GHG emissions, 50% of all methane emissions (especially due to rice cultivation, and pig and sheep production), and about 92% of estimated nitrous oxide emissions (due to fertilizer application).[42] It is likely that these percentages have shifted significantly in the intervening years, however.

China's GHG Abatement Policies and Programs

China has increasingly strengthened its policies and programs to curtail GHG emissions, culminating in a pledge under the 2009 Copenhagen Accord[43] to achieve a 40 to 45% reduction in its carbon intensity[44] by 2020. The government has sought to enforce and incentivize many programs to improve energy efficiency and expand the shares of non-emitting sources of energy. In addition, it has promoted policies in agriculture and other sectors to abate GHG emissions. Still, some critics are skeptical of China's ability to achieve its targets, while others believe that China's efforts are little more than "business-as-usual." One recent analysis concluded that achieving the carbon intensity target is feasible, but would require strengthening of existing policies to stimulate energy efficiency in multiple sectors and to increase shares of renewable and nuclear electricity generation.[45] Under existing policies, most analysts expect China's GHG emissions to slow their rate of growth but to continue to increase until around 2030.

As discussed earlier, China's government has felt pressure to abate choking levels of local pollution as well as to engage with other large GHG emitters in international cooperation to reduce its emissions. China had policies for many years to improve efficiency, and even to tax polluting emissions, but enforcement and effectiveness of those policies were less than anticipated. By 2007, when China was under strong international pressure to negotiate GHG reduction targets under the UNFCCC for the period beyond 2012, China released its National Climate Change Program, a plan to address climate change.

The most challenging aspect of China's policy, arguably, was its goal to lower energy intensity 20% by 2010. By 2010, the government says the nation fell just short of that goal, with a 19.1% improvement. However, under severe scrutiny towards the end of 2010, it appears that many energy managers met their goals by stopping or slowing production rather than improving efficiency.[46] This seems to have resulted in a slight "rebound" of energy intensity early in 2011. Chinese leadership has warned against such tactics to reduce energy intensity and tightened its objectives in the 12th 5-Year Plan, from 2011-2015.

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[42] Dong Hongmin "China GHG emission from agricultural activity and its mitigation strategy" (2007) at http://www.globalmethane.org/expo_china07/docs/postexpo/ag_hongmin.pdf.

[43] See CRS Report R40001, *A U.S.-Centric Chronology of the International Climate Change Negotiations*, by Jane A. Leggett for more information.

[44] Carbon intensity is the quantity of annual emissions relative to annual economic production, typically measured as Gross National Product.

[45] Nan Zhou, David Fridley, Michael McNeil, Nina Zheng, Jing Ke, and Mark Levine "China's Energy and Carbon Emissions Outlook to 2050," LBNL Report LBNL-4472E (April 2011).

[46] http://www.ccchina.gov.cn/en/NewsInfo.asp?NewsId=27352.

Besides the improvement in energy intensity, measures in the 11th 5-Year Plan resulted, according to China's claims, in

- The closure of thousands of small, inefficient, and polluting coal-fired power plants, iron and steel mills, cement kilns, aluminum plants, and others. China reports closures of old coal-fired power plants exceeding 71 GW of capacity in 2006-2010, and another 11 GW in the first half of 2011. The government says these plants would otherwise have emitted 164 $MMTCO_2$ annually.[47]
- The share of non-fossil energy reached 9.6% in 2010, up from about 7% in 2005. China became the largest wind power market by 2010, for both supply and use.
- The stock of carbon stored in forests increased by an estimated 13 billion cubic meters.[48]

The Chinese government has stated that some of the policies put in place to achieve China's targets for 2010 will likely continue into the future. Examples include

- investment in ultra-efficient coal fired electricity generation;
- improvement of existing coal-fired industrial boilers;
- closure of inefficient energy and industrial production capacity;
- expansion of combined heat-and-power;
- improvements of industrial motor efficiencies;
- standards for energy efficient lighting, buildings, and appliances;
- efficiency labels for appliances;
- improved enforcement of standards;
- financial incentives to build renewable energy capacity;
- requirements of feed-in tariffs to promote renewable energy generation;
- monetary awards for energy-saving achievements by companies and public institutions;
- vehicle efficiency standards that exceeded those of the United States;
- tightened efficiency standards for buildings and appliances, and forest coverage expanded to 20%.

Regarding CO_2 emissions and energy policies, the details of China's 12th 5-Year Plan (covering 2011 to 2015) and its implementing measures are still in draft. The national government has announced a number of its targets that, if achieved, would reduce growth of GHG emissions. By 2015:

- energy intensity should improve by 16% by 2015;

[47] Industrial Fuels and Power, "China succeeds in meeting target for obsolete coal-fired power plant closures, coal consumption falling back on abundant supply" (July 26, 2011) at http://www.ifandp.com/article/006210.html.

[48] http://www.f-paper.com/?i469938-Photo:-Sun-Cuihua:-Chinas-greenhouse-gas-control-policies-and-market-mechanisms

- carbon intensity should improve 17% by 2015, reaching 40-45% relative to 2005 levels by 2020;
- the share of non-fossil energy should reach 11.4% by 2015 and 15% by 2020;
- Forest coverage should increase by 12.5 million hectares (31 million acres) by 2015, and 40 million hectares (99 million acres) by 2020, compared to 2005 area;
- Nine pilot CO_2 cap and trade programs have been established across several cities;
- The length of high-speed railways is planned to increase to 45,000 km (27,962 miles).

Comprehensive laws to facilitate meeting those targets are now under consideration by the legislature. A variety of statements from the government indicate that some of the main policies China would use to achieve its goals are:

- continued economic restructuring toward higher value-added and less energy intensive production;
- financial awards to companies and public institutions for quantitative goals for saving energy and substituting alternative for fossil fuels in the transport sector;[49] and
- expansion of the "energy-saving service sector" with a focus on the transport and construction sectors, making energy efficiency a "criterion for market entry" and setting benchmarks for energy performance.[50]

Projected CO_2 Emissions

Just as China has not provided estimates of historical or current GHG emissions, it has not provided projections of future emissions. A variety of organizations have produced their own projections, with different assumptions about underlying "business as usual," efficacies of Chinese policies and programs, and rates of technological advance. In the longer term, Chinese officials are signaling possible absolute reductions in China's GHG emissions. As reported by the Xinhua news agency, a recent report by the Chinese Academy of Engineering concluded that

> China's energy development is projected to experience a "historic transition" around 2030 when its consumption of coal becomes restrained, the emission of carbon dioxide reaches its peak and energy-saving capacities around the world reaches an advanced level.[51]

This conclusion is consistent with other analyses and official statements suggesting that 2030 could mark the high point of Chinese CO_2 emissions if current policies continue. One analysis that seemed linked to the Chinese pledge to improve carbon intensity by 40-45% by 2020 is illustrated in **Figure 9**. (A very similar figure was made available at the time China announced its pledge.)

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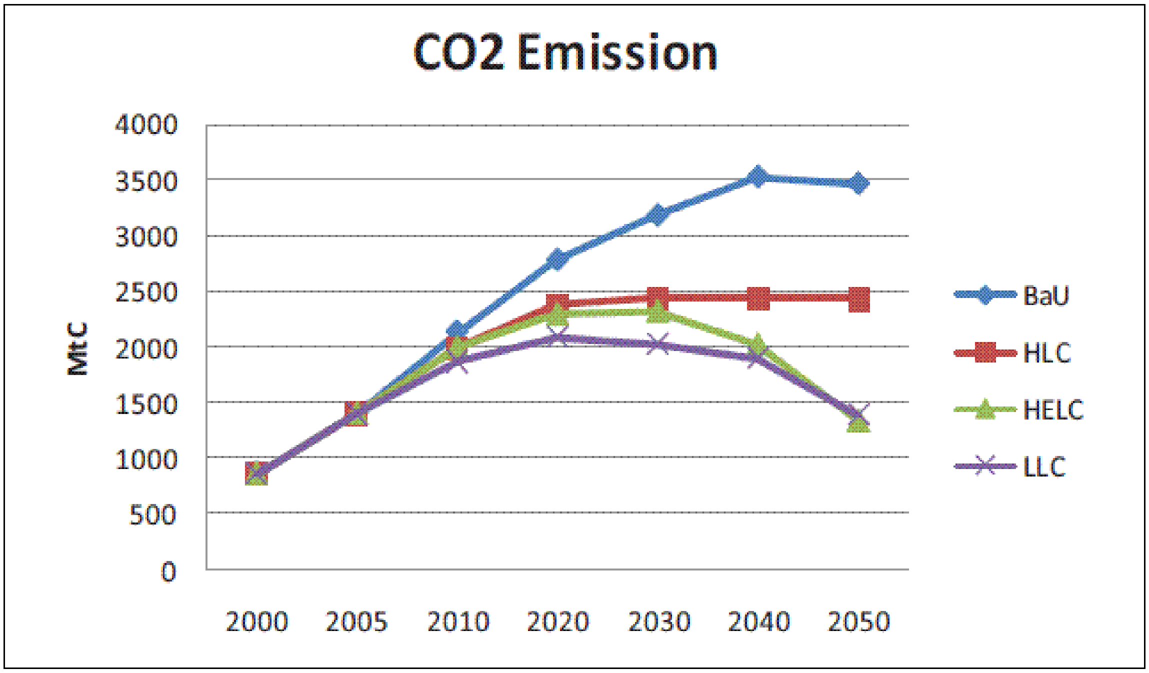
[49] http://www.ccchina.gov.cn/en/NewsInfo.asp?NewsId=28763.

[50] http://www.ccchina.gov.cn/en/NewsInfo.asp?NewsId=28694.

[51] Chinese Academy of Engineering, "Research Report on China's Mid-term and Long-term Energy Development Strategy" (2011) reported at http://news.xinhuanet.com/english2010/china/2011-02/28/c_13754385.htm.

Figure 9. One Projection of Future Chinese Emissions



Source: Kejun et al. "Technology roadmap for low carbon society in China" *J. Renewable Sustainable Energy* 2, 031008 (2010).

Notes: The figure depicts four scenarios for China's CO_2 emissions: BaU represents "taking no climate change policies under the high GDP growth rate assumption." The HLC scenario represents unilateral Chinese actions to address energy security, domestic environmental standards, and a low carbon development strategy. The HELC scenario represents further technological efforts to abate CO_2 emissions, including large-scale deployment of Carbon Capture and Storage (CCS) in China. This scenario assumes China would act in the context of global efforts. All three of these scenarios assume high rates of economic growth in China. The LLC scenario assumes lower economic growth rates, along with efforts to transition to a low carbon economy. The reference paper provides more detailed assumptions.

Another recent analysis by Lawrence Berkeley National Laboratory (LBNL) concludes similarly that China's CO_2 emissions could begin to level off around 2030, due to saturation of some demand for greater energy services, as well as standards and incentives for more efficiency and non-fossil technologies.[52]

An alternative view is represented by the International Energy Agency's World Energy Outlook 2009. It suggests that China's current policies (before the 12th 5-Year Plan) would result in continually rising CO_2 emissions, reaching 12.6 $MMTCO_2$ by 2035.[53] That would be almost a doubling of China's 2005 emissions.

[52] Nan Zhou, David Fridley, Michael McNeil, Nina Zheng, Jing Ke, and Mark Levine "China's Energy and Carbon Emissions Outlook to 2050," LBNL Report LBNL-4472E (April 2011). See Figure ES-2, for example.

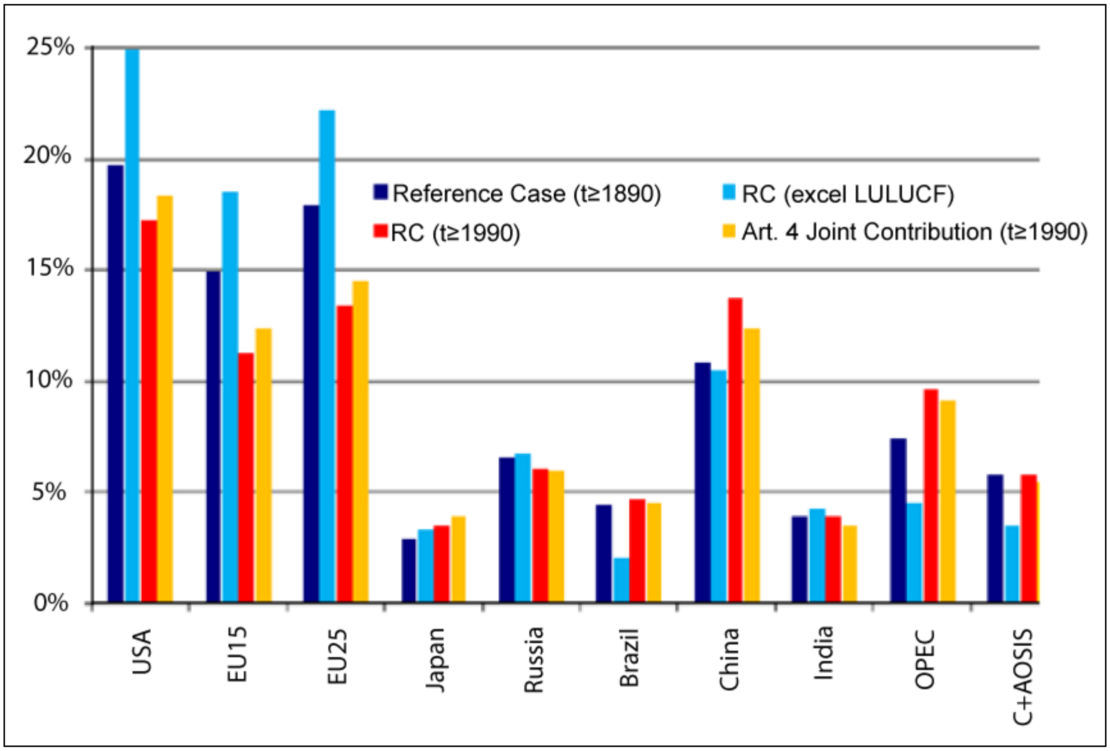
[53] Slide 30 at http://www.energy.eu/publications/weo_2010-China.pdf.

China's Stance on International Obligations

China and other countries that had low incomes in 1992 were exempted in the United Nations Framework Convention on Climate Change (UNFCCC) and the 1997 Kyoto Protocol from taking on quantified GHG reduction obligations, based on the principle of "common but differentiated responsibilities" contained in the Convention. While Parties agreed that the already industrialized Parties ("Annex I Parties") should take the first steps in abating their GHG emissions, it has been clear from a scientific standpoint that the objective of the UNFCCC—to stabilize atmospheric concentrations of GHG at a level that would avoid dangerous anthropogenic interference with the climate system (in Article 2)—could be met only when all significant emitters reduce their net emissions (i.e., emissions minus removals by photosynthesis) to near zero. China and other low income economies, however, resisted any discussion of when and how they might take on GHG obligations. At the same time, the United States and a few other countries rejected taking on GHG mitigation commitments unless *all* major emitters take on commitments. Impasse continued until agreement was reached on the 2009 Copenhagen Accord: countries associated with the Accord submitted pledges to GHG targets and mitigation actions they would take. These pledges are politically but not legally binding. Agreement on legally binding commitments under the UNFCCC or the Kyoto Protocol seems unlikely for the foreseeable future.

China's stance against legally binding obligations rests on several points. First, China argues that the existing, elevated concentrations of GHG in the atmosphere are due to historical emissions from the already industrialized countries, such as the United States. (The "Brazil Proposal" of 1997 suggests that developing countries should not take on GHG abatement requirements until their accumulated contributions to atmospheric concentrations equally the contributions of the Annex I Parties—in other words, not for decades.) China's large and rapidly growing emissions, however, may soon places its contributions to atmospheric concentrations on a par with the historic contributions of many smaller Annex I Parties. Also, China has extended its position on differentiation of obligations to cover GHG emission reporting and review, not just abatement responsibilities. As discussed earlier in the section on China's GHG emissions, that country's reticence to be transparent about its emissions and sequestration and quantification of its policies and programs, has been an important point of conflict in the UNFCCC negotiations.

Figure 10. Relative Contributions to Climate Change in 2000 Under Alternative Assumptions



Source: Muller et al. "Differentiating (historic) responsibilities for climate change" *Climate Policy*, Volume 9, Number 6, 2009 , pp. 593-611(19).

Notes: This figure was derived from analyses commissioned by the UNFCCC Parties, as Modelling and Assessment of Contributions to Climate Change (MATCH). Reference Case (t≥ 1890) calculates the contributions beginning in the year 1890, while RC (t≥ 1990) makes the calculation with emissions beginning in 1990. RC (excel LULUCF) excludes emissions from land use, land use change and forestry (LULUCF).

Second, China and other lower income countries point out that the industrialized economies benefited from essentially unconstrained use of energy to fuel their growth; lower income countries should also be exempt from constraints on their use of energy until their incomes have caught up. They also contend that, if global carbon emissions must be limited, each person should have an equal "right" to emissions; this would imply that the "rights" of each American would be small fraction of their current actual emissions, while citizens of developing would be allowed to expand their average emissions. (Even under this line of argument, however, China would need to reduce its per capita GHG emissions in scenarios that would stabilize GHG concentrations at many moderate, proposed targets.) An "equity" proposal rumored to be forthcoming from India, China, Brazil and South Africa would set a principle in the negotiations that a country would not take on GHG abatement obligations until each of its citizens had access to energy and had emerged from poverty. Such a proposal could illuminate the widely varying conceptions of "equity" among Parties and individuals, as well as perhaps being inconsistent with achieving the UNFCCC's objective of stabilizing GHG concentrations.

In addition, China and other non-Annex I Parties have underscored the greater financial capabilities of the wealthier countries to undertake GHG abatement, while China's priority must be to alleviate poverty and to raise average incomes towards those of the Annex I Parties. China, for decades, has sought financial and technological assistance as part of nearly every international issue. China's robust economy, large foreign reserves, and leading experience in manufacturing and deploying many advanced technologies has reduced the credibility of its requests. In contrast, China has increased its engagement in technology cooperation in recent years, including with the United States.

For many years, China and other non-Annex I Parties allied to block discussion of new commitments for non-Annex I Parties. By 2009 and the Copenhagen negotiations, however, some countries that feel vulnerable to the impacts of climate change began to perceive that it would not be in their interests to sustain the "no new commitments for developing countries" mantra. The fractious negotiations in Copenhagen spotlighted these diverging interests and added to pressure for China and others to agree to the political pledging processes that have emerged. For the foreseeable future, however, China is likely to continue its opposition to taking on legally binding GHG targets, as well as to enhanced requirements for GHG reporting and international review of its policies and progress.

Author Contact Information

Jane A. Leggett
Specialist in Energy and Environmental Policy
jaleggett@crs.loc.gov, 7-9525