Chapter 7

Energy-Related Carbon Dioxide Emissions

In 2005, non-OECD emissions of carbon dioxide exceeded OECD emissions by 7 percent. In 2030, carbon dioxide emissions from the non-OECD countries are projected to exceed those from the OECD countries by 72 percent.

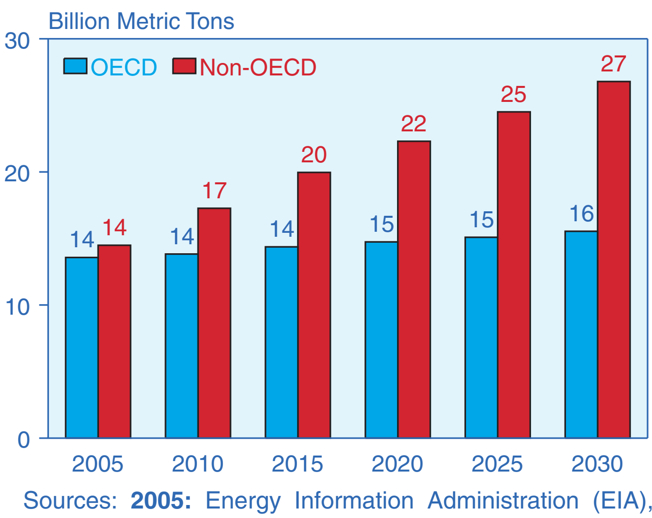
Carbon dioxide is the most abundant anthropogenic (human-caused) greenhouse gas in the atmosphere. Atmospheric concentrations of carbon dioxide have been rising at a rate of about 0.6 percent annually in recent years, and that growth rate is likely to increase. As a result, by the middle of the 21st century, carbon dioxide concentrations in the atmosphere could be double their pre-industrialization level (see box on page 90).

Because anthropogenic emissions of carbon dioxide result primarily from the combustion of fossil fuels for energy, world energy use has emerged at the center of the climate change debate. In the *IEO2008* reference case, world carbon dioxide emissions are projected to rise from 28.1 billion metric tons in 2005 to 34.3 billion metric tons in 2015 and 42.3 billion metric tons in 2030.[19]

From 2004 to 2005, total energy-related carbon dioxide emissions from the non-OECD countries grew by 6.6 percent, while emissions from the OECD countries grew by less than 1 percent. Consequently, annual emissions from the non-OECD countries currently exceed total annual emissions from the OECD countries, and the difference is growing (Figure 75). In addition, the projected average annual increase in non-OECD emissions from 2005 to 2030 (2.5 percent) is five times the increase projected for the OECD countries (0.5 percent). In 2030, non-OECD emissions, projected at 26.8 billion metric tons, exceed the projection for OECD emissions by 72 percent. The *IEO2008* reference case projections are, to the extent possible, based on existing laws and policies. The projections for carbon dioxide emissions could change significantly if existing laws and policies aimed at reducing the use of fossil fuels, and thus greenhouse gas emissions, changed.

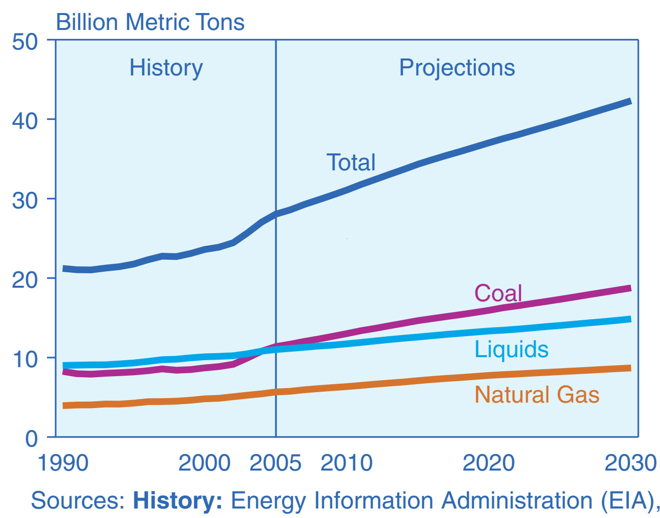
The relative contributions of different fossil fuels to total energy-related carbon dioxide emissions have changed over time. In 1990, emissions from the combustion of liquids and other petroleum made up an estimated 42 percent of the world total; in 2005 their share was 39 percent; and in 2030 it is projected to be 35 percent (Figure 76). Carbon dioxide emissions from natural gas combustion, which accounted for 19 percent of the total in 1990, increased to 20 percent of the 2005 total. That share is projected to stabilize at between 20 and 21 percent from 2005 to 2030.

Figure 75. World Energy-Related Carbon Dioxide Emissions, 2005-2030



Sources: **2005:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2008).

Figure 76. World Energy-Related Carbon Dioxide Emissions by Fuel Type, 1990-2030



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2008).

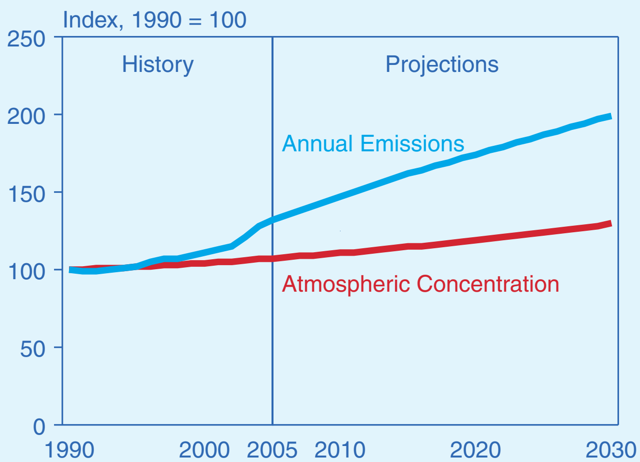
[19]In keeping with current international practice, *IEO2008* presents data on greenhouse gas emissions in billion metric tons carbon dioxide equivalent. The figures can be converted to carbon equivalent units by multiplying by 12/44.

What Will It Take To Stabilize Carbon Dioxide Concentrations?

Currently, world energy-related carbon dioxide emissions are increasing at a rate of about 2.1 percent per year. Carbon dioxide concentrations, on the other hand, are rising by only about 0.6 percent per year (see figure below). There are two major reasons for the difference:

- First, the base from which growth in the atmospheric carbon dioxide concentration is calculated is much larger than the base from which increases in annual emissions are calculated. Before the industrial revolution, the weight of carbon dioxide in the atmosphere was about 2,163 billion metric tons,[a] and in the early stages of industrialization the concentration increased slowly—at a rate of about 0.04 percent per year.
- Second, the Earth's oceans and soils absorb carbon dioxide. Over time, about 42 percent (at current emission rates, between 11 and 12 billion metric tons) of the net carbon dioxide emitted through the burning of fossil fuels and deforestation has been absorbed by the planet and has not accumulated in the atmosphere. The other 58 percent has been added to the atmospheric balance. One of the uncertainties in projecting future concentrations is whether the same absorption ratio will hold for future emissions.

Growth in Carbon Dioxide Emissions and Atmospheric Concentration, 1990-2030



Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2008).

In pre-industrial times, the concentration of carbon dioxide in the atmosphere was about 280 parts per million (ppm). The atmospheric concentration of carbon dioxide at present is about 380 ppm, and according to the *IEO2008* reference case projections, by 2030 it would be about 450 ppm.[b] If the growth of world carbon dioxide emissions continues unabated, the concentration of carbon dioxide in the Earth's atmosphere could reach 560 ppm by the middle of the 21st century.

Many possible actions beyond those currently projected in the business-as-usual baseline would be needed to stabilize the atmospheric concentration of carbon dioxide at a level below 560 ppm (still double the pre-industrial level). There is no unique path for achieving any stabilization goal. In addition, a number of "wild cards" could alter the relationship between emissions rates and atmospheric concentrations—such as the Earth's capacity to absorb carbon, which some scientists believe could be diminished by global warming. Each of the options outlined below could be expected to mitigate 1 billion metric tons or more annually by 2030, relative to the *IEO2008* reference case projection. It is beyond the scope of this analysis to project either the upper bound or the economic cost of each option.

- *Reductions in energy demand growth*. Reducing the growth of energy demand in residential and commercial buildings would require adoption of more energy-efficient lighting systems (such as compact fluorescent bulbs and, eventually, light-emitting diodes) and of more efficient heating, cooling, and refrigeration systems, as well as energy-efficient building shell retrofits and new construction. In the transportation sector, it would require more fuel-efficient vehicles and more use of public transit and telecommuting. In the industrial sector, more combined heat and power and more efficient processes would be needed to lower energy demand per unit of industrial output.
- *Increases in nuclear electricity generation*. According to the World Nuclear Association, the achievement of 740 gigawatts of installed nuclear electricity capacity by 2030—36 percent more than projected in the *IEO2008* reference case—is possible. If additional nuclear power displaced only coal, such an increase would achieve a reduction of about 1 billion metric tons annually by 2030.

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[a]Scientists typically measure carbon dioxide concentrations by the weight of the carbon only, because some carbon exchanges (fluxes) do not involve carbon dioxide. For this analysis, however, the weight of carbon dioxide is used for consistency with the rest of the chapter.

[b]The concentration levels calculated here are based only on energy-related carbon dioxide. Taking into account other sources of carbon dioxide and concentrations of other heat-trapping gases, total greenhouse gas concentrations will be somewhat higher.

- *Increased use of nonhydropower renewables for electricity generation in the OECD economies*. For nonhydropower renewables to provide 20 percent of the electricity consumed in the OECD economies in 2030, the use of renewables would have to increase by an average of 7.4 percent annually from 2010 to 2030, as compared with the 2.5-percent average increase in the *IEO2008* reference case. The increase would yield 1 billion metric tons of abatement annually by 2030.

- *Increased use of hydropower and nonhydropower renewables for electricity generation in the non-OECD economies*. Assuming that there are more opportunities for hydropower expansion in the non-OECD economies than in the OECD economies, if the combined use of hydropower and nonhydropower renewables in non-OECD countries grew by 3.5 percent per year from 2020 to 2030, as compared with 1.3 percent in the *IEO2008* reference case, 1 billion metric tons of carbon dioxide emissions would be avoided annually by 2030.

- *Increased use of renewable fuels for transportation.* If new technologies were employed to minimize carbon dioxide emissions from input fuels and indirect emissions of other greenhouse gases, so that an additional 20 quadrillion Btu of biofuels was consumed in the transportation sector, assuming a life-cycle savings of 80 percent in carbon dioxide emissions compared to conventional petroleum, 1 billion metric tons of carbon dioxide emissions could be avoided by 2030.

- *Carbon capture and storage.* It is unlikely that significant amounts of carbon capture and storage will be implemented before 2020. When the technology does become available commercially, its application to about 250 gigawatts of coal-fired generation capacity with a 90-percent removal rate would result in the mitigation of 1 billion metric tons of carbon dioxide emissions annually. The *IEO2008* reference case does not include carbon capture and storage. Although there are some small projects in pilot phases around the world, the assumption is that without binding constraints on carbon dioxide emissions throughout the projection period there would be no economic incentive to engage in carbon capture and storage.

- *Anthropogenic sequestration.* The latest assessment by the Intergovernmental Panel on Climate Change estimates that about 3.7 billion tons carbon dioxide equivalent per year is sequestered by anthropogenic activity, including projects such as reforestation and other land-use programs. A 27-percent increase in such activity by 2030 would represent an emissions reduction of 1 billion metric tons.

For many of the options listed above, the magnitude of the required changes relative to the reference case projections points to the difficulty of achieving stabilization at an atmospheric concentration that is at or below twice preindustrial levels. The effectiveness of reductions in electricity demand as a way to decrease carbon dioxide emissions depends on the fuel mix, the efficiency of generation, and the resultant carbon intensity of electricity supply (carbon dioxide emitted per kilowatthour of generation). For example, because coal-fired generation is more carbon-intensive than natural-gas-fired generation, achieving a given level of reduction in carbon dioxide emissions would require a smaller cut in coal use than the cut in natural gas use that would be required for the same reduction in emissions. Similarly, as the overall carbon intensity of electric power production declines, larger reductions in electricity demand will be needed to achieve a given level of emission abatement (see figure below).

Over time, increases in the efficiencies of generation technologies, such as new natural gas combined-cycle generation, will mean that demand reductions avoid smaller amounts of carbon dioxide emissions. With the average efficiency of electricity generation improving over time, the 2030 reference case intensity of 0.48 metric tons carbon dioxide per megawatthour of electricity supplied is lower than the 2005 historical carbon intensity of 0.56 metric tons per megawatthour supplied. As a result, if more non-carbon-emitting electricity supply is added, such as nuclear and renewables, the demand reduction requirement for the same amount of carbon dioxide emissions savings increases over time.

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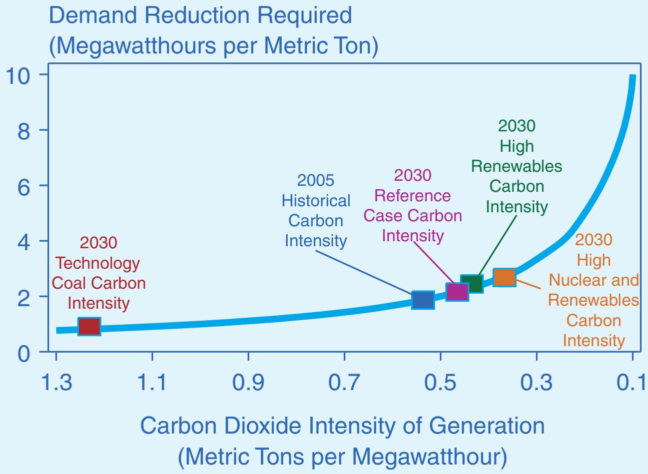
Impact of Carbon Dioxide Intensity of Electricity Supply on Effectiveness of Demand Reduction



Sources: **2005:** Derived from Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **Projections:** Estimated by EIA, Office of Integrated Analysis and Forecasting.

What Will It Take To Stabilize Carbon Dioxide Concentrations? (Continued)

There are wide ranges of estimates both for the marginal cost levels required to achieve various reduction levels and for the corresponding impacts on GDP. Policies to achieve emission abatements can have a large effect on the cost estimates, as can the rate of development of low- or non-carbon technologies. Specific questions that would have to be answered in order to estimate costs include:

- Are all greenhouse gases included in the analysis? Are emissions credits freely traded?
- Is nuclear power allowed to grow at a rapid pace?
- Are biomass and other renewable technologies allowed to penetrate rapidly?
- What discount rates are used for future costs and benefits?
- Do new technologies, such as carbon capture and storage, enter the technology base early enough to be employed in the abatement strategy?

If, by 2030, world GDP were 1 percent lower as a result of mitigation efforts, it would mean an annual cost of about $1.5 trillion (in constant 2000 dollars). The costs must of course be weighed against future benefits in the form of avoiding human-caused climate disruptions.

Coal's share of world carbon dioxide emissions grew from 39 percent in 1990 to 41 percent in 2005 and is projected to increase to 44 percent in 2030. Coal is the most carbon-intensive of the fossil fuels, and it is the fastest-growing energy source in the *IEO2008* reference case projection, reflecting its important role in the energy mix of non-OECD countries—especially China and India. In 1990, China and India together accounted for 13 percent of world carbon dioxide emissions; in 2005 their combined share had risen to 23 percent, largely because of strong economic growth and increasing use of coal to provide energy for that growth. In 2030, carbon dioxide emissions from China and India combined are projected to account for 34 percent of total world emissions, with China alone responsible for 28 percent of the world total.

The Kyoto Protocol, which requires participating "Annex I" countries to reduce their greenhouse gas emissions collectively to an annual average of about 5 percent below their 1990 level over the 2008-2012 period, entered into force on February 16, 2005. Annex I countries include the 24 original OECD countries, the European Union, and 14 countries that are considered "economies in transition."[20] As of December 3, 2007, 174 countries and the European Commission had ratified the Kyoto Protocol; however, only the Annex I countries that have ratified the Protocol are obligated to reduce or limit their carbon dioxide emissions. The United States has not ratified the Protocol; and although both China and India have ratified it, neither is subject to emissions limits under the terms of the treaty.

Although the Protocol is technically "in force," it would have an effect on only one year of the *IEO2008* forecast, namely, 2010. The *IEO2008* projections do not explicitly include the impacts of the Kyoto Protocol, because the treaty does not indicate the methods by which ratifying parties will implement their obligations.

Further, although some countries have passed laws intended to implement the goals of the Kyoto Protocol, it is difficult to interpret those laws in the *IEO2008* reference case. Many of the Kyoto goals are being met by "Kyoto mechanisms," such as reforestation, which are not reflected in the projections. Additionally, greenhouse gases other than carbon dioxide often are the least expensive to reduce, and those reductions may account for a larger proportion of some countries' Kyoto goals. In the *IEO2008* projections only energy-related carbon dioxide emissions are calculated; estimates of other greenhouse gas emissions are not included.

Finally, the participants have been unable to agree on a second commitment period or on any actions that might occur after 2012. Until those issues are resolved, it will be difficult to project the effects of the Kyoto Protocol through 2030.[21]

There are signs that concerns about global climate change are beginning to affect the world fuel mix. In recent years, many countries have begun to express new interest in expanding their use of non-carbon-emitting nuclear power, in part to stem the growth of greenhouse gas emissions. The *IEO2008* reference case projection for electricity generation from nuclear power in 2030 is almost 4 percent higher than the *IEO2007* projection, which in turn is 10 percent higher than the *IEO2006* projection. The changes reflect a generally more favorable

[20]Turkey is an Annex I country that has not ratified the Framework Convention on Climate Change and did not commit to quantifiable emissions targets under the Kyoto Protocol.

[21]For a modeling analysis of the effects of the Kyoto Protocol, see Energy Information Administration, *International Energy Outlook 2006*, DOE/EIA-0484(2006) (Washington, DC, June 2006), "Kyoto Protocol Case," pp. 75-79, web site www.eia.doe.gov/oiaf/ieo.

perception of nuclear power as an alternative to carbon-producing fossil fuels for electricity generation.

Reference Case

Carbon Dioxide Emissions

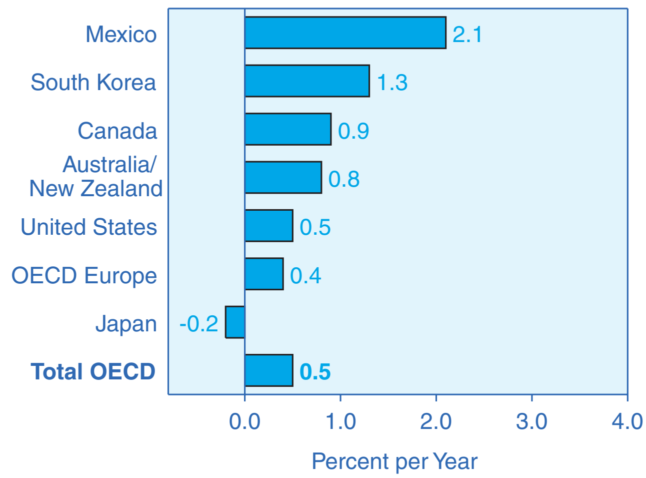
In the *IEO2008* reference case, world energy-related carbon dioxide emissions are projected to grow by an average of 1.7 percent per year from 2005 to 2030 (Table 12). For the OECD, annual increases in carbon dioxide emissions are projected to average 0.5 percent, from 13.6 billion metric tons in 2005 to 14.4 billion metric tons in 2015 and 15.5 billion metric tons in 2030.

The highest rate of increase in annual emissions of carbon dioxide among the OECD countries is projected for Mexico, at 2.1 percent per year (Figure 77). Mexico is projected to have the highest GDP growth rate among the OECD countries, and much of its growth is expected to come from energy-intensive industries. For all the other OECD countries, annual increases in carbon dioxide emissions are projected to average less than 1.5 percent. South Korea, which still is industrializing, is the only OECD country other than Mexico for which the average is projected to be greater than 1 percent. Japan's emissions are projected to *decrease* by an average of 0.2 percent per year from 2005 to 2030, and for OECD Europe an average annual increase of 0.4 percent per year is projected.

Although the United States has not ratified binding emissions constraints, recent changes in U.S. environmental laws and regulations (in addition to other factors) have lowered the projections for carbon dioxide emissions relative to earlier estimates.[22] In the *IEO2007* reference case, U.S. emissions were projected to grow by an average of 1.1 percent per year from 2005 to 2030. In the *IEO2008* reference case, in contrast, the projected annual growth rate is 0.5 percent over the same period, leading to a 14-percent lower projection for energy-related carbon dioxide emissions in 2030 in *IEO2008* compared with *IEO2007* (Figure 78).

For the non-OECD countries, total carbon dioxide emissions are projected to average 2.5-percent annual growth

Figure 77. Average Annual Growth in Energy-Related Carbon Dioxide Emissions in the OECD Economies, 2005-2030



Sources: **2005:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **2030:** EIA, World Energy Projections Plus (2008).

Table 12. World Energy-Related Carbon Dioxide Emissions by Region, 1990-2030
(Billion Metric Tons)

Region	History		Projections					Average Annual Percent Change	
	1990	2005	2010	2015	2020	2025	2030	1990-2005	2005-2030
OECD	**11.4**	**13.6**	**13.8**	**14.4**	**14.7**	**15.1**	**15.5**	**1.2%**	**0.5%**
North America	5.8	7.0	7.1	7.4	7.7	7.9	8.3	1.3%	0.7%
Europe	4.1	4.4	4.5	4.7	4.8	4.8	4.8	0.4%	0.4%
Asia	1.5	2.2	2.2	2.3	2.3	2.4	2.4	2.3%	0.4%
Non-OECD	**9.8**	**14.5**	**17.3**	**20.0**	**22.3**	**24.5**	**26.8**	**2.6%**	**2.5%**
Europe and Eurasia	4.2	2.9	3.1	3.3	3.5	3.6	3.8	-2.5%	1.1%
Asia	3.6	8.2	10.2	12.2	13.9	15.7	17.5	5.6%	3.1%
Middle East	0.7	1.4	1.6	1.8	2.0	2.1	2.3	4.7%	1.9%
Africa	0.6	1.0	1.1	1.2	1.4	1.4	1.5	2.7%	1.8%
Central and South America	0.7	1.1	1.3	1.4	1.5	1.6	1.7	3.2%	1.9%
Total World	**21.2**	**28.1**	**31.1**	**34.3**	**37.0**	**39.6**	**42.3**	**1.9%**	**1.7%**

Sources: **1990 and 2005:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **2010-2030:** EIA, World Energy Projections Plus (2008).

[22] For example, the Energy Independence and Security Act of 2007, which was signed into law in December 2007 (Public Law 110-140), includes a number of provisions aimed at reducing greenhouse gas emissions. Other factors that contribute to the lower projections for carbon dioxide emissions include higher energy prices and lower projected economic growth rates in comparison with previous outlooks.

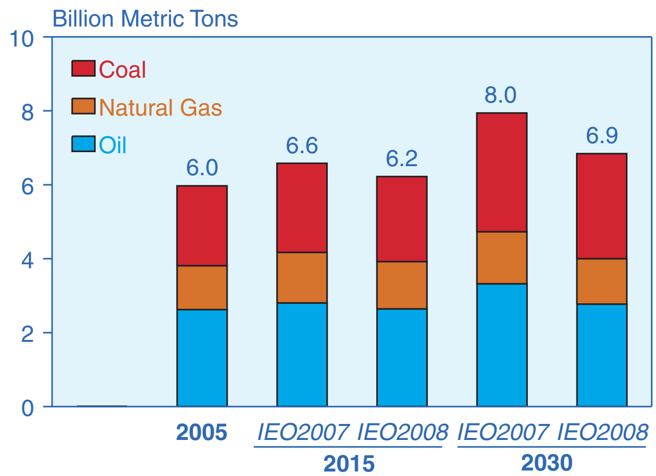
(Figure 79). The highest growth rate among the non-OECD countries is projected for China, at 3.3 percent annually from 2005 to 2030, reflecting the country's continued heavy reliance on fossil fuels, especially coal, over the projection period. China's energy-related emissions of carbon dioxide are projected to exceed U.S. emissions by almost 15 percent in 2010 and by 75 percent in 2030. The lowest growth rate among the non-OECD countries is projected for Russia, at 0.9 percent per year. Over the projection period, Russia is expected to expand its reliance on indigenous natural gas resources and nuclear power to fuel electricity generation, and a decline in its population is expected to slow the overall rate of increase in energy demand.

By fuel, world carbon dioxide emissions from the consumption of liquid fuels and other petroleum are projected to grow at an average annual rate of 1.2 percent from 2005 to 2030. The average growth rates for the OECD and non-OECD countries are projected to be 0.3 percent and 2.2 percent per year, respectively (Figure 80). The highest rate of growth in petroleum-related carbon dioxide emissions is projected for China, at 3.5 percent per year, as its demand for liquid fuels increases to meet growing demand in the transportation and industrial sectors. The United States is expected to remain the largest source of petroleum-related carbon dioxide emissions throughout the period, with projected emissions of 2.8 billion metric tons in 2030—still 34 percent above the corresponding projection for China.

Carbon dioxide emissions from natural gas combustion worldwide are projected to increase on average by 1.7 percent per year, to 8.7 billion metric tons in 2030, with the OECD countries averaging 1.0 percent and the non-OECD countries 2.4 percent (Figure 81). Again, China is projected to have the most rapid growth in emissions, averaging 5.5 percent annually; however, China's emissions from natural gas combustion amounted to only 0.1 billion metric tons in 2005, and in 2030 they are projected to total only 0.4 billion metric tons, or less than 5 percent of the world total. The growth in U.S. emissions from natural gas use is projected to average 0.1 percent per year, but the projected level of 1.2 billion metric tons in 2030 is triple the projection for China.

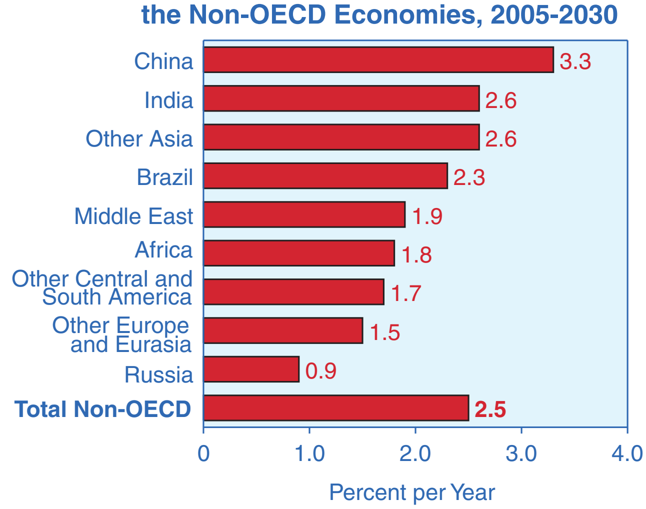
Total carbon dioxide emissions from the combustion of coal throughout the world are projected to increase by 2.0 percent per year on average, from 11.4 billion metric tons in 2005 to 18.8 billion metric tons in 2030. Total coal-related emissions from the non-OECD countries have been greater than those from the OECD countries since 1987, and in 2030 they are projected to be more than 2.5 times the OECD total (Figure 82), in large part because of the increase in coal use projected for China and India. Together, China and India account for 79 percent of the projected increase in the world's coal-related carbon dioxide emissions from 2005 to 2030. For China alone, coal-related emissions are projected to grow by an average of 3.2 percent annually, from 4.3 billion metric tons in 2005 to 9.6 billion metric tons (51 percent of the world total) in 2030. India's carbon dioxide emissions from coal combustion are projected to total 1.4 billion metric tons in 2030, accounting for more than 7 percent of the world total.

Figure 78. U.S. Energy-Related Carbon Dioxide Emissions in *IEO2007* and *IEO2008*, 2005-2030



Sources: Energy Information Administration, *Annual Energy Outlook 2007*, DOE/EIA-0383(2007) (Washington, DC, January 2007), and *Annual Energy Outlook 2008*, DOE/EIA-0383(2008) (Washington, DC, April 2008).

Figure 79. Average Annual Growth in Energy-Related Carbon Dioxide Emissions in the Non-OECD Economies, 2005-2030



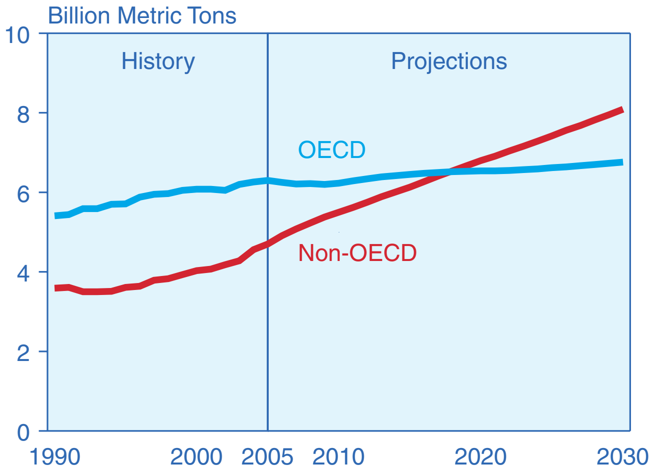
Sources: **2005:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **2030:** EIA, World Energy Projections Plus (2008).

Carbon Dioxide Intensity Measures

Emissions per Dollar of GDP

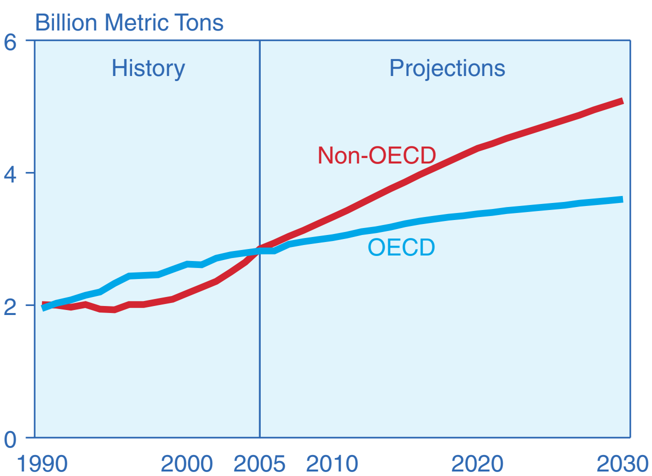
In all countries and regions, energy-related carbon dioxide intensities—expressed in emissions per unit of economic output—are projected to improve (decline) over the projection period as all world economies continue to use energy more efficiently. In 2005, estimated carbon dioxide intensities were 461 metric tons per million dollars of GDP in the OECD countries and 529 metric tons in the non-OECD countries (Table 13).[23]

Figure 80. World Carbon Dioxide Emissions from Liquids Combustion, 1990-2030



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2008).

Figure 81. World Carbon Dioxide Emissions from Natural Gas Combustion, 1990-2030

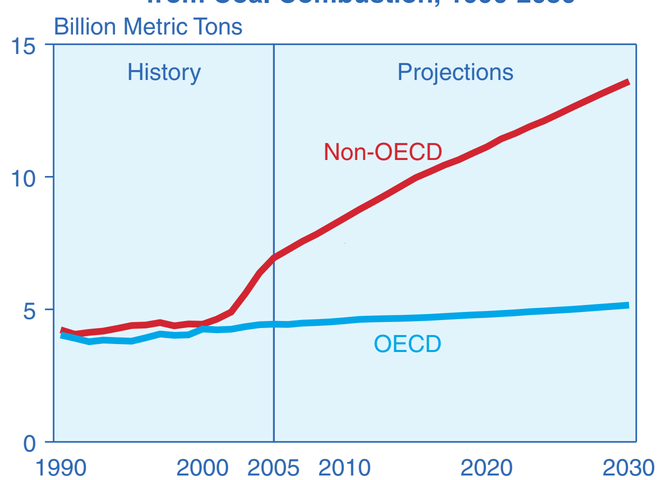


Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2008).

Fossil fuel use in the non-OECD countries is projected to increase strongly over the projection period; however, their economic growth is expected to be even stronger. As a result, non-OECD carbon dioxide intensity is projected to decline by an average of 2.6 percent per year, from 529 metric tons per million dollars of GDP in 2005 to 274 metric tons per million dollars of GDP in 2030. In particular, China, with a relatively high projected rate of growth in emissions (3.3 percent per year), has an even higher projected growth rate for GDP (6.4 percent). As a result, its emissions intensity falls from 693 metric tons per million dollars in 2005 to 334 metric tons in 2030.

For all the OECD countries, average carbon dioxide intensity in 2030 is projected to be 296 metric tons per million dollars. OECD Europe is projected to have the lowest carbon dioxide intensity among the OECD economies in 2030, at 241 metric tons per million dollars, followed by Mexico at 247 metric tons and Japan at 262 metric tons. (Mexico's relatively low carbon dioxide intensity results in large part from its projected 3.9-percent annual GDP growth rate, the highest among the OECD countries.) Without carbon dioxide constraints, Canada is projected to have the highest carbon dioxide intensity of the OECD countries in 2030, at 422 metric tons per million dollars, followed by South Korea at 396 metric tons and Australia/New Zealand at 365 metric tons. U.S. carbon dioxide intensity in 2030 is projected to be 339 metric tons per million dollars of GDP. The average for the entire world is projected to fall from 494 metric tons per million dollars of GDP in 2005 to 282 metric tons in 2030.

Figure 82. World Carbon Dioxide Emissions from Coal Combustion, 1990-2030



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2008).

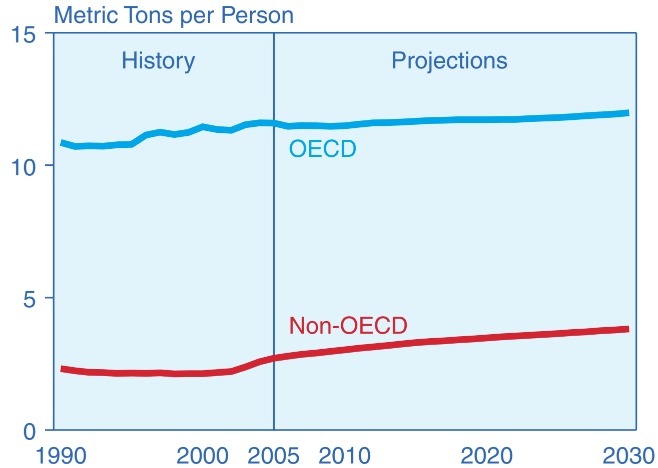
[23]GDP is measured in chain-weighted 2000 dollars converted to the currency of the relevant country or region, based on purchasing power parity.

Emissions per Capita

Another measure of carbon dioxide intensity is emissions per person. Carbon dioxide emissions per capita in the OECD economies are significantly higher (about fourfold in 2005) than in the non-OECD economies (Figure 83). If non-OECD countries consumed as much energy per capita as the OECD countries, the projection for world carbon dioxide emissions in 2030 would be much larger, because the non-OECD countries would consume almost four times more energy than the current reference case estimate of 409 quadrillion Btu. Further, given the expectation that non-OECD countries will rely heavily on fossil fuels to meet their energy needs, the increase in carbon dioxide emissions would be even greater.

Among the non-OECD countries, Russia has the highest projected increase in carbon dioxide emissions per capita in the *IEO2008* reference case, from 12 metric tons per person in 2005 to 17 metric tons in 2030 (Figure 84 and Table 14). A projected decline in Russia's population, averaging 0.6 percent per year from 2005 to 2030,

Figure 83. World Carbon Dioxide Emissions per Capita, 1990-2030



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2008).

Table 13. Carbon Dioxide Intensity by Region and Country, 1980-2030
(Metric Tons per Million 2000 U.S. Dollars of Gross Domestic Product)

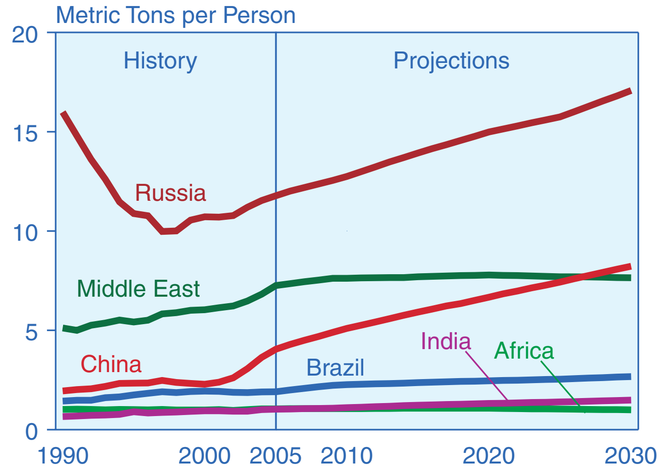
Region	History			Projections					Average Annual Percent Change	
	1980	1990	2005	2010	2015	2020	2025	2030	1990-2005	2005-2030
OECD	**732**	**565**	**461**	**411**	**379**	**347**	**319**	**296**	**-1.3%**	**-1.8%**
United States	916	701	544	483	439	399	366	339	-1.7%	-1.9%
Canada	867	679	607	563	521	486	453	422	-0.7%	-1.4%
Mexico	394	441	381	337	312	288	266	247	-1.0%	-1.7%
Europe	674	508	383	343	318	290	264	241	-1.9%	-1.8%
Japan	482	353	358	316	297	284	273	262	0.1%	-1.2%
South Korea	942	729	670	580	521	464	424	396	-0.6%	-2.1%
Australia/New Zealand	694	679	633	558	500	449	404	365	-0.5%	-2.2%
Non-OECD	**694**	**711**	**529**	**440**	**388**	**344**	**306**	**274**	**-2.0%**	**-2.6%**
Europe/Eurasia	1,019	1,166	804	615	531	469	410	368	-2.4%	-3.1%
Russia	900	1,060	836	649	554	494	432	392	-1.6%	-3.0%
Other	1,215	1,339	762	573	504	440	385	342	-3.7%	-3.2%
Asia	755	624	498	411	363	322	289	261	-1.5%	-2.5%
China	1,959	1,242	693	552	478	421	373	334	-3.8%	-2.9%
India	295	333	287	221	189	165	148	135	-1.0%	-3.0%
Other	400	352	360	313	299	270	246	224	0.1%	-1.9%
Middle East	450	854	903	827	747	679	605	539	0.4%	-2.0%
Africa	398	448	421	362	327	292	255	220	-0.4%	-2.6%
Central and South America	317	310	305	290	262	234	209	187	-0.1%	-1.9%
Brazil	212	211	219	224	208	192	175	162	0.2%	-1.2%
Other	403	398	379	342	303	267	234	205	-0.3%	-2.4%
Total World	**716**	**624**	**494**	**427**	**384**	**345**	**311**	**282**	**-1.6%**	**-2.2%**

Note: GDP is expressed in terms of purchasing power parity.
Sources: **1980-2005:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **2010-2030:** EIA, World Energy Projections Plus (2008).

slows the growth in its total carbon dioxide emissions to an average annual rate of 0.9 percent, but the population decline leads to a higher rate of increase in emissions per capita. The lowest levels of per capita emissions in the world are in India and Africa. For India, emissions per capita are projected to increase by about 50 percent, from 1.0 metric tons per person in 2005 to 1.5 in 2030. For Africa, emissions per capita are projected to remain at about 1 metric ton per person through 2030.

The OECD countries have higher levels of carbon dioxide emissions per capita, in part because of their higher levels of income and fossil fuel use per capita. In the United States, emissions per capita are projected to fall slightly, from 20 metric tons per person in 2005 to 19 metric tons in 2030 (Figure 85). Canada's emissions per capita are projected to rise slightly, from 19 metric tons per person in 2005 to 20 metric tons in 2030, in the absence of binding constraints on carbon dioxide emissions. In Mexico, with the lowest level of per capita emissions among the OECD countries, an increase from 4 metric tons in 2005 to 5 metric tons in 2030 is projected.

Figure 84. Non-OECD Carbon Dioxide Emissions per Capita by Country and Region, 1990-2030



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2008).

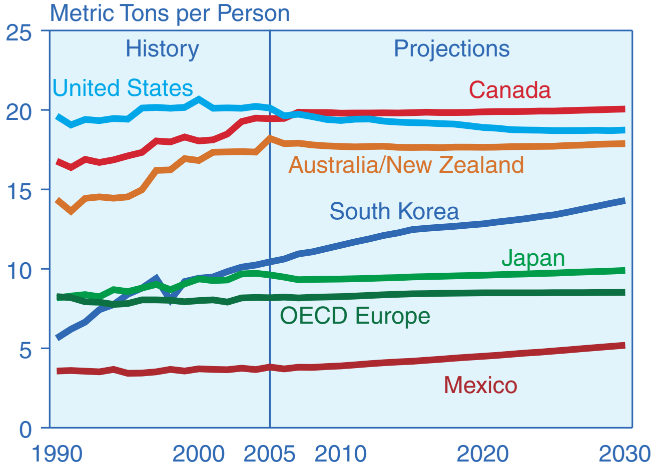
Table 14. Energy-Related Carbon Dioxide Emissions per Capita, 1980-2030
(Metric Tons per Person)

Region	History			Projections					Average Annual Percent Change	
	1980	1990	2005	2010	2015	2020	2025	2030	1990-2005	2005-2030
OECD	**11.3**	**10.9**	**11.6**	**11.5**	**11.7**	**11.7**	**11.8**	**12.0**	**0.4**	**0.1**
United States	20.6	19.6	20.1	19.3	19.2	18.9	18.7	18.7	0.2	-0.3
Canada	18.3	16.8	19.5	19.8	19.8	19.9	19.9	20.1	1.0	0.1
Mexico	3.2	3.6	3.8	3.9	4.2	4.5	4.8	5.2	0.4	1.2
Europe	9.1	8.3	8.2	8.3	8.4	8.5	8.5	8.5	-0.1	0.2
Japan	8.0	8.2	9.6	9.4	9.5	9.6	9.7	9.9	1.1	0.1
South Korea	3.5	5.6	10.4	11.5	12.5	12.8	13.4	14.3	4.2	1.3
Australia/New Zealand	12.3	14.4	18.2	17.7	17.6	17.6	17.7	17.9	1.6	-0.1
Non-OECD	**2.0**	**2.3**	**2.7**	**3.0**	**3.3**	**3.5**	**3.6**	**3.8**	**1.1**	**1.4**
Europe/Eurasia	10.6	12.1	8.4	9.0	9.9	10.5	11.0	11.8	-2.4	1.4
Russia	13.5	16.0	11.8	12.7	13.9	15.0	15.8	17.1	-2.0	1.5
Other	8.4	9.1	5.9	6.4	7.1	7.6	8.0	8.5	-2.9	1.5
Asia	1.0	1.3	2.4	2.8	3.2	3.5	3.8	4.1	4.1	2.2
China	1.5	2.0	4.1	5.1	5.9	6.7	7.4	8.2	5.0	2.9
India	0.4	0.7	1.0	1.1	1.2	1.3	1.4	1.5	3.0	1.5
Other	0.8	1.1	1.7	1.8	2.1	2.2	2.3	2.4	3.2	1.4
Middle East	3.9	5.1	7.3	7.6	7.7	7.8	7.7	7.7	2.4	0.2
Africa	1.0	1.0	1.0	1.1	1.1	1.1	1.0	1.0	0.2	-0.2
Central and South America	2.1	1.9	2.4	2.7	2.8	2.8	2.9	3.0	1.7	0.9
Brazil	1.5	1.4	1.9	2.3	2.4	2.5	2.5	2.7	1.9	1.4
Other	2.5	2.2	2.7	3.0	3.1	3.1	3.1	3.1	1.5	0.6
Total World	**4.1**	**4.0**	**4.3**	**4.5**	**4.7**	**4.8**	**4.9**	**5.1**	**0.5**	**0.7**

Sources: **1980-2005:** Derived from Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **2010-2030:** EIA, World Energy Projections Plus (2008).

Other factors that can affect carbon dioxide emissions per capita include climate (in general, more energy is used per capita for heating in colder climates than is used for cooling in warmer climates) and population density (densely populated countries use less energy per capita for transportation). For example, Canada has a relatively cold climate with a low population density, and its carbon dioxide emissions in 2005 are estimated at 19.5 metric tons per capita, whereas Japan has a more temperate climate and a much higher population density, and its emissions in 2005 are estimated at 9.6 metric tons per capita—about half the rate for Canada.

Figure 85. OECD Carbon Dioxide Emissions per Capita by Country and Region, 1990-2030



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2008).

Alternative Macroeconomic Growth Cases

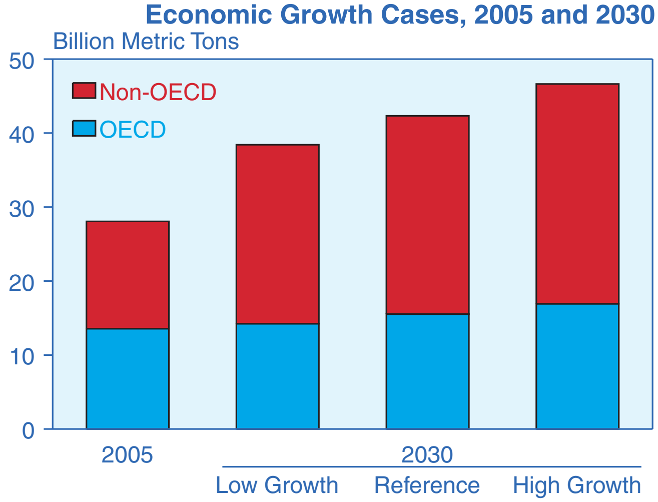
Economic growth is the most significant factor underlying the projections for growth in energy-related carbon dioxide emissions in the mid-term, as the world continues to rely on fossil fuels for most of its energy use. Accordingly, projections of world carbon dioxide emissions are lower in the *IEO2008* low economic growth case and higher in the high economic growth case.

In the high growth case, world carbon dioxide emissions are projected to increase at an average rate of 2.1 percent annually from 2005 to 2030, as compared with 1.7 percent in the reference case. For the OECD countries, the projected average increase is 0.9 percent per year; for the non-OECD countries, the average is 2.9 percent per year. In the low growth case, world carbon dioxide emissions are projected to increase by 1.3 percent per year, with averages of 0.2 percent per year in the OECD countries and 2.1 percent per year in the non-OECD countries (compared with 0.5 percent and 2.5 percent, respectively, in the reference case). Total emissions worldwide are projected to be 38.4 billion metric tons in 2030 in the low growth case and 46.6 billion metric tons in the high growth case—21 percent higher than projected in the low growth case (Figure 86). The projections for emissions by fuel show similar variations across the cases.

Alternative Price Cases

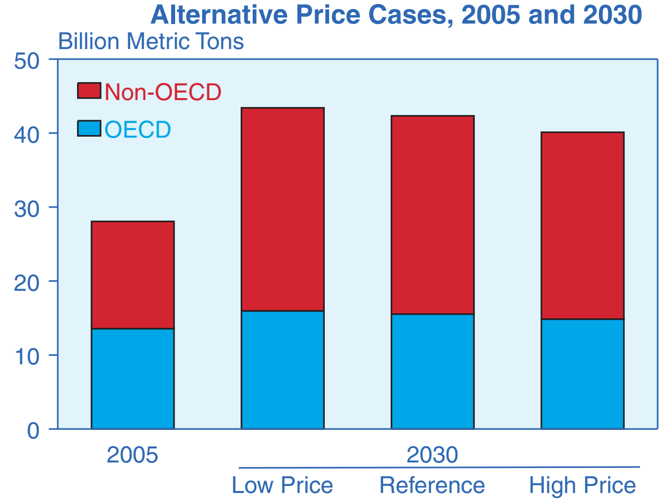
The projections for carbon dioxide emissions in the *IEO2008* low and high price cases (Figure 87) show smaller variations from the reference case than do those in the alternative macroeconomic growth cases. In 2030,

Figure 86. Carbon Dioxide Emissions in Three Economic Growth Cases, 2005 and 2030



Sources: **2005:** Energy Information Administration, *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **2030:** Energy Information Administration, World Energy Projections Plus (2008).

Figure 87. Carbon Dioxide Emissions in Three Alternative Price Cases, 2005 and 2030



Sources: **2005:** Energy Information Administration, *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **2030:** Energy Information Administration, World Energy Projections Plus (2008).

as compared with the reference case projection (42.3 billion metric tons), total carbon dioxide emissions are projected to be higher in the low price case (43.4 billion metric tons) and lower in the high price case (40.1 billion metric tons). Thus, there is an 8-percent difference between the projections in the two alternative world oil price cases, as compared with a 21-percent difference between the alternative macroeconomic growth cases.

In the alternative price cases, world oil and natural gas prices are affected more strongly than coal prices. As a result (and in the absence of policies to limit the use of coal), in the high price case both liquids and natural gas lose global market share to coal relative to the reference case projection. In the *IEO2008* reference case, coal's share of total energy use is projected to increase to 29 percent in 2030; in the high price case, its share increases to 30 percent; and in the low price case, its share drops to 27 percent in 2030.

Prices have the greatest impact on world liquids consumption and the associated carbon dioxide emissions. In the high price case, where nominal world oil prices reach $186 per barrel in 2030, nations choose alternative fuels over liquids wherever possible, so that liquids-related emissions total 13.1 billion metric tons in 2030, down from 14.9 billion metric tons in the reference case. In the low price case, world oil prices decline to $69 per barrel in 2030, substantially lower than the $113 per barrel projected in the reference case and providing little economic incentive for nations to turn to other forms of energy. Consequently, liquids-related emissions in 2030 in the low price case, at 16.2 billion metric tons, are 1.3 billion metric tons higher than projected in the reference case.

The impact of high prices on natural gas use is smaller than the impact on liquids consumption, but a similar trend away from natural gas to other fuels, particularly coal, is projected. In the high price case, world carbon dioxide emissions from natural gas combustion in 2030 total 8.3 billion metric tons, down from 8.7 billion metric tons in the reference case. In the low price case, natural-gas-related emissions in 2030 are projected to total 9.2 billion metric tons.