# Chapter 8
# Energy-Related Carbon Dioxide Emissions

***In 2006, non-OECD energy-related emissions of carbon dioxide exceeded OECD emissions by 14 percent. In 2030, energy-related carbon dioxide emissions from the non-OECD countries are projected to exceed those from the OECD countries by 77 percent.***

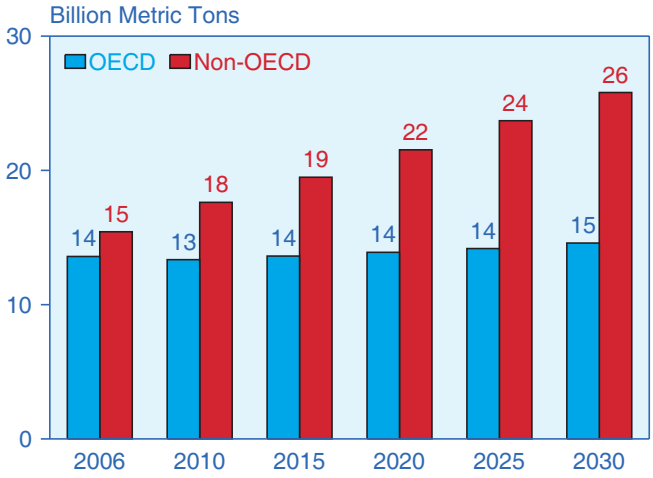
Because anthropogenic emissions of carbon dioxide result primarily from the combustion of fossil fuels, world energy use continues to be at the center of the climate change debate. In the *IEO2009* reference case, world energy-related carbon dioxide emissions grow from 29.0 billion metric tons in 2006 to 33.1 billion metric tons in 2015 and 40.4 billion metric tons in 2030.[44]

From 2005 to 2006, total energy-related carbon dioxide emissions from the non-OECD countries grew by 5.2 percent, while emissions from the OECD countries declined by 0.3 percent. The decline in OECD countries' carbon dioxide emissions is projected to continue through 2010, as fossil fuel demand contracts, in part because of the current global recession. Consequently, annual emissions from the non-OECD countries exceed those from the OECD countries by more than 30 percent in 2010 (Figure 80). Over the 24-year projection period, the average annual increase in non-OECD emissions from 2006 to 2030 (2.2 percent) is seven times the rate projected for the OECD countries (0.3 percent). In 2030, non-OECD emissions (25.8 billion metric tons) exceed OECD emissions (14.6 billion metric tons) by 77 percent.

The *IEO2009* reference case projections are, to the extent possible, based on existing laws and policies. Projections for carbon dioxide emissions may change significantly if existing laws and policies aimed at reducing greenhouse gas emissions are changed or new ones are introduced. In addition, beyond carbon dioxide there are other gases and sources that contribute to greenhouse gas emissions. The other gases and sources may be addressed in existing legislation and international treaties, but their reductions would not be reflected either in EIA's historical data or in the projections in this report.

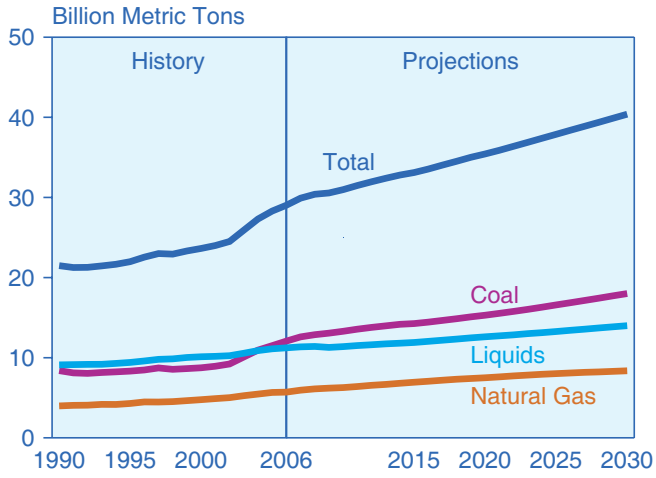
The relative contributions of different fossil fuels to total energy-related carbon dioxide emissions have changed over time. In 1990, emissions from the combustion of liquid fuels made up an estimated 42 percent of the world total; in 2006 their share was 39 percent; and in 2030 it is projected to be 35 percent (Figure 81). Carbon dioxide emissions from natural gas combustion, which accounted for 19 percent of the total in 1990, increased to 20 percent of the 2006 total, and their share is projected to stabilize at between 20 and 21 percent from 2006 to 2030.

**Figure 80. World Energy-Related Carbon Dioxide Emissions, 2006-2030**




Sources: **2006:** Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2009).

**Figure 81. World Energy-Related Carbon Dioxide Emissions by Fuel Type, 1990-2030**




Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2009).

[44] In keeping with current international practice, *IEO2009* 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.

Coal's share of world carbon dioxide emissions grew from 39 percent in 1990 to 42 percent in 2006 and is projected to increase to 45 percent in 2030. Coal is the most carbon-intensive of the fossil fuels, and it is the fastest-growing carbon-emitting energy source in the *IEO2009* 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 2006 their combined share had risen to 25 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 29 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."[45] Although 174 countries and the European Commission have ratified the Kyoto Protocol, 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 of those countries is subject to emissions limits under the terms of the treaty. Table 14 compares carbon dioxide emissions in selected Annex I countries or regions in 1990 and 2006 and their projected reference case values in 2010, 2020, and 2030.

Many of the Kyoto goals are being addressed by "Kyoto mechanisms," such as reforestation, which are not reflected in EIA's projections of energy-related carbon dioxide emissions. Additionally, some greenhouse gases other than carbon dioxide often are the least expensive to reduce (for example, by capturing fugitive emissions of methane). Those reductions may account for a larger proportion of some countries' Kyoto goals than would their carbon dioxide emissions reductions.

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 demonstrate an interest in expanding their use of non-carbon-emitting renewable energy and nuclear power, in part to stem the growth of greenhouse gas emissions. The *IEO2009* reference case projection for energy from hydropower and other renewable energy sources in 2030 is 26 percent higher than the projection in *IEO2008*, which in turn was 10 percent higher than the *IEO2007* projection. Similarly, the *IEO2009* projection for world electricity generation from nuclear power is up by 2 percent from the *IEO2008* projection, which was 4 percent higher than the corresponding projection in *IEO2007*.

## Reference Case

### Carbon Dioxide Emissions

In the *IEO2009* reference case, world energy-related carbon dioxide emissions increase by an average of 1.4 percent per year from 2006 to 2030 (Table 15). For the OECD, annual increases in carbon dioxide emissions are projected to average 0.3 percent over the 24-year period. The annual increases are not uniform, however. OECD carbon dioxide emissions in the reference case decline from 13.6 billion metric tons in 2006 to 13.4 billion metric tons in 2010 and return to 13.6 billion metric tons in 2015 (essentially no increase in OECD emissions over the decade), then increase to 14.6 billion metric tons in 2030.

Projected emissions growth for the OECD countries over the 2006-2030 period is much lower than was the case for

**Table 14. World Energy-Related Carbon Dioxide Emissions in Selected Annex I Areas, 1990, 2006, and 2010**
(Billion Metric Tons)

| | Australia/ New Zealand | Canada | United States | Japan | OECD Europe | Total |
|---|---|---|---|---|---|---|
| **History** | | | | | | |
| 1990 . . . . . | 0.3 | 0.5 | 5.0 | 1.1 | 4.1 | **11.0** |
| 2006 . . . . . | 0.5 | 0.6 | 5.9 | 1.2 | 4.4 | **12.6** |
| **Projections** | | | | | | |
| 2010 . . . . . | 0.5 | 0.6 | 5.8 | 1.2 | 4.3 | **12.4** |
| 2020 . . . . . | 0.5 | 0.7 | 6.0 | 1.2 | 4.4 | **12.8** |
| 2030 . . . . . | 0.5 | 0.7 | 6.4 | 1.2 | 4.5 | **13.4** |

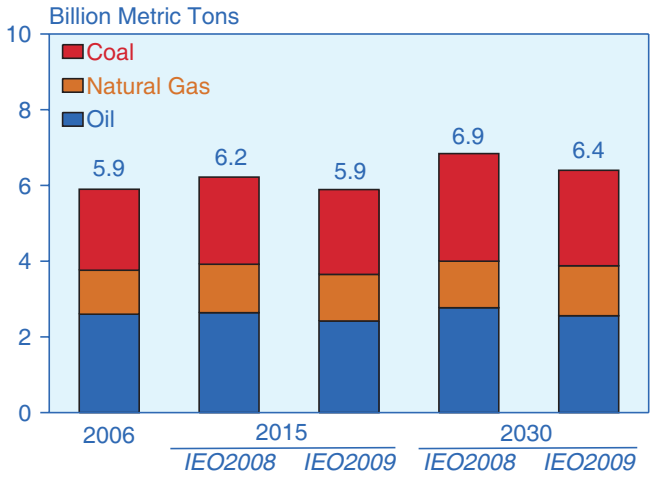
Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2009).

[45] 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.

the 1990-2006 historical period. In addition, although the United States has not yet accepted internationally binding emissions constraints, recent changes in U.S. laws and regulations (as well as broader price and economic developments and observed behavior) have lowered the projections for U.S. carbon dioxide emissions relative to earlier estimates.[46]

In the *IEO2008* reference case, the projection for U.S. emissions growth was 0.5 percent per year from 2005 to 2030. In the *IEO2009* reference case, U.S. energy-related carbon dioxide emissions are projected to grow at an average annual rate of 0.3 percent from 2006 to 2030.[47] As a result, the projection for U.S. emissions in 2030 is 20 percent lower in *IEO2009* than it was in *IEO2007* (Figure 82). Moreover, a recent Presidential Memorandum that directs the U.S. Environmental Protection Agency to reassess California's request for a waiver under the Clean Air Act that would allowing the State to place stricter standards on greenhouse gas emissions from vehicles could have an additional impact on U.S. emissions growth.[48]

**Figure 82. U.S. Energy-Related Carbon Dioxide Emissions by Fuel in *IEO2008* and *IEO2009*, 2006, 2015, and 2030**




Sources: Energy Information Administration, *Annual Energy Outlook 2007*, DOE/EIA-0383(2007) (Washington, DC, February 2007), *Annual Energy Outlook 2008*, DOE/EIA-0383 (2008) (Washington, DC, January 2008), and *Annual Energy Outlook 2009*, DOE/EIA-0383(2009) (Washington, DC, March 2009).

**Table 15. World Energy-Related Carbon Dioxide Emissions by Region, 1990-2030**
(Billion Metric Tons)

| Region | History | | Projections | | | | | Average Annual Percent Change | |
|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2006 | 2010 | 2015 | 2020 | 2025 | 2030 | 1990-2006 | 2006-2030 |
| **OECD** | **11.5** | **13.6** | **13.4** | **13.6** | **13.9** | **14.2** | **14.6** | **1.0%** | **0.3%** |
| North America | 5.8 | 6.9 | 6.8 | 7.0 | 7.1 | 7.3 | 7.7 | 1.2% | 0.4% |
| Europe | 4.1 | 4.4 | 4.3 | 4.4 | 4.5 | 4.5 | 4.5 | 0.4% | 0.1% |
| Asia | 1.6 | 2.2 | 2.2 | 2.3 | 2.3 | 2.3 | 2.4 | 2.1% | 0.3% |
| **Non-OECD** | **10.0** | **15.4** | **17.6** | **19.5** | **21.5** | **23.7** | **25.8** | **2.8%** | **2.2%** |
| Europe and Eurasia | 4.2 | 2.9 | 3.1 | 3.2 | 3.3 | 3.4 | 3.4 | -2.4% | 0.7% |
| Asia | 3.7 | 9.0 | 10.5 | 11.9 | 13.6 | 15.4 | 17.0 | 5.7% | 2.7% |
| Middle East | 0.7 | 1.5 | 1.7 | 1.8 | 1.9 | 2.1 | 2.3 | 4.6% | 1.9% |
| Africa | 0.7 | 1.0 | 1.1 | 1.2 | 1.2 | 1.3 | 1.4 | 2.5% | 1.5% |
| Central and South America | 0.7 | 1.1 | 1.3 | 1.4 | 1.4 | 1.5 | 1.7 | 3.0% | 1.6% |
| **Total World** | **21.5** | **29.0** | **31.0** | **33.1** | **35.4** | **37.9** | **40.4** | **1.9%** | **1.4%** |

Sources: **1990 and 2006:** Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **2010-2030:** EIA, World Energy Projections Plus (2009).

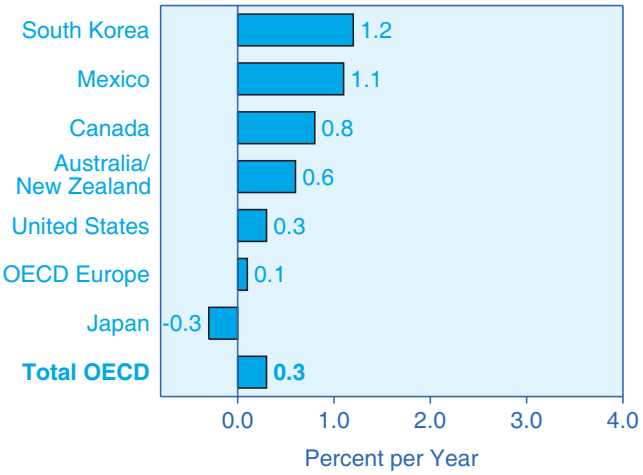
[46] For example, the Energy Independence and Security Act of 2007, which was signed into law in December 2007 (Public Law 110-140), includes a number of provisions aimed at reducing greenhouse gas emissions. Other factors that contribute to the lower projections for carbon dioxide emissions include lower projected economic growth rates in comparison with previous outlooks. In addition, ARRA2009 includes a number of provisions designed to increase energy efficiency and renewable electricity generation, which will also reduce greenhouse gas emissions in the United States, and the impact of these provisions can be seen in the *updated AEO2009* reference case (April 2009).

[47] In the the *updated AEO2009* reference case (April 2009), U.S. carbon dioxide emissions increase by 0.2 percent per year from 2006 to 2030, and the projection for U.S. energy-related carbon dioxide emissions in 2030 is 3.0 percent lower than in the *published AEO2009* reference case (March 2009). The lower projections result largely from the impacts of ARRA2009 on renewable electricity generation and overall energy consumption, including energy efficiency gains and renewable incentives that lead to reduced use of fossil fuels.

[48] The Presidential Memorandum of January 26, 2009, on the State of California Request for Waiver Under 42 U.S.C. 7543(b), the Clean Air Act, and addressed to the Administrator of the U.S. Environmental Protection Agency (EPA) states: "In order to ensure that the EPA carries out its responsibilities for improving air quality, you are hereby requested to assess whether the EPA's decision to deny a waiver based on California's application was appropriate in light of the Clean Air Act. I further request that, based on that assessment, the EPA initiate any appropriate action."

The highest rate of increase in annual emissions of carbon dioxide among the OECD countries is projected for South Korea, at 1.2 percent per year (Figure 83). Mexico (1.1 percent per year), which is also still industrializing, is the only OECD country other than South Korea for which the average growth is projected to exceed 1 percent per year. The GDP growth rates projected for South Korea and Mexico in *IEO2009* are about the same, at 3.3 percent and 3.4 percent, respectively. Japan's emissions are projected to *decrease* by an average of 0.3 percent per year from 2006 to 2030, and OECD Europe's energy-related carbon emissions are projected to grow only slightly (by 0.1 percent per year).

**Figure 83. Average Annual Growth in Energy-Related Carbon Dioxide Emissions in the OECD Economies, 2006-2030**

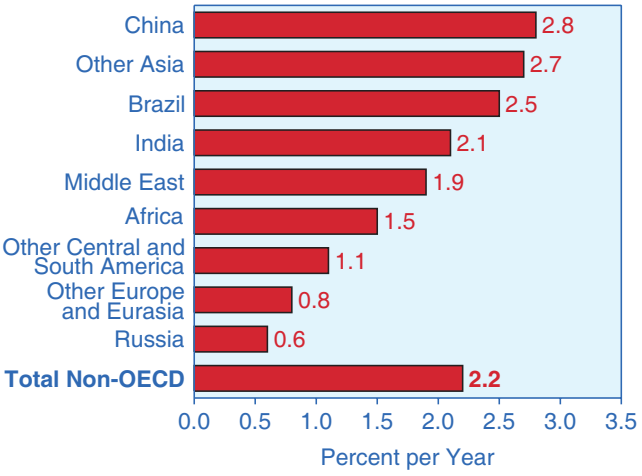



Sources: **2006:** Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **2030:** EIA, World Energy Projections Plus (2009).

For the non-OECD countries, total energy-related carbon dioxide emissions are projected to average 2.2-percent annual growth (Figure 84). The highest growth rate among the non-OECD countries is projected for China, at 2.8 percent annually from 2006 to 2030, reflecting the country's continued heavy reliance on fossil fuels, especially coal, in the projection. The lowest growth rate among the non-OECD countries is projected for Russia, at 0.6 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 its overall rate of increase in energy demand.

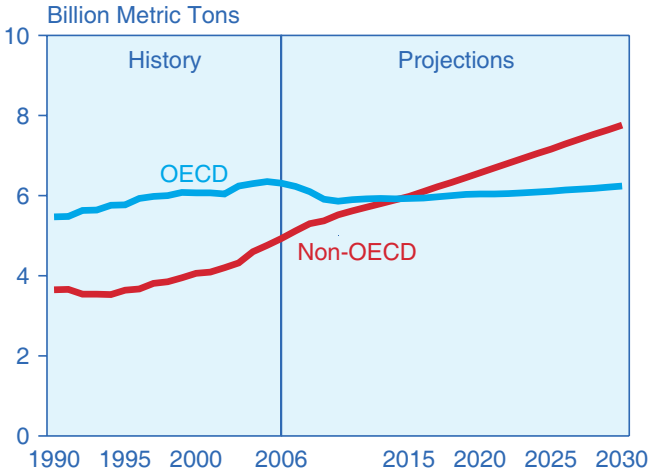
By fuel, world carbon dioxide emissions from the consumption of liquid fuels are projected to grow at an average annual rate of 0.9 percent from 2006 to 2030. All the growth in carbon dioxide emissions is projected to come from non-OECD countries, as total emissions from the OECD countries decline in the early years of the projection period and return only to 2006 levels in 2030 (Figure 85). The highest rate of growth in petroleum-related carbon dioxide emissions is projected for China, at 3.2 percent per year, as its demand for liquid fuels increases to meet growing demand in its 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 2.6 billion metric tons in 2030.

**Figure 84. Average Annual Growth in Energy-Related Carbon Dioxide Emissions in the Non-OECD Economies, 2006-2030**




Sources: **2006:** Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **2030:** EIA, World Energy Projections Plus (2009).

**Figure 85. World Carbon Dioxide Emissions from Liquids Combustion, 1990-2030**




Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2009).

Carbon dioxide emissions from natural gas combustion worldwide are projected to increase on average by 1.6 percent per year, to 8.4 billion metric tons in 2030, with the OECD countries averaging 0.9 percent per year and the non-OECD countries 2.2 percent per year (Figure 86). Again, China is projected to have the most rapid growth in emissions, averaging 5.2 percent annually; however, China's emissions from natural gas combustion amounted to only 0.1 billion metric tons in 2006, and in 2030 they are projected to total only 0.4 billion metric tons—equivalent to 3 percent of China's total energy-related emissions and less than 5 percent of the world's total emissions from natural gas combustion. The much lower projected growth in U.S. emissions from natural gas use, averaging 0.5 percent per year, still results in 1.3 billion metric tons of emissions in 2030, which is more than triple the projection for China.

Total carbon dioxide emissions from the combustion of coal throughout the world are projected to increase by 1.7 percent per year on average, from 12.1 billion metric tons in 2006 to 18.0 billion metric tons in 2030. Total coal-related emissions from the non-OECD countries were already greater than those from the OECD countries in 1990, and in 2030 they are projected to be more than 2.5 times the OECD total (Figure 87), in large part because of the increase in coal use projected for China and India.

China accounts for 74 percent of the total increase in the world's coal-related carbon dioxide emissions from 2006 to 2030, and India accounts for 8 percent. For China alone, coal-related emissions are projected to grow by an average of 2.7 percent annually, from 4.9 billion metric tons in 2006 to 9.3 billion metric tons (or 52 percent of the world total) in 2030. India's carbon dioxide emissions from coal combustion are projected to total 1.3 billion metric tons in 2030, accounting for more than 7 percent of the world total. In the United States—the world's other major coal consumer—coal-related carbon dioxide emissions rise more slowly, by 0.7 percent per year, to 2.5 billion metric tons (14 percent of the world's total coal-related carbon emissions) in 2030.

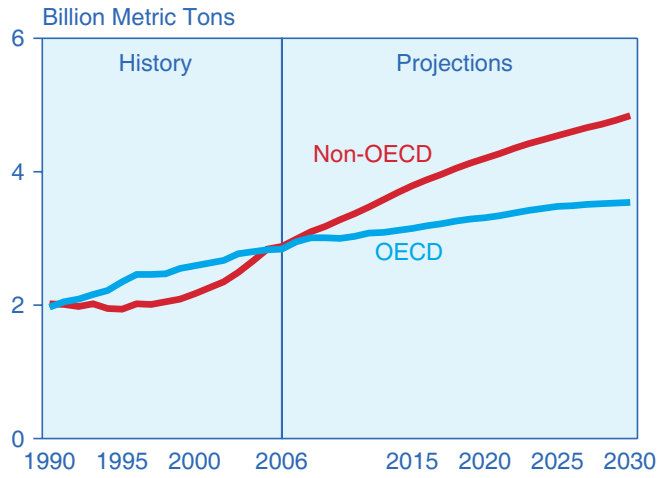
## Carbon Dioxide Intensity Measures

### *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 2006, estimated carbon dioxide intensities were 386 metric tons per million dollars of GDP in the OECD countries and 624 metric tons per million dollars of GDP in the non-OECD countries (Table 16).[49]

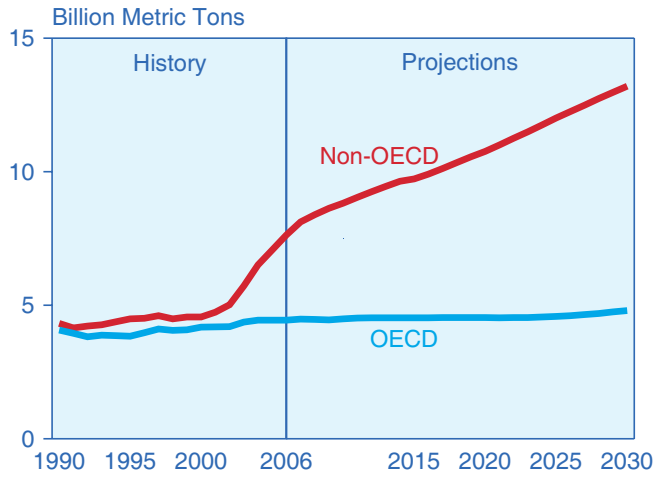
Fossil fuel use in the non-OECD countries increases strongly in the reference case projection, but their economic growth is even stronger. As a result, non-OECD carbon dioxide intensity declines by an average of 2.6 percent per year, from 624 metric tons per million dollars of GDP in 2006 to 330 metric tons per million dollars in 2030. In particular, China, with a relatively high rate of growth in emissions (2.8 percent per year), has an

**Figure 86. World Carbon Dioxide Emissions from Natural Gas Combustion, 1990-2030**




Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2009).

**Figure 87. World Carbon Dioxide Emissions from Coal Combustion, 1990-2030**




Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2009).

[49] GDP is measured in chain-weighted 2005 dollars, converted to the currency of the relevant country or region, based on purchasing power parity.

even higher GDP growth rate (6.4 percent per year). As a result, its emissions intensity falls from 1,001 metric tons per million dollars in 2006 to 443 metric tons per dollars in 2030.

For all the OECD countries combined, average carbon dioxide intensity in 2030 is projected to be 246 metric tons per million dollars of GDP. Mexico has the lowest carbon dioxide intensity among the OECD economies in 2030 in the reference case, at 184 metric tons per million dollars, followed by OECD Europe at 196 metric tons and Japan at 242 metric tons. (Mexico's relatively low carbon dioxide intensity results in large part from its projected 3.4-percent annual GDP growth rate, the highest among the OECD countries.) Canada has the highest carbon dioxide intensity among the OECD countries in 2030, at 359 metric tons per million dollars of GDP, followed by South Korea at 351 metric tons and Australia/New Zealand at 322 metric tons. U.S. carbon dioxide intensity in 2030 is 282 metric tons per million dollars of GDP. For the entire world, average carbon dioxide intensity falls from 484 metric tons per million dollars of GDP in 2006 to 294 metric tons in 2030.

### *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 higher in 2006) than in the non-OECD economies (Figure 88). Among the non-OECD countries, China has the highest percentage increase in carbon dioxide emissions per capita in the *IEO2009* reference case, from 4.6 metric tons per person in 2006 to 8.0 metric tons per person in 2030 (Table 17 and Figure 89). Russia has the highest absolute increase, from 11.9 metric tons per person in 2006 to 16.0 metric tons per person in 2030. Among the *IEO2009* country groupings, the lowest levels of emissions per capita in the world are in India and Africa. India's emissions per capita increase from 1.1 metric tons per person in 2006 to 1.4 metric tons per person in 2030, and Africa's emissions per capita remain at about 1.0 metric ton per person from 2006 to 2030.

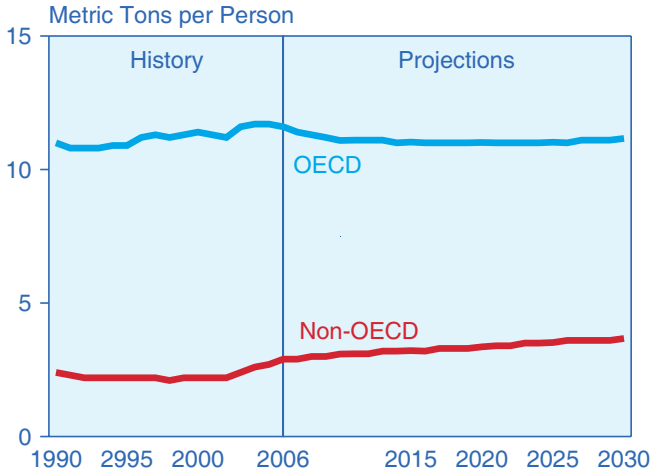
**Table 16. Carbon Dioxide Intensity by Region and Country, 1980-2030**
(Metric Tons per Million 2005 U.S. Dollars of Gross Domestic Product)

| Region | History | | Projections | | | | | Average Annual Percent Change | |
|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2006 | 2010 | 2015 | 2020 | 2025 | 2030 | 1990-2006 | 2006-2030 |
| **OECD** | **491** | **386** | **360** | **321** | **293** | **267** | **246** | **-1.5%** | **-1.9%** |
| North America | 597 | 453 | 423 | 371 | 334 | 302 | 277 | -1.7% | -2.0% |
| United States | 620 | 463 | 436 | 380 | 341 | 308 | 282 | -1.8% | -2.0% |
| Canada | 609 | 507 | 488 | 444 | 414 | 387 | 359 | -1.1% | -1.4% |
| Mexico | 361 | 317 | 250 | 230 | 215 | 198 | 184 | -0.8% | -2.2% |
| Europe | 428 | 311 | 289 | 259 | 237 | 215 | 196 | -2.0% | -1.9% |
| Asia | 391 | 391 | 367 | 338 | 318 | 300 | 283 | 0.0% | -1.3% |
| Japan | 327 | 314 | 285 | 271 | 265 | 254 | 242 | -0.2% | -1.1% |
| South Korea | 651 | 581 | 575 | 480 | 414 | 380 | 351 | -0.7% | -2.1% |
| Australia/New Zealand | 615 | 558 | 505 | 444 | 402 | 357 | 322 | -0.6% | -2.3% |
| **Non-OECD** | **816** | **624** | **555** | **469** | **407** | **364** | **330** | **-1.7%** | **-2.6%** |
| Europe/Eurasia | 1,397 | 913 | 779 | 665 | 580 | 514 | 464 | -2.6% | -2.8% |
| Russia | 1,272 | 932 | 774 | 664 | 584 | 517 | 468 | -1.9% | -2.8% |
| Other | 1,599 | 888 | 785 | 666 | 576 | 510 | 458 | -3.6% | -2.7% |
| Asia | 825 | 670 | 584 | 484 | 415 | 371 | 335 | -1.3% | -2.8% |
| China | 1,812 | 1,001 | 832 | 669 | 558 | 494 | 443 | -3.6% | -3.3% |
| India | 563 | 483 | 391 | 323 | 277 | 240 | 214 | -0.9% | -3.3% |
| Other | 373 | 355 | 326 | 284 | 254 | 234 | 221 | -0.3% | -2.0% |
| Middle East | 657 | 709 | 679 | 604 | 535 | 485 | 447 | 0.5% | -1.9% |
| Africa | 475 | 420 | 378 | 322 | 283 | 256 | 236 | -0.8% | -2.4% |
| Central and South America | 306 | 299 | 292 | 253 | 223 | 203 | 185 | -0.1% | -2.0% |
| Brazil | 225 | 235 | 231 | 212 | 197 | 186 | 174 | 0.3% | -1.2% |
| Other | 375 | 346 | 336 | 282 | 242 | 216 | 194 | -0.5% | -2.4% |
| **Total World** | **603** | **484** | **450** | **394** | **353** | **321** | **294** | **-1.4%** | **-2.1%** |

Note: GDP is expressed in terms of purchasing power parity.

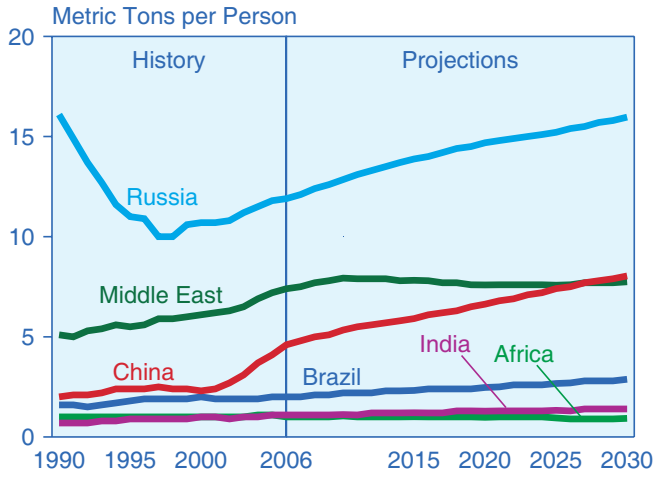
Sources: **1980-2006:** Derived from Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **2010-2030:** IHS Global Insight, *World Economic Outlook 4th Quarter 2008*, and EIA, World Energy Projections Plus (2009).

**Figure 88. World Carbon Dioxide Emissions per Capita, 1990-2030**




Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2009).

**Figure 89. Non-OECD Carbon Dioxide Emissions per Capita by Country and Region, 1990-2030**




Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2009).

**Table 17. Energy-Related Carbon Dioxide Emissions per Capita by Region and Country, 1990-2030**
(Metric Tons per Person)

| Region | History | | Projections | | | | | Average Annual Percent Change | |
|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2006 | 2010 | 2015 | 2020 | 2025 | 2030 | 1990-2006 | 2006-2030 |
| **OECD** | **11.0** | **11.6** | **11.1** | **11.0** | **11.0** | **11.0** | **11.2** | **0.3%** | **-0.1%** |
| North America | 15.7 | 15.9 | 14.9 | 14.6 | 14.3 | 14.1 | 14.2 | 0.1% | -0.5% |
| United States | 19.6 | 19.7 | 18.6 | 18.1 | 17.5 | 17.1 | 17.1 | 0.0% | -0.6% |
| Canada | 17.0 | 18.7 | 18.4 | 18.3 | 18.4 | 18.6 | 18.7 | 0.6% | 0.0% |
| Mexico | 3.6 | 4.1 | 3.4 | 3.6 | 3.9 | 4.1 | 4.3 | 0.8% | 0.3% |
| Europe | 8.3 | 8.2 | 7.9 | 7.9 | 7.9 | 7.9 | 8.0 | -0.1% | -0.1% |
| Asia | 8.5 | 11.1 | 11.0 | 11.3 | 11.5 | 11.7 | 12.0 | 1.6% | 0.4% |
| Japan | 8.5 | 9.8 | 9.2 | 9.5 | 9.8 | 9.8 | 9.8 | 0.8% | 0.0% |
| South Korea | 5.7 | 10.7 | 12.3 | 12.5 | 12.5 | 13.3 | 14.0 | 4.0% | 1.1% |
| Australia/New Zealand | 14.7 | 18.5 | 17.7 | 17.4 | 17.5 | 17.4 | 17.6 | 1.4% | -0.2% |
| **Non-OECD** | **2.4** | **2.9** | **3.1** | **3.2** | **3.4** | **3.5** | **3.7** | **1.2%** | **1.1%** |
| Europe/Eurasia | 12.2 | 8.4 | 9.0 | 9.6 | 10.0 | 10.2 | 10.6 | -2.3% | 1.0% |
| Russia | 16.1 | 11.9 | 12.8 | 13.9 | 14.7 | 15.2 | 16.0 | -1.9% | 1.2% |
| Other | 9.3 | 6.0 | 6.4 | 6.7 | 6.9 | 7.1 | 7.3 | -2.7% | 0.8% |
| Asia | 1.3 | 2.6 | 2.9 | 3.1 | 3.4 | 3.7 | 4.0 | 4.2% | 1.8% |
| China | 2.0 | 4.6 | 5.3 | 5.9 | 6.6 | 7.4 | 8.0 | 5.3% | 2.4% |
| India | 0.7 | 1.1 | 1.1 | 1.2 | 1.3 | 1.3 | 1.4 | 3.3% | 0.9% |
| Other | 1.1 | 1.7 | 1.8 | 1.9 | 2.0 | 2.2 | 2.4 | 2.8% | 1.5% |
| Middle East | 5.1 | 7.4 | 7.9 | 7.8 | 7.6 | 7.6 | 7.8 | 2.3% | 0.2% |
| Africa | 1.0 | 1.0 | 1.1 | 1.0 | 1.0 | 1.0 | 0.9 | 0.0% | -0.5% |
| Central and South America | 1.9 | 2.4 | 2.7 | 2.7 | 2.7 | 2.7 | 2.8 | 1.5% | 0.6% |
| Brazil | 1.6 | 2.0 | 2.2 | 2.3 | 2.5 | 2.7 | 2.9 | 1.4% | 1.6% |
| Other | 2.2 | 2.8 | 3.1 | 2.9 | 2.8 | 2.8 | 2.8 | 1.5% | 0.0% |
| **Total World** | **4.1** | **4.4** | **4.5** | **4.5** | **4.6** | **4.7** | **4.9** | **0.5%** | **0.4%** |

Sources: **1980-2006:** Derived from Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **2010-2030:** UN Population Statistics (2006 Revision), and EIA, World Energy Projections Plus (2009).

The OECD countries have higher levels of carbon dioxide emissions per capita, in part because of their higher per-capita levels of income and fossil fuel use. In the reference case U.S. emissions per capita fall from 19.7 metric tons per person in 2006 to 17.1 metric tons per person in 2030 (Figure 90). Canada's emissions remain stable at around 19 metric tons per person over the period. In Mexico, with the lowest level of emissions per capita among the OECD countries in 2006 (approximately 4 metric tons per person) there is essentially no change over the projection period.

Per-capita income is the most important determinant of carbon dioxide emissions per capita, but other factors also affect the calculation. For example, climate is important, because in general more energy is used per capita for heating in colder climates than in warmer climates. Similarly, population density is important, because densely populated countries use less energy for transportation per capita than do more sparsely populated countries. For example, Canada has both a relatively cold climate and low population density, and its carbon dioxide emissions in 2006 are estimated at 18.7 metric tons per capita, whereas Japan has a more temperate climate and a much higher population density, and its emissions in 2006 are estimated at 9.8 metric tons per capita. Income per capita in Japan, by comparison, was only 16 percent lower than Canada's in 2006.

## 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 *IEO2009* low economic growth case and higher in the high economic growth case.

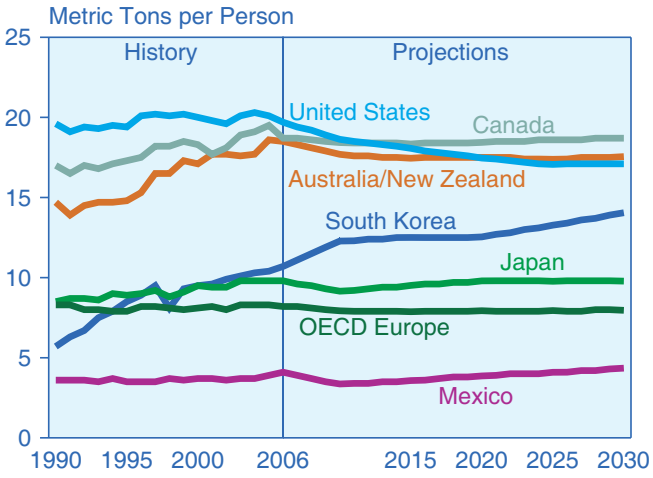
In the high growth case, world carbon dioxide emissions increase at an average rate of 1.8 percent annually from 2006 to 2030, as compared with 1.4 percent in the reference case. For the OECD countries, the projected average increase in the high growth case is 0.6 percent per year; for the non-OECD countries, the average is 2.6 percent per year.

In the low growth case, world carbon dioxide emissions increase by 1.0 percent per year from 2006 to 2030, with averages of -0.1 percent per year for the OECD countries and 1.8 percent per year for the non-OECD countries (compared with 0.3 percent and 2.2 percent, respectively, in the reference case). In 2030, total energy-related carbon dioxide emissions worldwide (Figure 91) range from a projected 37.0 billion metric tons in the low growth case to 44.1 billion metric tons in the high growth case—19 percent higher than projected in the low growth case. The projections for emissions by fuel show similar variations across the cases.

## Alternative Oil Price Cases

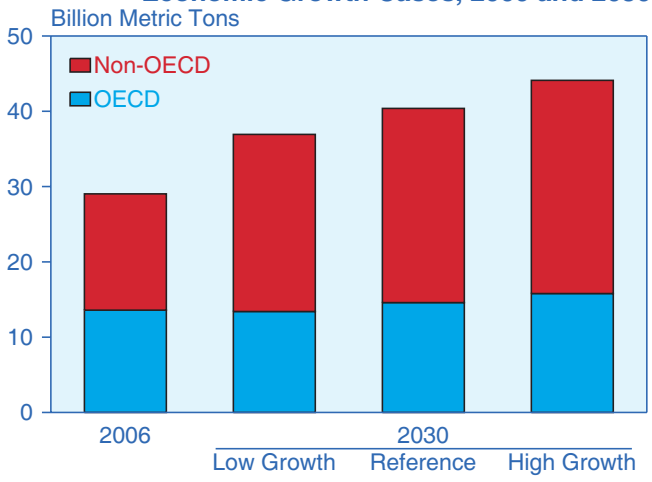
The projections for carbon dioxide emissions in the *IEO2009* low and high oil price cases (Figure 92) show smaller variations from the reference case than do those in the alternative macroeconomic growth cases. In 2030, as compared with the reference case projection (40.4 billion metric tons), total carbon dioxide emissions are higher in the low price case (42.2 billion metric tons) and

**Figure 90. OECD Carbon Dioxide Emissions per Capita by Country and Region, 1990-2030**




Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2009).

**Figure 91. Carbon Dioxide Emissions in Three Economic Growth Cases, 2006 and 2030**




Sources: **2006:** Energy Information Administration, *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **2030:** Energy Information Administration, World Energy Projections Plus (2009).

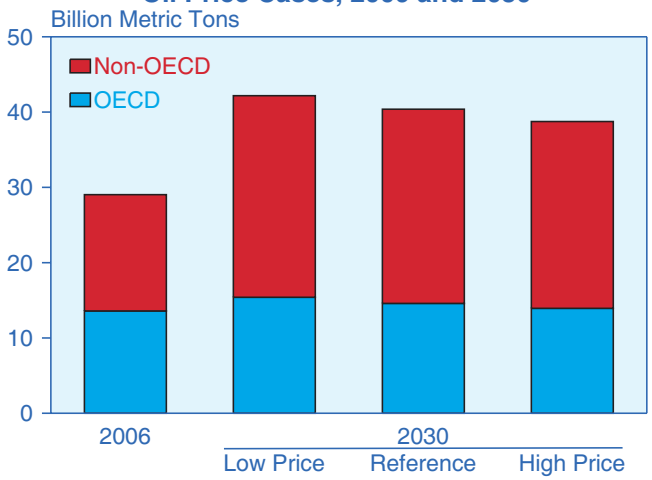
lower in the high price case (38.7 billion metric tons), largely as a result of greater demand for liquids in the low price case and lower demand in the high price case. Thus, there is a 9-percent difference between the projections in the two alternative oil price cases, as compared with a 19-percent difference between the alternative economic growth cases.

In the alternative oil price cases, world carbon dioxide emissions from liquids consumption are affected more strongly than emissions from either coal or natural gas, both of which are higher in the high price case and lower in the low price case. Coal-related emissions in 2030 increase by 1 percent in the high price case relative to the reference case and decline by 0.4 percent relative to the reference case in the low price case.

In the high price case, where world oil prices reach $200 per barrel in real 2007 dollars in 2030 (as compared with $130 per barrel in the reference case), nations choose alternative fuels over liquids wherever possible. Consequently, liquids-related emissions total 11.7 billion metric tons in 2030 in the high price case, down by 16 percent from the total of 14.0 billion metric tons in 2030 in the reference case. In the low price case, where world oil prices decline to $50 per barrel in 2030, there is little economic incentive for nations to turn to other forms of energy. Consequently, liquids-related emissions in 2030 in the low oil price case, at 16.0 billion metric tons, are 2.0 billion metric tons (14 percent) higher than projected in the reference case.

World carbon dioxide emissions from natural gas combustion in 2030 total 8.8 billion metric tons in the high oil price case, 5 percent above the projection of 8.4 billion metric tons in the reference case. In the low price case, with higher levels of liquids consumption, natural-gas-related emissions in 2030 total 8.3 billion metric tons, or 1 percent lower than projected in the reference case.

**Figure 92. Carbon Dioxide Emissions in Three Oil Price Cases, 2006 and 2030**




Sources: **2006:** Energy Information Administration, *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **2030:** Energy Information Administration, World Energy Projections Plus (2009).