ISBN 978-92-64-04048-9
OECD Environmental Outlook to 2030


*Chapter 17*

# Energy

*This chapter examines the recent trends and future projections for energy demand and supply in different regions around the world to 2030. Despite continuing improvements in energy efficiency, world primary energy use is projected to grow by 54% between 2005 and 2030 under the* Outlook *Baseline. Fossil fuels are expected to continue to dominate the energy mix. Increasing energy production and use will affect the stability of ecosystems, global climate and the health of current and future generations. The chapter also outlines some of the key government policies that are needed to promote a lasting technology shift towards a more sustainable energy path, and examines some of the costs and environmental benefits of specific policy options.*

## KEY MESSAGES

World primary energy use is projected to grow by 54% between 2005 and 2030 in the Baseline – an average annual rate of 1.8% per year.

Fossil fuels are likely to continue to dominate primary energy use, accounting for most of the increase in energy between 2005 and 2030 (84%). Oil looks to remain the largest single global energy source in 2030, though its share of total energy use is projected to fall from 36% to 33%. Power generation and transport account for most of the increase in energy consumption. Electricity is the fastest growing final form of energy.

For as long as fossil fuels dominate the world energy system, rising energy production and use threaten the stability of ecosystems, global climate and the health of current and future generations. Fossil fuel combustion is the main contributor to air pollution and greenhouse gas emissions, especially carbon dioxide.

Energy intensity – the amount of energy needed to produce one unit of gross domestic product – is projected to continue to decline, thanks to improved energy efficiency and a structural economic shift in all regions towards less energy-intensive activities.

The net environmental effect of switching to renewable energy sources is expected to be positive, despite some adverse environmental effects which need to be addressed through policy.

### Policy options

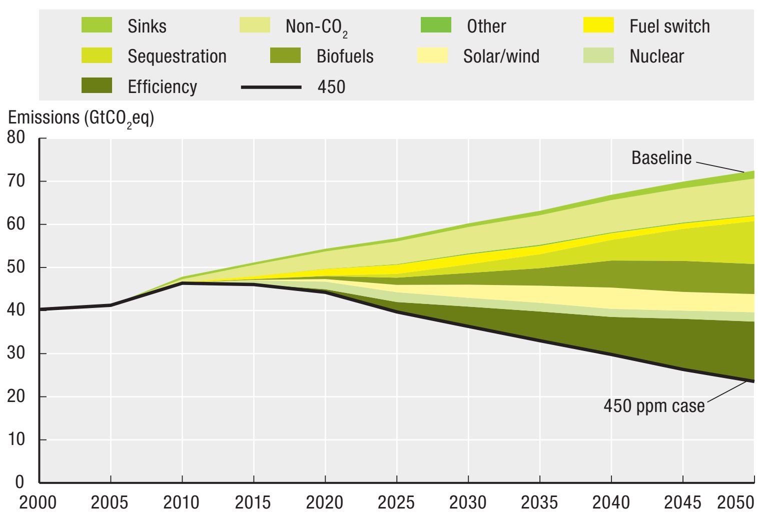
Government policies will be critical to promote a lasting technology shift which steers the world onto a more sustainable energy path. To keep the costs of mitigation low while also stimulating innovation, policies will need to:

- Emphasise market-based instruments in the policy mix to establish a clear price on carbon and other greenhouse gas emissions and encourage mitigation where it is least-cost.
- Reverse growth in energy-related greenhouse gas emissions.
- Encourage more efficient energy use and promote the supply of renewable and low-carbon energy sources.
- Commercialise carbon capture and storage technologies to permit the environmentally acceptable use of coal and other fossil fuels.
- Alter radically the way energy is produced and consumed. Ultimately, the world will need to move away from carbon-intensive fossil fuels towards renewables and/or nuclear power. No one technology or fuel choice will dominate; a mix will be required.

Greater deployment of cleaner technologies in this sector will also deliver a wide range of other benefits, from energy security to environmental benefits (*e.g.* healthier people, cleaner cities, clearer skies).

This figure shows the mix of technologies and mitigation options likely to be important to achieve very low emission levels, *i.e.*, to stabilise atmospheric concentrations of greenhouse gases at 450 ppm $CO_2$ equivalent. Key approaches in the short term will be low-cost measures that reduce non-$CO_2$ greenhouse gases, combined with expanding sinks and avoiding emissions from land use and forestry as well as energy efficiency measures. Also essential by 2020 to achieve this objective will be the use of second generation biofuels and carbon capture and storage (CCS) technologies on a worldwide basis, along with increased renewables.

**450 ppm $CO_2$eq emission pathway compared to Baseline: technology "wedges" of emission reduction**

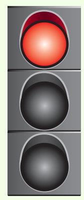



StatLink http://dx.doi.org/10.1787/262100311684

## Introduction

The relationships between energy supply and use, economic activity, human development and the environment are extremely complex. Increased energy use is both a cause and an effect of economic growth and development. Energy is essential to most economic activities. Industrialised economies rely on commercial energy to transport goods and people, to heat homes and offices, to power engines and appliances, and to run shops and factories. The prosperity generated by economic development stimulates, in turn, demand for more and better-quality energy services, especially in the early stages of economic development. But the production, transportation and use of energy can have major adverse effects on the environment and on the health and well-being of current and future generations.

Today, energy use is the largest source of air pollution and of the greenhouse gases (GHGs) that threaten to change global climate (see Table 17.1 and Chapter 7). These environmental problems arise principally from the combustion of fossil fuels, which provides the bulk of the world's energy needs. Air pollution occurs through the noxious gases and pollutants – including sulphur dioxide ($SO_2$), nitrogen oxides (NOx), particulates, methane ($CH_4$) and volatile organic compounds (VOCs) – emitted either through fuel combustion or in leakages from delivery systems (see Chapter 8, Air pollution). The use of fossil fuels is the leading cause of urban smog, particulate matter air pollution and acid rain. Local and regional air pollution is a major human health problem, especially in the developing world, and also affects the health of natural systems and biodiversity worldwide. Indoor air pollution, caused largely by inefficient and poorly ventilated stoves burning traditional fuels or coal, is a leading cause of health problems in many developing countries. Producing and transporting oil can pollute the sea, freshwater supplies and the soil through accidental leaks or poor management. Combustion of fossil fuels is also the predominant source of greenhouse gases, most notably carbon dioxide ($CO_2$), while coal mining and natural gas distribution are an important source of methane.



*Energy is a leading source of pollution and GHG emissions. Global primary energy consumption is projected to grow rapidly to 2030 in the Baseline.*

Alternatives to fossil energy use include renewable and nuclear energy; however, these energy forms are not problem-free either. Renewable energy sources, such as hydroelectric and wind energy, are cleaner, but can also carry limited environmental risks of their own. For example, large-scale hydroelectric dams can be a significant source of $CH_4$ emissions when they cause deforestation and alter natural river flow, with a range of cascading ecological impacts. Wind energy causes noise pollution and alters the landscape. Nuclear power production gives rise to radioactive waste and waste management problems, raises the risk of accidental contamination as well as a range of national (and international)

Table 17.1. **Environmental impact of the energy sector, 1980 to 2030**

**Climate change**

| | | 1980 (%) | | 2005 (%) | | 2030 (%) | | Total % change 1980-2005 | Total % change 2005-2030 |
|---|---|---|---|---|---|---|---|---|---|
| GHG emissions ($GtCO_2eq$) | | 32.9 | 100% | 46.9 | 100% | 64.1 | 100% | 43% | 37% |
| $CO_2$ emissions from energy ($GtCO_2$) | Industry and other[a] | 7.6 | 39% | 9.0 | 32% | 12.5 | 29% | 19% | 39% |
| | Power generation | 6.2 | 32% | 11.0 | 39% | 18.0 | 42% | 78% | 65% |
| | Residential | 2.0 | 11% | 2.3 | 8% | 2.8 | 7% | 14% | 22% |
| | Transport | 3.5 | 18% | 6.1 | 21% | 9.6 | 22% | 73% | 58% |
| | Total | 19.3 | 100% | 28.4 | 100% | 43.0 | 100% | 47% | 52% |
| $CO_2$ emissions from energy (t $CO_2$/per capita) | | 4.3 | | 4.4 | | 5.2 | | 1% | 19% |
| $CO_2$ concentration (ppm) | | 339 | | 383 | | 465 | | 13% | 21% |
| Global mean temperature increase (°C) (above pre-industrial levels) | | 0.21 | | 0.69 | | 1.34 | | | |

**Air pollution**

| | 1980 | 2005 | 2030 | Total % change 1980-2005 | Total % change 2005-2030 |
|---|---|---|---|---|---|
| Nitrogen oxides emission (Mt) | 30.5 | 29.6 | 29.4 | –3% | –1% |
| Sulphur oxides emission (Mt)[b] | 80.5 | 64.4 | 67.3 | –20% | 5% |

| | 2000 | 2030 | Total % change |
|---|---|---|---|
| Loss of health (per million inhabitants)[c] | 1 632 | 3 507 | 115% |
| Mortality (deaths/per million inhabitants)[d] | 164 | 412 | 150% |

StatLink http://dx.doi.org/10.1787/257488858217

*Note:* Totals may not add up due to number rounding.

*a)* The term "other" includes energy-related emissions of $CO_2$ from: services, bunkers, energy transformation, losses and leakages, etc.

*b)* The total sulphur dioxide emission considers both industry related and energy related emissions.

*c)* The figures for loss of health were obtained by adding loss of health attributable to outdoor exposure to ozone, to loss of health attributable to particulate matter per million inhabitants.

*d)* Mortality was defined as the sum of deaths related to outdoor exposure to ozone and deaths attributable to particulate matter per million inhabitants.

*Source:* OECD *Environmental Outlook* Baseline.

security issues. Beyond economic and technical questions, switching to non-fossil energy sources thus involves trade-offs and consideration of a range of environmental and security consequences, issues that can only be resolved when taking local contexts and preferences into account.

Access to electricity is particularly important for human development. Electricity is needed for activities such as lighting, refrigeration and the running of household appliances. Yet an estimated 1.6 billion people in developing countries, equal to just over a quarter of the world's population, have no access to electricity in their homes (IEA, 2006a). Indeed, 2.5 billion people rely almost exclusively on traditional biomass fuels – such as wood, charcoal, crop waste and dung – for cooking and heating (IEA, 2006a). As incomes rise, households usually switch to modern energy services for cooking, heating, lighting and electric appliances. Rising incomes also boost demand for personal mobility and, therefore, for transport fuels. The shift to modern energy services initially leads to an increase in the energy intensity of the economy – the amount of energy needed for each unit of GDP – through industrialisation, improved comfort levels and increased personal and freight mobility. As industrialisation proceeds, energy intensity eventually peaks and then begins to decline due to structural changes, including a shift to less energy-intensive service activities. Most OECD countries have already reached this stage. Economic development ultimately leads to saturation in demand for bulk industrial goods and increased demand for smaller, less energy-hungry miniaturised products. Technological advances also raise the average energy efficiency of equipment and appliances and reinforce the long-term decline in intensity.

## Key trends and projections

### *Primary energy consumption*

Barring a radical change in government policies, major technological breakthroughs, an unexpected change in oil prices or disruption to global economic expansion, the world's energy needs are set to continue to grow steadily over the coming decades. Global primary energy consumption[1] in the *OECD Environmental Outlook* Baseline is projected to increase from 460 exajoules in 2005 to 710 EJ in 2030 and 865 EJ in 2050, which represents an average annual increase of 1.8% in 2005-2030 and 1% in 2030-2050 (Table 17.2; and see Box 17.1 for methodological details). Energy use has grown by 1.7% per year since 1980. Fossil fuels continue to dominate the primary fuel mix. Oil, gas and coal account for 86% of the projected increase in total energy use between 2005 and 2030. The combined share of fossil fuels in total primary energy use remains essentially constant from 2005 to 2030, hovering at about 85%, and then drops to 80% in 2050.

Table 17.2. **World primary energy consumption in the Baseline (EJ), 1980-2050**

| | | | | | Compound annual growth rate (%) | | |
|---|---|---|---|---|---|---|---|
| | 1980 | 2005 | 2030 | 2050 | 1980-2005 | 2005-2030 | 2030-2050 |
| Coal | 75.5 | 129.0 | 198.1 | 224.2 | 2.2 | 1.7 | 0.6 |
| Oil | 132.4 | 168.1 | 239.0 | 287.8 | 1.0 | 1.4 | 0.9 |
| Natural gas | 55.3 | 98.1 | 174.9 | 221.4 | 2.3 | 2.3 | 1.2 |
| Modern biofuels | 0.5 | 2.2 | 16.4 | 39.1 | 6.1 | 8.4 | 4.5 |
| Traditional biofuels | 33.5 | 44.4 | 52.8 | 50.7 | 1.1 | 0.7 | –0.2 |
| Nuclear[a] | 2.5 | 9.3 | 12.9 | 12.1 | 5.4 | 1.3 | –0.4 |
| Solar/wind | 0.1 | 0.6 | 4.9 | 12.6 | 7.9 | 9.1 | 4.9 |
| Hydro | 6.0 | 10.5 | 15.1 | 17.6 | 2.3 | 1.5 | 0.7 |
| Total | 305.8 | 462.3 | 714.2 | 865.4 | 1.7 | 1.8 | 1.0 |

StatLink http://dx.doi.org/10.1787/257501561404

*a)* These numbers differ by approximately a factor of three from those reported by the International Energy Agency (IEA). This is because the IEA defines the amount of primary nuclear energy consumption as three times the amount of energy produced in the form of electricity – this is the "fossil fuel replacement method" to report primary energy supply associated with this energy carrier. We define all direct electricity options using a simpler method, on the basis of electricity output.

*Source: OECD Environmental Outlook* Baseline.

Oil remains the single largest fuel in the global primary energy mix throughout the projection period, with consumption growing by 42% between 2005 and 2030. Its share nonetheless stays flat at 33% (Figure 17.1). The bulk of the increase in oil use is projected to come from the transport sector. Natural gas sees the biggest increase in primary consumption in volume terms in 2005-2030, ahead of coal and oil. The share of natural gas in primary energy is projected to grow to 24% by 2030. Nevertheless there is a large projected increase in the volume of coal use over the coming decades (nearly 70 EJ), which drives up GHG emissions. Demand for coal is driven mainly by the power generation sector, especially in China and India (see Box 17.2). Coal's share of world primary energy consumption remains stable at 28% in 2005 and 2030. Nuclear power is projected to grow

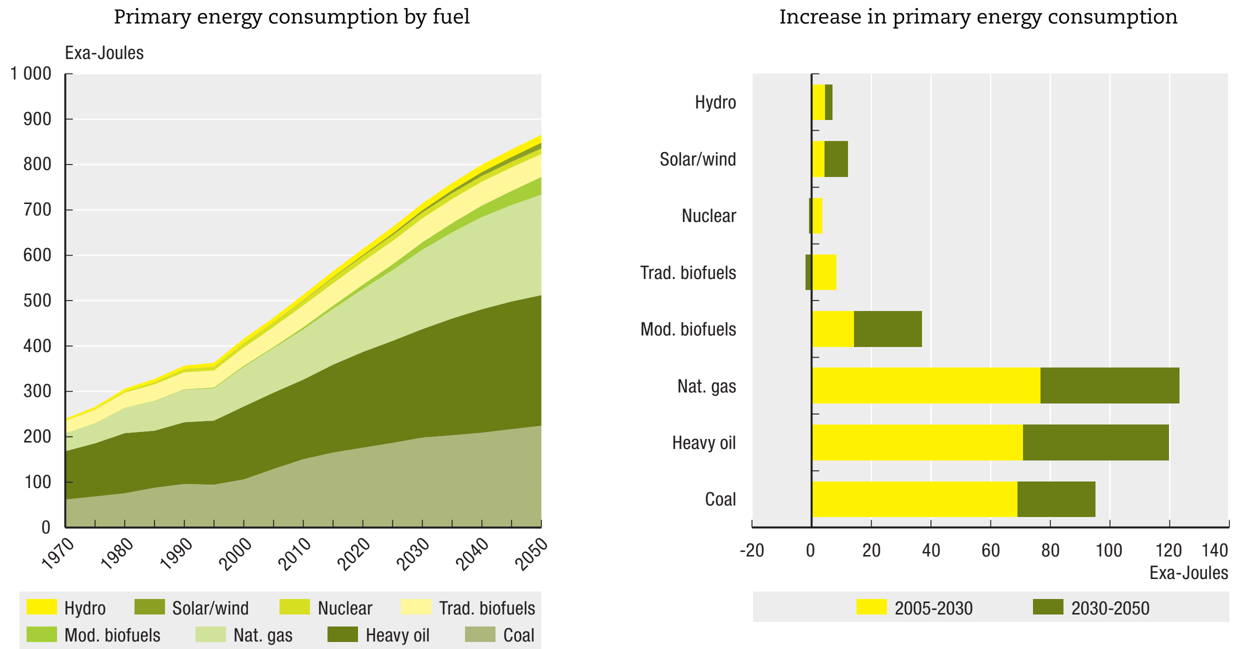
### Box 17.1. **Key uncertainties and assumptions**

The energy projections presented in this chapter are subject to a wide range of uncertainties, including the rate of economic and population growth, energy prices, the availability and cost of developing energy resources, technological progress, investment trends and government policies on energy and the environment. The Baseline assumes no change in government policies.

The Baseline projections presented here have been calibrated to the Reference Scenario projections of the 2006 edition of the *World Energy Outlook*, which also assumes no new government policies (IEA, 2006a). This was done by running the IMAGE energy model so as to reproduce as closely as possible the *WEO-2006* energy projections based on the population and economic assumptions used in that study. This involved adjusting income elasticities of energy demand and preferences for different fuels. Assumptions about electric power plant efficiency and primary energy prices are comparable. The IMAGE model was then re-run using the Baseline economic growth and population assumptions set out in Chapters 2 and 3 of this *Outlook*, together with the IEA's most recent energy price assumptions. The results of the IMAGE and *WEO-2006* projections differ slightly, mainly because the macroeconomic assumptions differ.

much more slowly than in the past, based on current policies, such that its share in primary consumption falls. The combined share of hydropower and traditional biomass is projected to increase slightly. In aggregate, modern renewables – a category that includes geothermal, wind, solar, wave and tidal energy and biofuels – are expected to grow faster than any other energy source, their contribution to global primary energy rising from nearly 1% in 2005 to 3% in 2030. Modern biofuels (liquid transport fuels derived from biomass) account for most of this increase (see Box 17.3).

Figure 17.1. **World primary energy consumption in the Baseline, to 2050**




StatLink http://dx.doi.org/10.1787/261660538475

*Source:* *OECD Environmental Outlook* Baseline.

## Box 17.2. **Power generation in China**

Power generation in China has been growing extremely rapidly over the last decades, almost quadrupling from its 1990 level of 650 Terawatt hours (TWh) to reach 2 544 TWh in 2005 (an annual average of growth rate of 9.6%, more than three times the global average for this period). In 2005, Chinese electricity production accounted for 14% of global electricity production. Although Chinese electricity production is large in absolute terms, per capita consumption is still relatively low: only two-thirds of the global average of 2.8 MWh (megawatt hours) per capita in 2005.

The Reference Scenario of the IEA's *World Energy Outlook* (2007a) expects Chinese electricity production to continue to grow at a fast pace after 2005, to reach 8 472 TWh in 2030. This projection is 11% higher than that made a year previously (on which this *Outlook* is based). This increase reflects the extremely rapid growth in recent years: electricity generation in China grew 30% from 2003 to 2005, and 105 gigawatts (GW) of electricity generating capacity (more than the entire capacity of the UK and Netherlands combined) was added in 2006 alone.

Chinese electricity generation is projected to continue to grow, and to account for an increasing proportion of global energy-related $CO_2$ emissions. Projected growth to 2030 would lead to total electricity generation in 2030 being more than three times the level of electricity generation in 2005 (2 544 TWh), despite growing at a slower rate during this period than in the recent past (4.9% p.a., which is nevertheless almost double the world average for the same time period).* Under such a scenario, Chinese electricity production would account for almost a quarter (24%) of global electricity production, and almost 15% of global energy-related $CO_2$ emissions, by 2030.

More than three-quarters (78.5%) of Chinese electricity is currently generated from coal. Under the IEA Reference Scenario, this proportion is hardly expected to change by 2030, despite large growth rates for Chinese electricity generation from nuclear power, as well as hydro and other renewables. However, the Reference Scenario projects the $CO_2$-intensity of electricity production to fall by 18% between 2005 and 2030.** This drop is due almost entirely to the increased share of electricity generation from "clean coal" technologies, such as super-critical and ultra-supercritical pulverised fuel technologies (see below). Further reductions are feasible, for example via an accelerated phase-out of inefficient power generating technologies, more rapid deployment of clean coal technologies, and greater uptake of both nuclear power and renewable electricity. Under such assumptions (the Alternative Policy Scenario of the IEA's 2007 *World Energy Outlook*), emissions from China's electricity sector could be 4.5 billion tonnes of $CO_2$ in 2030 (1.5 billion tonnes less than in the Reference Scenario).

* The WEO2007 data here are different from data in the *Outlook*, which suggests a 4% annual growth rate for electricity between 2005-2030 (the WEO calculates 2.7%) (IEA, 2007a).

** Personal communication, Maria Argiri, IEA, 19.11.07.

*Source:* IEA statistics 2007; IEA *World Energy Outlook*, 2007a.

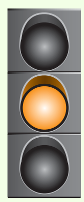
## Box 17.3. **Biofuels in the energy mix**

Interest in biofuels is growing in many countries (see also Box 14.2 in Chapter 14 on agriculture and Box 16.3 in Chapter 16 on transport). Many OECD countries are subsidising biofuels production for energy security and climate change reasons. Indigenously produced biofuels can replace imported oil, diversifying the sources of energy and bringing energy-security benefits to importing economies. Biofuels can lead to marginally lower greenhouse gas emissions compared with fossil fuels; however, they may also harm the environment if the biomass raw materials are not produced in an environmentally sustainable manner, and may also raise the cost of food production. Policies to support the production and use of biofuels need to reflect the full life-cycle of their effect on greenhouse gas emissions and the economy.

Today, the overwhelming bulk of biofuels produced around the world are ethanol and esters (known as biodiesel). Ethanol is usually produced from starchy crops, including cereals and sugar, while biodiesel is produced mainly from oil-seed crops, such as rapeseed. Ethanol is usually blended with gasoline (either pure or in a derivative form, known as ETBE), while biodiesel is normally blended with diesel. Global production of biofuels in 2005 amounted to over 640 thousand barrels per day (kb/d), almost 80% of which was in Brazil and the United States, which produce almost exclusively ethanol. Production of biofuels in Europe, the bulk of which is biodiesel, is increasing rapidly thanks to strong fiscal incentives in several countries, notably Germany. Current investment plans point to a continued rapid expansion of biofuels capacity in these regions in the coming years.

In the longer term, the prospects for biofuels in these and other parts of the world hinge on government policies, technological advances and reductions in production costs. New technologies being developed today, including enzymatic hydrolysis and gasification of woody ligno-cellulosic feedstock to make ethanol – the so-called "second generation" biofuels – could be more economically competitive than existing technologies and lead to more certain environmental benefits.

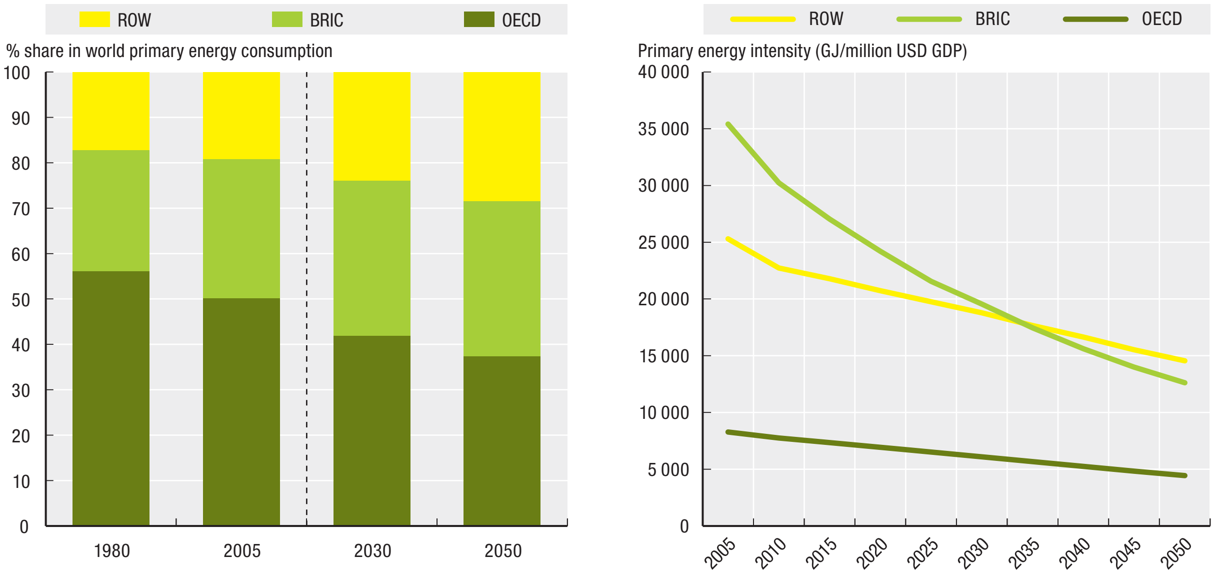
Over three-quarters of the increase in world primary energy consumption through to 2030 is projected to come from non-OECD countries (Figure 17.2), where the economy and population will be expanding faster. As a result, the share of OECD countries in total primary energy consumption looks likely to drop, from 50% in 2005 to 42% in 2030, and to 37% by 2050. Developing Asia[2] sees the fastest rates of growth in energy consumption, increasing by almost 94% between 2005 and 2030. Energy intensity, measured as total primary energy use per dollar of gross domestic product, is projected to decline in all regions. On average, it is projected to fall by 1% per year worldwide between 2005 and 2030, quickening to 1.1% between 2030 and 2050. Intensity falls most quickly in the BRIC developing regions, as energy prices are reformed, more energy-efficient technologies are introduced and wasteful energy practices are discouraged. The shift to service sector economic activity is more advanced in the OECD countries, so there is less scope for them to reduce energy intensity. Per capita primary energy consumption is also projected to continue diverging from income growth in all regions. Globally, per capita energy



*Per capita energy consumption is likely to grow more slowly than per capita incomes across the world to 2030.*

 OECD ENVIRONMENTAL OUTLOOK TO 2030 – ISBN 978-92-64-04048-9 – © OECD 2008

Figure 17.2. **Primary energy consumption and intensity by region in the Baseline, to 2050**



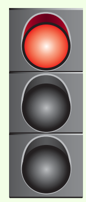

StatLink http://dx.doi.org/10.1787/261664035504

*Source:* *OECD Environmental Outlook* Baseline.

consumption looks likely to grow by 0.8% per year on average to 2030 and, as global economies become more fully industrialised, to increase by 0.5% per year between 2030 and 2050 – well below the 1.8% per year rate of per capita GDP growth.

### *Power generation and other energy uses*

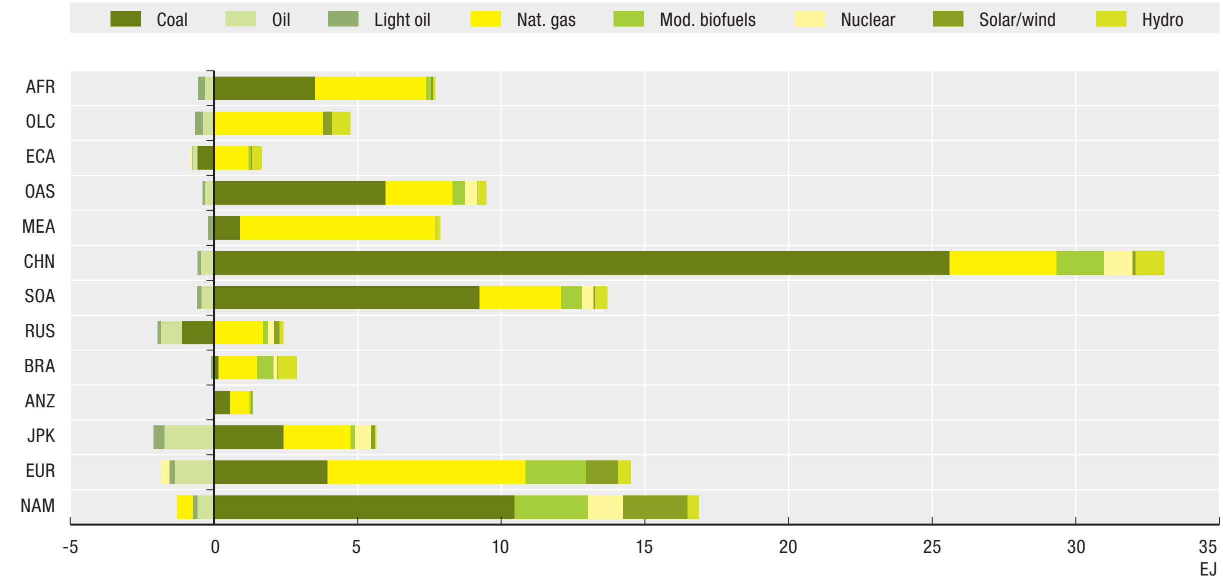
Use of primary energy to generate power is projected to continue to grow steadily in every region in the Baseline, driven by strong final demand for electricity.[3] Globally, electricity consumption is projected to grow by 4% per year between 2005 and 2030, down from 5.1% between 1980 and 2005. Non-OECD countries account for 64% of the increase. There is considerable variation across regions in the fuel mix (Figure 17.3). Worldwide, coal accounts for well over half of the total increase in fuel inputs to generation, its share in total generation remains 55% in 2005 and in 2030. Coal-fired power stations are the most competitive generation option for large-scale power generation in the majority of regions, especially developing Asia. In fact, power generation accounts for the bulk of the projected increase in overall coal demand in both the developing world and the OECD countries.



*The share of coal in the fuel mix in power generation is expected to rise from 46% to 55% between 2005 and 2030, driving GHG emissions up.*

The share of oil, nuclear and hydro-energy in the primary energy mix for power generation is likely to decrease between 2005 and 2030. The share of natural gas is expected to increase from 21% in 2005 to 27% in 2030 and that of coal from 46% to 55%. The share of modern biofuels looks likely to increase from 1% to 4%. As a result of higher prices, the use of oil in power stations is projected to decline in every region, its share of generation worldwide plunging from 7% in 2005 to 1% in 2030. The share of nuclear power drops from 6% in 2005 to 5% in 2030. The decline is expected to accelerate over the projection period, on the assumption that few new reactors are built and several existing

Figure 17.3. **Increase in primary energy use in power generation by fuel and region in the Baseline, 2005-2030**




StatLink http://dx.doi.org/10.1787/261805403568

*Note:* Regional country groupings are as follows: NAM: North America (United States, Canada and Mexico); EUR (western and central Europe and Turkey); JPK: Japan and Korea region; ANZ: Oceania (New Zealand and Australia); BRA: Brazil; RUS: Russian and Caucasus; SOA: South Asia; CHN: China region; MEA: Middle East; OAS: Indonesia and the rest of South Asia; ECA: eastern Europe and central Asia; OLC: other Latin America; AFR: Africa.

*Source: OECD Environmental Outlook* Baseline.

reactors are retired. However, nuclear power production could turn out to be a lot higher if governments change their policies to facilitate investment in nuclear plants and extend the lifetimes of existing plants.

The relative importance of hydropower is set to diminish. Much of the industrialised countries' low-cost hydropower resources have already been exploited and growing environmental concerns in developing countries will discourage further large-scale projects there. World hydropower production looks likely to grow slowly to 2030, but its share in global electricity generation will drop, from 7% to 6%. Power generation using modern renewable technologies is currently limited, but is projected to grow rapidly in the Baseline. According to the model, the share of such renewables in total generation jumps from 1% in 2005 to 6% in 2030 (including modern biofuels). In absolute terms, the increase is much bigger in the OECD countries, because many of them have adopted strong policy incentives.

The long lifespans of most power plants and the high capital-intensity of power generation mean that changes in the fuel mix occur gradually. Most fossil-fired plants last more than 50 years. Therefore, much of the capacity that will be used to meet electricity demand in 2030 has already been built or is under construction, especially in the industrialised countries. A significant amount of new capacity will nonetheless be needed. Cumulative investment in power stations alone over 2005-2030 is expected to cost USD 5.2 trillion in 2005 prices – just over half of this is likely to be in developing countries (IEA, 2006a).

Primary energy inputs to other transformation activities, including oil refining and district-heat production, will rise broadly in line with final energy demand. A small but growing share of primary natural gas demand will come from gas-to-liquids plants, which convert natural gas and coal into high-value oil middle distillates and other oil products, and from fuel cells for the production of hydrogen. Coal-to-liquids production, which is already under development in China and some other countries, is also expected to increase.

Under Baseline conditions, an important environmental factor is the conversion efficiency of power generation in fossil-fired facilities. This efficiency can vary widely within and between technology types, and will determine the level of local pollutants, as well as the carbon-intensity, of power production. Demonstrated and emerging clean coal technologies offer significant improvements over conventional coal technologies (CIAB, 2006). For example, super-critical or ultra-supercritical pulverised fuel technologies are more efficient than conventional (sub-critical) units and produce significantly less $CO_2$, $SO_2$ and $NO_x$ per unit of power generated. Coal gasification technologies promise even greater efficiencies in the future.

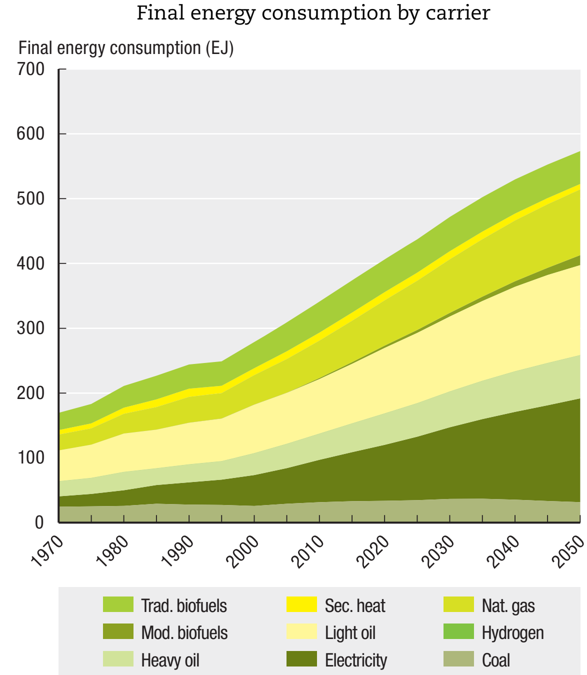
### *Final energy consumption*[4]

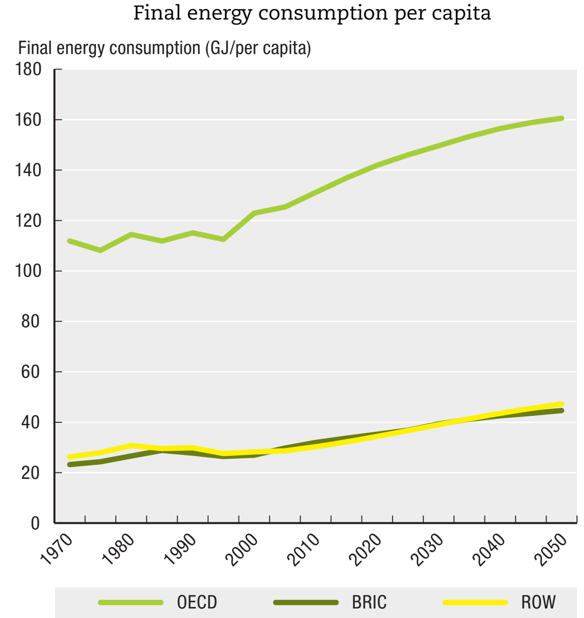
Global energy consumption in final-use sectors – industry, transport, residential, services, agriculture and non-energy uses – is projected to increase from 308 exajoules (EJ) in 2005 to 472 EJ in 2030 in the Baseline, an average annual growth rate of 1.7%. This means that final consumption grows at roughly the same rate as primary consumption. Transport sees the most rapid growth, 2% per annum, and is projected to overtake industry by 2050 as the largest final-use sector. Transport demand increases fastest in the developing countries, where car ownership rates are still very low (see Chapter 16, Transport). In OECD countries, transport demand slows because of saturation of vehicles for a given population; however, it still remains the fastest growing major energy end-use by 2050.

The use of electricity is projected to grow faster than that of any other final form of energy worldwide, by 2.8% per year from 2005 to 2030. Electricity consumption more than doubles over that period, while its share in total final energy consumption rises from 18% to 23%. Electricity use expands most rapidly in non-OECD countries as the number of people with access to electricity and per capita consumption increase. Natural gas consumption in end uses continues to increase steadily, mainly driven by industrial demand in developing countries and by the residential sector in OECD countries. The share of gas in total final consumption is projected to slightly increase from 17% in 2005 to 18% in 2030. Although conventional oil-based fuels are expected to remain the dominant source of energy for road, sea and air transportation, biofuels are also expected to make a growing contribution to transport energy needs over the projection period (Box 17.3). The final use of coal is projected to rise slowly, its share of total final consumption falling from 9% in 2005 to 8% in 2030.

In per capita terms, final energy consumption is projected to rise in all regions (Figure 17.4). Between 2005 and 2030, per capita consumption is projected to increase 20% in the OECD, 32% in BRIC and 36% in the rest of the world. It increases by more than 50% in Asia. Per capita demand rises less in OECD countries because of saturation effects and slower economic growth, yet in absolute terms is still projected to be much higher than in the rest of the world in 2030. Final energy use remains below 60 gigajoules (GJ) per capita in 2030 in the medium-income regions, such as Brazil, China region, and Latin America, and below 30 GJ/capita in the poorest regions – South Asia and Africa. In the OECD, it reaches 148 GJ/capita by 2030.

Figure 17.4. **Final energy consumption in the Baseline, 1970-2050**




StatLink http://dx.doi.org/10.1787/262028451155

*Source:* *OECD Environmental Outlook* Baseline.

## Policy implications

Based on current policies, rising consumption of fossil energy threatens to undermine the security of energy supply and exacerbate harmful environmental effects of energy use. Moreover, under current policies, much of the world's population will continue to have little or no access to modern energy services. In principle, establishing an environmentally sustainable energy system that is compatible with continued economic and social development is possible through changes in the fuel mix, more efficient use of energy, conservation and the use of new technologies such as carbon capture and storage (Box 17.4). But doing so will undoubtedly take several decades, given the slow pace of change in the physical energy infrastructure and in institutions, business practices and behaviour.

### *Technological developments*

Technology and innovation are key to achieving energy and environmental goals and are a central goal of environmental policy. Environmental and energy policies affect both the use of existing energy-related technologies and the development and use of new technologies in the future. Pricing pollution emitted by energy use through environmental policies is an important driver for technological innovation and change (Jaffe *et al.*, 2003). The main technological avenues for mitigating the environmental effects of energy, by curbing the growth in energy use and/or related emissions of greenhouse gases or other pollutants, are:

- Improving end-use energy efficiency and conservation through a variety of process and technical innovations.
- Increasing reliance on non-fossil sources and carriers of energy, including renewables (notably hydro and wind power, photovoltaic and thermal solar energy,[5] liquid biofuels for transport and sustainable biomass technologies) and nuclear power.



OECD ENVIRONMENTAL OUTLOOK TO 2030 – ISBN 978-92-64-04048-9 – © OECD 2008

- Improving efficiency of fossil-based power-generation technologies and switching to less carbon-intensive fuels (for example, from coal to gas).
- Using carbon capture and storage technology (Box 17.4).
- Using hydrogen technology.

Considerable progress could be made in making energy systems more sustainable by accelerating the uptake of state-of-the-art technologies that are already available (IEA, 2006a and b). These include cleaner and more efficient end-use equipment, vehicles and appliances, energy-efficient housing and less or zero carbon-intensive energy production. In many cases, such technologies are already competitive, yet are not widely used because of market barriers such as a lack of information or because they involve higher initial investment. In other cases, technologies are commercially proven, but may be more costly, even when the energy savings associated with their use are taken into account. The environmental, economic and social benefits of switching to such technologies may nonetheless outweigh the financial cost, justifying policy intervention. In the longer term, government action can accelerate the process of technology development (Box 17.4).

Box 17.4. **The outlook for energy technology**

A number of technologies currently being developed could improve energy efficiency significantly and mitigate the environmental effects of energy production and use. Prominent consumer demand-side technologies include plug-in hybrid vehicles, hydrogen fuel cells and zero-energy building designs. In power generation, research is focused on solar photovoltaics and concentrating solar power, in combination with long-distance electricity transportation, ocean energy, offshore wind turbines, hot dry rock geothermal, large-scale storage systems for intermittent power sources and distributed power generation. New nuclear reactor designs are also the subject of research. Analysis carried out by the IEA (see Box 17.5) suggests that efficiency improvements in end-uses could contribute up to half of the reduction in carbon dioxide emissions by 2050 in an accelerated technology scenario (IEA, 2006b) and these conclusions were recently confirmed by the IPCC (2007).

Carbon capture and storage (CCS) in geological formations is also a promising possibility. There are many different types of technologies that can be used to capture, transport and store $CO_2$, and these technologies are at different stages of development. The capture and transportation of carbon dioxide has been carried out for decades, albeit generally on a small scale and not with the purpose of ultimately storing it. There is a need to improve these technologies for use on a large scale and to lower the cost. At present, most CCS research and development is focused on post-combustion capture from burning fossil fuels in power plants. Much more work also needs to be done on carbon storage to demonstrate its viability and reduce the cost.

### *Economic instruments*

Economic instruments, including taxes and subsidies (applied to the sale of fuels or to purchase energy-related equipment), mandatory emissions caps and trading, can be used to internalise the environmental externalities of energy production and use, and encourage the use of existing cleaner technologies and the development of new ones (see also Chapter 7 on climate change). Indeed, emissions trading schemes are already in place or planned in most OECD countries, as well as elsewhere: a cap and trade scheme is already in place in Norway and EU25 (to be extended to EU27 in January 2008); a small voluntary scheme is in place in

### Box 17.5. **IEA technology scenarios**

The IEA scenarios lay out five different accelerated technology (ACT) energy futures and one TECH Plus Scenario. They are based on the same macroeconomic assumptions and underlying demand for energy services as used by the IEA in its Reference Scenario in the *World Energy Outlook 2005*. These scenarios do not consider the option of reducing the demand for energy services, such as restricting personal travel activity. Instead, they investigate the potential of energy technologies and best practices for reducing energy demand and emissions, and diversifying energy sources.

- Map Scenario (MAP) is optimistic in all technology areas: barriers to CCS are overcome, with costs reduced to USD 25/t $CO_2$ or less; cost reductions for renewable energy continue with increased deployment through learning effects; expansion of nuclear capacity occurs where it is economic to reduce $CO_2$ emissions and is acceptable; and progress in energy efficiency is accelerated as a result of successful policies. The other scenarios are mapped against the results of this scenario.
- Low Renewable Scenario (Low RenEn) assumes slower cost reductions for wind and solar.
- Low Nuclear Scenario reflects the limited growth potential of nuclear if public acceptance remains low, and nuclear waste non-proliferation issues remain significant.
- No CCS Scenario assumes that the technological issues facing CCS remain unsolved.
- Low Efficiency Scenario assumes less effective energy-efficiency policies.
- Technology Plus (TECH Plus) assumes faster technical progress.

Japan; and Switzerland, New Zealand, Australia, Canada, and several individual US states have all made proposals for emissions trading schemes that could be implemented within the next few years (Reinaud and Philibert, 2007; Ellis and Tirpak, 2006). A handful of OECD countries have also established – or are planning to implement – carbon taxes that are levied on selected uses of fossil fuels, electricity and/or heat.

Removing or reforming existing subsidies to energy production and use would also lead to price incentives to increase energy efficiency and switch to cleaner fuels. This has also been undertaken in some countries, *e.g.* Germany, which has provided tax relief for plants that generate both heat and power (IEA, 2007b).

#### *Regulations and government ownership*

A wide range of regulatory interventions in energy markets is in use today, including competition rules and environmental and technical standards. Minimum fuel-efficiency standards for equipment, appliances and vehicles, and labelling can be effective ways to encouraging the development and use of more efficient technology. Feed-in tariffs – the regulated price per unit of electricity that a utility or supplier has to pay for renewables-based electricity from private generators – have been used successfully in several countries. Other countries have preferred the use of renewable portfolio standards.

Direct government administration, management and control of energy resources and production are also common. Direct ownership can allow governments to dictate fuel and technology choices, such as the fuel mix in power generation. For example, the French government has been able to implement its preference for nuclear power through state ownership of the country's main electricity utility.

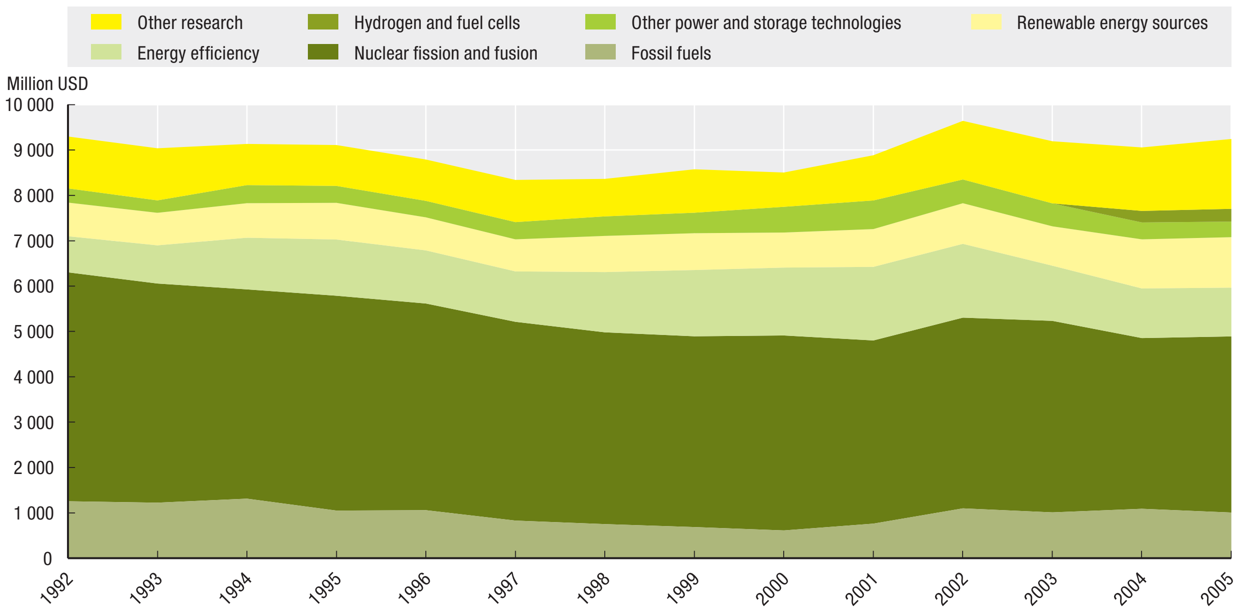


OECD ENVIRONMENTAL OUTLOOK TO 2030 – ISBN 978-92-64-04048-9 – © OECD 2008

### Research and development

Research and development (R&D) can be carried out directly by public organisations or indirectly through public financing of private-sector programmes. In practice, the level of commitment to R&D varies considerably across countries and over time, as well as among different fuels. In OECD countries, funding has increased since the mid-1990s. Despite some gains in funding for renewables, R&D funding remains heavily oriented to nuclear energy (Figure 17.5). In 2005, OECD country governments are estimated to have spent USD 9.6 billion in total to support R&D for energy, of which USD 1.1 billion was on energy efficiency and conservation, USD 1.1 billion on renewables, about USD 1 billion on fossil fuels and USD 3.9 billion on nuclear (IEA, 2007a; IEA, 2006c).

Figure 17.5. **Public energy research and development funding in IEA countries**




StatLink http://dx.doi.org/10.1787/262065785848

*Note:* Among OECD member states, only Iceland, Mexico, Poland and the Slovak Republic are not IEA members.

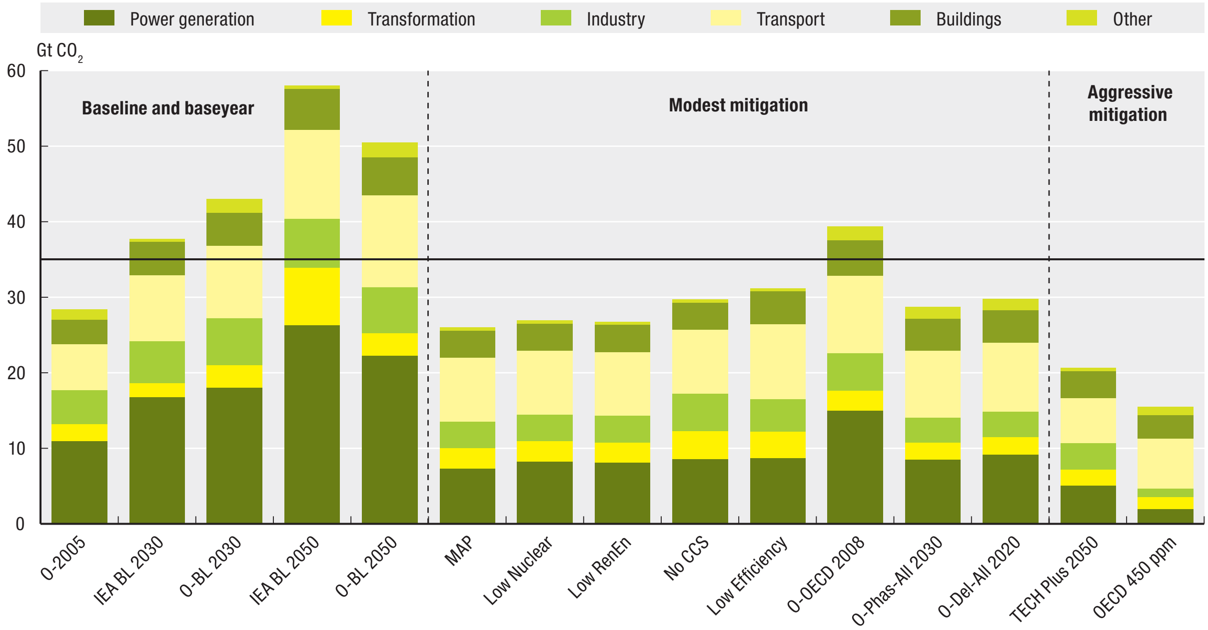
*Source:* IEA 2007, R&D database [accessed 4 July 2007].

## Climate change policy simulations

Successfully addressing the threat of climate change will undoubtedly involve major changes in the pattern and level of energy use and production. Climate change policies will need to provide timely incentives to industry to shift the energy economy away from conventional fossil-based energy technologies towards more efficient and cleaner options. The OECD *Outlook* considers a variety of different GHG mitigation strategies, using GHG emission taxes as a proxy for climate policy action (see Chapter 7 for a discussion of climate change and more detail on these policy simulations, as well as Chapter 20 on environmental policy packages).

Figure 17.6 compares $CO_2$ emissions by energy sector for the OECD *Outlook* base year (2005) and Baseline projections (to 2050) with future emissions under mitigation policy scenarios in the 2050 timeframe. It presents results from the IEA Accelerated Technology Scenarios (IEA, 2006b and see Box 17.5) alongside the OECD *Outlook* policy cases. Interestingly all mitigation scenarios show significant emission reductions in the power generation

Figure 17.6. **IEA and OECD selected policy scenarios: $CO_2$ from energy in 2005 and 2050**




StatLink http://dx.doi.org/10.1787/262084451755

*Note:* OECD Outlook cases are indicated with O-OECD; all other cases are from IEA (2006b). See Box 17.5 for further detail.

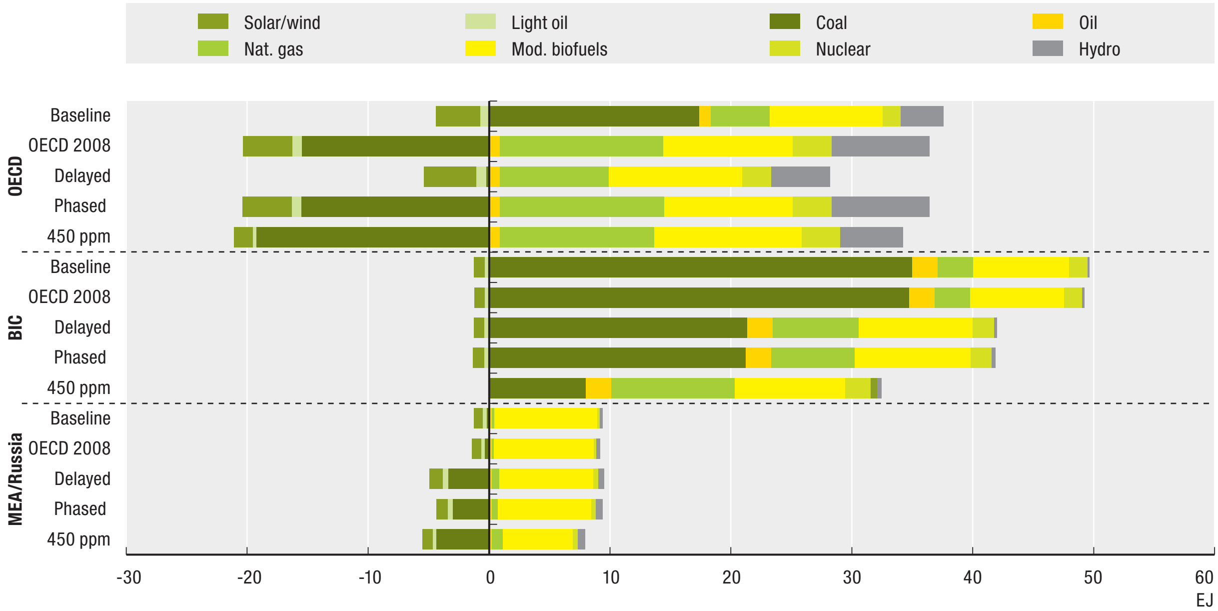
*Source:* Adapted from IEA (2006b), *Energy Technology Perspectives 2006: Scenarios and Strategies to 2050*, OECD, Paris (Figure 2.1, p. 46).

sectors, highlighting the importance of the introduction of cleaner fuels and more efficient technologies. The most aggressive (and more costly) mitigation scenarios (TECH Plus, All 2008 and 450 PPM stabilisation) achieve even greater emission reductions from the power sector compared to the more modest mitigation scenarios. By comparison transport emissions become the largest source of energy $CO_2$ emissions in 2050 across all scenarios, replacing power generation as the dominant source today and in the 2050 Baseline.

Figure 17.7 shows the effect of policy scenarios on primary energy use in power generation between 2005 and 2030. More aggressive and earlier mitigation policy in the OECD and Brazil, India and China (BIC) lead to significant reductions in coal use in this sector by 2030, and an increase in natural gas and modern biofuels (especially in BIC). While the OECD *Outlook* shows an increase under Baseline conditions in the power sector's use of coal, this trend will reverse under a climate policy constraint; across all policy scenarios coal use is projected to grow less in absolute terms relative to 2005, except the Delayed case where climate policy is not imposed until 2020 (in the OECD and elsewhere). The 450 PPM case also drives reductions in coal use in all countries, including in Brazil, India and China, compared to the situation under less stringent or no mitigation policy (Baseline) conditions; what coal remains in the power sector is likely to be coupled with CCS in the last half of the simulation period to 2050.

Figure 17.8 shows the Baseline (top line) and the 450 PPM case (lower line). It highlights how, in the 450 PPM case, a wide variety of technologies and end-use changes will be required to reduce emissions to these very low levels to 2050 and beyond. Energy efficiency measures are central, as are low-cost measures that reduce non-$CO_2$ greenhouse gases, land use and forestry, all of which combine in the near to medium-term to keep mitigation costs low. Also essential by 2020 to achieve this objective is the use of advanced biofuels, carbon capture and storage (CCS) technologies and increased renewables on a worldwide basis.

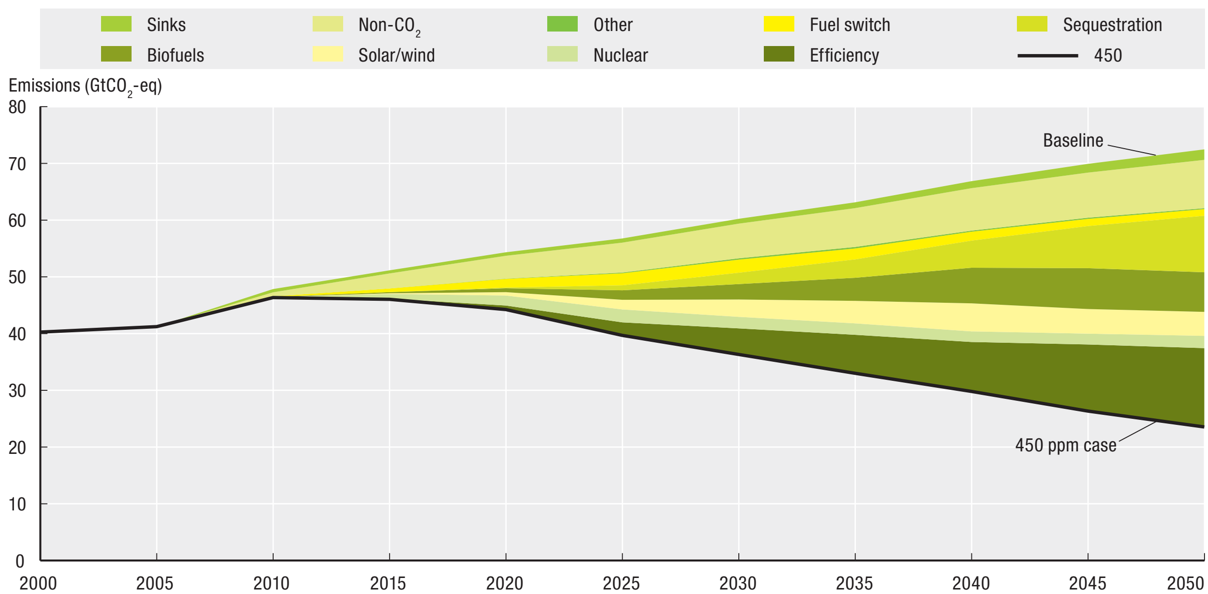
Figure 17.7. **Change in primary energy use in power generation by fuel and region: policy scenarios compared with Baseline, 2005-2030**




StatLink http://dx.doi.org/10.1787/262088583285

*Source:* *OECD Environmental Outlook* Baseline and policy simulations.

Figure 17.8. **450 ppm $CO_2$eq emission pathway compared to the Baseline: technology "wedges" of emission reduction**




StatLink http://dx.doi.org/10.1787/262100311684

*Source:* *OECD Environmental Outlook* Baseline and policy simulations.

The costs of achieving substantial $CO_2$ emission reductions are significant but manageable. Even for the most stringent of cases, they are estimated to be less than a few percent of GDP by 2050 (see Chapter 7, Climate change). However without an explicit mechanism for burden-sharing, cost-effective implementation of climate change goals suggests that the costs will be greatest in non-OECD regions. Thus any comprehensive agreement on climate change must seek a means to redistribute the costs of mitigation amongst participants in a manner that is perceived to be fair, while not compromising the effectiveness of the outcome.

In conclusion, achieving an environmentally sustainable energy system that is compatible with continued economic and social development is possible. However, substantial new policies will be needed to redirect and generate new investment for cleaner ways of supplying and consuming energy. Major technological advances and cost reductions, underpinned by these stronger government policies, can accelerate innovation in the energy sector and beyond to achieve aggressive environmental goals such as for climate change. There is a growing recognition on the part of policy-makers and the public generally that action is needed urgently to address the environmental challenges raised by our reliance on fossil energy.

Amongst the most pressing of environmental issues of the day is climate change. Seriously tackling global climate change requires significant new policies in the near-term. In particular, it will require "early action" and broad participation across all large emitting nations and sources in the near to medium-term to limit the risk of the most severe consequences in the long-term.

### *Notes*

1. Primary energy refers to energy in its initial form, after production or importation. World primary consumption includes international marine bunkers, which are excluded from the regional totals. Some primary energy is transformed, mainly in refineries, power stations and heat plants. Final consumption refers to consumption in end-use sectors, net of losses in transformation and distribution. The level and mix of fuels in primary energy use determine environmental effects.
2. China, South Asia and other Asia in the IMAGE model.
3. Electricity production is modelled here on the basis of electricity demand, which is met by fossil-fuel based power plants, biomass-based power plants, solar, wind, hydro and nuclear power. Fuel choice in each region is determined by a combination of the relative cost of each technology and government policy. Nuclear power and renewables inputs to generation are projected on a gross basis.
4. This discussion focuses on final energy delivered to end-users (as defined in IEA energy statistical terms) but does not consider the various end-uses and services provided by this energy. For example, roughly half of final energy uses provides heat (*e.g.* space heating of buildings, drying, washing or cooking, industrial process heat), with the remainder being used for work and light. Thinking about energy use in terms of these end-uses provides some insights into the requirements for alternative energy forms and systems.
5. The latter includes both concentrating solar power and solar thermal energy used as heat.

### *References*


CIAB (Coal Industry Advisory Board) (2006), *Regional Trends in Energy-Efficient, Coal-Fired Power Generation Technologies*, November, International Energy Agency, Paris.

Ellis, J. and D. Tirpak (2006), *Linking GHG Emission Trading Systems and Markets*, OECD/IEA Information Paper, *www.oecd.org/env/cc/aixg*.

IEA (International Energy Agency) (2005a), *World Energy Outlook: Middle East and North Africa Insights*, OECD, Paris.

IEA (2006a), *World Energy Outlook 2006*, OECD, Paris.

IEA (2006b), *Energy Technology Perspectives 2006: Scenarios and Strategies to 2050*, OECD, Paris.

IEA (2006c), *Energy Policies of IEA Countries: 2006 Review*, OECD, Paris.

IEA (2007a), *World Energy Outlook 2007*, OECD, Paris.

IEA (2007b), *Energy Policies of IEA Countries – Germany: 2007 Review*, OECD, Paris.

IPCC (Intergovernmental Panel on Climate Change) (2007), *Summary for Policymakers,* in B. Metz *et al.* (eds.), *Climate Change 2007: Mitigation, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK and New York.

Jaffe, A.B., R.G. Newell and R.N. Stavins (2003), "Technological Change and the Environment", in K.G. Mäler and J.R. Vincent (eds.), *Handbook of Environmental Economics*, Vol. 1, Elsevier Science, Amsterdam.

Reinaud, J. and C. Philibert (2007), *Emissions Trading: Trends and Prospects*, OECD/IEA Information Paper, *www.oecd.org/env/cc/aixg*.

ISBN 978-92-64-04048-9
OECD Environmental Outlook to 2030


# *Introduction: Context and Methodology*

## Purpose of the report

The purpose of the *OECD Environmental Outlook* is to help government policy-makers to identify the key environmental challenges they face, and to understand the economic and environmental implications of the policies that could be used to address those challenges.

The *Outlook* provides a baseline projection of environmental change to 2030 (referred to as "the Baseline"), based on projected developments in the underlying economic and social factors that drive these changes. The projections are based on a robust general equilibrium economic modelling framework, linked to a comprehensive environmental modelling framework (see below, and Annex B, for more details). Simulations were also run of specific policies and policy packages that could be used to address the main environmental challenges identified, and their economic costs and environmental benefits compared with the Baseline.

This is the second *Environmental Outlook* produced by the OECD. The first *OECD Environmental Outlook* was released in 2001, and provided the analytical basis on which ministers adopted an *OECD Environmental Strategy for the First Decade of the 21st Century*. This second *Outlook:*

- extends the projected baseline used in the first *Outlook* from 2020 to 2030, and even 2050 for some important areas;
- is based on a stronger and more robust modelling framework;
- focuses on the policies that can be used to tackle the main challenges;
- expands the country focus to reflect developments in both OECD and non-OECD regions and their interactions.

Many of the priority issues and sectors identified in this *Outlook* are the same as those highlighted as needing most urgent policy action in the first *OECD Environmental Outlook* (2001) and in the *OECD Environmental Strategy for the First Decade of the 21st Century*. These include the priority issues of climate change, biodiversity loss and water scarcity, and the key sectors exerting pressure on the environment (agriculture, energy and transport). Added to these is a new priority issue: the need to address the health impacts of the build-up of chemicals in the environment. The 2001 *Outlook* indicated the environmental challenges expected in the next couple of decades; this *Outlook* not only deepens and extends this analysis, it also focuses on the policy responses for addressing these challenges. It finds that the solutions are affordable and available if ambitious policy action is implemented today, and if countries work together in partnership to ensure comprehensive action, avoid competitiveness concerns and share the responsibility and costs of action fairly and equitably. This latest *Outlook* analyses the policies that can be used to achieve the *OECD Environmental Strategy*. It will provide the main analytical material to support discussions on further implementation of the *OECD Environmental Strategy* at the OECD Meeting of Environment Ministers planned for early 2008.

## Policy context

Why develop an environmental outlook? Many of the economic or social choices that are being made today – for example, investments in transport infrastructure and building construction, fishing fleets, purchase of solar heating panels – will have a direct and lasting affect on the environment in the future. For many of these, the full environmental impacts will not be felt until long after the decisions have been taken. These factors make policy decisions difficult: the costs of policy action to prevent these impacts will hit societies today, but the benefits in terms of improved environmental quality or damage avoided may only be realised in the future. For example, the greenhouse gases released today continue to build up in the atmosphere and will change the future climate, with serious impacts for the environment, the economy and social welfare.

But politicians tend to reflect the short-term interests of the voting public, not the long-term needs of future generations. They also tend to focus on the immediate costs and benefits to their own populations of a given policy approach, rather than on the global impacts. But many of the main environmental challenges countries face in the early 21st century are global or transboundary in nature, including global climate change, biodiversity loss, management of shared water resources and seas, transboundary air pollution, trade in endangered species, desertification, deforestation, etc. Building public understanding and acceptance of the policies that are needed to address these challenges is essential for policy reform.

These political challenges are exacerbated by uncertainty about the future. Often the exact environmental impacts of social and economic developments are poorly understood or disputed. In some cases, scientific uncertainty about environmental or health impacts is a main cause of policy inaction, while in others it is used as a justification for precautionary action. Scientific understanding and consensus about environmental change has been developing rapidly in a number of areas in recent years, for example through the 2005 Millennium Ecosystem Assessment and the 2007 IPCC Fourth Assessment Report on the Science of Climate Change. Despite the improvements in the scientific understanding of such issues, a gap remains in the development and implementation of effective environmental policies based on this scientific understanding.

This *Environmental Outlook* examines the medium to long-term environmental impacts of current economic and social trends, and compares these against the costs of specific policies that could be implemented today to tackle some of the main environmental challenges. The purpose is to provide more rigorous analysis of the costs and benefits of environmental policies to help policy-makers take better, more informed policy decisions now.

Many environmental problems are complex and inter-connected. For example, species loss is often the result of multiple pressures – including hunting, fishing or plant harvesting, loss of habitat through land use change or habitat fragmentation, impacts of pollutants – and thus a mix of policy instruments is needed to tackle the various causes of this loss. These policy packages need to be carefully designed in order to achieve the desired environmental benefits at the lowest economic cost. This *Outlook* examines the policy packages that could be used to tackle some of the key environmental challenges, and the framework conditions needed to ensure their success.

The transboundary or global nature of many of the most pressing environmental challenges identified in this *Outlook* require countries to increasingly work together in partnership to address them. The ways in which OECD environment ministries can work together in partnership with other ministries, stakeholder partners and other countries are explored in this *Outlook*.

### A special focus on the emerging economies in the *Outlook*

This *Outlook* identifies the main emerging economies as the most significant partners for OECD countries to work with in the coming decades to tackle global or shared environmental problems. This is because these countries are responsible for an increasingly large share of the global economy and trade, and thus have an increasing capacity to address these challenges, in part because their economies are so dynamic. Moreover, the pressures that they exert on the environment are also growing rapidly.

In some chapters, where data are available and relevant, the BRIICS countries (Brazil, Russia, India, Indonesia, China and South Africa) are highlighted for attention as a country grouping. In other chapters, the smaller country grouping of BRIC (Brazil, Russia, India and China) is examined, or even further disaggregated to each of these four countries individually. The BRIC grouping is used for most of the modelling projections and simulations in the *Outlook*.

## Modelling methodology and sources of information

The analysis presented in this *Environmental Outlook* was supported by model-based quantification. On the economic side, the modelling tool used is a new version of the OECD/World Bank JOBS/Linkages model, operated by a team in the OECD Environment Directorate and called ENV-Linkages. It is a global general equilibrium model containing 26 sectors and 34 world regions and provides economic projections for multiple time periods. It was used to project changes in sector outputs and inputs of each country or region examined to develop the economic baseline to 2030. This was extended to 2050 to examine the impacts of policy simulations in specific areas, such as biodiversity loss and climate change impacts. The economic baseline was developed with expert inputs from, and in co-operation with, other relevant parts of the OECD, such as the Economics Department, the International Energy Agency and the Directorate for Food, Agriculture and Fisheries.

The Integrated Model to Assess the Global Environment (IMAGE) of the Netherlands Environmental Assessment Agency (MNP) was further developed and adjusted to link it to the ENV-Linkages baseline in order to provide the detailed environmental baseline. IMAGE is a dynamic integrated assessment framework to model global change, with the objective of supporting decision-making by quantifying the relative importance of major processes and interactions in the society-biosphere-climate system. The IMAGE suite of models used for the *Outlook* comprises models that also appear in the literature as models in their own right, such as FAIR (specialised to examine burden sharing issues), TIMER (to examine energy), and GLOBIO3 (to examine biodiversity). Moreover, for the *Outlook* the IMAGE suite included the LEITAP model of LEI at Wageningen and the WaterGap model of the Center for Environmental Systems Research at Kassel University. IMAGE and associated models provided the projections of impacts on important environmental endpoints to 2030, such as climate, biodiversity, water stress, nutrient loading of surface water, and air quality. Annex B provides a more detailed description of the modelling framework and main assumptions used for the *Outlook* report.

The Baseline Reference Scenario presents a projection of historical and current trends into the future. This Baseline indicates what the world would be like to 2030 if currently existing policies were maintained, but *no new policies* were introduced to protect the environment. It is an extension of current trends and developments into the future, and as such it does not reflect major new or different developments in either the drivers of environmental change or environmental pressures. A number of major changes are possible in the future, however, that would significantly alter these projections. A few of these were examined as "variations" to the Baseline, and their impacts are described in Chapter 6 to show how these changes might affect the projections presented here.

Because the Baseline reflects no new policies, or in other words it is "policy neutral", it is a reference scenario against which simulations of new policies can be introduced and compared. Simulations of specific policy actions to address key environmental challenges were run in the modelling framework. The differences between the Baseline projections and these policy simulations were analysed to shed light on their economic and environmental impacts.

The simulations undertaken for the *Environmental Outlook* exercise are illustrative rather than prescriptive. They indicate the type and magnitude of the responses that might be expected from the policies examined, rather than representing recommendations to undertake the simulated policy actions. As relevant, some of the policy simulation results are reflected in more than one chapter. The table below summarises the policy simulation analyses and lists the different chapters containing the results.

Sensitivity analysis was undertaken to test the robustness of key assumptions in ENV-Linkages, and some of the results of this analysis are presented in Annex B. This, in conjunction with the Baseline variations described in Chapter 6, provides a clearer picture for the reader of the robustness of the assumptions in the Baseline.

Throughout the *Outlook*, the analysis from the modelling exercise is complemented by extensive data and environmental policy analysis developed at the OECD. Where evidence is available, specific country examples are used to illustrate the potential effects of the policies discussed. Many of the chapters in this *Outlook* have been reviewed by the relevant Committees and Expert Groups of the OECD, and their input has strengthened the analysis.

The *Outlook* is released at about the same time as a number of other forward-looking environmental analyses, such as UNEP's Fourth Global Environment Outlook (GEO-4); the IPCC Fourth Assessment Report (AR-4); the International Assessment of Agricultural Science and Technology for Development supported by the World Bank, FAO and UNEP; and the CGIAR Comprehensive Assessment of Water Use in Agriculture. Through regular meetings and contacts, efforts have been made by the organisations working on these reports to ensure co-ordination and complementarity in the studies, and to avoid overlap. The *OECD Environmental Outlook* differs from most of the others in its emphasis on a single baseline reference scenario against which specific policy simulations are compared for the purpose of policy analysis. Most of the others explore a range of possible "scenarios", which provide a useful communication tool to illustrate the range of possible futures available, but are less amenable to the analysis of specific policy options. The *OECD Environmental Outlook* also looks at developments across the full range of environmental challenges, based strongly on projected developments in the economic and social drivers of environmental change, while many of the other forward-looking analyses focus on a single environmental challenge.

Table I.1. **Mapping of the *OECD Environmental Outlook* policy simulations by chapter**

| Simulation title | Simulation description | Chapters in which the results are reflected | Models used |
|---|---|---|---|
| Baseline | The "no new policies" Baseline used throughout the *OECD Environmental Outlook*. | All chapters | ENV-Linkages; IMAGE suite |
| Globalisation variation | Assumes that past trends towards increasing globalisation continue, including increasing trade margins (increasing demand by lowering prices in importing countries) and reductions in invisible costs (*i.e.* the difference between the price at which an exporter sells a good and the price that an importer pays). | 4. Globalisation<br>6. Key variations to the standard expectation | ENV-Linkages; IMAGE suite |
| High and low growth scenarios | Variation 1: High economic growth – examines impacts if recent high growth in some countries (*e.g.* China) continues, by extrapolating from trends from the last 5 years of growth rather than the last 20 years.<br>Variation 2: Low productivity growth – assumes productivity growth rates in countries converge towards an annual rate of 1.25% over the long-term, rather than 1.75% as in the Baseline.<br>Variation 3: High productivity growth – assumes productivity growth rates in countries converge towards an annual rate of 2.25% over the long-term. | 6. Key variations to the standard expectation | ENV-Linkages |
| Greenhouse gas taxes | Implementation in participating countries of a tax of USD 25 on $CO_2$eq, increasing by 2.4% per annum.<br>OECD 2008: only OECD countries impose the tax, starting in 2008.<br>Delayed 2020: all countries apply the tax, but starting only in 2020.<br>Phased 2030: OECD countries implement the tax from 2008; BRIC countries from 2020, and then the rest of the world (ROW) from 2030 onwards.<br>All 2008: in a more aggressive effort to mitigate global GHG emissions, all countries implement the USD 25 tax from 2008. | 7. Climate change<br>13. Cost of policy inaction (Delayed 2020)<br>17. Energy<br>20. Environmental policy packages | ENV-Linkages; IMAGE suite |
| Climate change stabilisation simulation (450 ppm) | Optimised scenario to reach a pathway to stabilise atmospheric concentrations of GHG at 450 ppm $CO_2$eq over the longer term and limit global mean temperature change to roughly 2 °C.<br>A variation on this case was developed to explore burden-sharing, using a cap and trade approach to implementation. | 7. Climate change<br>13. Cost of policy inaction<br>17. Energy<br>20. Environmental policy packages | ENV-Linkages; IMAGE suite |
| Agriculture support and tariff reform | Gradual reduction in agricultural tariffs in all countries to 50% of current levels by 2030.<br>Gradual reduction in production-linked support to agricultural production in OECD countries to 50% of current levels by 2030. | 9. Biodiversity<br>14. Agriculture | ENV-Linkages |
| Policies to support biofuels production and use | Demand for biofuels growing in line with the IEA *World Energy Outlook* (2006) scenario.<br>DS: a scenario whereby growth in biofuel demand for transport is driven by exogenous changes, keeping total fuel for transport close to the Baseline.<br>OilS: a high crude oil price scenario to determine the profitability of biofuel in the face of increasing costs of producing traditional fossil-based fuels.<br>SubS: a subsidy scenario in which producer prices of biofuels are subsidised by 50%. | 14. Agriculture | ENV-Linkages |
| Fisheries | Global fisheries cap and trade system, representing a 25% reduction in open fisheries catch, with trading allowed within six geographical regions. | 15. Fisheries and aquaculture | ENV-Linkages |
| Steel industry $CO_2$ tax | Implementation of a carbon tax of 25 USD per tonne $CO_2$, applied respectively to OECD steel industry only, all OECD sectors, and all sectors worldwide. | 19. Selected industries – steel and cement | ENV-Linkages |
| Policy mix | Three variations of policy packages were modelled, depending on the participating regions:<br>OECD countries only<br>OECD + BRIC<br>Global<br>The policy packages included:<br>• reduction of production-linked support and tariffs in agriculture to 50% of current levels by 2030.<br>• tax on GHG emissions of USD 25 tax $CO_2$eq, increasing by 2.4% per annum (phased with OECD starting in 2012, BRIC in 2020, ROW in 2030).<br>• moving towards, although not reaching, Maximum Feasible Reduction in air pollution emissions, phased over a long time period depending on GDP/capita.<br>• assuming that the gap to connecting all urban dwellers with sewerage will be closed by 50% by 2030, and installing, or upgrading to the next level, sewage treatment in all participating regions by 2030. | 8. Air pollution<br>10. Freshwater<br>12. Health and environment<br>20. Environmental policy packages | ENV-Linkages; IMAGE suite |

## Structure of the report

The *OECD Environmental Outlook* is divided into two main parts:

*i)* *The World to 2030 – the Consequences of Policy Inaction:* describes the Baseline, *i.e.* the projected state of the world to 2030 in terms of the key drivers of environmental change and the developing environmental challenges, as well as analysing some possible variations to the Baseline.

*ii)* *Policy Responses:* focuses on the policy responses at both the sectoral level and in terms of implementing a more comprehensive and coherent policy package.

The first part describes the key elements of the Baseline to 2030, including the main drivers of environmental change (consumption and production patterns, technological innovation, population dynamics and demographic change, economic development, globalisation, and urbanisation) and the key environmental challenges (climate change, air pollution, biodiversity, freshwater, waste and material flows, health and environment). For each of these, the key recent trends and projections to 2030 are presented, as well as some of the policy approaches that are being used to address the environmental challenges. Chapter 6 describes some key variations to the Baseline – for example, how the Baseline would differ if key economic drivers (such as economic growth or global trade) were changing faster than projected in the Baseline. The chapter also explores other sources of uncertainty in the *Outlook* projections. Finally, this first part of the report examines the consequences and costs of policy inaction – essentially the environmental, health and economic impacts embodied in the "no new policies" Baseline scenario.

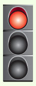
The second part of the *Outlook* report examines the possible policy responses to address the key environmental challenges, and assesses the economic and environmental impact of these responses. The key sectors whose activities affect the environment are examined, with a brief summary of the trends and outlook for their impacts, followed by an assessment of the policy options that could be applied in that sector to reduce negative environmental impacts. This section assesses the environmental benefits of specific policy options and their potential costs to the sector involved and/or economy-wide (and disaggregated by region where appropriate). This analysis can be used by environment ministries in discussing specific policy options for tackling environmental challenges with their colleagues in other ministries, such as finance, agriculture, energy or transport. The sectors examined include those that were prioritised in the *OECD Environmental Strategy* – agriculture, energy and transport – and also other sectors which strongly affect natural resource use or pollution, such as fisheries, chemicals and selected industries (steel, cement, pulp and paper, tourism and mining).

In addition to analysing sector-specific policies, this part of the *Outlook* also examines the effects of a package of policies (the EO policy package) to tackle the main environmental challenges. The analysis of this EO policy package highlights the potential synergies between policies (*i.e.* where the benefits of combining two or more policies may be greater than the simple sum of their benefits as separate policies), or potential conflicts where policies may undermine each other. Chapter 21 outlines the key framework conditions needed to ensure the successful identification and implementation of appropriate environmental policies at the national level, in particular institutional capacity and policy implementation concerns. Chapter 22, on global environmental co-operation, highlights the issues for which OECD countries will need to work together in partnership with other countries in order to reduce overall costs of policy implementation and maximise benefits. It also assesses the costs of inaction.

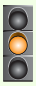
 

### Traffic lights in the *OECD Environmental Outlook*

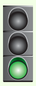
As with the 2001 *Outlook*, this report uses traffic light symbols to indicate the magnitude and direction of pressures on the environment and environmental conditions. Traffic lights are used to highlight the key trends and projections in the summary table in the Executive Summary, in the Key Messages boxes at the start of each chapter and throughout the chapters. The traffic lights were determined by the experts drafting the chapters, and then refined or confirmed by the expert groups reviewing the report. They represent the following ratings:



**Red lights** are used to indicate environmental issues or pressures on the environment that require urgent attention, either because recent trends have been negative and are expected to continue to be so in the future without new policies, or because the trends have been stable recently but are expected to worsen.



**Yellow lights** are given to those pressures or environmental conditions whose impact is uncertain, changing (*e.g.* from a positive or stable trend toward a potentially negative projection), or for which there is a particular opportunity for a more positive outlook with the right policies.



**Green lights** signal pressures that are stable at an acceptable level or decreasing, or environmental conditions for which the outlook to 2030 is positive.

While the traffic light scheme is simple, thus supporting clear communication, it comes at the cost of sensitivity to the often complex pressures affecting the environmental issues examined in this *Outlook*.

While each of the individual chapters discusses the regional developments for the drivers or environmental impacts analysed, Annex A also provides an easily accessible "summary" of the economic, social and environmental developments in the Baseline for each region. Annex B provides a more detailed analysis of the modelling framework used in the development of the *OECD Environmental Outlook*. A number of background working papers, which provide further information on specific issues addressed in the *Outlook*, were developed to complement the report (see: *www.oecd.org/environment/outlookto2030*).

# *Table of Contents*

## II. Impacts of Environmental Change

## POLICY RESPONSES

## III. Sectoral Developments and Policies

## IV. Putting the Policies Together

**List of boxes**

**List of tables**

OECD ENVIRONMENTAL OUTLOOK TO 2030 – ISBN 978-92-64-04048-9 – © OECD 2008

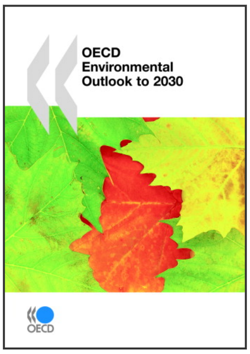
**List of figures**

## Acronyms and Abbreviations

| | |
|---|---|
| **BRIC** | Brazil, Russia, India and China |
| **BRIICS** | Brazil, Russia, India, Indonesia, China and South Africa |
| **CBD** | Convention on Biological Diversity |
| **CCS** | Carbon capture and storage |
| **CDM** | Clean Development Mechanism |
| **CFC** | Chlorofluorocarbon |
| **$CH_4$** | Methane |
| **CO** | Carbon monoxide |
| **$CO_2$** | Carbon dioxide |
| **$CO_2eq$** | Carbon dioxide equivalents |
| **CSD** | Commission on Sustainable Development |
| **DAC** | OECD Development Assistance Committee |
| **EJ** | Exajoules |
| **EU15** | Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom |
| **EU25** | Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom |
| **EUR** | Euro (currency of European Union) |
| **FAO** | Food and Agriculture Organization of the United Nations |
| **GBP** | Pound sterling |
| **GDP** | Gross domestic product |
| **GHG** | Greenhouse gas |
| **GJ** | Gigajoules |
| **GNI** | Gross national income |
| **Gt** | Giga tonnes |
| **GW** | Gigawatt |
| **HFC** | Hydrofluorocarbon |
| **IEA** | International Energy Agency |
| **IMAGE** | Integrated Model to Assess the Global Environment |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **LULUCF** | Land use, land use change and forestry |
| **MAD** | Mutual Acceptance of Data |
| **MDGs** | Millennium Development Goals |
| **MEA** | Multilateral environmental agreement |
| **MNP** | Netherlands Environmental Assessment Agency |
| **MSA** | Mean species abundance |

| | |
|---|---|
| **Mt** | Million tonnes |
| **MWh** | Megawatt-hour |
| **$NO_2$** | Nitrogen dioxide |
| **$N_2O$** | Nitrous oxide |
| **$NO_x$** | Nitrogen oxides |
| **ODA** | Official development assistance |
| **ppb** | Parts per billion |
| **ppm** | Parts per million |
| **PFC** | Perfluorocarbon |
| **PM** | Particulate matter |
| **$PM_{2.5}$** | Particulate matter, particles of 2.5 micrometres (µm) or less |
| **$PM_{10}$** | Particulate matter, particles of 10 micrometres (µm) or less |
| **ppmv** | Parts per million by volume |
| **ROW** | Rest of world |
| **RTA** | Regional trade agreement |
| **$SO_2$** | Sulphur dioxide |
| **$SO_x$** | Sulphur oxides |
| **$SF_6$** | Sulphur hexafluoride |
| **TWh** | Terawatt hour |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **USD** | United States dollar |
| **VOC** | Volatile organic compound |
| **WHO** | World Health Organization |
| **WSSD** | World Summit on Sustainable Development |
| **WTO** | World Trade Organization |


OECD ENVIRONMENTAL OUTLOOK TO 2030 – ISBN 978-92-64-04048-9 – © OECD 2008




**From:**

## OECD Environmental Outlook to 2030

**Access the complete publication at:**

https://doi.org/10.1787/9789264040519-en

**Please cite this chapter as:**

OECD (2008), “Energy”, in *OECD Environmental Outlook to 2030*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/9789264040519-19-en