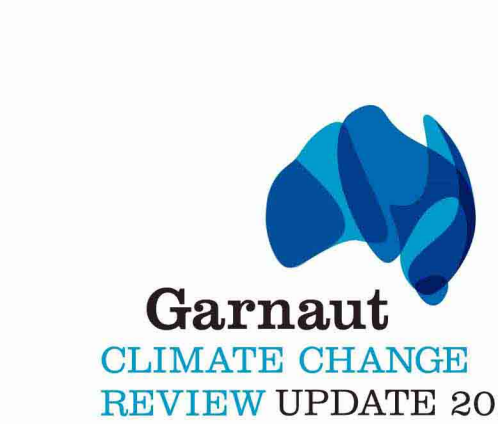
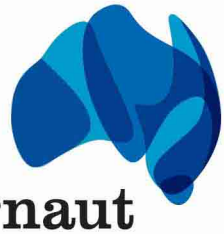


3

Global emissions trends

Update Paper 3



Garnaut CLIMATE CHANGE REVIEW UPDATE 2011

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Garnaut Climate Change Review – Update 2011

Update Paper three:

Global emissions trends

Ross Garnaut

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GLOBAL EMISSIONS TRENDS

Key points

- Without mitigation, and in the absence of negative feedback from climate change, global emissions will double between 2005 and 2030. This updated business as usual projection is in line with the projections of the 2008 Review.

- The shift in global growth momentum towards developing countries discussed in the 2008 Review has become more pronounced.

    - Developing countries are now projected to account for 70 per cent of global emissions at 2030 under the business as usual scenario, compared with the Review's projection of 63 per cent.

    - China and India are growing strongly, and other developing countries are also experiencing an acceleration of growth that began in the early twenty first century.

    - China is heading towards developed country income levels even more rapidly than anticipated in the 2008 Review, and therefore will need to accept developed country emissions constraints at an earlier date, if global objectives are to be met.

    - China's Copenhagen mitigation commitments to 2020 are stronger than anticipated by the 2008 Review, providing a platform for what will subsequently be required.

- The Great Crash of 2008 has pushed the developed countries of the northern hemisphere onto a lower long-term economic growth trajectory. This and other factors will result in lower underlying emissions growth in developed countries, but is fully offset by stronger emissions growth in the developing world.

- There has been a large recent expansion of known gas reserves that has reduced the relative price of gas and which may provide significant opportunity for reductions in business as usual emissions over the next decade beyond what is anticipated in these projections.

- Australia is unique among the developed countries: its business as usual emissions are set to grow considerably.

    - Growth in projected business-as-usual emissions is primarily due to expected strength in the resources sector in the years ahead.

    - The Department of Climate Change and Energy Efficiency estimates that Australia's emissions are projected to rise by 24 per cent above 2000 levels by 2020, under current policies (which are below 'business as usual').

- Mitigation efforts in higher income developing countries will need to be stronger and earlier, and other developing countries will need to be brought within emissions constraints sooner than once may have seemed necessary.

- This is unlikely to be possible without an acceleration of mitigation effort in the developed countries. Achieving a given abatement target has become easier in most developed countries, given lower growth prospects.

Table of contents

List of figures, tables and boxes

1. Introduction

This Update paper re-examines likely trends in global emissions in the absence of effective mitigation and in the absence of major feedbacks from climate change to economic growth. It analyses changes in the variables affecting emissions growth (namely population, economic output, energy demand, and the economic and technological factors affecting the choice among sources of energy) in major countries and regions. It explores the implications of the Great Crash of 2008, which lowered the long-term growth trajectory of developed countries, but did not slow the immense growth momentum of the largest developing countries, nor end the higher growth of the early twenty first century in other developing countries.

This paper provides an update of observed global emissions to 2009, and updates business as usual projections to 2030. The projections provide a basis for reassessing the task of reducing global emissions and the distribution of that effort among developed and developing countries.

The paper is a building block in the construction of a revised internally consistent set of emissions targets for all countries that can meet various objectives for constraining concentrations of atmospheric emissions and therefore risks of dangerous climate change. While it is in two important ways an artificial task, it nevertheless provides essential perspective on the global emissions reduction challenge.

It is artificial because it assumes that no mitigation policies are already in place. The reality is that established mitigation policies have bent the anticipated trajectory of future emissions significantly downwards from business as usual in many developed countries and in the major developing countries—most notably China. The paper discusses the recent assessment of the International Energy Agency on the effects of established policy—while noting that the Agency may still (after major upward adjustments from 2008) have underestimated the likely growth in developing countries that underlie these projections.

The projections do not take into account the effects of mitigation policies on emissions, nor do they take account of the costs of mitigation on economic growth and therefore on associated emissions. In reality, these are likely to be modest if economically efficient approaches are adopted, but potentially high if they take the form of discretionary and variable interventions. The costs would be highest of all if, as with protection in the first eight decades of the Australian Federation, they were associated with opportunities for firms to obtain preferment through the application of pressure and influence on the policy process, and resulting in major diversion of corporate effort from productive enterprise.

The exercise is also artificial in not taking into account the possibility of diminution of growth as a result of climate change over the next two decades. As discussed in the 2008 Review, the science informs us that the effects of the growth in atmospheric concentrations of greenhouse gases are experienced with a lag of perhaps several decades. The science advises us that the increase in global average temperatures that has already occurred—a bit less than one degree over pre-industrial levels—is the result of changes in atmospheric concentrations that were in place several decades ago. The greenhouse gas concentrations that are already in place will be the main determinants of warming in the period to 2030. Nevertheless, these effects, although representing the early stages of anthropogenic warming, may be significant—for example through the intensification of extreme weather events. Extreme weather events may affect (and may be affecting) global food production and the levels and volatility of food prices. It is possible that in some countries, food price volatility and other manifestations of extreme events may affect the stability of political systems in ways that feed back negatively into economic growth. These risks of feedback from climate change to economic growth can be seen as part of the risks of disorder to any long-term economic projections.

Lower rates of growth associated with political disorder in individual states, or in the international system, or declines in the quality of economic decision-making, are unlikely to be helpful to the reductions in emissions. The effects of lower growth on emissions are likely to be greatly outweighed by lower priority of, and effectiveness in, mitigation policies.

1.1 Findings of the 2008 Garnaut Climate Change Review

The 2008 Garnaut Climate Change Review (the Review) developed new projections of global business as usual emissions growth, with a particular focus on the growth prospects of large developing countries. It embodied more realistic expectations of economic growth, the energy intensity of economic output and emissions intensity of the energy supply than at the time had been applied by the Intergovernmental Panel on Climate Change, the International Energy Agency and other international organisations.

The Review showed that, without steps to cut greenhouse gas emissions, the level of global emissions would be substantially higher than had been predicted in the most commonly used IPCC emissions scenarios, principally because of the prospect of higher rates of carbon-intensive growth in the large developing countries. The Review contributed to the widespread realisation that, without effective global mitigation action, the world was set for a much higher emissions trajectory than had hitherto been anticipated.

The Review showed that economic growth, energy demand and the carbon intensity of energy in China and other large developing countries were all substantially above previous expectations. China alone would account for 37 per cent of global business as usual emissions by 2030 and developing countries overall for 63 per cent. Further, developing countries would account for about 84 per cent of the increase in global emissions to 2030.

The Update finds that developments since 2008 have left the trajectory for global emissions in the absence of effective mitigation policy largely unchanged. However, the balance is shifting even more strongly towards developing countries. This has important implications for global climate policy.

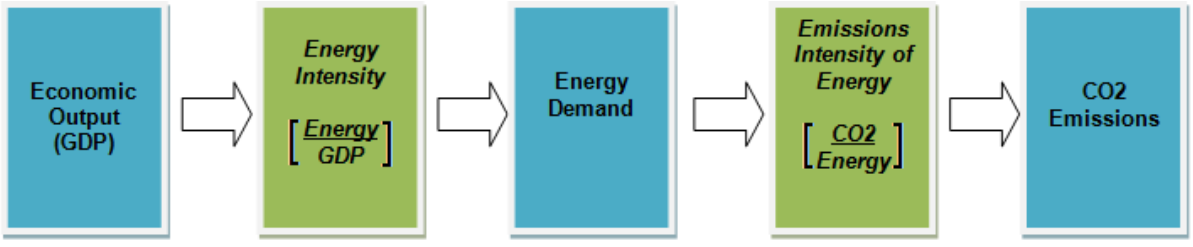
Australia is the exception to the general story for developed countries, with projected strong momentum in business as usual emission growth.

1.2 Framework of analysis and methodology

Projections of business as usual emissions start with a consideration of projections of economic output. The projections of output take into account trends in population growth, productivity and investment. Then judgements are made as to the likely energy intensity of this projected growth in output from which overall demand for energy can be derived. Finally judgements are applied regarding the emission intensity of energy demand which allows us to derive projections of carbon dioxide (CO_2) emissions. Changes in the emission intensity of energy demand will reflect different sources of energy supply, developments in energy efficiency and related technological developments.

The chain, linking economic output to energy demand and energy demand to carbon emissions, is displayed graphically below.

Figure 1: The decomposition of emissions growth



Emission projections in the Update cover carbon dioxide emissions from the combustion of fossil fuels, but do not cover carbon emissions from other sources (such as sequestration) and emissions of other greenhouse gases. The analysis covers almost 60 per cent of total global carbon dioxide equivalent (CO_2-e) emissions (Garnaut 2008, p53). This coverage represents most of the projected future growth in CO_2-e emissions.

The business as usual projection in this paper represents a world without policy to moderate climate change. This scenario is distinct from an 'existing policies' scenario, such as that used by the

International Energy Agency, which projects lower emissions to the extent that existing policy has been effective. While a business as usual case is increasingly difficult to construct due to the expansion existing climate policies, business as usual projections are an important reference point for assessing the size of the challenge the global community faces to reduce carbon emissions.

Section 2 of the paper describes the change in global emissions between 2005 and 2010, including the impact of the Great Crash of 2008. It draws comparisons between the experiences of developing and developed countries during this period. Section 3 provides projections for emissions between 2010 and 2030. Section 4 provides analysis of the differences between developed countries and developing countries. Australia's recent emissions and trends are discussed separately in Box 2.

2. Recent trends in global emissions

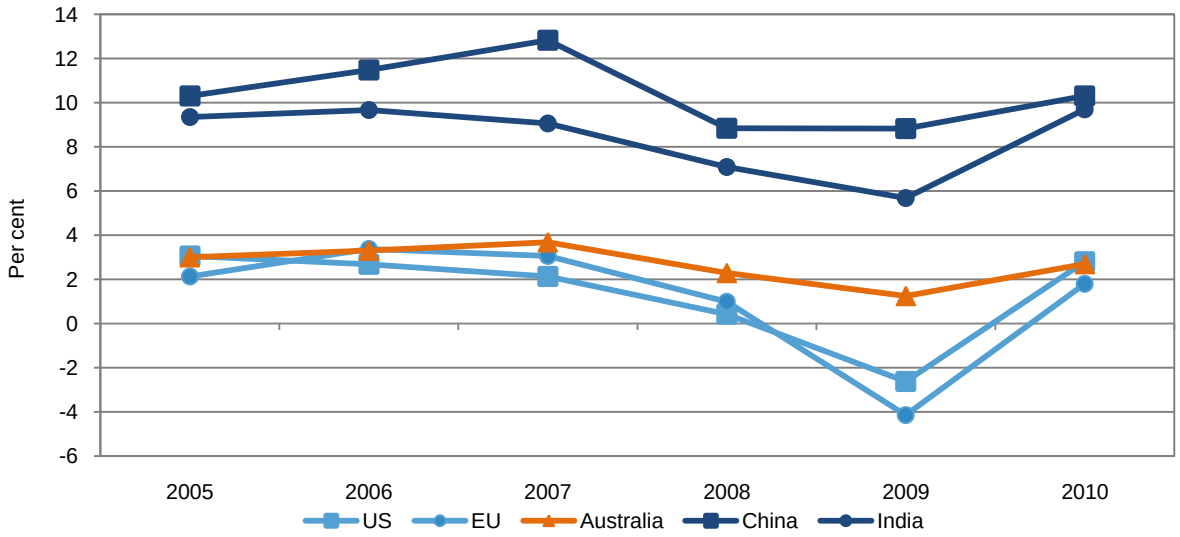
This section uses the framework outline above to describe recent trends in global emissions.

2.1 Economic growth

Through late 2008 and early 2009, the world experienced a sharp contraction of economic output (Garnaut with Llewellyn-Smith 2009). As discussed in Update Paper two (*Progress towards effective global action on climate change*), the sharp financial shock of the Great Crash of 2008 was followed by most developed and many developing countries implementing large scale fiscal and monetary stimulus.

The Great Crash reflected a pronounced economic downturn in most of the developed world, but only a temporary deceleration of growth in developing countries (Figure 2). Australia is unlike most developed countries in this respect, with the slowdown in growth being only modest.

Figure 2: GDP growth in selected countries, 2005 to 2010



Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing"; IMF, 2011, "World Economic Outlook Update Jan 2011. "World Economic Outlook Update: Global Recovery Advances but Remains Uneven"; and, ABS, 2010, "Catalogue 5206: Australian National Accounts: National Income, Expenditure and Product, Sep 2010".

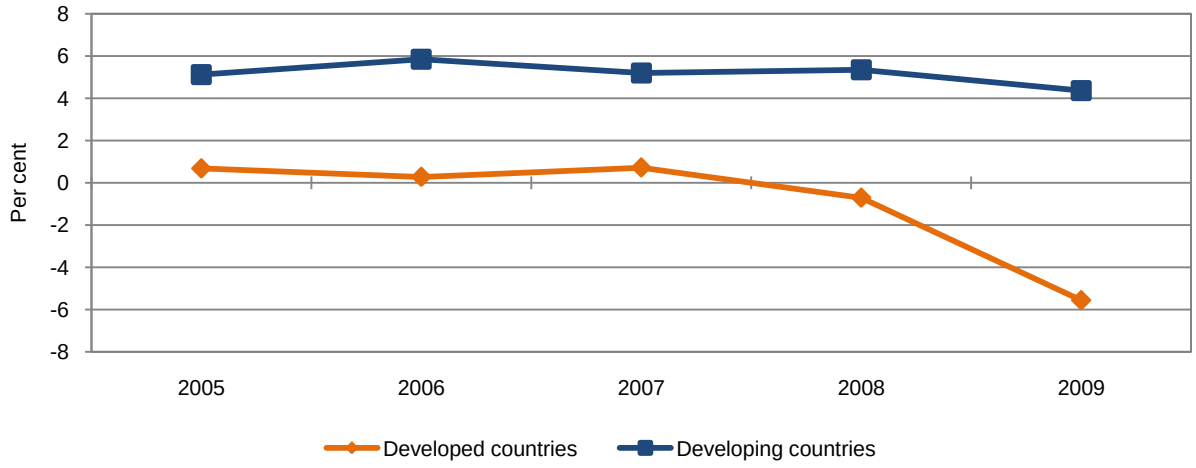
While the recovery is underway in much of the developed world, the Great Crash has shifted the developed countries of the northern hemisphere onto a lower long-term growth trajectory. It has left most of Western Europe and the United States with an awful legacy of unemployment, public sector debt and financial vulnerability that have sapped the confidence of communities and weakened the influence and power of even the most able leaders (Garnaut 2011).

The Great Crash only briefly slowed the immense growth momentum of the large developing countries, led by China and India but extending to and beyond Indonesia and Brazil. The changed outlook for global economic growth and the shift in weight towards developing countries are reflected in the updated projections presented in Section 3.

2.2 Energy demand, energy intensity and carbon intensity of GDP

The contraction in economic activity in developed countries is reflected in lower consumer and producer demand for goods and services. And these changes are evident in reduced growth in energy supply from 2008 onwards (see Figure 3).

Figure 3: Energy supply growth in developed and developing countries, 2005 to 2009



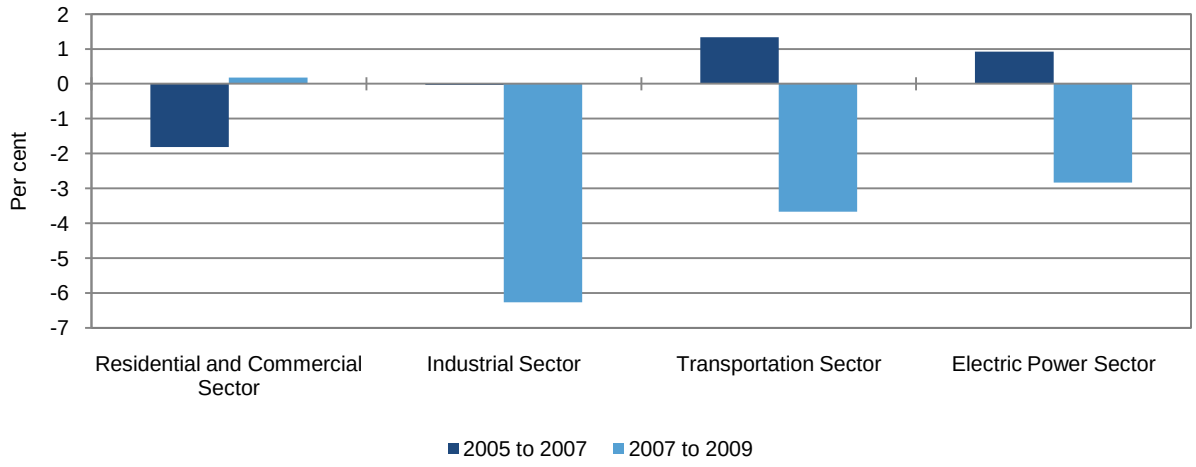
Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; International Energy Agency, 2010, "World Energy Outlook 2010"; BP, 2010, "Statistical Review of World Energy 2010".

Energy demand fell faster than economic output in the developed world, representing a decline in the energy intensity of GDP. Energy intensity typically declines over time for two reasons: improvements in technology allow greater energy efficiency; and the share of services in the economy typically increases, and these services use less energy per unit of economic value. However, the decline in energy intensity between 2007 and 2009 was lower than the decline during the preceding two years, in both developed and developing countries. Globally, the fall in energy intensity was 1.5 per cent per year during 2007-09, compared to 2.7 per cent during 2005-07.

There are likely to be a couple of reasons why the rate of decline in energy intensity has slowed. Residential energy use (electricity as well as fuel use for heating and cooking) is not affected much by short-term economic fluctuations, thus while economic activity may slow or even fall, households continue to demand similar amounts of energy. In contrast, industrial and transport energy use are more responsive to changes in economic growth and are not likely to have been a factor in the slowing of the rate of fall in energy intensity (see Figure 4).

The carbon intensity of the energy supply decreased slightly during 2007 to 2009, compared to an increase during 2005 to 2007. It therefore contributed to a dampening in global emissions growth. The fall in carbon intensity was mostly due to a less carbon intensive energy supply in developed countries, though the carbon intensity of energy in developing countries also grew more slowly from 2007 to 2009 compared with 2005 to 2007.

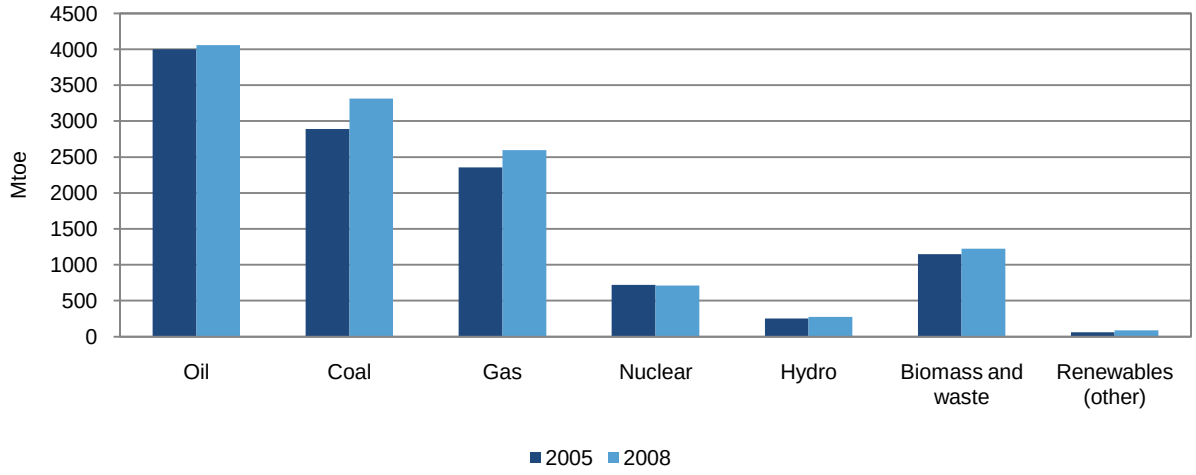
Figure 4: Average annual growth in US energy consumption by sector, 2005-07 and 2007-09



Source: United States Energy Information Administration, 2010, "Annual Energy Review 2010".

The changes in carbon intensity can be traced to shifts in the global energy mix (see Figure 5). From 2005 to 2008, the dominant change in the global energy system was an increased use of coal in developing countries. Renewable energy technologies, such as wind and solar power, experienced higher growth rates than other energy sources, albeit off a small base. This was the case in both developed and developed countries.

Figure 5: Change in global energy demand by source, 2005 to 2008



Source: International Energy Agency, 2010, "World Energy Outlook 2010"; and, International Energy Agency, 2007, "World Energy Outlook 2007".

These shifts in energy mix are linked to changes in fossil fuel prices, with a higher increase in coal prices throughout 2007 and 2008 than for other fuels (Figure 6). Differentials in relative growth rates between sectors and regions (where composition of energy supply differs) can also play a role in shaping the energy mix.

The Great Crash of 2008 resulted in a significant fall in demand for gas. This coincided with the increasing realisation of the extent to which an expansion of gas reserves had changed the prospects for gas price levels and volatility relative to other fuels.

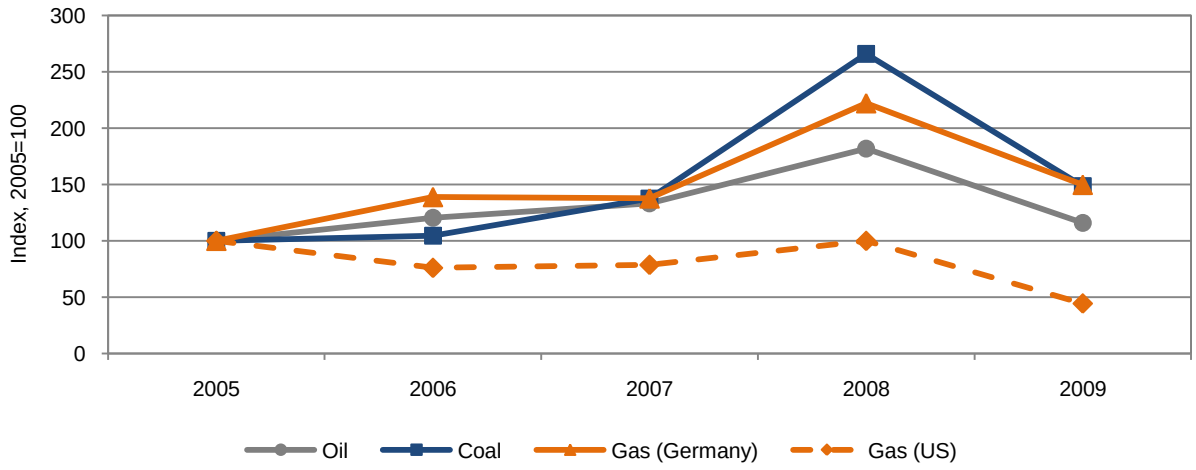
The expansion of gas reserves has taken the United States by surprise. A recent study of the United States gas position by the Massachusetts Institute of Technology (2010) estimates that gas reserves, after depletion, increased by 77 per cent from 1990 to 2010. This expansion of reserves has already

reduced both average prices and their volatility, making gas a much more competitive fuel for power generation (Garnaut 2011). The shift from coal to gas will help the United States to meet emissions reduction targets over the next decade.

The International Energy Agency has predicted some recovery in demand for gas in 2010, although at a less rapid rate than oil demand. Oil prices are surging, driven mostly by strong demand out of China and other non-OECD countries that are less dependent on gas. This gas-market imbalance has seen a large and unprecedented gap emerge between gas prices in the competitive markets of North America, and those in continental Europe, where gas prices remain largely indexed to oil prices under long-term contracts (International Energy Agency 2010).

The regional gas price decoupling is already putting pressure on buyers of gas under oil-linked contracts in Europe to seek changes in pricing terms from their suppliers. Gas buyers are facing pressure from customers to supply gas under long-term contractual arrangements at more competitive prices. There is strong pressure to move away from automatic adjustment of gas prices based on the oil price.

Figure 6: Index of fossil fuel commodity prices, 2005 to 2009



Source: IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing" October 2010

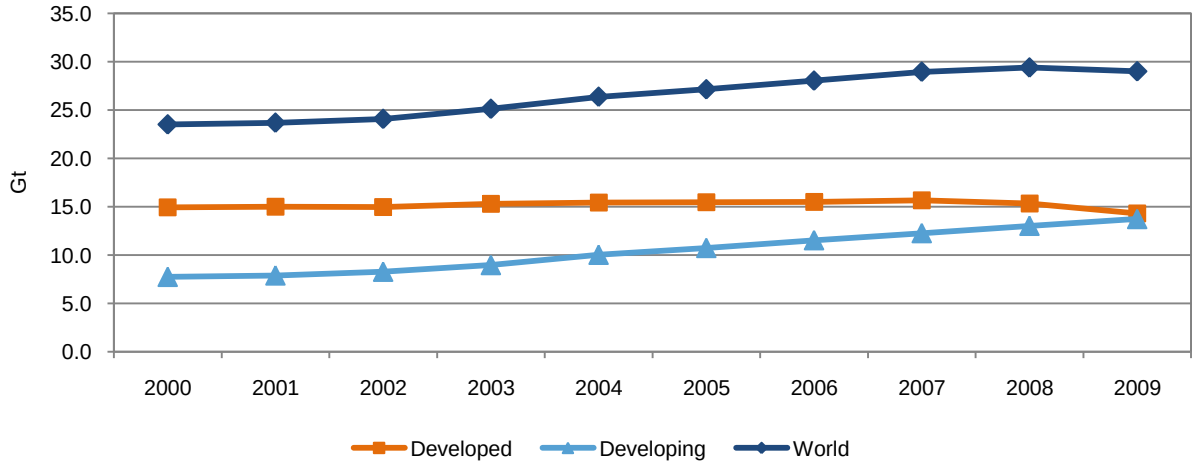
It is likely that lower prices of gas relative to other fossil fuels will emerge in most markets and support an increasing role of gas, with its lower emissions. This likelihood is not fully reflected in the projections.

2.3 Carbon dioxide emissions

The slowdown in global economic growth during 2008-09, coupled with moderate declines in the energy intensity of the global economy and the carbon intensity of global energy supply, resulted in the level of global carbon dioxide emissions falling modestly in 2009. The fall in developed countries' aggregate emissions following the Great Crash (after a long period of roughly constant emissions levels), more than offset continued growth in developing countries' emissions (see Figure 7).

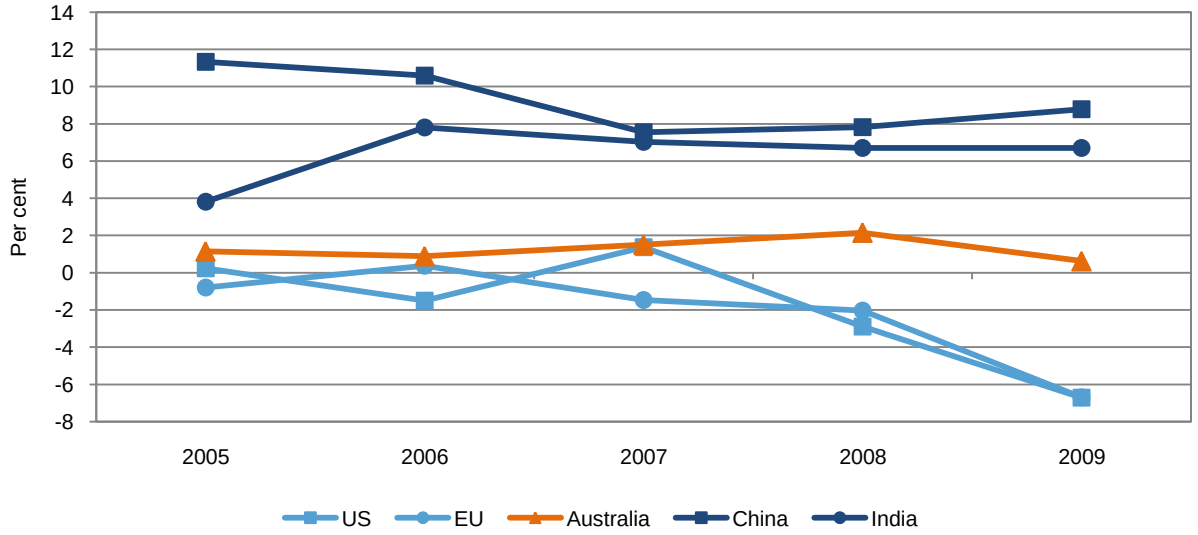
The same picture is reflected in the growth in annual emissions of the large countries (see Figure 8). While emissions in the US and EU fell in 2008 and 2009, China's estimated emissions rose at a faster rate than in 2007 (although not as fast as during the period 2003-2006). Growth in India's emissions remained high at around 7 per cent throughout most of the period. Australia's recent emissions growth has bucked the trend across the developed world, with the emissions growth rate just below zero (for more detail on Australia's emissions, see Box 2).

Figure 7: CO_2 emissions in developed and developing countries, 2000 to 2009



Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; and, BP, 2010, "Statistical Review of World Energy 2010".

Figure 8: CO_2 emissions growth in selected countries, 2005 to 2009



Sources for USA, EU, China and India: International Energy Agency, 2010, "CO_2 Emissions from Fossil Fuel Combustion 2010"; and, BP, 2010, "Statistical Review of World Energy 2010". Sources for Australia (2005-2008): Australian Government, 2010, National Inventory Submission to the UNFCCC Source for 2009: Australian Government, 2011, "Australia's Emissions Projections 2010".

Data for 2010 emissions are not yet available for most countries. However, preliminary data on economic growth during 2010 show that GDP rose by 7.4 per cent in the developing world, 3.1 per cent in the developed world, and by 5.0 per cent globally (International Monetary Fund 2011). This is only marginally below the growth rates during the years 2005 to 2007. Unless the energy intensity or carbon intensity of economic growth fundamentally changed during 2010, this would see a return to global emissions growth rates in the order of 3 per cent per year.

3. Business as usual projections over the next two decades

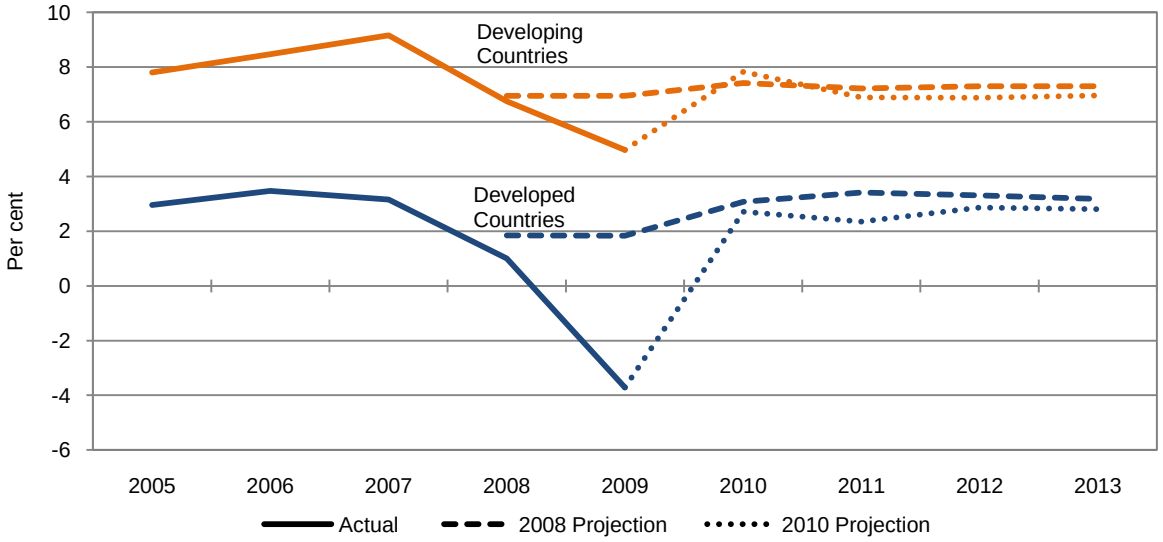
Future growth in global carbon emissions will be determined by economic growth, changes in energy intensity and changes in carbon intensity, brought about by changes in the energy mix. This section examines how the outlook for economic growth, energy intensity and carbon intensity in the absence of mitigation has changed since the Review and presents an updated set of business as usual emissions projections to 2030.

3.1 Economic growth

The developed world

As noted earlier, the Great Crash of 2008 had a profound effect on economic activity in most developed countries. Although most economies are growing again, the follow-on effects are likely to be felt for some time. Growth expectations for most developed countries have been lowered, as illustrated by downward revisions in International Monetary Fund growth forecasts (Figure 9).

Figure 9: Growth in GDP in developed and developing countries, 2005 to 2013



Sources: International Monetary Fund, 2008, "World Economic Outlook 2008"; International Monetary Fund, 2010, "World Economic Outlook 2010"; and, International Energy Agency, 2010, "CO_2 Emissions from Fossil Fuel Combustion 2010".

Overall, developed economies contracted by 2.7 per cent from 2007 to 2009, with the biggest falls in Europe. Australia was one of the few developed countries to avoid recession, with GDP growing by 3.6 per cent from 2007 to 2009. The International Monetary Fund expects that for the next few years, growth in OECD countries is likely to remain relatively weak, with risks to the downside.

Government spending in developed countries increased dramatically in response to the Great Crash of 2008, as governments implemented fiscal stimulus packages and provided massive support to ailing private financial institutions. Combined with a collapse in revenues this has led to greatly increased public debt in developed countries, many of which already had substantial debt burdens entering the crisis. Government net debt in the advanced economies averaged just over 50 per cent of GDP in 2008, and this is expected to rise to just over 80 per cent by 2015 (International Monetary Fund 2010).

Higher levels of public debt will cost governments more to service and over time will require some combination of lower government spending or higher taxes. A wave of fiscal austerity has already begun to sweep across Europe and will be extended to other developed countries. This affects short- to medium-term growth prospects. The fiscal deterioration across the developed world has hindered, and will continue to hinder, the ability of governments to fund productivity-enhancing investments in infrastructure, health, education, and technology.

The Great Crash of 2008 and its aftermath has revealed vulnerabilities in the American and European economies that had previously not been apparent. Many of the fundamental weaknesses, for example in financial institutions and economic policy frameworks, are yet to be corrected. Reasonable expectations of medium- and long-term growth in the developed world are lower than projected in 2008.

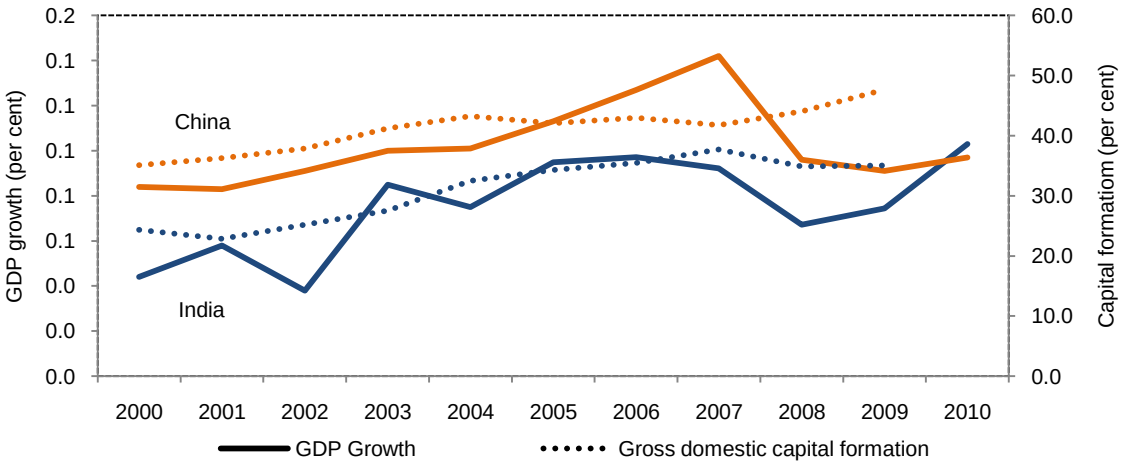
The developing world

The outlook is much more positive for developing countries. Prospects are good for continued rapid growth in China and India, and there is greater growth momentum in many other developing countries.

Through much of the developing world there has been considerable learning from policy mistakes in the last quarter of the twentieth century, and also from the successful developing countries, about the policies and institutional arrangements that are likely to be associated with higher economic growth.

Chinese growth in recent years has consistently outperformed expectations. While an unusually sharp demographic transition, reflected in an early movement to absolute decline in the labour force, will reduce the contribution of labour to increases in economic output, other sources of growth will remain strong into the 2020s, giving it increasing weight in the global economy (Garnaut 2010) until late in that decade. China's growth has been underpinned by unusually high savings (well over half of incomes) and investment rates (approaching half) in recent years (see Figure 10).

Figure 10: GDP growth and capital formation in China and India



Sources: Asian Development Bank, 2010, "Key Indicators for Asia and the Pacific 2010"; and, IMF, 2011, "World Economic Outlook Update: Global Recovery Advances but Remains Uneven".

China began its era of strong growth with economic reform and opening to the international economy in 1978 as a labour-surplus economy. Growth continued for a long time with wages lagging behind labour productivity, the wage share of income falling, and with increasing inequality in income distribution. The era of the labour surplus came to an end about five or so years ago. Since then, wages have been rising rapidly and the fall in the wage share has been reversed, although this change was temporarily reversed as exports and industrial employment were suddenly hit by the global financial crisis in late 2008. The annual increment in demand for labour has been tending to exceed the declining number of new entrants of low-skill workers into the economy over this period, with rapidly rising real wages maintaining the balance between supply and demand for labour.

This is a period of huge adjustment in the Chinese economy, but not one that need significantly reduce growth rates for a considerable while. The rate of increase in the capital stock per worker can continue to increase strongly: the increase in the wage share is likely to result in a reduction in the savings rate, but not necessarily a reduction in the investment rate, which might indeed rise at least for a while as the external surplus in trade and current payments is reduced (Garnaut 2010).

The economic quality of China's workforce will continue to improve, with a continued increase in the proportion of high school and tertiary educated workers. Rapidly rising real wages is a source of pressure for higher total factor productivity.

Together, these factors suggest that continued productivity growth and technological improvement can support China's rapid growth until its average productivity and incomes are over half of those in the advanced industrial countries—a position that is likely to be reached around 2030.

Success in maintaining high growth rates through this long period depends on the flexibility of China's economy, the continuation of openness to foreign trade, investment and ideas, continued improvements in the education and regulatory systems, and on sound, growth-oriented macroeconomic policy.

There are the usual policy risks to sustained growth that are present in any successful economy. In China, macro-economic policy is particularly demanding in the period immediately ahead. The adjustment out of the labour-surplus, relatively low-wage economy is necessarily associated with large increases in the real exchange rate. This can be achieved in a non-inflationary way with a strong emphasis on nominal currency appreciation, or an inflationary way with a more rigid nominal exchange rate. China accepted a reasonably rapid rate of nominal currency appreciation from July 2005 until the 2008 financial crisis, but then restored a fixed exchange rate against the United States dollar (a relatively weak currency in global terms through most of this period) until mid-2010. The Chinese authorities have been concerned about inflation, and have been tightening demand policies in response to it. Tighter monetary policy, in the absence of nominal currency appreciation, is unlikely to be successful, encouraging capital inflow at a time of massive external payments surpluses, and making it difficult to control monetary growth, demand and inflation. The maintenance of strong growth with moderate inflation will require a period of more rapid nominal currency appreciation. Attempts to constrain inflation mainly through restrictions in domestic demand could fail, and incidentally damage growth and, through increasing external payments surpluses, be destabilising to the international economy and to relations with the United States.

This is not the largest economic policy challenge that China has faced in the period of reform. Its monetary and fiscal authorities contain people who understand the problem well. It is more likely than not that the Chinese authorities will find their way to policies that maintain strong growth, although not without risks of an occasional bump in the road.

Of the large economies, India has the strongest growth prospects in the longer term. Its recent growth performance has outstripped expectations, and forecasts in 2010 put India's medium-term growth rates at substantially higher levels than forecast two years ago. Rising expectations of growth have strong foundations. Two factors have been fundamentally important to the acceleration of economic growth over the past two decades. Most basic of all has been the steady opening of the economy to international trade and investment. Acceleration of growth has been underpinned by the steady rise in the savings rate—broken only temporarily by the global financial crisis—supporting sustainably high and rising rates of investment (Montek 2010).

India continues to undergo a demographic transition that is favourable to growth, with the proportion of the population of working age set to gradually increase over the next two decades. If this increasing 'demographic dividend' is accompanied by continued improvements in the skills of the Indian workforce and by continuing economic reform, then rapid economic growth can be sustained for decades to come. India's lower income per capita relative to China, and gradual rather than sudden transition to lower fertility with associated opportunity to transit out of the labour surplus economy, holds out the prospects for continued strong economic growth long after Chinese growth has eased to the more gradual trajectory of a high-income country from the late 2020s.

Indonesia, the world's third most populous developing country, also has strong and sustainable growth momentum. Indonesia managed to maintain solid growth at around 5 per cent through the years straddling the Great Crash, and is now returning to stronger growth rates. Since the traumatic democratic transition of the final years of the twentieth century, it has been building the institutions that are necessary for sustained strong growth within a democratic polity.

The three largest developing economies (China, India and Indonesia) are all at stages of development in which growth is highly energy-intensive, and all three happen to have considerable domestic endowments of coal. Emissions of greenhouse gases grow strongly in the absence of strong and effective mitigation policies.

The stronger growth trajectories of the three most populous developing countries were established in the late twentieth century, although Indonesia had to find its way through political and economic dislocation in the late 1990s. Through the early twenty first century, there has been an acceleration of economic growth in the developing world more generally, including in regions—for instance, large parts of Africa that are not experiencing extreme political disorder—that had earlier been considered to have poor prospects. While some low-income developing countries were severely damaged by the global financial crisis, the general story has been of resilience.

The projections presented in this Update are based on a reworking of the growth prospects of the largest developing countries in the growth accounting framework that had been used in the 2008 Review. For the rest of the developing world, less rigorous adjustments have been made for stronger expectations of economic growth. The projections embody higher growth expectations than is common in the literature, but may understate the likely reality under the business as usual.

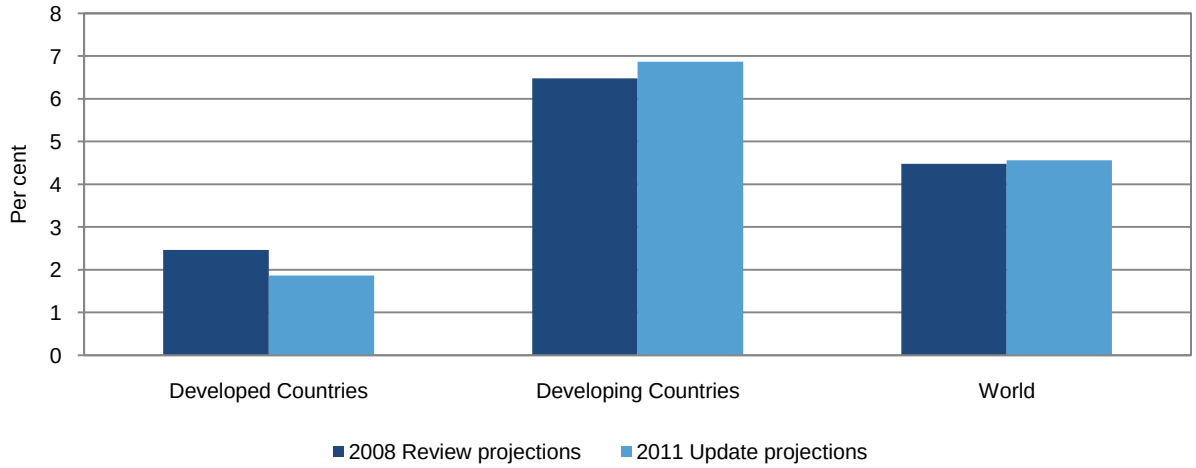
Updated projections

The shift in the balance of growth prospects towards developing countries is reflected in the Review's economic growth projections. Projected global economic growth to 2030 remains almost unchanged; however, the balance has now shifted further towards developing countries (Figure 11). Growth projections to 2030 for developed countries have been revised downwards, in particular for North America and Europe. Following an average annual growth rate of just 0.9 per cent for the developed countries as a whole for the period 2005 to 2009, the Update works on the basis of 2.2 per cent from 2009 to 2015 and 2.0 per cent from 2015 to 2030. Taken together, this results in an average growth rate for developed countries of 1.9 per cent from 2005 to 2030, compared to 2.5 per cent in the Review.

Growth projections for developing countries have been revised upwards over the period to 2030. Despite the Great Crash, recent developing country performance has been closely in line with the expectations published in 2008. The average growth rate for developing countries was 7.3 per cent from 2005 to 2009, compared with the 2008 Review's 7.1 per cent average rate from 2005 to 2015. Other projections and forecasts at that time substantially underestimated developing country growth, despite the slowing during 2008-09. For example the International Energy Agency (2007) projected developing country growth over the period 2005 to 2015 of only 6.1 per cent.

The updated assumptions have developing countries' economies as a whole growing at 7.6 per cent for 2009-15, and 6.4 per cent for 2015 to 2030. This results in an average 2005 to 2030 growth rate of 6.9 per cent, compared to the Review's 6.5 per cent. The downward revisions for developed and upward revision for developing countries add up to a slight increase in average annual global growth from 4.5 per cent to 4.6 per cent between 2005 and 2030.

Figure 11: Projections of average annual GDP growth in 2008 Review and 2011 Update, 2005 to 2030



Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing" October 2010; International Energy Agency, 2010, "World Energy Outlook 2010"; and, Garnaut, R. 2008.

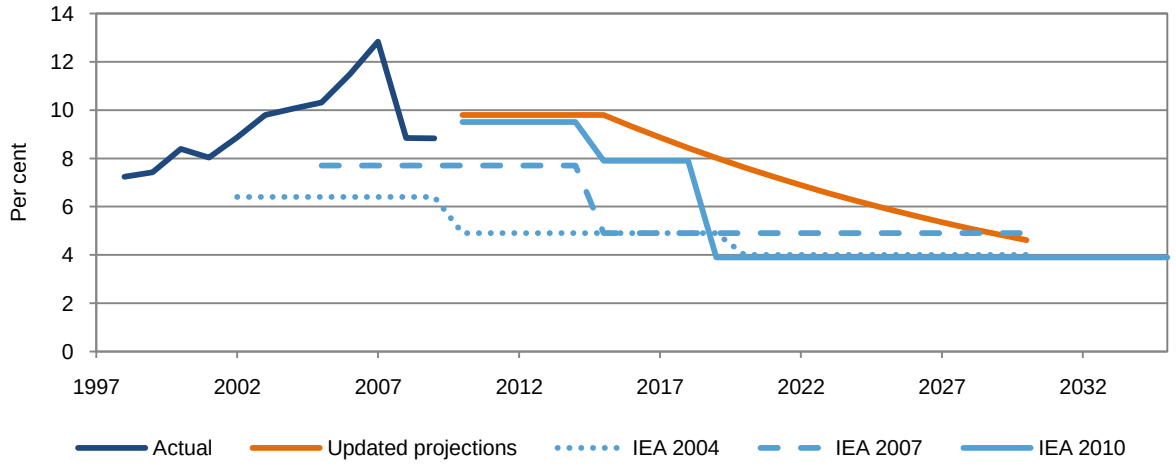
For China, the Review's economic growth accounting framework was updated systemically. This framework computes growth from assumptions about capital formation, labour input (determined by demographic developments and weighted by expected future workforce skill levels), and improvements in technology and general economic efficiency (total factor productivity). The growth accounting exercise in Garnaut et al. (2008) has been updated by including recent data to 2009, adjusting the assumptions about future investment share (50 per cent falling to 40 per cent by 2025). Assumptions

about both education-augmented labour force growth (2 per cent per year until 2015, 1 per cent per year thereafter) and growth in total factor productivity (3.1 per cent per year) remain unchanged. Together with China's stronger than expected recent growth performance, this results in an upward adjustment to economic growth rates to 8.0 per cent per year over the period 2005 to 2030, compared to 7.7 per cent in the Review.

The Update's economic growth assumptions for China are broadly in line with International Monetary Fund and International Energy Agency assumptions for the period to 2015, following substantial upward revisions from earlier assumptions by the International Energy Agency, among other agencies. For the period from 2015 to 2030, however, the International Energy Agency (2010) assumes economic growth in China plateaus, falling to around 5 per cent per year on average. The Update does not consider this assumption to be realistic. A similar picture emerges for other developing countries, where the International Energy Agency assumes growth rates falling from the rates assumed to 2015. The Update, by contrast, sees no reason to expect developing countries' growth rates to fall in this way at this time. Of course, this judgement is qualified by the earlier statements of no large negative feedbacks from climate change or its mitigation.

It is noteworthy that the published growth expectations of the public international institutions, including the International Energy Agency—and, for that matter, most of the large private financial institutions—have lagged China's actual growth performance by large margins. While growth assumptions were successively raised as the results of new projections exercises were published, they remained below the actual growth rate. Meanwhile, International Energy Agency projections for the period beyond 2020 have remained at less than half the rates observed in recent years (Figure 12). A similar effect of 'stickiness' in mainstream growth assumptions, leading to underestimates, seems now to be working in relation to other developing countries.

Figure 12: China GDP growth and projections



Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing" October 2010; International Energy Agency, 2010, "World Energy Outlook 2010"; International Energy Agency, 2007, "World Energy Outlook 2007"; and, International Energy Agency, 2004, "World Energy Outlook 2004".

India's growth from 2005 to 2009 was 7.9 per cent, around 0.4 per cent per year higher than anticipated in the 2008 Review. An upward adjustment is applied to the Update's 2009 to 2015 projections, which produce 9.0 per cent annual growth. This expectation of an upward adjustment is in line with the views of Montek (2010). As argued above, India's growth prospects remain strong in the long term—the Update embodies this expectation with 8.5 per cent average growth from 2015 to 2030.

For Indonesia, the upwardly revised short-term projections by the International Monetary Fund and International Energy Agency now accord with the Review's expectation of 6.5 per cent average annual growth for 2009 to 2015. The Update anticipates that this growth rate will be maintained on average over the next two decades, unchanged from 2008.

The growth outlook for other developing countries is generally favourable. The Update uses the latest International Energy Agency 2009 to 2015 growth assumptions for other Asian regions, Africa, the

Middle East and Latin America (between 4.0 and 5.5 per cent per year), and extends them to 2030. This is a moderate upward revision from the Review's assumptions, and may be low.

3.2 Energy demand

Energy intensity has declined over time in most countries as more energy efficient equipment is used and as a greater share of economic activity comes from services and other less energy intensive activities. There are, however, great differences in the underlying rate of change in different countries, depending on their stage of development, resource endowment, economic structure and other factors (e.g. Stern and Jotzo 2010).

The outlook for future improvements in energy intensity is also affected by government policy, as well as changes in the expected future costs of energy.

Since 2008 various policies have been introduced in many countries to curb the growth in carbon emissions (see Update paper two: *Progress towards effective global action on climate change*). As noted in the introduction, this Update provides a business as usual projection—an estimate of global emissions in the absence of policy targeted at climate change mitigation. New climate polices are, to the extent that this is practical, excluded from the update of the projections. In practice, the distinction is not always clear cut. For example, some policies dampen energy demand growth, but do not have climate change mitigation as their primary objective, so a degree of judgement is needed in calibrating projections.

In contrast, the International Energy Agency's *World Energy Outlook* includes the effects of all existing policies in their projections. The International Energy Agency produces an 'existing policies scenario' (or 'reference case') that is a projection with current policies taken into account, but with the assumption of no future policy changes.

Changes in energy prices

Since 2007, there have been changes in expectations regarding future prices of fossil fuels and energy from other sources, largely due to upward revisions of the expected costs of fossil fuel extraction. In general, there has been an upwards revision of price projections, with long run prices assumed to converge to a higher level.

The shift in price assumptions can be seen in comparisons for 2030 between the International Energy Agency's *Energy Technology Perspectives* reports of 2008 and 2010 (Table 2). The anticipated 2030 price of crude oil has increased by over 70 per cent, from US$66 per barrel in 2008 to US$115 in this Update. The expected price of steam coal imports to OECD countries has increased by more than 60 per cent, from US$67 per tonne in 2008 to US$109 in this Update. The price of natural gas has increased by between 35 per cent and 90 per cent, with the US having the smallest increase in prices and Japan the largest (US$8.4 per Million British Thermal units (MBtu) to US$11.4 per MBtu in the US and US$8.4 per MBtu to US$15.9 per MBtu in Japan).

These are sizeable price impacts, which would result in faster decreases in energy intensity of GDP, as consumers and businesses respond to higher prices by shifting away from energy intensive goods and services, and invest more in energy saving technologies.

Box 1: Population dynamics, economic growth and emissions

Population growth is one potential driver of emissions growth.

Assumptions about global population growth (UN 2008 and 2010) have changed only minimally since the Review, but there is always a degree of uncertainty in projections of future population. To capture the diversity in possible outcomes, the United Nations has developed three scenarios for future population growth, where world population at 2030 varies by almost 1 billion people (or 12 per cent) between the high and low scenarios.

Table 1 UN population scenarios:

Population	UN population variant	Global population in 2030, billion	Total growth 2009 to 2030 (%)
Developed countries	**Medium**	1.6	6
	High	1.7	12
	Low	1.5	1
Developing countries	**Medium**	6.7	26
	High	7	33
	Low	6.3	19
World	**Medium**	8.3	22
	High	8.7	28
	Low	7.8	15

Source: United Nations, 2008 "World Population Prospects: The 2008 Revision Population Database" http://esa.un.org/unpp/index.asp, accessed 14/12/2010. Note: 2009 value calculated by assuming constant percentage annual growth between 2005-2010.

The projections in this paper are based on the UN's medium scenario. However, if economic growth in developing countries is faster than expected, as suggested in the Review's analysis, this may lead to lower birth rates and lower rates of population growth.

A decline in fertility leads to lower population levels and therefore lower levels of economic activity and emissions, with partially offsetting effects from greater longevity. However, the relationship will not be one-to-one. Parents who choose to have fewer children (and societies with declining fertility) are likely to invest more heavily in education per child, leading to higher labour productivity per worker. A decline in fertility will also be reflected for a while in a reduction in the ratio of labour force to population that is favourable to economic growth—the well-known "demographic dividend". In the medium term, this will be reflected in greater purchasing power, and to some increase in demand for emissions-intensive goods and services. A decline in fertility will bring forward in time the transition to a high-incomes services-based economy, and this is where large gains in reductions of emissions are likely to be seen. The time profile of the relationship between population growth and emissions is therefore complex, although large and positive in the long run. It is also worth noting that population dynamics are very persistent through time, so that changing the global population trajectory would make comparatively little difference for climate change mitigation outcomes in the first half of the century. As an illustration, the difference of 12 per cent between the UN high and low population scenarios at 2030 is a small fraction of the extent of emissions reductions necessary for effective climate change mitigation.

Some participants in the immigration discussion argue that policy can reduce fertility and population and that such policy should be part of the approach to reducing emissions. Certainly the global mitigation task would be much more daunting if there were several hundred million more Chinese, as some analysts estimate that there would have been without strong anti-natal policies over the past three decades. Less draconian policies based on denial of services and financial penalties seem to have been influential for a while in Singapore.

But strong measures along these lines are unacceptable in most societies. The Indira Ghandi Government ran into strong community resistance in seeking to implement less draconian approaches to reductions in fertility in India.

Policy to expand relevant information and education on fertility control has some role to play in reducing population growth. But for the most part, the reduction of fertility will depend on economic development, higher incomes and the improved nutrition, health services and education (especially of women) with which it is associated. Fortunately, the news here is not bad, with global fertility falling steadily over recent decades. According to the UN projections, the global population reaches a peak of 9.2 billion (medium case) in about 2075. It may well be the case that future global population trends turn out to be much closer to the UN low population scenario where global population peaks at approximately 7.5 billion and falls to 2.3 billion by 2300, especially in the light of improved economic outcomes, and assuming no feedback effects from climate change.

It is sometimes said that the emissions mitigation task in Australia would be assisted by reduced population growth, being brought about by reduced immigration. That depends on living standards and consumption of emissions-intensive goods and services rising as people move from other countries to Australia—which will sometimes but not always be the case in the short term given the Australian immigration programme's focus on skills that are likely to generate reasonably high incomes wherever they are applied. In the longer term, global allocations of emissions entitlements are likely to be based on population, so that immigrant Australians will reduce allocations to the countries from whence they have come, at the same time as Australia's entitlements are increased to reflect their presence.

Table 2: Assumptions regarding future fossil fuel prices

	Unit	2008 price (ETP 2010)	2030 price expectation (ETP 2010) (US$ 2008)	2030 price expectation (ETP 2008) (US$2008)	Difference in projections (%)
Crude oil imports	Barrel	97	115	66	74
Natural gas					
US	Mbtu	8.3	11.4	8.4	35
EU	MBtu	10.3	14	7.8	79
Japan	MBtu	12.6	15.9	8.4	90
OECD steam coal imports	Tonne	121	109	65	67

Sources: International Energy Agency, 2010, "Energy Technology Perspectives 2010"; and, International Energy Agency, 2008, "Energy Technology Perspectives 2008".

The combined impacts of changes in policies and expected future energy costs result in significantly faster projected rates of energy intensity improvements. The International Energy Agency's 2007 and 2010 reports (refer Table 8 in Appendix 1) identify an average 0.4 per cent per year faster decline in energy intensity. Differences between regions are large, which is probably largely because of differences in the effect of new policies reflected in the International Energy Agency's projections. For example, China's annual rate of energy intensity was projected by the International Energy Agency to fall by 2.7 per cent per year, but will now fall by 3.7 per cent per year. This is likely to be based on China's domestic commitment to energy efficiency measures including industrial restructuring away from highly energy intensive installations and products. For China, India and other developing country regions, the International Energy Agency's downward revisions in projected energy intensity more than cancel out upward revisions in projected GDP, resulting in lower projected energy use.

Updated projections for energy intensity

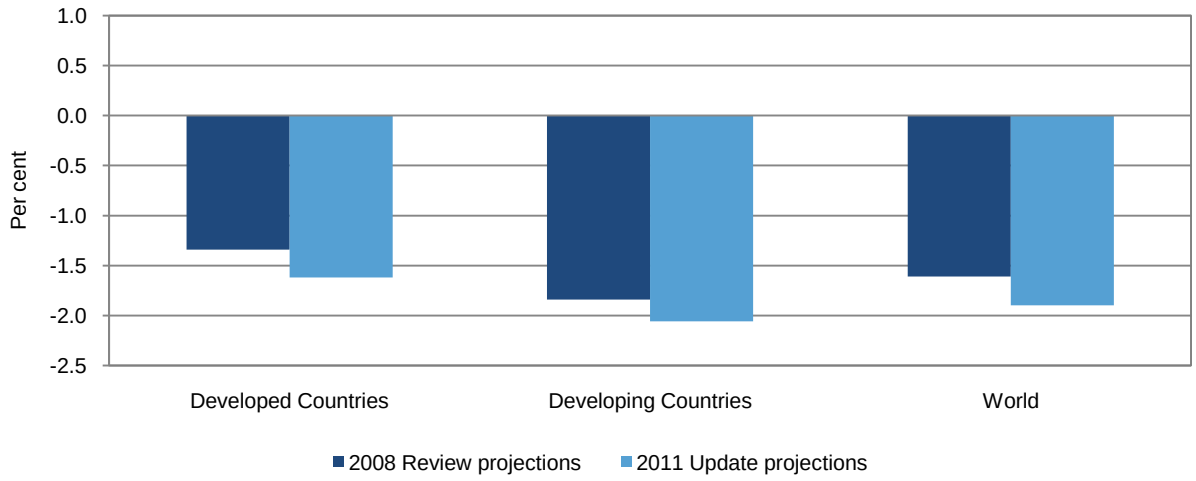
In this Update the energy intensity of GDP is projected to fall in all regions, with the ratio of energy consumption to GDP declining at average rates between 0.9 and 2.7 per cent per year. The global average is projected to decline by 1.9 per cent annually between 2005 and 2030. This is 0.3 percentage points faster than under the Review's 2008 projections and leads a projection of global energy intensity that is 8 percentage points lower at 2030 than under the previous projection.

Around one third of the adjustment is due to faster than expected improvements in energy intensity from 2005 to 2009, and two thirds to the revision of projections for the next two decades. The change in the projection reflects mainly the expectation of higher energy prices, which will drive greater investment in technical energy efficiency and some substitution away from energy intensive products and processes.

The change in the projection is calibrated with reference to changes in the International Energy Agency projections of energy intensity. In its 2010 report, the International Energy Agency projects global energy intensity to improve by 0.4 per cent per year faster than it did in its 2007 report. As discussed above, this decline is due both to change in government policy and to higher energy prices. We assume that half of the global increase is due to fuel prices and policies that are independent of climate change mitigation, and only those changes are reflected in the Review's business as usual projections. Thus each region's projected rate of change in energy intensity is revised by 0.2 per cent per year, compared to the 2009 to 2030 period in the Review. Faster than expected decreases in energy intensity from 2005 to 2009 result in a small additional reduction over the period 2005 to 2030, compared to the earlier projections.

The projected decline in energy intensities from 2005 (Figure 13), is close to 2 per cent per year for the world, and slightly faster on average in developing than in developed countries. Differences between countries are smaller than in projected GDP growth. The rate of projected decrease in business as usual energy intensity is not closely correlated with either the projected rate of economic growth, or with per capita income.

Figure 13: Projections of average annual change in energy intensity in 2008 Review and 2011 Update, 2005 to 2030



Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; "BP, 2010, Statistical Review of World Energy"; International Energy Agency, 2010, "World Energy Outlook 2010"; and, Garnaut, R. 2008.

Applying these projections of energy intensity to the projections of economic growth yields projections of total energy use (refer Table 10 Appendix 1). These indicate that growth is tailing off across developed countries to a 0.2 per cent annual increase over the period 2005 to 2030. This is a sizeable shift from the Review's projections which had developed countries' energy use growing at 1.1 per cent. The reasons are reductions in energy demand from 2005 to 2009, slower projected GDP growth, and slightly faster projected declines in energy intensity of GDP.

Developing countries by contrast are projected to experience continued strong growth in energy use, at 4.7 per cent per year, up slightly from the 2008 projections. Underlying energy demand growth is fastest in the rapidly growing economies of Asia, but strong across all developing country regions.

Many governments have policies in place to curb energy demand. As a result, the actual future energy demand, in the absence of further government policy, is likely to be below the rates in this business as usual scenario.

3.3 Carbon intensity of energy

The extent to which increases in energy demand translate to increased emissions depends on the amount of emissions per unit of energy consumed (carbon intensity of energy). Carbon intensity is largely determined by the fuel mix in the energy system. Amongst the fossil fuels, coal is the most carbon intensive energy source, followed by oil, then gas. The mix changes over time, driven by renewable and nuclear energy, as well as energy from biomass that produces essentially zero carbon emissions in net terms.

Changes in fuel mix

The prevailing fuel mix differs greatly between countries, determined by the availability and cost of different energy sources and by the nature of the electricity supply system, structure and size of energy intensive industries, as well as the transport and housing stock.

Changes in the fuel mix and carbon intensity tend to be relatively slow, as they mainly come about through gradual replacement of or addition to, a large stock of long-lived energy infrastructure. At the margin, changes in fuel mix can occur in the short term through substitution between different types of available energy infrastructure. Long-term fuel mix is strongly influenced by climate change policies as well as energy policies—for example, energy policies directed at reduced reliance on overseas purchases.

Relative prices of different energy sources are the other principal determinant of the fuel mix. If oil prices increase relative to other energy sources as is widely considered to be likely (refer Table 11 Appendix 1), then this will trigger a substitution away from oil and toward other energy sources. The effect on carbon emissions is ambiguous. Replacement energy sources may be lower in carbon intensity, as in the case of electricity from gas or from renewable sources or nuclear power. Alternatively, they may have greater carbon intensity, as in the case of coal, and coal-based liquid fuels, tar sands, and conversion of gas to liquids.

For the time being, the relative price of gas will be lower in the US and probably other regions. However, the International Energy Agency argues that the decoupling of contract gas prices from oil prices would not necessarily mean weaker gas prices in the longer term: gas prices are likely to come under renewed upward pressure relative to oil prices, with the rising cost of supplying gas from remote and difficult locations (International Energy Agency 2010). The price incentives to replace coal and oil by gas are likely to be influential for a while, but may not be long-lived.

The International Energy Agency has forecast that global gas demand will resume its long term upward trajectory from 2010, following an estimated 2 per cent fall in demand in 2009—the largest fall since the 1970s. In the International Energy Agency's New Policies scenario global gas demand grows annually by 1.4 per cent between 2008 and 2035, and by 1.6 per cent annually over the same period under the International Energy Agency's Current Policies scenario. International trade in gas is also set to grow by 80 per cent from 2008 to 2035 with China accounting for a significant 40 per cent of this trade. Most growth in this trade is in the form of LNG, which doubles between 2008 and 2035.

A comparison of the global energy mix at 2030 under old and new International Energy Agency projections illustrates the point (refer Table 11 Appendix 1). The International Energy Agency's most recent projections have the share of oil in global energy supply at 2030 contributing at 28.5 per cent, down from 31.5 per cent. This reduction is made up for in roughly equal measure by increased use of coal, nuclear power, and electricity from renewables/biomass. The net effect of this particular aggregate substitution effect would be to slightly reduce aggregate carbon intensity of energy supply. The substitution effects differ greatly between regions. For example, in the United States almost half of the reduction in the share of oil is compensated by greater use of gas, whereas the share of both oil and gas was revised downward for Europe.

The overall changes in International Energy Agency's 2007 and 2010 projections of carbon intensity have been small. There is an aggregate global difference of just 0.1 per cent annually (refer Table 12 Appendix 1). This comprises a 0.15 per cent per year downward revision for developed countries – probably in significant part due to re-assessment of climate policy action captured in the International Energy Agency projections – and a tiny upward revision for the developing world as a whole.

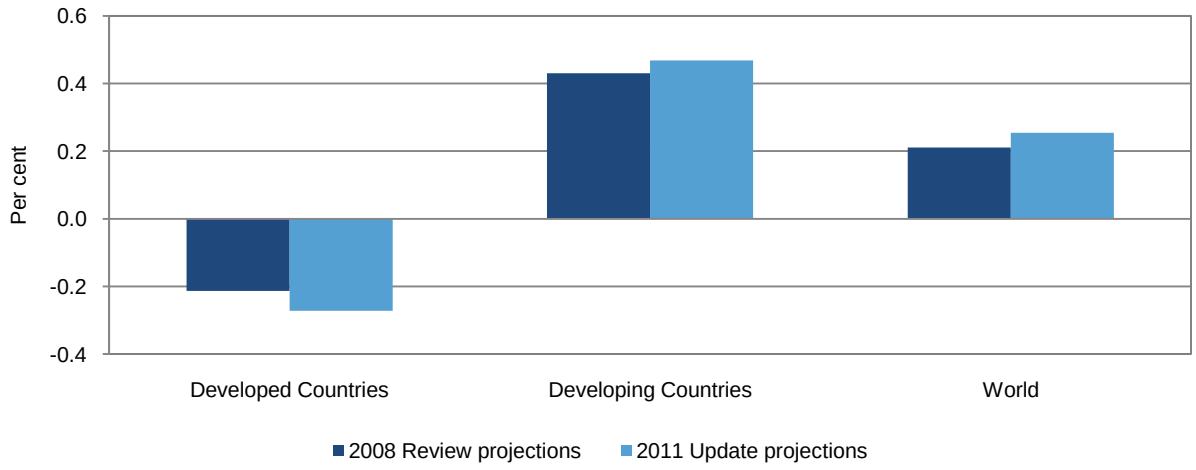
It may be that the International Energy Agency has underestimated the long-term effects of price-induced substitution of gas for coal and oil. This same underestimation will have been carried over into our own business as usual projections.

Updated projections of the carbon intensity of energy

The Update's projections of carbon intensity are derived using actual data from 2005 to 2009, but leaving the projections for the period 2009 to 2030 unchanged from the Review, which in turn, were taken from International Energy Agency (2007). As discussed above, there is no solid case to change expectations about future trends in carbon intensity of energy supply under a business as usual scenario. Differences over the period 2005 to 2030 between the Update and Review's projections are due to developments over the period 2005 to 2009.

The projections are for a 0.3 per cent per year increase in the global carbon intensity of energy supply between 2005 and 2030, with variations between regions in a relatively narrow band (refer Table 13 Appendix 1). Carbon intensity is projected to fall slightly in developed countries, and to increase on average in the developing world. This is in line with recent trends, although with further moderation over time. India is projected to experience the fastest rate of increase in carbon intensity, as more of its energy supply is derived from coal. China's carbon intensity of energy rose significantly from 2005 to 2009, but under these projections remains constant over the next two decades.

Figure 14: Projections of average annual change in carbon intensity in 2008 Review and 2011 Update, 2005 to 2030



Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; "BP, 2010, Statistical Review of World Energy"; International Energy Agency, 2010, "World Energy Outlook 2010"; and Garnaut R., 2008.

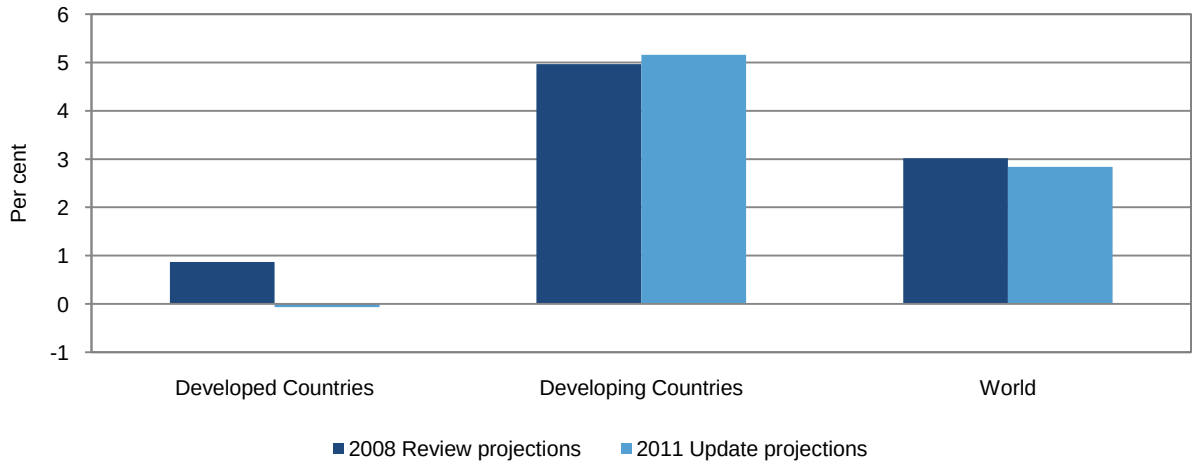
3.4 Emissions projections

Amalgamating the above projections of the individual drivers produces the Update's projections of global business as usual emissions (refer table 14 Appendix 1).

Global emissions growth under business as usual to 2030 is almost unchanged compared with the Review, at an average of 2.8 per cent per year compared to 3.0 per cent under the 2008 projections. This means that global emissions are projected to double between 2005 and 2030 under business as usual.

The Update has the level of global emissions in 2030 at just 4 per cent below the Review—or about one and a half years' worth of emissions growth. This difference is entirely due to the dip in global emissions growth in the aftermath of the Great Crash of 2008.

Figure 15: Projections of average annual growth in emissions in 2008 Review and 2011 Update, 2005 to 2030



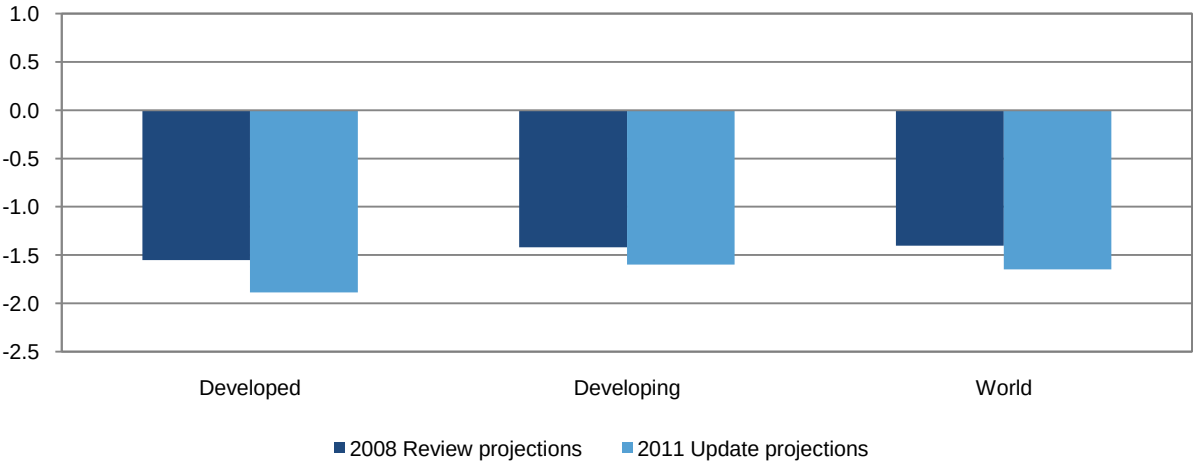
Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; "BP, 2010, Statistical Review of World Energy"; International Energy Agency, 2010, "World Energy Outlook 2010"; and Garnaut R., 2008.

The fundamental difference in the updated projections is that in the absence of effective climate change mitigation action, developing countries are now set to play an even greater role in global emissions.

Under the updated projections, developing countries contribute 70 per cent of global business as usual emissions at 2030, compared to 36 per cent under the 2008 projection. China's and India's share in global emissions would be 41 and 11 per cent respectively, both up by 3 percentage points from the Review's projections. The share of other developing countries would remain at 19 per cent of the global total.

All of the increase in global business as usual emissions is now projected to come from developing countries, with developed countries' combined emissions projected to remain at approximately the same level between 2005 and 2030.

Figure 16: Projections of average annual change in the emissions intensity of GDP in 2008 Review and 2011 Update, 2005 to 2030



Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing" October 2010; "BP, 2010, Statistical Review of World Energy"; International Energy Agency, 2010, "World Energy Outlook 2010"; International Energy Agency, 2007, "World Energy Outlook 2007"; and Garnaut R., 2008.

3.5 Comparisons with International Energy Agency projections

The International Energy Agency's (2010) latest analysis of energy related greenhouse gas emissions looks at three scenarios: a current policies scenario; a new policy scenario, and a 450 scenario. Under the current policies scenario, it is assumed that no change in policies as of mid-2010 takes place i.e.

recent commitments such as Copenhagen commitments are not acted upon. The International Energy Agency projections are conceptually different from the business as usual projections provided here, as even the International Energy Agency's current policies scenario include some climate policy action. A further difference, as discussed above, is that in the Update's analysis, likely GDP growth rates in the developing world are substantially higher than often assumed, including by International Energy Agency.

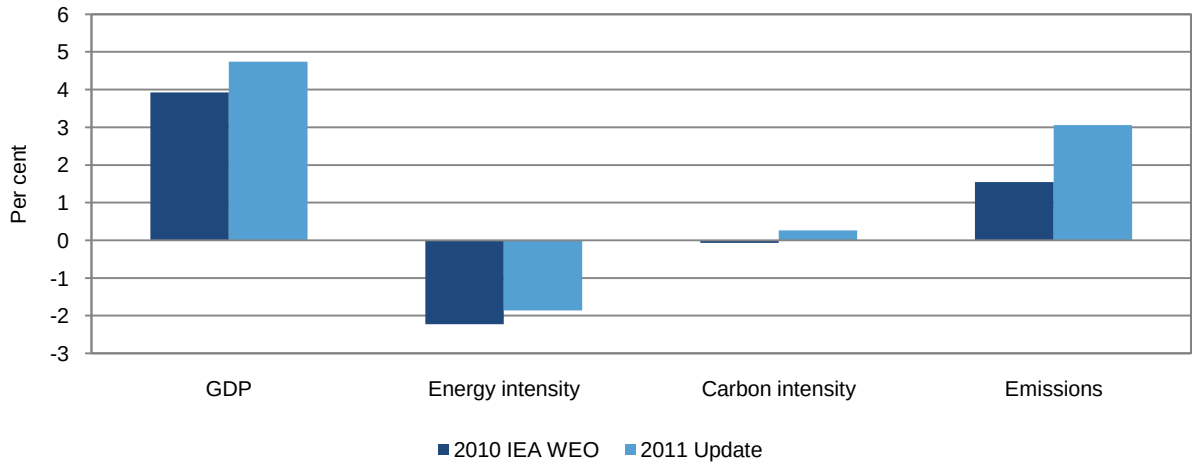
The global emissions projections by the Update and the International Energy Agency's current policies scenario are compared in Figure 17, along with projected growth rates in the drives of emissions growth—GDP, energy intensity and carbon intensity of energy. Table 17 in Appendix 1 shows the differences between the two sets of growth rates, for the main countries and regions.

The Update has global business as usual emissions growing 1.5 per cent faster per year during 2009 to 2030 than the International Energy Agency. This amounts to a substantial difference in levels at 2030: the Update projections have global emissions at 88 per cent higher in 2030 than at 2009, International Energy Agency current policies scenario projects an increase of only 38 per cent.

Just over half of this global difference in emissions is due to higher GDP growth projections for developing countries in the Update. Just less than half is, conceptually, due to the difference between assuming continuation of current policies and assuming a business-as-usual scenario.

About a quarter of the total difference— conceptually attributable to policy—is in energy intensity that is the effect of policies that improve energy efficiency and that induce a shift away from energy intensive processes and products. Here, the largest absolute contributions to the difference come from less optimistic assumptions by reductions in energy intensity in China, India and the United States. The remaining quarter of the difference comes from carbon intensity of energy supply, which can be interpreted as policy-induced differences in fuel mix. Differences are again higher in developing countries, but are also marked in developed countries.

Figure 17: Annual growth in global emissions and its drivers, 2009-30, Update and International Energy Agency



Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing" October 2010; "BP, 2010, Statistical Review of World Energy"; International Energy Agency, 2010, "World Energy Outlook 2010"; International Energy Agency, 2007, "World Energy Outlook 2007"; and Garnaut R., 2008.

Box 2: Growth in Australia's emissions

The contents of this box draw heavily on the Department of Climate Change and Energy Efficiency report, Australia's emissions projections 2010 *(DCCEE 2010)*

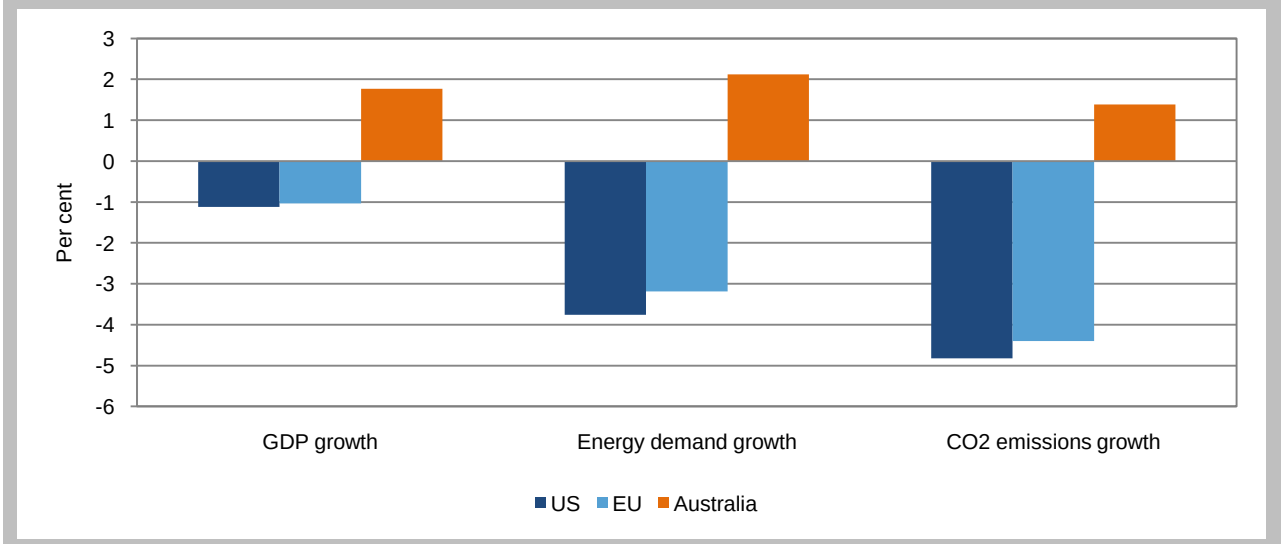
Australia weathered the Great Crash of 2008 better than any of the major advanced economies. Unemployment in Australia peaked at around 5.5 per cent in 2009, a year before it peaked in the US and the UK at over 9.5 per cent and 7.5 per cent, respectively (International Monetary Fund 2010). Australia escaped recession through the Great Crash and its aftermath. This outcome was the result of the interaction of sound institutions and policy settings prior to the crisis, early and strong fiscal and monetary expansion, and the quick return to strong growth in China and some other of Australia's major export customers. In 2009, following the unravelling of the global financial system, the US economy contracted by over 2.5 per cent, and the EU by more than 4 per cent. China, on the other hand, grew by almost 9 per cent in 2009, and India by over 5.5 per cent. Australia's economy grew by just over 1 per cent.

The strength of economic activity held up energy demand between 2007 and 2009, compared with sharp falls in energy demand in the US and EU. This translated into relatively robust emissions in Australia, compared to sharp emissions reductions in the US and EU. Most of Australia's emissions (65 per cent) result from fossil fuel combustion (DCCEE 2010, Pitt & Sherry 2010). Emissions from the energy sector have contributed 90 per cent of the total increase in emissions since 1990 (Pitt & Sherry 2010).

Emissions grew only two thirds as much as energy demand between 2007 and 2009 (and four fifths as much as GDP), reflecting a fall in the carbon intensity of energy (and a smaller fall in the carbon intensity of GDP) during the period. In August 2010, the carbon intensity of the Australian electricity supply reached its lowest level since the establishment of the National Electricity Market in 1998 (Pitt & Sherry 2010).

This is explained by a shift in energy generation away from coal and towards gas and renewables (with the latter driven by Australia's Renewable Energy Target), as well as improved energy efficiency (Pitt & Sherry 2010). Black coal fired generation declined by more than 7 per cent between 2008 and 2010, while renewable energy generation increased by half, albeit from a low base. In the year to August 2010, gas generation supplied more than 11 per cent of eastern states' electricity demand, while black coal supplied 56 per cent and brown coal 24 per cent. Renewables, including hydroelectric and wind, supplied the remaining 9 per cent.

Figure 18: Average annual growth in GDP, energy demand and CO_2 emissions, 2007 to 2009



Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing" October 2010; BP, 2010, "Statistical Review of World Energy 2010"; Australian Government, 2010, National Inventory Submission to the UNFCCC; Australian Government, 2011, "Australia's Emissions

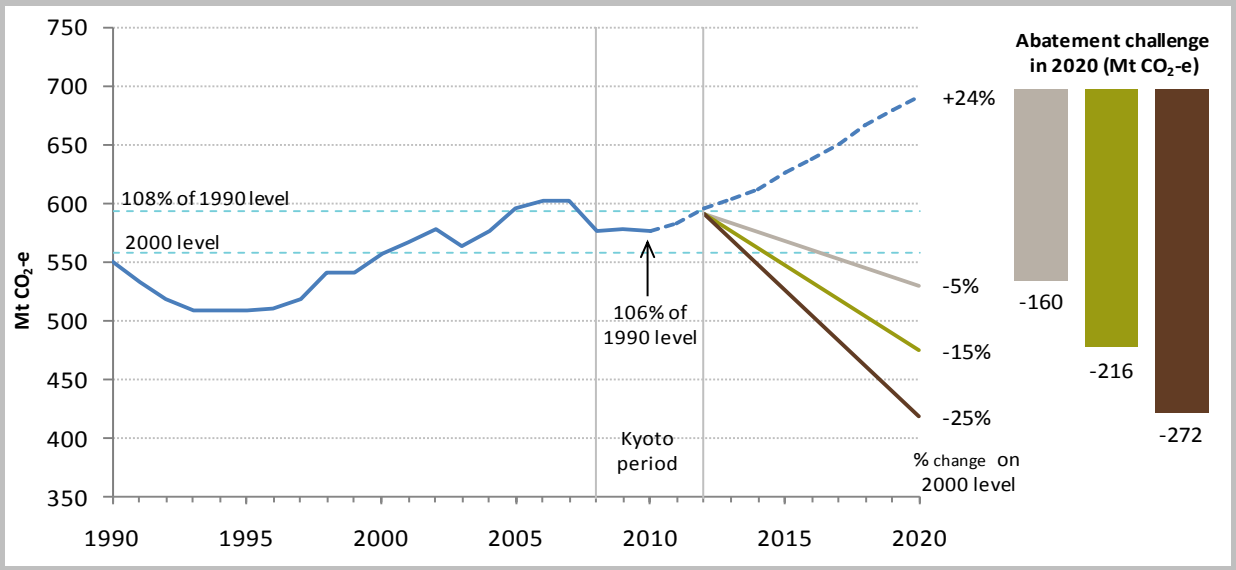
Projections 2010", Department of Climate Change and Energy Efficiency; and, Garnaut, R. 2008.

The factors that have driven the strong growth in Australia's economy, energy demand, and emissions are expected to continue and, in some cases, accelerate in the coming decades. Australia's natural resources are likely to continue to fuel the growth in China and India in the years ahead, although the relative importance of gas, coal and uranium is likely to change over time in ways that depend on technological and price developments as well as climate mitigation policies. The strength of the resources sector will encourage Australian emissions growth through two channels. The first is through the effect of increased economic activity on increased energy demand. The second is through the fugitive emissions that are a by-product of the extraction of many natural resources (particularly natural gas and coal).

The Australian Department of Climate Change and Energy Efficiency (DCCEE 2010) recently released its annual emissions projections for Australia. The projections lay out Australia's emissions trajectory on the basis of current policies. The report finds that Australia is on track to meet its Kyoto protocol target of limiting emissions to 108 per cent of 1990 levels in 2012, with emissions projected to reach 106 per cent of 1990 levels. The report expects strong growth in emissions in the absence of further policy action, with emissions projected to increase by 24 per cent from 2000 levels by 2020. This represents a 4 per cent upward revision of the previous year's projections.

Australia's 2020 emissions target is a range of 5 to 25 percent reduction relative to 2000, as recommended in the Review. The projected growth in emissions thus presents a substantial mitigation task in the decade ahead. The higher levels of ambition in particular would be extremely costly to attain without the purchase of overseas abatement (see Update Paper 2 *Progress towards effective global action on climate change*).

Figure 19: Australia's emissions trends, 1990 to 2020



Source: Australian Government, 2011, "Australia's Emissions Projections 2010", Department of Climate Change and Energy Efficiency; page 8.

The strong growth in emissions over the coming decade is expected to be dominated by the extraction and processing of energy resources. Fugitive emissions from coal mining and oil and gas extraction, as well as direct fuel combustion emissions from LNG projects account for almost half the growth in Australia's emissions to 2020. Fugitive emissions alone are set to account for just over a quarter of emissions growth. Electricity generation is expected to play a much smaller role in emissions growth in the coming decade. While it has accounted for the majority of the growth of emissions for many periods in the past, it is expected to account for only 12 per cent of emissions growth to 2020, due mainly to an increase in the use of renewable energy (driven by Australia's Renewable Energy Target).

4. Implications for global mitigation policy

An overarching conclusion from the Review was that effective global mitigation will only be possible with comprehensive involvement by developing countries. This conclusion has been further strengthened after the Great Crash of 2008, which has not diminished the overall global growth prospects, but has shifted the momentum even more firmly to the developing world. This has increased the magnitude of the challenge for global climate policy, by increasing the weight of that part of the world in which emissions growth is most rapid, and in which its diminution is for the time being most challenging.

4.1 The rise and rise of developing countries

The rapid growth of developing countries means that their share in the global greenhouse gas emissions is set to keep rising. The updated business as usual projections see developing countries accounting for 70 per cent of global carbon dioxide by 2030, up from around half today. This is a substantial upward revision to the Review's projections (Garnaut 2008) which had developing country emissions at 63 per cent by 2030.

Confounding the challenge is that the ascendency of developing countries is nowhere near completed by 2030. Under our projections, taking into account diminished growth prospects in the Northern Hemisphere developed countries, the average per capita income in developing countries would be a little over a quarter of that in the United States (refer Table 18 in Appendix 1). Today's differential is well over twice that large, so the next two decades would see a substantial narrowing but nowhere near the closure of the gap in economic activity and living standards. China would see its per capita income at half that of the United States in purchasing power parity terms. This does not take into account the likely large appreciation in China's real exchange rate, which will have the effect of raising national accounts-based income expressed in international currency more rapidly than purchasing power. But India's purchasing power per person would remain below a quarter of that in the United States.

The same continued potential for catch-up exists for greenhouse gas emissions. The 70 per cent of global emissions at 2030 would come from economies that are home to 80 per cent of the global population. In our updated business as usual projection, China's per capita emissions reach those in the United States by 2030 (at around 15 tonnes of CO_2 per person from fossil fuel combustion only). Across the developing countries however per capita emissions would still only amount to 38 per cent of those in the United States (or China), with obvious strong further potential for growth.

The picture could change dramatically under effective mitigation. Developing countries have many exceptional opportunities to de-carbonize energy supply, to increase energy efficiency, and to cut emissions from sources such as forests, agriculture and industrial activities. It is often less costly not to enter a path of carbon-intensive development, than to disentangle an economy from an established carbon-intensive structure. These circumstances of developing countries will need to be brought fully to account if rapid increases in economic output and transformative improvements in the living conditions of the majority of the humanity is to be reconciled with the avoidance of dangerous climate change.

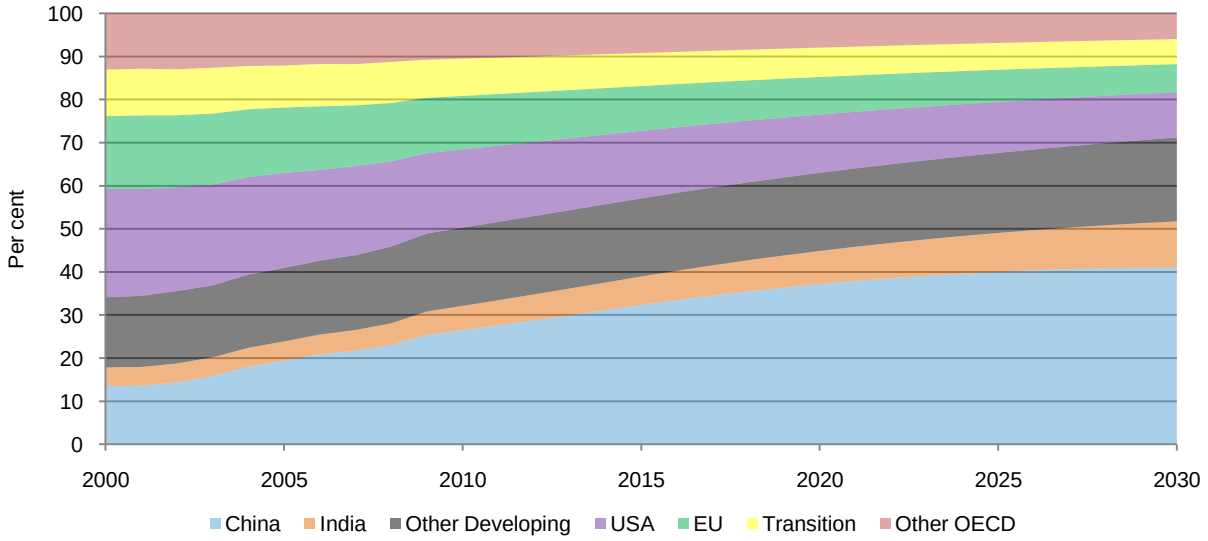
There should be no underestimation of the magnitude of the challenge. The shift in the locus of growth in economic activity and emissions to the developing countries adds to the magnitude of the task.

4.2 Challenges for China

The rapid rise of China poses challenges for its role in the global climate change mitigation effort.

The Review (Chapter 9) argued that there would be no effective global mitigation unless China accepted binding emissions targets within a global agreement. The Review proposed that the rule for allocating emissions entitlements should be convergence between countries to equal (and declining) per capita emissions entitlements. As a transitional arrangement for rapidly growing developing countries, including China, emissions entitlements would grow at half the rate of GDP (effectively a target for emissions intensity) until 2020 or until a country's entitlements per capita reached those of the developed country average.

Figure 20: Global business as usual emissions shares by region, 2000 to 2030

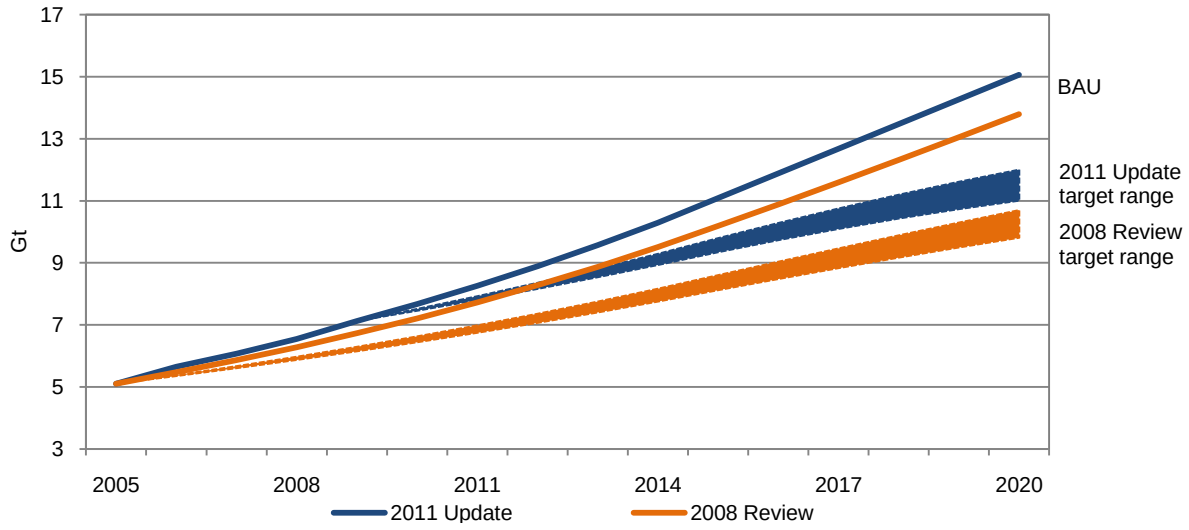


Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; and, BP, 2010, "Statistical Review of World Energy 2010"

As shown in Update Paper 2 (*Progress towards effective global action on climate change*), the emissions intensity target adopted by China and pledged under the Copenhagen Accords is significantly more ambitious than that suggested by the Review, in terms of the required annual reductions in emissions intensity. However, higher GDP growth also means faster growth of absolute emissions, for any given target framed in emissions intensity of GDP.

Under the updated business as usual projections, China's target of a 40 to 45 per cent reduction in emissions intensity from 2005 to 2020 would see China's per capita fossil fuel emissions grow to around 8 tonnes of CO_2 per person, compared to around 7 tonnes under the Review's projections. At these growth rates, China would exceed the declining average developed country emissions entitlement before 2020, under the Review's (ambitious) scenario towards stabilisation of global emissions at 450ppm CO_2-e. Hence, under the Review's proposed framework for strong global climate change mitigation, China would face declining absolute per capita emissions allocations before the end of the decade.

Figure 21: China's emissions under its Copenhagen target and business as usual



Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing" October 2010; International Energy Agency, 2010, "World Energy Outlook 2010"; BP, 2010, "Statistical Review of World Energy 2010"; and Garnaut, 2008.

5. Conclusion

The world has moved through the economic disruption of the Great Crash of 2008, and its recessionary aftermath, with a small but little change in expectations of business as usual growth in emissions. However, there has been a shift in the anticipated locus of economic and emissions growth towards the developing countries, beyond the considerable shift anticipated in 2008.

The further upward revisions of expectations of average rates of economic and emissions growth in China over the next two decades should be seen in the context of the upgrading of China's own mitigation commitments (Update Paper 2 *Progress towards effective global action on climate change*). China will reach the (falling) average emissions levels of developed countries earlier than anticipated despite the implementation of ambitious mitigation policies. The mitigation goals accepted by the international community at Copenhagen and Cancun will only remain within reach if China's emissions entitlements begin to fall absolutely from this (early) point.

The decline in emissions and expectations of emissions growth in developed countries in the aftermath of the Great Crash make it easier to realise announced mitigation targets. But this easing of demands on emissions in developed countries is fully matched by increased demands from developing countries. The arithmetic of greater concentration of anticipated global emissions growth in the developing countries points to the need for earlier and stronger constraints on emissions in developed and developing countries alike.

There are two small points of light in the underlying emissions reductions challenge.

One important driver of emissions, global population growth, has been gradually easing over the past several decades in response to rising living standards in the developing world—augmented in China by strong anti-natal policies. The acceleration of economic growth in developing countries in the early twenty first century holds our prospects for further reductions in fertility and population growth. However, the main effects of lower population growth on emissions is realised only in the long-distance future, and the global mitigation task is an urgent one.

Second, a surprising expansion of global gas reserves in the United States and in many countries creates an opportunity for greater reductions in emissions intensity of energy use than anticipated in the business as usual projections, through gas replacing more emissions-intensive coal. We may not have given sufficient weight to this factor in the Update's projections of business as usual emissions growth.

The emissions growth outlook is especially challenging for Australia. We stand out as the developed country whose anticipated business as usual emissions growth bucks the general tendency of developed countries, largely as a result of the expansion of the relative role of resources in the economy. This will not be easily understood by other countries, and is likely to bring Australian mitigation policy under close scrutiny. It is unlikely that Australia will meet international expectations of proportionate effort without getting credit for substantial international purchases of legitimate international entitlements. More fundamentally, any failure of proportionate mitigation effort will invite critical and in some circumstances damaging international responses.

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Appendix 1: Tables

Table 1: Annual GDP growth in selected countries, 2005 to 2010

	2005 (%)	2006 (%)	2007 (%)	2008 (%)	2009 (%)	2010 (%)
Developed	3	3.5	3.2	1	-3.7	*n.a.*
USA	3.1	2.7	2.1	0.4	-2.6	2.8
EU	2.1	3.4	3.1	1.0	-4.1	1.8
Russian Federation	6.4	7.7	8.1	5.6	-7.9	3.7
Japan	1.9	2.0	2.4	-0.7	-5.2	4.3
Canada	3.0	2.9	2.5	0.4	-2.5	2.9
Mexico	3.3	5.0	3.4	1.3	-6.5	5.2
Australia	3.0	3.3	3.7	2.3	1.2	2.7
Other Developed	5.3	6.2	5.8	2.5	-2.6	*n.a.*
Developing	7.8	8.5	9.2	6.7	5.0	*n.a.*
China	10.3	11.5	12.8	8.8	8.8	10.3
India	9.4	9.7	9.1	7.1	5.7	9.7
Indonesia	5.7	5.5	6.3	6.1	4.5	*n.a.*
Brazil	3.2	4.0	5.7	5.1	-0.2	7.5
South Africa	5.0	5.3	5.1	3.1	-1.8	2.8
Other Developing	6.0	6.2	6.4	4.8	1.5	*n.a.*
World	4.8	5.5	5.6	3.4	0.1	5

GDP is measured in purchasing power parities, 2000, US$. Data from 2005 to 2008 is taken from IEA (2010a). 2009 data was constructed by adjusting IMF(2010) data to purchasing power parities, calculating the 2008 to 2009 growth rate and applying this on a country by country basis to the 2008 data. 2010 data is taken from IMF (2011). 2010 growth rate for Australia is calculated from Australian Bureau of Statistics (2010) by annualising seasonally adjusted growth rates in the March, June and September Quarters.

Sources: International Energy Agency, 2010, “CO2 Emissions from Fossil Fuel Combustion 2010”; IMF, 2010, “World Economic Outlook – Recovery, Risk and Rebalancing”; IMF, 2011, “World Economic Outlook Update Jan 2011. “World Economic Outlook Update: Global Recovery Advances but Remains Uneven”; and, ABS, 2010, “Catalogue 5206: Australian National Accounts: National Income, Expenditure and Product, Sep 2010”.

Table 2: Average annual global growth in primary energy demand by source, 2005-08

	Developed (%)	Developing (%)	World (%)
Total	-0.2	5.0	2.4
Coal	0.5	8.0	4.7
Oil	-2.8	2.3	0.5
Gas	1.7	7.7	3.3
Nuclear	-0.7	4.0	-0.4
Hydro	0.6	6.1	3.2
Biomass and waste	5.6	1.4	2.2
Other renewables	9.4	18.5	13.4

Sources: International Energy Agency, 2010, “World Energy Outlook 2010”; and, International Energy Agency, 2007, “World Energy Outlook 2007”.

Table 3: Average annual growth in energy use, energy intensity and carbon intensity, selected countries, 2005-07 and 2007-09

	Energy demand		Energy intensity (energy demand/GDP)		Carbon intensity of energy (CO2/energy)	
Energy/ GDP	2005 to 2007 (%)	2007 to 2009 (%)	2005 to 2007 (%)	2007 to 2009 (%)	2005 to 2007 (%)	2007 to 2009 (%)
Developed	0.5	-3.2	-2.7	-1.8	0.1	-1.3
USA	0.4	-3.8	-2	-2.7	-0.5	-1.1
EU	-0.6	-3.2	-3.7	-1.6	0	-1.3
Russia	1.6	-2.4	-5.8	-1	0.4	-1.6
Japan	-0.5	-6.3	-2.7	-3.4	1.4	-3.6
Canada	0	-3.4	-2.7	-2.4	1.1	-1.4
Mexico	1.8	0.2	-2.3	3	1.7	-1.8
Australia	2.0	2.1	-1.4	0.4	-0.8	-0.7
Other Developed	2.8	-1.5	-3.0	-1.4	0.8	-0.3
Developing	5.5	4.8	-3.0	-1	1.3	0.9
China	7.6	8.1	-4.1	-0.7	1.4	0.2
India	5.3	5.3	-3.7	-1	2.0	1.3
Indonesia	3.1	3.5	-2.7	-1.7	2.9	0.4
Brazil	4.5	2.3	-0.3	-0.1	-1.6	-1.7
South Africa	3.3	-1.6	-1.8	-2.2	-1.5	-0.8
Other Developing	4.1	2.2	-2.1	-0.9	0.3	0.4
World	2.6	0.3	-2.7	-1.5	0.6	-0.2

GDP is measured in purchasing power parities, 2000, US$; Energy supply is measured in Megatonnes oil equivalent; and, CO2 is measured in Megatonnes. For Australia, emissions data is CO2 emissions from fossil fuel only derived from Australian Government 2010 and Australian Government 2011. All other data from 2005 to 2008 is taken from IEA 2010a. For GDP, 2009 data was constructed by adjusting IMF 2010 data to purchasing power parities, calculating the 2008 to 2009 growth rate and applying this on a country by country basis to the 2008 data. For energy supply and CO2, 2009 data was constructed by calculating the 2008 to 2009 the growth rates of energy demand and CO2 from BP 2010 and applying this on a country or regional basis to the 2008 data.

Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing" October 2010; BP, 2010, "Statistical Review of World Energy 2010"; Australian Government, 2010, "National Inventory Submission to the UNFCCC"; and, Australian Government, 2011, "Australia's Emissions Projections 2010", Department of Climate Change and Energy Efficiency.

Table 4: Annual CO2 emissions growth in selected countries, 2005 to 2009

	2005 (%)	2006 (%)	2007 (%)	2008 (%)	2009 (%)
Developed	0.3	0.3	1.0	-2.0	-6.7
USA	0.2	-1.5	1.4	-2.9	-6.7
EU	-0.8	0.4	-1.5	-2	-6.7
Russian Federation	0.2	4.2	-0.1	1.0	-8.7
Japan	0.7	-1.3	3.1	-7.3	-12.0
Canada	0.9	-2.7	5.0	-3.5	-6.1
Mexico	6.0	1.8	5.2	-2.2	-0.9
Australia	1.1	0.9	1.5	2.2	0.6
Other Developed	0.2	4.2	3.0	1.3	-4.8
Developing	7.0	7.5	6.3	6.2	5.4
China	11.3	10.6	7.5	7.8	8.8
India	3.8	7.8	7.0	6.7	6.7
Indonesia	3.2	4.4	7.7	5.6	2.3
Brazil	1.7	1.5	4.2	5.8	-4.4
South Africa	-2.1	0.4	3.2	-1.6	-3.3
Other Developing	4.0	4.4	4.5	4.2	1.2
World	2.9	3.3	3.3	1.5	-1.3

CO2 is measured in Megatonnes. For Australia, emissions data is CO2 emissions from fossil fuel only derived from Australian Government 2010 and Australian Government 2011. All other data from 2005 to 2008 is taken from IEA 2010a. For all other regions, 2009 data was constructed by calculating the 2008 to 2009 the growth rates of CO2 from BP 2010 and applying this on a country or regional basis to the 2008 data.

Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; BP, 2010, "Statistical Review of World Energy 2010"; Australian Government, 2010, "National Inventory Submission to the UNFCCC"; and, Australian Government, 2011, "Australia's Emissions Projections 2010", Department of Climate Change and Energy Efficiency.

Table 5: Average annual change in emissions intensity in selected countries, 2005-07 and 2007-09

CO2/ GDP	2005 to 2007 (%)	2007 to 2009 (%)
Developed	-2.6	-3.1
OECD North America	-2.3	-3.4
OECD Europe	-3.2	-2.8
OECD Pacific	-1.9	-3.4
Transition	-5.4	-2.9
Developing	-1.8	-0.1
China	-2.8	-0.5
India	-1.8	0.3
Indonesia	0.2	-1.3
Other Asia	-2.9	-1.5
Latin America	-2.4	-1.5
Middle East	0.3	1.8
Africa	-2.6	-3.6
World	-2.1	-1.6

GDP is measured in purchasing power parities, 2000, US$; and, CO2 is measured in Megatonnes. For Australia, emissions data is CO2 emissions from fossil fuel only derived from Australian Government 2010 and Australian Government 2011. All other data from 2005 to 2008 is taken from IEA 2010a. For GDP, 2009 data was constructed by adjusting IMF 2010 data to purchasing power parities, calculating the 2008 to 2009 growth rate and applying this on a country by country basis to the 2008 data. For CO2, 2009 data was constructed by calculating the 2008 to 2009 the growth rates of energy demand and CO2 from BP 2010 and applying this on a country or regional basis to the 2008 data.

Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing" October 2010; BP, 2010, "Statistical Review of World Energy 2010"; Australian Government, 2010, "National Inventory Submission to the UNFCCC"; and, Australian Government, 2011, "Australia's Emissions Projections 2010", Department of Climate Change and Energy Efficiency.

Table 6: Projected annual average GDP growth

	Actual (%)	Updated projections (%)		Comparison (%)	
	2005 to 2009	2009 to 2015	2015 to 2030	2008 Review 2005 to 2030	2011 Update 2005 to 2030
Developed countries	0.9	2.2	2.0	2.5	1.9
OECD North America	0.6	2.2	2.0	2.4	1.8
OECD Europe	0.8	1.6	1.6	2	1.4
OECD Pacific	0.7	2.6	1.6	1.8	1.7
Transition	3.5	3.9	4	4.7	3.9
Developing countries	7.3	7.6	6.4	6.5	6.9
China	10.5	9.8	6.7	7.7	8.0
India	7.9	9	8.5	7.5	8.5
Indonesia	5.6	6.5	6.5	6.5	6.4
Other	4.3	5.0	5.0	4.7	4.9
Latin America	4.4	4.0	4.0	3.9	4.1
Middle East	4.5	4.3	4.3	4.6	4.3
Africa	4.9	5.5	5.5	4.6	5.4
World	3.6	4.9	4.7	4.5	4.6

GDP is measured in purchasing power parities, 2000, US$. For GDP, 2009 data was constructed by adjusting IMF 2010 data to purchasing power parities, calculating the 2008 to 2009 growth rate and applying this on a country by country basis to the 2008 data. GDP from 2009-2030 as projected by author. 2008 Review Annual Growth Projections are taken from published and unpublished data from Garnaut (2008).

Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing" October 2010; International Energy Agency, 2010, "World Energy Outlook 2010"; and, Garnaut, 2008.

Table 7: Assumptions regarding future fossil fuel prices

	Unit	2008 price (ETP 2010)	2030 projection (ETP 2010) (US$ 2008)	2030 projection (ETP 2008) (US$2008)	Difference in projections (%)
Crude oil imports	Barrel	97	115	66	74
Natural gas					
US	Mbtu	8.3	11.4	8.4	35
EU	MBtu	10.3	14	7.8	79
Japan	MBtu	12.6	15.9	7.5	112
OECD steam coal imports	Tonne	121	109	67	62

Sources, International Energy Agency, 2010, "Energy Technology Perspectives 2010"; and, International Energy Agency, 2008, "Energy Technology Perspectives 2008".

Table 8: Projected average annual change in energy intensity 2009 to 2030, IEA 2007 and 2010

	Latest IEA projection (WEO 2010) (%)	Earlier IEA projection (WEO 2007) (%)	Change in projections (%)
Developed countries	-1.4	-1.4	0
OECD North America	-1.7	-1.3	-0.4
OECD Europe	-1.3	-1.5	0.2
OECD Pacific	-1.0	-1.0	0
Transition	-2.1	-2.3	0.2
Developing countries	-2.8	-2.2	-0.6
China	-3.7	-2.7	-1
India	-3.3	-2.5	-0.8
Indonesia	-1.2	-1.0	-0.2
Other	-1.2	-1.4	0.3
Latin America	-1.2	-0.9	-0.4
Middle East	-1.4	-1.1	-0.4
Africa	-2.3	-2.0	-0.3
World	-2.2	-1.8	-0.4

GDP is measured in purchasing power parities, 2000, US$; Energy supply is measured in Megatonnes oil equivalent; and, CO2 is measured in Megatonnes. Data from 2005 to 2008 is taken from IEA 2010a. For GDP, 2009 data was constructed by adjusting IMF 2010 data to purchasing power parities, calculating the 2008 to 2009 growth rate and applying this on a country by country basis to the 2008 data. For energy supply and CO2, 2009 data was constructed by calculating the 2008 to 2009 the growth rates of energy demand and CO2 from BP 2010 and applying this on a country or regional basis to the 2008 data. The "latest IEA projection" is taken from IEA (2010). For GDP growth we use the 2010-2015 projected growth rate for the period from 2009-2015 and a composite of the 2008-2020 and 2020-2035 growth rates for the 2015 to 2030 growth rate. The exception is Indonesia and other Asia. Indonesia's energy and CO2 growth rates from 2009-2030 are assumed to be the same as that used in the 2008 Review, its GDP growth rate is assumed to equal the growth rate of "other Asia" grouping given in IEA 2010, other Asia is calculated as the residual. For "previous IEA projection" the 2009 base year from which growth is measured is calculated by using the original projected growth rates over the 2005 to 2009 period. To allow comparison between the latest and previous projections, the 2007 projections need to be augmented to include aviation bunkers. For the 2005 to 2030 period we assumed an annual growth rate equal to the growth rate of total bunkers in the 2009 to 2030 period in the latest IEA projections.

Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; BP, 2010, Statistical Review of World Energy; International Energy Agency, 2010, "World Energy Outlook 2010"; IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing"; International Energy Agency, 2007, "World Energy Outlook 2007"; and, Garnaut 2008.

Table 9: Projected average annual change in energy intensity (change in energy use per unit of GDP)

	Actual (%)	Updated projections (%)	Comparison (%)	
	2005 to 2009	2009 to 2030	2008 Review 2005 to 2030	2011 Update 2005 to 2030
Developed countries	-2.3	-1.5	-1.3	-1.6
OECD North America	-2.2	-1.5	-1.3	-1.6
OECD Europe	-2.4	-1.7	-1.5	-1.8
OECD Pacific	-1.8	-1.2	-0.9	-1.3
Transition	-3.9	-2.5	-2.4	-2.7
Developing countries	-2.0	-2.1	-1.8	-2.1
China	-2.4	-2.0	-1.8	-2.1
India	-2.4	-2.7	-2.6	-2.6
Indonesia	-2.2	-1.2	-1.2	-1.4
Other	-2.3	-1.6	-1.5	-1.7
Latin America	-1.5	-1.1	-0.9	-1.1
Middle East	1.0	-1.3	-1.1	-0.9
Africa	-2.6	-2.2	-2.1	-2.3
World	-2.1	-1.9	-1.6	-1.9

GDP is measured in purchasing power parities, 2000, US$; Energy supply is measured in Megatonnes oil equivalent; and, CO2 is measured in Megatonnes. Data from 2005 to 2008 is taken from IEA (2010a). For GDP, 2009 data was constructed by adjusting IMF (2010) data to purchasing power parities, calculating the 2008 to 2009 growth rate and applying this on a country by country basis to the 2008 data. For energy supply and CO2, 2009 data was constructed by calculating the 2008 to 2009 the growth rates of energy demand

and CO2 from BP (2010) and applying this on a country or regional basis to the 2008 data. The "08 Review Projections" are taken from Garnaut (2008), adjusted to include energy and CO2 aviation bunkers. For bunkers we assume that over the 2005 to 2030 period the annual growth rate is equal to the growth rate of total bunkers in the 2009 to 2030 period in the latest IEA projections.

Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; BP, 2010, Statistical Review of World Energy; IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing"; International Energy Agency, 2010, "World Energy Outlook 2010"; and, Garnaut 2008.

Table 10: Projected average annual growth in energy use (change in total primary energy supply)

	Actual (%)	Updated projections (%)	Comparison (%)	
	2005 to 2009	2009 to 2030	2008 Review 2005 to 2030	2011 Update 2005 to 2030
Developed countries	-1.4	0.5	1.1	0.2
OECD North America	-1.5	0.5	1.0	0.1
OECD Europe	-1.6	-0.1	0.5	-0.4
OECD Pacific	-1.2	0.7	0.9	0.4
Transition	-0.6	1.4	2.2	1.1
Developing countries	5.2	4.6	4.5	4.7
China	7.8	5.4	5.8	5.8
India	5.3	5.7	4.7	5.7
Indonesia	3.3	5.2	5.2	4.9
Other	1.9	3.3	3.2	3.0
Latin America	2.8	2.9	3.0	2.9
Middle East	5.5	3.0	3.5	3.4
Africa	2.2	3.2	2.4	3.0
World	1.4	2.8	2.8	2.6
Bunkers	-0.3	1	1	0.8

Energy supply is measured in Megatonnes oil equivalent. Data from 2005 to 2008 is taken from IEA (2010a). For energy supply, 2009 data was constructed by calculating the 2008 to 2009 the growth rates of energy demand from BP (2010) and applying this on a country or regional basis to the 2008 data. The "08 Review Projections" are taken from Garnaut (2008), adjusted to include energy aviation bunkers. For bunkers we assume that over the 2005 to 2030 period the annual growth rate is equal to the growth rate of total bunkers in the 2009 to 2030 period in the latest IEA projections.

Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; BP, 2010, Statistical Review of World Energy; International Energy Agency, 2010, "World Energy Outlook 2010"; and, Garnaut 2008.

Table 11: World energy mix (global primary energy demand by fuel)

	2008 (%)	2030, latest IEA projection (WEO 2010) (%)	2030, earlier IEA projection (WEO 2007) (%)	Difference in projected shares at 2030 (%)
Coal	27.0	29.1	28.2	0.9
Oil	33.1	28.5	31.5	-3.0
Gas	21.2	22.0	22.3	-0.3
Coal + Oil + Gas	81.2	79.6	82	-2.4
Nuclear	5.8	6.1	4.8	1.3
Hydro	2.2	2.5	2.3	0.1
Biomass and waste	10.0	9.6	9.1	0.5
Other renewables	0.7	2.3	1.7	0.5
TPED	*100*	*100*	*100*	

World Energy Mix 2008 and Projections for 2030.

Sources: International Energy Agency, 2007, "World Energy Outlook 2007"; and, International Energy Agency, 2010, "World Energy Outlook 2010"

Table 12: Projected average annual change in carbon intensity of energy, IEA 2007 and 2010 projections

Carbon intensity of energy	Latest IEA projection (WEO 2010) (%)	Earlier IEA projection (WEO 2007) (%)	Change in projections (%)
Developed countries	-0.4	-0.2	-0.2
OECD North America	-0.3	-0.2	-0.2
OECD Europe	-0.4	-0.1	-0.4
OECD Pacific	-0.7	-0.5	-0.2
Transition	-0.1	-0.3	0.2
Developing countries	0.1	0.2	-0.1
China	-0.1	0	-0.2
India	0.5	0.7	-0.1
Indonesia	0.5	0.5	0
Other	0.5	0.3	0.2
Latin America	-0.1	-0.1	0
Middle East	-0.2	0	-0.1
Africa	0.2	0.4	-0.2
World	-0.1	0.1	-0.1

For further information on data and sources, please refer to table 9 in appendix.

Table 13: Projected average annual growth in carbon intensity of energy (carbon dioxide emissions per unit of primary energy supply)

	Actual (%)	Updated projections (%)	Comparison (%)	
	2005 to 2009	2009 to 2030	2008 Review 2005 to 2030	2011 Update 2005 to 2030
Developed countries	-0.6	-0.2	-0.2	-0.3
OECD North America	-0.7	-0.2	-0.2	-0.2
OECD Europe	-0.6	-0.1	-0.1	-0.1
OECD Pacific	-0.8	-0.5	-0.5	-0.5
Transition	-0.2	-0.3	-0.3	-0.3
Developing countries	1.1	0.3	0.4	0.5
China	0.8	0	0.1	0.2
India	1.7	0.7	0.7	0.8
Indonesia	1.6	0.5	0.5	0.7
Other	0.1	0.3	0.3	0.3
Latin America	-0.4	-0.1	-0.1	-0.1
Middle East	0.1	0	0	0
Africa	-0.6	0.4	0.4	0.2
World	0.2	0.3	0.2	0.3
Bunkers	*1.1*	*1.5*	*1.4*	*1.4*

Energy supply is measured in Megatonnes oil equivalent; and, CO2 is measured in Megatonnes. Data from 2005 to 2008 is taken from IEA (2010a). For energy supply and CO2, 2009 data was constructed by calculating the 2008 to 2009 the growth rates of energy demand and CO2 from BP (2010) and applying this on a country or regional basis to the 2008 data. The “08 Review Projections” are taken from Garnaut (2008), adjusted to include energy and CO2 aviation bunkers. For bunkers we assume that over the 2005 to 2030 period the annual growth rate is equal to the growth rate of total bunkers in the 2009 to 2030 period in the latest IEA projections.

Sources: International Energy Agency, 2010, “CO2 Emissions from Fossil Fuel Combustion 2010”; BP, 2010, Statistical Review of World Energy; International Energy Agency, 2010, “World Energy Outlook 2010”; and, Garnaut 2008.

Table 14: Projected average annual growth in carbon dioxide emissions

	Actual (%)	Updated projections (%)	Comparison (%)	
	2005 to 2009	2009 to 2030	2008 Review 2005 to 2030	2011 Update 2005 to 2030
Developed countries	-1.9	0.3	0.9	-0.1
OECD North America	-2.2	0.3	0.8	-0.1
OECD Europe	-2.2	-0.2	0.4	-0.5
OECD Pacific	-2	0.2	0.4	-0.1
Transition	-0.8	1.0	1.9	0.8
Developing countries	6.3	4.9	5.0	5.2
China	8.7	5.5	5.8	6.0
India	7.1	6.4	5.4	6.5
Indonesia	5.0	5.7	5.7	5.6
Other	2.0	3.6	3.6	3.3
Latin America	2.4	2.8	2.9	2.7
Middle East	5.6	2.9	3.4	3.4
Africa	1.6	3.5	2.7	3.2
World	1.7	3.1	3	2.8
Bunkers	*0.8*	*2.6*	*2.9*	*2.3*

CO2 is measured in Megatonnes. Data from 2005 to 2008 is taken from IEA (2010a). For CO2, 2009 data was constructed by calculating the 2008 to 2009 the growth rates of energy demand and CO2 from BP (2010) and applying this on a country or regional basis to the 2008 data. The "08 Review Projections" are taken from Garnaut (2008), adjusted to include CO2 aviation bunkers. For bunkers we assume that over the 2005 to 2030 period the annual growth rate is equal to the growth rate of total bunkers in the 2009 to 2030 period in the latest IEA projections.

Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; BP, 2010, Statistical Review of World Energy; International Energy Agency, 2010, "World Energy Outlook 2010"; and, Garnaut 2008.

Table 15: Comparison of 2030 emissions levels with 2008 Review

	Comparison with 2008 Review		Comparison with 2008 Review (GDP only changes)		Share of global emissions	
	Diff. at 2030 (%)	Diff. at 2030 (Gt)	Diff. at 2030 (%)	Diff. at 2030 (Gt)	2011 Update (%)	2008 Review (%)
Developed countries	-21.1	4.1	-8.5	1.4	27.9	33.8
OECD North America	-21.3	1.8	-7.3	0.5	12.0	14.6
OECD Europe	-20.5	0.9	-5.6	0.2	6.6	7.9
OECD Pacific	-11.5	0.3	-13.4	0.3	3.7	4
Transition	-26.7	1.1	-10.9	0.4	5.6	7.4
Developing countries	5.6	-2	-1	0.4	69.1	62.7
China	3.1	-0.7	-3.5	0.8	39.9	37
India	31.1	-1.3	9.8	-0.5	10.3	7.6
Indonesia	-7.6	0.1	6.3	-0.1	2.3	2.4
Other	0.3	0	2.0	-0.1	4.6	4.4
Latin America	-2.6	0	-6.0	0.1	3.4	3.4
Middle East	-1.7	0.1	-5.1	0.2	5.2	5.1
Africa	11.5	-0.2	3.2	-0.1	3.3	2.9
World	-4.2	2.4	-3.7	2.1	100	100
Bunkers	-16.2	0.3	not applicable		3	3.5

CO2 is measured in Megatonnes. GDP only changes assumed no change in energy intensity of GDP or carbon intensity of energy. The "08 Review Projections" are taken from Garnaut (2008), adjusted to include CO2 aviation bunkers. For bunkers we assume that over the 2005 to 2030 period the annual growth rate is equal to the growth rate of total bunkers in the 2009 to 2030 period in the latest IEA projections.

Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; BP, 2010, Statistical Review of World Energy; International Energy Agency, 2010, "World Energy Outlook 2010"; and, Garnaut 2008.

Table 16: Projected average annual growth in emissions intensity of GDP (carbon dioxide emissions per unit of primary energy supply)

	Actual (%)	Updated projections (%)	Comparison (%)	
	2005 to 2009	2009 to 2030	2008 Review 2005 to 2030	2011 Update 2005 to 2030
Developed Countries	-2.8	-1.7	-1.6	-1.9
OECD North America	-2.9	-1.7	-1.5	-1.9
OECD Europe	-3.0	-1.7	-1.6	-1.9
OECD Pacific	-2.6	-1.6	-1.4	-1.8
Transition	-4.1	-2.8	-2.7	-3.0
Developing Countries	-0.9	-1.7	-1.4	-1.6
China	-1.6	-2.0	-1.7	-1.9
India	-0.7	-2.0	-1.9	-1.8
Indonesia	-0.6	-0.8	-0.7	-0.7
Other Asia	-2.2	-1.3	-1.1	-1.5
Latin America	-1.9	-1.2	-1.0	-1.3
Middle East	1.1	-1.3	-1.1	-0.9
Africa	-3.1	-1.9	-1.8	-2.1
World	-1.9	-1.6	-1.4	-1.6

GDP is measured in purchasing power parities, 2000, US$; and, CO2 is measured in Megatonnes. Data from 2005 to 2008 is taken from IEA (2010a). For GDP, 2009 data was constructed by adjusting IMF (2010) data to purchasing power parities, calculating the 2008 to 2009 growth rate and applying this on a country by country basis to the 2008 data. For and CO2, 2009 data was constructed by calculating the 2008 to 2009 the growth rates of CO2 from BP (2010) and applying this on a country or regional basis to the 2008 data. The "08 Review Projections" are taken from Garnaut (2008), adjusted to include CO2 aviation bunkers. For bunkers we assume that over the 2005 to 2030 period the annual growth rate is equal to the growth rate of total bunkers in the 2009 to 2030 period in the latest IEA projections.

Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing"; BP, 2010, Statistical Review of World Energy; International Energy Agency, 2010, "World Energy Outlook 2010"; and, Garnaut 2008.

Table 17: Difference in projected average annual growth in emissions and its drivers, 2009-30, Update and IEA

	GDP (%)	Energy intensity (energy/GDP) (%)	Carbon intensity (CO2/energy) (%)	CO2 emissions (%)
Developed countries	-0.12	-0.08	0.15	-0.04
OECD North America	-0.30	0.18	0.18	0.07
OECD Europe	-0.25	-0.39	0.36	-0.28
OECD Pacific	0.17	-0.17	0.19	0.18
Transition	0.54	-0.43	-0.20	-0.13
Developing countries	1.32	0.78	0.25	2.38
China	1.15	1.65	0.17	3.07
India	1.91	0.63	0.12	2.67
Indonesia	2.79	-0.03	0.02	2.76
Other	1.27	-0.46	-0.22	0.55
Latin America	0.79	0.17	0.03	0.98
Middle East	0.31	0.17	0.13	0.61
Africa	1.53	0.10	0.19	1.80
World	0.81	0.37	0.33	1.52

GDP is measured in purchasing power parities, 2000, US$; Energy supply is measured in Megatonnes oil equivalent; and, CO2 is measured in Megatonnes. Data from 2005 to 2008 is taken from IEA (2010a). For GDP, 2009 data was constructed by adjusting IMF (2010) data to purchasing power parities, calculating the 2008 to 2009 growth rate and applying this on a country by country basis to the 2008 data. For energy supply and CO2, 2009 data was constructed by calculating the 2008 to 2009 the growth rates of energy demand and CO2 from BP (2010) and applying this on a country or regional basis to the 2008 data. The "latest IEA projection" is taken from IEA (2010). For GDP growth we use the 2010-2015 projected growth rate for the period from 2009-2015 and a composite of the 2008-2020 and 2020-2035 growth rates for the 2015 to 2030 growth rate. The exception is Indonesia and other Asia. Indonesia's energy and CO2 growth rates from 2009-2030 are assumed to be the same as that used in the 2008 Review, its GDP growth rate is assumed to equal the growth rate of "other Asia" grouping given in IEA (2010b), other Asia is calculated as the residual. For "previous IEA projection" the 2009 base year from which growth is measured is calculated by using the original projected growth rates over the 2005 to 2009 period. To allow comparison between the latest and previous projections, the 2007 projections need to be augmented to include aviation bunkers. For the 2005 to 2030 period we assumed an annual growth rate equal to the growth rate of total bunkers in the 2009 to 2030 period in the latest IEA projections.

Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; BP, 2010, Statistical Review of World Energy; IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing" October 2010; International Energy Agency, 2010, "World Energy Outlook 2010"; International Energy Agency, 2007, "World Energy Outlook 2007"; and, Garnaut 2008.

Table 18: Emissions per capita and GDP per capita

	Region/ country/ economy	2009 (%)	2030 (%)	Comparison: 2008 Review [a] (%)
Emissions per capita as share of US emissions per capita	**Developed country average**	55.8	61.9	61.8
	Developing country average	15.7	37.8	28.2
	China	31.7	98.7	75.3
	India	7.7	25.4	15.2
	USA	100	100	100
GDP per capita as share of US per capita income (at 2009 PPP adjusted exchange rates)	**Developed country average**	61.8	68.8	68.7
	Developing country average	11.6	26.6	21
	China	15.4	50.7	40.7
	India	6.7	23.9	16.5
	USA	100	100	100

Sources: International Energy Agency, 2010, "CO2 Emissions from Fossil Fuel Combustion 2010"; BP, 2010, "Statistical Review of World Energy 2010"; IMF, 2010, "World Economic Outlook – Recovery, Risk and Rebalancing"; UN, 2008, "World Population Prospects: The 2008 Revision Population Database".

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