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# ***Green race is on*** Low carbon economy index 2010

*December 2010*



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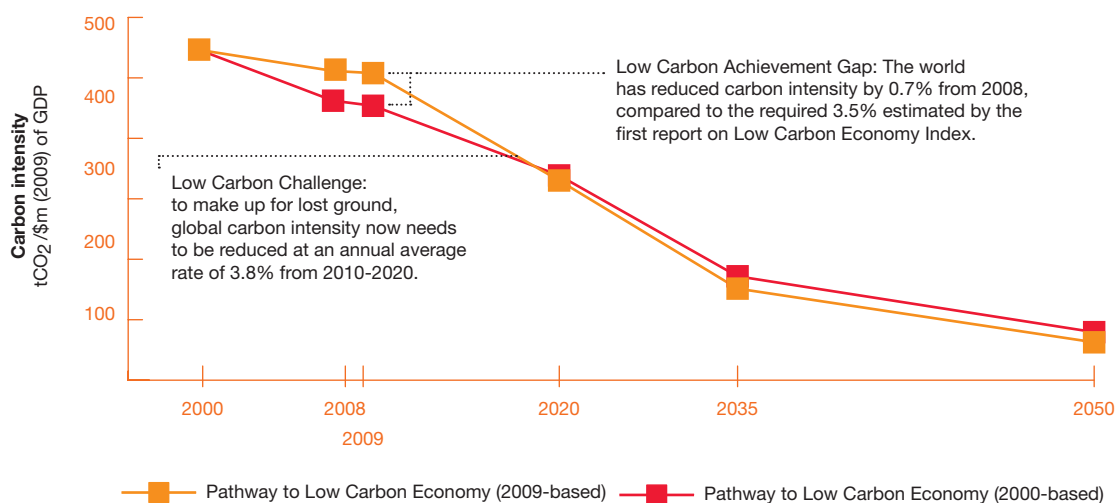
## *Key findings*

The world needs to reduce carbon intensity by around 88% by 2050 to stabilise atmospheric carbon concentrations at 450ppm CO<sub>2</sub>e and limit climate change to two degrees of warming.

Starting in 2000, the global economy would have needed to decarbonise by around 2% a year each year until 2020 to get onto a low carbon pathway.

PwC's analysis shows the progress of the major economies in reducing carbon intensity. The average rate of decarbonisation between 2000 and 2008 was around 0.8%. In 2009, the carbon intensity fell by around 0.7%. The world now needs to decarbonise significantly faster, at 3.8% a year until 2020, to keep to the 450ppm target.

**Figure 1. Global Low Carbon Achievement Gap (2009)**



Source: PwC analysis

**PwC's analysis shows:**

- Despite ambitious targets and policy commitments announced in 2009, many of the world's largest economies have remained on their business-as-usual carbon pathways.** In 2009, global GDP shrank by 0.6% with a corresponding 1.3% fall in carbon emissions compared to 2008, resulting in a 0.7% reduction in global carbon emissions intensity. The lower intensity level is a step in the right direction but it is nowhere near the 3.5% a year reduction through to 2020 which PwC estimates is required.
- Global Low Carbon Achievement:** Figure 1 shows the 2009 Global Low Carbon Achievement Gap, which measures the performance of the world's economy between 2000 and 2009 against a low carbon pathway for 2000 – 2050. The world economy is currently just over 10% adrift from the low carbon pathway. Based on current trends in carbon intensity, the world will have used up its estimated global carbon budget for the first half of this century by 2034, 16 years ahead of schedule.
- The world now needs to decarbonise significantly faster, at 3.8% per year instead of 3.5% to 2020.** The Low Carbon Challenge Index assesses the 'distance to go' in reducing carbon intensity. Overall, the slow progress in the first decade of this century has magnified the challenge of transitioning to a low carbon economy. The global 'carbon debt' (cumulative global budget overshoot) since 2000 is around 17GtCO<sub>2</sub>. As a result, PwC estimates that a global reduction in carbon intensity by around 88% by 2050 is required in order to meet within the global carbon budget.

# Low Carbon Economy Index

## Introduction

Ahead of the United Nations Framework Convention on Climate Change (UNFCCC) Fifteenth Conference of Parties (COP15) in Copenhagen last December, PwC published the first Low Carbon Economy Index.

The report looked at the progress of the G20 economies against their estimated carbon budgets, with:

- **The PwC Low Carbon Achievement (LCA) Index**, assesses how much progress countries have made this century in reducing the carbon intensity<sup>1</sup> of their economies relative to a low carbon pathway; and
- **The PwC Low Carbon Challenge (LCC) Index**, assesses the distance to go for key countries in reducing their carbon intensity.

One year on, PwC re-examines the progress of the G20 economies against the Low Carbon Achievement and Low Carbon Challenge Index. This post-Copenhagen report provides an update on the progress over 2009.

## Key messages from the first report on Low Carbon Economy Index

The Low Carbon Economy Index draws on the estimates by many climate scientists (Including Intergovernmental Panel on Climate Change (IPCC 4th Assessment Report) 2007, NASA and others) that for a fair chance to limit increases in average global temperature to 2°C and avoid significant climate change, the levels of greenhouse gases (GHG) need to stabilise at a concentration of 450 ppm CO<sub>2</sub>e by 2100<sup>2</sup>.

Since it is cumulative global emissions that drive atmospheric CO<sub>2</sub> concentrations rather than emissions in any one year, there is therefore an implied global carbon budget between 2000 and 2050 that the global economy can 'consume' without risking significant climate change. After taking into account the role of land use change and forestry and carbon sinks, PwC has estimated the cumulative global energy-related carbon budget to be just under 1,300 GtCO<sub>2</sub>. The low carbon economy will have to be delivered without compromising economic growth through a combination of significant energy efficiency improvements. A structured shift towards low carbon power generation (such as renewable and nuclear energy) and decarbonising remaining fossil fuel usage through carbon capture and storage is needed.

Individual country contribution to emissions reduction over a business-as-usual scenario, however, will vary depending on their existing fuel mix, their rate of energy efficiency improvements, and their potential for carbon capture and storage. PwC has estimated a country allocation of the global carbon budget for the G20 economies, which collectively make up over 80% of global carbon emissions, based on assumptions in these areas. These assumptions lead to country level projections of energy-related emissions, with some common features across countries but also some variations to reflect differing starting points, stages of economic development and energy resource endowments. Further details of the methodology are available in the appendix of this report.

The estimated global carbon budget implies that annual emissions of global total greenhouse gases will need to fall to below 20GtCO<sub>2</sub>e by 2050, half the global annual emissions today, while sustaining a global economy nearly four times larger and global population one and a half times bigger. Carbon intensity – or the amount of carbon emissions released per unit of GDP – needs to decrease steadily for all countries, effectively decoupling economic growth from emissions.

PwC's first analysis in 2009 revealed that, despite a global trend of decarbonisation – i.e. reducing the amount of carbon emitted for every unit of GDP produced – there is a widening gap between the global carbon budget and actual carbon emissions. For 2000-2008, the cumulative global budget overshoot, or 'carbon debt', was estimated at around 13 GtCO<sub>2</sub>. Global carbon emissions in 2008 were around 10% above levels implied by these estimated annual budgets.

These estimates amplify the challenge of moving towards a low carbon economy. If the world had started taking active measures to reduce carbon intensity in 2000, an average decarbonisation rate of 2% a year would meet the carbon budget. But the global rate of carbon intensity reduction actually achieved up to 2008 was only around 0.8%. The world now needs to decarbonise significantly faster, at 3.8% a year until 2020, to keep to the 450ppm target. This amounts to a reduction of around 20GtCO<sub>2</sub>e below business-as-usual by 2020, and is greater than the levels of improvement in carbon intensity seen even in the 1990s in the UK (with its 'dash for gas') and after German reunification.

**Post-Copenhagen update:  
No decoupling of carbon from  
economic growth**

In 2009, global GDP (by purchasing power parity (PPP) measure) shrank by 0.6%, with an estimated 1.3% fall in carbon emissions released compared to 2008. The lower emission level is a step in the right direction for the climate system, but there is the potential that this dampens the urgency to act.

Technology-led changes in energy mix and the end-use efficiency of equipment and buildings have led to a decrease in global energy intensity since 2000. The fluctuations in oil prices in the past decade have also led to increased urgency in energy efficiency improvements, as well as greater policy emphasis on diversifying away from traditional fossil fuels towards renewable and nuclear energy sources in many countries.

The reduction in carbon intensity since 2000 as a result of these changes, however, has not been sufficient for the world to stay within the carbon budget for the first decade of this century.

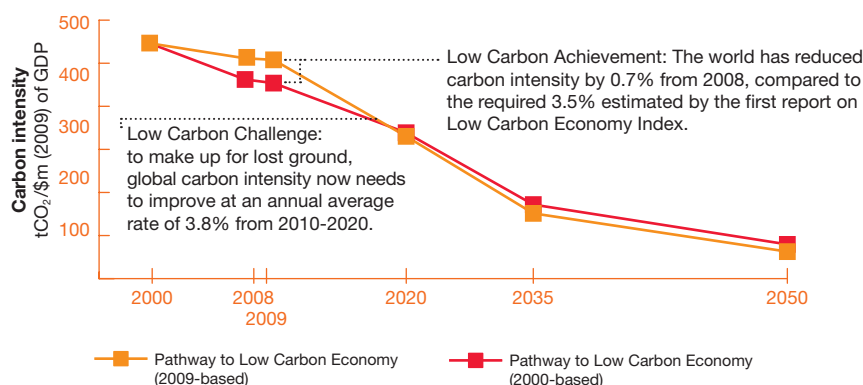
Figure 1 shows the 2009 Global Low Carbon Achievement Gap which measures the performance of the world's economy between 2000 and 2009 against a low carbon pathway for 2000 – 2050. The 2000-based pathway to a low carbon economy shows the trend of carbon intensity from 2000 to 2050 if the world economy had started decarbonising from 2000. This is achieved through improvements in energy efficiency and fuel mix to around 2020, and then more rapidly from 2020 to 2050 with the scale up of Carbon Capture and Storage (CCS). The 2009 based pathway shows an adjusted pathway from 2010 to 2020 based on actual rate of decarbonisation achieved from 2000 to 2009.

Many of the world's largest economies have in the past year remained on their business-as-usual pathways. While global carbon intensity in 2009 fell by 0.7% compared to 2008, this is significantly below the average rate of decarbonisation to 2050 of 3.5% that was needed to meet the low carbon challenge.

The world economy is currently just over 10% adrift from the low carbon pathway. Based on current trends in carbon intensity, the world will have used up its estimated global carbon budget for the first half of this century by 2034, 16 years ahead of schedule. The global 'carbon debt' (cumulative global budget overshoot) since 2000 now stands at around 17GtCO<sub>2</sub>.

Overall, the slow progress in the first decade of this century has magnified the challenge of transitioning to a low carbon economy. The Low Carbon Challenge index assesses the 'distance to go' in reducing carbon intensity. The world now needs to decarbonise significantly faster, at 3.8% per year instead of 3.5% to 2020. From then on, with the assumption that Carbon Capture and Storage (CCS) technology can be mobilised, the world then needs to reduce carbon intensity by 5.4% a year to 2050<sup>3</sup>. This would imply a reduction in carbon intensity by around 88% by 2050.

**Figure 1. Global Low Carbon Achievement Gap (2009)**



Source: PwC analysis

**Low Carbon Achievement Gap**

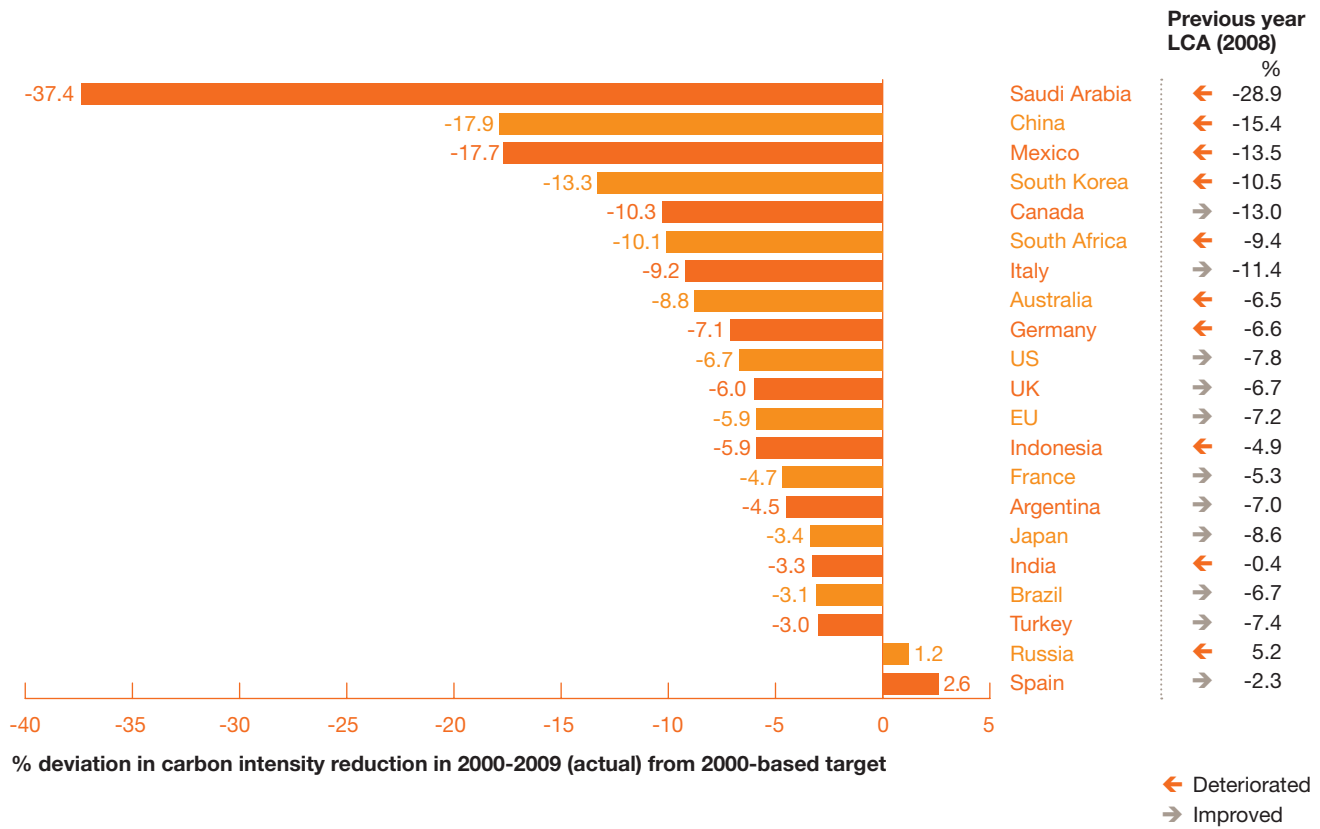
Our Low Carbon Economy Index is measured based on carbon intensity (the ratio of emissions to GDP) and against a fixed carbon budget that would meet greenhouse gas stabilisation targets outlined by the IPCC.

Therefore if there have been higher levels of carbon emissions when compared with the low carbon pathway (measured by the Low Carbon Achievement Index), the remaining carbon budget available to consume shrinks, and an economy needs to reduce its carbon intensity even further to meet within the carbon budget by the end of 2050 (measured by the Low Carbon Challenge Index and required rate of decarbonisation).

**Low carbon economy index**

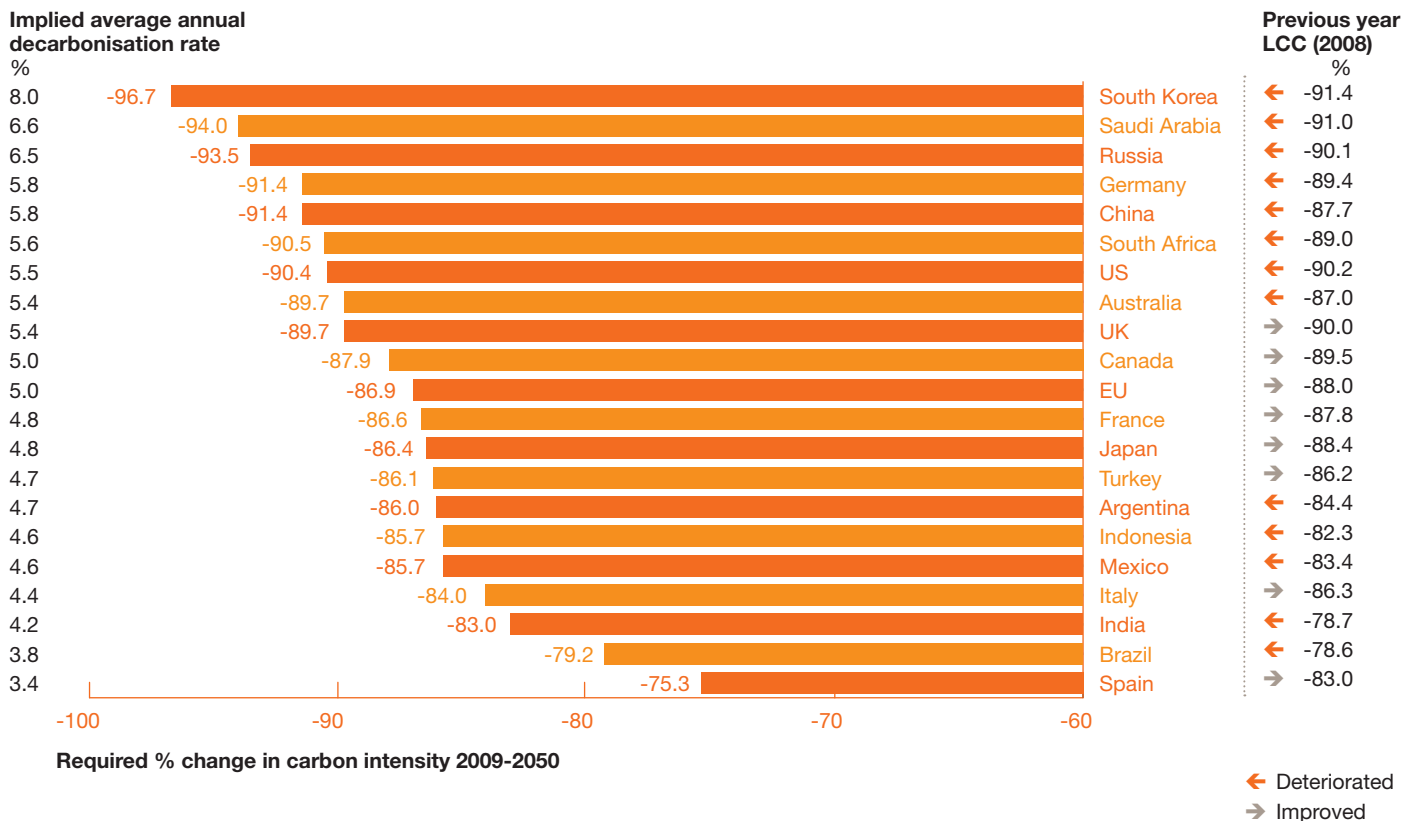
	World	
	2009	2008
GDP (PPP) growth rate	-0.6%	3.3%
Emissions growth rate	-1.3%	1.8%
Low Carbon Achievement index	-10.4%	-9.4%
Low Carbon Challenge index	-87.8%	-85.1%
<b>Required rate of decarbonisation</b>		
2010-2020	3.8%	3.5%
2021-2050	5.4%	4.8%

**Figure 2. Low Carbon Achievement (LCA)**



Source: PwC analysis

**Figure 3. Low Carbon Challenge (LCC)**



Source: PwC analysis



Figure 2 shows the Low Carbon Achievement index for the G20 countries, which assesses the progress in reducing carbon intensity in each G20 member between 2000 and 2009 compared to the low carbon pathway for 2000 – 2050.

Figure 3 presents the Low Carbon Challenge index, which highlights the extent of decarbonisation required, i.e. distance to go from 2009 to 2050. The left column of the diagram shows the implied average annual rate of decarbonisation required, for example, South Korea would need to decarbonise at an average rate of 8% from 2010 to 2050 to meet its low carbon pathway.

### ***Business-as-usual for many, but emerging signs of change***

At the country level, the relative positions for many countries on the LCA Index and LCC Index remain unchanged as expected, but for a few, they are starting to show how the low carbon economy race is shaping up.

### ***Developing countries propping up the global economy but also the level of carbon emissions.***

Broadly, developing countries have shown a more pronounced decline in their LCA performances, whereas most developed countries have improved, largely thanks to the slowdown in economic activities over the last two years. In many advanced economies, consumption levels fell markedly and manufacturing and industry have suffered disproportionately throughout the recession, all with knock-on effects on emissions. Japan's carbon emissions in 2008 were impacted by the country's temporary reliance on coal-fired power generation, as a result of a series of earthquakes which damaged nuclear power stations in 2007-2008. A return to nuclear power in 2009 helped decrease Japan's carbon intensity substantially, giving it a strong lead in the LCA index.

Developing countries, on the other hand, weathered the global downturn comparatively better, led by domestic demand and boosted by heavy fiscal stimuli, often focused on carbon intensive infrastructure construction.

The fluctuations of the LCA index in response to these cyclical factors suggest that economic performance is not yet decoupled from carbon emissions.

### ***Brazil stand out as a good performer***

The exception was Brazil, with a reduction in carbon intensity of 5.4% compared to 2008, leading to an improved LCA index of -3.1% in 2009 (compared to -6.7% in 2008). The country has experienced higher than forecasted economic growth, while developing a stronger portfolio of renewable energy, and paving the way for further improvements in decarbonisation. Within the G20, Brazil is also one of the closest to the 2050 low carbon economy goal although challenges around deforestation and land use remain.

### ***Asia fails to reduce carbon beyond business-as-usual***

China's LCA index fell slightly from 2008 to 2009, with fossil fuel consumption outpacing economic growth by a small margin and energy intensity (energy consumption per unit of GDP) unchanged. India has also fallen in the LCA ranking, as fossil fuel consumption rose in line with economic growth, albeit with a shift away from coal towards cleaner natural gas. Despite a strong fiscal stimulus focussed on clean technology, South Korea's LCA index has fallen from 2008 to 2009 – although it is too early to judge the longer-term impacts of the stimulus package.

As they drift further away from the low carbon pathway, China and India now need to decarbonise at an average rate of 5.8% and 4.2% respectively to 2050. These rates will be difficult to sustain in rapidly industrialising and urbanising economies, but at the same time this presents an opportunity for these economies to leapfrog the West if they embrace low carbon technologies. South Korea also ranks unfavourably on the LCC index, but there is scope for substantial improvement if its recent stimulus can deliver sustained reductions over the longer term.

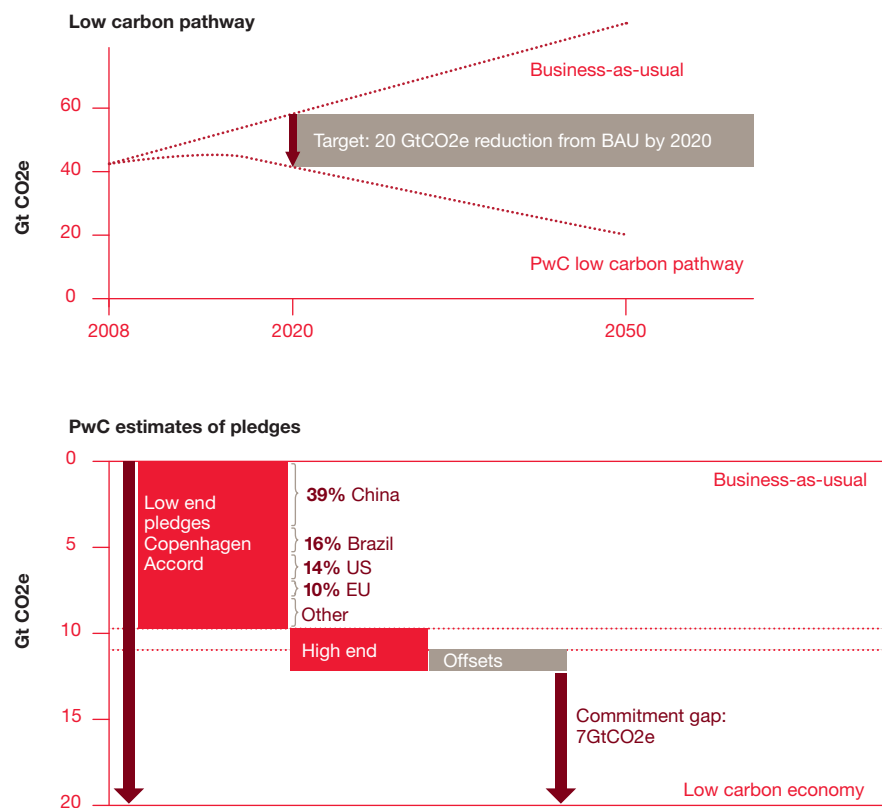
# The green growth race is on

## Copenhagen Accord – the starting line

The Copenhagen Accord, brokered by the US and the BASIC bloc (Brazil, South Africa, India and China), reflects the intent to stay within 2°C of warming, but does not have binding national emissions targets or mitigation plans for either 2020 or 2050. Countries were asked to submit targets and mitigation action plans to 2020 voluntarily to the UN. Notwithstanding the debate on burden sharing between developed and developing countries on the required levels of emissions reductions, forty three countries, both developed and developing, have submitted their national plans and targets in response to the Copenhagen Accord.

According to PwC estimates, at 9.7GtCO<sub>2</sub>e the pledges total just under half the 20GtCO<sub>2</sub>e reduction from business-as-usual required to stay on the low carbon pathway ('Low end pledges'). Some countries also made conditional pledges to step up their efforts if others do the same ('High end'). But even taking into account these conditional pledges, they still fall short of the 20GtCO<sub>2</sub>e target. The implied global reduction in carbon intensity from these pledges averages 2% a year to 2020. This falls short of the 3.8% calculated by our analysis as necessary to get back on the low carbon pathway.

Figure 4. PwC estimates of pledges to the Copenhagen Accord



Note: Graphs are for illustration purposes only, and are not drawn to scale.

Source: PwC estimates of the impact of pledges on carbon emissions in 2020, based on a series of assumptions including long term GDP projections and business-as-usual emissions.

There has been some strong criticism of the outcome of the Copenhagen conference, the organisation of the COP and the UNFCCC process. However despite the lack of a binding agreement, or perhaps because of it, there has been an increasing shift towards voluntary national action.

Many countries now see the prospect of low carbon growth and the risks of failing to decarbonise and falling behind. Many of the leading emitters have made unprecedented, and largely unconditional, pledges to limit or reduce carbon emissions. While these pledges collectively fall short of targets required under a low carbon pathway, active step changes are still needed for countries to successfully deliver these goals.

Perhaps in time Copenhagen may be remembered not as a failure, but as marking the start of the green growth race.

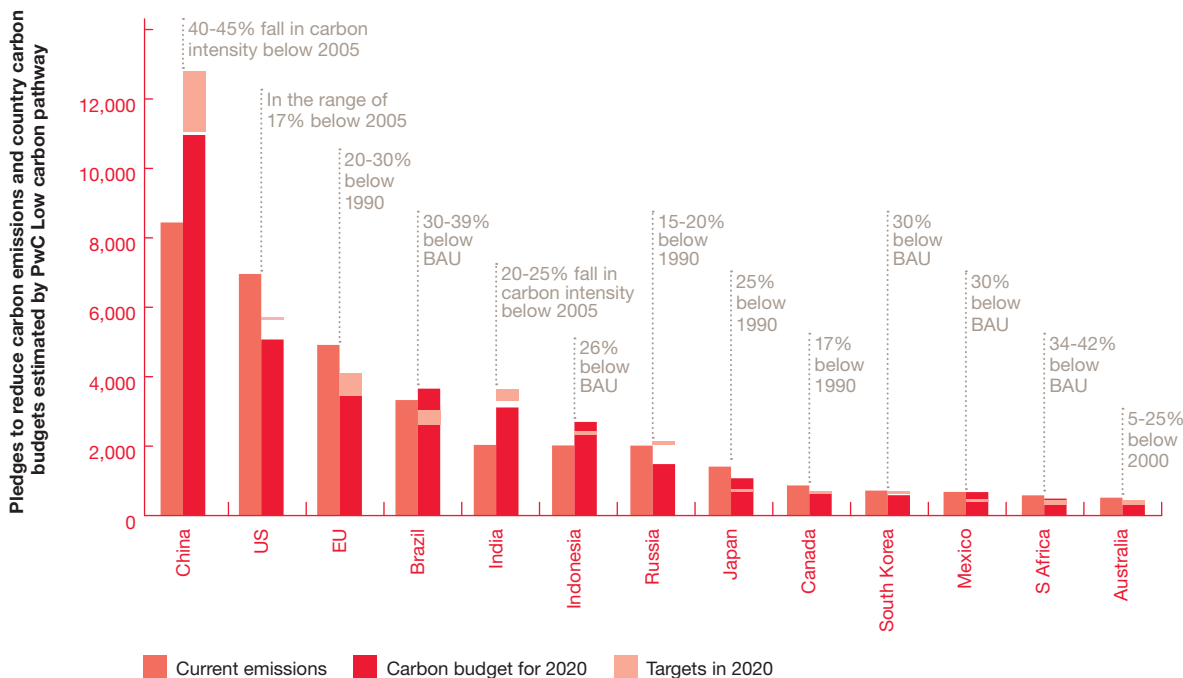
### Country pledges

Figure 5 shows PwC estimates of the impact of these pledges on carbon emissions, based on a series of assumptions such as long term GDP projections and business-as-usual emissions for 2020<sup>4</sup>.

We have compared these pledges against the country allocation under the PwC low carbon pathway and global carbon budget. Some countries fall short of its country allocation but it is the collective effort that matters.

At the end of the day, achieving emissions targets is much more important than setting them and it will be actions on the ground which will drive the change needed.

**Figure 5. 2020 Pledges to reduce carbon emissions under Copenhagen Accord relative to low carbon pathway estimates**



Source: PwC estimates based Low Carbon Economy Index model and Copenhagen Accord pledges

# Sector progress



## **Taking action**

The Low Carbon Economy Index highlights the scale of the challenge for the world's largest economies, and the costs of delay and inaction, in trying to reduce or limit carbon emissions while sustaining long-term growth. The current performance of most economies, however, need not be a prediction of future performance.

The range and credibility of key policies will be as important an indicator, if not more so, of the countries' commitment to address climate change. Many countries are scaling up policy responses and looking at the restructuring of their economic systems to help achieve long-term low carbon growth. This section considers the current progress and planned actions across the different areas of climate change mitigation; energy efficiency, renewable and low carbon energy, transport and land-use and forestry.

### Examples of policies

UK	Deployment of smart meters to reduce energy consumption on homes.
India	New building codes, appliance eco-labels, and conservation contests. Plans to impose energy efficiency targets on large firms.

### Energy efficiency

Fluctuations in oil prices and increased focus on fuel costs efficiency have made energy efficiency improvement an increasing priority for many countries. This is reflected in the general trend of reductions in both the carbon and energy intensity of major economies.

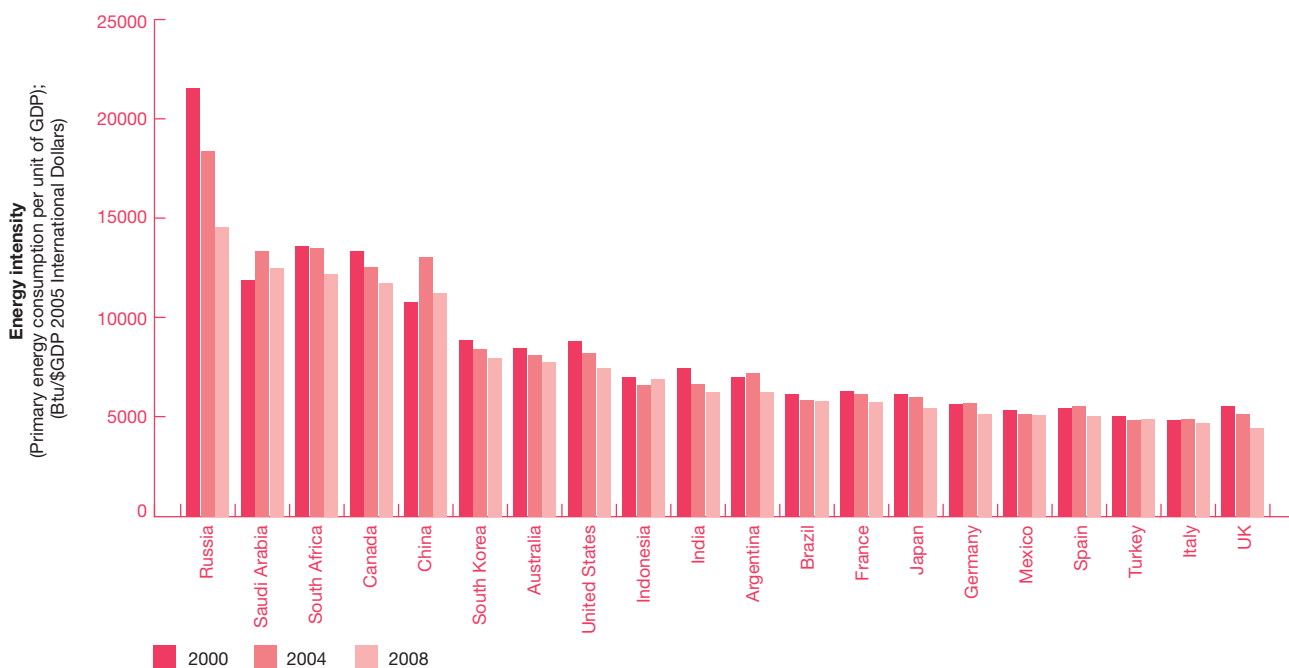
Several countries stood out in terms of progress on energy efficiency (see Figure 6): those that had made the greatest improvement between 2000 and 2008 include Russia (by 33%, albeit from a high level), UK (20%), India (16%) and the US (15%).

These trends reflect both the impact of government policies and changes in the economic structure. For example, energy intensity of Russia's GDP has fallen consistently for most of the 2000s compared with the early 1990s. However, overall energy efficiency in Russia remains low compared with both developed and developing countries.

Russia's goal to cut the energy intensity of GDP by 40% by 2020 from 2007 levels is likely to require substantial increases in energy tariffs. United Nations Development Programme (UNDP) estimated that tariffs would have to rise by at least 13% annually until 2020<sup>5)</sup> and major structural changes to key industries and the domestic sector. Similarly in Spain, its energy intensity was stagnant until the Spanish Saving and Energy Efficiency Strategy was put in place for 2004-2012. From 2005 onwards, with the establishment of an energy savings target and integration with the EU Action Plan on Energy Efficiency, the Spanish economy averaged over 3% efficiency improvement year-on-year<sup>6)</sup>.

Improvements in energy efficiency will continue to be a major contributor to reductions in carbon intensity, especially over the short-term, and represent an area where tangible savings (in energy costs) can be observed. The main challenge for major economies is to deliver them quickly and cost effectively to meet decarbonisation targets by 2020.

Figure 6. Energy efficiency trends for major economies



Source: PwC estimates based on World Bank and U.S. Energy Information Administration (EIA)  
btu: British Thermal units



Examples of policies	
Spain	One of the top countries in terms of existing and new investment in renewable capacity through feed-in tariffs and government investments.
South Korea	The Million Green Homes scheme provides subsidies to households to install relevant technologies such as solar PV, solar thermal, geothermal, small wind and bio energy.
Brazil	Aims to maintain the share of electricity from renewable energy at around 85% by 2020 through capitalising on competitive advantages in natural resources (biofuel).

### Renewable and nuclear energy

Despite the global financial crisis and falling oil prices, the past year has been marked by continued growth in the renewable energy sector.

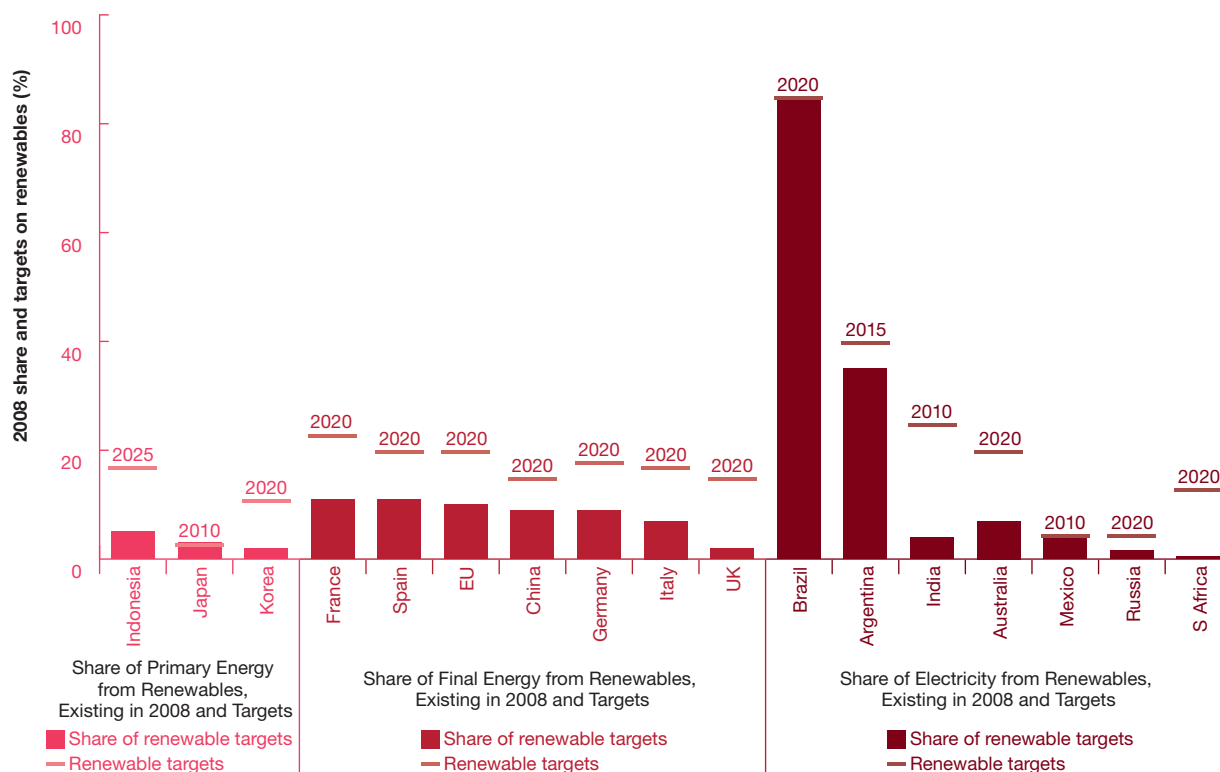
Investment in renewable energy has grown around the world across all market sectors, including power generation, heating, cooling and transport fuels. Globally, renewable energy now accounts for one quarter of total power capacity and delivered 18% of global electricity supply in 2009 (albeit a large proportion being hydro power – with 20% of capacity and 16% of electricity). This trend is underlined by interest in this sector: more than 100 countries now have policies of some form promoting renewable energy.

Renewable energy is increasingly perceived as a viable investment opportunity, and some of the concerns around policy uncertainties are no longer barriers impeding growth. Almost all renewable energy industries worldwide saw a growth in manufacturing and increase in investment from both public and private sector in 2009. Nuclear power generation is also rising on the agenda for several countries facing concerns over long-term security of supply of power.

A number of countries have set ambitious targets for renewable energy; these, however, are based on different metrics and baselines (see Figure 7). It remains to be seen which are best equipped to meet them. On the other hand, absence of a target does not mean a lack of action. Both Europe (which has targets) and the US (which currently has no targets at the federal level) have continued for the second consecutive year to add more renewable power capacity than conventional power (coal, gas, nuclear). As a percentage of GDP, Spain led by a margin in terms of foreign direct investment attracted in 2009 – over 1% of GDP compared to less than 0.3% in other major economies.

Looking forward, in the EU, 17 countries are expected to reach their 2020 domestic targets<sup>7</sup>. At the same time, China has pledged substantial investment in renewable energy in the coming decade, South Korea has committed four fifths of its fiscal stimulus packages to green technology and services, while India launched an ambitious National Solar Mission targeting the solar sector.

**Figure 7. Renewable energy, current share and targets**



**Notes:**

1. Different countries set their renewable targets using different measures and target year, making direct comparison difficult.
2. The US and Canada have state- or province-level targets but currently no national targets and therefore have not been included in this chart. The US is considering a federal renewable electricity target/standard in several legislative proposals.

Source: Renewables 2010 Global Status Report, REN21, 2010; Global Climate Change Policy Tracker, Deutsche Bank October 2009 and April 2010

Nuclear energy has benefitted significantly less from green growth policies, and has failed to grow its contribution to low carbon energy over the past few years, and in some countries has even reduced. There are fewer nuclear reactors operating in the world in 2009 than in 2002<sup>8</sup>. As old nuclear plants are decommissioned, many governments will struggle to quickly replace them, leading to a potential downward trend for the next 20 years. Cost, technology, regulation and availability of trained workforce are all challenges faced by nuclear power generation.

Notwithstanding massive investments, major challenges remain for renewables too. In some economies, regulatory and structural barriers such as uncompetitive energy markets, inadequate access to the grid or subsidies on fossil fuel keep investors cautious. More fundamentally, there is under investment in grid infrastructure, which is essential to cope with the fluctuations in peak demands against the backdrop of the unpredictability of supply of some types of renewable sources (such as wind and wave). In continental Europe, for example, power grids were traditionally

constructed and regulated based on national needs, which brings challenges in terms of building a pan-EU Super Grid (a network of high-voltage international electricity interconnectors that enable power to be transmitted across Europe).

**Key examples**

China	Commits to 60% electrification of railways by 2020. State-owned firms investing in R&D for hybrid and electric vehicles.
Japan	Strong performance in terms of increasing fuel productivity.

**Transport**

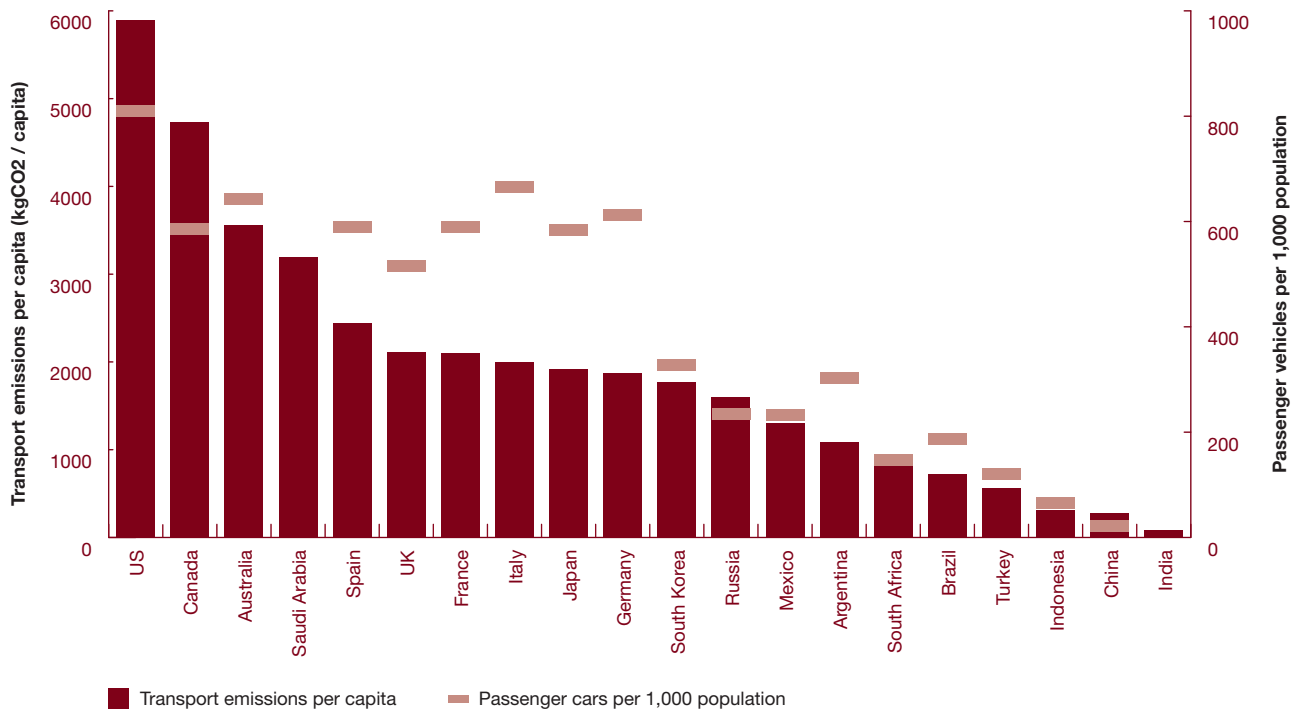
Across most economies, the increase in demand for transportation (particularly personal transport and aviation) has outstripped gains in fuel economy improvements. Emissions from transport are therefore a growing contributor to global emissions.

North America and Australia have high transport emissions per capita, because of high car ownership rates and higher mileage per person as a result of their large geographic areas. European economies have comparable car ownership levels, but with denser populations, better fuel economy and greater use of public transport they have substantially lower transport emissions levels. Most developing countries, as Figure 8 demonstrates, have lower levels of car ownership and therefore transport emissions per capita are correspondingly lower. However, the rate of increase in car ownership in

these economies is likely to be higher than the saturated EU or North American market in the future, with potentially significant consequences for emissions levels.

These emerging countries also contain the highest abatement potential in transport emissions compared to business-as-usual. China and India have both demonstrated leadership in implementing ambitious low carbon public transport policies and in developing their railway networks. China in particular is setting ambitious targets to reduce transport emissions and is investing heavily in research and development (R&D) for hybrid and electric vehicles. If developing economies can leapfrog towards zero emissions vehicles, not only would this achieve significant carbon abatement, it could also provide new economic opportunities for automotive industries based in developing countries.

**Figure 8. Transport emissions per capita and passenger vehicles per 1,000 population (2009)**



Source: PwC analysis based on CAIT and WDI data; data on passenger vehicles ownership rate not available for India and Saudi Arabia



### Key examples

China	Average 1.4% increase in forest coverage, supported by strong land management policies.
Spain	Land use policies focus on increasing the capacity of CO <sub>2</sub> sequestration between 2008 and 2012. Strong monitoring of emissions in place using Geographical Information System in agriculture.

### Land-use and forestry

The world's forests store nearly 300 billion tonnes of carbon, but carbon stocks in forest biomass have been decreasing by an estimated 0.5 billion tonnes of carbon annually during 2005-2010 due to deforestation<sup>9</sup>. Figure 9 illustrates the change in forest coverage for the G20 economies.

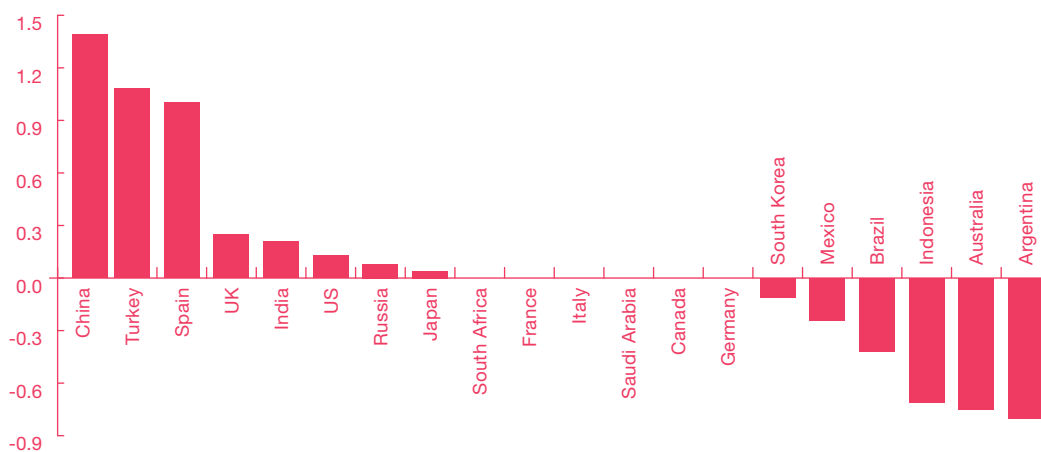
Global forest coverage is estimated to be around 4 billion hectares, corresponding to around 0.6 hectare per capita, and on average global deforestation is declining. Brazil and Indonesia, which had the highest net loss of forest in the 1990s, have significantly reduced their deforestation rates in the last five years. However, as forest area is unevenly distributed, comparison across countries is difficult. Russia, Brazil, Canada, US and China account for more than half of the global total forest area, whereas a large number of countries have much smaller forest coverage, or no forest at all. The focus on sustainable land management and policies to prevent deforestation and land degradation therefore also varies across countries.

In Europe, forest resources have been growing, with good land management policies and stringent timber standards. Declining land dependence, increasing income and greater consumer demand for 'sustainable' products have all played a role.

Developing countries with high forest areas, for example Brazil and Indonesia are still heavily reliant on timber export and land-based activities. Improving land management regulation, such as land tenure laws, prevention of illegal deforestation activities and strengthening monitoring capabilities will be important focus areas for the next decade, enabling these countries to benefit from substantial international financial support for reducing emissions from deforestation and land degradation (REDD+)<sup>10</sup>.

The tenth meeting of Parties to the (COP10) Convention on Biological Diversity held in October 2010 in many ways marked a step change in global forest policies. The main outcome of the meeting was a Ten Year Strategic Plan, which gives a set of specific targets to be met by 2020. The plan not only emphasises the need for business to be included in global efforts, but also sends a clear message: certain extraction, harvesting, and production techniques have less than 10 years to alter drastically. Several billion dollars have been pledged by key donor governments to finance capacity building, knowledge networks and ground projects for biodiversity. These activities will have synergies with REDD+ and can help strengthen the incentives for countries and the private sector for better management of forest resources.

Figure 9. Annual change in Forest coverage 2005-2010



Source: PwC analysis based on Food and Agriculture Organisation of the United Nations (FAO) data

## Concluding remarks



Organisations in public and private sectors around the world are taking steps toward a resource efficient, low carbon economy. This includes raising energy efficiency, deploying renewable and nuclear energy, reducing transport emissions, and transforming land use and forestry practices. Yet, the current rate of decarbonisation is well below a level sufficient to achieve a 450ppm target.

The challenge now is to align the actions and policies necessary to bring decarbonisation initiatives to an appropriate scale. To do this, businesses are moving forward, while also watching for governments to send clear, long-term signals about the pace and direction policies will take.

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# *Appendix*

# Methodology and additional modelling results

## PwC Macroeconomic Model

The study focuses on the G20 economies with grossed-up estimates for the world as a whole:

- G7 economies (US, Japan, Germany, UK, France, Italy, Canada)
- E7 economies which covers the BRICs (Brazil, Russia, India and China), and Indonesia, Mexico and Turkey
- Other G20 (Australia, Korea, EU, South Africa, Saudi Arabia, Argentina)

The study draws on long-term GDP projections from an updated version of PwC's 'World in 2050' model, which is based on a long-term GDP growth model structure.

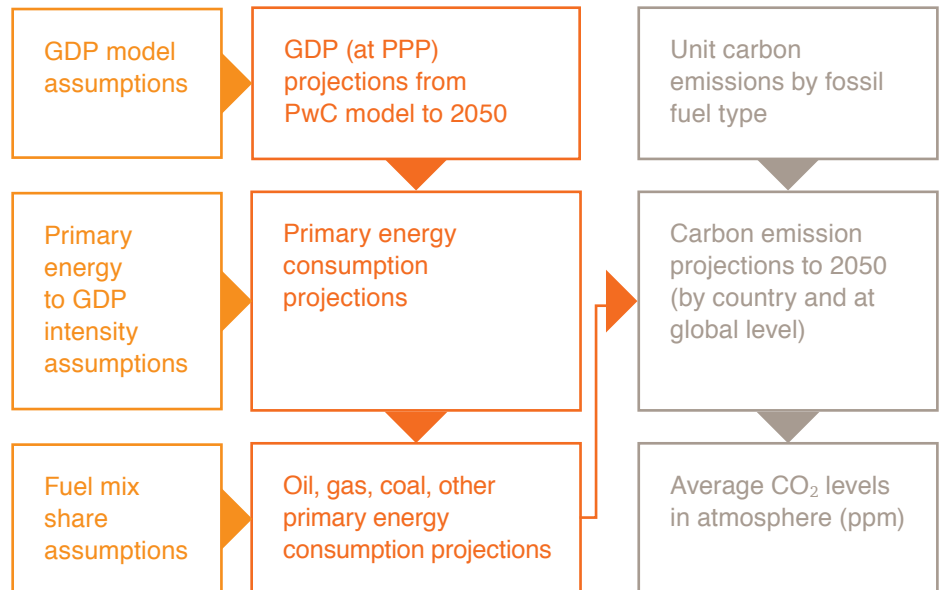
Each country is modelled individually but connected with linkages via US productivity growth (known as the global technological frontier). Each country is driven by a Cobb-Douglas production function with growth driven by:

- Investment in physical capital
- Working age population growth (UN projections)
- Investment in human capital (rising average education levels)
- Catch-up with US productivity levels (at varying rates)

Real exchange rates will also vary with relative productivity growth.

The results are not forecasts, but rather indicate growth potential assuming broadly growth-friendly policies are followed and no major disasters (e.g. nuclear war, radical climate change before 2050).

The study considers energy-related carbon emissions, driven by a series of assumptions including the primary energy intensity and fuel mix share.



Note: all projections done by country then aggregated to global level

## Business-as-usual (BAU) scenario

A BAU scenario is constructed assuming

- Energy efficiency improvements in line with historic trends (around 1.5% per annum with country variations).
- Stable fuel mix.
- No carbon capture and storage (CCS).

This is not intended as being the most likely scenario, but as a reasonable benchmark which serves as a starting point for constructing other scenarios.

## Greener Growth plus CCS (GG+CCS) scenario

This is intended to be a very challenging but technically feasible scenario on which the Low Carbon Economy index is based.

In deriving the global carbon budget, we adopted the general consensus of aiming for global CO<sub>2</sub>e concentrations to stabilise around 450ppm by 2100. This broadly corresponds to a peaking

of concentration by 2050 at around 515ppm and then declining towards 450ppm by the end of the century. Climate scientists broadly agree that this level of greenhouse gas concentration stabilisation will provide a fair chance of limiting the increase in global average temperature to around 2°C.

The three key sets of assumptions which underpin this scenario in terms of energy-related carbon emissions at global and country level are discussed in turn below. Additional assumptions at global level for carbon emissions from land use change and forestry are then discussed later together with assumptions on natural carbon sink capacity at global level.

### 1. Energy intensity improvements significantly in excess of historic trends

Declines in the ratio of primary energy consumption to GDP ('energy intensity') are assumed to average 3% per annum at the global level between 2010 and 2050, which is almost twice the historic average since 1980 and seems to be the limit of what might reasonably be achievable in this area. All countries are assumed to converge on this 3% per annum achievement trend from 2025 onwards, but with short term country variations up to 2025. For example for this earlier period from 2010-24, we assume that:

- China (4% pa) has one of the most ambitious scope for improvement, which reflects its higher initial level of energy intensity and the emphasis that the Chinese government has placed on improving energy efficiency since 2005, which is expected to remain a major focus of climate change policy in that country
- the US (3.5%) is also assumed to have high rates of energy efficiency improvements, as it has one of the highest energy intensity of major advanced economies and so the most potential scope to reduce this intensity level, for example through much tougher standards on automotive fuel efficiency levels
- the EU (2.7% pa) is assumed to have a somewhat lower, but still ambitious, potential to improve its energy intensity levels; nonetheless, this would still require a significantly better performance than the historic EU average trend improvement rate
- India (2% pa) is seen as having the least scope for energy intensity improvements in the next 15 years given that it is starting from a much lower level than China and has still got further to go on its industrialisation process, which will inevitably tend to create some headwind against very rapid energy intensity improvements; nonetheless, a 2% per annum improvement by India would still be above the global average rate of improvement in 1980-2009, so it is still a challenging prospect

We make individual assumptions here for all of the G20 countries based on the similar considerations as outlined above (which dominate the overall global picture as described earlier in the report).

### 2. Shift from fossil fuels to nuclear and renewables

At the global level, we assume a progressive shift in fuel mix away from coal and oil towards nuclear and renewables for the period 2010 to 2050. Trends in the share of natural gas are more mixed, with falling trends for the advanced economies but a rise for China and India where they are starting from low levels.

Overall, the global share of primary energy accounted for by nuclear and renewables<sup>11</sup> is assumed to rise to around 40% by 2050 in this scenario, which is very challenging but aligned with levels projected by previous studies by the International Energy Agency (IEA) and others. Key assumptions for the key economies for each fossil fuel are as follows:

- **Coal:** for the US, the share of coal in the fuel mix is assumed to decline by 0.3 percentage points per annum between 2010 and 2025 and at a faster rate of 0.5 percentage points per annum thereafter as renewable alternatives to coal for electricity generation become more economically attractive; for China, the same rate of decline is assumed as for the US up to 2025, but an even faster rate of decline of 0.8 percentage points per annum is then assumed after 2025 to reflect the fact that China is starting from a very heavy dependence on coal and so has more potential to reduce this in the long run as its economy shifts from heavy industry to services; India, with lower initial level of development is assumed to have potential for less rapid reductions in its coal share of 0.1 percentage points per annum up to 2025, but accelerating to 0.3 percentage points thereafter; assumptions for the EU countries, vary with Germany (as a relatively heavy coal user) being assumed to

have scope for reductions at the same pace as the US, while France (with its focus on nuclear power and very little use of coal by comparison) seeing only a token further reduction at a rate of 0.1 percentage points per annum throughout the period.

- **Oil:** assumptions here are less varied than for coal to reflect the fact that the oil share of the fuel mix is more uniform across the major economies than the degree of reliance on coal; we assume a trend rate of decline in the oil share of 0.3 percentage points up to 2025 and this is assumed to continue thereafter for China and India; for the US and the EU, we assume that the rate of decline in the oil share accelerates after 2025 to around 0.5-0.6 percentage points per annum due to a more fundamental shift away from reliance on oil in the automotive and other sectors; this may take longer in China and India since car ownership there will continue to rise after 2025 whereas in the US and EU this may already have reached saturation point by then (particularly with oil prices potentially rising as supplies pass their peak levels at some point).
- **Natural Gas:** as noted above, China and India currently make little use of natural gas compared to coal in particular, but this is expected to change with a particularly marked rise in China in the gas share of the overall fuel mix by around 0.3-0.4 percentage points per annum over the period to 2050; for India the corresponding rate of shift to gas is assumed to be slower but still moving steadily in that direction at an average of around 0.1-0.2 percentage points per annum. In contrast, natural gas fuel mix is assumed to remain relatively flat in the US and EU up to 2025 and then to decline thereafter at a rate of around 0.2 percentage points per annum as these economies shift increasingly into renewables (and nuclear in some countries).



### 3. Carbon capture and storage (CCS)

The third key set of assumptions relates to CCS. It is beyond the scope of this study to attempt to do a country-by-country assessment in any depth here, bearing in mind that CCS is at most at an early pilot stage in a few countries at this time. We therefore make a much simpler assumption here that global CCS capacity builds up steadily to an emissions reduction of 1.5 GtC (around 5.5GtCO<sub>2</sub>) between 2015 and 2050. This CCS capacity is apportioned to each country based on the share of total carbon emissions excluding CCS, which therefore automatically takes account of the fact that more coal-intensive (and so carbon-intensive) economies will tend to have more scope to use CCS.

The actual scale and geographical distribution of CCS capacity remains highly uncertain at this very early stage in its history, so these estimates may be subject to particularly wide margins of uncertainty at this time.

#### Summary

In differentiating countries in the way described above, we aim to generate energy-related carbon emission pathways that are challenging but fair in terms of recognising the different starting points of each country in terms of energy intensity and fuel mix and their differing stages of economic development and, in particular, industrial structure. CCS is then factored in using a consistent proportional formula as described above.

We have also made assumptions on non energy-related emissions and carbon sinks:

- Net annual CO<sub>2</sub> emissions from land use changes and forestry (LUCF) around 5.8GtCO<sub>2</sub> in 2008 declining to around 1.4GtCO<sub>2</sub> by 2020, and then at a slower rate to around just over -4GtCO<sub>2</sub> by 2050. Current estimates on reducing emissions from deforestation and forest degradation (REDD) expect it to deliver around 5GtCO<sub>2</sub> emissions reduction by 2020.
- Global absorption capacity of the planet (oceans, forests etc) is around 15 GtCO<sub>2</sub> per annum and broadly stable over time.

This scenario therefore has some common features across countries but also some variations to reflect differing starting points, stages of economic development and energy resource endowments. We have compared this with the IEA's 450 scenario for 2030 emissions, giving broadly similar results as the next chart shows. This gives some reassurance that our GG + CCS scenario, while clearly challenging, is reasonable both at global level and, broadly speaking, in terms of allocations to major countries/regions.

#### Further details on the construction of the low carbon achievement index

This index looks at the extent to which countries have consumed their carbon budget for the first half of the 21st century by 2009. Since it is cumulative global emissions that drive atmospheric CO<sub>2</sub> concentrations rather than emissions in any one year, there is an implied global carbon budget between 2000 and 2050, estimated here at just under 1,300 GtCO<sub>2</sub>.

Based on the same cumulative carbon budget, we constructed two GG + CCS scenario pathways beginning from 2000 and 2008. As GDP is also assumed the same in both variants, we can focus on carbon intensity rather than levels of carbon emissions in the analysis. Our assumptions include:

1. Same trend rates of decline for each particular country in the fossil fuel shares of primary energy consumption in 2001-2025 in the 2000-based model and in 2010-25 in the 2009-based model. In both variants, the 2026-50 trend rates of decline would be the same (but generally higher than the decline rates up to 2025 as the costs and feasibility of renewable fuels increases).
2. The rate of decline in energy intensity of GDP is set at 3% p.a. for all countries in 2026-50 in both GG + CCS variants.
3. Set country-specific rates of decline in energy intensity of GDP in 2001-25 to give the same cumulative 2000-50 carbon budgets in both variants (as in point 1 above). For reasons due to rounding, while in most cases, the levels of carbon emissions in 2050 are similar in the 2000-based and 2008-based scenarios, they are not necessarily identical.
4. By comparing the projected emissions pathway of 2000 – 2050 under the Greener Growth + CCS scenario against the actual emissions between 2000 and 2008, the low carbon achievement index compares how actual carbon intensity performs against a 2000-based low carbon pathway.

#### Endnotes

- 1 Carbon intensity is defined as the ratio of carbon emissions to GDP. By focusing on trends in carbon intensity rather than total carbon emissions, fluctuations in GDP due to the economic cycle (including the current recession) could also lead to changes in carbon intensity. Our report focuses on carbon emissions from energy use since these are the most significant factor behind global warming, but progress on reducing carbon emissions from forestry and land use changes will clearly also be important and are factored into our model projections at the global level.
- 2 CO<sub>2</sub>e refers to 'Carbon Dioxide Equivalent' (including all GHGs converted to a common scale). Our analysis focused on carbon dioxide as the major greenhouse gas, thus sometimes units of simply CO<sub>2</sub> have been used in results. Where data were from an external source, the given units were retained.
- 3 There are plans in several key economies (US, EU) for Carbon Capture and Storage (CCS) technology demonstration projects by 2020. The EU, in particular, plans for CCS to be commercially viable by 2020.
- 4 Some countries have made pledges on their carbon intensity, which means that the absolute carbon emissions will be dependent on economic growth. As our estimates are based on GDP growth forecasts for 2020, the absolute amount pledged may vary with other sources or national estimates.
- 5 National Human Development Report in the Russian Federation 2009, Energy Sector and Sustainable Development, United Nations Development Programme (UNDP) 2010
- 6 Enerdata ODYSEE Energy Database, Energy Efficiency Profile: Spain, October 2008, [http://www.odyssee-indicators.org/publications/country\\_profiles\\_PDF/esp.pdf](http://www.odyssee-indicators.org/publications/country_profiles_PDF/esp.pdf)
- 7 Renewable Energy Europe, Ends, September 2010
- 8 Schneider et.al., World Nuclear Energy Status Report, 2009, <http://www.nirs.org/neconomics/weltstatusbericht0908.pdf>
- 9 State of the World's Forests, UN Food and Agriculture Organisation, 2009. <ftp://ftp.fao.org/docrep/fao/011/i0350e/i0350e.pdf>
- 10 Reducing Emissions from Deforestation and Forest Degradation (REDD) refers to efforts to create market and financial incentives in order to reduce the emissions of greenhouse gases from deforestation and forest degradation. REDD+ is the term that goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.
- 11 For simplicity the model assumes both nuclear and renewables to have zero carbon emissions, which is not strictly correct but is a reasonable approximation for our purposes. We therefore do not try to break down fuel mix between nuclear and different types of renewables.

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