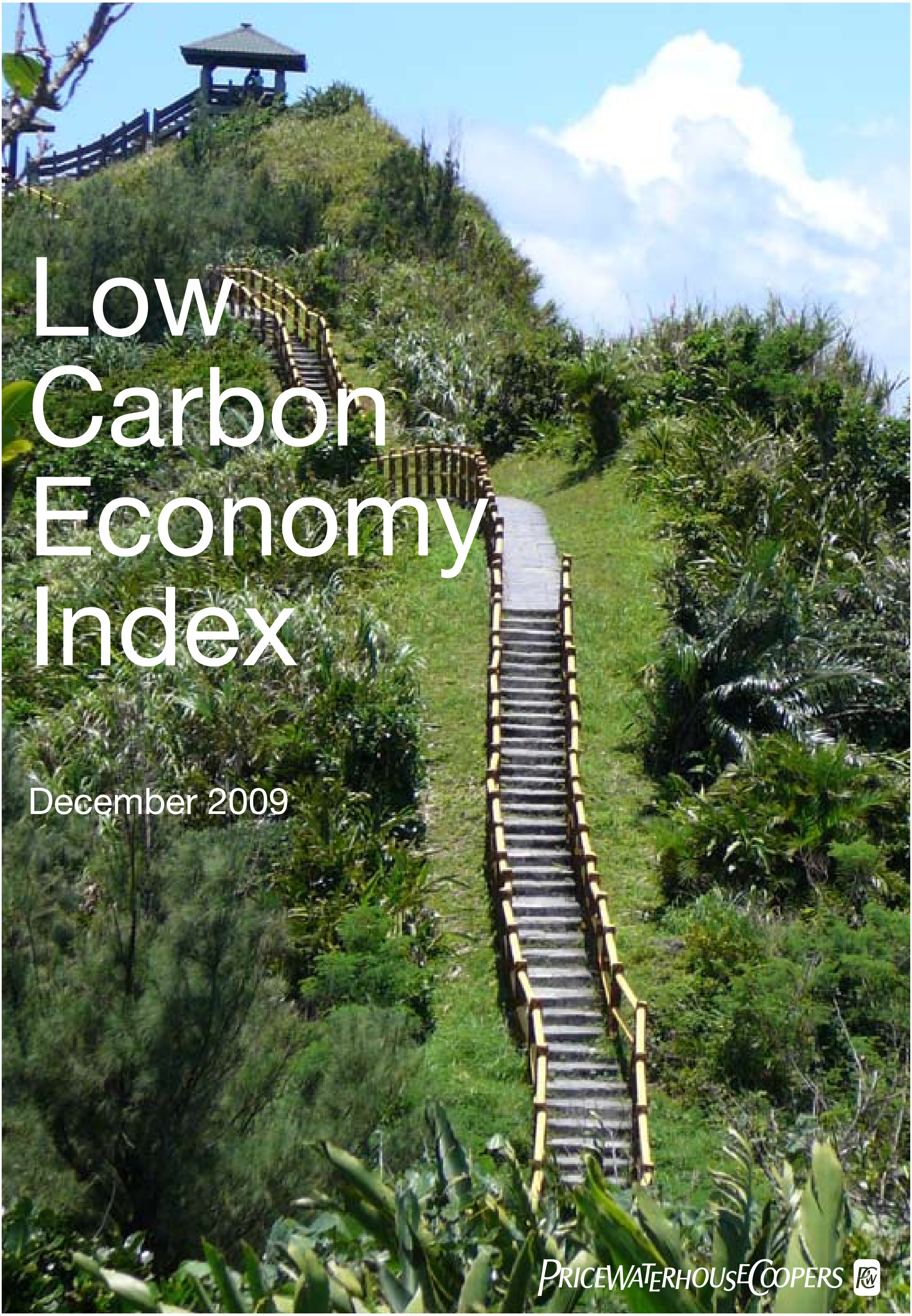


Low Carbon Economy Index

December 2009

PricewaterhouseCoopers

Summary and key findings

The world economy has been consuming the carbon budget required to limit warming to two degrees more quickly than modelled targets for 2020 and 2050 allow. In order to address this carbon debt, keeping atmospheric concentrations of carbon below 450 ppm, the world economy faces the challenge of decarbonising between 2008 and 2020 at more than four times the actual rate of carbon intensity reduction achieved globally since 2000.

Key findings

- **Carbon budget:** PwC's model estimates that there is a need to stay within a global carbon budget for the period from 2000 to 2050 of just under 1,300 $GtCO_2$, to have a fair chance of limiting global warming to 2°C.

- **Performance off track:** The report reveals a widening gap between this budget and actual carbon emissions. For 2000 – 2008, the cumulative global budget overshoot, or 'carbon debt', is estimated at around 13 $GtCO_2$ (roughly equivalent to the annual carbon emissions of China and the US combined in 2008). Global carbon emissions in 2008 were already around 10% above levels implied by these estimated annual budgets. Even the EU is 7% off track.

- **Carbon achievement gap:** The world will already have exceeded its estimated global carbon budget for the first half of this century by 2034, 16 years ahead of schedule, at current rates of carbon intensity improvement.

- **Carbon challenge:** If the world had started in 2000, it would have needed to decarbonise at around 2% a year up to 2008 according to these budgets. But the global rate of carbon intensity reduction actually achieved up to 2008 was only around 0.8%. The result is that the world now has to decarbonise at a rate of 3.5% a year between 2008 and 2020 to get back on track —more than four times faster than the rate achieved since 2000 at the global level.This is greater than the levels of improvement in carbon intensity seen in the 1990's in the UK (with its "dash for gas") and in Germany (after reunification). The PwC Low Carbon Challenge index indicates that the G20 now needs to cut its carbon intensity levels by around 35% by 2020, and around 85% by 2050.

- **Key players:** China, the US, the EU and India together account for around 63% of the estimated cumulative carbon budget for 2000-50. These 'Big 4' economies will therefore be critical to agreeing and implementing any global climate change deal at Copenhagen and beyond.

The low carbon challenge

- **Global investment opportunity:** According to IEA estimates, the level of incremental investments required globally to secure this decarbonisation amounts to £430 billion in 2020, rising to $1.15 trillion by 2030, above business as usual. This investment translates into 18,000 windmills of 3MW and 20 nuclear plants every year; as well as 300 concentrated solar plants; 50 hydro power plants; and for 30% of coal-fired power plants to be installed with CCS technology by 2030.

- **Key policies:** To be able to deliver this scale of investment, the private sector will need not just targets, but a binding and effective framework of policy commitments. Establishing a global market for carbon trading would be one element in this, together with adequately funded arrangements to support technology transfer to less developed countries. For the G20 economies, this also means keeping to their pledge on phasing out fossil fuel subsidies. Phasing out these subsidies, combined with strong domestic policy frameworks and mechanisms to put an international price on carbon emissions, are essential if low carbon alternatives are to attract the necessary investment flows within the timeframe required.

- **The importance of Copenhagen:** Two years ago in Bali, governments agreed that the Copenhagen summit would mark a turning point in international cooperation on climate change. In the weeks leading up to Copenhagen, the jigsaw pieces have started to come together, with most major countries pledging specific national emissions targets. There may not be sufficient time to complete the picture of a comprehensive legally binding protocol by mid-December, but an ambitious political deal will pave the way to more robust national and global measures. New policies and radical regulation will need to come into effect rapidly in the next few years. Businesses have a short window to prepare, and those that are ready for the transition will benefit from the opportunities arising from a low carbon economy.

Contents

Introduction

Copenhagen calling

The UN climate conference in Copenhagen in December 2009 presents a crucial opportunity for global leaders to lay the framework for a low carbon economy. Pledges from many of the world's largest economies in the immediate run up to the event have added new momentum. The priority now is to convert these into an ambitious global deal.

Many observers of the climate negotiations had lowered their expectations, fearing that Copenhagen would only deliver a less than satisfactory smörgåsbord of pledges and initiatives, rather than a comprehensive global deal. Pre-Copenhagen meetings at Bonn, Bangkok and Barcelona helped push the agenda forward, but at the same time revealed the many challenges that negotiators at Copenhagen will need to overcome before a deal could be struck. Three weeks before the UNFCCC meeting starts, world leaders who met in Singapore for the Asia-Pacific Economic Co-operation Forum indicated that it would "be unrealistic to expect a full, internationally legally-binding agreement to be negotiated" but that an "ambitious outcome" in Copenhagen may still be achieved. However, recent announcements from Washington and Beijing have increased expectations of the conference.

Stabilising greenhouse gases concentration levels at 450 ppm CO_2e

The Intergovernmental Panel on Climate Change (IPCC) recommended in 2007 that for a fair chance to limit increases in average global temperature to 2°C, the greenhouse gases (GHG) concentration levels need to stabilise at 450 ppm CO_2e. Emissions by developed nations need to fall by 25%-40% by 2020, and 80%-95% by 2050, while developing countries will need to "deviate substantially" from a business-as-usual scenario. This will mean a decoupling of carbon emissions from economic growth, through a series of measures including improvements in energy efficiency, changes in fuel mix and managing land use change.

The global target has always been a subject of debate. Latest figures place current concentration at approximately 390 ppm CO_2 and 435 ppm CO_2e. British climate change economist Lord Nicholas Stern published in May 2008 a recommendation of key elements required to achieve 450-500 ppm CO_2e (approx 450 ppm CO_2)[1] stabilisation levels by the end of the century, but commented in September 2008 that a stricter target is required. At the same time, other climate scientists claim that we have past the point of no return, that even the 450 ppm CO_2e ambition look unlikely to be feasible.

An ambition to stabilise GHG concentration levels at around 450 ppm CO_2e implies that annual emissions of global total greenhouse gases will need to fall to below $20GtCO_2e$ 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. However, current estimates suggest the costs of doing so will be manageable, with mitigation costs estimated at 0.5% – 1.1% of global GDP in 2030, if these are carried out whenever and wherever they are cheapest[2]. This will involve additional annual mitigation investment globally of $430 billion by 2020 and $1.15 trillion in 2030[3]. These figures are far lower than the costs of inaction.

Three questions are therefore paramount:

- **Carbon budgets:** What are the global and national carbon budgets that this translates into?
- **Adequacy of commitments:** Will the sum of national commitments made at Copenhagen keep us within the carbon budget this implies?
- **Policy framework:** Will governments implement a set of national policies to ensure they meet these targets?

To help assess the velocity of this transition to a low carbon economy, PricewaterhouseCoopers has developed two new indices for the G20 economies:

- The **PwC Low Carbon Achievement (LCA) Index**, which assesses how much progress countries have made this century in reducing the carbon intensity[4] of their economies; and
- The **PwC Low Carbon Challenge (LCC) Index**, which assesses the 'distance to go' for key countries in reducing their carbon intensity.

The index looks at the period going out to 2050, and an intermediate timeframe to 2020.

Part 1: The Global Carbon Budget

Implied carbon budget at 450 ppm stabilisation levels

In deriving the Global Carbon Budget, we adopted the general consensus of aiming for global CO_2e concentrations to stabilise around 450 ppm by 2100. This broadly corresponds to a peaking of concentration by 2050 at around 515 ppm and then declining towards 450 ppm by the end of the century.

Although some argue for different levels of greenhouse gas stabilisation, many climate scientists (including the IPCC, NASA and others) broadly agree that stabilisation at 450 pmm would provide a fair chance of limiting the increase in global average temperature to around 2^{o}C.

To achieve this, the global concentrations for CO_2 (which make up a large majority of total greenhouse gas emissions) would need to peak at around 440 ppm by 2050 declining thereafter to below 400 ppm by 2100.

This would imply that the cumulative rise in global CO_2 concentrations would need to be limited to around 70 ppm between 2000 and 2050. Since it is cumulative global emissions that drive atmospheric CO_2 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 resulting in dangerous climate change. We have estimated this overall net carbon budget (after taking account of sinks) to be c.550GtCO_2.

Role of land use change and forestry and carbon sinks

Our results assumed a significant contribution from limiting emissions from land use, land use change and forestry (LULUCF) and the continued role of existing carbon sinks. Specifically, we assumed that

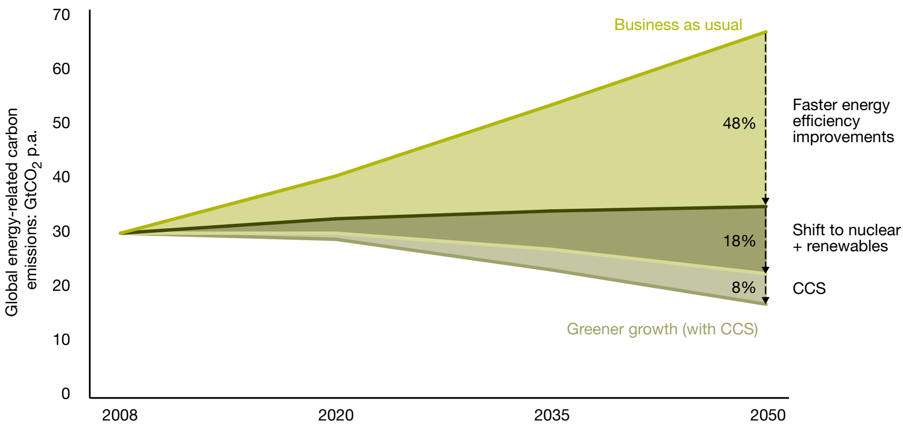
- Net annual CO_2 emissions from land use changes and forestry are around 5.8GtCO_2 in 2008, declining to around 1.4GtCO_2 by 2020, and then at a slower rate to just over -4GtCO_2 by 2050. Current estimates on reducing emissions from deforestation and forest degradation (REDD) expect it to deliver around 5GtCO_2 emissions reduction by 2020.
- Global absorption capacity of the planet (oceans, forests etc) is around 15 GtCO_2 per annum and broadly stable over time.

Excluding non-energy related emissions, the cumulative energy-related carbon budget[5] is estimated at just under 1,300GtCO_2.

Sharing the Global Carbon Budget

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 renewables and nuclear power) and decarbonising remaining fossil fuel usage through carbon capture and storage. **Figure 1** demonstrates this greener growth scenario, whereby the combination energy efficiency improvements, the shift to nuclear and renewables, and the rollout of carbon capture and storage capacity allows significant reductions in carbon emissions against a Business as Usual scenario.

Figure 1: PwC Greener Growth with CCS scenario



Source: BP data for 2008, PwC model projections for energy-related carbon emissions

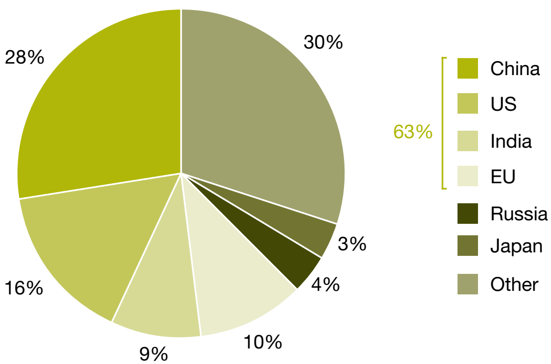
Individual country contribution to the emissions reduction over a business-as-usual scenario, however, will vary depending on their existing fuel mix and rate of energy efficiency improvements, and their potential for carbon capture and storage. The Global Carbon Budget is therefore split across countries based on a series of country-specific assumptions on these three key areas.

This implies, at a global level:

- Energy efficiency improvements in excess of historic trends: globally we need to achieve around 3% per annum, but with short term country variations up to 2025:
  - Between 2000 – 2008, global average annual improvement in energy efficiency were around 1.1%; however some countries have achieved improvements in excess of 2% per annum.
  - The required level of improvement in energy efficiency will need to come from more efficient power generation, transport, industry and buildings.
- Shift to nuclear and renewables: globally the share of non-fossil fuels rising to around 40% of primary energy by 2050, but at paces that vary by fuel and country.
- Carbon capture and storage (CCS): global capacity building up steadily to an emissions reduction of 5.5GtCO_2 between 2015 and 2050, apportioned to each country based on the share of total carbon emissions.

The above 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.

Figure 2: Cumulative Global Carbon Budget for 2000 – 2050 (c. 1,300GtCO_2)



Source: PwC analysis

As a plausibility test, we have compared our results with the International Energy Agency (IEA) World Energy Outlook 2009, including the cumulative carbon budget[6] and the 450 ppm scenario for 2030 emissions. We found the two sets of projections to be broadly similar (refer to **Appendix** for more details).

As it is global emissions that matter to avoid the impacts of climate change – rather than emissions in specific countries – looser budgets on carbon emissions in any one country would need to be made up by tighter caps elsewhere. The four largest emitting economies (China, US, the EU and India) will make up 63% of the world's carbon budget for the period 2000-2050:

- China has the largest share of the Global Carbon Budget, as the largest emitter, narrowly ahead of the US, and will inevitably draw further ahead over the next few decades as its trend economic growth rate remains higher than the US (but with a closing differential as it catches up).
- India also has a relatively high share of the carbon budget (compared to its current emission share) for the same reason that we are allowing room for its economic development, which has further to go than China given its lower initial GDP per capita level.
- The US gets a higher share of the overall carbon budget relative to the EU (16% vs 10%) because although the two economies are initially of similar size, the US is assumed to grow faster due to higher working age population growth between now and 2050. Also, as the US has a much higher initial carbon intensity than the EU, cumulative emissions are likely to be larger, although this carbon intensity gap is assumed to reduce gradually over time.

Given their relative share of emissions budget, there is therefore little margin for these economies to fail to limit emissions. A significant over spend in the big four could derail the world from the path to a low carbon economy.

Part 2: Low Carbon Achievement Index

At the global level, a clear conclusion emerges. Despite widening consensus around the need to decarbonise, few countries, historically, have reduced emissions without reducing growth.

Measuring carbon intensity

The challenge, confronted with the urgent imperative to reduce global carbon emissions whilst at the same time sustaining continued growth in developing economies, is to decouple growth from carbon, radically decreasing the carbon intensity of economic development.

Carbon intensity, which is defined as the amount of carbon emissions released per unit of GDP, is driven by a number of factors including the energy efficiency, fuel consumption mix, climate, population density and economic structure of a country.

In general more energy is used per capita for heating in colder climates than in warmer climates, and densely populated countries use less energy for transportation per capita than more sparsely populated countries (for example, compare Canada to France and Germany, which have similar income per capita levels, in **Figure 3**). Resource intensive countries, including the US, Australia and South Africa, also have higher carbon intensity. Notably, Russia, which has been expanding its reliance on indigenous natural gas resources and nuclear power to fuel electricity generation in recent years, has improved its carbon intensity significantly since 2000 despite a doubling of per capita income.

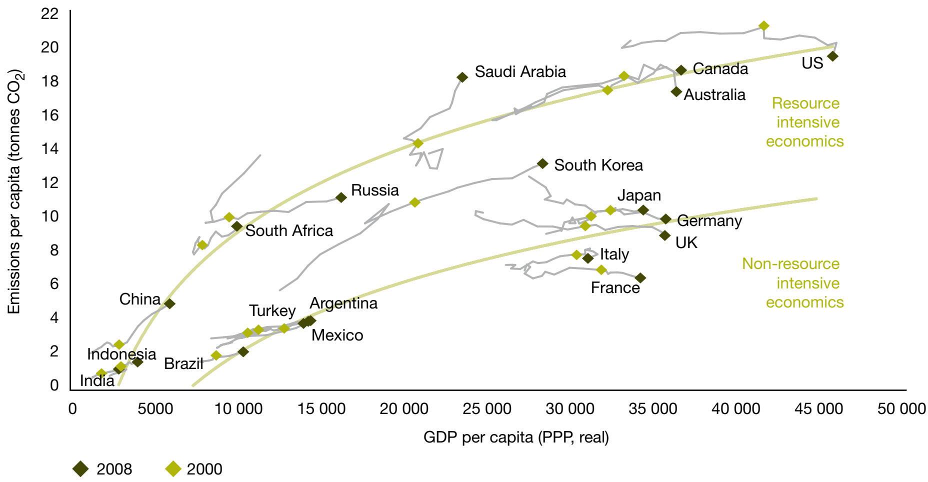
The rate of carbon intensity improvement is also driven substantially by the changing economic structure and fuel consumption mix within the G20 economies. For example, China's growing prominence as the world's manufacturing hub, in particular in high carbon heavy industries, affected its rate of improvement in carbon intensity in the early 2000s relative to the 1990s.

Figure 3 maps the changes in carbon intensity for leading economies from 1990 and 2000 to 2008.

The diagram maps the historical movements in the carbon intensity, showing how emissions per capita have changed with GDP per capita.

- Most of the OECD countries are experiencing a gradual but insufficient levelling of emissions per capita as their economies continue to grow (resulting in a decline in carbon intensity).
- Emissions per capita for developing countries, however, continue to increase with economic growth, albeit from a low base and at a decreasing rate.

Figure 3: Changes in carbon intensity: 1990 / 2000 to 2008



Source: PwC analysis from emissions data (BP statistical reviews 2009) and GDP (WorldBank)

Interpreting this chart:

Each line represents the path over the period 1990 – 2008 of emissions vs. GDP (on a per capita basis), covering the 19 countries in the G20 bloc.

Both the 2000 and 2008 data points are highlighted.

The group is loosely divided into two groups depending on the level of resource intensity (economies with greater resource intensity tend to generate higher carbon emissions per unit of GDP).

Note that reporting of emissions data tends to refer to the emissions arising from the production of goods. Thus, consumption of exported goods and services is realised in other countries instead of where emissions arise.

Progress in carbon intensity insufficient

The estimated global energy-related carbon budget in our model is around 16.5 Gt CO_2 in 2050, which implies a global carbon intensity of 0.06 $kgCO_2$ / $GDP. In 2008, the G20 countries have a carbon intensity of between around 0.2 and almost 1.0kg CO_2/$GDP. All countries will therefore need to reduce carbon intensity to around 10%-20% of current levels. The G20 will have to increase its rates of improvement radically from current levels if it were to achieve these level of carbon intensity.

Figure 4: Carbon intensity of G20 economies (excl. EU*)

Countries	Carbon intensity ($kgCO_2$/$GDP)			
	1990	2000	2008	Required intensity in 2050
France	0.25	0.22	0.19	0.023
Brazil	0.19	0.22	0.21	0.045
Italy	0.27	0.26	0.24	0.036
UK	0.41	0.31	0.25	0.024
Argentina	0.35	0.30	0.27	0.042
Mexico	0.29	0.27	0.27	0.049
Turkey	0.27	0.30	0.27	0.037
Germany	0.45	0.32	0.28	0.029
Japan	0.31	0.32	0.30	0.035
Indonesia	0.32	0.42	0.39	0.068
India	0.50	0.47	0.40	0.084
US	0.60	0.50	0.42	0.042
Korea	0.45	0.52	0.46	0.041
Australia	0.61	0.54	0.47	0.064
Canada	0.59	0.55	0.50	0.056
Russia**	1.30	1.05	0.68	0.063
Saudi Arabia	0.63	0.68	0.77	0.077
China	1.73	0.88	0.83	0.107
South Africa	1.07	1.05	0.94	0.104

* Analysis does not include EU as changes in the composition of EU over 1990-2008 complicates the comparison.
**Data for 1990 unavailable, figure is for 1992

Source: PwC estimates

	Top 5 Most Improved (based on % annual change)		
	1990 – 2000	2000 – 2008	1990 – 2008
(1)	China (-6.6%)	Russia (-5.2%)	China (-4.0%)
(2)	Germany (-3.3%)	UK (-2.5%)	Russia (-3.9%)
(3)	UK (-3.0%)	US (-2.2%)	UK (-2.8%)
(4)	Russia (-2.7%)	India (-2.1%)	Germany (-2.7%)
(5)	US (-1.7%)	Germany (-1.8%)	US (-1.9%)

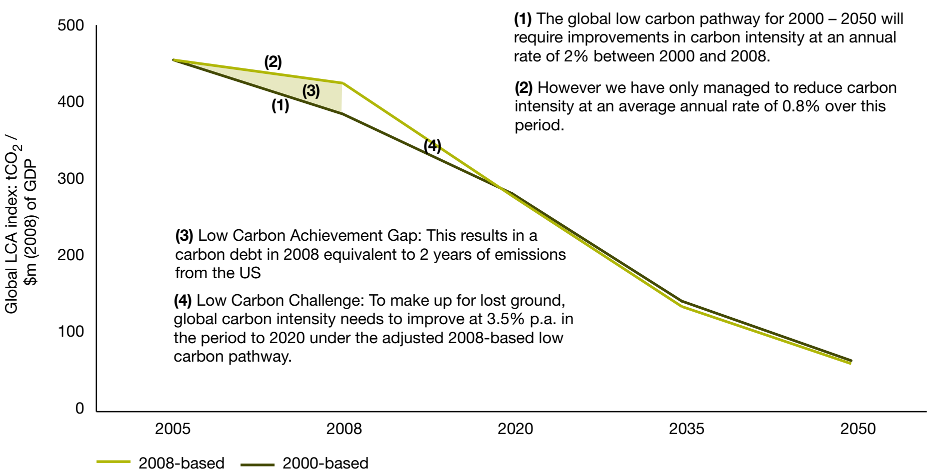
Source: PwC estimates

Low Carbon Achievement Index

We have projected a global low carbon pathway under the Greener Growth + CCS scenario over the period 2000 – 2050. The carbon budget for each country also determines a country-specific low carbon pathway for 2000 – 2050.

By comparing the actual carbon intensity between 2000 and 2008 against this low carbon pathway, the low carbon achievement index measures the progress since 2000 in the G20 economies in transitioning to a low carbon economy.

Figure 5: Global Low Carbon Achievement gap

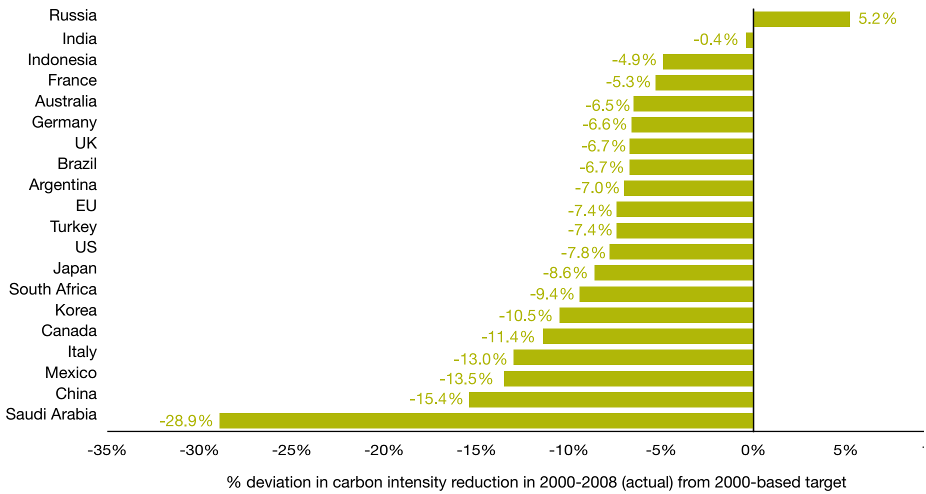


Source: BP data for 2000 and for 2008 in 2008-based variant, PwC model projections for Greener Growth + CCS scenario variants

PwC estimates that a reduction in global carbon intensity of 2% per year between 2000 and 2008 was needed to stay within the Global Carbon Budget. In reality, the world has achieved reductions averaging only around 0.8% per annum. At the current rate of carbon intensity improvements, the world will exceed the Global Carbon Budget by around 2034 and will fail to reach stabilisation levels at 450 ppm. Atmospheric concentration will exceed 1,000 ppm CO_2e by the end of the century.

Figure 6 below summarises our assessment of how far progress in reducing carbon intensity in each G20 member (including the EU) between 2000 and 2008 compares to each country's low carbon pathways.

Figure 6: PwC Low Carbon Achievement Index (2008)



Source: PwC estimates

Russia and India meets required levels

Only Russia has reduced its carbon intensity by more since 2000 than the budgeted amount. This reflects rapid improvements in Russian energy intensity over this period rather than any reduction in its dependence on fossil fuels (the proportion of fossil fuel consumption remained unchanged from 2000 to 2008 at 89%, despite a shift from coal to gas).

The only other country to broadly meet its pathway is India. Like Russia, India has also achieved significant improvements in energy efficiency over the period since 2000, but has made less progress so far in diversifying away from its reliance on fossil fuels, particularly coal (the share of coal consumption relative to total primary energy consumption increased from 49% in 2000 to 53% in 2008).

US and EU rank middle of G20

The US and the EU rank towards the middle of the G20, with carbon intensity reductions around 7-8% adrift from their 2000 – 2050 low carbon pathway according to our analysis. This reflects the fact that, although both the EU and the US have made reasonable progress on energy efficiency since 2000, they have not yet moved significantly towards a lower carbon fuel mix involving greater use of nuclear and renewables. This varies by country within the EU, however, with France being a relatively good performer and Italy rather less strong. Germany and the UK have intermediate results compared to other EU states, with carbon intensity reductions by 2008 that are around 6-7% adrift from their pathway.

China does less well, but improving since 2005

China scores less well over this particular period, although it should be noted that this follows a much better performance in reducing its carbon intensity during the 1990s, when China would have ranked at the top of the G20 list. Its shortfall in the present decade reflects a brief period in 2003-4 when energy consumption rose significantly faster than GDP in China as it continued with its rapid industrialisation process. Over the period since 2005, however, China's performance has been much better, with strong gains in energy efficiency as government policy has focused more on this objective. As yet, however, China remains heavily dependent on coal and action to reduce this dependency through some combination of a shift to nuclear and renewables and (in the longer run) widespread introduction of CCS at coal-fired power stations will be critical in reining in Chinese carbon emissions without unduly damaging its economic growth potential.

Challenging task for fossil fuel dependent Saudi Arabia

Saudi Arabia scores poorly on this index, as it has a uniquely high dependence on fossil fuel production amongst the G20 nations as one of the world's leading oil and natural gas producers. Moving away from fossil fuel production is likely to involve more short term challenges relative to other countries in the G20, but reducing its dependence on oil / gas production towards more renewable sources may be a viable long term strategy. In particular, the region has been identified as a potential market for growth in concentrated solar power (CSP).

Figure 7: Change in energy efficiency and fuel mix

Description
Very good Efficiency: >0.5% above prediction Fuel Mix: >5% above predicted share of renewable fuel mix
Good Efficiency: 0.25%-0.5% above prediction Fuel Mix: 2%-5% above predicted share of renewable fuel mix
Par Efficiency: within +/- 0.25% of prediction Fuel Mix: within +/- 2% of prediction
Sub-par Efficiency: 0.25%-0.5% below prediction Fuel Mix: 2.5%-5% below prediction
Poor Efficiency: >0.5% below prediction Fuel Mix: >5% below prediction

Source: PwC estimates

Part 3:
Low Carbon Challenge Index

With a 10% shortfall from its low carbon pathway in 2008, the world has to make up for lost ground in the period to 2050.

Under an adjusted low carbon pathway from 2008 to 2050, the world needs to reduce its carbon intensity by around 3.5% a year up to 2020.

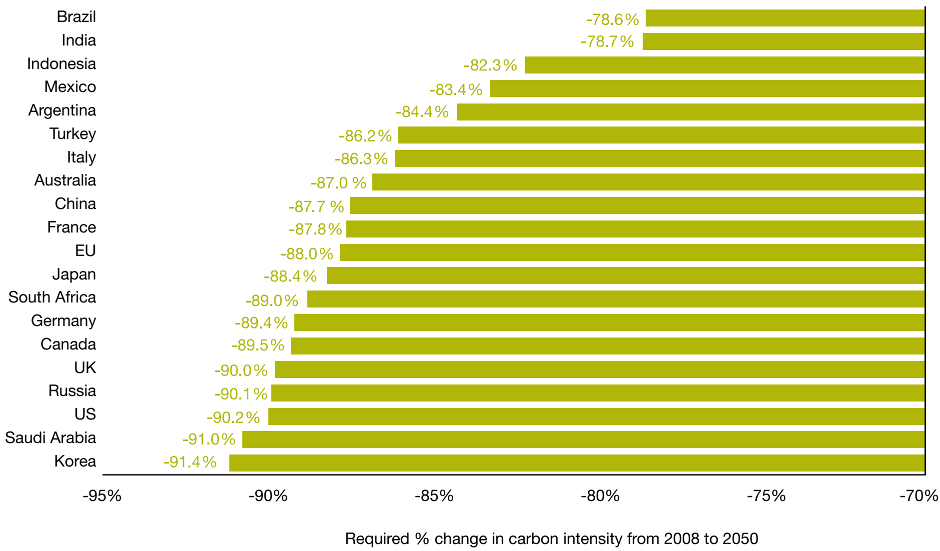
Challenges ahead

The global recession over the past year will have helped to reduce the level of carbon emissions in 2009 relative to business-as-usual – the IEA has estimated that global energy use fell for the first time since 1981 this year – but this will have a relatively small effect in relation to the long-term reductions required. This could anyway be partly reversed, as the world economy gradually recovers over the next few years, which will probably involve a period of above trend economic growth at some point based on normal cyclical trends.

Given the global and country performances relative to their 2000 – 2050 low carbon pathways up to 2008, in order to achieve the desired energy-related CO_2 budget by 2050, we will have to increase the rate of decarbonisation, i.e. move onto an adjusted low carbon pathway which will make up for lost ground since 2000. Under the adjusted low carbon pathway for 2008 – 2050, the Low Carbon Challenge Index presents our country-specific estimates of the distance still to go, as summarised in **Figure 8**.

Emerging economies like India and Brazil[7] have the least far to go on this measure. However, this is only a relative judgement, because a required carbon intensity reduction of around 77% between 2008 and 2050 is still extremely challenging for such economies, bearing in mind (particularly in the case of India) the stage they are at in their industrialisation process. At the same time, recent histories of emerging economies suggest that they may be able to leapfrog towards low-carbon technologies, providing an opportunity for economic growth to be decoupled from carbon emissions.

Figure 8: PwC Low Carbon Challenge Index (2008 – 2050)



Source: PwC estimates

Of the Big 4, China and the EU are in the middle of the pack on this measure, with carbon intensity reductions of around 88% between 2008 and 2050. The US, with a required carbon intensity reduction of just over 90% by 2050, is at the top end of this particular scale, reflecting its relatively high starting level of carbon intensity compared to most other advanced economies.

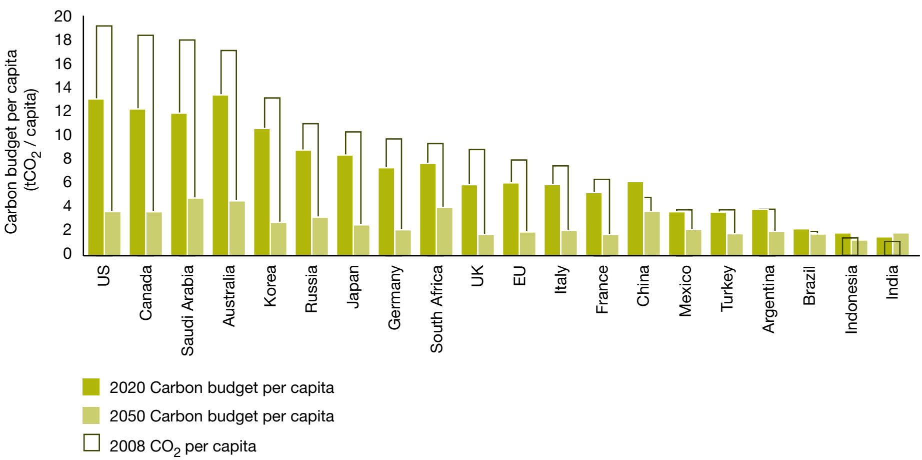
In emissions per capita terms, this requires a significant emissions reduction over the interim (up to 2020) and long term (to 2050) for the G20 economies, for example:

- Emissions per capita in the US needs to fall from around 19 tCO_2 to below 4 tCO_2.
- China's per capita emissions could rise in the interim to just over 6 tCO_2 in 2020, but will need to fall back to levels similar to the US.
- India is one of the very few countries where per capita emissions will be higher in 2050 than now, but only by a small margin and against a backdrop of a rapidly growing economy.

This is equivalent to the world reducing its carbon intensity by around 3.5% a year up to 2020. This is greater than the levels of improvement in carbon intensity seen in the 1990's in the UK (with its "dash for gas") and in Germany (after reunification). It is more than four times faster than the actual rate of carbon intensity reduction achieved globally since 2000.

Figure 9 displays current G20 $C0_2$ emissions per capita, against each country's required 2020 and 2050 budgets.

Figure 9: Carbon budget by emissions per capita in 2020 and 2050



Source: PwC analysis

Part 4: Emissions reduction commitments and policy actions

Current emissions reduction commitments are more ambitious than they have ever been, but gaps remain in terms of both adequacy of targets and policies implementation to achieve them.

Progress in 2009

In the last year, both the developed world and emerging economies have articulated pledges that are, in many cases, more ambitious than in the past. For example:

- **G8**: In July 2009, the G8 reaffirmed the importance of the recommendations by the IPCC to limit the increase in global average temperature above pre-industrial levels to 2°C. The leaders committed to achieving at least a 50% reduction of global emissions by 2050, with a goal of developed countries reducing emissions of greenhouse gases by 80% or more by 2050 compared to 1990, complemented by major emerging economies reducing emissions significantly below a business-as-usual scenario.

- **G20**: The G20 in Pittsburgh, in September 2009, made no specific commitments on reductions targets, but emphasised commitments to “phase out and rationalise over the medium term inefficient fossil fuel subsidies while providing targeted support for the poorest”. The biggest developing economies spend $310 billion a year in such subsidies, according to the IEA, while the OECD subsidised around $20-30 billion a year[8]. Reducing fossil fuel subsidies makes clean energy sources more attractive economically, spurring the investments necessary to help reduce emissions.

Despite broad agreement on the need for large long-term global emission reductions, the great challenge for Copenhagen remains burden sharing across countries. Developing countries are asking the developed world to take responsibility for their past emissions, and commit to substantial emissions reductions. Developed countries, on the other hand, demand that the large developing countries and emerging economies, which are set to grow significantly in terms of economy and population, should also curb their emissions to some degree.

The result is a commitment gap, in which the collective emissions reductions pledges of both developed and developing nations appears insufficient to drive the reductions required. In a rapidly evolving space, **Figure 10** highlights key reductions commitments to date.

Figure 10: Key reductions commitments to date

G20 countries	Energy-related carbon emissions in 2008 (est.) Mt CO_2	Commitments for 2020 (or earlier)	Implied commitments for 2020 (relative to 1990 levels)[9]	Commitments for 2050
China	6,570	40-45% reduction in carbon intensity by 2020; 20% reduction in energy intensity from 2005 – 2010.		
US	5,980	17% below 2005 levels by 2020.	4% reduction	83% below 2005 levels by 2050
EU	3,990	20% below 1990 levels by 2020; 30% if other major economies make similar commitment.	20%-30% reduction.	80% below 1990 levels by 2050.
Germany	810	40% below 1990 levels by 2020.	40% reduction.	
UK	540	34% below 1990 levels by 2020 (42% if Copenhagen deal). Three five-year carbon budgets for 2008 – 2022.	34%-42% reduction.	80% below 1990 levels by 2050.

Renewable energy	Energy efficiency	Transport	Forestry and land use
15% of primary energy consumption from renewables by 2020.	Improve energy intensity by 20% from 2005 to 2010.	Rural vehicle fuel economy standard with expected saving of 488 $MtCO_2e$ by 2030.	Increase forest coverage to 20% Increase carbon sink by 50 million tons over the level of 2005 by 2010.
Combined renewable electricity and electricity savings of 6% 2012 rising to 20% by 2020.	Achieve all cost-effective energy efficiency by 2025. Other: Phase out incandescent light bulbs by 2014, improve lighting efficiency by more than 70% by 2020.	Fleet average efficiency of 35.5 miles per gallon by 2016.	
Increasing the share of renewables in energy use to 20% by 2020.	Cutting energy consumption by 20% of projected 2020 levels - by improving energy efficiency.	Average CO_2 emissions to fall to 130g/km in 2015, and 95g/km by 2020; 10% transport fuel from biofuel by 2020.	
30% share of electricity consumption from renewables by 2020.	11% cut in electricity consumption from 2005 levels by 2020.	Low tax rate fixed up to 2020 for natural gas fuel.	
20% of gross electricity from renewables by 2020.	All homes to be fitted with smart meters by 2020.	The average new car will emit 40% less carbon than now.	

Figure 10: Key reductions commitments to date continued...

G20 countries	Energy-related carbon emissions in 2008 (est.) Mt CO_2	Commitments for 2020 (or earlier)	Implied commitments for 2020 (relative to 1990 levels)[9]	Commitments for 2050
Italy	450	20% below 1990 levels by 2020 (following EU targets)		
France	400	20% below 1990 levels by 2020 (following EU targets).	20% reduction.	75% below 1990 levels by 2050.
Russia	1,560	22%-25% below 1990 levels by 2020 (revised from 10%-15%).	22%-25% reduction.	
India	1,350	Per capita emissions not to exceed developed countries.		
Japan	1,310	25% below 1990 levels by 2020 conditional on an ambitious global agreement 60-80% from current levels (2008) by 2050.	25% reduction.	
South Korea	630	4% below 2005 levels by 2020[10] (30% below BAU).	c. 82%-90% increase.	
Canada	610	20% below 2006 levels by 2020.	3% reduction.	60%-70% below 2006 levels by 2050.

Renewable energy	Energy efficiency	Transport	Forestry and land use
17% of gross final energy consumption from renewable sources by 2020.	Energy saving target of 9.6% by 2016 (118,464 GWh).	Introduction of a 140g of CO_2/km emissions limit.	
23% of gross final energy consumption from renewables by 2020.	Phase out incandescent light bulbs by 2012.		
Share of power to come from renewables (20% incl. hydropower or 4.5% excluding hydropower) by 2020.	40% reduction in energy intensity per unit of GDP from 2007 levels by 2020.		
10% (4-5%) of primary energy (electricity) from renewable sources by 2012.	Reduce energy intensity per unit by 20% from 2007–08 to 2016–17.	Auto Fuel Policy (to control vehicle emissions) tightened to cover all cities and to implement Euro IV standards.	Afforestation of 6 million hectares of degraded forest lands and expanding forest cover from 23% to 33%.
7% of primary energy from renewable sources by 2015; 10% by 2020; 3GW wind power by 2010; 79GW of solar power by 2030.		50% efficiency improvement for new gasoline vehicles by 2050; 39.5 mpg fuel efficiency standard by 2015.	6% increase in forest sink by 2010.
5% of electricity consumption from renewable sources by 2011; 11% by 2030.	Energy intensity level of 0.185 tonnes of oil equivalent (Toe)/USD 1 000 by 2030 (46% reduction from current levels).	Average fleet fuel efficiency of 40 mpg by 2015.	US$1.7billion from stimulus for forest restoration.
90% of electricity provided by low carbon sources (hydro, nuclear, clean coal or wind power) by 2020.	Reduce national industrial emissions intensity to 18% below 2006 by 2010.	Reduce average fuel consumption and CO_2 emissions from new vehicles by 20% compared with 2007.	

Figure 10: Key reductions commitments to date continued...

G20 countries	Energy-related carbon emissions in 2008 (est.) Mt CO_2	Commitments for 2020 (or earlier)	Implied commitments for 2020 (relative to 1990 levels)[9]	Commitments for 2050
South Africa	460	10% above 2003 levels in 2020.	c. 40% increase.	30%-40% below 2003 by 2050.
Saudi Arabia	450			
Mexico	420	c. 2% below 2000 levels by 2020.	c. 30% increase.	50% below 2000 levels by 2050.
Brazil	410	36%- 39% reduction below business-as-usual by 2020		
Australia	360	5%-15% below 2000 levels by 2020; 25% below 2000 levels by 2020 conditional on a global deal with a 450 ppm CO_2e GHG stabilisation target.	5%-18% increase; 7% reduction conditional.	60% below 2000 levels by 2050.

Renewable energy	Energy efficiency	Transport	Forestry and land use
4% electricity supply, from renewables by 2013.	12% energy efficiency improvement by 2015 from 2005.	Promotion of electric vehicles.	
	National energy efficiency program on demand management and energy conservation.		
Renewable energy to form 8% of power mix.	Efficiency standards.	Improve CO_2 efficiency; bus rapid transit system.	Range of measures e.g. sustainable management of 6.6m ha of forest; reforestation of 1.4m ha.
Increase electricity supply from cogeneration to 11% of total supply by 2030, new hydro-electric power plants 34,460 MW.	Reduction in electricity consumption of around 10% in 2030	3% biodiesel blending requirement since 2008; 5% biodiesel requirement from 2010.	Reduction of 40% in the average deforestation rate in 2006 – 2009 relative to 1996 – 2005, and further 30% reduction in following two periods of four years.
Renewable Energy Target Scheme: at least 20% of electricity supply from renewables by 2020.	Phase out incandescent light bulbs and new lighting standards by 2009 – 2010.	Short and medium term non-binding fuel efficiency 'aspiration goal' of 2% per annum. Green Car Innovation Fund to provide assistance over ten years on RD&D of low carbon vehicles.	

Figure 10: Key reductions commitments to date continued...

G20 countries	Energy-related carbon emissions in 2008 (est.) Mt CO_2	Commitments for 2020 (or earlier)	Implied commitments for 2020 (relative to 1990 levels)[9]	Commitments for 2050
Indonesia	350			
Turkey	280			
Argentina	160			

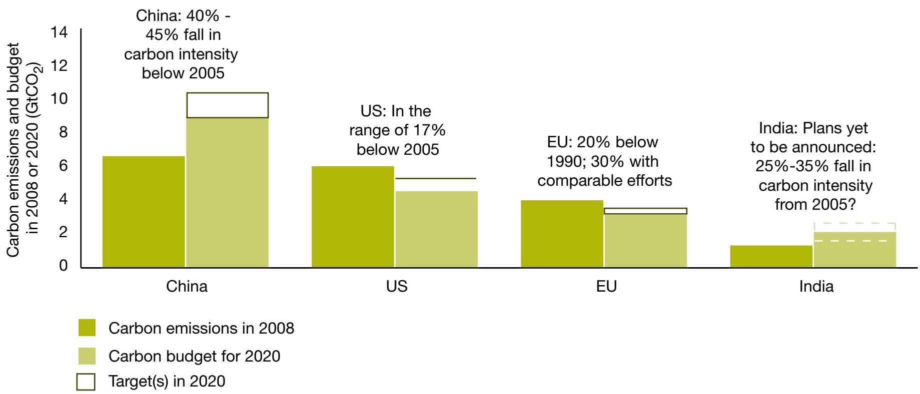
Sources: Country websites of ministry / department dealing with climate change; Sustainability Analysis of Economic Stimulus Packages, SRI Blog, Fortis Investment

Renewable energy	Energy efficiency	Transport	Forestry and land use
15-17% of primary energy from renewable/ alternative sources by 2025.	Various policies to save 10%-30% energy.		Management of forest fire, peat and illegal logging. Targeted rehabilitation of 36.31 millions ha of forest by 2025.
10% wind and solar in installed energy mix by 2020.	Demand management to lower emissions by 75 million tons per year or 12% by 2020.		
8% of electricity from renewable sources by 2016.			

Key pledges for 2020: how they compare

The performance of the four key economies that collectively account for nearly two-thirds of global energy-related carbon emissions will determine whether the 450 ppm stabilisation level can be achieved. Existing pledges by these economies for 2020, however, present a mixed message.

Figure 11: Carbon pledges relative to required levels in 2020 (India illustrative)[11]



Source: PwC analysis

The 2020 target proposed by the US is slightly weaker than the carbon budget derived from our analysis. Pledges by the EU, on the other hand, are reasonably close to their carbon budget, suggesting that they are taking a "fair share of the burden" through to 2020.

China recently announced a new target for a 40-45% reduction in carbon intensity. Because this pledge is intensity based, the target range is indicative only, depending on GDP growth during the period. However, the full 45% reduction is likely to bring them close to budget; just 40% would leave them some way short.

India's current targets around fuel efficiency, building codes and share of renewable sources are expected to reduce India's energy intensity by a further 5-10%. There is speculation that India will announce a 2020 intensity target ahead of Copenhagen, in response to China's new proposals. As an illustration, we have presented potential range of commitments on a reduction in carbon intensity for India of 25%-35% by 2020 from 2005 levels.

Policies rather than pledges that really matter

Achieving emissions targets is much more important than setting them and it will be national regulations and policies which will drive the change needed. The range and credibility of key policies are therefore an important indicator of the commitment of countries to addressing climate change.

Recognising their pivotal role, we have included in this report a high level analysis of the policies for three of the four key economies, the US, China and India. The policies that will lead to the success of the EU achieving its targets will be dependent on both EU-wide and national initiatives. Rather than look at policies in all 27 EU member states, we have focused here on one key EU economy, the UK, as a representative sample for such an analysis.

The policy analyses are aimed at identifying the potential for these countries to meet their announced targets. We adopted an approach analogous to the Princeton technology wedges, as set out by Socolow and Pacala[12], but focusing instead on the emissions reduction potential of each "policy wedge". The analysis concentrates on existing announced and planned policies going out to 2020, and compares the extent to which the sum of the wedges add up to the pledges at the national level.

Constructing policy wedges, particularly over a long timeframe, is subject to substantial uncertainties and difficulties, including:

- Complex interactions between climate policies and non-climate policies, including how state or local government programmes would interact with national initiatives.
- Policy gaps relating to the actual implementation of policy levers (e.g. a low-carbon fuel standard)
- Methodological gaps, including errors due to assumptions on price volatility, cost containment and baselines.
- Avoiding double- or over-counting, where several policies could lead to the same effect.
- Assumptions around behaviour and responses by private sector and consumers.

US – Low carbon commitment to kick-start the economy, proposed legislation to drive the transaction

The Green New Deal

The American Recovery and Reinvestment Act 2009 (ARRA) has provided unprecedented focus and financial stimulus to low carbon technologies: for example, the US$16.8 billion funding to the Office of Energy Efficiency and Renewable Energy (EERE) for a package of measures is nearly ten times the EERE's annual budget. The US Energy Information Administration (EIA) predicted that ARRA would have a significant short-term impact, reducing emissions by 1%-1.5% a year between now and 2020[13]. In fact, annual U.S. emissions of the main greenhouse gas from the burning of coal, natural gas and petroleum are forecast to fall 5% in 2009, according to the US EIA. This is partly attributed to the recession, but also reflects a shift towards natural gas away from coal in electricity generation.

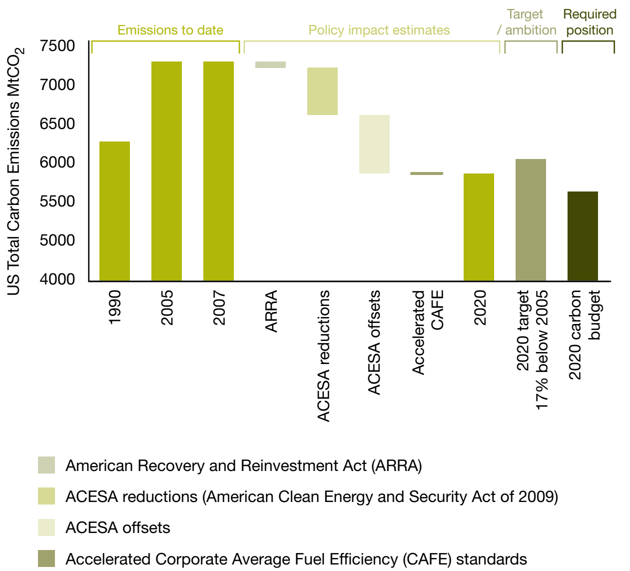
Over the longer term, however, reducing greenhouse gases emissions in the US will depend critically on emissions legislation currently being considered by Congress. Although President Obama has announced a target of reducing emissions in the range of 17% below 2005 by 2020, and 83% by 2050, the level of ambition and the timing of cuts will ultimately be determined by the legislation, which will not be passed at least until some time after Copenhagen.

The Waxman Markey bill, which has already been passed by the House of Representatives, would set a goal for emission reductions of 17% by 2020 relative to 2005 levels, 42% by 2030 and 83% by 2050, consistent with the President's announcement. The Kerry Boxer Bill, which was introduced in the Senate, targets higher cuts in earlier years, with a 20% target for 2020, but has comparable targets for later period through to 2050. However, in both bills, the impact on domestic greenhouse gases emissions depends on the level of international offsets allowed and used. In the absence of legislation, regulation of greenhouse gas emissions is the responsibility of the US Environmental Protection Agency. Our analysis focuses on the Waxman Markey bill (the American Clean Energy and Security Act (ACESA)) which, although almost certain to be superseded by other proposals, provides an indication of the direction of travel of US climate policies[14].

Offsets relieving pressure on domestic action, funding reductions internationally

Figure 12 shows the relative contribution of the major carbon-related policies to reducing emissions from current and baseline levels in the US, as well as how this compares to the estimated carbon budget for 2020. In our policy wedges scenario (based on EIA analysis of the potential impact of ACESA), international offsets are likely to form a significant proportion of the offsets eligible under a federal cap-and-trade scheme[15]. Thus the US will be paying for other economies to reduce emissions (where it is more cost effective for them to do so), while US domestic emissions remain higher than 1990 levels even by 2020. Through international offsets, the US could potentially be funding low carbon technologies and avoided deforestation in developing economies by as much as US$25-30 billion annually by 2020.

Figure 12: Key carbon-related policies in the US (2020)



Source: PwC analysis

At a global level, it does not matter where emissions reduction are made. Indeed if international offsets carry the same level of environmental integrity as domestic reductions, they are likely to provide a lower cost option of reducing global emissions. However, relying too much on offsets may reduce the momentum of domestic efforts to decarbonise the domestic US economy in the longer term.

Meanwhile, the accelerated Corporate Average Fuel Economy (CAFE) standards, which brought forward plans to improve average fuel economy to 35.5 mpg to 2016 (from the original plan for 2020), should provide an important push for greater fuel efficiency in the US, which historically has been poor relative to other major economies (for example, US level of fuel economy in the early 2000s is at around 25mpg, compared to around 30mpg for China and over 45mpg for Japan[16]), but makes relatively little incremental impact on reducing emissions up to 2020.

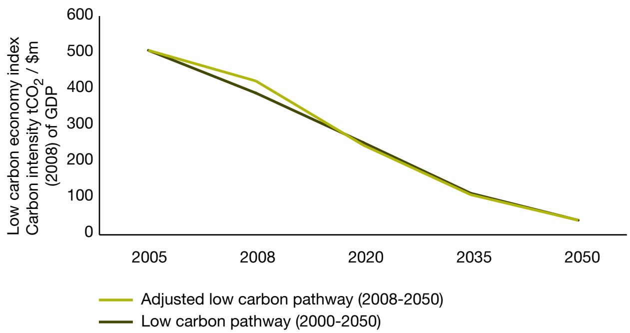
Political commitment translating into action but longer-term challenges

The US is demonstrating a willingness to commit to the climate change agenda through the range of proposals passing through legislation. Many of these policies will take a number of years before they have any noticeable impact on the level of emissions, but progress can already be seen in some areas. For example, a U.S. Department of Energy's report found that, to increase wind energy to 20% of US electricity supply by 2030, increasing installations of new wind power capacity of more than 16GW per year by 2018 will be required. In 2008, the US wind energy industry brought online over 8.5 GW of new wind power capacity, more than double what the report deemed necessary[17]. Even in 2009, where lower numbers were projected, installations will be 20% higher than projected by the report.

Country level fact box:

- 2008 energy-related emissions (est.): 5.98 $GtCO_2$
- Share of Global Carbon Budget: 16%
- Existing commitments: 17% below 2005 levels by 2020
- LCA index: -7.8% adrift from low carbon pathway
- LCC index: -90% reduction in carbon intensity required
- Notable policies: ARRA, ACESA, accelerated CAFE standards

Figure 13: US LCE index



Source: BP data for 2000 and for 2008 in 2008-based variant, PwC model projections for Greener Growth + CCS scenario variants

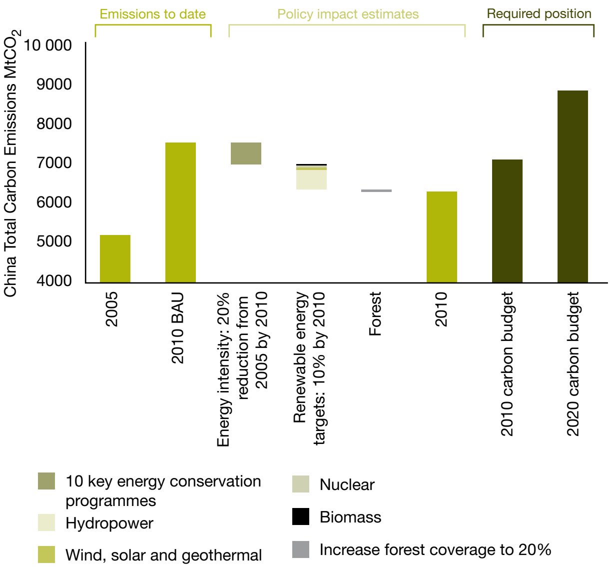
China

Strong short term targets

The announcement last month of a proposed new target to reduce carbon intensity by 40%- 45% from 2005 levels by 2020 is underpinned by strong performance in current shot term targets. China has rejected mandatory caps on GHG emissions that might prejudice its continued rapid economic growth and so the new target is ascribed as ‘voluntary’, consistent with the ‘responsible attitude’ towards climate change articulated in the National Climate Change Programme.

The Programme, released in June 2007, presents a set of 52 policies and measures up to 2010. Most notable are an overall target on energy intensity of a 20% reduction by 2010 from 2005, and a target of 15% of primary energy supply from renewable energy. Figure 20 shows the relative contribution of these major policies towards reducing emissions below business as usual, and how this compares to our estimated carbon budget for China in 2010 and 2020.

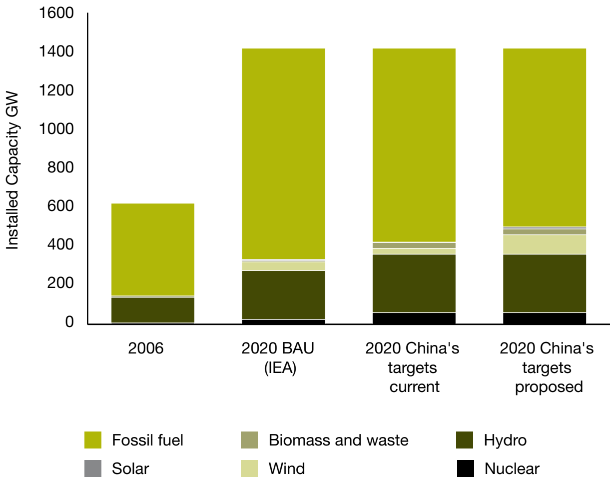
Figure 14: Key carbon-related policies in China (2010)



Source: PwC analysis

As the national climate change programme is aligned with the 11th 5-year plan, detailed targets are only set for the period 2005 – 2010, with lesser clarity on targets to 2020. However, along with the draft of the 12th 5-year plan and planning around the outcome of the Copenhagen negotiations, the National Development and Reform Commission (NDRC) is now providing more detail on climate change commitments beyond 2010.

Figure 15: Share of renewable energy in installed capacity in 2020



Source: PwC analysis from IEA

Since the launch of the programme, China has raised its renewable energy ambitions, with wind and solar (mainly PV and thermal) expected to be scaled up dramatically, from 30 to 100GW for wind and from 1.8 to 20 GW installed capacity for solar energy by 2020 (see **Figure** 15 on China's renewable energy targets for 2020). In 2008, installed capacity of wind power was around 12GW, or 10% of the world's total, while solar photovoltaic (PV) capacity reached 150 MW. Solar PV capacity remains relatively low domestically. However, China has played a critical role in the development of the sector internationally through its global leadership in the manufacture of PV cells. It exports nearly all the cells it manufactures, accounting for nearly 30% of global PV cells production[18].

China's recent economic stimulus plan (at US$586 bn) includes a hefty 37% share dedicated to the development and deployment of green technologies. The China Greentech Report (2009) forecast that the market size of the green tech industry in China could reach 15% of China's forecasted GDP by 2013, which would constitute a significant stride towards the low carbon economy.

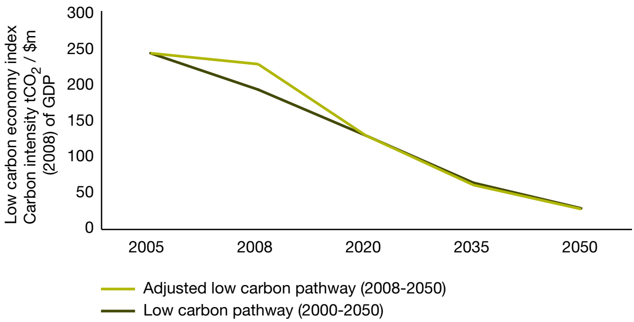
Despite the rapid diversification of China's energy supply and impressive progress against renewable energy targets, coal will continue to play a major role in powering China's economic development, reflecting its substantial installed coal-fired electricity generation capacity and abundant coal reserves. Carbon capture and storage technology is therefore seen as potentially playing an important role in China's GHG emissions abatement in the future.

The existing policies up to 2010 are expected to deliver a substantial reduction in China's emissions level relative to business as usual. Over the longer term, the challenge will be to sustain and build on the momentum towards lower carbon intensity.

Country level fact box:

- 2008 energy-related emissions (est.): 6.6 $GtCO_2$
- Share of Global Carbon Budget: 28%
- Existing commitments: 20% reduction in energy intensity from 2005 levels by 2010.
- LCA index: -15.4% adrift from low carbon pathway
- LCC index: -88% reduction in carbon intensity required
- Notable policies: Energy intensity reduction, renewable expansion plans

Figure 16: China LCE index



Source: BP data for 2000 and for 2008 in 2008-based variant, PwC model projections for Greener Growth + CCS scenario variants

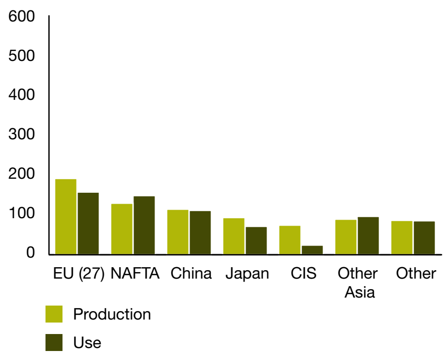
Case of China and the steel industry

Carbon intensity for China almost halved during the 1990s from 1.7 $kgCO_2$ to 0.9 kg CO_2 per unit of GDP, despite a doubling of GDP per capita. However, in the period from 2003 – 2004 in particular, a sharp rise in the share of heavy industry and manufacturing, driven by strong domestic and export demand, led to a significant slowdown in the rate of energy and carbon intensity improvement. Carbon intensity in 2008 is estimated at 0.83 $kgCO_2$ per unit of GDP, only 8% lower than in 2000. Central to this challenge is steel. China has more than doubled its share of the world's steel production over the past decade and currently accounts for 38% of the world's crude steel production. This is reflected in its annual double digit growth, averaging over 20% p.a., in its steel and iron products. Rapid industrialisation and urbanisation has meant that China is the world's largest consumer of steel. In addition, having had very low net exports of steel a decade ago, China is now the leading net steel exporter globally.

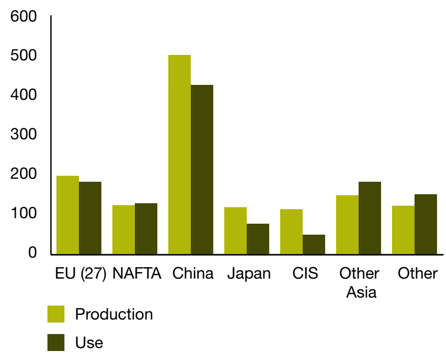
	Volumes of production (10 000 tonnes)			Average annual rate of growth (CAGR)	
	1990	2000	2007	1990 – 2000	2000 – 2007
Crude steel	6,635	12,850	48,929	6.8%	21.0%
Rolled steel	5,153	13,146	56,561	9.8%	23.2%

Sources of data: WorldSteel Association, China's National Statistics (including from China Steel Association)

Steel production and use 1998



Steel production and use 2008



Sources of data: WorldSteel Association, China's National Statistics (including from China Steel Association)

This stage of economic development, when energy-intensive industries dominate the economy, presents substantial challenges to China in trying to decouple carbon emissions from economic growth. Steel features heavily in China's Action Plan on climate change, and significant strides have been made by the steel industry, of which energy efficiency improvement has been one of the industry's key priorities over the past three decades – leading to a halving of the energy consumed per tonne of steel produced. But as steel demand could double over the next 40 years, given the expected growth in developing countries and in construction, housing and transport, low carbon usage of steel is important to ensure sustainable economic development. The World Steel Association recognises that:

- The modern steel industry has pushed steel production processes very close to their theoretical minimum CO_2 intensity per tonne of steel output based on current technologies. Some minor gains can be made through the increased use of scrap in primary production. However, development of breakthrough steelmaking technologies is vital if global steelmaking CO_2 intensity is to be further reduced in the long term. Implementation of appropriate new technologies requires significant major investment in research and development, testing in pilot plants and careful upscaling to commercial volumes.

- Maximising end-of-life steel recycling and using by-products from steelmaking will reduce CO_2 emissions. For example, one main physical by-product from steelmaking is slag. When used in cement production, slag reduces CO_2 emissions from the process. Slag can also be used as fertiliser or as a base in road building. Combustible gases produced during steelmaking are reused as an energy source to generate power or as a source of heat for other processes. It is possible to make steel with nearly no waste going to landfill. Current material efficiency rates have reached 97% and some companies have an internal recycling and by-product usage rate of nearly 98%.

Sectoral approaches have been advocated to help target specific energy-intensive sectors such as steel in reducing the impact on carbon emissions. Sectoral agreements will include, for example, setting targets at the sector level corresponding to the highest efficiency levels. The World Energy Outlook 2009, in particular, has identified the iron and steel sector to be a key pillar in reducing emissions from the industrial sector. The right framework and policies for positive action by the steel industry that help to avoid cost differences in different countries could help address carbon leakage as well as creating the right incentives for steel industries (particularly in emerging economies such as China) to further improve carbon intensity.

India

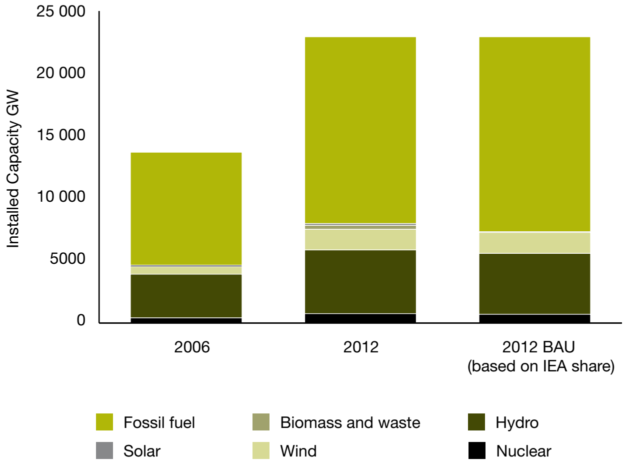
Growing while decarbonising

Like China, India faces the challenge of limiting carbon emissions at the same time as delivering rapid economic growth. It is at an earlier stage in its development than China and has a particular priority to help the rural sector enjoy the benefits of economic development.

India's 'Integrated Energy Policy' introduced in 2006, sets out the broad vision of India's energy sector, with specific focus on the electrification of rural areas, through off-grid, potentially renewable options for areas with no connectivity. The government's national economic development plan also place focus on increasing the installed capacity of hydropower and nuclear (see **Figure 17**).

	Policies	Overview
Energy efficiency	Energy Conservation Act 2001	
	Energy conservation building code ECBC 2007	Supporting adoption and implementation of efficiency savings and savings in GHG emissions.
	Energy Audits of large industrial consumers 2007	Mandatory energy audits in large energy consuming units in 9 industrial sectors.
Transport	National Urban Transport Policy	Expansion of mass transit systems in cities.
	Biodiesel Purchase Policy 2003	Mandates biofuel procurement by petroleum industry.
	National Auto Fuel Policy	All new four-wheeled vehicles in eleven cities to meet Bharat Stage III emission norms for conventional air pollutant and comply with EuroIV standards by 2010.
Renewable energy	National Electricity Policy 2005	Progressive increase of share of renewable energy generation.
	Electricity Act 2003	Promoting co-generation and renewable energy generation (including stand-alone renewable energy generation), optimal utilisation of resources.
	Tariff Policy 2006	Preferential tarrifs for renewable energy; Renewable Purchase Obligation.
	National Rural Electrification Policy 2006	Minimum percentage of power from renewable sources.
Clean energy	Nuclear	Integrated Energy Policy target of 20GW by 2020.

Figure 17: Share of renewable energy in installed capacity in 2012



Source: Statistics from Ministry of Renewable Energy and Ministry of Power (on installed capacity for the 11th plan).
Note: Does not include latest announcements on National Solar Mission, which aims for 20GW installed capacity by 2022.

The National Action Plan on Climate Change (NAPCC) released in June 2008, comprise eight missions:

- Enhanced energy efficiency in industry
- Sustainable Habitat
- Solar mission
- Strategic Knowledge for climate change
- Sustainable Agriculture
- Sustaining the Himalayan Ecosystem
- Water Mission
- ‘Green India’ (increasing forest cover and density)

India has long resisted mandatory caps on emissions, concerned that these would hamper its industrail development. However there is speculation that the recent announcement of a carbon intensity targets by China may prompt an intensity commitment by India, either before or at Copenhagen.

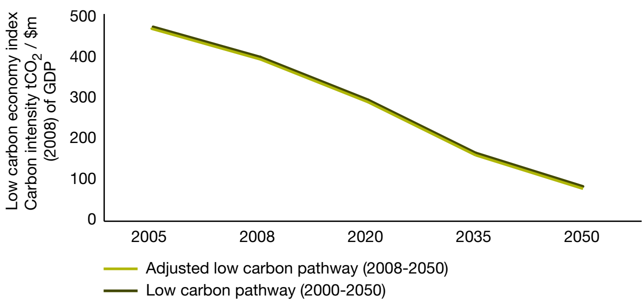
Meanwhile, plans such as the National Mission for Enhanced Energy Efficiency and the National Solar Mission demonstrate the growing ambition of the Indian Government. Like China, India is expected to take advantage of the potential growth in renewable energy domestically and abroad. In particular, the Solar Mission aims to create the conditions to drive down the costs of solar power to be comparable to coal, encourage the deployment of 20,000 MW of solar power by 2022, and ramp up the solar manufacturing capability in India.

India's main challenge will be to leapfrog the high-carbon industrialising stage that many developed economies have undergone, and taking advantage of the opportunities that a low carbon economy can provide.

Country level fact box:

- 2008 energy-related emissions (est.): 1.35 $GtCO_2$
- Share of Global Carbon Budget: 9%
- Existing commitments: Not to exceed per capita emissions of developed world
- LCA index: -0.4% adrift from low carbon pathway
- LCC index: -79% reduction in carbon intensity required
- Notable policies: National Mission for Enhanced Energy Efficiency and National Solar Mission

Figure 18: India LCE Index



*Apart from an insignificant difference that is lost in the rounding

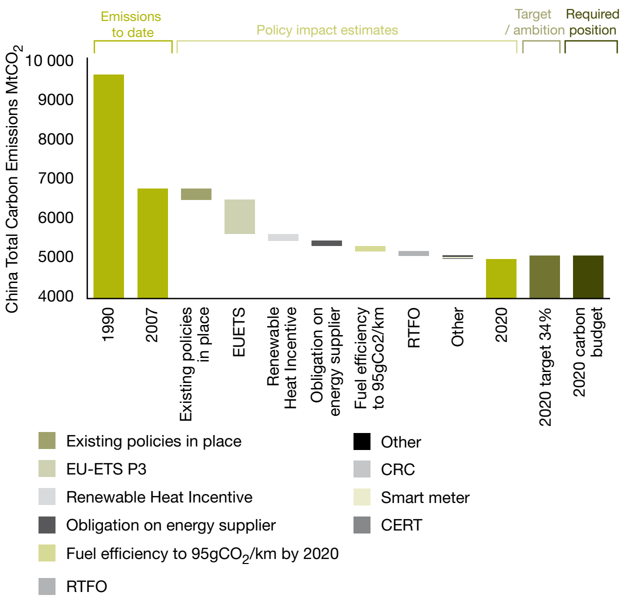
Source: BP data for 2000 and for 2008 in 2008-based variant, PwC model projections for Greener Growth + CCS scenario variants

UK – A low carbon transition?

The carbon budget and transition plan

The UK is one of the first economies setting a legally binding carbon budget, and early this year released a "Low Carbon Transition Plan" outlining the measures that will help drive the low carbon economy. The EU ETS remains the central plank of policy that will drive emissions reduction, supported by many other domestic policies each delivering a sliver of the emissions reduction wedge. The UK has a mixed track record in meeting targets - being more successful than many other countries in reducing its emissions since 1990 against its Kyoto targets but missing several key other targets, for example on increasing the share of renewables in electricity generation. **Figure 19** shows the key policies that help reduce carbon emissions and their relative contribution towards the UK's target of 34% reduction below 1990 by 2020.

Figure 19: Key carbon-related policies in UK (2020)



Source: PwC analysis

It's still the economy, stupid

In October 2009, the Committee on Climate Change (CCC) published the first annual report to Parliament on the progress in emissions reductions relative to the UK's carbon budgets. The CCC concluded that a step change is required in the pace of UK emissions reduction to meet carbon budgets, with the annual rate of emissions reduction in recent years averaging 0.5%, against the 2-3% required to meet the carbon budget.

The only marked progress in emissions reduction was in 2008, where emissions fell by around 2% as a result of the recession, highlighting the continuing linkages between emissions and the economy. Success in achieving the first carbon budget, through to 2012, will likely boil down to the impact of the current recession, rather than any significant increase in carbon productivity.

Helping the markets work

In the UK, the key mechanism to limit emissions is through carbon pricing, via the EU ETS and the forthcoming Carbon Reduction Commitment. This has yet to deliver the level of new investment and changed behaviours required to transition to the low carbon economy. However, lessons learnt in the EU ETS pilot phase have led to new scheme rules, tighter caps and a preference towards auctioning of allowances, which should improve the effectiveness of this policy instrument.

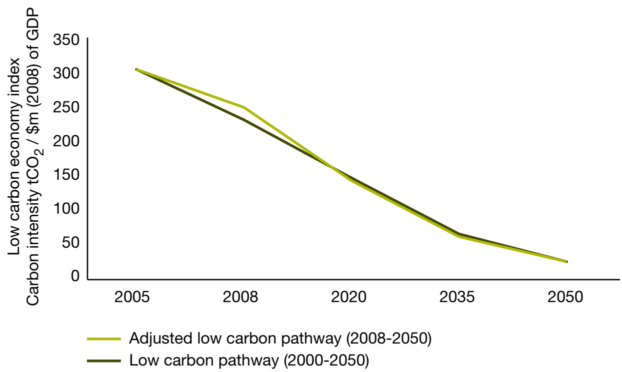
To stimulate low-carbon investment in the next decades, carbon price signals will need to be stronger and clearer. They also need to be complemented by other measures, including direct investments and promotion of low carbon technologies such as CCS, or targeted consumer campaigns such as street-by-street approaches involving local government on residential energy efficiency measures.

Other barriers also need to be addressed. Meeting the UK's renewable energy target of 15% will require capacity additions of around 23GW of onshore and offshore wind generation. The typical small size of an onshore farm means that approximately 400 wind projects will be needed to deliver the capacity required, each of which face the challenge of obtaining planning permission. Offshore wind farms are significantly larger so fewer of them are needed, but they require greater capital investment and so face higher risks in accessing finance.

Country level fact box:

- 2008 energy-related emissions (est.): 540 $MtCO_2$
- Share of Global Carbon Budget: 1% (EU share of Global Carbon Budget: 10%)
- Existing commitments: 80% reduction by 2050; 34% reduction by 2020
- LCA index: -6.7% adrift from low carbon pathway
- LCC index: -90% reduction in carbon intensity required
- Notable policies: EU ETS, renewable heat incentive, fuel efficiency requirements to 2020

Figure 21: UK LCE Index



Source: BP data for 2000 and for 2008 in 2008-based variant, PwC model projections for Greener Growth + CCS scenario variants

Concluding remarks

Despite increasing scientific consensus on the potential long-term threat from climate change and a growing political momentum on the need to act to avert this, progress to date has been limited in moving towards a low carbon economy:

- At a global level, the world was around 10% adrift in 2008 from what would have been a reasonable low carbon pathway for carbon intensity reduction in the period since 2000.
- This general conclusion applies to almost all of the G20 economies, including the US, the EU and China (although the latter's performance has improved significantly since 2005 as Chinese government policy has focused increasingly on energy intensity reductions).
- The PwC Low Carbon Challenge index indicates that the G20 now needs to cut its carbon intensity levels by around 35% by 2020, and around 85% by 2050. We therefore have to decarbonise at a rate of 3.5% a year between 2008 and 2020 to get back on track — more than four times faster than the rate achieved since 2000 at the global level.

The low carbon investment challenge

The technologies to achieve this scale of reduction are available, and in many cases economically viable; what is required is the political momentum and the right policy framework that will help scale up the deployment of these measures and technologies. According to IEA estimates, the level of incremental investments required globally to secure this decarbonisation amounts to £430 billion in 2020, rising to $1.15 trillion by 2030, above business as usual. This investment translates into 18,000 windmills of 3MW and 20 nuclear plants every year; as well as 300 concentrated solar plants; 50 hydro power plants; and for 30% of coal-fired power plants to be installed with CCS technology by 2030.

To be able to deliver this scale of investment, the private sector will need not just targets, but a binding and effective framework of policy commitments. Establishing a global market for carbon trading would be one element in this, together with adequately funded arrangements to support technology transfer to less developed countries. For the G20 economies, this also means keeping to their pledge on phasing out fossil fuel subsidies . Phasing out these subsidies, combined with strong domestic policy frameworks and mechanisms to put an international price on carbon emissions, are essential if low carbon alternatives are to attract the necessary investment flows within the timeframe required.

The importance of Copenhagen

Two years ago in Bali, governments agreed that the Copenhagen summit would mark a turning point in international cooperation on climate change. In the weeks leading up to Copenhagen, the jigsaw pieces have started to come together, with most major countries pledging specific national emissions targets.

There may not be sufficient time to complete the picture of a comprehensive legally binding protocol by mid-December, but an ambitious political deal will pave the way to more robust national and global measures. New policies and regulation will need to come into effect rapidly and radically in the next few years. Businesses have a short window to prepare, and those that are ready for the transition will benefit from the opportunities arising from a low carbon economy.

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:

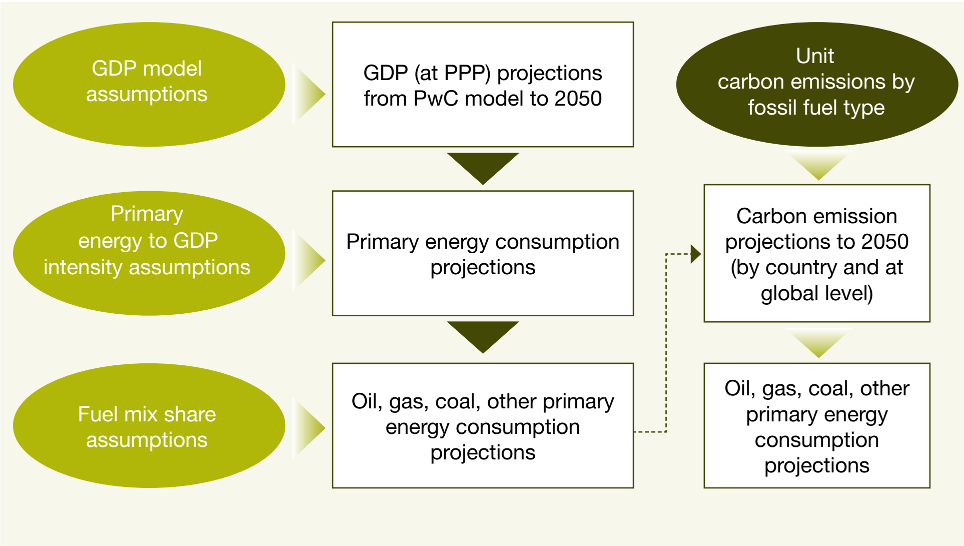
- Investment in physical capital.
- Working age population growth (UN projections).
- Investment in human capital (rising average education levels).
- Catch-up with US productivity levels (at varying rates).

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.

Figure 22: Outline of PwC carbon emissions model structure



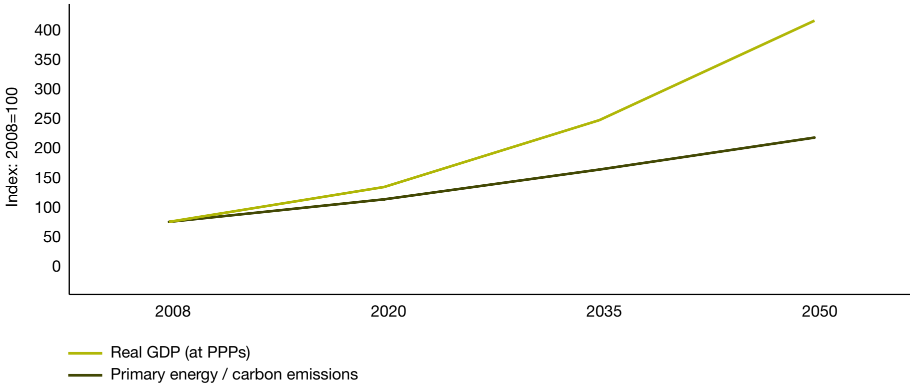
Business as Usual (BAU) scenario

A BAU scenario is constructed assuming

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

This is NOT intended as being the most likely scenario, just a convenient and reasonable benchmark which serves as a starting point for constructing other scenarios.

Figure 23: Real GDP, primary energy consumption and carbon emissions growth in BAU scenario



Source: World Bank and BP data for 2008, PwC model estimates for later years
Note: due to constant fuel mix assumption, energy-related carbon emissions grow in line with primary energy consumption in the BAU scenario

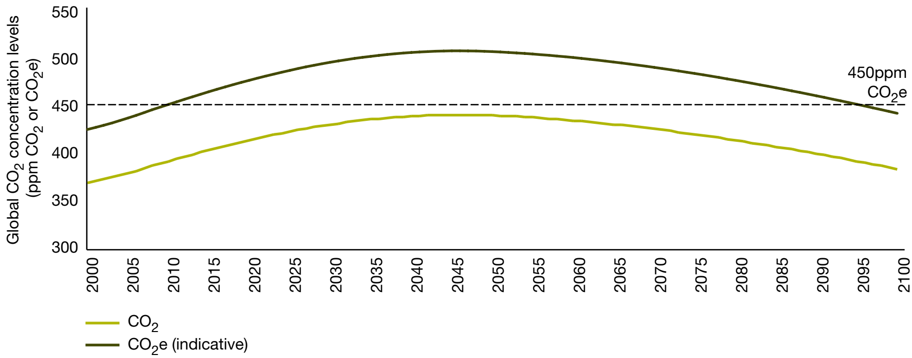
Greener Growth plus CCS (GG+CCS) scenario

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

In deriving the Global Carbon Budget, we adopted the general consensus of aiming for global CO_2e concentrations to stabilise around 450 ppm by 2100. This broadly corresponds to a peaking of concentration by 2050 at around 515 ppm and then declining towards 450 ppm 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.

To achieve this, the global concentrations for CO_2 gases would need to peak at around 440 ppm by 2050 and declining thereafter to below 400 ppm by 2100.

Figure 24: Global atmospheric concentration levels of CO_2



Source: PwC model projections
Note: CO_2e concentration levels are indicative only as non-CO_2 emissions not included in analysis.

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 the global level for carbon emissions from land use change and forestry are then discussed later together with assumptions on natural carbon sink capacity at the 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 2009 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. Specifically for this earlier period from 2009-24, we assume that:

- Of the Big 4 economies, **China** (4% pa) has the most ambitious scope for improvement here, which reflects it 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 assumed to have the next most ambitious target based on the fact that it has the highest energy intensity of the major advanced economies (relative to EU and Japan) 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 given it has already made more progress on this than the US and so has less far to travel here on the pathway to a low carbon economy; 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 1980-2008, so it is still a challenging prospect.

For the Big 4 as a whole, the average energy intensity improvement is slightly above 3% per annum, so other countries collectively are assumed to have rates of improvement that average slightly below this global rate. But we make individual assumptions here for all of the G20 based on the same kind of considerations as outlined above for the Big 4 economies (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 entire period from 2009 to 2050. Trends in the share of natural gas are more mixed, being assumed to tend to decline for the advanced economies but to 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[19] is assumed to rise to around 40% by 2050 in this scenario, which is certainly very challenging but not unachievable when compared to other previous studies by the IEA and others.

More specifically, key assumptions for the Big 4 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 2009 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 becomes less oriented to heavy industry and more to services; India, with its 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 (any more than this would eliminate coal from its fuel mix entirely before 2050).

- **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 5.5GtCO2) 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.

Clearly, though, 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 relation to 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.

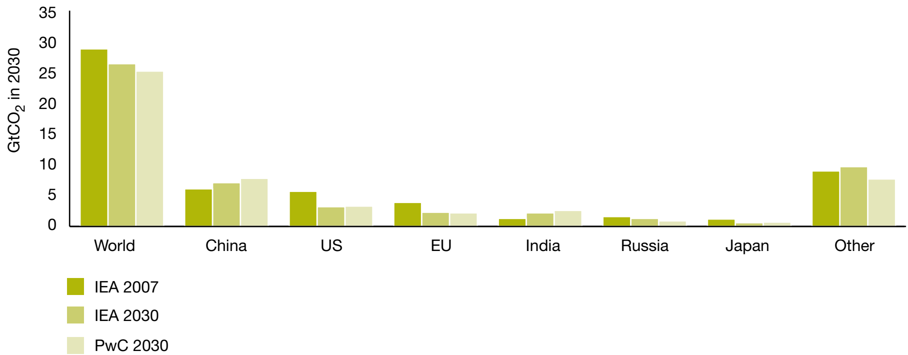
Inevitably, the precise assumptions used are open to debate, particularly at country level, and the resulting allocation of carbon budgets is therefore subject to some margin of judgement and uncertainty. But we believe that the broad shape of the allocation is reasonable and, as described below, we believe that this is reinforced by the cross-checks with the IEA's latest 450 scenario and with alternative rule-based methods of allocating carbon budgets that are much simpler do not take any account of what countries can realistically be expected to achieve given their starting points and stages of economic development.

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

- Net annual CO_2 emissions from land use changes and forestry (LUCF) around 5.8GtCO_2 in 2008 declining to around 1.4GtCO_2 by 2020, and then at a slower rate to around just over -4GtCO_2 by 2050. Current estimates on reducing emissions from deforestation and forest degradation (REDD) expect it to deliver around 5GtCO_2 emissions reduction by 2020.
- Global absorption capacity of the planet (oceans, forests etc) is around 15 GtCO_2 per annum and broadly stable over time.

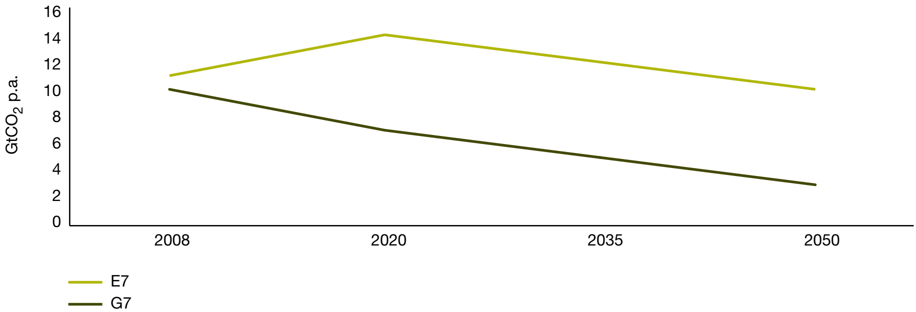
This scenario therefore has some common features across countries but also some variations to reflect differing starting points, stages of economic development and energy resource endowments. We have compared this with the IEA's 450 scenario for 2030 emissions, giving broadly similar results as the next 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.

Figure 25: Comparison of PwC Greener Growth + CCS scenario with IEA 450 scenario for energy-related carbon emissions in 2030



Source: IEA World Energy Outlook 2009, PwC GG + CCS scenario

Figure 26: G7 and E7 carbon emissions projections in Greener Growth + CCS scenario: G7 countries bear the brunt of earlier adjustment



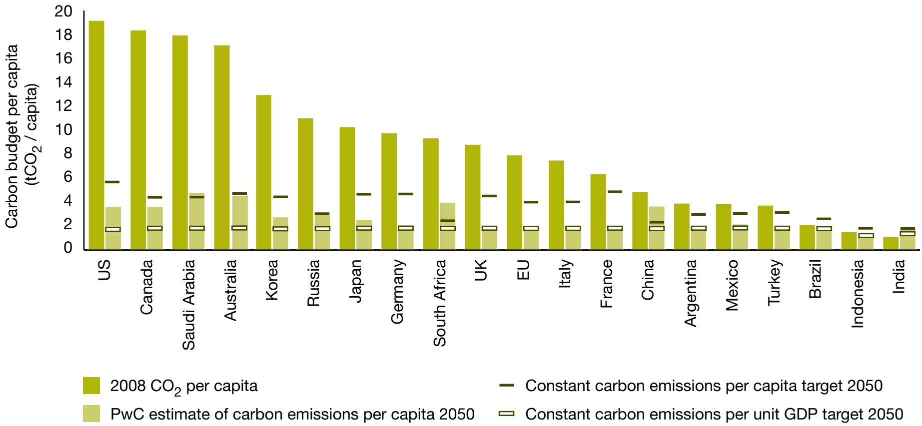
Source: BP data for 2008, PwC model projections for Greener Growth + CCS scenario
Note: E7 = China, India, Brazil, Russia, Mexico, Indonesia and Turkey; G7 = US, Japan, Germany, UK, France, Italy and Canada

We have also compared our projected carbon budget against two alternatives methods of burden sharing:

- Equal per capita carbon emissions (estimated at just under $2tCO_2$ per capita).
- Equal carbon intensity (estimated at around 0.06 kg CO_2 / $GDP).

For nearly all the G20 economies, our model projection lies between these two figures. Importantly, regardless of which method used, the degree of emissions reduction required for many of these economies are substantial.

Figure 27: Alternative methods to share the Global Carbon Budget



Source: PwC analysis

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 2008. Since it is cumulative global emissions that drive atmospheric CO_2 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 $GtCO_2$.

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:

- 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 2009 – 2025 in the 2008-based model. In both variants, the 2026-50 trend rates of decline would be the same.

- The rate of decline in energy intensity of GDP is set at 3% p.a. for all countries in 2026 – 2050 in both GG + CCS variants.

- Set country-specific rates of decline in energy intensity of GDP in 2001 – 2025 to give the same cumulative 2000 – 2050 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.

- 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.

Reference notes

1. There are some variations around the conversion of CO_2e to CO_2. 440-485 ppm CO_2 is consistent with 535-590 ppm CO_2e in the IPCC 2007 AR4 Synthesis Report.
2. Analysis of research by World Development Report 2010: Development and Climate Change and the World Energy Outlook 2009. WDR Chapter 4: Energizing Development without Compromising the Climate. Mitigation costs include additional capital investment costs, operation and maintenance costs, and fuel costs, compared to the baseline.
3. World Energy Outlook IEA, 2009
4. Carbon intensity is defined as the ratio of carbon emissions to GDP. By focusing on trends in carbon intensity rather than total carbon emissions we do not penalise fast-growing emerging economies such as China and India and we automatically adjust for fluctuations in GDP due to the economic cycle (including the current recession). Our report focuses on carbon emissions from energy use, 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.
5. The timing of the pathways clearly matters as well, see Appendix for details.
6. The World Energy Outlook (2009) estimated that the cumulative global CO_2 budget for 2000 – 2049 of 1.4 trillion tCO_2 will have moderate likelihood (50% probability) of keeping the global temperature increase below 2ºC. A 1 trillion tCO_2 budget will have a 75% probability.
7. It should be noted that these figures only relate to carbon emissions from energy use, however, and Brazil will also have a major role to play in reducing emissions from deforestation. The same applies to countries such as Indonesia, Canada and Russia.
8. Carrots and sticks: taxing and subsidising energy, IEA Economic Analysis Division, 2006, http://www.iea.org/papers/2006/oil_subsidies.pdf
9. Where direct data is not available, we have estimated the change relative to 1990 levels. Figures therefore may not be exact depending on measure of emissions and baselines.
10. South Korea is not an Annex 1 country, therefore not obliged to set binding targets, but is considered an OECD / developed economy.
11. Note that we have estimated the targets based on energy-related carbon emissions (i.e. assume the same percentage reduction for energy-related carbon emissions). In practice these targets may also include non-energy carbon emissions or other greenhouse gases.
12. Pacala S., and Socolow R.,Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies, August 2004, Science
13. Updated Annual Energy Outlook 2009 Reference Case Service Report, April 2009, and comparison of associated data tables (Carbon Dioxide Emissions by Sector and Source, Year-by-Year Updated Annual Energy Outlook 2009 Reference Case with ARRA Tables (2006-2030) vs. No stimulus case)

14. More recent proposals have not been analysed in depth, in terms of their impact on emissions or costs.
15. Other scenarios were also modelled by the EIA, including options with less offset allowances. These scenarios would imply higher level of domestic reduction and less reliance on international offsets.
16. Comparison of passenger vehicle fuel economy and greenhouse gas emission standards around the world, Pew Center on Global Climate Change, December 2004
17. American Wind Energy Association Annual Wind Industry Report, Year Ending 2008
18. Source: The China Greentech Report™ 2009, from the China Greentech Initiative of which PricewaterhouseCoopers China was a co-founding partner.
19. 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.

PwC Climate Change Services

PwC is a leader in climate change consulting, working with policy makers and companies since 1997 to analyse issues and develop practical solutions for our clients.

With an international network of over 200 professionals in climate change consulting, PwC offers a broad range of advisory, assurance and professional services that collectively guide clients through the complexities of climate change and emissions trading.

For more details about these climate change services, please visit our website (www.pwc.com/gx/en/climate-ready/index.jhtml)

PwC Economics Advisory

In addition to macroeconomic analysis of the kind contained in this report, our Economics practice provides a wide range of services covering competition and regulation issues, litigation support, bids and business cases, public policy and project appraisals, financial economics, brand economics, business forecasting and strategy.

For more details about these economics services, please visit our website (www.pwc.co.uk/economics)

Acknowledgements

The authors would like to thank the following for their contributions to the paper: Malcolm Preston, Paul Rawlinson, Jonathan Grant, Peter Collins, Rowena Mearley, Brian Bannister, Tim Ogier and Alex Baker.

Contact details

Leo Johnson
Partner, Sustainability and Climate Change

+44 (0) 20 7212 4147
leo.f.johnson@uk.pwc.com

John Hawksworth
Head of Macroeconomics

+44 (0) 20 7213 1650
john.c.hawksworth@uk.pwc.com

Richard Gledhill
Global Head of Climate Change

+44 (0) 20 7804 5026
richard.gledhill@uk.pwc.com

Lit Ping Low
Sustainability and Climate Change

+44 (0) 20 7804 0345
lit.ping.low@uk.pwc.com

www.pwc.co.uk

hb05396