

Too late for two degrees?

Low carbon economy
index 2012

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Foreword

It's time to plan for a warmer world. The annual Low Carbon Economy Index centres on one core statistic: the rate of change of global carbon intensity. This year we estimated that the required improvement in global carbon intensity to meet a 2°C warming target has risen to 5.1% a year, from now to 2050. We have passed a critical threshold – not once since World War 2 has the world achieved that rate of decarbonisation, but the task now confronting us is to achieve it for 39 consecutive years.

The 2011 rate of improvement in carbon intensity was 0.7%, giving an average rate of decarbonisation of 0.8% a year since 2000. If the world continues to decarbonise at the rate since the turn of the millenium, there will be an emissions gap of approximately 12 GtCO₂ by 2020, 30GtCO₂ by 2030 and nearly 70GtCO₂ by 2050, as compared to our 2-degree scenario.

Even doubling our current rate of decarbonisation, would still lead to emissions consistent with 6 degrees of warming by the end of the century. To give ourselves a more than 50% chance of avoiding 2 degrees will require a six-fold improvement in our rate of decarbonisation.

In the emerging markets, where the E7 are now emitting more than the G7, improvements in carbon intensity have largely stalled, with strong GDP growth closely coupled with rapid emissions growth. Meanwhile the policy context for carbon capture and storage (CCS) and nuclear, critical technologies for low carbon energy generation, remains uncertain. Government support for renewable energy technologies is also being scaled back. As negotiators convene every year to attempt to agree a global deal, carbon emissions continue to rise in most parts of the world.

Business leaders have been asking for clarity in political ambition on climate change. Now one thing is clear: businesses, governments and communities across the world need to plan for a warming world – not just 2°C, but 4°C, or even 6°C.



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Too late for two degrees?

The PwC Low Carbon Economy Index evaluates the rate of decarbonisation of the global economy that is needed to limit warming to 2°C. This is based on a carbon budget that would stabilise atmospheric carbon dioxide concentrations at 450 ppm and give a 50% probability of limiting warming to 2°C.

This report shows that global carbon intensity decreased between 2000 and 2011 by around 0.8% a year. In 2011, carbon intensity decreased by just 0.7%.

The global economy now needs to cut carbon intensity by 5.1% every year from now to 2050 to achieve this carbon budget. This required rate of decarbonisation has not been seen even in a single year since the mid-20th century when these records began. Keeping to the 2°C carbon budget will require unprecedented and sustained reductions over four decades.

Governments' ambitions to limit warming to 2°C appear highly unrealistic.

Stabilising atmospheric carbon dioxide concentrations at 450 ppm, according to broad scientific consensus, will give the world a 50% probability of limiting warming to 2°C above pre-industrial levels. The 2°C target was formally agreed at COP-15 at Copenhagen 2009. Governments have since agreed to launch a review in 2013 to consider strengthening the long-term goal to 1.5°C in Cancun.

We published the first Low Carbon Economy Index (LCEI) ahead of COP-15, to look at the progress of the G20 economies against a global carbon budget¹ necessary to stabilise atmospheric carbon dioxide concentrations at 450 ppm. We estimated a low carbon pathway for the 21st century for the global economy, which required the world to decarbonise at 3.7% a year to 2050.

This is the fourth edition of our Low Carbon Economy Index, and a stock-take of progress since the Copenhagen summit. The failure of the global economy to reduce carbon intensity beyond business-as-usual levels has magnified the low carbon challenge.

Since 2000, the rate of decarbonisation has averaged 0.8% globally, a fraction of the required reduction. From 2010 to 2011, global carbon intensity continued this trend, falling by just 0.7%. Because of this slow start, global carbon intensity now needs to be cut by an average of 5.1% a year from now to 2050.

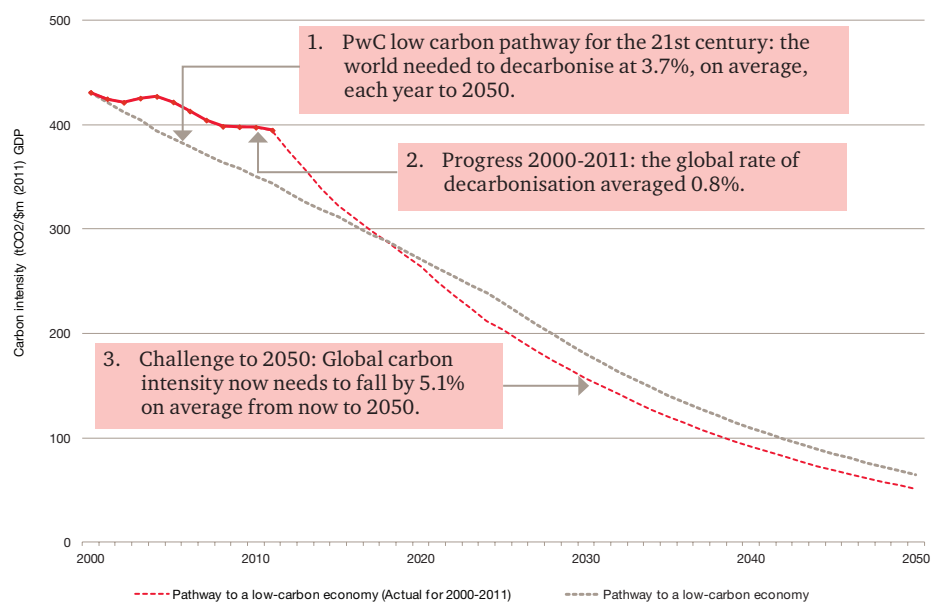
¹ See appendix for an explanation of how the carbon budget is derived.



This rate of reduction has not been achieved in any of the past 50 years. Even if it might be achievable in the longer term, it is unrealistic to expect that decarbonisation could be stepped up immediately – which means that the reduction required in future years is likely to be far greater than 5.1%.

Governments' ambitions to limit warning to 2°C now appear highly unrealistic. This new reality means that we must contemplate a much more challenging future. Whilst the negotiators continue to focus on 2°C, a growing number of scientists and other expert organisations are now projecting much more pessimistic scenarios for global temperatures. The International Energy Agency, for example, now considers 4°C and 6°C scenarios as well as 2°C in their latest analysis.

Figure 1: PwC's Low Carbon Economy Index* – Global



* We use the carbon intensity for countries as a measure of progress towards a low carbon economy. The carbon intensity of an economy is the emissions per unit of GDP and is affected by a country's fuel mix, its energy efficiency and the composition of the economy (i.e. extent of activity in carbon-intensive sectors).

Source: PwC's analysis, data from World Bank (2012) and BP Statistical Review (2012)



Progress in 2011

The pace of reducing global carbon intensity has been slow, despite the growing international focus on climate change. The financial crisis, which started in 2008, has dampened progress even further – carbon intensity has fallen less than 1% in these four years. Continued slow progress in 2011 means that our estimate of the required annual rate of decarbonisation to 2050 has increased to 5.1%, from 4.8% in last year's LCEI.

Total emissions from the E7 countries grew by 7.4% while those of the G7 economies fell by 2.0% in 2011¹. The E7 now emits more than the G7 countries, and further projected economic growth implies that emissions will continue the upward trend.

Developed countries

In the last year, major EU economies top our league table of countries with the highest rate of decarbonisation, with the **UK, Germany and France** all reducing carbon intensity by over 6% in 2010-2011. The irony is that a key reason for lower energy use was the milder winter in the region. Both UK and France also witnessed increased generation in low emissions nuclear power, whereas Germany's exit from nuclear is reflected in its relatively lesser decline in emissions.

Emissions in the **United States** fell by 1.9% in 2011. A mild winter helped, but the shift from coal towards shale gas in its fuel mix and more efficient vehicles on the road signalled that decarbonisation may continue.

At the bottom of the league table for 2011 is **Australia**, a region where climate change is projected to cause more frequent and severe extreme weather. The result reflects an anomalous 2010 rather than a structural shift; since 2000, Australia averaged 1.7% reduction in carbon intensity, on a par with other developed countries. Carbon intensity grew significantly in 2011 (6.7%), reversing the decarbonisation seen in 2010 (of 10.9%). Heavy rainfall in Australia boosted hydro generation and also disrupted mining operations in Queensland and impacted on the level of coal stocks at power stations. A return to normality in 2011 saw Australia's carbon intensity increase correspondingly, a large part of this due to the timing of the re-stocking of coal².

Emerging economies

In **China** and **India**, the reduction in carbon intensity seen in the last decade appears to have stalled. In both countries strong GDP growth was closely coupled with rapid emissions growth, despite commitments at Durban to significantly reduce carbon intensity by 2020 (40-45% for China and 20-25% for India respectively, relative to 2005 levels). Meanwhile **Indonesia** has managed to hold energy emissions broadly stable as its economy grew, with the resulting energy-related carbon intensity falling by 5.2% in 2011. Emissions from deforestation and land use change, which account for a large proportion of Indonesia's emissions, grew significantly in the last few years (see Box 1).

Production vs. consumption data

In line with the approach adopted by the UNFCCC³, the LCEI measures the source of carbon emissions, i.e. where emissions are produced, rather than 'consumed'. But it is important to remember that it is consumption that drives emissions and, indeed, many of the other sustainability challenges the world faces.

Many developed countries are increasingly outsourcing their manufacturing needs abroad, so on a consumption basis would report higher emissions. The emission levels of those emerging economies that provide a manufacturing base for the rest of the world would be adjusted downwards, if exports were fully accounted for.

1 Countries in the E7 group of emerging economies are: Brazil, Russia, India, China, Turkey, Indonesia and Mexico

2 Stocking and de-stocking of fossil fuels impacts the reported emissions data for some countries

3 United Nations Framework Convention on Climate Change

Figure 2: PwC's Low Carbon Economy Index – G20

Country	Change in energy-related emissions 2010-2011	Real GDP growth (PPP) 2010-2011	Carbon intensity (tCO2/2011\$m) 2010-2011	Change in carbon intensity 2010-2011		Annual average change in carbon intensity 2000-2011	Required annual decarbonisation rate 2012-2050
World	3.0%	3.7%	395	-0.7%	↘	-0.8%	-5.1%
France	-6.1%	1.7%	153	-7.7%	↘	-2.4%	-4.4%
UK	-6.4%	0.7%	209	-7.0%	↘	-2.8%	-5.2%
Germany	-3.6%	3.0%	235	-6.4%	↘	-2.2%	-5.2%
Indonesia	0.9%	6.5%	377	-5.2%	↘	-1.0%	-4.9%
EU	-3.6%	1.5%	213	-5.1%	↘	-2.3%	-5.2%
USA	-1.9%	1.7%	374	-3.5%	↘	-2.1%	-5.2%
Italy	-2.5%	0.4%	203	-2.9%	↘	-1.2%	-4.3%
Mexico	1.7%	3.9%	244	-2.1%	↘	-0.2%	-4.6%
South Africa	1.5%	3.1%	781	-1.6%	↘	-1.4%	-5.6%
Russia	2.9%	4.3%	510	-1.4%	↘	-3.9%	-6.0%
Brazil	1.7%	2.7%	197	-1.0%	↘	-0.7%	-4.1%
Argentina	7.9%	8.9%	242	-0.9%	↘	-1.6%	-5.0%
South Korea	2.9%	3.6%	464	-0.7%	↘	-1.0%	-6.5%
Canada	2.0%	2.5%	416	-0.4%	↘	-1.4%	-5.3%
Saudi Arabia	6.7%	6.8%	817	0.0%	→	1.9%	-7.0%
India	6.9%	6.9%	377	0.0%	→	-1.4%	-4.4%
Turkey	8.6%	8.5%	244	0.1%	↗	-0.5%	-5.0%
China	9.4%	9.1%	754	0.2%	↗	-1.4%	-6.1%
Japan	0.1%	-0.7%	281	0.8%	↗	-0.8%	-4.8%
Spain	2.2%	0.7%	211	1.5%	↗	-1.9%	-3.6%
Australia	8.7%	1.8%	415	6.7%	↗	-1.7%	-5.3%

Source: PwC's analysis, data from World Bank (2012) and BP Statistical Review (2012)

The low carbon challenge

Too much carbon, too little time

In the period leading up to the Copenhagen UN summit on climate change in 2009, major economies came forward and pledged carbon reduction targets for 2020. Analyses of those pledges suggest that they are collectively insufficient to meet a 2°C target. Even more worryingly, with eight years to go, it is questionable whether several of these pledges can be met.

Our calculations show the scale of the challenge, from now to 2020, for some of the largest developed economies. In some respects the economic downturn may make these absolute pledges less challenging¹; but at the same time economic pressures may make it much harder to finance the necessary transition towards a low carbon economy.

Figure 3: Major developed countries – pledges and the scale of challenge

Country	Pledge for 2020		Progress at 2011		Outstanding commitment	
	Pledge	Required fossil fuel emissions in 2020 (MtCO ₂ e)	Progress against pledge	Actual Fossil fuel emissions in 2011 (MtCO ₂ e)	Fall in emissions required from 2011 (MtCO ₂ e)	Emissions reduction is equivalent to ...
US	17% below 2005 levels	5,390	7% below 2005 levels	6,017	627	100% of coal power generation replaced by gas
EU-15	20% below 1990 levels	2,774	5.5% below 1990 levels	3,277	503	Removing all of UK's current emissions
Japan	25% below 1990 levels	873	12% below 1990 levels	1,307	435	Removing all industrial sector emissions
UK	34% below 1990 levels	391	18% below 1990 levels	511	101	All coal-fired power plants to shut down or use 100% biomass or be fitted with CCS.

Source: PwC analysis, pledges based on countries' announcement, data from BP Statistical Review

¹ This is in contrast to the intensity pledges that some emerging economies have made.

The challenge isn't necessarily easier for emerging economies – pledges to reduce carbon intensity mean curbing emissions at the same time as promoting rapid economic growth (see Figure 4). **China** and **India** are expected to nearly double the size of their economies by the end of the decade, but emissions must level off soon for them to meet their targets. The majority of any new energy demand will have to be met from renewable energy

or nuclear and not fossil fuel generation (unless this can be fitted with carbon capture and storage (CCS)). **Russia** and **Brazil** expect slower economic growth, but their emissions pledges imply a more drastic cut in carbon intensity than either China or India.

Figure 4: BRIC countries – pledges and the scale of challenge

Country	Pledge for 2020	Progress at 2011		Outstanding commitment		
		Progress against pledge	2011 total fossil fuel emissions (MtCO ₂ e)	GDP change projected 2011-2020 (%)	Emissions change required 2011-2020 (%)	Annual decarbonisation rate required (%)
China	40-45% below 2005 carbon intensity	17% below 2005 carbon intensity	8,979	92%	+12%	-4.5%
India	20-25% below 2005 carbon intensity	3% below 2005 carbon intensity	1,798	86%	+31%	-2.8%
Russia	15-25% below 1990 absolute emissions	5% below 1990 absolute emissions	1,675	38%	-19%	-5.8%
Brazil*	36-39% below BAU emissions	n/a	482	41%	-25%	-6.8%

* Brazil's emissions reported here are fossil fuel emissions only and do not include emissions from deforestation, which is the biggest source of emissions for the country – business-as-usual emissions are not estimated. See also Box 1.

Source: PwC analysis and projection are of GDP growth, pledges based on countries' announcement

The shale gas dilemma

The boom of shale gas in the United States that has helped pushed down emissions there has sparked a debate on the use of gas as a transition fuel to a low carbon economy. The development and widespread deployment of fracking technology in the US has lowered the price of natural gas and resulted in a fall in greenhouse gas emissions as it displaces coal in power generation (although some analysts have raised questions around the lifecycle emissions of shale gas). Despite concerns about the possible environmental impacts of fracking, a world-wide hunt for unconventional gas reserves had already begun – China, India, Canada, Mexico, Australia, Russia and Saudi Arabia are all known to have significant reserves.

Gas may buy some time much needed by the global climate system and help limit emissions growth – displacing coal with gas in power generation roughly halves carbon emissions. But low gas prices may also reduce the incentive for investment in lower-carbon nuclear power and renewable energy. Large scale renewables and low carbon technology such as CCS and nuclear will require significant amounts of political will, finance and time.

Our analysis suggests that at current rates of consumption, replacing 10% of global oil and coal consumption with gas could deliver a savings of around 1 GtCO₂e per year, or 3% of global energy emissions. A shift to gas away from oil and coal can provide temporary respite, a necessary but not sufficient move to the low carbon challenge.

At the same time, an over-reliance on gas, particularly in emerging economies expecting high energy demand growth, could lock in the dependence on fossil fuel. Avoiding lock-in will require discipline in governments that encourage gas generation, to ensure that incentives are not diverted away from renewable energy. To avoid stranding new gas generation assets, new investments should be CCS-ready, with at least space to retrofit CO₂ separation equipment and an agreed CO₂ transport solution and storage site.



Increasing degrees of risk

We estimate that the world economy now needs to reduce its carbon intensity by 5.1% every year to 2050 to have a fair chance of limiting warming to 2°C above pre-industrial levels. Even to have a reasonable prospect of getting to a 4°C scenario would imply nearly quadrupling the current rate of decarbonisation.

The decarbonisation rate required for a 2°C world has not been achieved in a single year since World War 2. The closest the world came to that rate of decarbonisation was during the severe recessions of the late 1970s/early 1980s (4.9% in 1981) and the late 1990s (4.2% in 1999). The expected reduction in emissions resulting from the current economic slowdown has not materialised, partly because of sustained growth in emerging markets. The observed relationship between economic growth and CO₂ emissions is also asymmetric – emissions tend to grow proportionally with economic growth, but fall by less than the rate of economic decline.

Regardless of the outcomes at the UN climate change summit in Doha this year, one thing is clear. Governments and businesses can no longer assume that a 2°C warming world is the default scenario. Any investment in long-term assets or infrastructure, particularly in coastal or low-lying regions needs to address more pessimistic scenarios. Sectors dependent on food, water, energy or ecosystem services need to scrutinise the resilience and viability of their supply chains. More carbon intensive sectors need to anticipate more invasive regulation and the possibility of stranded assets. And governments' support for vulnerable communities needs to consider more drastic actions.

The only way to avoid the pessimistic scenarios will be radical transformations in the ways the global economy currently functions: rapid uptake of renewable energy, sharp falls in fossil fuel use or massive deployment of carbon capture and storage, removal of industrial emissions and halting deforestation. This suggests a need for much more ambition and urgency on climate policy, at both the national and international level.

Either way, business-as-usual is not an option.

Figure 5: Implied concentration levels at different rates of decarbonisation

Average annual rate of global decarbonisation to 2050 (%)	Implied concentration levels, approximate* ppm CO ₂ e	IPCC 'best guess' of average global temperature increase above pre-industrial levels, rounded to nearest °C
1.6%	1,200 ppm	6°C
3.0%	750 ppm	4°C
4.5%	550 ppm	3°C
5.1%	450 ppm	2°C

Source: PwC analysis, IPCC AR4 WGI, Chapter 10, Table 10.8

* Note: This high-level analysis has rounded figures and made several simplifying assumptions, for example on carbon sinks, and ignored complex interactions in the carbon cycle (such as any feedback effects), consistent with the LCEI model described in Appendix 1. In table 10.8, the IPCC also provides the likely range of temperature outcomes at different CO₂ equivalent concentrations. The likely range of temperature increase is greater at higher concentrations.

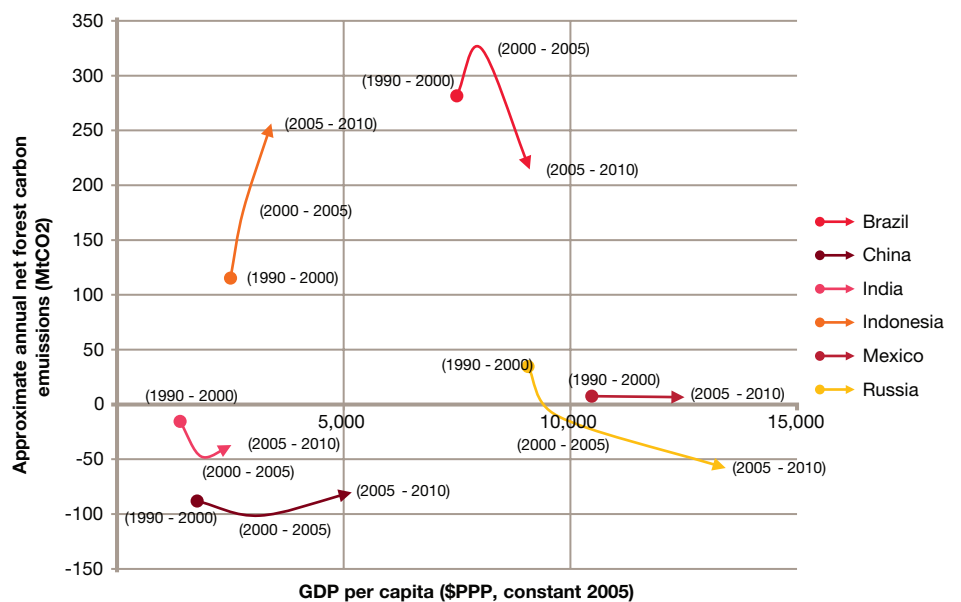
Box 1

Decoupling economic growth and deforestation emissions

Deforestation and land use change accounts for about 17% of global greenhouse gas (GHG) emissions, more than the entire global transportation sector and second only to the energy sector. The majority of these emissions stem from deforestation and forest degradation in tropical areas. Economic growth in tropical countries typically involves growth in primary sectors, such as agriculture, which are one of the main direct drivers of deforestation in the tropics.

A low carbon economy will therefore need to decouple economic growth from emissions from forestry. Figure 6 below provides an overview of the link between GDP per capita and net annual carbon emissions from forests¹ for tropical and non tropical countries with the largest forest carbon stocks in the G20.

Figure 6: The link between GDP per capita and net forest carbon emissions



Source: PwC analysis, FAO (2011), and World Bank (2012)

¹ Annual forest carbon emissions have been estimated using the annual net change in carbon stock in above-ground forest biomass. The lines are constructed by connecting three annual averages that represent three time intervals: 1990 – 2000, 2000 – 2005, and 2005 – 2010. The corresponding GDP per capita is calculated using the mean value for each of these periods.

Figure 6 reveals a number of interesting relationships between economic activity and forest emissions over time. Brazil has reduced its annual emissions from deforestation while increasing GDP. Russia also appears to have started to decouple economic growth from forest emissions. Whilst we need to be aware of the potential for emissions 'leakage', these appear to be positive trends.

This decoupling may be the reflection of several different factors, including:

1. Improvements in **forest governance**, improved **law enforcement**, and stronger **environmental regulation and policies**. For example in Brazil the legal protection of forests has recently been enhanced and law enforcement improved, which have lead to better regulation of the informal agriculture sector and improvements in forest management.

2. **Agricultural** intensification leading to increased productivity without the need for agricultural expansion on to forest land.
3. Agricultural expansion occurring on land that has been **previously degraded or non forested land** rather than on primary forest land.
4. **Reforestation** activities that lead to increased forest plantations and offset the emissions generated elsewhere through deforestation, whilst also increasing economic activity through job creation and revenue from timber sales.

Indonesia, however, has drastically increased its forest emissions between 1990 and 2010, whilst GDP per capita has increased only slightly. This has largely been due to the expansion of plantation crops (such as palm oil) and pulpwood production. The government will likely need to strengthen policies to reverse this trend if it is to meet its ambitious target of reducing greenhouse gas (GHG) emissions in 2020 by 26% from business-as-usual levels.

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Appendix

PwC LCEI Model

This section offers a summary of our model. More details are available in our first LCEI report, available [here](#).

The study contains energy and macroeconomic data from individual G20 economies, as well as world totals.

The G20 is portioned into three blocks:

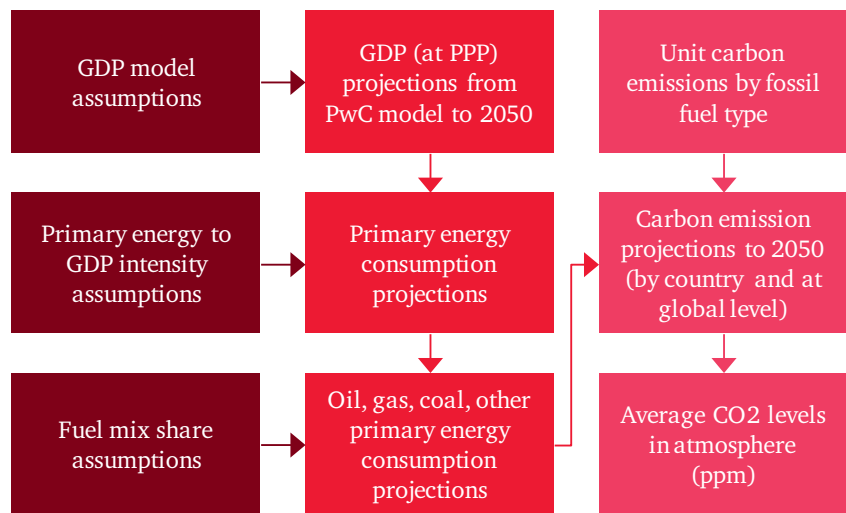
- G7 economies (US, Japan, Germany, UK, France, Italy, Canada).
- E7 economies which covers the BRICs (Brazil, Russia, India and China), and Indonesia, Mexico and Turkey.
- Other G20 (Australia, Korea, EU, South Africa, Saudi Arabia, Argentina).

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. In 2012, we have made two key changes to the assumptions in previous model versions:

- Delaying the start of commercial CCS at scale from 2016 to 2021.
- Updating country-specific rates of decline in energy intensity of GDP in 2001 – 2025 to better reflect relative historical progress between countries, and explicit policy targets in this area.

Summary

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

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

- Net annual CO₂ emissions from land use changes and forestry (LUCF) around 5.8GtCO₂ in 2008 declining to around 1.4GtCO₂ by 2020, and then at a slower rate to around just over – 4GtCO₂ by 2050. Current estimates on reducing emissions from deforestation and forest degradation (REDD) expect it to deliver around 5GtCO₂ emissions reduction by 2020.
- Global absorption capacity of the planet (oceans, forests etc.) is around 15 GtCO₂ per year 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. 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.

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