



Busting the carbon budget

Low Carbon Economy Index 2013

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Foreword

Last year's Low Carbon Economy Index (LCEI) had the title 'Too late for two degrees?'. In other words, the jury was still out. This year the question mark looks harder to justify.

For the fifth year running we have examined the rate of decarbonisation in the G20. And it's not good reading.

In 2008, when we first started the LCEI, we calculated that to maintain growth without exceeding two degrees of warming, the G20 needed to reduce its carbon intensity at 3.5% per year. Over the next four years the rate of decarbonisation failed to exceed 0.7%. By 2012, to make up for lost ground, the rate had risen to 5.1%, requiring a rate of decarbonisation never achieved in a single year to be sustained for the rest of the century.

This year the challenge has again increased. Our model shows we now need to reduce carbon intensity by 6% every year from now till 2100. This is over eight times our current rate of decarbonisation. Even doubling the current 0.7% rate of decarbonisation puts us on a path consistent with the most extreme scenario presented by the IPCC, and potential warming of around 4°C by 2100. On current trends we will use up this century's carbon budget by 2034 – sixty six years early. Put simply, we are busting the carbon budget.

There are three factors that add grounds for pessimism. First the IPCC's Fifth Assessment Report has further strengthened the scientific consensus linking anthropogenic carbon emissions to climate change. The World Bank, second, with its report 'Turn Down the Heat' has highlighted the social and economic costs of four degrees of warming. Third, a number of the technological silver bullets - the big bets banked on for heavy duty decarbonisation - appear to be failing.

Nuclear power, despite the UK's announcement of its first new plant in twenty years, is in retreat in Japan and Germany. The deployment of carbon capture and storage appears to have stalled, with no commercial scale projects integrating CCS with power generation. Shale gas has displaced coal in the US, but cheaper coal contributed to higher coal consumption in Europe last year. Our model shows that 92% of the small reduction in carbon intensity achieved last year is primarily down to one factor, improvements in energy efficiency. While this is positive, there is the possibility that incremental efficiency improvements will tail off once the low hanging fruit has been picked.

But there are also grounds for optimism. At the national level, countries like Brazil, France and Argentina present examples of economies with significantly lower carbon emissions per unit of GDP. China provides the example of using carbon pricing to underwrite risk and stimulate innovation in clean tech sectors. At the level of the city, a number of cities and councils globally have delivered high levels of decarbonisation while enhancing liveability. At the level of technology, finally, the costs of renewables continue to decrease and at an accelerating rate.

What would be a game-changer? One would be this. Six years after Copenhagen's COP-15, with renewables proving their capacity to reach cost parity, a global climate deal in 2015 could provide the regulatory framework and financial stimulus to catalyse a low carbon transition.

Leo Johnson

Partner

Sustainability and Climate Change, PwC

Busting the carbon budget by 2034

The PwC Low Carbon Economy Index calculates the rate of decarbonisation of the global economy that is needed to limit warming to 2°C. In 2013, the Intergovernmental Panel on Climate Change (IPCC) issued its Fifth Assessment Report, which includes a carbon budget for the remainder of this century giving a reasonable probability of limiting warming to 2°C.

This report shows that based on this carbon budget, the global economy needs to cut carbon intensity by 6.0% every year from now to 2100. This is a monumental challenge given current decarbonisation rates are only 0.7% a year. Even doubling this rate would lead to a scenario of over 4°C warming by 2100.

Our first Low Carbon Economy Index (LCEI) published in 2009, looked at the progress of the G20 economies against a 2°C global carbon budget. Our main premise is that current GDP is too carbon intensive. Unless economic growth is decoupled from carbon emissions we would face significant global warming which will have serious and far reaching implications.

This year is the fifth anniversary of our LCEI, and it has coincided with the September release of the IPCC Fifth Assessment Report (AR5), the most comprehensive review of climate science in six years. Historically, these Assessment Reports have provided significant markers in the development of international climate change policies. The first report, published in 1990, preceded the adoption of the UN Climate Change Convention. The Second Assessment Report galvanised efforts to adopt the Kyoto Protocol in 1997. The fourth in 2007 led to a commitment to agree a deal in Copenhagen two years later, and prompted many major emitters to pledge emission targets. Commentators are already speculating on the role of AR5 in shaping the negotiations of a robust deal in Paris in 2015.

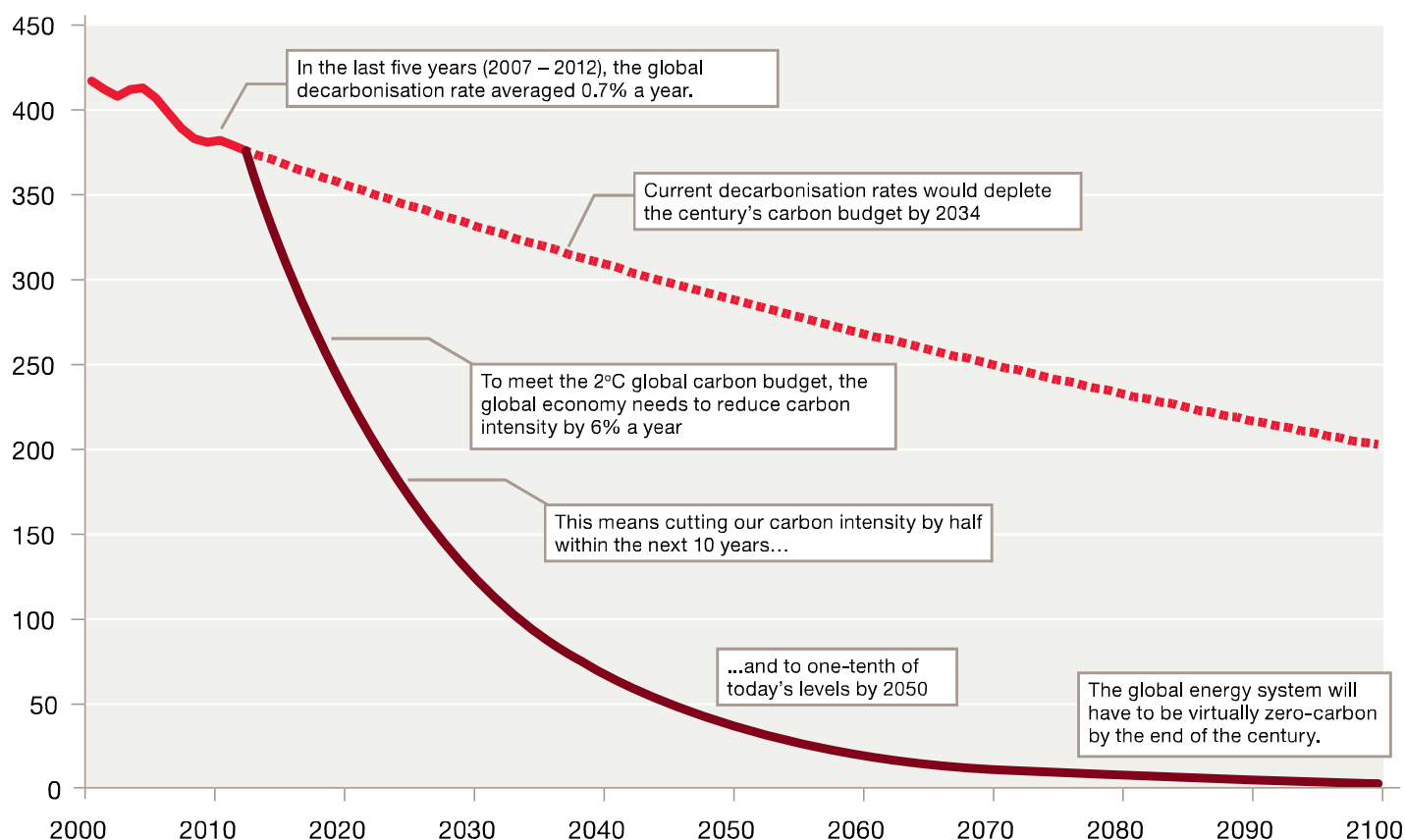
AR5 sets out four carbon budgets that correspond to different degrees of warming by the end of the 21st century. The current consensus target by governments, convened by the UN Framework Convention on Climate Change (UNFCCC), is to limit temperature increase to not more than 2°C. Based on the carbon budgets calculated by the IPCC, we re-examined our LCEI to evaluate the progress of the G20 economies in meeting this target. To meet the most conservative warming scenario (known as RCP2.6 in AR5), cumulative fossil fuel CO₂ emissions between now and 2100 needs to be around 270GtC (or around 990GtCO₂). This compares with total annual energy-related emissions of 32 GtCO₂ in 2012.

Based on current economic projections, ***the global economy would need to decarbonise by 6% a year, every year to 2100***, to stay within this carbon budget. This is equivalent to halving our carbon intensity within the next ten years, and reducing it to one-tenth of today's levels by 2050. The global energy system by the end of the century would have to be virtually zero-carbon.

This decarbonisation rate substantially exceeds the 0.7% achieved in the past five years, with policies and technology failing to decouple growth from carbon in the global economy. If the world continues at its current rate of decarbonisation, the carbon budget – which is for the period 2012 to 2100 – would be exhausted by 2034. We would have spent the carbon budget allocated for 89 years in less than a quarter of that time.

Pathway to a low-carbon economy

Figure 1: Carbon intensity (tCO₂/\$m2012)



Even doubling the current decarbonisation rate to 1.4%, gives projections close to RCP8.5, the most extreme scenario presented by the IPCC, and potential warming of around 4°C by 2100. The projections under this scenario suggest that significant adverse effects on humans and ecosystems are likely to occur through water stress, food security threats, coastal flooding from sea-level rise, ecosystem shifts and species extinction both on land and in the sea. The World Bank's 'Turning Down the Heat' report provides more detail on why this is a future we do not want.

Our model assumes long term modest economic growth in emerging and developing economies, and slow steady growth in developed economies. By 2050 the global economy is expected to be triple its size today and twelve times by 2100. Some economists now question whether this assumption of long term growth is reasonable and compatible with a future where we fail to limit and tackle climate change.

Table 1: Required decarbonisation rates for the IPCC scenarios

IPCC scenario (Representative Concentration Pathways)	Cumulative fossil fuel emissions 2012 – 2100 (GtC)	Required decarbonisation rates p.a. 2013 – 2100 (%)	Global mean surface temperature increase (°C) by end of century Mean ²
RCP2.6	270	6.0%	1.6
RCP4.5	780	3.0%	2.4
RCP6.0	1,060	2.3%	2.8
RCP8.5	1,685	1.4%	4.3

Dealing with the carbon deficit

The LCEI has been tracking the changes in the world's and the G20's carbon intensity since 2008, shortly after the publication of the last IPCC report (AR4). Despite warnings by scientists that climate change will bring unprecedented adverse impacts around the world, the growth of greenhouse gas emissions remains largely unabated.

In the LCEI 2012 we calculated that the global economy needed to reduce carbon intensity (the amount of carbon emissions per unit of GDP) by 5.1% a year to limit warming to 2°C. Three countries achieved this last year: the US, Australia and Indonesia. However, not a single G20 country has come close to sustaining this rate of decarbonisation over the five years since 2007.

The range of carbon intensity across the G20 suggests that there is tremendous scope for reductions. The most carbon intensive country, Saudi Arabia, has a carbon intensity five times that of France, which has the lowest carbon intensity. The contrast between the G7 and E7 economies is also striking. The G7 averaged a 2.3% reduction in carbon intensity last year, while the E7 – which includes much of the manufacturing base of the global economy – only managed 0.4%. The carbon intensity of the E7 is over 70% higher than the G7 average in 2012, reflecting how carbon emissions remain fundamentally the economic structure of a country.

Highlights of the IPCC Fifth Assessment Report

The IPCC report is the most authoritative review of the science of climate change we have ever had, with an intensive process of review and scrutiny of the findings. While there may be debate about some of the details, the main message of the report are straightforward: human influence on the global climate is clear; unchecked, it will have far reaching negative implications; and governments and business need to take action to address the potential risks. There are two more significant headlines.

The report addresses the so-called global warming 'pause' – the observation that the rate of warming has slowed since 1998. It notes that the multi-decadal trends are clear and that 'due to natural variability, trends based on short records are very sensitive to the beginning and end dates and do not in general reflect long-term climate trends'. In other words, picking 1998 (a very warm El Nino year) as the start of the 'pause' does not give a complete view of the warming trend in the last three decades. Using 1995, 1996 or 1997 as a start date gives results more consistent with the 30 year warming trend.

This is the first time that the IPCC has published carbon budgets associated with different emissions pathways – these are called Representative Concentration Pathways (or RCPs). The AR5 notes that total CO₂ emissions since the mid-19th century should not exceed 800 GtC to achieve the goal to limit warming to 2°C. Emissions by 2111 were approximately 531 GtC leaving a limited budget between now and 2100 to achieve that 2°C goal.

Other key messages include:

- Warming of the climate system is unequivocal, and since the 1950s many of the observed changes are unprecedented over decades to millennia.
- The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, the sea level has risen, and the concentrations of greenhouse gases have increased.
- Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010.
- Human influence on the climate system is clear. This is evident from the increasing greenhouse gas

concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system.

- Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system.
- Global surface temperature change by the end of the 21st century is likely to exceed 1.5°C relative to 1850 to 1900 for all RCP scenarios except RCP2.6. It is likely to exceed 2°C for RCP6.0 and RCP8.5, and more likely than not to exceed 2°C for RCP4.5.
- Warming will continue beyond 2100 under all RCP scenarios except RCP2.6.
- Cumulative emissions of CO₂ largely determine global mean surface warming by the late 21st century and beyond. Most aspects of climate change will persist for many centuries even if emissions of CO₂ are stopped. This represents a substantial multi-century climate change commitment created by past, present and future emissions of CO₂.

The full AR5 science report can be downloaded at <http://www.ipcc.ch/>

Table 2: Low Carbon Economy Index – country summary

Country	2011-2012				Five year trend	
	Change in energy related emissions	Real GDP growth (PPP)	Carbon Intensity (tCO2/2012\$m)	Change in carbon intensity	Annual average change in carbon intensity	Average Change in GDP
	2011-2012	2011-2012	2012	2011-12	2007-2012	2007-2012
World	2.2%	2.9%	376	-0.8%	-0.7%	2.7%
G7	-1.3%	1.4%	291	-2.7%	-2.3%	0.3%
E7	5.1%	5.2%	498	-0.1%	-0.4%	6.1%
US	-3.8%	2.2%	341	-5.9%	-3.1%	0.6%
Australia	-2.1%	3.4%	366	-5.3%	-3.0%	2.7%
Indonesia	0.9%	6.2%	382	-5.0%	-1.4%	5.9%
Russia	-0.2%	3.4%	467	-3.5%	-1.2%	1.8%
Italy	-5.8%	-2.4%	186	-3.5%	-2.4%	-1.4%
Turkey	-1.1%	2.2%	219	-3.3%	-1.4%	3.1%
Canada	-0.7%	1.7%	387	-2.3%	-1.8%	1.1%
South Africa	1.1%	2.6%	726	-1.5%	-2.0%	2.1%
China	6.3%	7.8%	703	-1.4%	-1.9%	9.3%
EU	-1.4%	-0.3%	218	-1.1%	-2.1%	-0.2%
South Korea	1.3%	2.0%	468	-0.8%	0.6%	2.9%
Argentina	3.2%	3.7%	221	-0.5%	-3.3%	5.8%
Mexico	4.5%	3.9%	228	0.6%	0.4%	1.6%
France	0.7%	0.0%	149	0.7%	-2.3%	0.1%
Germany	1.6%	0.7%	227	0.9%	-1.7%	0.7%
Saudi Arabia	6.6%	5.6%	752	1.0%	1.7%	4.2%
Brazil	2.9%	0.9%	185	2.1%	0.8%	3.2%
UK	2.6%	0.3%	211	2.4%	-1.7%	-0.4%
India	7.3%	3.2%	361	3.9%	-0.1%	6.5%
Japan	6.9%	1.9%	296	4.9%	0.2%	-0.2%

Unimplemented wedges

The International Energy Agency (IEA) and others have identified three broad technology ‘wedges’ to reduce energy-related emissions:

- Energy efficiency improvements: for example in power generation and energy end-use
- Shift towards lower carbon power generation: for example coal to gas, use of biofuels, renewable energy and nuclear
- Carbon capture and storage

Progress in implementing these technology wedges in the G20 has been limited and rarely sustained.

Energy efficiency: A bright spot

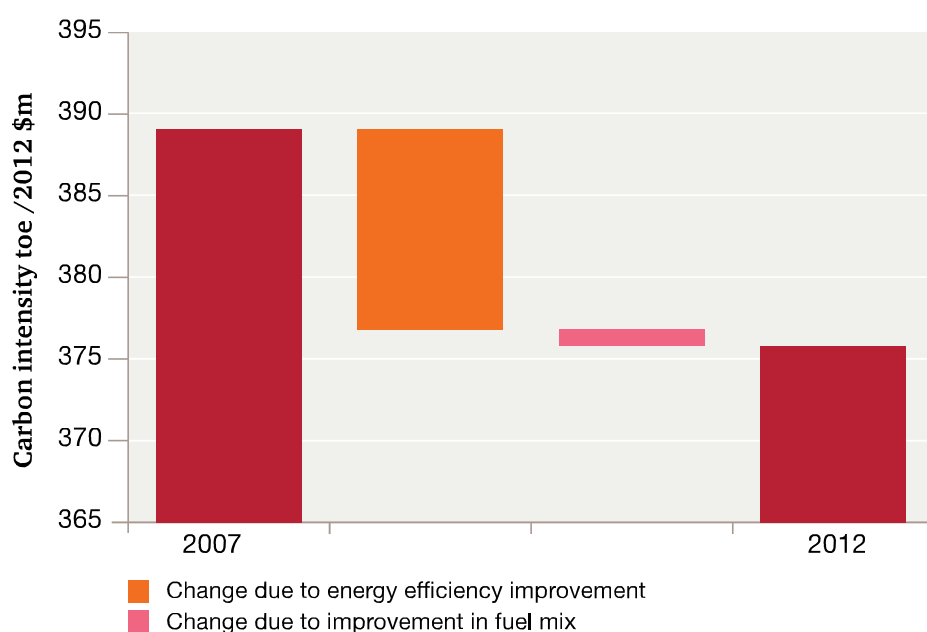
Globally, almost all of the change in carbon intensity can be attributed to improvements in energy efficiency. W

ly 8% through a shift towards cleaner energy mix.

Italy, the **UK** and **Turkey** are the most energy efficient economies in the G20 league, each consuming less than 90 toe of energy for every \$m of GDP generated. In terms of rate of efficiency improvement, the leaders since 2007 are **Argentina** (3.7% a year), **Australia** (2.5% a year) and the **US** (2.0% a year). Argentina’s improvement in carbon efficiency is because its increase in GDP is partly the result of a substantial increase in the value of its agricultural exports – particularly soya – rather than energy-based activities. Recent changes in rainfall patterns in the country has resulted in falling hydro power output since 2007, and so all the increase in electricity demand has been met with thermal generation.

Raising energy efficiency is essential to reduce dependency on carbon; however efficiency measures typically result in a rebound and there is a limit to which we can cut energy use per unit of GDP. These measures are also typically the lower cost options for carbon abatement (such as behaviour changes), suggesting that further efficiency options (such as combined heat and power) are likely to require greater cost and incentives. Nevertheless, while several larger emerging economies were able to increase efficiency – **South Africa** averaged 1.9% a year, and **Indonesia** managed 1.6% a year – there is still scope for improvements in most emerging economies. The energy intensity (energy consumed per unit of GDP) of E7 economies remains more than one-third higher than G7 economies.

Figure 2: Causes of change in global carbon intensity



Source: PwC analysis

Energy mix: still carbon-intensive

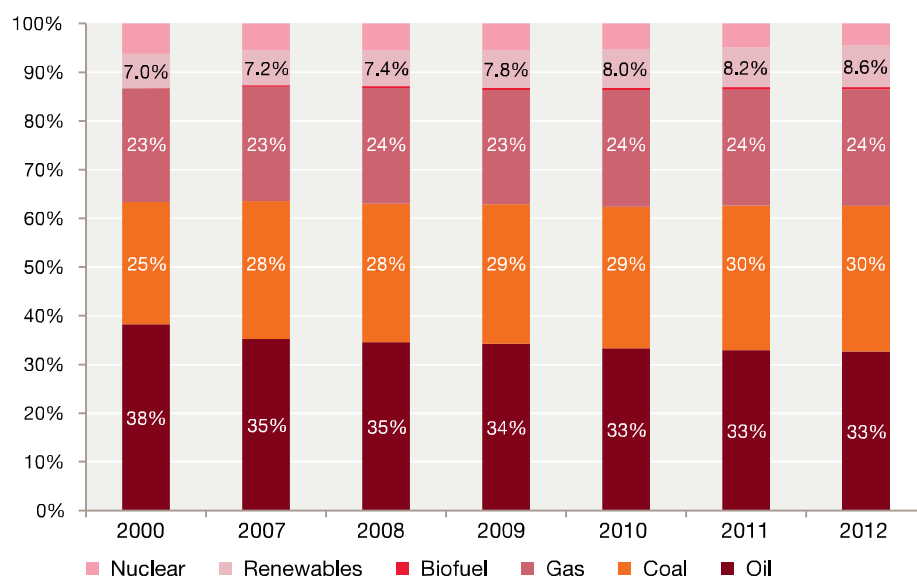
The amount of CO₂ emitted for each unit of energy consumed fluctuated but broadly remained at approximately 2.6 tCO₂ per toe in the last five years. Even as we become less dependent on oil for energy, the global fuel mix is dominated by fossil fuels, and coal in particular has experienced an increase in its use (see Figure 3). The use of fracking to commercialise previously inaccessible resources has prompted hype around the world about the potential of shale gas as a low cost, clean burning and lower carbon fuel. In 2011, the IEA asked if the world is entering a 'golden age of gas'. The reality is that, so far, the shale revolution is mainly confined to the United States. Abundant shale gas has lowered energy prices, supported job creation and the switch away from coal for power generation. This explains much of the impressive decarbonisation in the United States in recent years. However, fracking has not yet had a global impact on the energy mix. In fact natural gas has remained at roughly a quarter of the global energy mix since 2000. Although investment in renewables has increased dramatically since 2000 its share of the global energy mix has risen from only 7.2% in 2007 to 8.6% in 2012.

The shale movement failed to shift coal to gas

The **United States** topped the G20 table this year, with a decarbonisation rate of 5.9%, as the shale gas boom helped to cut energy-related carbon emissions. The proportion of natural gas in electricity generation⁵ in the US has increased from 25% to 30%, matched by a fall in coal-fired electricity generation from 42% to 37%.

While carbon emissions fell in the US, the availability of cheap natural gas there depressed coal prices and raised coal consumption elsewhere. A triple whammy in the EU of low coal prices,

Figure 3: Change in global energy mix since 2000



Source: PwC analysis

low carbon prices and the impending shut-down of older carbon intensive power generation plants triggered by the EU Large Combustion Plant Directive (LCPD) has led to a steep increase in coal use. The Northwest Europe coal marker price⁶ decreased from an average price of \$121 per tonne in 2011 to \$92 per tonne in 2012. Carbon prices fell below three euros this year compared with over €17 two years earlier. Combined with the EU LCPD, which limits carbon intensive power generation plants above 50MWh to 20,000 operating hours until 2015 when they must shut down, older power plants are using up all their operating hours with the cheapest fuel source. The **UK**, for example, saw an increase of its electricity produced by coal⁷ from 30% in 2011 to 39% in 2012; with an equivalent reduction in gas from 40% to 28%.

While the effect of LCPD on the EU may be temporary, it is less clear that low coal and carbon prices can be reversed without significant policy intervention. In 2012, the European Commission first proposed a plan to delay auctions of some carbon permits issued by the EU Emissions Trading Scheme (EU-ETS),

also known as 'backloading', to help boost low carbon prices. The backloading proposal was still being debated at the time of writing, as were broader structural reforms that the EU ETS urgently requires to provide adequate incentives to invest in low carbon technologies.

Biofuels consumption largely confined to the Americas

The **US** and **Brazil** continue to be the largest producers of ethanol and biodiesel. Biofuels accounted for 1.2% of US total energy demand and 4.2% of Brazil's total energy demand. Nearly all gasoline in the US was blended with 10% ethanol by 2011, which is the maximum blend level approved by the Environmental Protection Agency for cars and light trucks⁸. Oil demand in the US has fallen since 2007, due to a combination of economic recession leading to fewer miles driven, tighter CAFE standards and biofuel use.

In Brazil, demand for biofuels continues to be supported by mandated percentage of ethanol blended with gasoline (20% in 2012, rising to 25% by the 2013) as well as demand from the US⁹.

Slow rise in renewable energy but reliance on fossil fuels unchanged

China has nearly tripled coal consumption since 2000, with an over 40% increase since 2007. However China also accounted for two-thirds of the increase in renewable energy consumption since 2007. China surpassed the US in 2012 with the largest investments in renewable energy in 2012, pouring \$67bn into the sector primarily in solar¹⁰. Its own carbon intensity has fallen by an average of 1.9% a year, compared to the world's 0.7%. China also ranks third in the growth in renewable energy consumption in the G20 economies, at 25% from 2011 to 2012.

Other countries which had high growth in renewable energy consumption (not including hydro) in the last year include **Italy** (30%), the **UK** (29%), **Brazil** (25%), **Australia** (24%) and **France** (23%). The Australian experience was particularly notable because the growth coincided with the introduction of a carbon price, suggesting that creating market incentives can have a material impact. Solar energy output nearly doubled, and both wind and hydro generation increased by more than 15% over the year. As China introduces its first pilot emission trading scheme, it remains to be seen whether carbon pricing will drive more significant levels of decarbonisation.

India has seen its oil consumption fall from 33% of the energy mix in 2007 to 30% in 2012, but this has been offset by an increase in coal consumption (50% to 53% over the same time frame). The share of renewable energy remained largely unchanged – India's new investments in renewable energy halved in 2012 compared to the peak in 2011 (f¹¹). Notably, India's rate of investments in renewable energy has fallen behind other Asian economies: in 2007 China invested 2.5 times more in renewable energy than India; by 2012 China's investment was ten times greater than India's. At its peak in 2011, India increased renewable energy investments by 136% compared

Will carbon pricing help the world's largest emitter?

In June 2013, China launched the Shenzhen Emissions Trading Scheme (ETS), its first of seven pilot emission trading programmes (other schemes will cover Guangdong, Hubei, Beijing, Tianjin, Shanghai and Chongqing). The Shenzhen ETS will cover over 600 industrial companies from 26 industries. This is a strong signal that the country will put a price on carbon emissions, which has traditionally relied on more administrative measures rather than market based incentives.

The Shenzhen scheme gives participants 100 mtCO₂ of emission allowances over the next three years, but the cap is set using carbon intensity rather than in absolute terms, which the government will review and adjust annually. If the companies are limited to the current allocation, this would be equal to roughly a 30% reduction in emission intensity.

The Shenzhen scheme thus far has shown healthy signs of activity, with the price of a carbon credit rising from 30 RMB/tonne (4.86 USD/tonne) in June 2013, to over 68 RMB/tonne (11.03 USD/tonne) in October.

to 2007, the rest of Asia-Oceania (excluding China) saw an increase of 167%¹².

As a region, Europe invested as much as the US, China and India combined into renewable energy throughout 2008-2012, and the **EU** continues to dominate the global share of solar PV capacity, generating 28 TWh in 2012, almost double the 2011 output and accounting for 0.8% of total energy demand. **Italy** had the largest proportion of total electricity generation from solar PV in 2012, 5.6% as compared to 4.8% in Germany¹³; this has contributed to Italy achieving the greatest reduction in carbon intensity in the EU. Despite the levels of investment, however, the share of renewable energy remains below 10% of total energy mix in the EU.

Many other countries in the G20 showed signs of increasing use of renewable energy: from **Turkey** to **South Korea** and **Argentina**, the share of renewables in energy consumption has risen. However the reliance on fossil fuel based generation remains. For example in Argentina carbon intensity fell by its slowest ever since 2007, as the growing local demand for energy has been largely met by increases in thermal power generation. Overall, renewables remain a small part of the global energy

mix – rising to 8.6% last year from 7.0% in 2000 – despite the double digit growth seen in many countries.

Nuclear loses ground after Fukushima

The Fukushima disaster in **Japan** led to all of their atomic reactors closing down and a shift back to more emissions intensive fossil fuel electricity generation. This has placed Japan at the bottom of the decarbonisation table.

Germany, also suffered a loss of confidence in nuclear, shutting down 8 out of 17 nuclear power plants by end of 2011 and reducing the nuclear proportion of their electricity production¹⁴ from 17.6% in 2011 to 15.8% in 2012, while electricity generation from brown and hard coal increased from 42.8% to 44.2%. Current policies plan for the remaining nuclear plants is to be phased out by 2022.

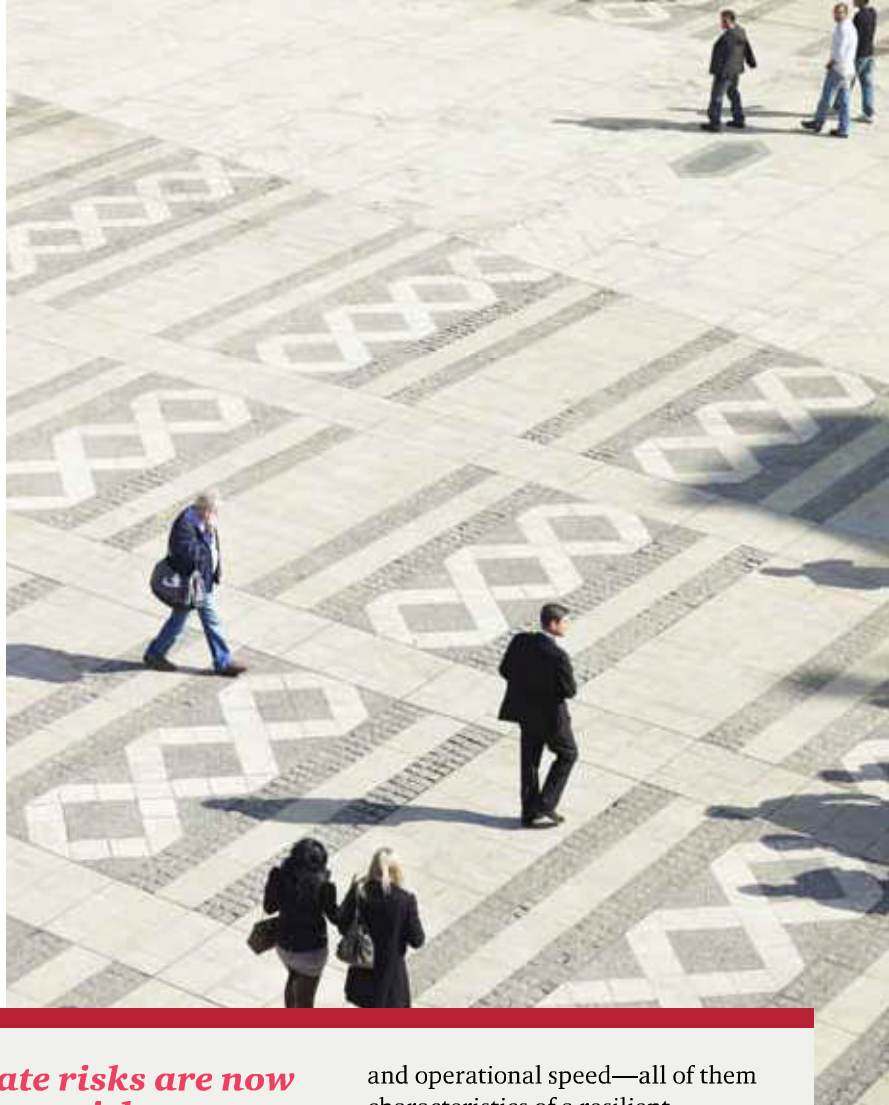
On the other end of the spectrum, however, **France** continues to be at the top of the G20 table in terms of absolute carbon intensity because of its successful nuclear programme, which accounts for over 75% of its electricity generation¹⁵. However, it is unlikely that going nuclear, like France, is a realistic option for many other countries.

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ligible progress with the deployment of CCS technology. The number of operational CCS projects has not changed since 2011: 7 industrial plants were capturing approximately 24 mtCO₂ per year. However the number of plants under construction grew in 2012, and when operational they could increase the global capture capacity by 50%¹⁶. A fundamental issue is the lack of progress of CCS projects integrated with power generation. Most existing CCS projects are associated with natural gas processing, hydrogen production and fertiliser production.

More than three quarters of CCS projects in operation or under construction are located in the **US** and **Canada**. This includes the first two power generation, large scale CCS plants under construction in the US, which are due to become operational in 2014. The **EU** contribution to CCS development has been slower than anticipated. The European Commission's NER300 competition aimed to fund several CCS projects but none was successful in the first round due to lack of support by the member states concerned or funding gaps. The **UK's** Department of Energy and Climate Change announced support for two projects that would capture 4.5 million tonnes of CO₂ per year from power plants.

The limited progress in CCS is cause for concern. It represents, currently, the most promising option to allow fossil fuels to be continually used as a source of energy without releasing carbon emissions into the atmosphere. Without rapid deployment of this technology, and with no signs of reduction in the use of fossil fuels, there is a limit to how much carbon emissions can be abated in the short run.



Climate risks are now business risks

The CEOs of global corporations typically don't focus on one IPCC climate scenario or another. They comment that their top issues are growth, costs, resilience and reputation – climate change will impact each of these.

PwC's reports for CDP this year show that some companies have a sophisticated and long term response to climate risk and are evaluating the potential impacts of climate change on their operations, customers and supply chain. Others have a shorter term and narrower horizon.

Active management of climate change is now a necessary component of continued viability and success, and business transformation lies at the core. The transformation process experienced by companies managing climate change goes beyond strategic targets and investments to reduce emissions. Preparedness, adaptability,

and operational speed—all of them characteristics of a resilient organization—mark the adaptation of business models designed to gain competitive advantage and to protect infrastructure, customers, and supply chains.

Through the day-to-day course of running a business and managing risk, companies are identifying climate-related threats to the existing model, implementing solutions to mitigate immediate risk, and creating adaptation strategies for unknown future hazards. At the same time, management is looking at climate change with a competitive mind-set and finding opportunities to enable the creation of value both within the enterprise and at large. The drive to produce decision-useful data is enabling companies to better understand and communicate the impact, likelihood, time horizon, and financial implications of taking action on climate change.

Source: CDP & PwC: Investment, transformation and leadership – CDP S&P 500 Climate Change Report 2013

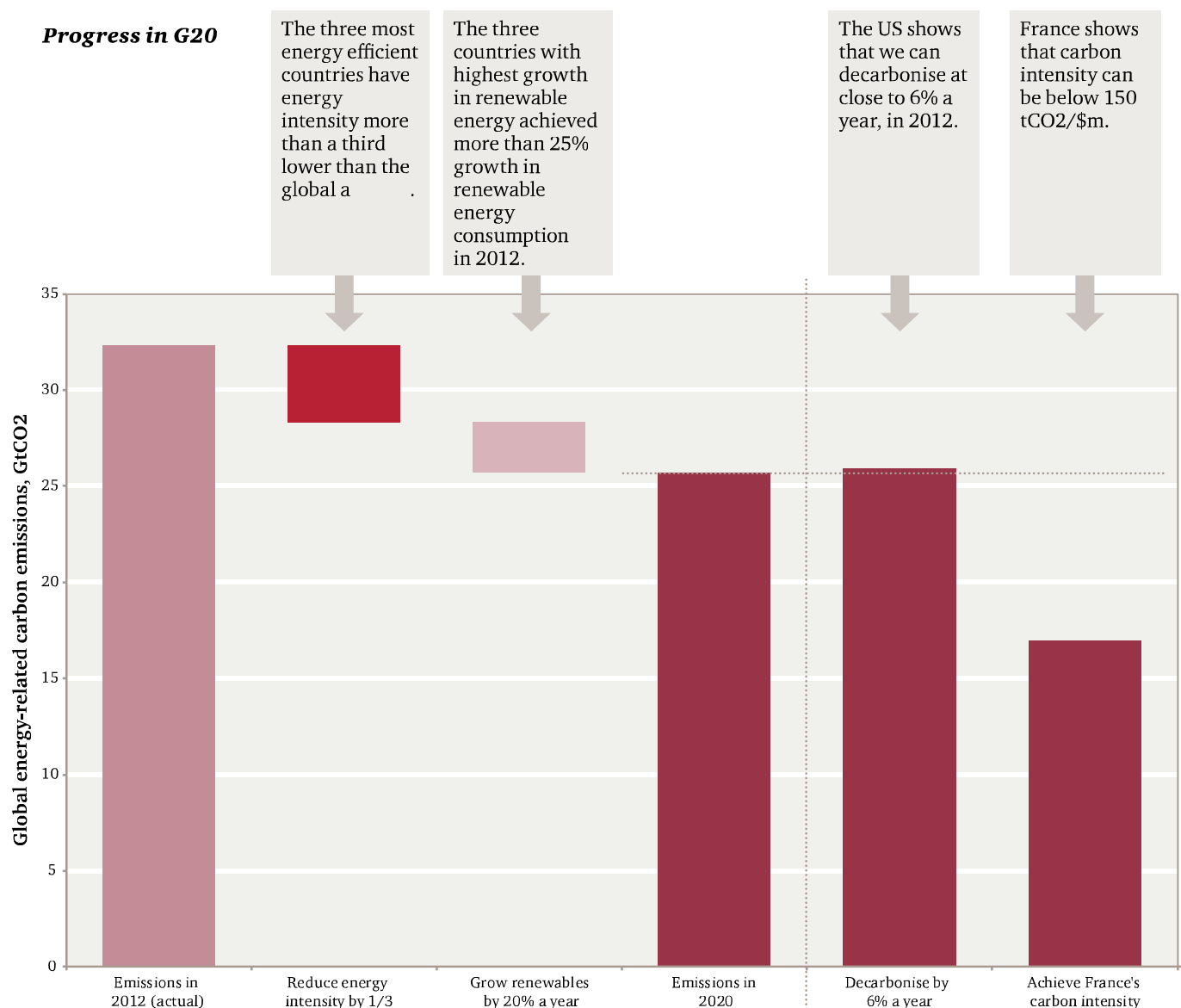
Improbable, but possible?

Last year, our report questioned whether the global economy was too late in trying to limit warming to 2°C. The implied decarbonisation rate that the global economy needed to achieve was unprecedented since the mid-20th century when comprehensive energy and GDP records began. For the fifth year running, with new information from the IPCC on the size of the global carbon budget, we find that the required decarbonisation rate is higher than ever before, at 6.0% per annum between now and 2100. The technological shifts that need to happen have not materialised. The window to act is shorter, and the scale of challenge larger.

The data is sobering but there are several examples which show that rapid decarbonisation and a low carbon economy is possible. We studied these pockets of national progress at the global level to see if it might be possible to achieve the global 6% decarbonisation target.

The exercise showed that if the global economy can emulate the respective leaders on energy efficiency and renewable energy, it is still possible to achieve around 6% of decarbonisation a year to 2020 with concerted and sustained actions.

Figure 4: What if we match signs of progress globally?



But with rising energy demand, there is a zero-sum game in our use of the carbon budget. The experience with the shale gas boom contributing to coal price falls demonstrated that a good news story for one economy and the environment does not necessarily translate globally. Key manufacturing countries have good reasons to be concerned about carbon leakage as a result of the imposition of strict regulations. A globalised, agile market means that carbon emissions will find ways into the atmosphere through paths of least resistance, whether it is in a more relaxed regulatory environment or through the interaction of commodity prices. Fossil fuel reserves remain vast, and the carbon is currently more valuable out of the ground than under it. Fracking technology has just increased the amount of carbon we have access to. CCS is needed at scale if fossil fuels extraction is to continue.

To keep carbon emissions within this budget globally we will need much greater investment in energy efficiency, renewables, nuclear power and carbon capture and storage. We will also have to tackle emissions from deforestation and land use. Putting a price on carbon is important to internalise the issue for businesses.

Crucial is the collective will to act. A low carbon transition will not be possible without support from consumers, investors and voters. Governments have until the end of 2015 to seal a global deal on climate change. That deal will form the central piece in the jigsaw and allow the other pieces to come together. Like AR4, the latest IPCC publication sets high expectations for a global deal on climate change. Avoiding a Copenhagen déjà vu will determine our chances of changing our global emissions pathway.



Appendix: Updates to PwC's LCEI model

In summary, the LCEI model considers energy-related carbon emissions, driven by a series of assumptions including the economic growth projections, primary energy intensity and fuel mix share. The model covers energy and macroeconomic data from individual G20 economies, as well as world totals. Details of our model structure are available in our first LCEI report, accessible at the link www.pwc.com/gx/en/low-carbon-economy-index/assets/low-carbon-economy-index.pdf. This appendix provides a summary of changes in this year's LCEI model.

This year, in response to the publication of the Working Group 1 contribution to the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5 WG1), the LCEI model has been updated to reflect the carbon budgets presented by IPCC. The AR5 WG1 presented four carbon budgets associated with different concentration pathways (known as Representative Concentration Pathways or RCP's) that lead to different warming outcomes by the end of the 21st century. The LCEI model has adopted the carbon budget associated with RCP2.6 as the core scenario of a low carbon economy and one which gives the greatest probability of limiting warming to 2°C.

This represents a different approach in interpreting the carbon budgets used in previous years. Findings from the AR4 suggested that limiting concentration levels to 450ppm will lead to a 'fair chance' (50%) of limiting warming to 2°C. The LCEI up to 2012 used the 450ppm metric as the basis of our carbon budget. In AR5 WG1, scientists have medium confidence that we are 'unlikely' (<33%) to exceed 2°C by 2100 under the RCP2.6 scenario. The carbon budget

used in this year's LCEI, in keeping with the scientific consensus, corresponds to a marginally higher probability in terms of limiting warming, and the benchmarking of performance across the two years is not exact. The total budget we use for the period 2000-2100 in LCEI 2012 is 1,700 GtCO₂ compared with 1,300 GtCO₂ this year (or 990GtCO₂ from 2012-2100 based on RCP2.6). This explains some of the revision of the decarbonisation rate from 5.1% to 6.0%.

In the 2012 report (p9), we presented the decarbonisation rates required to achieve different concentration levels (in parts per million) based on AR4, w

t levels of temperature increase above pre-industrial levels. These levels of temperature increase were considered equilibrium levels, after temperatures have stabilised, and the time period over which this happens could be beyond the 21st century. This year, again aligned with the IPCC, levels of temperature increase are reported for the end of the 21st century. We have also changed our reporting of results to decarbonisation rates to 2100 for consistency. We have opted to report one 'average' decarbonisation rate to 2100 though in practice, short term decarbonisation rates can vary (see AR5 WG1 for an explanation of how the cumulative carbon budget affects the climate).

We have also made other minor revisions in response to data updates by our sources (our two main sources are BP statistical review 2013 and World Development Indicators 2013). These proved to be immaterial in forming our conclusions in previous LCEI reports. These minor revisions are immaterial in comparing our conclusions this year with previous LCEI reports.

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We have maintained the 2°C target in developing the LCEI but highlight a difference in interpreting the carbon budgets used in previous years affecting inter-year levels to 450ppm will lead to a ‘fair chance’ (50%) of limiting warming to 2°C. The LCEI up to 2012 used the 450ppm metric as the basis of our carbon budget. In AR5, scientists have medium confidence that that we are unlikely (<33%) to exceed 2°C by 2100 under the RCP2.6 scenario. The carbon budget used in this year’s LCEI, in keeping with the scientific consensus, corresponds to a marginally higher probability in terms of limiting warming. Given the different carbon budgets used, the decarbonisation rate in this year’s LCEI is not directly comparable with our previous reports.

1. The IPCC presents surface temperature increases for each of the four scenarios relative to 1986-2005, and noted that temperature change from 1986-2005 since 1850-1900 0.61°C. These figures take these into account and therefore reflect temperature increases relative to pre-industrial levels.
2. Our emissions data covers energy use only and does not capture the possible impact of deforestation and other land use related emissions following the increase in agricultural production.
3. The IEA has lower estimates, at around 2.4 tCO₂ per toe. See <http://www.iea.org/etp/tracking/esci/> for their figures.
4. Source: EIA.
5. Source: Statistical Review of World Energy 2013, BP.
6. Source: Digest of United Kingdom Energy Statistics 2013, DECC https://www.gov.uk/uploads/system/uploads/attachment_data/file/225067/UKES_2013_published_version.pdf.
7. Biofuels markets face blending constraints and other challenges, October 2012, EIA.
8. Brazil sugar, ethanol exports at peaks, Jan 2013, Reuters.
9. Global Trends in Renewable Energy Investment 2013, Bloomberg New Energy Finance.
10. Ibid.
11. Estimated from Global Trends in Renewable Energy Investment 2013.
12. Renewables 2013 Global Status Report, REN21.
13. Source: Gross electricity production in Germany from 2010 to 2012, accessed October 2013, Destatis, <https://www.destatis.de/EN/EconomicSectors/Energy/Production/Tables/GrossElectricityProduction.html>.
14. Nuclear Power in France, accessed October 2013, World Nuclear Association.
15. Global CCS Institute.

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