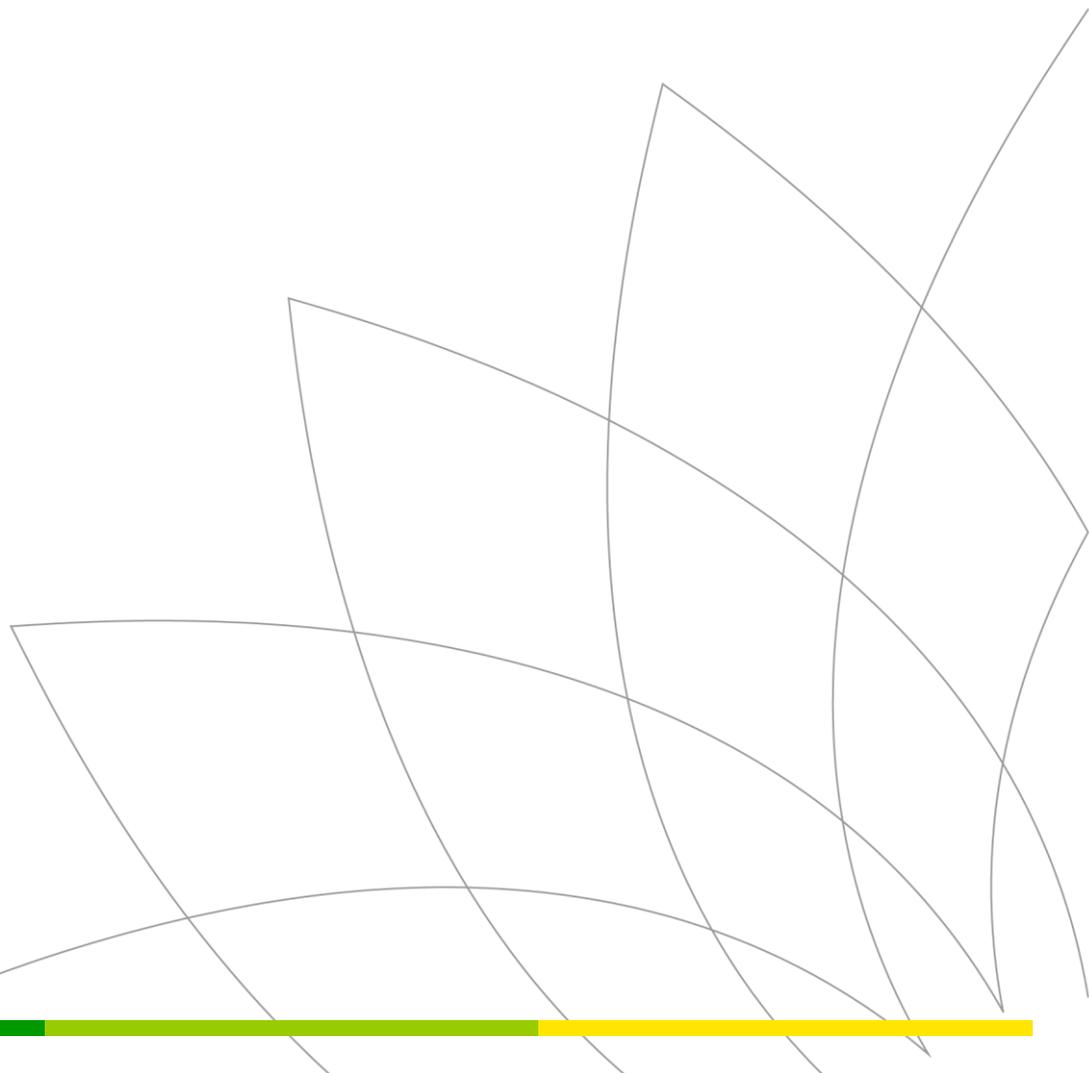




Energy in 2018: an unsustainable path

Spencer Dale
Group chief economist

London
11 June 2019



1. Introduction

This is the 68th edition of the Stats Review.

As I have travelled around the world with BP over the past few years, I have come to appreciate the esteem in which the Statistical Review is held.

One of the most tangible examples of this is when executives or officials in different parts of the world pull me towards their bookshelves to show me a set of Stats Review booklets going back the past 20 or 30 years.

At first I was a little perplexed by this: why keep a copy of last year's Stats Review once a new updated Review and dataset have been published.

Even more so, given that all the data are available online.

But I came to realise that the commentary that's also included in the Stats Review provides a snapshot of the issues dominating the industry in that year.

It's a bit like those birthday cards which reproduce newspaper headlines from the year in which the person was born. They jolt your memory of different events.

As well as the raw data, the Stats Review provides a record of key energy developments and events of the day.

My guess is that when our successors look back at Statistical Reviews from around this period, they will observe a world in which there was growing societal awareness and demands for urgent action on climate change, but where the actual energy data continued to move stubbornly in the wrong direction.

A growing mismatch between hopes and reality.

In that context, I fear – or perhaps hope – that 2018 will represent the year at which this mismatch peaked.

As people protested, school children went on strike and shareholders passed resolutions, energy demand and carbon emissions grew at their fastest rate for years.

The Stats Review can't solve this mismatch, but it can provide an objective assessment of the factors driving energy developments in 2018 and their possible implications for the future.

2. Key features of 2018

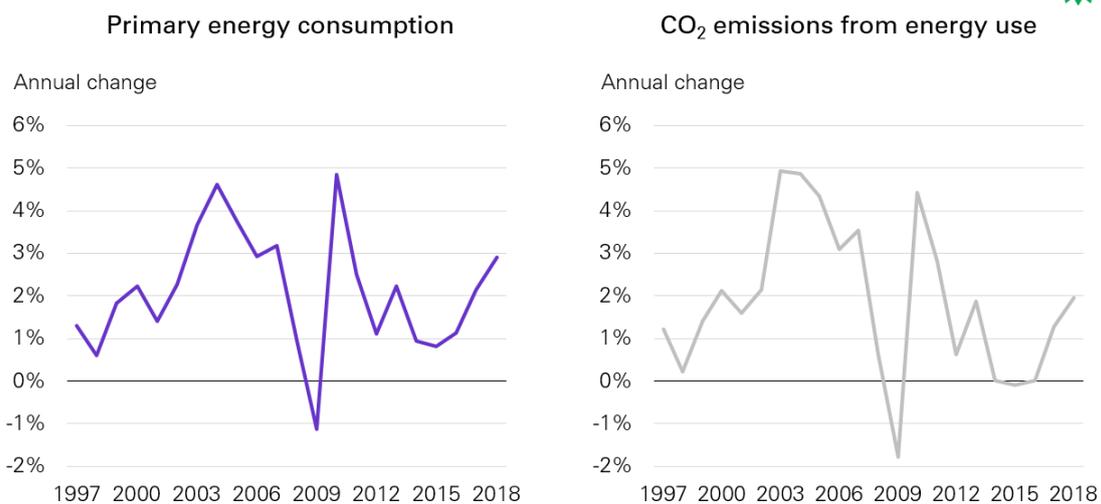
So what happened in 2018?

The headline numbers are the rapid growth in energy demand and carbon emissions.

Global primary energy grew by 2.9% in 2018 – the fastest growth seen since 2010.

This occurred despite a backdrop of modest GDP growth and strengthening energy prices.

Growth in primary energy and carbon emissions



BP Statistical Review of World Energy
© BP p.l.c. 2019

At the same time, carbon emissions from energy use grew by 2.0%, again the fastest expansion for many years, with emissions increasing by around 0.6 gigatonnes.

That's roughly equivalent to the carbon emissions associated with increasing the number of passenger cars on the planet by a third.

These increases are material.

So what drove these increases in 2018? And how worried should we be?

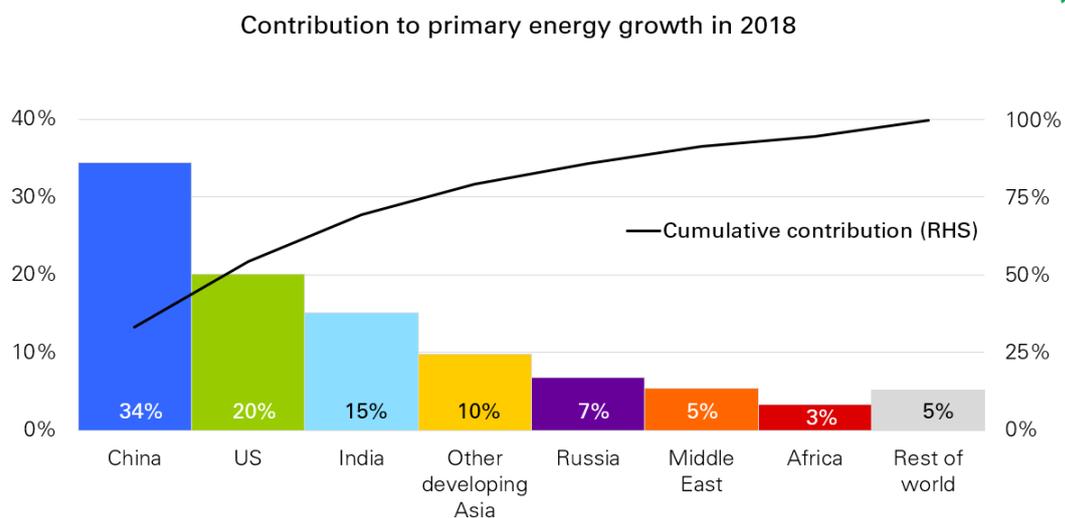
Starting first with energy consumption.

As I said, energy demand grew by 2.9% last year.

This growth was largely driven by China, US and India which together accounted for over two thirds of the growth.

Relative to recent historical averages, the most striking growth was in the US, where energy consumption increased by a whopping 3.5%, the fastest growth seen for 30 years and in sharp contrast to the trend decline seen over the previous 10 years.

Primary energy



Contributions shown do not sum to 100% due to rounding

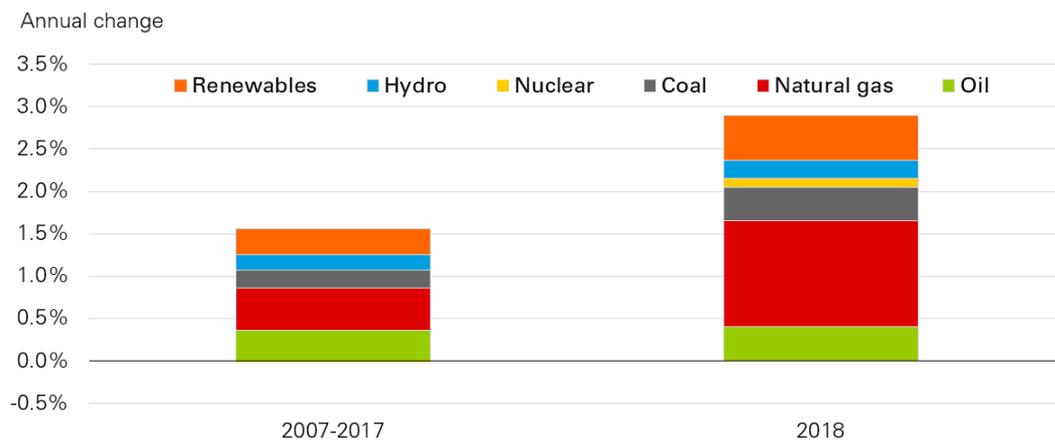
BP Statistical Review of World Energy
© BP p.l.c. 2019

The strength in energy consumption was pretty much reflected across all the fuels, most of which grew more strongly than their historical averages.

This acceleration was particularly pronounced in natural gas demand, which increased 5.3%, one of its strongest growth rates for over 30 years, accounting for almost 45% of the entire growth in global energy consumption.

Growth in renewable energy (14.5%) eased back slightly relative to past trends although remained by far the world's fastest growing energy source.

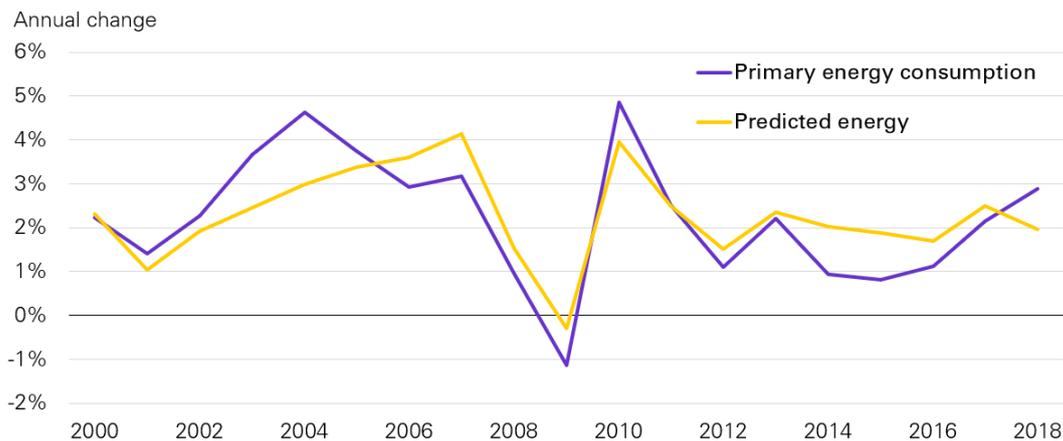
Primary energy growth by fuel



BP Statistical Review of World Energy
© BP p.l.c. 2019

In terms of why energy demand was so strong: the chart provides a way of gauging the extent of the surprise in this year's energy data.

Global energy consumption growth



BP Statistical Review of World Energy
© BP p.l.c. 2019

The 'predicted' line uses a simple framework of GDP growth and changes in oil prices (as a proxy for energy prices) to predict primary energy growth at a country level and then aggregates to global energy.

Although very simple, the framework is able to explain much of the broad contours in energy demand over the past 20 years or so.

This framework predicts that the growth in energy demand should have slowed a little last year, reflecting the slightly weaker economic backdrop and the strengthening in energy prices.

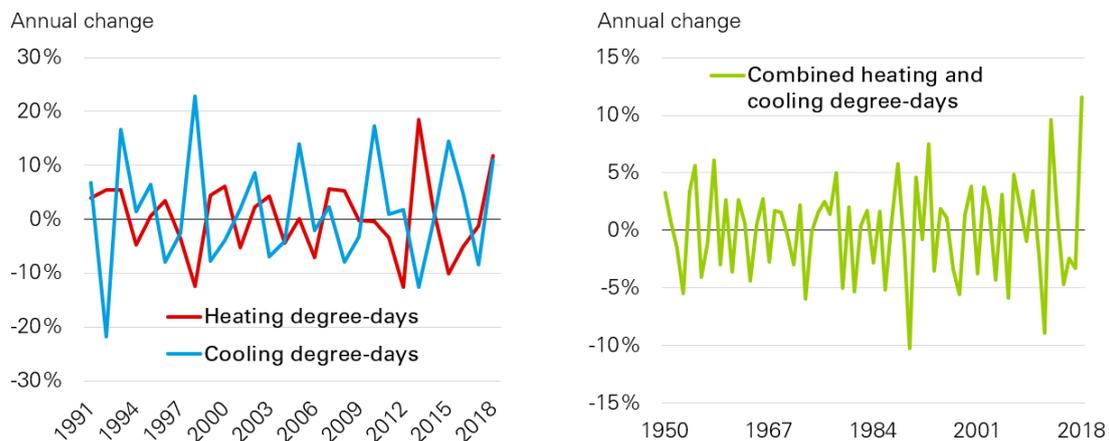
Instead, energy demand picked up quite markedly.

Digging into the data further, it seems that much of the surprising strength in energy consumption in 2018 may be related to weather effects. In particular, there was an unusually large number of both hot and cold days last year, which led to higher energy consumption as the demand for cooling and heating services increased.

The increasing frequency and intensity of heating and cooling days was pretty widespread across many of the world's major demand centres last year, particularly in the US, China and Russia helping to explain the strong growth in energy consumption in each of these countries.

To give a little more context, the chart shows a measure of US heating and cooling days which combines both the frequency and intensity of unusually cold and hot days. What was particularly unusual about the US last year was that there was an increase in both heating and cooling days; in past years, high numbers of heating days have tended to coincide with low numbers of cooling days or vice versa. As a result, the increase in the combined number of US heating and cooling days last year was its highest since the 1950s, boosting US energy demand.

US heating and cooling days*



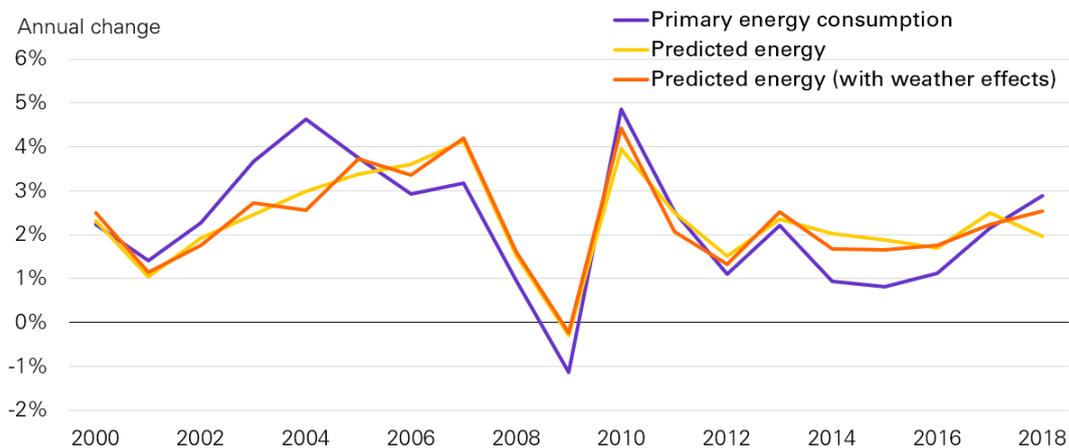
*Heating Degree Days and Cooling Degree Days, available from the Energy Information Agency (EIA). Information on how HDD and CDD are calculated can be found at National Oceanic and Atmospheric Administration (NOAA) BP Statistical Review of World Energy © BP p.l.c. 2019

If we augment our framework to include a measure of heating and cooling days for those countries for which data are available, this greatly reduces the extent of the surprise in last year's energy growth.¹

Indeed, this analysis suggests that the stimulus from weather effects in US, China and Russia alone could account for around a quarter of the increase in energy consumption last year.

¹ The framework is based on estimating individual relationships for 79 countries and 12 small regions. Historical observations going back to mid-1990s for heating and cooling days are available for 21 countries, accounting for around 70% of global energy demand.

Global energy consumption growth



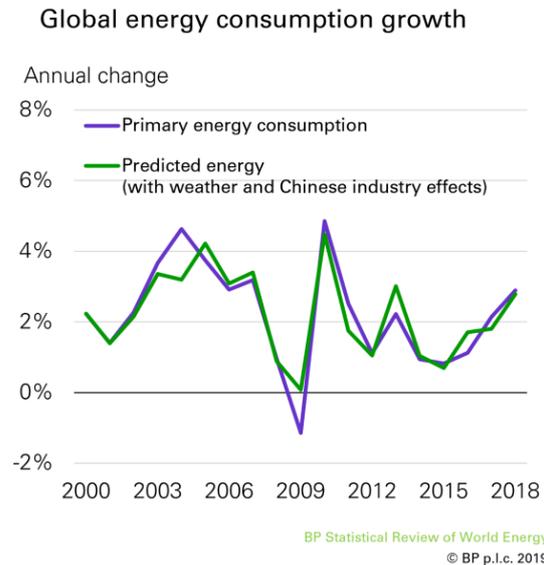
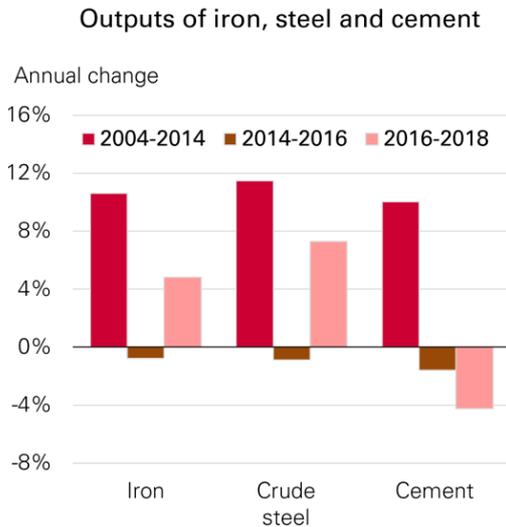
BP Statistical Review of World Energy
© BP p.l.c. 2019

Once these weather effects are included, the growth in energy demand in 2018 still looks a little stronger than expected, but more striking is the surprising weakness of demand growth in the period 2014-16, which is far lower than the framework predicts.

For those loyal stalwarts amongst you who have been regular followers of the Stats Review in recent years, you may recall that much of this weakness appears to stem from the pattern of Chinese economic growth during this period, in particular the pronounced weakness of some of China's most energy-intensive sectors – iron, steel and cement – which account for around a quarter of China's energy consumption and greatly dampened overall energy growth.

At the time, I speculated that some of the slowing in these sectors reflected the structural rebalancing of the Chinese economy towards more consumer and service-facing sectors and so was likely to persist. But I also noted that the scale of the slowdown suggested that some of it was likely to be cyclical and would reverse over time. And indeed that is what began to happen in iron and steel in 2017 and gathered significant pace last year.

Chinese industrial growth



If we adjust the framework to also take account of movements in these key Chinese industrial sectors, the over-prediction of energy growth in 2014-16 is greatly reduced, as is the remaining 'unexplained' strength of energy demand in 2018.

So in answer to the question of why energy demand was so strong in 2018: it appears that the strength of demand last year was largely due to weather-related effects – especially in the US, China and Russia – together with a further unwinding of cyclical factors in China.

How does this relate to the worrying acceleration in carbon emissions?

To a very large extent, the growth in carbon emissions is simply a direct consequence of the increase in energy growth. Relative to the average of the previous five years, growth in energy demand was 1.5 percentage points higher in 2018 and the growth in carbon emissions was 1.4 percentage points higher.

One led to the other.

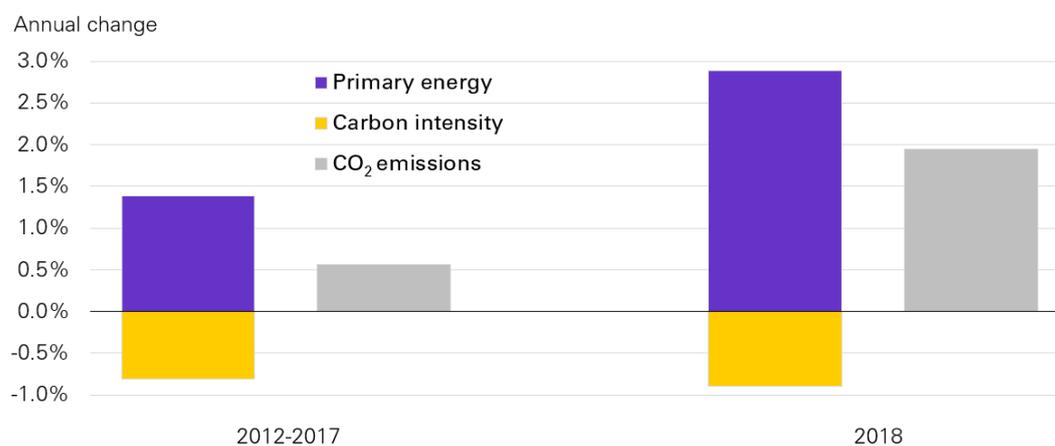
If anything, given the growth in energy demand, the growth in carbon emissions could have been even greater.

This reflects the fact that year-to-year growth in non-fossil fuels, especially renewable energy, is largely determined by policy and technological factors, and so are typically less responsive to cyclical movements in energy growth than are oil, gas and coal.

As a result, strong growth in overall energy demand tends to be associated with a greater-than-normal contribution from hydrocarbons, as they expand to balance the system. This shift in the fuel mix means the carbon intensity of the fuel mix tends to increase during periods of strong energy growth, further adding to carbon emissions.

And indeed, oil, gas and coal collectively accounted for almost three-quarters of the growth in energy demand in 2018 – its highest share for five years. But thankfully much of this growth was in natural gas, gaining share relative to coal and oil, such that the improvement in the carbon intensity of the fuel mix last year was similar to its recent average.

Energy demand and carbon emissions



BP Statistical Review of World Energy
© BP p.l.c. 2019

Finally in terms of the headline data, what signal might the increasing growth of energy demand and carbon emissions in 2018 contain for the future?

I think this depends in large part on how you interpret the increasing number of heating and cooling days last year.

I should stress that this is not my area of competence, but there seems to be (at least) two possibilities.

On the one hand, to the extent that the unusually high number of hot and cold days last year just reflects random variation, we might expect weather effects in the future to revert to more normal levels, allowing the growth in energy demand and carbon emissions to fall back.

On the other hand, if there is a link between the growing levels of carbon in the atmosphere and the types of weather patterns observed in 2018 this would raise the possibility of a worrying vicious cycle: increasing levels of carbon leading to more extreme weather patterns, which in turn trigger stronger growth in energy (and carbon emissions) as households and businesses seek to offset their effects.

As I said, there are zillions of people better qualified than I to make judgements on this.

But even if these weather effects are short lived, such that the growth in energy demand and carbon emissions slows over the next few years, the recent trends still feel very distant from the types of transition paths consistent with meeting the Paris climate goals.

Hopes and reality.

So, in that sense, there are grounds for us to be worried.

That is all I wanted to say in terms of the headline data on energy demand and carbon emissions. My plan now is to consider the key fuels in a little more detail, starting with oil.

3. Oil and refining

2018 was another rollercoaster year for oil markets, with prices starting the year on a steady upward trend, reaching the dizzying heights of \$85/bbl in October before plunging in the final quarter to end the year at close to \$50/bbl.

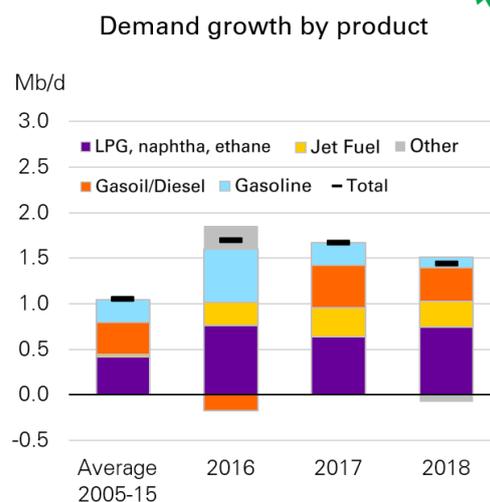
Oil demand provided a relatively stable backdrop for this excitement, continuing to grow robustly, increasing 1.4 Mb/d last year. In an absolute sense, the growth in demand was dominated by the

developing world, with China (0.7 Mb/d) and India (0.3 Mb/d) accounting for around two thirds of the global increase.

But relative to the past 10 years or so, the big outlier was the US, where oil demand grew by 0.5 Mb/d in 2018, its largest increase for well over 10 years and in sharp contrast to the trend decline seen in the decade or so prior to the oil price crash of 2014.

The strength in US oil demand in recent years has been concentrated in first gasoline and then diesel, buoyed by lower prices and economic recovery respectively. But the further step up in growth seen last year was driven by increased demand for ethane as new production capacity came on stream.

Oil demand



BP Statistical Review of World Energy
© BP p.l.c. 2019

The increased importance of petrochemicals in driving oil demand growth was also evident in the global product breakdown, with products most closely related to petrochemicals (ethane, LPG and naphtha) accounting for around half of the overall growth in demand last year.

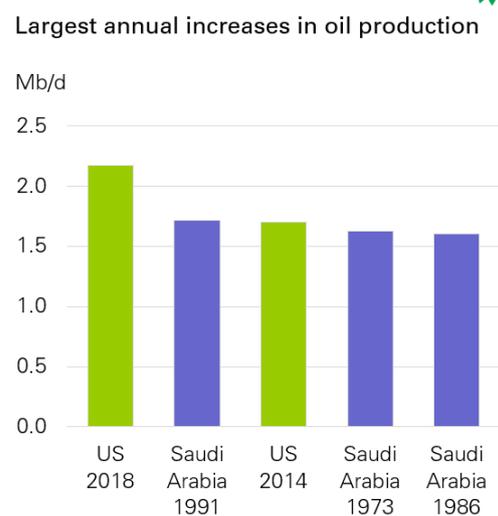
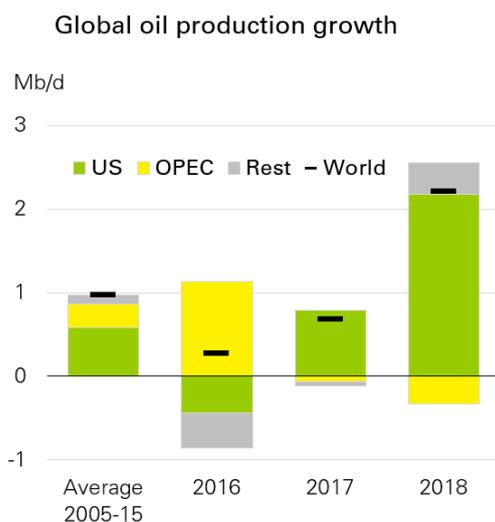
Against this backdrop of solid demand growth, all the fun and excitement of the fair came from the supply side, where global production grew by a whopping 2.2 Mb/d, more than double its historical average.

The vast majority of this growth was driven by the 2.2 Mb/d increase in US production, which flowed almost entirely from increases in tight oil and natural gas liquids (NGLs). There was also growth in some other non-OPEC countries, led by Canada (0.4 Mb/d) and Russia (0.2 Mb/d).

The increase in US production was the largest-ever annual increase by any country.

Indeed, since 2011 and the onset of the tight oil revolution, US production has increased by over 7 Mb/d – broadly equivalent to Saudi Arabia’s crude oil exports – an astonishing increase which has transformed both the structure of the US economy and global oil market dynamics. Largely as a consequence, US net oil imports shrunk to less than 3 Mb/d last year, compared with over 12 Mb/d in 2005.

Oil production



BP Statistical Review of World Energy
© BP p.l.c. 2019

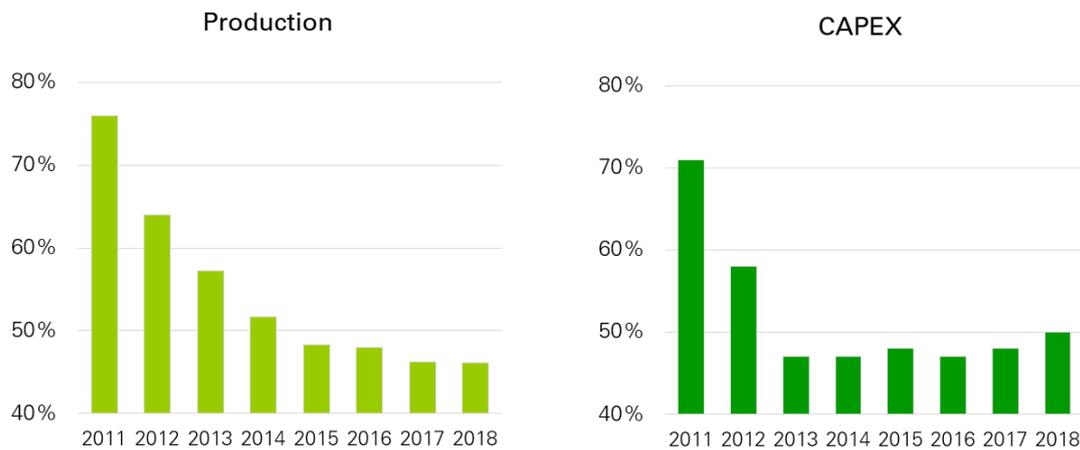
There has been much talk recently about the changing structure of L48 production, as Big Oil has increased its footprint and the incentives for consolidation to exploit the benefits of scale and contiguous acreage have increased.

Interestingly, this process of consolidation is not yet evident in the extent to which production is concentrated amongst the top few producers. Indeed, the ratio of total production accounted for by the top 10 US tight oil producers has declined pretty consistently over the past decade as the tight oil revolution has taken hold.

Concentration of US tight oil production and CAPEX



Share of top 10 US tight oil firms by:



BP Statistical Review of World Energy
© BP p.l.c. 2019

That said, there is evidence of increasing concentration in investment spending, which may be a leading indicator for production. And the corresponding ratio for US shale gas production has increased over the past couple of years to a little over 55% – quite a bit higher. So levels of concentration may start to increase in coming years.

The extent to which it does could have an important bearing on the future dynamics of US tight oil production, particularly in terms of its responsiveness to oil prices and to the availability of capital.

Watch this space.

Switching from US production to OPEC: OPEC production fell by 0.3 Mb/d in 2018, with a marked increase in Saudi Arabian production (+0.4 Mb/d) offset by falls in Venezuela (-0.6 Mb/d) and Iran (-0.3 Mb/d). But this year-on-year comparison doesn't do justice to the intra-year twists and turns in OPEC production.

The ride began in the first half of 2018 with the continuation of the OPEC+ agreement from December 2016, which included OPEC, together with 10 non-OPEC countries led by Russia. The OPEC+ group consistently overshot their agreed production cuts during 2017 and this overshooting increased further during the first half of 2018, largely reflecting continuing falls in Venezuelan output.

These production cuts helped push OECD inventories below their five year moving average for the first time since the collapse in oil prices in 2014.

The first major OPEC twist came in the middle of 2018, amid growing concerns surrounding the possible scale of future supply disruptions. Venezuelan production was continuing to fall. Moreover, the US announced in May its intention to impose sanctions on all Iranian oil exports.

In response, the OPEC+ group in June committed to achieving 100% compliance of their production cuts for the group as a whole. This commitment contained two important signals. First, given the extent to which production was below the target level, it signalled the prospect of an immediate increase in production. Second, it helped reduce the uncertainty associated with the possibility of future disruptions to either Iranian and Venezuelan production since the commitment to maintain “100% compliance” in essence signalled the willingness of other members of the OPEC+ group to offset any lost production.

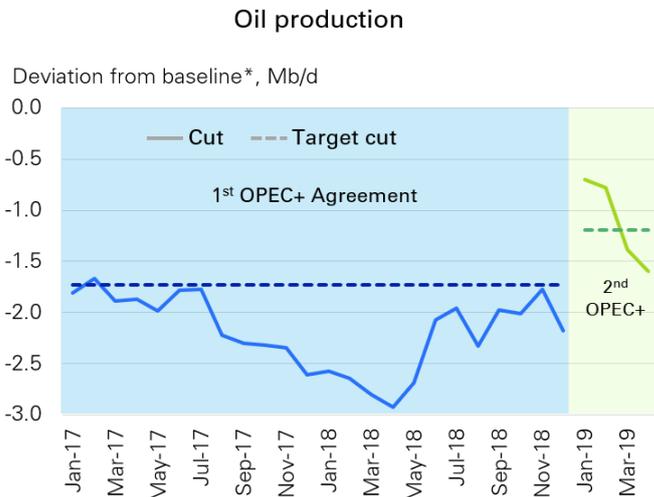
And that is exactly what happened between May and November of last year: net production by the OPEC+ group increased by 900 Kb/d, close to achieving the 100% compliance, despite Iranian and Venezuelan production falling by a further 1 Mb/d.

Job done. Or was it?

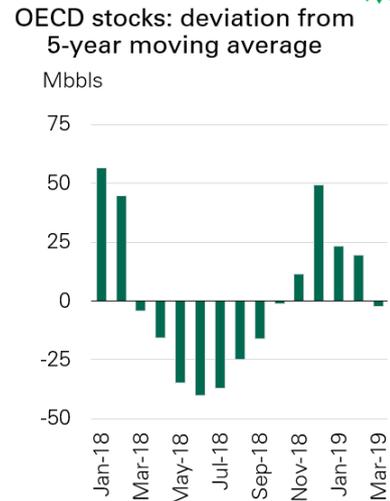
The problem with trying to stabilise oil markets is that there is always some other pesky development that you hadn't expected.

In this case, oil production by Libya and Nigeria – neither of which were part of the OPEC+ agreement – increased by almost 600 Kb/d between June and November of last year. As a result, rather than OECD inventories stabilising, they started to grow again, reversing much of the falls relative to the five year average. This growing sense of excess supply was compounded by the US announcing in November that it would grant temporary waivers for some imports of Iranian oil.

OPEC+ production agreements and OECD oil stocks



*Baseline in the 1st OPEC+ Agreement was October 2016.
For the 2nd OPEC+ Agreement it was October 2018



BP Statistical Review of World Energy
© BP p.l.c. 2019

This triggered another twist: a new OPEC+ group was formed in December of last year – this time excluding Iran and Venezuela, as well as Libya, but including Nigeria – with a commitment to reduce production by 1.2 Mb/d relative to October 2018 levels. After a slow start, by the spring of this year, the reconstituted OPEC+ group was once again overshooting their production cuts. These reductions, together with further sharp falls in Venezuela production, have been sufficient to cause inventories to fall back to around their five year average.

It's tempting to interpret these twists and turns as indicative of OPEC's waning powers. But I'm not sure that's the correct interpretation. The role that OPEC+ played in more than offsetting the falls in Iranian and Venezuelan output last year was very significant. For me, the twists and turns simply reflect the difficulty of market management, especially in a world of record supply growth in one part of the world and heightened geopolitical tensions in others.

It feels like the oil market rollercoaster will run for some time to come.

The gyrations in supply, together with a host of macroeconomic factors, including the festering trade dispute between the US and China, were reflected in oil prices, which trended higher through much of the year, before tumbling in the final quarter. For the year as a whole, Brent averaged \$71/bbl, up from \$54/bbl in 2017.

Oil price



BP Statistical Review of World Energy
© BP p.l.c. 2019

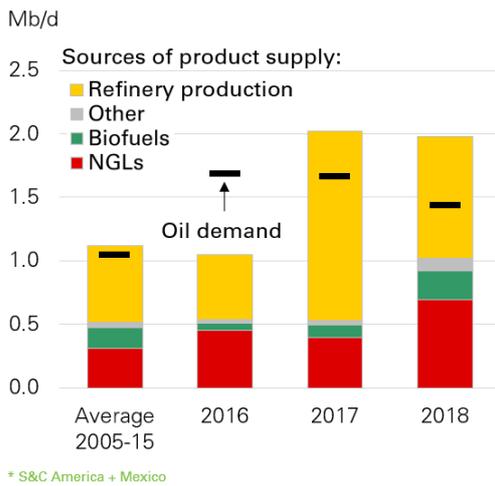
Turning briefly to refining.

Refinery throughput increased by 1.0 Mb/d in 2018, quite a bit weaker than the increase seen in the previous year (1.5 Mb/d). Some of this slower growth stems from the easing in overall oil demand growth, but more important was the strong growth in non-refined liquids, especially the record growth in the production of NGLs (0.7 Mb/d), which are separately identified in the Statistical Review for the first time.

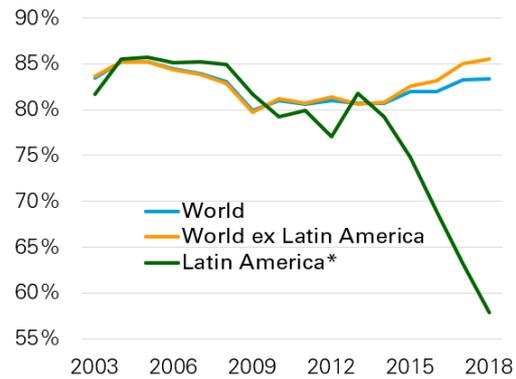
Refinery production and utilization



Growth of oil demand and product supply



Refinery utilization by region

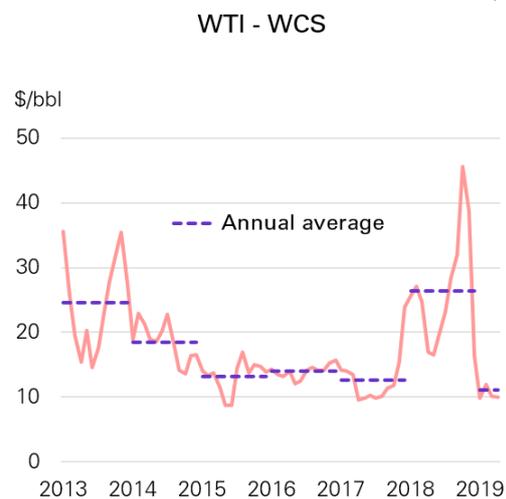
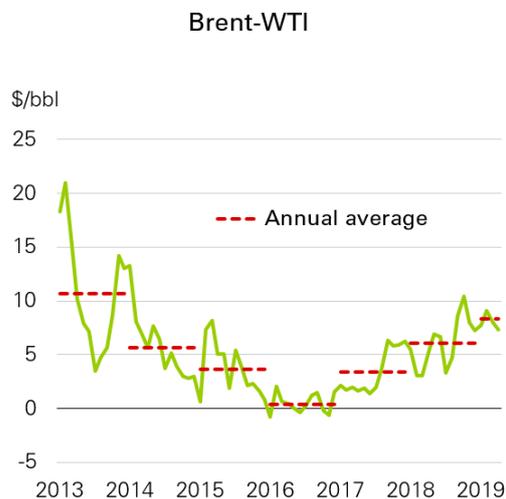


BP Statistical Review of World Energy
© BP p.l.c. 2019

Despite the smaller increase in refining runs, measured utilisation rates increased for the fourth consecutive year in 2018 to reach their highest level for more than 10 years. Indeed, taking account of the large and growing disruptions to refining capacity in Latin America and Africa, 'effective' utilisation rates were even higher, as evidenced by utilisation rates outside of Latin America reaching record high levels. Despite increasing levels of utilisation, margins eased slightly relative to last year as the impact of Hurricane Harvey unwound and product stock levels increased.

Oil price differentials continued to be dominated by logistical constraints and bottlenecks. The limited pipeline capacity to transport Canadian heavy oil to the US caused the WTI-WCS differential to blow out to around \$45/bbl in October of last year, before the Albertan government stepped in to regulate production causing the differential to narrow sharply. Likewise, bottlenecks and constraints associated with both transporting crude to the Gulf coast and subsequently exporting some of this crude caused the average Brent-WTI differential to widen to over \$6/bbl in 2018.

North American crude differentials



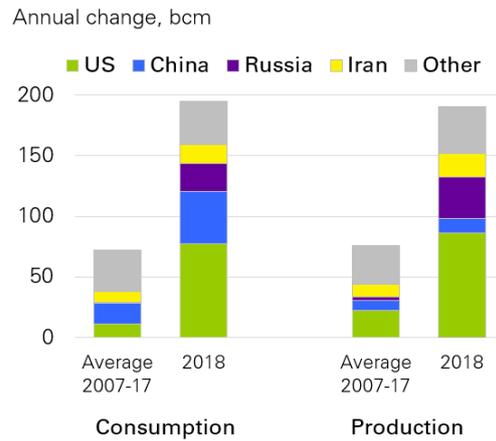
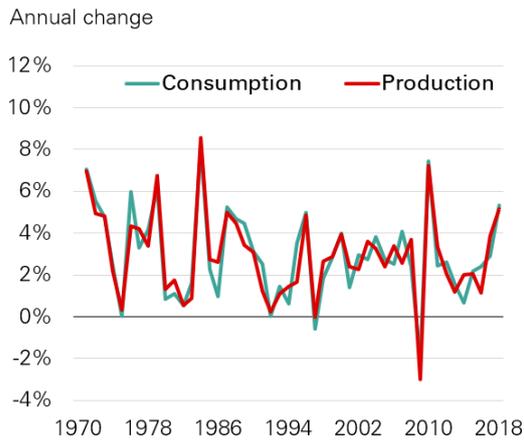
BP Statistical Review of World Energy
© BP p.l.c. 2019

4. Natural Gas

Turning next to natural gas.

As I mentioned, 2018 was a bonanza year for natural gas, with both global consumption and production increasing by over 5%, one of the strongest growth rates in either gas demand or output for over 30 years.

Global growth in natural gas



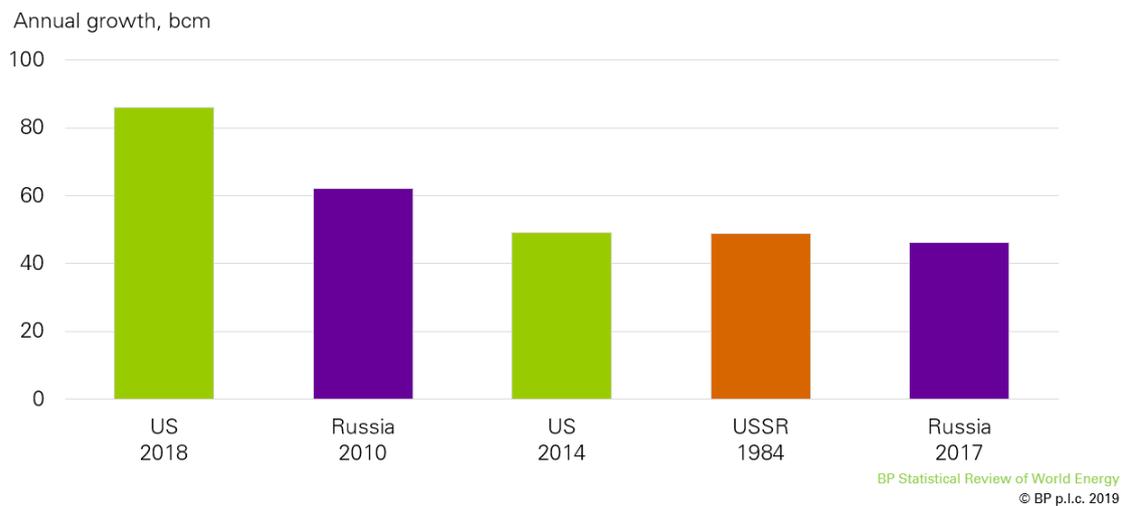
BP Statistical Review of World Energy
© BP p.l.c. 2019

The main actor here was the US, accounting for almost 40% of global demand growth and over 45% of the increase in production.

US gas production increased by 86 bcm, an increase of almost 12%, driven by shale gas plays in Marcellus, Haynesville and Permian. Indeed, the US achieved a unique double first last year, recording the single largest annual increases by any country in both oil and gas production.

In case there was any doubt: the US shale revolution is alive and kicking.

Largest increases in gas production



The gains in global gas production were supported by Russia (34 bcm), Iran (19 bcm) and Australia (17 bcm).

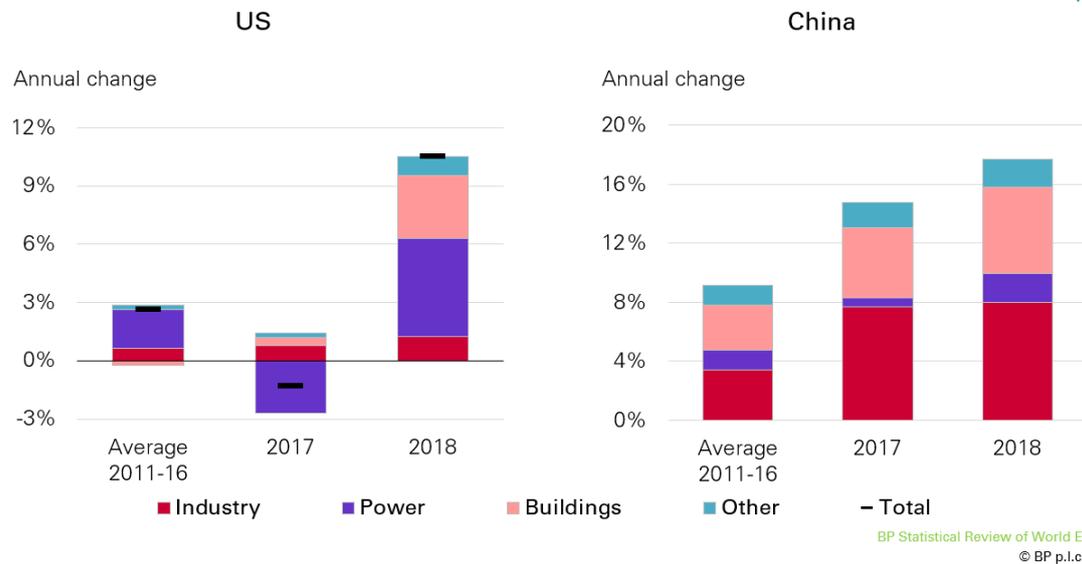
Although some of the increase in US gas supplies was used to feed the three new US LNG trains which came on stream last year, the majority was used to quench the thirst of domestic demand.

US gas consumption increased by 78 bcm last year – to put that in context, that is roughly the same growth as achieved over the previous six years in the US; or broadly equivalent to the entire gas consumption of the UK.

You will not be surprised to hear that this exceptional strength appears to be largely driven by the same weather-related effects, with rising demands for space heating and cooling fuelling increased gas consumption, both directly in commercial and residential buildings, and, more importantly, indirectly via growing power demand. The expansion of gas consumption within the US power sector was further boosted by around 17 gigawatts of coal-fired generation capacity being retired last year.

Overall, the growth in gas-fired power generation accounted for around half of the increase in US gas consumption last year.

Growth in US and Chinese gas consumption



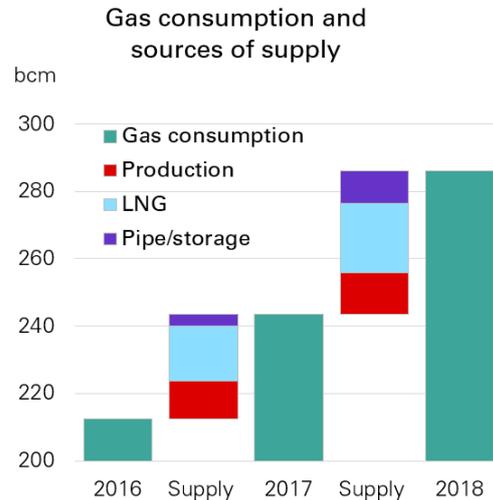
Outside of the US, the growth in global gas demand was concentrated across three other countries: China (43 bcm), Russia (23 bcm) and Iran (16 bcm), which together with the US, accounted for 80% of global growth.

China gas consumption grew by an astonishing 18% last year. This strength stemmed largely from a continuation of environmental policies encouraging coal-to-gas switching in industry and buildings in order to improve local air quality, together with robust growth in industrial activity during the first half of the year.

These coal-to-gas switching policies have been instrumental in increasing Chinese gas consumption by over a third in the past two years alone. Official estimates suggest that as many as 10 million households – roughly half the number of households in the UK – switched from coal-to-gas boilers over this 2-year period, with even greater switching in the industrial sector.

Importantly, a series of improvements in import capacity, distribution and demand management meant that this second successive year of rapid growth in Chinese gas consumption was achieved largely without a repeat of the price spikes and shortages which characterised the winter of 2017/18, with increased imports from both LNG and pipelines.

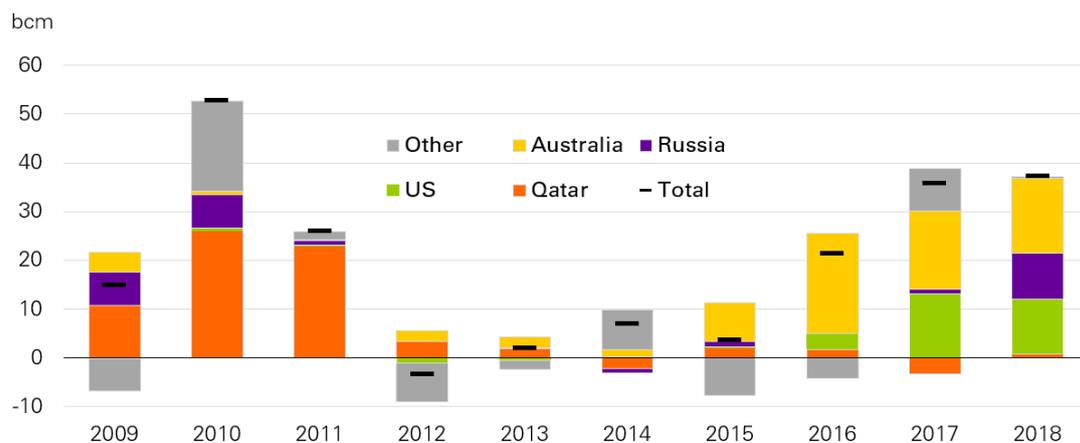
China gas prices and consumption



BP Statistical Review of World Energy
© BP p.l.c. 2019

Global LNG supplies continued their rapid expansion last year, increasing by almost 10% (37 bcm) as a number of new liquefaction plants in Australia, US and Russia were either started or ramped up.

Annual increase in LNG exports



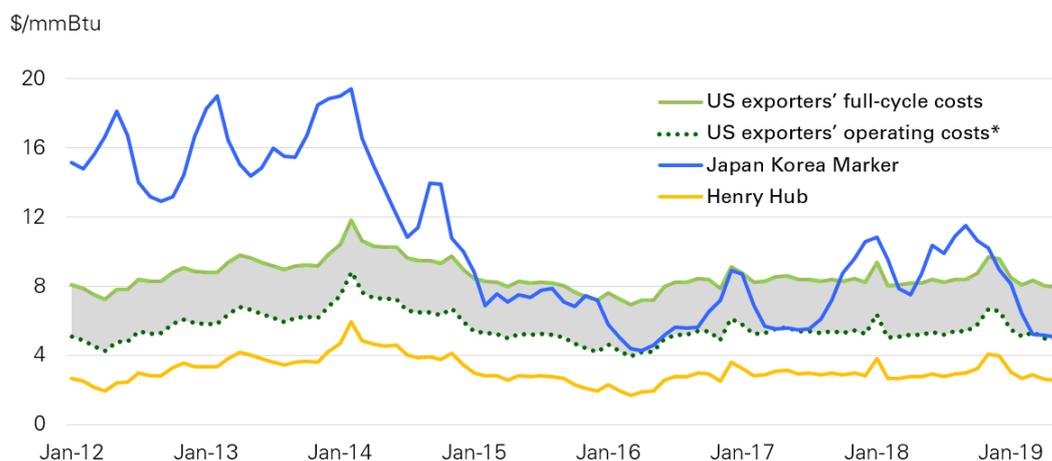
BP Statistical Review of World Energy
© BP p.l.c. 2019

For much of the year, the strength of Asian gas demand, led by China, was sufficient to absorb these increasing supplies. But a waning in the strength of Asian demand towards the end of the year,

combined with a mini-surge in LNG exports, caused prices to fall back and the differential between Asian and European spot prices to narrow significantly.

Asian prices have fallen further in the first part of this year, towards the bottom of the price band defined by US exporters' full-cycle and operating costs. The prospect of further substantial expansion of LNG supplies this year means there is a possibility of a first meaningful curtailment of some LNG supply capacity.

US LNG exporters' costs & Asian spot prices



* Operating costs = 1.15* Henry Hub + \$2/mmBtu (transport) ; Full costs also include liquefaction fee (\$3/mmBtu)

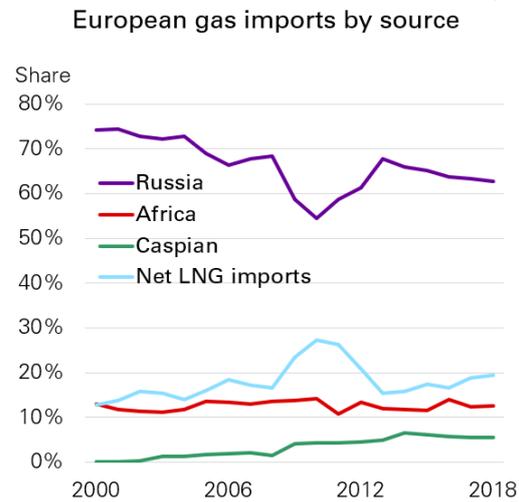
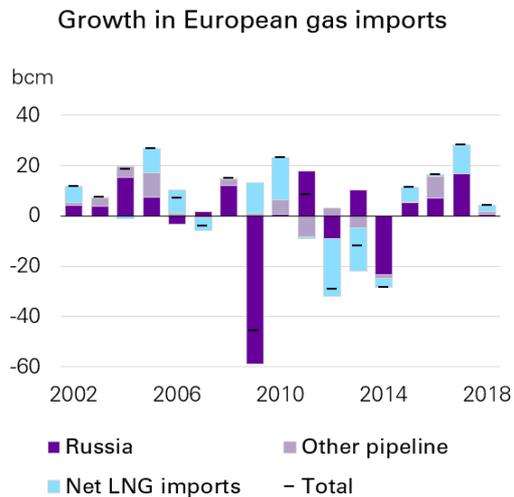
BP Statistical Review of World Energy
© BP p.l.c. 2019

The extent of any eventual shut-in will depend importantly on the European market, which acts as the de facto 'market of last resort' for LNG supplies.

Europe's gas demand contracted by a little over 2% (11 bcm) last year, but this fall in demand was more than matched (-13 bcm) by continuing declines in Europe's aging gas fields. The small increase in European gas imports was largely met by LNG cargoes diverted from Asia towards the end of the year as the Asian premium over European prices almost disappeared.

Russian pipeline exports to Europe were largely unchanged on the year, maintaining the record levels built up in recent years, although with a slight decline in their share of Europe's gas imports. A key factor determining the role that Europe will play in balancing the global LNG market over coming years will be the extent to which Russia seeks to maintain its market share.

European gas imports



BP Statistical Review of World Energy
© BP p.l.c. 2019

5. Coal

2018 saw a further bounce back in coal – building on the slight pickup seen in the previous year – with both consumption (1.4%) and production (4.3%) increasing at their fastest rates for five years.

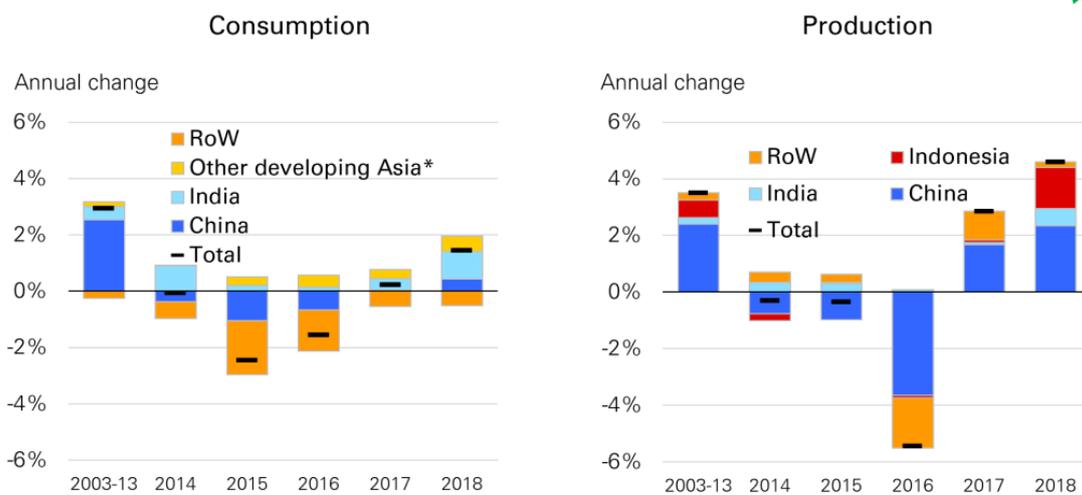
This strength was concentrated in Asia, with India and China together accounting for the vast majority of the gains in both consumption and production.

The growth in coal demand was the second consecutive year of increases, following three years of falling consumption. As a result, the peak in global coal consumption which many had thought had occurred in 2013 now looks less certain: another couple of years of increases close to that seen last year would take global consumption comfortably above 2013 levels.

The growth in coal consumption was more than accounted for by increasing use in the power sector. This is despite continuing strong growth in renewables: renewable energy increased by over 25% in both India and China last year, which together accounted for around half of the global growth in

renewable energy. So really rapid growth. But even this was not sufficient to keep pace with the strong gains in power demand, with coal being sucked into the power sector as the balancing fuel.

Global coal consumption and production



* Other emerging Asia is defined as all Asia-pacific countries excluding four OECD countries, China, and India.

BP Statistical Review of World Energy © BP p.l.c. 2019

This highlights an obvious but important point: even if renewables are growing at truly exceptional rates, the pace of growth of power demand, particularly in developing Asia, limits the pace at which the power sector can decarbonize.

We can explore this point in more detail by looking at the power sector specifically.

6. Power sector and renewable energy

As I have bored many of you for several years now, the power sector needs to play a central role in any transition to a low carbon energy system: it is the single largest source of carbon emissions within the energy system; and it is where much of the lowest-hanging fruit lie for reducing carbon emissions over the next 20 years.

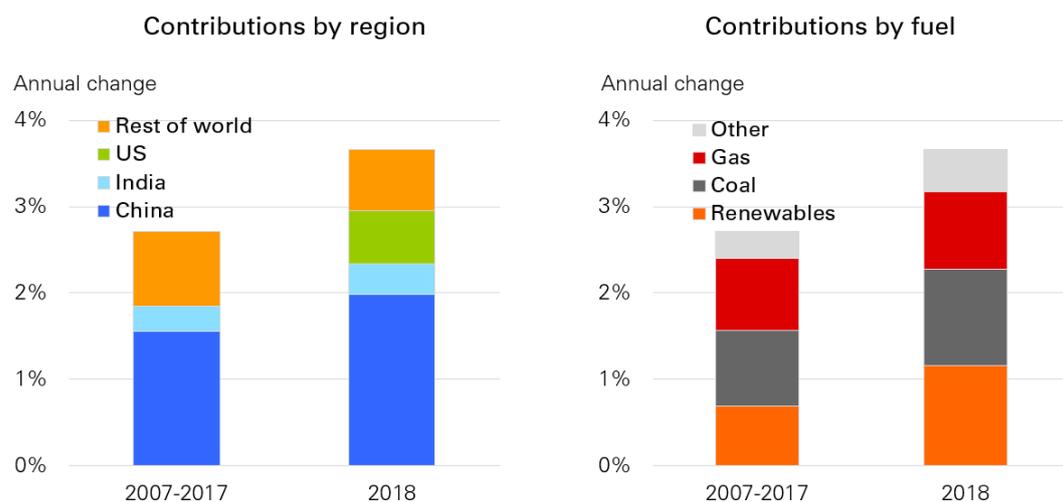
So what happened last year?

Global power demand grew by 3.7%, which is one of the strongest growth rates seen for 20 years, absorbing around half of the growth in primary energy.

The developing world continued to drive the vast majority (81%) of this growth, led by China and India who together accounted for around two thirds of the increase in power demand.

But the particularly strong growth of power demand in 2018 owed much to the US, where power demand grew by a bumper 3.7%, boosted by those weather effects, in sharp contrast to a slight trend decline seen over the past 10 years.

Growth in power generation



BP Statistical Review of World Energy
© BP p.l.c. 2019

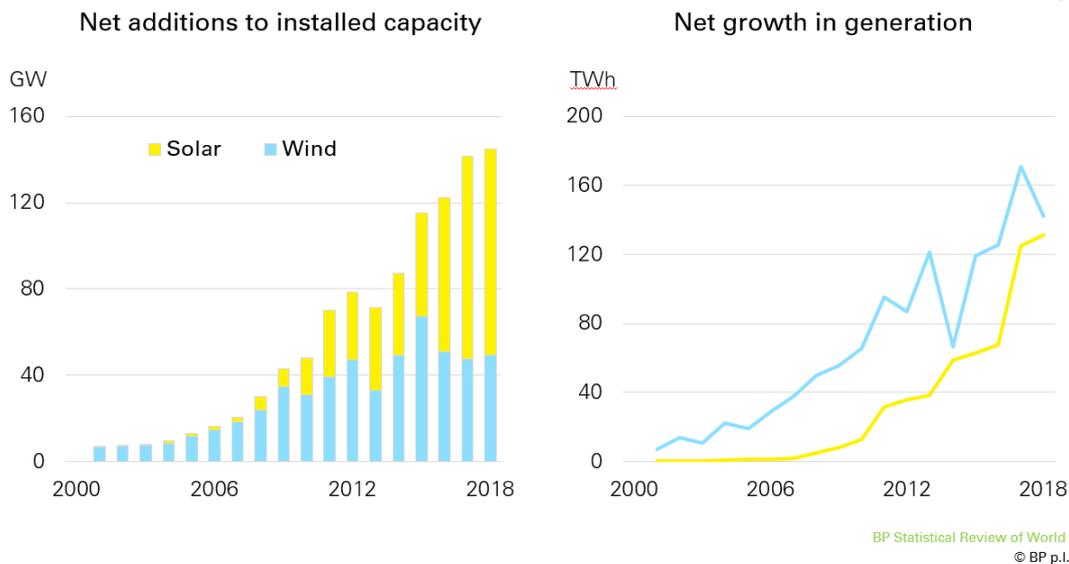
On the supply side, the growth in power generation was led by renewable energy, which grew by 14.5%, contributing around a third of the growth; followed by coal (3.0%) and natural gas (3.9%).

China continued to lead the way in renewables growth, accounting for 45% of the global growth in renewable power generation, more than the entire OECD combined.

One feature of last year's data is that the increase in wind and solar capacity flattened out in 2018 at around 150 GW. This is at odds with much of the past 20 years where the scale of capacity increases has tended to increase year after year. Although it's important not to overplay this flattening: the growth in renewable capacity last year was still at its highest ever level.

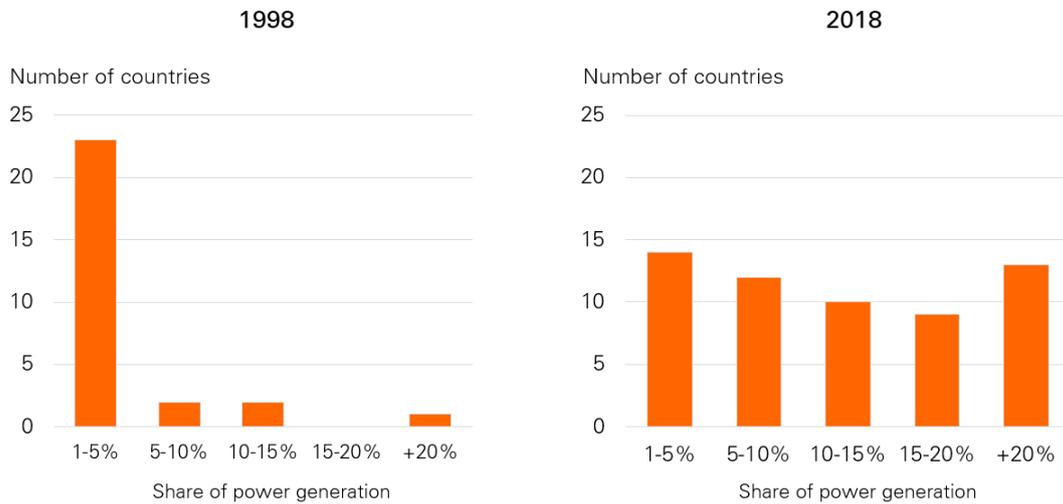
The growth in power generation was also close to its highest ever increase, with wind and solar providing broadly similar increments.

Wind and solar power



Stepping back from this year's data and looking at the growth of renewables over a longer period, these two histograms summarise the increasing adoption and penetration of renewable energy over the past 20 years, focussing on the 78 major countries which are individually tracked in the Stats Review.

Penetration of renewables



BP Statistical Review of World Energy
© BP p.l.c. 2019

Going back 20 years to 1998, only around a third of the tracked countries had any form of renewable power, with the vast majority of those countries with renewable energy employing only very small quantities, clustered in the 1-5% range of domestic power generation.

Fast-forward 20 years to 2018 and the picture has changed quite substantially. Three-quarters of the tracked countries have adopted some form of renewable energy, with the degree of penetration pretty evenly spread across the range.

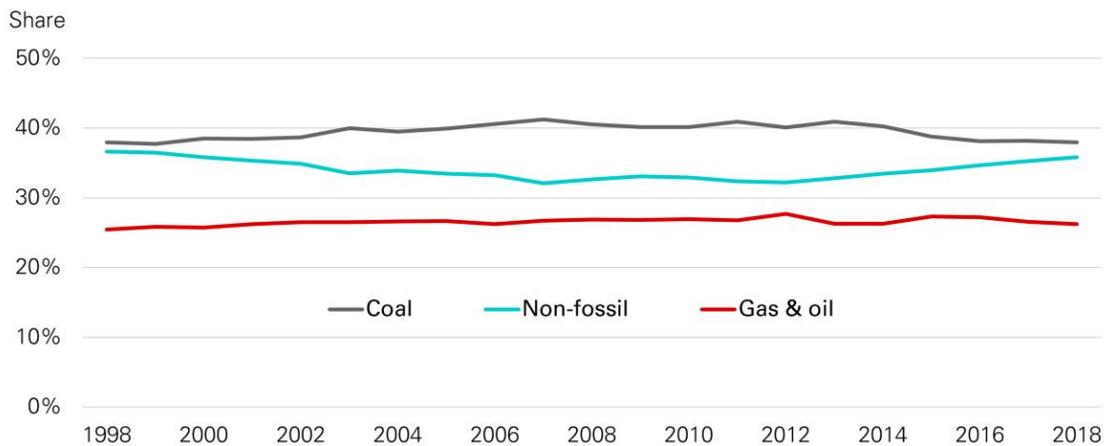
Renewable energy has come of age.

The 13 countries in the 20%+ penetration range are almost entirely European, with the only exception being New Zealand.

But to repeat a point I made last year, despite the increasing adoption and penetration of renewable power, the fuel mix in the global power system remains depressingly flat, with the shares of both non-fossil fuels (36%) and coal (38%) in 2018 unchanged from their levels 20 years ago.

Three flat lines.

Power sector fuel mix



BP Statistical Review of World Energy
© BP p.l.c. 2019

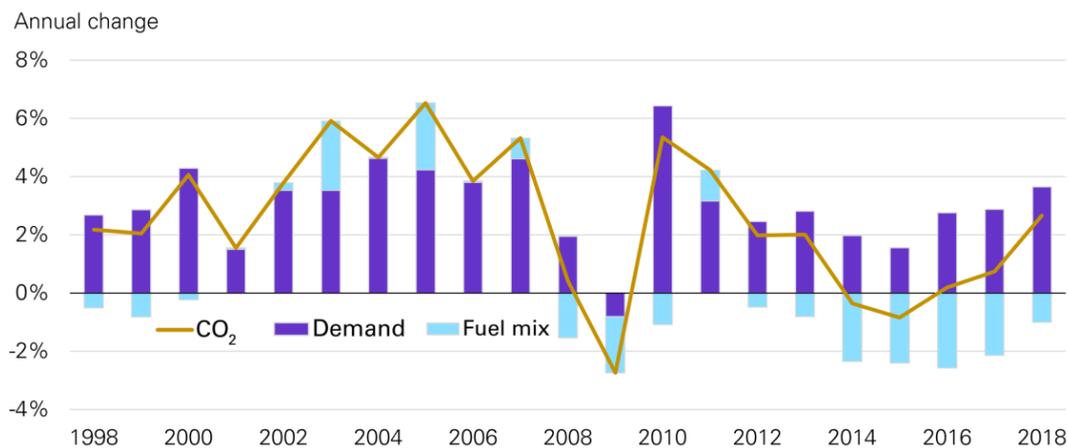
This persistence in the fuel mix highlights a point that the International Energy Agency (IEA) and others have stressed recently; namely that a shift towards greater electrification helps as a pathway to a lower-carbon energy system only if it goes hand-in-hand with a decarbonization of the power sector.

Electrification without decarbonizing power is of little use.

In that vein, carbon emissions from the power sector are estimated to have increased by 2.7% in 2018, their highest rate of growth for seven years, accounting for around half of the growth in global carbon emissions.

For much of the past 20 years, changes in the carbon intensity of the power sector have been relatively small (or even perverse), such that increases in power demand fed through directly into higher carbon emissions.

Carbon emissions from power sector



BP Statistical Review of World Energy
© BP p.l.c. 2019

Electrification without decarbonization.

Over the past five years or so, the rapid growth in renewable energy, together with an edging down in the coal share, has led to a more sustained improvement in the carbon intensity of the power sector, such that the impact of increasing power demand on carbon emissions has been partially offset.

But it's still only partial: despite the rapid gains in renewable energy, the pace of growth in power demand has meant that overall carbon emissions from the power sector have increased substantially over the past three years.

It hasn't been possible to decarbonize the power sector quickly enough to offset the growth in demand.

To give a sense of the challenge posed by the strength of growth in power demand, I did a simple thought experiment of the extent to which the mix of fuels used by the power sector would have needed to change over the past three years to maintain the level of carbon emissions from the power sector at its 2015 level, for the same growth in power demand.

That is, the pace of decarbonization necessary to offset the entire growth in demand.

If we focus solely on renewable energy, renewable generation over the past three years would need to have grown more than twice as quickly than it actually did. Rather than growing by a little over 800 Twh over the past three years, renewable generation would have needed to grow by over 1800 Twh.

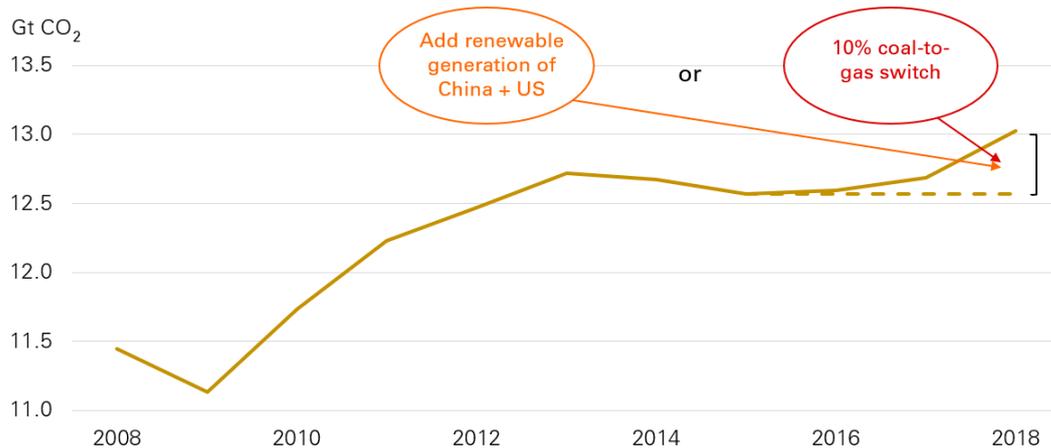
A staggering number: that additional renewable generation of around 1000 Twh is roughly equivalent to the entire renewable generation of China and the US combined in 2018.

So in addition to the rapid growth in renewable generation we actually saw, the world would have also needed to have added the entire renewable generation of China and the US, in just three years, just to keep carbon emissions from the power sector flat.

Alternatively, the same outcome for carbon emissions could have been achieved by replacing around 10% of coal in the power sector with natural gas.

The intuition is that renewables are still a relatively small share of power generation relative to coal, and so the proportional movements in coal are a lot smaller.

Carbon emissions from power sector



BP Statistical Review of World Energy
© BP p.l.c. 2019

I took two points from this simple thought experiment.

First, the general point that the robust growth in power demand, particularly in the developing world, greatly adds to the difficulty of decarbonizing the power sector.

You have to run very fast just to stand still.

Second, relying solely on renewables to achieve this is an almost impossible task.

Rapid growth in renewable energy is essential but it's unlikely to be sufficient.

This highlights the importance of adopting a range of technologies and fuels; rather than just relying on renewables.

To win the race to Paris, the world is likely to require many fuels and technologies for many years to come.

This includes widespread coal-to-gas switching; significant adoption of carbon capture use and storage (CCUS); and increasing energy efficiency, especially in the developed world, where the vast majority of people already enjoy relatively high levels of electricity consumption.

7. Conclusions

Let me conclude.

At a time when society is increasing its demands for an accelerated transition to a low carbon energy system, the energy data for 2018 paint a worrying picture, with both energy demand and carbon emissions growing at the fastest rates seen for years.

As I explained, in a statistical sense, it's possible to explain this acceleration in terms of a combination of weather-related effects and an unwinding of cyclical movements in China's pattern of growth.

What is less clear is how much comfort we can take from this explanation.

What does seem fairly clear is that the underlying picture is one in which the actual pace of progress is falling well short of the accelerated transition envisaged by the Paris climate goals.

Last year's developments sound yet another warning alarm that the world is on an unsustainable path.

It is sometimes said that history is written by the victors.

Although the Statistical Review provides a history of sorts, it is a very specific, near-term, history: documenting the developments in the global energy system in the previous year.

In that context, the only victors are the power of comprehensive, objective data.

The data write the story.

That is the role the Stats Review has been playing for the past 68 years.

More importantly, looking ahead, I hope that the understanding and insight provided by future Statistical Reviews will continue to inform judgements and decisions as society navigates its path to a low carbon energy system.