Thanks Bernard.

Let me add my welcome and thanks to everyone for joining *bp week* and for the launch of this year's *Energy Outlook*.

There are lots of differences to this year's Outlook.

Not least this launch venue – in a very high-tech film studio.

I'm not sure the basement room in bp's offices that we normally use will ever quite feel the same again.

And I'm missing the crowd of familiar faces that normally join me for the launch.

I know watching on-line is not the same but do stay with us.

The issues surrounding the energy transition are hugely interesting and have never been more important.

Please submit your questions as I go along for the Q+A session that follows – always the most fun and interesting part.

And as we did last year, as part of the Q+A session we plan to conduct a poll of your views about the energy transition – so stay tuned for that as well.

Despite all these changes, two aspects of the Outlook remain the same.

First, the Energy Outlook is still very much a team effort.

That includes the other members of the Economics team, who have been stretching Zoom to its very limits in recent months.

As well as a host of bp colleagues from far-and-wide who have contributed their expertise.

The Economics team holds the pen, but the insights come from right across bp.

So, a huge thanks to all those involved.

Second, the purpose of the Outlook has not changed.

In particular, the role of the Energy Outlook is not to predict or forecast how the energy system is likely to change over time.

All the scenarios discussed in this year's Outlook will be wrong.

We can't predict the future.

Moreover, we know we can't predict the future.

Rather, the role of the Outlook is to help better understand the range of uncertainty we face.

Which developments seem pretty similar across a range of scenarios? And which are highly dependent on the precise policy or technology assumptions made?

Improving our understanding of this uncertainty is important input into designing a strategy that is robust and resilient to the range of different outcomes we may face.

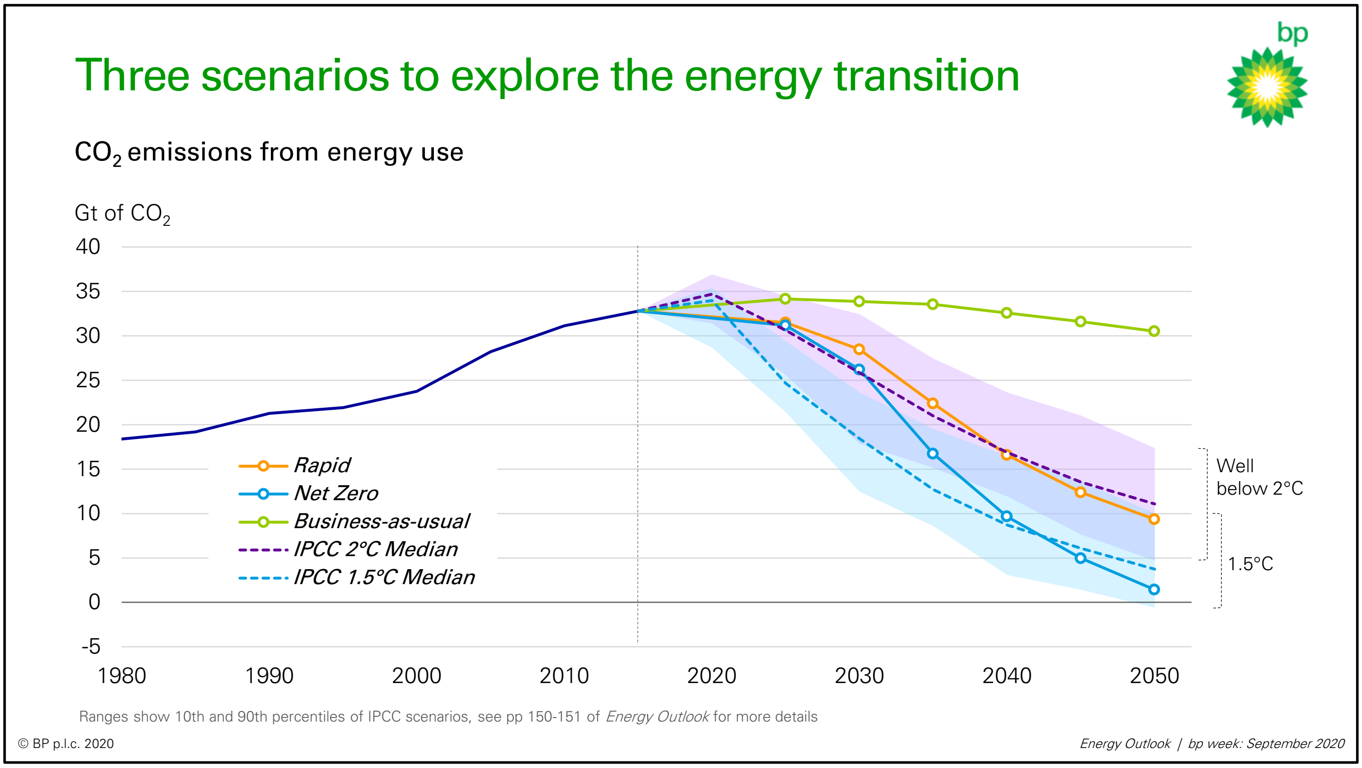
As Bernard said – that's why we're launching this year's Outlook as part of *bp week*, which is looking in depth at bp's new strategy.

A key part of bp's new ambition is also to help the world get to net zero.

In that context, I hope this year's Outlook will be of use to others who are seeking ways to accelerate the energy transition and get to net zero.

So lots of new analysis in this year's bumper booklet.

If we start to take a peek inside……



…much of the analysis is focussed around three main scenarios which explore the possible nature of the energy transition over the next 30 years.

Rapid – shown here in orange - is based on a series of policy measures, led by a significant increase in carbon prices, such that carbon emissions from energy use fall by around 70% by 2050.

This scenario is broadly comparable to the "Rapid Transition Scenario" included in last year's

Net Zero – in blue – assumes that the policies in *Rapid* are reinforced by significant shifts in societal behaviours and preferences which further accelerate the reduction in carbon emissions.

The design of *Net Zero* is based on the view that there are limits to the extent to which a really accelerated energy transition can be driven solely by government policies.

Government policies may need to be reinforced by shifting societal preferences.

As the name suggests, carbon emissions from energy use are almost entirely eliminated in *Net Zero*, falling by over 95% by 2050.

And finally, *business-as-usual* - or *BAU* – shown in green, which assumes that government policies, technologies and social preferences continue to evolve in a manner and speed seen over the recent past.

A continuation of that progress – albeit slow – is enough to cause carbon emissions to peak by the mid-2020s, but little progress is made in actually decarbonising the energy system, with carbon emissions by 2050 around 10% below 2018 levels.

BAU is broadly comparable to last year's "Evolving Transition Scenario".

Primary energy demand increases over the next 10-to-15 years in *Rapid* and *Net Zero* before broadly plateauing, as gains in energy efficiency accelerate further.

In contrast, energy demand grows over the entire outlook in *BAU*.

In all three scenarios, the growth in energy demand is driven entirely by emerging economies, as prosperity and living standards improve.

In the main booklet, we describe how it's possible to compare these carbon pathways with the range of scenarios included in the 2019 IPCC Report…

…where this pink swathe shows the range of IPCC scenarios judged to be consistent with maintaining temperature rises well below 2°C….

…. and the blue swathe, the range of scenarios consistent with maintaining temperature rises below 1.5°C.

As you can see, *Rapid* is broadly in the middle of the pink "well below 2°C" swathe.

For *Net Zero*, the initial pace of decline in carbon emissions is outside the "below 1.5°C" swathe, but by the second half of the Outlook, it falls to the lower half of that range.

As always, the full booklet contains lots more than I can do justice to today.

So, if today's discussion whets your appetite, please do go on-line and delve deeper.

Today's discussion is built around eight questions.

Although there are many, many questions surrounding the energy transition, but most of my discussions with Bernard, Giulia and the rest of the strategy team over the past year as the new strategy has been developed have revolved around these eight questions:

Key questions

1. What DO we know?
2. How has Covid-19 affected the outlook?
3. How might oil demand be affected by the mobility revolution?
4. What role could natural gas play in the energy transition?
5. Just how quickly will renewables grow over time?
6. How will electricity and power markets shape the future?
7. What role for hydrogen and bioenergy?
8. What are the dangers of delaying the energy transition?

In a world of huge uncertainty, what do we know about how the energy system might change?

How might the Coronavirus pandemic affect the outlook?

What are the prospects for oil demand and how are they shaped by the mobility revolution?

What role could natural gas play in the energy transition?

Just how quickly will renewable energy grow over time – where the options seem to be somewhere between really quick and really, really quick.

How will the growing importance of electricity and power markets shape the energy transition?

What role for hydrogen and bioenergy as the world moves to a low-carbon energy system?

And, finally, what are the potential dangers and costs of delaying the energy transition?

Great questions.

I confess I'm not sure I have equally good answers to all of them.

But I can at least share where our thinking has got to on each of them.

In terms of this first question: what DO we know about how the energy system may change?

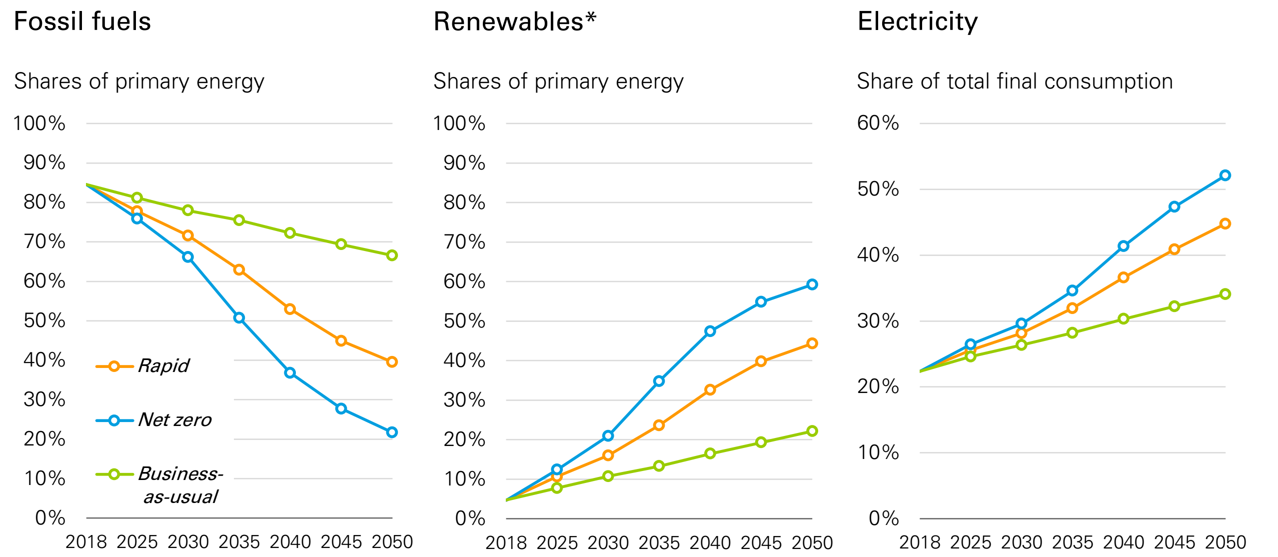
One way into this question: is to consider changes in the energy system which are common across all three of the scenarios.

Although the three scenarios – *Rapid*, *Net Zero* and *BAU* - are by no means comprehensive, they do span a wide spectrum of possible transition paths and outcomes.

As such, if some features of the energy transition are common across all three scenarios, that may give us some confidence that they might materialise in some shape or form.

In that context, three features in particular are worth highlighting.

Changing structure of global energy demand



*Renewables includes wind, solar, geothermal, biomass, biomethane and biofuels and excludes large-scale hydro

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First, the role of fossil fuels – coal, oil and natural gas – declines over time. Falling from around 85% of primary energy in 2018 to between 65% and 20% by 2050 in the three scenarios.

In all three scenarios, this corresponds to a decline in the absolute demand for fossil fuels over the next 30 years.

This would be entirely unprecedented.

In the modern history of energy, there has never been a sustained decline in the consumption of any traded fuel.

The shares of coal and oil have declined over time, but not their "absolute levels of consumption". That changes in all three of the scenarios.

Second, the growth in primary energy is dominated by renewable energy, which for the purposes of the Outlook includes wind, solar, geothermal and bioenergy, but excludes hydroelectricity.

The share of renewables in primary energy increase from 5% in 2018 to between 20 and 60% by 2050 in the three scenarios.

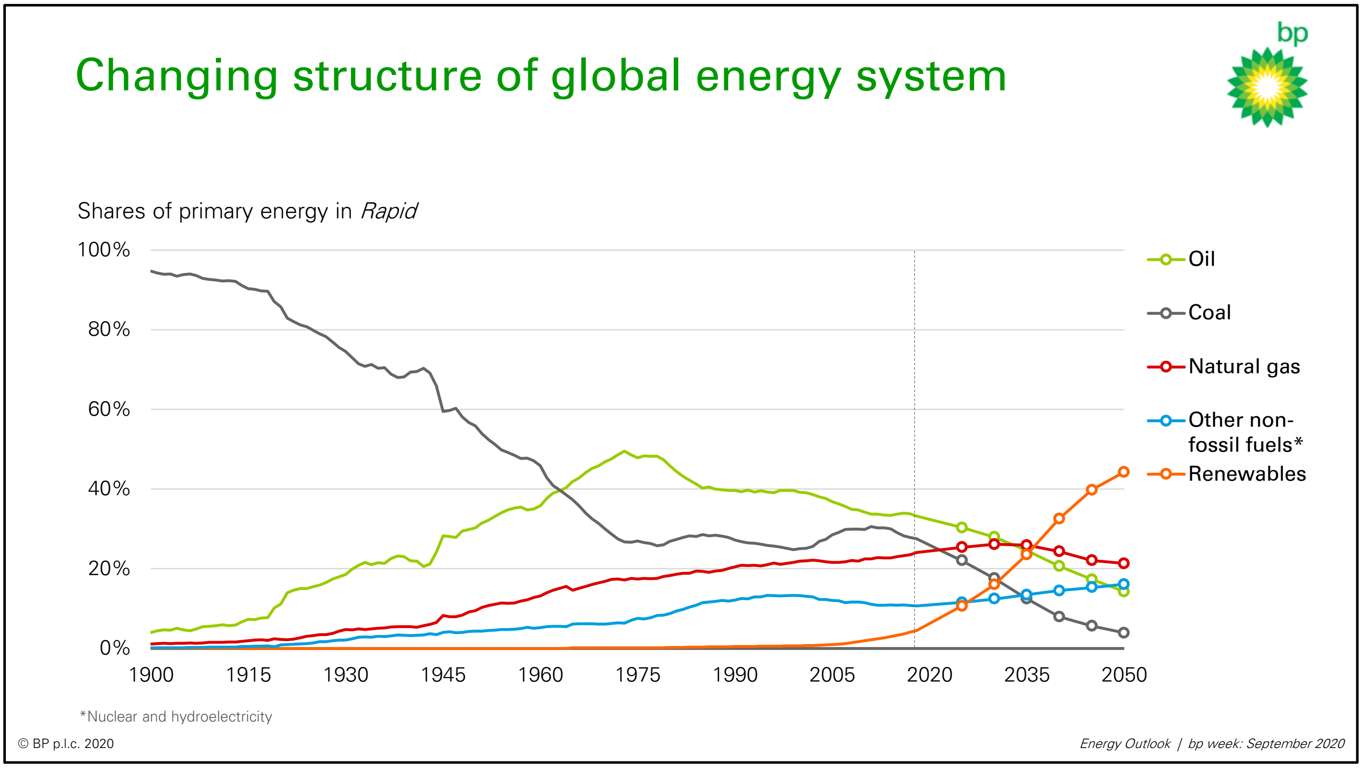
In doing so, renewables in all three scenarios – including BAU – penetrate the energy system more quickly than any fuel in modern history.

Again, unprecedented developments common across all three scenarios.

Third, the growth in renewables is supported by the increasing role of electricity as the world continues to electrify, with the share of electricity in total final energy consumption increasing in all three scenarios.

Three features of energy demand apparent in all three scenarios: a decreasing role for fossil fuels; increasing share of renewable energy; supported by the growing electrification of the energy system.

Another way into this question of "What DO we know" – rather than identify common trends – is to ask how the structure of the energy system may change, if, and when, there is a sustained transition to a lower-carbon energy system?



To do this we can focus on how the energy system evolves in *Rapid*, which to remind you is broadly consistent with maintaining temperature rises well below 2^{o}C.

The point here is not to focus on the precise profiles in *Rapid* since these will vary across different scenarios.

Rather, I want to highlight some more generic features of how the energy system might evolve, if, and when, there is a material transition to a lower-carbon energy system.

Now the eagled eyed amongst you may have spotted this chart starts in 1900 - so it's covering a wide span of history.

The point of doing so is to highlight how – for much of modern history – the global energy system has tended to be dominated by a single energy source.

For the first half of the previous century, coal – in black – provided most of the world's energy.

As the importance of coal declined, oil – shown here in green – became the predominant source.

In contrast, the energy transition in *Rapid* means that for much of the next 20 years, the global energy mix is far more diversified than previously seen: with oil, natural gas, renewables, other non-fossil fuels and coal all providing significant shares of world energy.

This greater variety of fuels means that the mix is likely to be increasingly driven by customer choice rather than fuel availability-which has been the dominant driver for much of the past 100 years.

This more diversified fuel mix will also increase the need for integration across different energy sources and carriers.

Linking back to the previous chart, the growing differentiation is further enhanced in *Rapid* by the increasing importance of electricity and, to a lesser extent, hydrogen.

These energy carriers are more costly and inefficient to transport long distances than traditional hydrocarbons, causing energy markets to become more localised.

The increasing diversification of the fuel mix also leads to greater competition, both across different forms of energy as they compete for market share, and within individual fossil fuels, as resource owners compete to ensure their energy resources are produced against a backdrop of falling demand.

This heightened competition increases the bargaining power of consumers, with economic rents shifting away from traditional upstream producers.

To repeat: the precise timing and extent of these changes will vary across different scenarios.

But a transition to a lower-carbon energy system – if, and when, it happens – seems likely to be characterised by at least some of the generic features highlighted in *Rapid*:

(i) a more diversified fuel mix driven by customer choice, supported by increased levels of integration across fuels,

(ii) increasingly localised energy markets, and

(iii) growing competition with economic rents shifting away from the upstream.

That's all I wanted to say on this first question.

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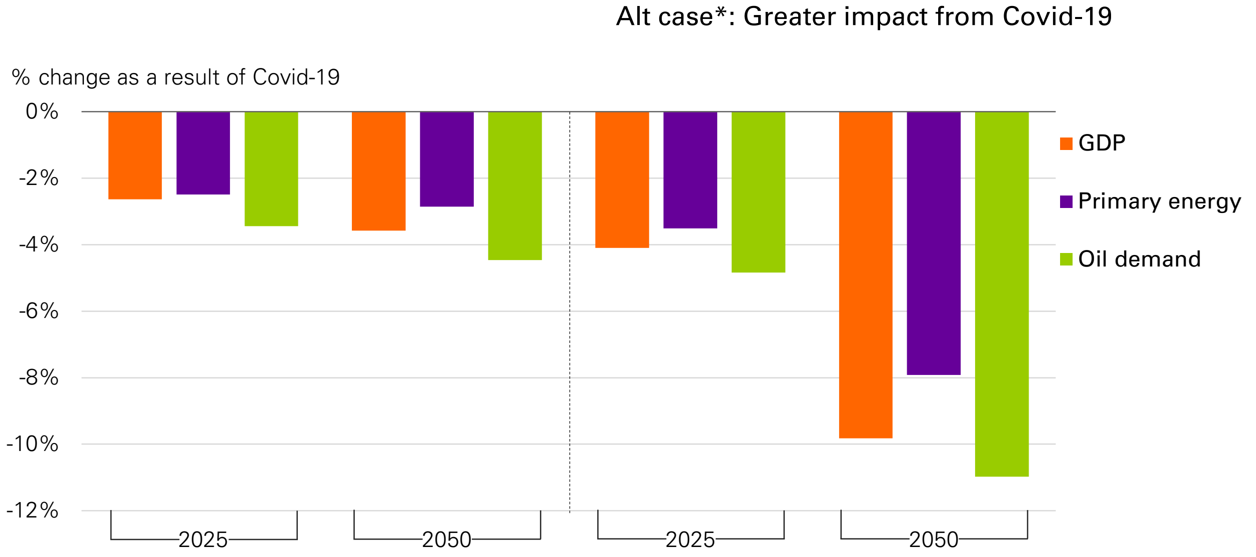
Turning to the next question: How has Covid-19 affected the Outlook?

Impact of Covid-19 in *Rapid*



*Alternative case showing the impact if Covid-19 leads to higher economic losses

The Covid-19 pandemic is primarily a humanitarian crisis, with the reported death toll as of now exceeding 900,000 people.

The fact that the number of new cases continues to increase and there is still no generally approved vaccine means that any assessment of the ultimate impact of the virus on the economy and energy system is obviously very preliminary and highly uncertain.

The central view used in all three scenarios – shown here for *Rapid* – is that economic activity partially recovers from the impact of the pandemic over the next few years – as the virus is brought under control and restrictions are eased – but some effects persist.

The pandemic is assumed to reduce the level of global GDP by around 2.5% in 2025, increasing to 3.5% in 2050.

These economic impacts fall disproportionately on emerging economies – particularly India, Brazil and Africa – whose economic structures are most exposed to the economic fallout from Covid-19.

Energy demand is assumed to be reduced by around 2.5% in 2025 and 3% in 2050.

The majority of this impact stems from the weaker economic environment, but there is also an assumed impact from the various behavioural changes triggered by the pandemic, as people travel less, switch away from public transport into alternative modes of travel, and work from home more frequently.

Many of these behavioural changes are projected to dissipate over time as the virus subsides and public confidence is restored. But some changes, particularly increased working from home, are assumed to persist.

As shown in the green bars, the impacts from the virus are most pronounced on oil demand, reducing consumption by around 3 Mb/d in 2025 and 2 Mb/d in 2050.

The greater impact on oil demand largely reflects the disproportionate impact of the virus on emerging economies, which are the principle source of oil demand growth over the Outlook….

….and – to a lesser extent – the impact of the behavioural changes which are concentrated in the transport sector.

Although the assumed impacts from Covid-19 don't change the fundamental shape of any of the scenarios, three other points are worth highlighting.

First, the impact of Covid-19 on oil demand means that in both *Rapid* and *Net Zero*, the level of demand never recovers to its pre-crisis level.

As such, the pandemic has the effect of bringing forward the implied peaking in oil demand to 2019 in both *Rapid* and *Net Zero*.

The same is also true for the profile of "carbon emissions from energy use", which also peaks in 2019 in both *Rapid* and *Net Zero*.

Second, there is considerable risk that the impact from Coronavirus may be greater than the central assumption.

The main booklet considers an alternative case – shown here in the right-hand chart - in which Covid-19 reduces the level of global GDP by 4% in 2025 and by almost 10% in 2050, with correspondingly bigger impacts on the demand for energy.

Third, it's possible that the fragilities exposed by Covid-19, together with the growing commitment to build back better – supported by unprecedented levels of government intervention – may help to accelerate the energy transition.

That possibility is not explored explicitly in the Outlook – which doesn't attach weights to the different scenarios – but if that were the case, the impact of Covid-19 on the future energy system could be far more substantial.

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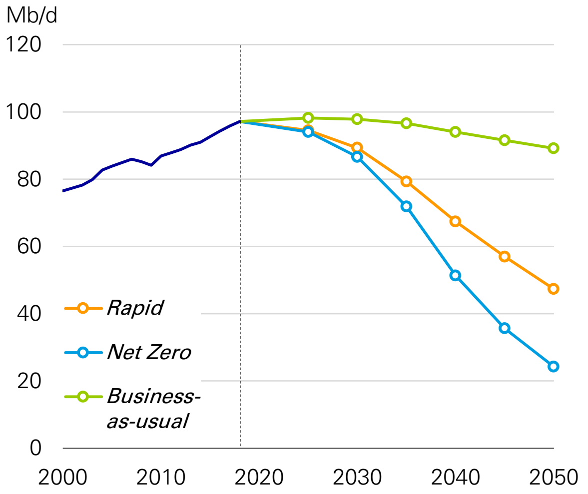
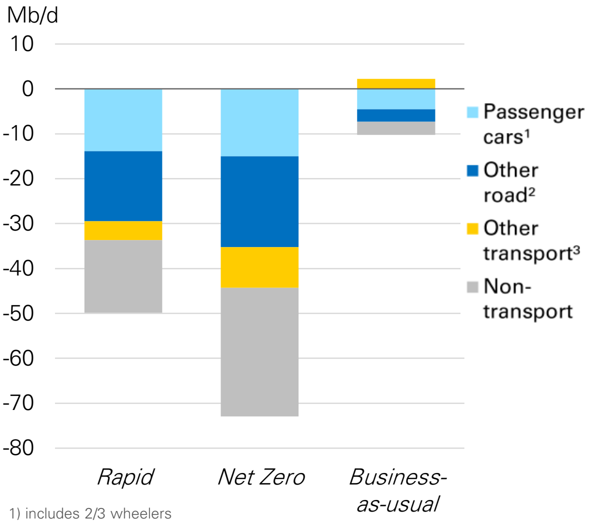
The third question concerns the outlook for oil demand and how that might be affected by the mobility revolution?

Outlook for oil demand

Oil consumption



Change in oil demand, 2018-2050



1) includes 2/3 wheelers
2) trucks and buses
3) aviation, marine and rail

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Oil demand falls over the Outlook in all three scenarios.

This decline is most pronounced in *Rapid* and *Net Zero* – in which after peaking in 2019 at close to 100 Mb/d – oil demand by 2050 falls to a little below 50 Mb/d in *Rapid* and to around 25 Mb/d in *Net Zero*.

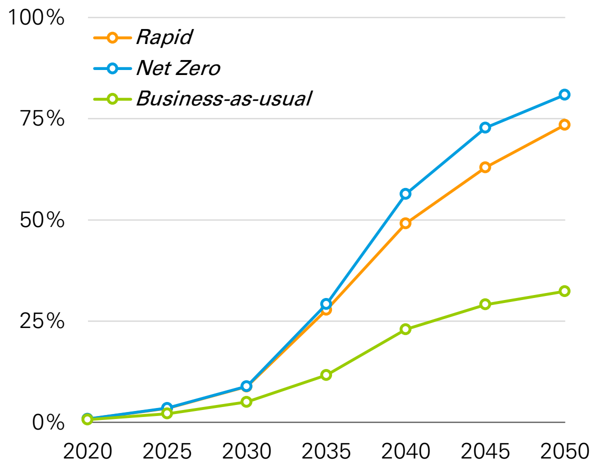
The outlook for oil consumption in BAU is more resilient, with demand recovering to around its pre-Covid levels, where it remains for the next 10-to-15 years, before edging gradually lower in the second half of the Outlook to around 90 Mb/d by 2050.

The scale and pace of these falls stem primarily from the "increasing efficiency and electrification of road transportation", with the declining use of oil within road transport – shown here by the two blue bars – accounting for between 50 and 60% of the total reduction in oil demand in *Rapid* and *Net Zero,* and an even greater proportion in BAU.

If we dig a little deeper into the role of electrification….

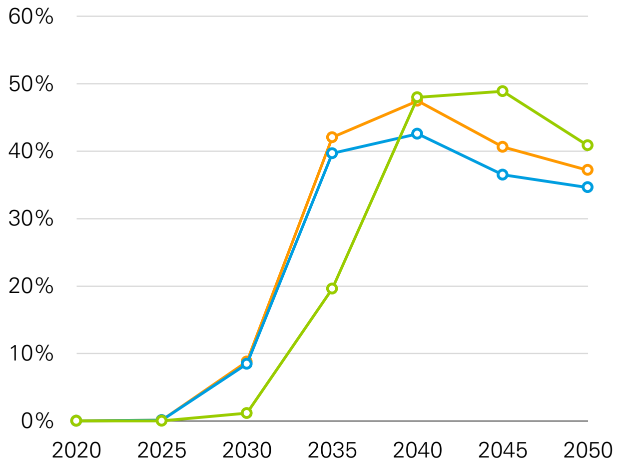
Mobility revolution: electrification, shared-mobility and autonomy

Share of car and truck VKM[1] electrified[2]



1) vehicle kilometres
2) includes buses

Robotaxi share of passenger car VKM[1] powered by electricity



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…the electrification of road transportation is most pronounced in *Rapid* and *Net Zero*, supported by ever tightening vehicle efficiency standards, higher carbon prices and – especially within *Net Zero* – a further shift in societal preferences towards electric vehicles.

By 2050, upwards of three-quarters of all kilometres travelled by passenger car and trucks are electrified in *Rapid* and *Net Zero*.

Even in *BAU*, over 25% of road transportation is electrified by 2050, compared with less than 1% in 2018.

On the passenger car side, the steep rise in the electrification of road transportation from the early 2030s is driven by the interaction of "electric vehicles, with shared mobility and autonomous vehicles".

The three elements combining to revolutionise the mobility sector.

The emergence of fully autonomous vehicles from the early 2030s in *Rapid* and *Net Zero* significantly reduces the cost of shared-mobility services, causing consumers to shift away from both public transport and private vehicles into these so-called robotaxis.

Think: fully autonomous Uber or Didi.

Now: the important point here is that the vast majority of these robotaxis are electrified.

That partly reflects the lower running costs of electric vehicles – which really matters for robotaxis since they are driven far more intensely than privately-owned cars.

It's also supported by the improved air quality associated with electric vehicles, especially in major cities and towns where the use of robotaxis is concentrated.

As you can see from the slide on the right, the competitiveness of robotaxis, combined with their greater intensity-of-use, means that by the early 2040s in all three scenarios, they account for between 40-50% of passenger car kilometres powered by electricity.

The nature of the mobility revolution – particularly with the emergence of autonomous vehicles – means electrification is likely to go hand-in-hand with the increasing importance of shared-mobility services.

That's the interaction of oil demand with the mobility revolution…

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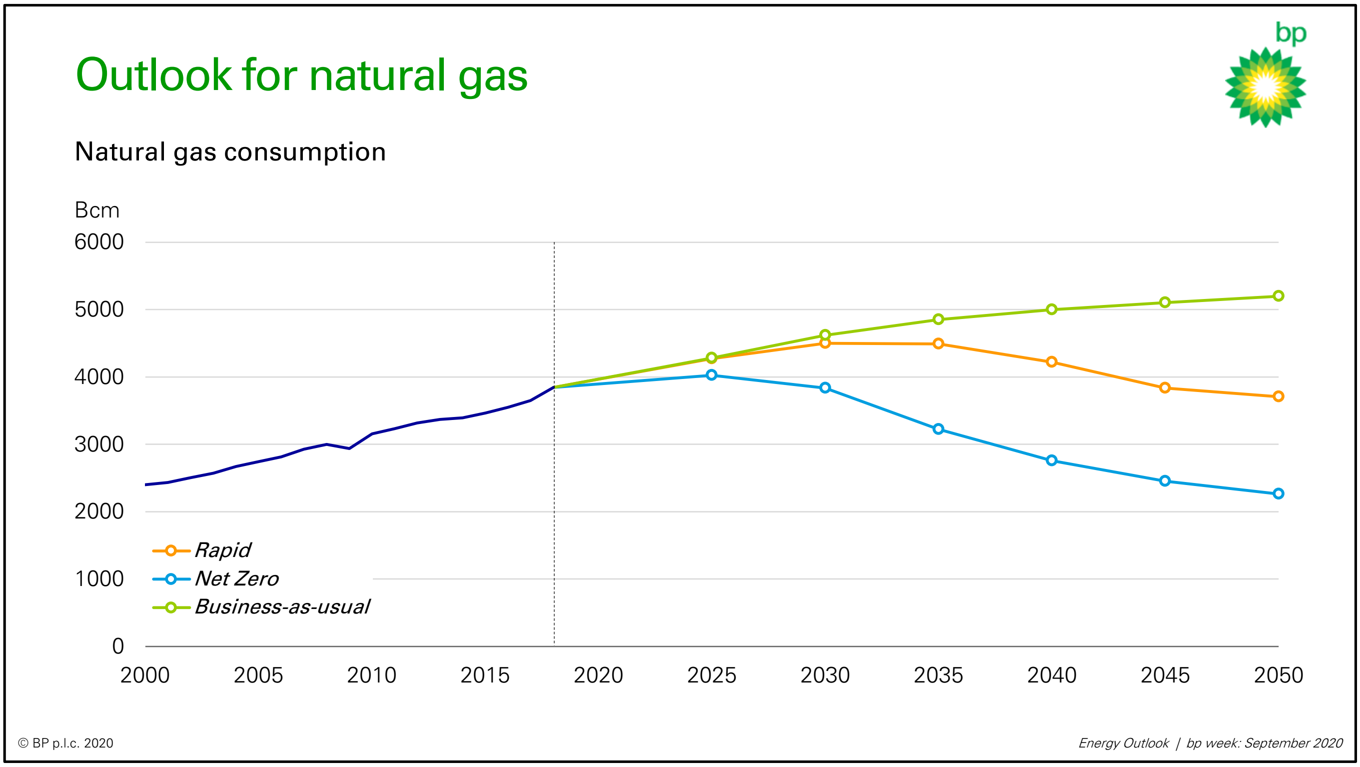
…the next question concerns the role that natural gas might play in the energy transition.



The outlook for natural gas is more resilient than for oil in all three scenarios.

Take, for example, the outlook in *Rapid*.

You may recall that oil consumption in *Rapid* peaked in 2019 and fell by around 50% by 2050.

In contrast, consumption of natural gas in *Rapid* continues to grow for the next 15 years or so. It subsequently declines, but only to slightly below its current level.

This more resilient outlook for natural gas reflects two main components:

the role of natural gas in supporting a shift away from coal in fast growing, developing economies, particularly in Asia over the next 15 years or so; and

the role of natural gas when combined with Carbon Capture Use and Storage – CCUS – as a source of near zero-carbon energy as the world increasingly decarbonises.

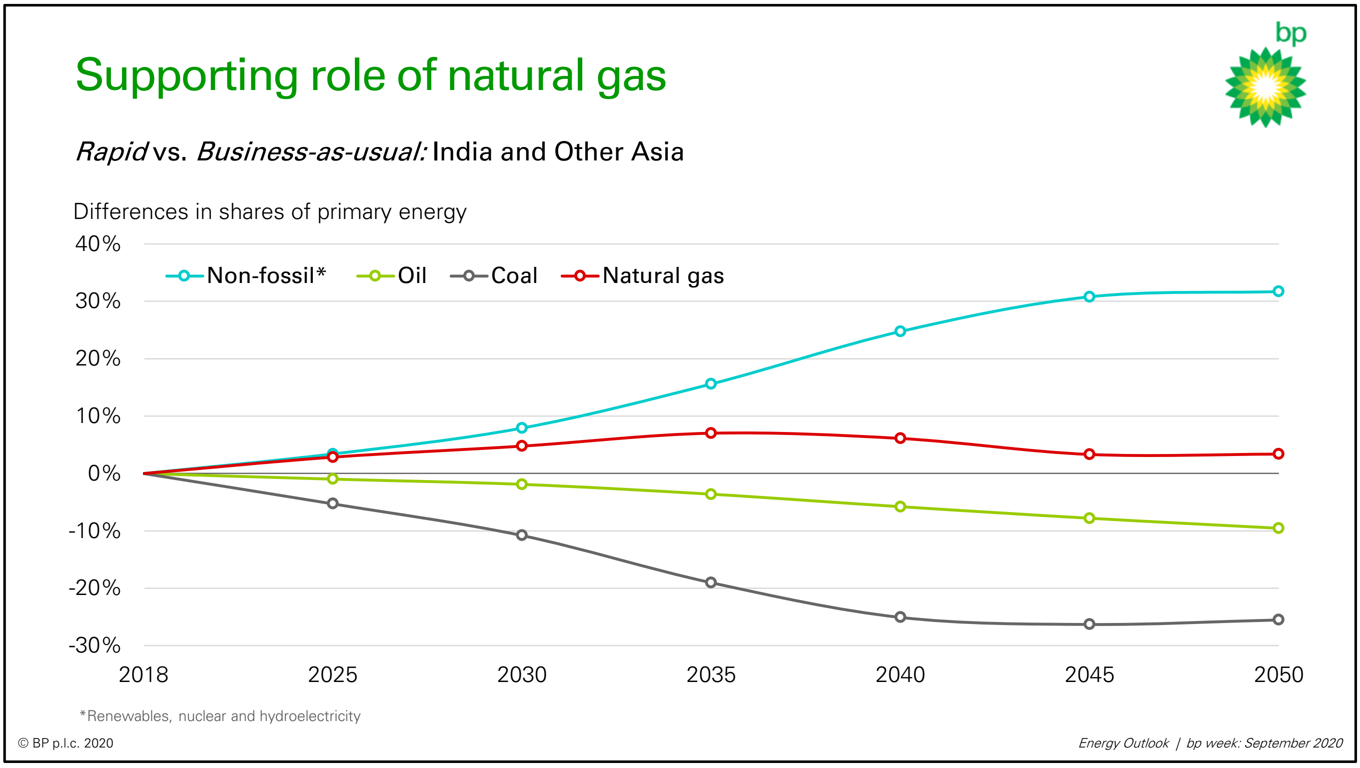
Lets take these two components in turn.

The role of natural gas in supporting a shift away from coal stems from the possibility that renewables and other non-fossil fuels may not be able to grow sufficiently quickly to replace the coal on their own, at least in the short-to-medium run.

This may particularly be the case in emerging economies in which energy demand is growing quickly, making it hard for non-fossil fuels to both meet the growing new demand and replace the existing coal.

In these situations, natural gas may also need to increase for a period to help fill the gap left by coal.

This next chart illustrates this supporting role….



The idea of the chart is to consider the role of natural gas in a scenario is which there is an accelerated energy transition – such as in *Rapid* – compared with a slower transition, like *BAU*.

And the chart focusses on India and other parts of developing Asia where energy demand is growing quickly, and so there is greatest need for this supporting role.

The chart compares how the shares of different types of energy evolve in *Rapid* relative to those in *BAU*.

In particular, the black line shows how the share of coal in *Rapid* declines far more quickly than in *BAU* reflecting the faster pace of decarbonisation.

A similar – but less pronounced – trend can also be seen for the relative shares of oil – shown in green.

Much of this faster decline in the role of coal and oil is offset by faster growth in the share of renewables and other non-fossil fuels – shown by the blue line.

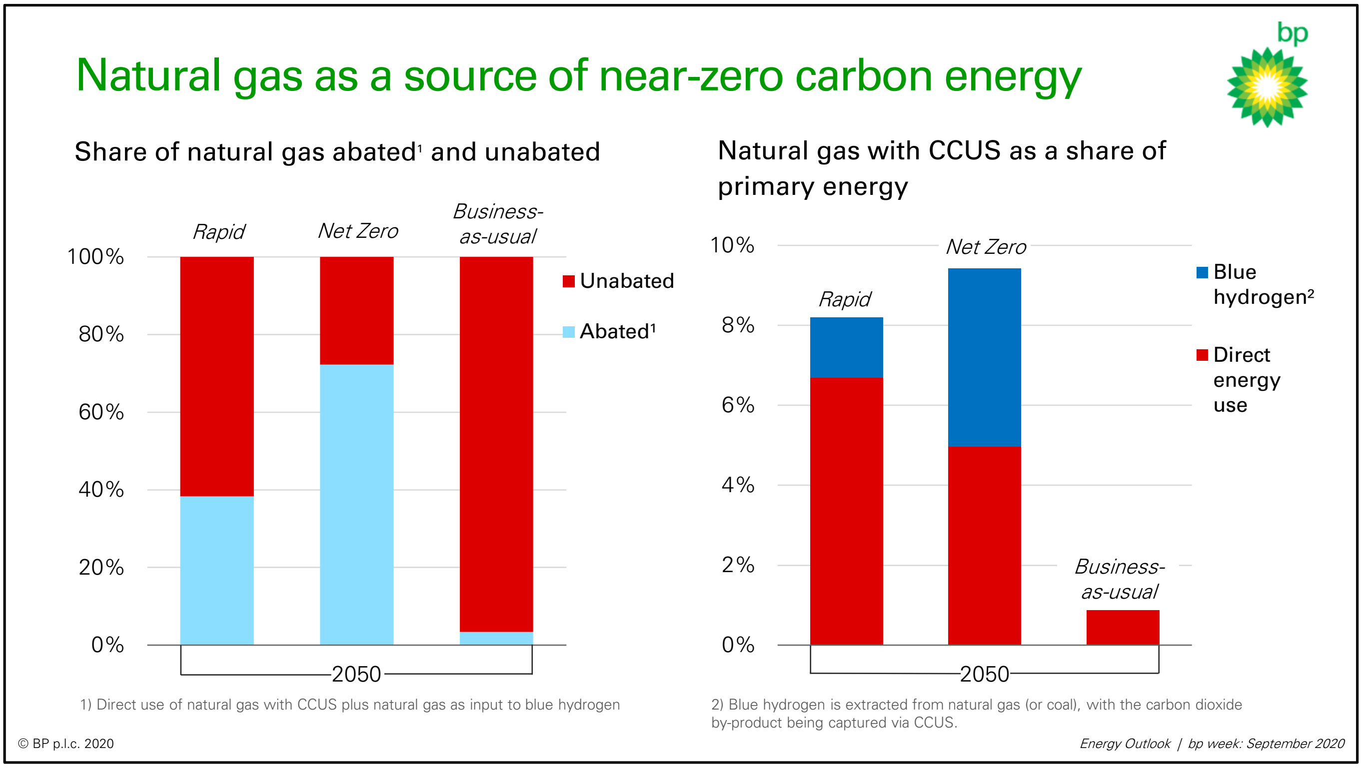
Indeed, renewable energy increases more than 30-fold by 2050.

But even that is not fast enough to fill all of the gap left by coal and oil.

And so the share of natural gas – shown in red – also increases, particularly over the first half of the Outlook.

To put these movements in context: natural gas demand in India and other Asia more than doubles over the first 15 years in *Rapid*, accounting for around two-thirds of the global growth in demand over this period.

So the boost to natural gas from this supporting role in scenarios like *Rapid* – in which there is a relatively fast energy transition – can be quite substantial.



The second component underpinning the relative resilience of natural gas is its increasing role of a source of near-zero carbon energy, when combined with CCUS.

By 2050, around 40% of the natural gas consumed in *Rapid* is used in conjunction with CCUS, capturing over 2.5 Gigatonnes of Co2 emissions.

This share is even higher in *Net Zero*, with around three-quarters of natural gas used with CCUS.

As you can see in the chart on the right, natural gas used with CCUS accounts for between 8 and 10% of primary energy in 2050 in *Rapid* and *Net Zero*…

…providing near-zero carbon energy both directly to the industrial and power sectors and indirectly via the production of blue hydrogen.

I will say more about hydrogen in just a moment...

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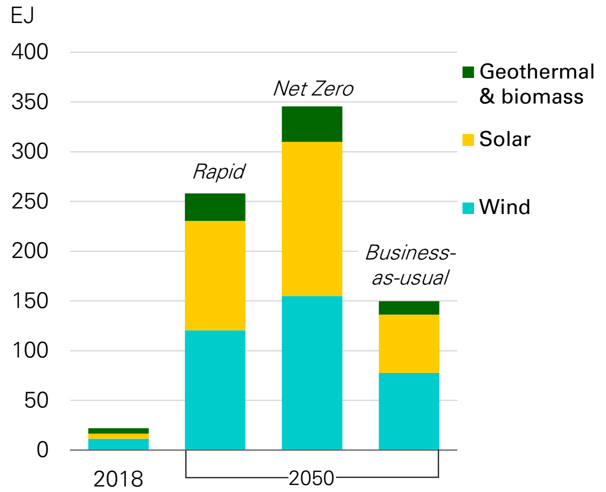
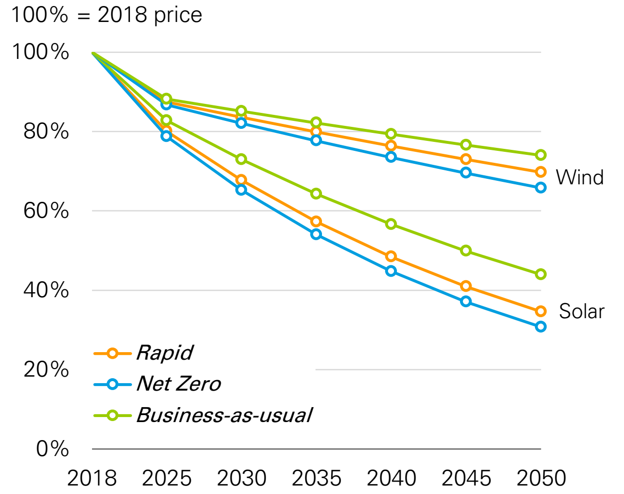
…but before I do, I want to turn the fifth question: Just how quickly will renewables grow over the next 30 years?

Renewable energy in power

Renewable energy used in power sector*



Cost of wind and solar energy

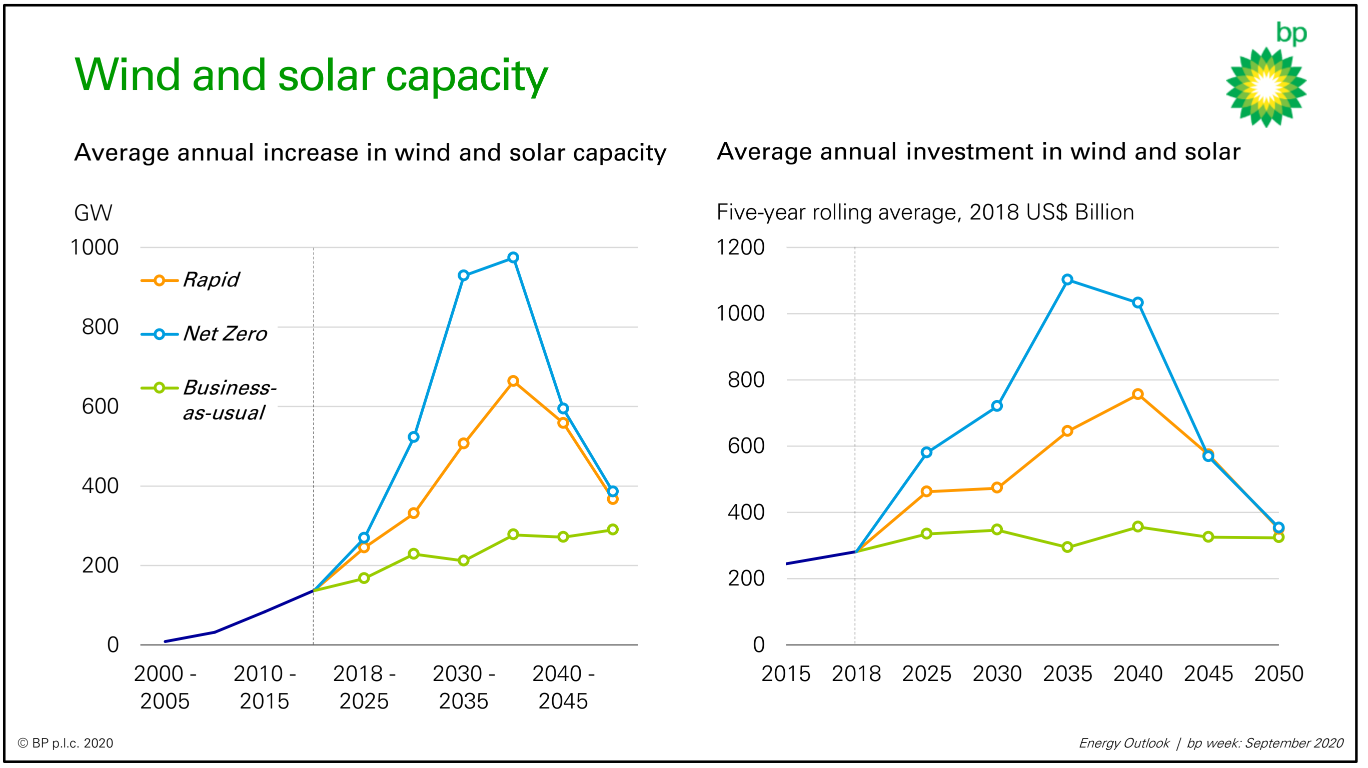


*On a primary energy basis (see *Energy Outlook* p154 for more details)

The focus here is on renewable energy used in the power sector, which includes wind and solar power, biomass and geothermal.

As I mentioned at the outset, renewable energy increases sharply in all three scenarios, led by wind and solar power – shown here in blue and yellow respectively.

As shown on the chart of the right, this strong growth is underpinned by continuing pronounced falls in the cost of wind and solar energy, as they move down their learning curves; with solar costs falling by close to 60% or more in all three scenarios over the next 30 years.



This rapid growth in wind and solar power generation is made possible by a significant acceleration in the development of new wind and solar capacity.

As you can see from this chart, the growth in new capacity is particularly pronounced in *Rapid* and *Net Zero* over the next 15 years or so, with increases in new capacity averaging close to 350 GW per year in *Rapid* and almost 550 GW per year in *Net Zero*.

That compares with record increases seen in recent years of around 150 GW – so a pronounced acceleration.

The sharp slowing in the built-out rate in the second half of the Outlook reflects an easing in the pace at which wind and solar penetrate the power sector as the intermittency costs associated with their increasing use grows.

Although the pace of new capacity development in BAU is less dramatic, average increases of between 200-300 GW per year are still significantly greater than recent build out rates.

So, all three scenarios pointing to a significant pickup in the pace of wind and solar development.

This faster pace of build out in turn implies a significant increase in the level of investment needed to finance this development – shown on the chart on the right.

The average investment in wind and solar capacity in *Rapid* and *Net Zero* is between 500-750 bn dollars per year.

That is several times greater than recent investment levels in wind and solar, and also considerably higher than the levels of investment in upstream oil and gas in these two scenarios.

These levels of investment in wind and solar power may seem eye-bogglingly high. But it's worth noting that they are roughly equivalent to only around 3% of total global business investment in 2019.

So, they are perfectly achievable if there is sufficient collective will and support.

And there is more analysis of the investment implications of the different scenarios in the main booklet.

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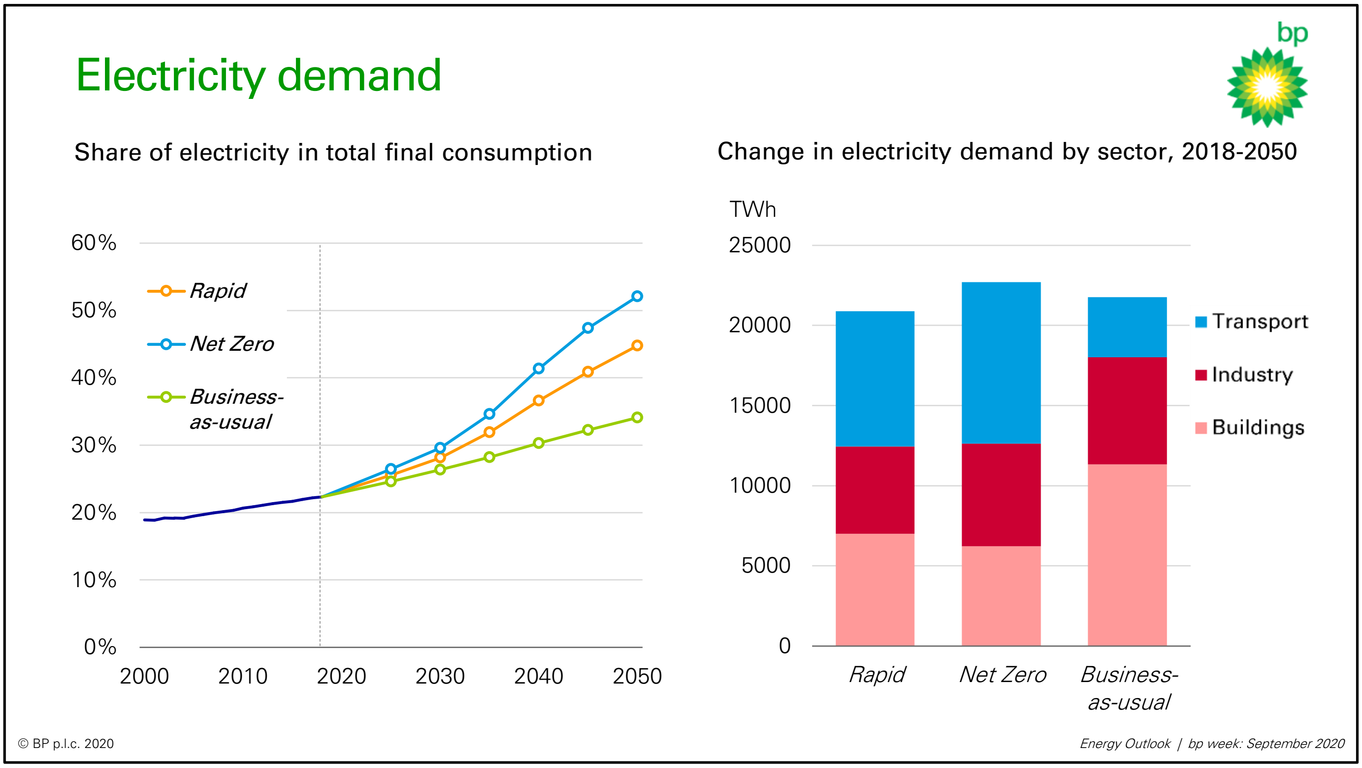
The strong growth in renewable energy goes hand-in-hand with the increasing electrification of the energy system – which is the focus of our next question.



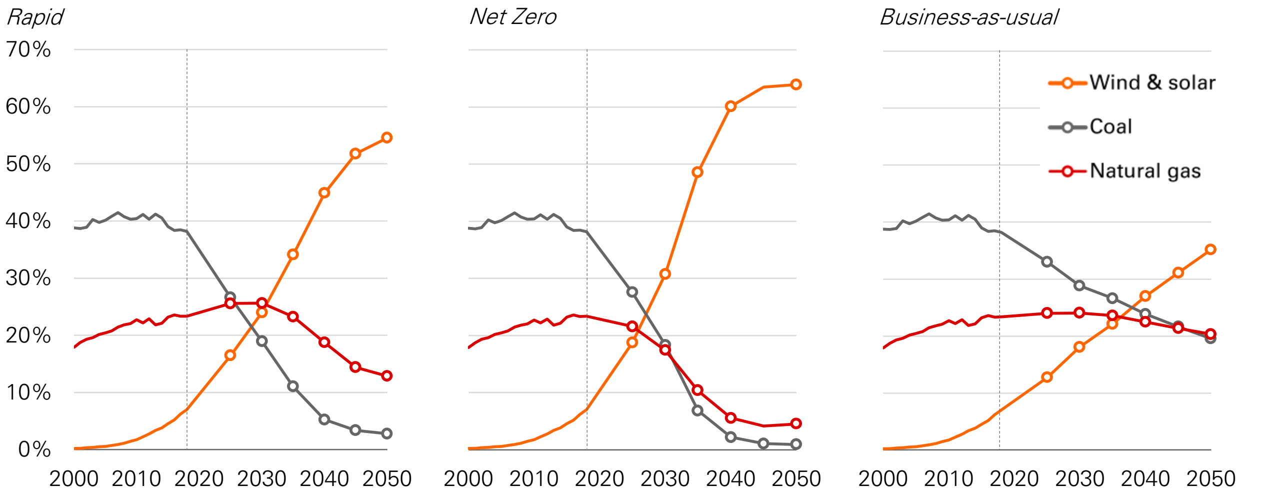
As I mentioned earlier, the share of electricity in total final energy use increases in all three scenarios.

What's also striking – as shown on the right-hand chart – is that the increase in electricity demand is very similar in all three scenarios, growing by around 80% over the next 30 years.

Strong growth in electricity in all three scenarios.

Global power generation

Share of global power generation by energy source



In terms of the power sector generating this electricity, the key common trend in all three scenarios is a shift to a lower-carbon energy mix, driven by wind and solar power – shown here in orange – gaining share relative to coal – in black.

This shift in the fuel mix underpins the strong growth in renewables we just spoke about.

Moreover, it plays a crucial role in decarbonising the entire energy system.

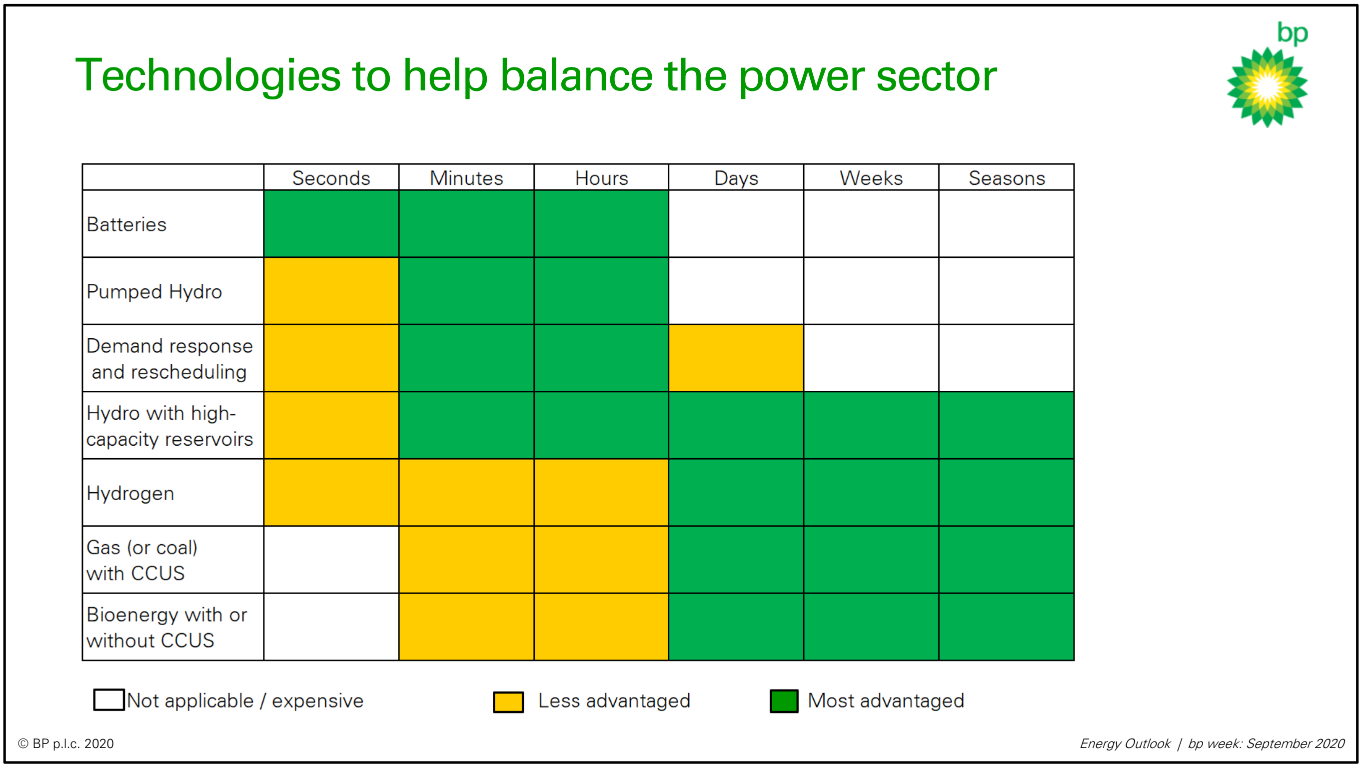
A move to greater electrification – be it in transport or heating or industry – has little benefit if the energy used to generate that electricity is not decarbonised.

The carbon intensity of power generation in *Rapid* falls by 90% by 2050, compared with just 50% in *BAU*.

Indeed, in BAU, the power sector remains the largest single source of carbon emissions over the entire outlook.

In contrast, in *Net Zero*, the increasing use of bioenergy combined with CCUS – so-called BECCS – means that Co2 emissions from the power sector are net negative by 2050.

The shift towards an ever-increasing share of wind and solar power begins to flatten out in the 2040s in both *Rapid* and *Net Zero*, as the cost of managing the associated intermittency rises.



Batteries play an increasing role in managing this intermittency.

But it’s important to remember that balancing issues don’t just arise over very short-term intervals – seconds, minutes and hours – they also concern much longer periods – across days, weeks and, importantly, seasons.

Batteries – at least based on current technologies – are less well equipped to deal with managing these longer frequencies.

And so – as this diagram suggests – as the importance of wind and solar power increases in different power systems, a variety of technologies and responses to balancing the energy system and ensuring the availability of firm power are likely to be needed, including hydrogen, bioenergy and natural gas with CCUS.

So, the increasing use of electricity and the changing mix of power generation likely to play a central role in shaping global energy markets over the next 30 years.

Key questions

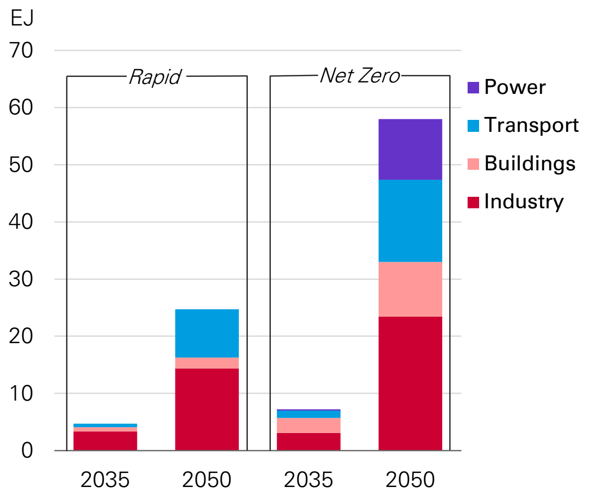
1. What DO we know?
2. How has Covid-19 affected the outlook?
3. How might oil demand be affected by the mobility revolution?
4. What role could natural gas play in the energy transition?
5. Just how quickly will renewables grow over time?
6. How will electricity and power markets shape the future?
7. What role for hydrogen and bioenergy?
8. What are the dangers of delaying the energy transition?

Thinking about the essential characteristics of a low-carbon pathway, decarbonising the power sector and electrifying end-energy-uses are core components.

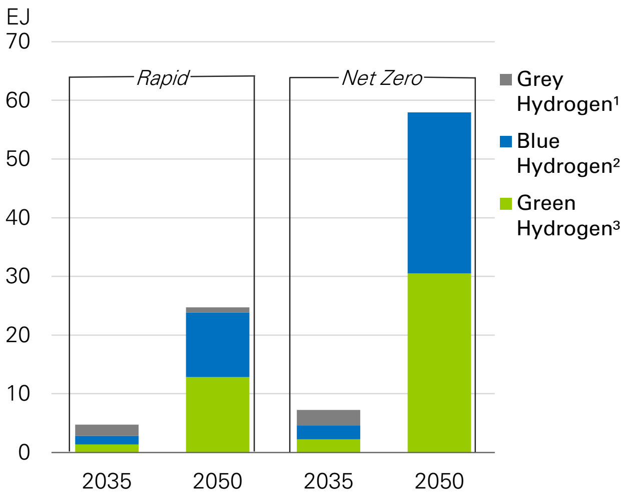
But not all activities can be easily or efficiently electrified – meaning there is a role for other types of energy and energy carriers in a low-carbon transition, including hydrogen and bioenergy – which is the focus of the next question.

Consumption and production of hydrogen

Hydrogen use by sector



Hydrogen production by type



1) produced from natural gas (or coal), without CCUS.
2) produced from natural gas (or coal) with CCUS
3) made by electrolysis, using renewable power

The use of hydrogen as an energy carrier increases significantly in the second half of the Outlook in both *Rapid* and *Net Zero*.

The role of hydrogen in *BAU* is far more limited and so is not included on these charts.

Hydrogen complements the increasing electrification of the energy system in *Rapid* and *Net Zero* by providing energy to activities which are difficult or costly to electrify, including high-temperature processes in industry and long-distance transportation, particularly heavy-duty trucks.

By 2050, hydrogen accounts for around 6% of total-final-energy-consumption in *Rapid* and over 15% in *Net Zero*.

The production of hydrogen in both scenarios is dominated by so-called green and blue hydrogen.

In the Outlook, all the green hydrogen is assumed to be made by electrolysis of water using renewable power; the blue hydrogen is mainly extracted from natural gas combined with CCUS.

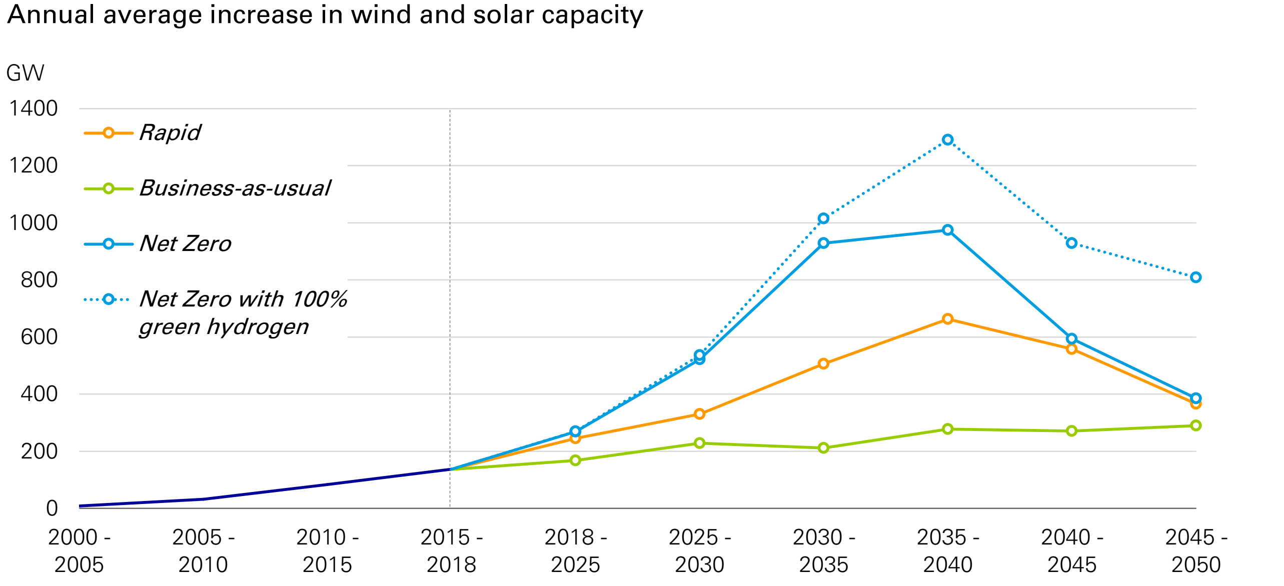
By 2050, there are broadly equal amounts of blue and green hydrogen in both scenarios.

Importantly, the production of blue hydrogen helps overall global supplies of hydrogen to grow relatively quickly, without relying too heavily on renewable energy.

This matters for two reasons.

First, relying exclusively on green hydrogen would require an even faster expansion in wind and solar capacity.

Wind and solar capacity



You may recall this chart from earlier, showing the sharp acceleration in wind and solar capacity in the three scenarios.

In the extreme case, in which all hydrogen was produced using wind and solar power, to achieve the same production of hydrogen as in *Net Zero*, would require wind and solar capacity to grow even faster…

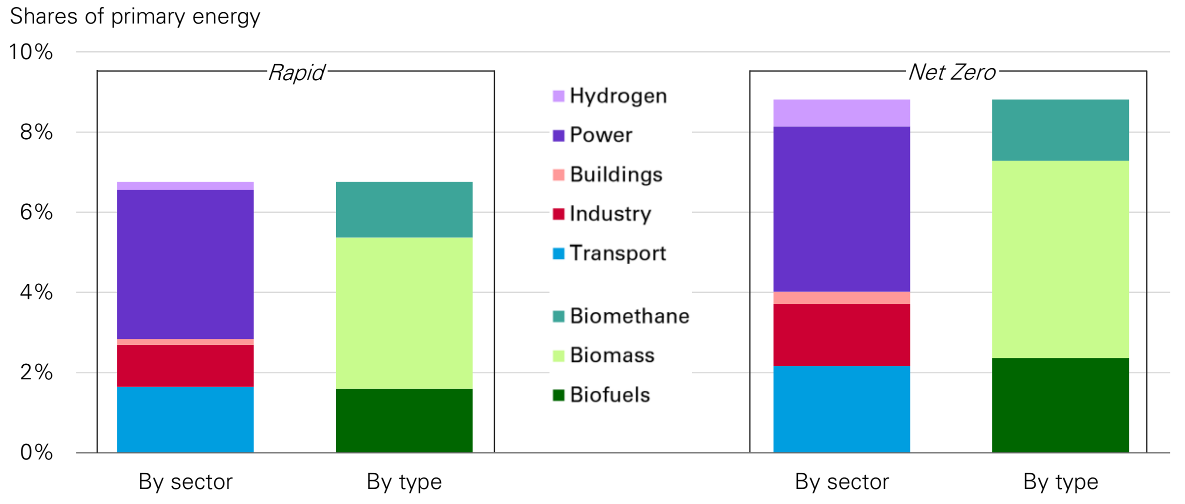
…shown by this dotted line.

The general point here: is that relying too heavily on green hydrogen could constrain the pace at which the hydrogen economy can grow.

Second, the production of green hydrogen diverts renewable energy that could otherwise be used to decarbonise the electricity used in everyday uses.

This is important given that the vast majority of domestic power sectors are not fully decarbonised over the first 20 years or so of the Outlook.

Bioenergy in *Rapid* and *Net Zero*



The shift away from fossil fuels and towards a low-carbon energy system in *Rapid* and *Net Zero* also leads to an increasing role for bioenergy.

The bioenergy takes several different forms, with….

Biofuels – used mainly in long-distance transportation – doubling or more in the two scenarios;

Biomethane – increasingly used as a direct substitute for natural gas, accounting for between 6-10% of total gas consumption by 2050 in *Rapid* and *Net Zero*; and

Biomass used predominantly in the power sector.

By 2050, bioenergy accounts for around 7% of primary energy in *Rapid* and close to 10% in *Net Zero*.

Key questions

1. What DO we know?
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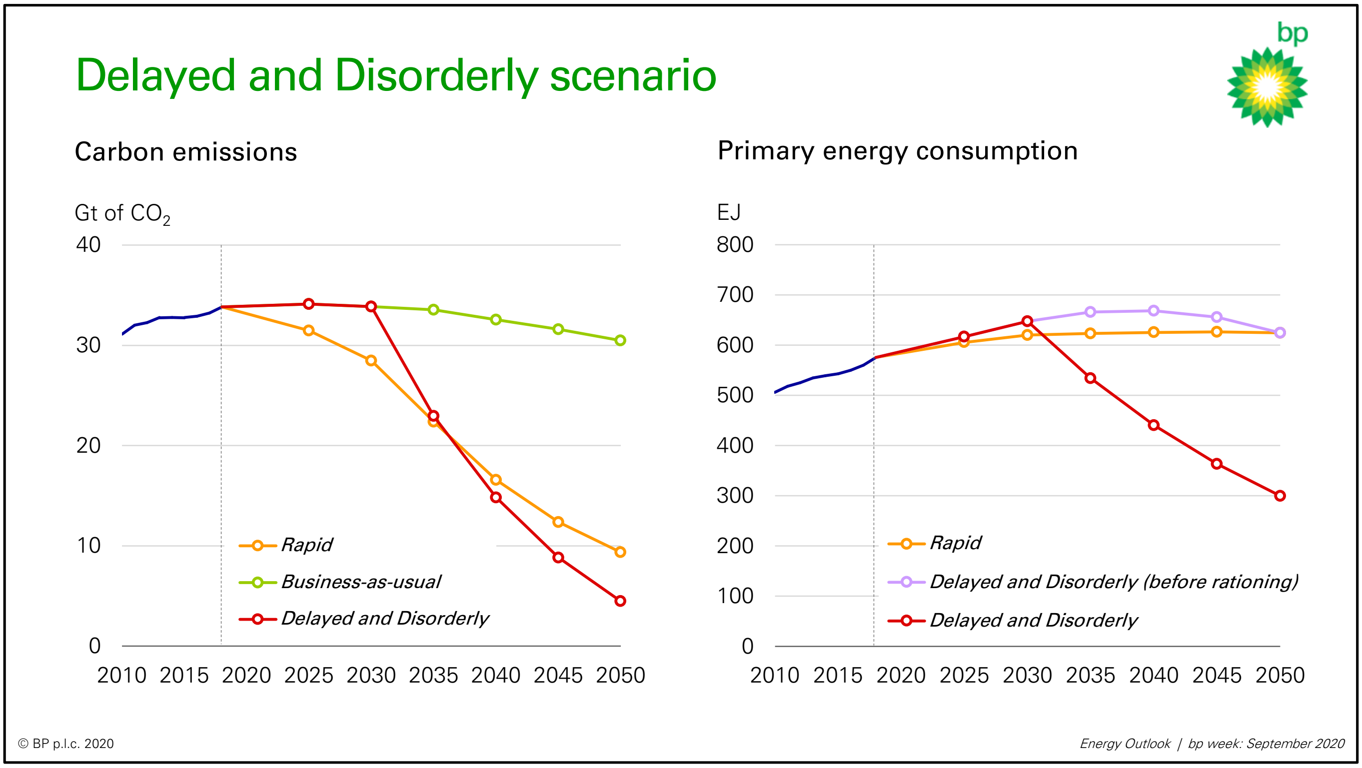
Our final question concerns the dangers of delaying the start of a decisive transition to a low-carbon energy system.

Rapid and *Net Zero* both assume that governments-and-society begin to change policy-and-behaviour relatively quickly, such that carbon emissions from energy use start to fall over the next few years.

But, in reality, there could be an extended delay before these types of changes are implemented, with the world continuing on its current, unsustainable path.



This possibility is explored in an alternative *Delayed and Disorderly* scenario, in which the global energy system is assumed to move in line with *BAU* until 2030, after which sufficient policies and actions are undertaken, such that cumulative carbon emissions over the entire Outlook are the same as in *Rapid*.

This assumed target for cumulative carbon emissions reflects the existence of a finite carbon budget, which implies that continuing high levels of emissions in the near-term have to be compensated for at a later date.

This is shown by the red line in this chart, where the period of continuing high levels of carbon emissions over the next 10 years is compensated by a period further out in which carbon emissions are lower than in *Rapid*.

Delayed and Disorderly is based on the view that the longer the world continues along an unstable path, the greater the likelihood that societal pressures will grow, triggering a decisive change.

To paraphrase the late, great German economist Rudi Dornbusch "the energy transition can take much longer to come than you think, but then happen much faster than expected".

The scenario is obviously very stylised since the nature of any delayed transition path will depend on the factors triggering the eventual change and the subsequent response of government and society.

But importantly, the scenario is based on the assumption that it's not possible to make greater progress in energy efficiency or fuel switching by 2050 than is achieved in *Rapid*.

The significance of this is that there are real costs to delay.

If the required reductions in carbon emissions cannot be met through energy efficiency or fuel switching, the only other way they can be achieved in this scenario is via widespread energy rationing.

That is, policies which stop or restrict energy-using outputs or activities – generating significant economic costs and disruption.

Now, in reality, other options may be possible rather than outright rationing, such as various negative emissions technologies.

But the general point is that, the existence of a finite carbon budget, means that the longer the world continues on an unsustainable path and decisive action is delayed, the more costly and disruptive the eventual pathway is likely to be.

The famous adage by Rudi Dornbusch was based on an earlier observation from the American economist Harold Stein, which states that "if something cannot go on forever, it will stop."

When applied to the current unsustainable path of the global energy system, Stein's law has pretty clear and important implications.

Sometimes the simplest observations, can be the most insightful.

That all I wanted to say on the eight questions in this whistle stop tour of the new Energy Outlook.

To conclude.

This year's Outlook has changed in several respects.

It has been extended to 2050 to include the period in which – at least in some scenarios – the pace of transition really accelerates.

And the range of scenarios explored in detail has been expanded to help build a clearer sense of the range of uncertainty surrounding the future of the energy system.

That span of uncertainty – and common trends across the scenarios – have helped to inform some core beliefs that underpin bp's new strategy.

Core beliefs as to how the structure of energy demand may change over the next 30 years: with the role of fossil fuels diminishing, offset by the increasing importance of renewable energy and electricity.

And core beliefs as to how the structure of energy markets may evolve as the world transitions to a low-carbon energy system: with a more diverse energy mix, greater consumer choice, more localised energy markets, and increasing levels of integration and competition.

Bernard, Giulia and the rest of the leadership team will be coming back to these core beliefs over the next few days as they discuss the new strategy in more detail.

I've been able to provide only a brief glimpse of the analysis in this year's Outlook.

So if you have time, please do take a look at the full booklet.

And, also please let us know what you think.

We are all very aware of the huge uncertainty surrounding the energy transition and the future of energy markets, so any feedback on the analysis and – even better – how it could be improved would be very welcome.