T-L.com insight session on future energy 23rd September 2020

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Those of you who have read this week's *Economist* will be well briefed about what I am going to say.
This is my third talk on energy. The path has been a winding one!
In 2007, I presented to the 'Changing Climates' event at Chatham House, reviewing potential energy sources and the prospects for renewables. Investment, I argued should be made in carbon capture and nuclear power. The fossil fuel industry successfully lobbied against the extra cost of carbon capture and Fukushima happened.
In 2013, I discussed fracking and argued that natural gas would provide a short-term route to reduce CO2 emissions by displacing coal. Aside from frightening the world with lax regulation, this is what happened in the US as well as largely eliminating American dependency on imported oil.
Today, the world of energy generation is in flux. Traditional companies are facing a business crisis and the world of renewables is on the rise.
There are some startling tends out there and I'm going to tell you about them.

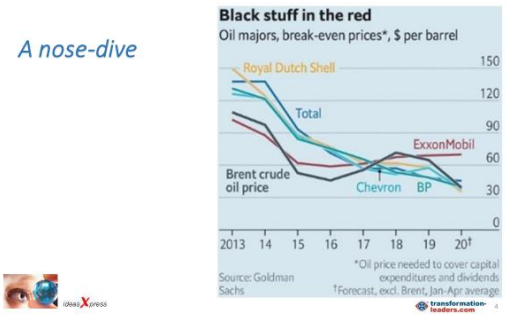
Slide 2

This presentation will not discuss the consumption or saving of energy nor specifically address climate; important as both those issues are.
What it will do is review some radical transformations taking place in energy generation, and trends which will provide for commercial opportunities and reduced emissions.
Here is the cast list who will help me through this presentation.

Slide 3

The storyline will focus on five key themes for energy generation:

1. How Big-Oil companies in America are choosing the wrong path
2. How government policy will make fossil fuels more expensive
3. How fossil-fuel power plants can stay working in a net-zero world
4. How progress in renewables will stall and what to do about this
5. Lastly, I will mention two wild cards in the energy mix

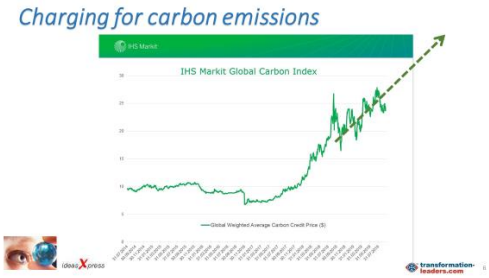


Slide 4

Here's how the oil majors have reduced their beak-even price since 2013.

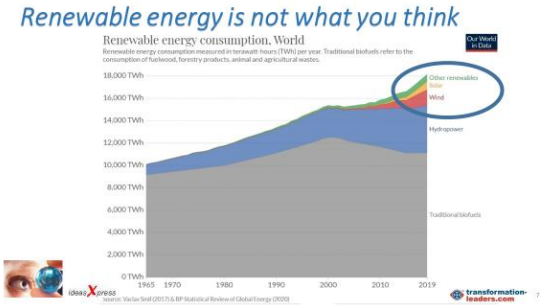
Slide 5

Oil majors in Europe are reinventing themselves.



Slide 6

Carbon is getting pricier.



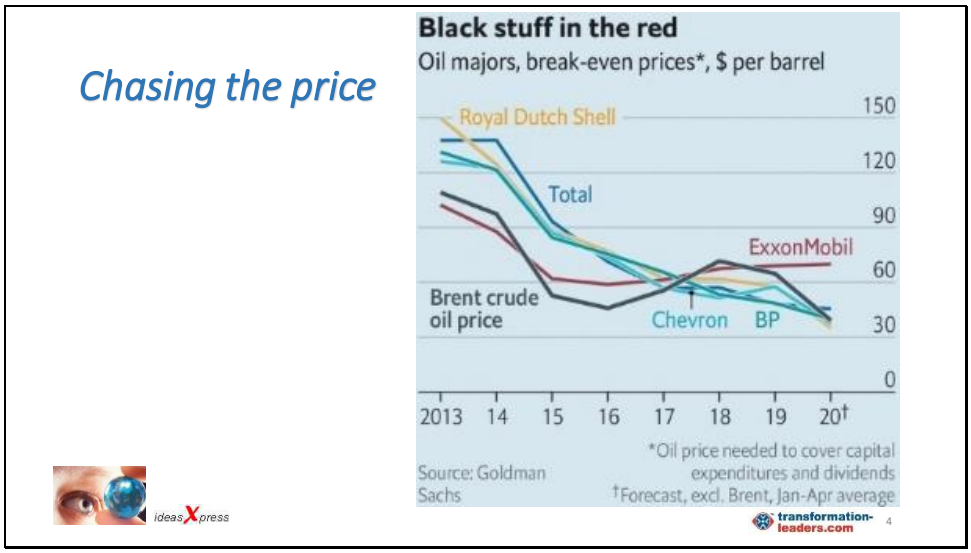
Slide 7

Wind and solar are only a small part of the mix.

Slide 8

You can't believe everything you hear.

Slide 9



This has been the story of Big-Oil over recent years.
West Texas Intermediate buyers were being paid to take surplus stocks away earlier this year.
Global demand for oil has been cut by up to a third worldwide. Oversupply has only exacerbated the situation
ExxonMobil and BP shares fell by over 40% this year
The oil majors have steadily reduced their break-even price by around 50% 2013.
ExxonMobil currently need a price of $70 to cover investment and dividends compared to around $40 for their main competitors.
BP are committed to major reductions in oil production.

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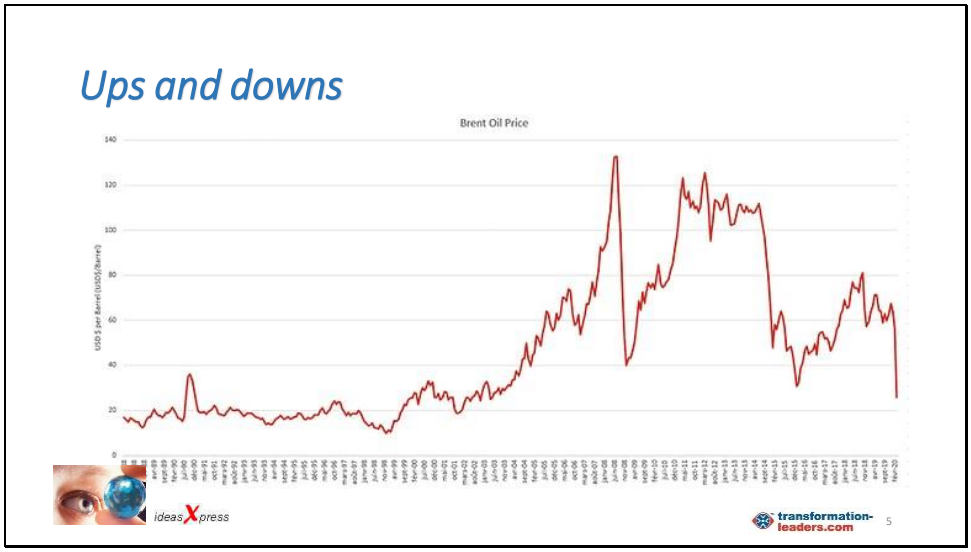

Black gold has lost its lustre.
Volatility in the price of oil has become a major barrier to investment.
This graph shows Brent oil prices (US$/bbl) between 1988 and March 2020. Source : Reuters.
Expensive disasters haven't helped either.
The pay-out after BP's Deep Water Horizon accident has equalled the total value of the company. ExxonMobil are still paying reparations for the Valdez incident in 1989.
Just as the French made nuclear power their route out of escalating oil prices in 1973, fears of geopolitical battles in the 2020s will find many investors seeking alternatives to fossil fuels.

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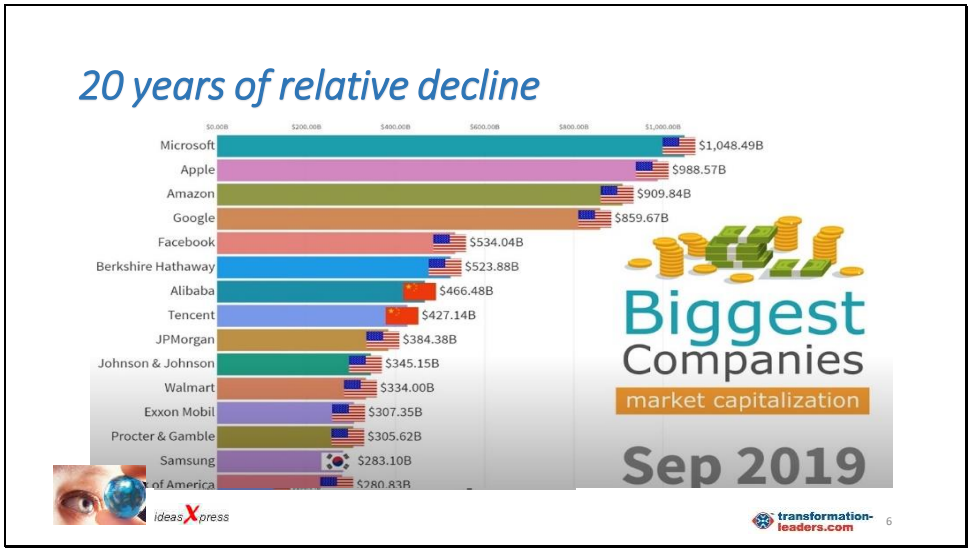

There were three oil majors in the top ten in 1999. ExxonMobil, Shell and BP in tenth position.
Now there are none, even ExxonMobil has fallen to twelfth position. They were once the giants of industry. But, in twenty years, other companies got twice as big!

The top five are all now technology companies.
These companies now represent a market capitalisation of $20Tn and account for a quarter of stock market value. Only thirty years ago, this was indeed, the total value of the stock market.
Oil and gas companies now account for just 4.4% of the S&P 500, while in 1980 they represented more than 28% of the index.

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After the IPO last December, Aramco became the world's highest value and most profitable company. Aramco can more or less put their hand in the sand and scoop up the oil. Their break-even price is $10 a barrel. But look more closely - that hides the truth that Aramco **IS** Saudi Arabia which needs a price of $80 to sustain its economy.

Slide 13

Aramco and the US Oil-majors see petrochemicals as the answer.
This shows construction underway for ExxonMobil's new plant in Texas. Traditional Oil Majors are investing heavily in petrochemicals – $20Bn from ExxonMobil alone.

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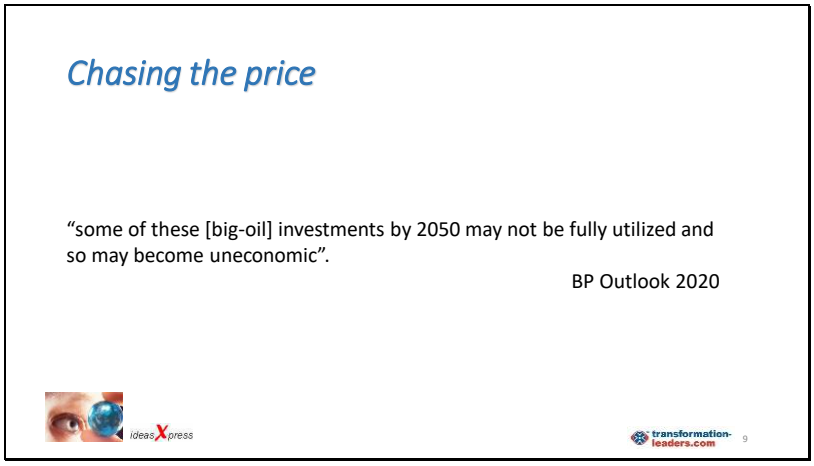

BP believe that traditional investments will not provide a return on investment.
The problem is that, like oil production itself, petrochemicals may turn into another case of massive production investment chasing weak market demand.
Not all are following this route. BP sold 14 of its petrochemical manufacturing plants this year for $5Bn.
BP is reducing oil and gas production by 40% by 2030, betting heavily on blue hydrogen (from gas) and promising to increase renewables from 1Gw to 50Gw, also by 2030.

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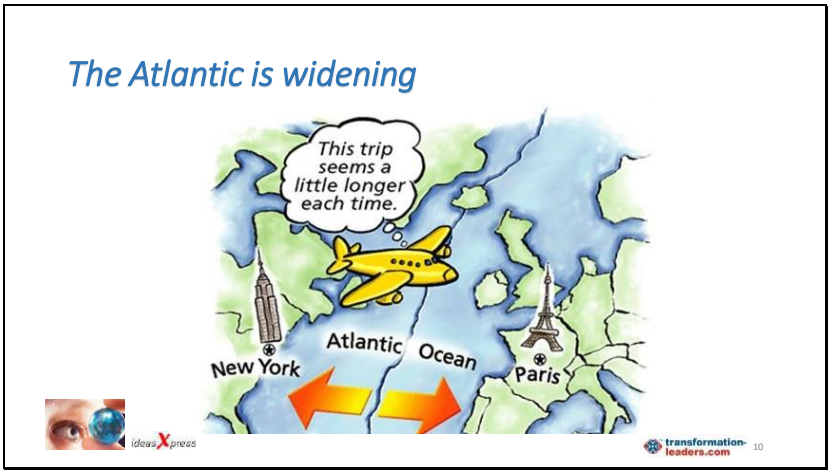

It's not just the Mid Atlantic ridge that's widening.
Big oil is splitting into two camps – The US and Europe, with European companies changing their business model and moving into renewables.

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Like most of the oil majors, this company's valuation plummeted this year.
It was BP
Now we have a renewable energy company that is worth more than BP
This is the Spanish renewables company, Iberdrola which owns Scottish Power. BP share capitalisation was $87Bn in June, Iberdrola (Spain) was $71Bn
As you can see, their share valuation climbed over the last two years and has now overtaken that of BP.
In April, Iberdrola's CEO, said he intends to "turbocharge" the Spanish economy by increasing global renewable investments to €10 billion in 2020, compared to €8.15 billion in 2019.

Slide 17

Orsted (Denmark) has installed a quarter of the world's offshore wind capacity. Last year, it sold its oil and gas business to Ineos.
Equinor (Norway) which used to be known as Statoil is investing up to 20% in renewables by 2030. BP partnering with Equinor in off-shore wind in off NY and MA US (4.4Gw)
BP is also partnering with Lightsource, the largest solar operator in Europe.

EDP (Portugal) took over Texas Horizon wind power.
RWE (Germany) – took over E-on. From being the worst polluter in Europe they now have a 60% renewable generation portfolio.

Slide 18

The world of big-oil will be changed indelibly according John Brown who was CEO of BP between 1995 and 2007. He renamed BP. The day is approaching when Europe's oil-majors finally move 'beyond petroleum'.

Slide 19

Governments can make a big difference if they want to.
The head of the EU Commission has announced big plans for a 'green recovery'.
As well as questioning established business models, COVID-19 provides governments with an opportunity to make tax changes which will reduce fossil fuel subsidies and introduce carbon pricing.
The EU has already set out such a path, proposing €260 billion of additional investment a year and debating 'the hydrogen economy'.

Who knows, we might even see a President Biden attending a reinvigorated 2021 UN Climate Change Conference in the UK with a $2Tn 4 year programme for clean energy infrastructure.
The EU's plan seeks to pour money into emissions-busting sectors: €91bn a year for home energy efficiency and green heating, €25bn of renewable energy, and €20bn for clean cars over two years, plus 2m charging points in five years. Up to €60bn will go to zero-emissions trains and the production of 1m tonnes of clean hydrogen is planned.
border tax on carbon-intensive industrial imports from other nations potentially raising up to €14bn.
One million new jobs are promised.
Who knows, we might even see a President Biden attending a reinvigorated 2021 UN Climate Change Conference in the UK with a programme for clean energy infrastructure.

Slide 20

But the path may continue to be a rocky one. The danger is that American oil companies will continue to pay for a delay in government action.

Slide 21

Fossil fuels still attract huge subsidies and government investment.
UK Fossil fuel subsidies have been estimated to be north of £10Bn p.a..

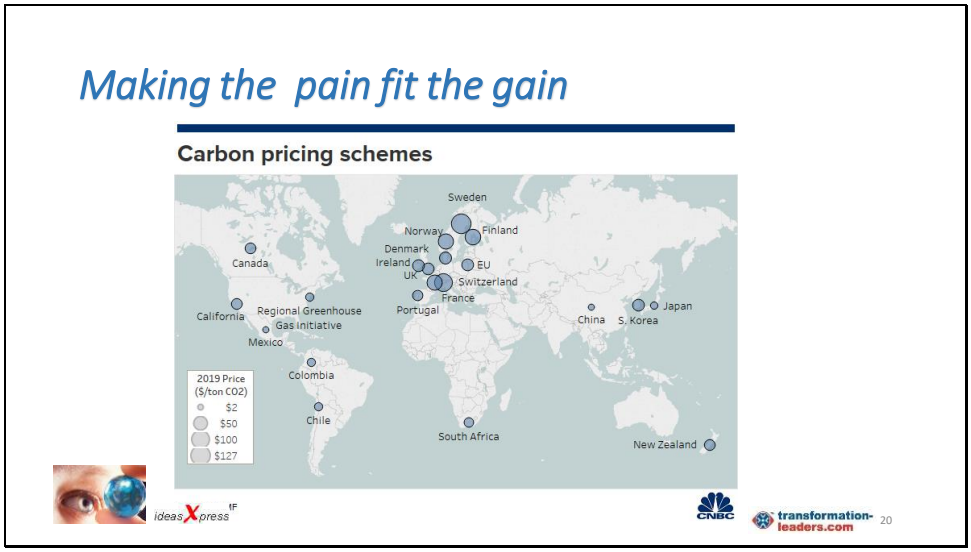
Slide 22

Jeff Bezos is the richest man in the world with wealth estimated at $200Bn.
World-wide fossil fuel subsidies total twice this much each year.
Taxes on fossil fuels are tiny by comparison.

Slide 23

Bill Gates has already spent over $1Bn on renewable energy and believes much more is needed.
Jo Biden is promising a $2Tn programme designed to tackle the climate emergency.
70% of the world's clean energy investments are government-driven, either through direct government finance or in response to policies such as subsidies or taxes (IEA).
Governments can swing the balance in other ways too…

Slide 24



Last year, global carbon pricing initiatives covered around 20% of global greenhouse gas (GHG) emissions - up from 15% in 2017.
But on a global scale, governments generated only $30Bn in 2017.
This reflects the fact that global prices are currently between $5 and $25 per tonne and the world average is only one dollar. Key people demand more.
Carbon prices are widespread and should be increased.

Slide 25

Making the pain fit the gain

"Price it right, tax it smart, do it now."
Christine Lagarde, managing director of the IMF (2017)

"Carbon pricing today is understood as a crucial element in the fight to mitigate climate change. "There are relatively few things that are almost unanimously agreed upon among economists, but this is surely one of them,"
Michael Spence, chairman of the USA Commission on Growth and Development (2018)

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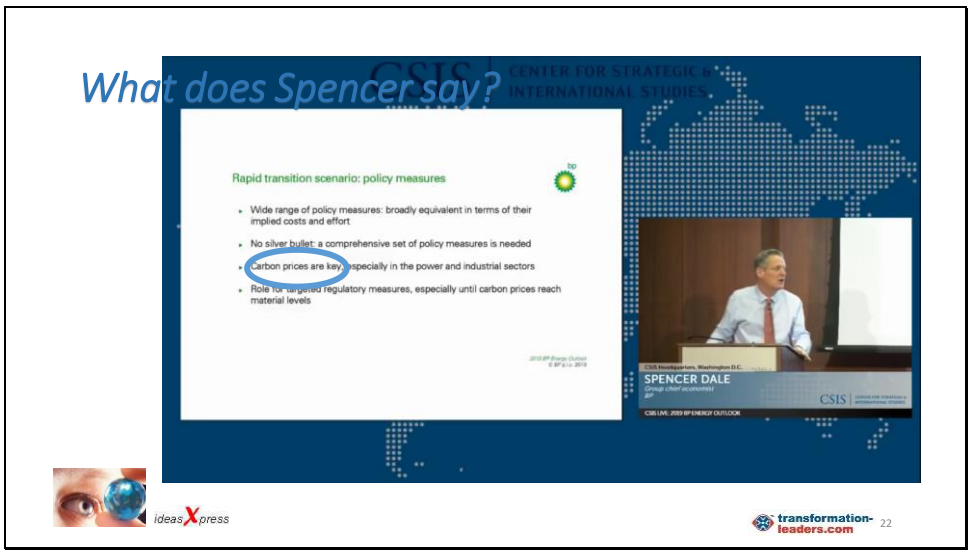
The 2006 Stern review (The Economics of Climate Change) estimated that each tonne of CO2 we emit causes damages worth at least $85.
Christine Legarde when she was head of the IMF said… READ IT
The IMF now believe that $75 would be needed to contribute to keeping global temperatures below 2 degrees.
Low levels of carbon pricing and a weak EU Emissions Trading System has failed to provide the appropriate signals either for emissions reductions now, or long term investment towards a low carbon economy.
Carbon pricing is generally viewed as an essential government device for tackling climate change.
Current prices are too low and the rise in prices is too slow.

Slide 26



On 6th Feb, last year, BP presented their 2019 energy outlook. Their scenario to meet Paris climate goals is called the 'rapid transition scenario'. Here is what their Group Chief Economist, Spencer Dale had to say about carbon pricing…
BP still argue that carbon pricing will drive energy transition.

Slide 27

The common criticism of carbon pricing is that it will destroy the competitiveness of industry.
This is not true.
Unlike a pandemic, Stanford University argue that even aggressive pricing will not stop growth.
Governments need to listen and act.

Slide 28

What else is out there?
Stopping what we do from causing more harm

CCS is expected to contribute 19% to CO2 reductions.

Source: IEA

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How do we put the lid on further damage?
Despite what the UK climate change citizens' assembly might think, with Carbon capture and storage, or CCS we could be seeing up to a 19% reduction in CO2 emissions. CCS takes the harmful emissions from power stations and prevents them from reaching the atmosphere. This is Alstrom's Utah plant for CCS, one of seven working plants. It is attached to a coal-fired power station.

Slide 29

What else is out there?
Stopping what we do from causing more harm

"Technologies which capture carbon emissions or extract them from the atmosphere are likely to play a material role in a net-zero environment."

BP Outlook 2020

"Drax Power Station is already trialling Europe's first bioenergy carbon capture and storage project. This combination of sustainable biomass with carbon capture technology could remove and capture more than 16 million tonnes of CO2 a year."

DRAX is committed to become carbon negative by 2030

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BP's latest Outlook sees gas-fired plants using CCS as key strategy.
DRAX in N Yorkshire will cease to burn coal next March. It will then have a capacity of almost 4Gw of biomass energy. Its CCS project has the potential to remove 16 million tonnes of CO2 a year.

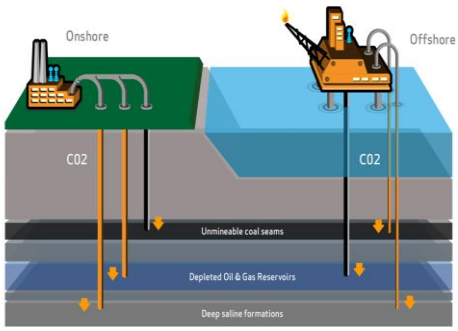
Slide 30

Carbon Capture & Storage (burying the CO2)

UK scrapped a £1Bn competition in 2015

Rishi Sunak's March 2020 budget announced £800m for two projects

Report of the Parliamentary Advisory Group on CCS Sep 2016



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Here is a graphic to explain CCS.
Does anyone spot the deliberate mistake in this picture?
CCS does not involve burning off natural gas. We are burying it, not burning it.
CCS will keep older fossil fuel power plants online speeding up the transition to green energy.
The Chancellor has recently revived the support for CCS which was cancelled in 2015.
Let us not forget that from plastics to concrete, CO2 is a basic industrial building block.

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The path to renewable energy

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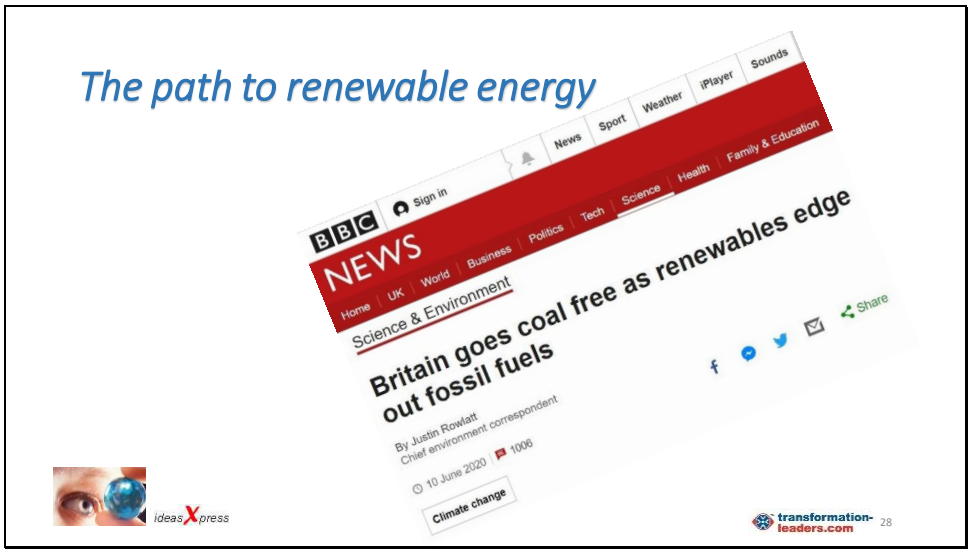
Over a quarter of the world's CO2 emissions come from energy supply.
Renewables are seen as key to reducing global emissions.
Despite 100 GW of solar Photovoltaic and about 60 GW of wind power projects being completed in 2019 only around a third of this will be usable.

Slide 32

This is because they don't always work when you need them.

Slide 33



This was headline news earlier this year, but it was fake news.
Renewable generation in the UK collapsed in early May 2020.
Despite the sunniest month ever, solar could not satisfy demand.
Through the 'record' period (April-May 2020) of no coal generation the UK imported 10 per cent of its electricity from Europe.
4GW of 'dirty' energy was imported for which UK generators paid no carbon tax as they do for home-grown energy.

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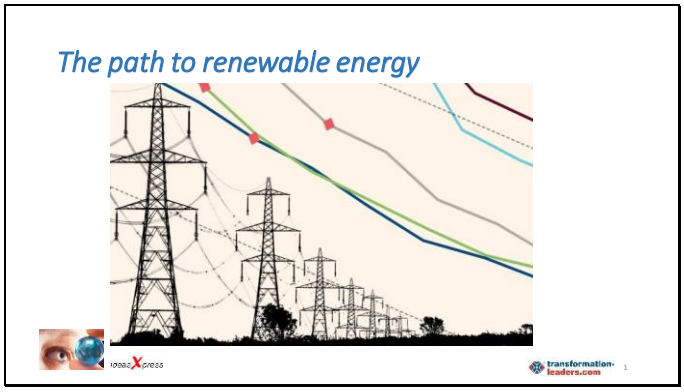

During lockdown, overall electricity demand in the UK fell by 20% and fuel sales fell 61%.
The UK economy shrank 19% and hours-worked fell 16%.
Despite this, GHG emissions only fell to 2006 levels.
We need to stay at this level all year and every year to limit climate change to 1.5 °C warming.
The pressure is on to make sure increased energy needs are satisfied by truly renewable resources.

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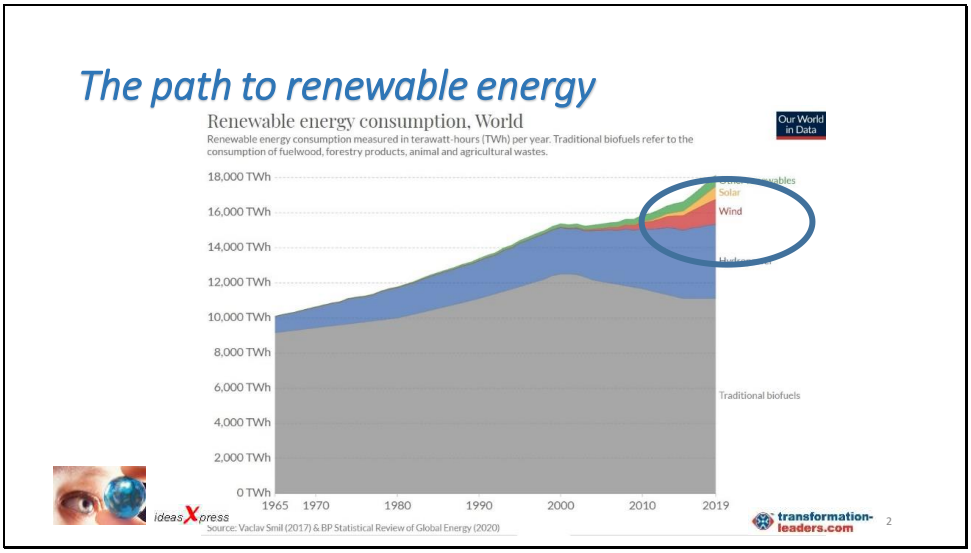

Hydro energy is shown in blue.
The grey bit is bioenergy
Bioenergy is a significant part of the energy economy, accounting for some 70% of renewable energy in use today (International Energy Agency, 2017b, 2019). The burning of biomass is controversial. Many doubt that it is truly renewable.
Wind & solar energy are only 11% of all renewable energy consumption.
Predominantly green energy is far from a reality today.
So, renewables aren't what you think they are and their contribution is rapidly reaching a plateaux.

Some fundamental barriers exist before renewables can become the majority source of our energy.

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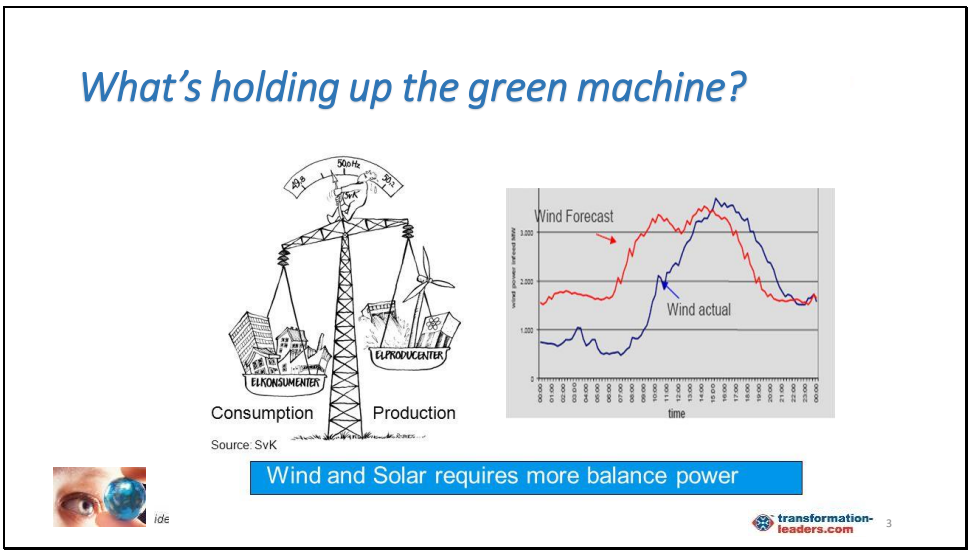
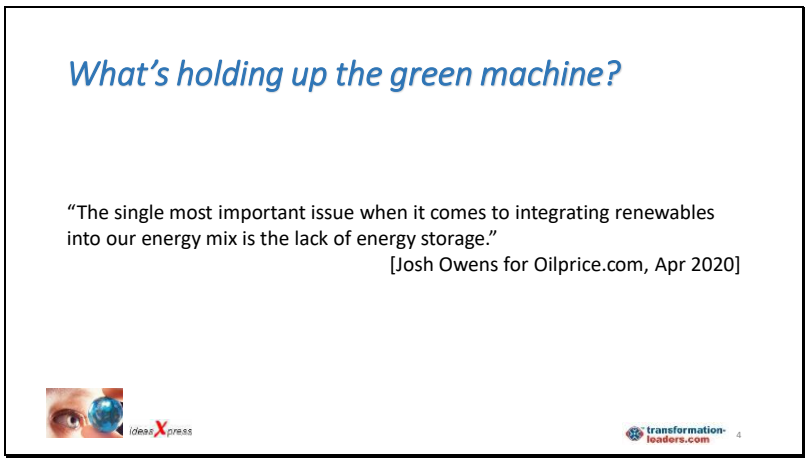


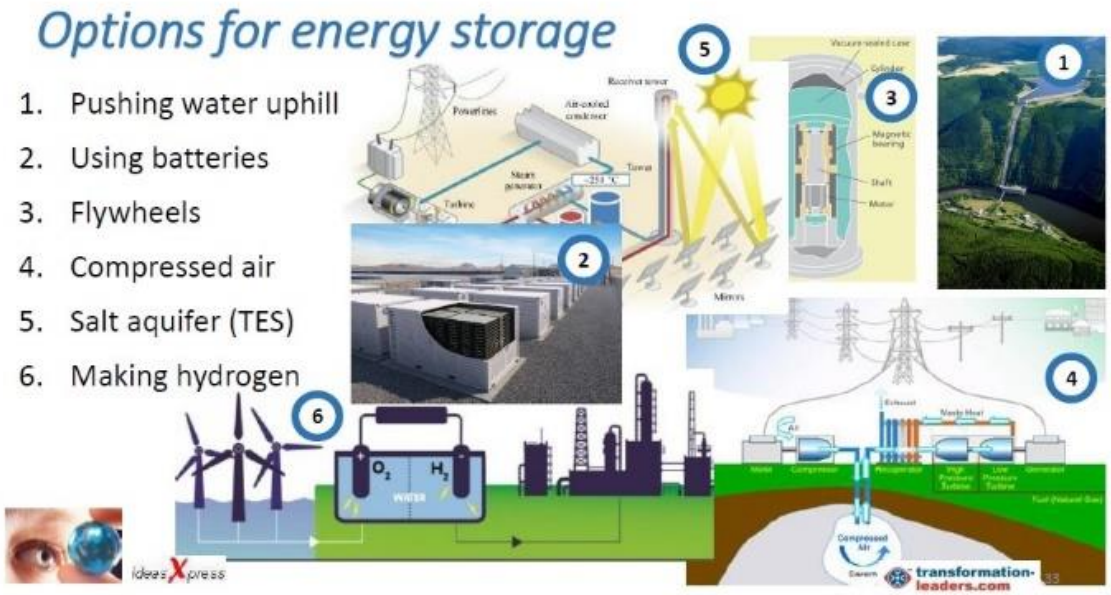
Baseload power is energy which can be brought into service at any time. But solar and wind are intermittent – you can't always switch them on when you need them.
The dilemma is that the electricity grid provides no in-built buffering mechanism to support the variable supply from renewable sources unless you have a geographically huge network as in China.
The major UK Grid failure on 9 August 2019 illustrates grid fragility. Following a lightning strike that triggered the failure of Hornsea windfarm and Little Barford gas-fired power station, supplies to over one million customers (1.15m) failed or were disconnected (what the industry calls 'load-shed'), and around 30 trains tripped on low frequency and most had to be manually reset, taking hours and causing disruption to around 590 services.

Slide 37



At other times, wind and soar provide more energy than can be used,
We either have to do something useful with excess energy or store it.
Building more wind and solar capacity will not be worthwhile if its energy cannot be used.
Currently we cannot match renewables with demand cycles.
Energy storage facilities will bridge the gap between service factors of 25-50% for wind and solar with the 85% service factors currently in place for conventional baseload power generation.

Slides 38-42



Providing energy storage for renewables can take many different forms.
The industry is in its infancy but I believe it is key to making renewables a fundamental element in energy supply.

I will review briefly a few of the most promising storage technologies:

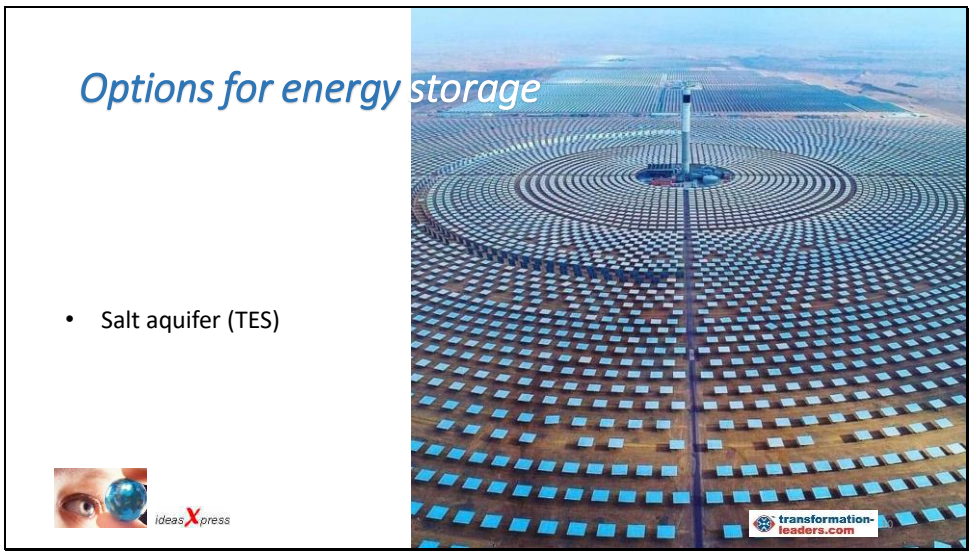
1. A proven process involves pumping water uphill where the topology exists; but it is costly and you have to have the right terrain.

2. Battery packs are popular but offer short discharge periods.

3. Flywheels are in use but are twice as expensive as batteries with just as short a discharge period.

4. Compressed air storage in underground chambers provides longer-term energy delivery.

Slide 43



Many solar farms rely on thermal energy storage.
This picture is of the world's largest Solar Power site in Morocco.
Covering 1.7 sq. miles it provides half a gigawatt using 2 million mirrors and molten salt for energy storage.

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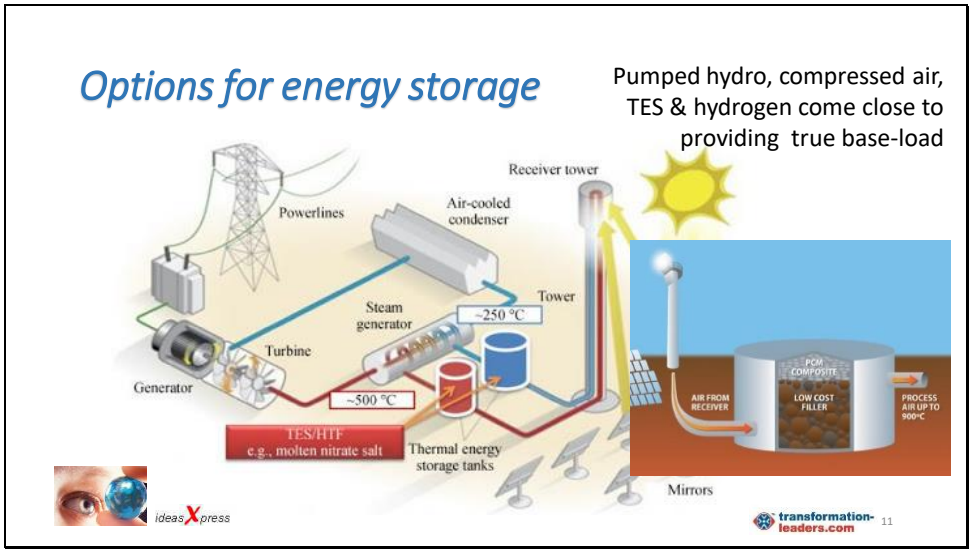
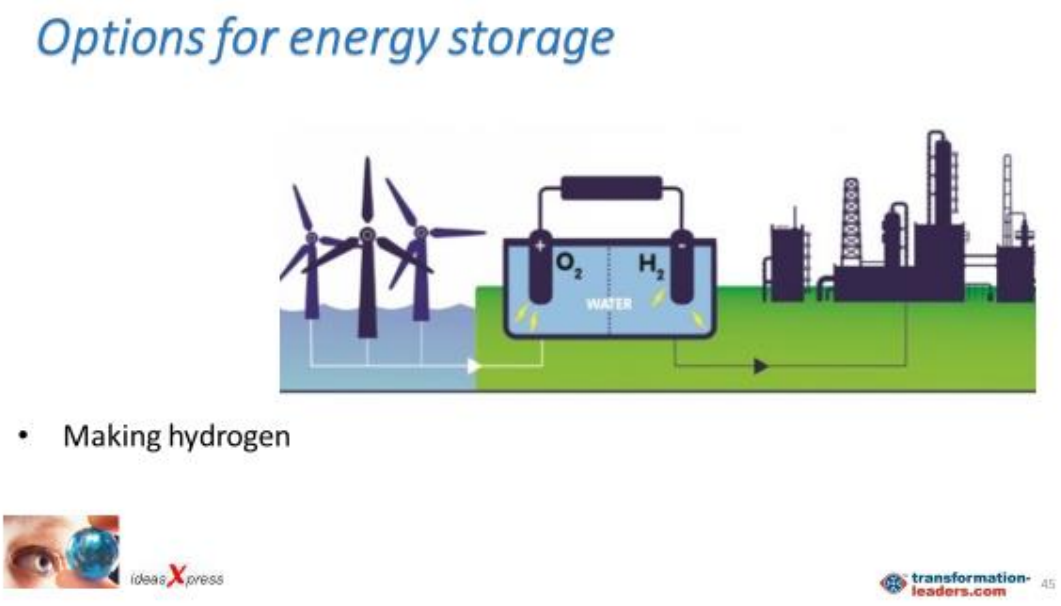


Thermal Energy Storage (TES) can be 30 times cheaper than batteries.
This illustrates molten salt storage as used in Morocco
The next illustration shows a heating rocks using air in place of the molten salt.

Slide 45



Whilst the other options are energy storage devices, hydrogen is first and foremost an energy carrier. It's a 'wild card' to which I will return later.
Making hydrogen is energy-intensive but offers a sensible fall-back for, and a usable fuel where suitable services exist. It carries the potential (e.g.) for replacing gas boilers in the UK with minimal consumer disruption.
BP's 2020 Outlook proposes using electricity to split water into hydrogen and oxygen. The electricity would be generated both by gas-fired power stations (blue-hydrogen) and by unwanted renewable energy (green hydrogen).
They envisage that 20-30% of wind and solar energy will go into the production of green hydrogen by 2050.

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Options for energy storage

• Pushing water uphill	Up to 3Gw, slow response time – need a hill - expensive
• Using batteries	Fast response – short discharge – short life
• Flywheels	Fast response – short discharge – cost more than batteries
• Compressed air	Up to 1Gw, slow response – need a hole – expensive – low efficiency
• Salt aquifer (TES)	Continuous cycle – high cost
• Making hydrogen	Energy intensive – flexible delivery

This is a simplified comparison but solutions will depend on local features as well as market needs. With the exception of hydro, compressed air and hydrogen, we are talking about delivering fast response Megawatts rather than persistent Gigawatts.

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Options for energy storage

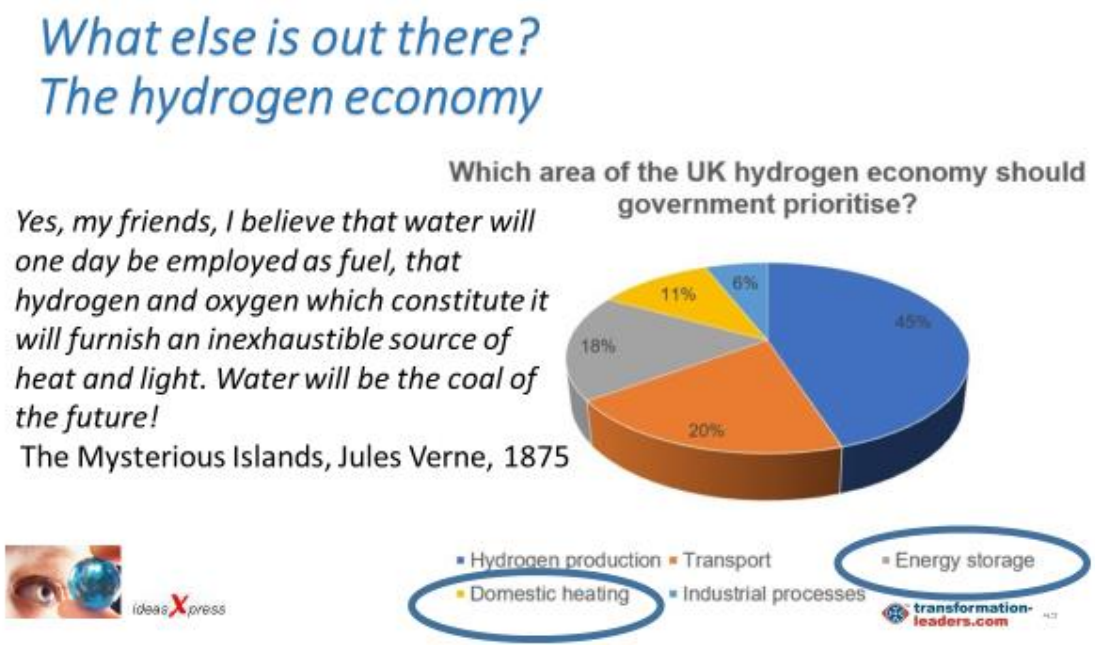
Energy storage installations around the world will multiply exponentially, from a modest 9GW/17GWh deployed as of 2018 to 1,095GW/2,850GWh by 2040.

BloombergNEF (BNEF)

That's 300 times as much in 20 years.
There are great opportunities here.

Slide 48

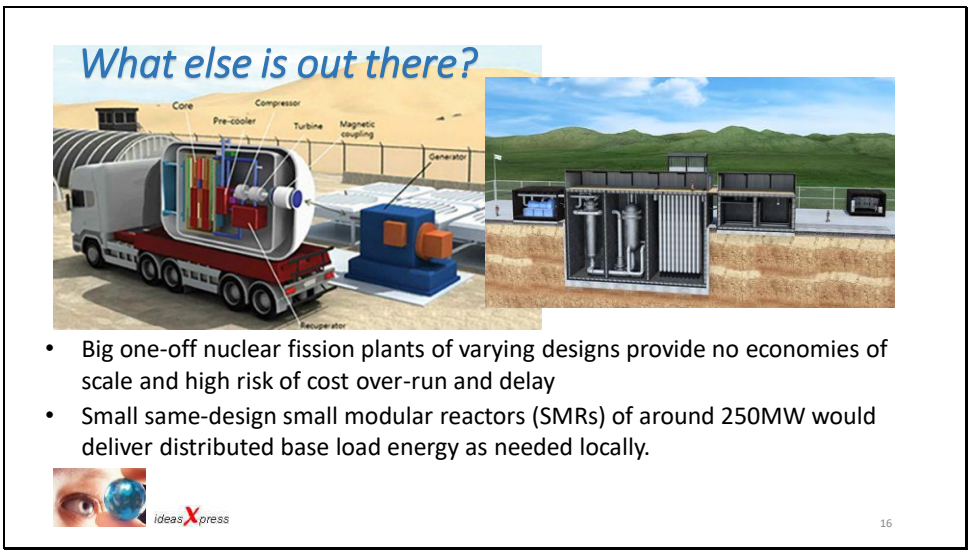
My wild cards are Nuclear & Hydrogen.
Henry Cavendish described hydrogen as “inflammable air” in 1766.
Ernest Rutherford wrote in 1933 “Anyone who expects a source of power from transformation of these atoms is talking moonshine”.
Now we deal in ‘Moonshots’, which of course is just another kind of moonshine.
Slide 49



Jules Verne anticipated a hydrogen economy by saying, “water will be the coal of the future”
Apart from its use to process crude oil into refined fuels, Hydrogen is a fundamental building block for the manufacture of ammonia, and hence fertilizers, and of methanol, used in the manufacture of many polymers.
55% of the hydrogen produced around the world is used for ammonia synthesis, 25% in refineries and about 10% for methanol production.
Generating hydrogen is energy-intensive but ideal for using surplus renewable energy.

EU's renewable hydrogen capacity will grow from 1GW today to 6GW by 2024 and 40GW by 2030.
If hydrogen becomes plentiful, it could be used for transportation, and delivered to household boilers instead of piped natural gas, greatly reducing the generation of domestic CO2 without needing wholesale replacement of existing equipment.
Apart from transportation, Hydrogen could be delivered to household boilers instead of piped natural gas, greatly reducing the generation of domestic CO2 without needing wholesale replacement of existing equipment.

Slide 50



There may be a future for nuclear fission but not as we have done it in the past; big one-off plants of varying designs, no economies of scale, everything a prototype.
This diagram represents the provision of a small modular reactor or SMR. But even with SMRs, we will still need geological repositories for spent fuel. To pursue fission power, that problem must be solved once and for all.
Much research is going on into advanced fission reactors.
Advanced fission reactors are designed to be safer than traditional water-cooled reactors.
Most advanced is the 'pebble bed' reactor, cooled by a gas such as helium; China will demonstrate a 200Mw reactor this year. This picture shows an experimental SMR using an advanced 'pebble bed' reactor cooled with helium.

Slide 51

What else is out there?
Nuclear Fusion

ITER - the International Thermonuclear Experimental Reactor

Fusion offers huge potential as a solution to the world's energy needs. But comes at a price both in terms of time and money.

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This picture was taken 28th Jul 2020 when ITER's gigantic Tokamak machine assembly began in Provence, southern France.
Fusion has always been said to be 30 years away, but through advances in both materials engineering and computer simulation, current forecasts have become more bullish.
But the biggest barrier of all is pubic perception…

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It's all nuclear, right?

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Nuclear comes with a round ball and an oval one. The way you play the game is different and so are the results. Like Lucy, the public could care less.

Slide 53

Few people have heard of…
The new technologies of

- Nuclear fusion
- SMR,
- Pebble beds or Triso particles

But they certainly know about…

- 3 Mile Island 1979
- Chernobyl 1986
- Fukushima 2011

In some places it doesn't matter what people think!
China is forging ahead with new-nuclear projects.

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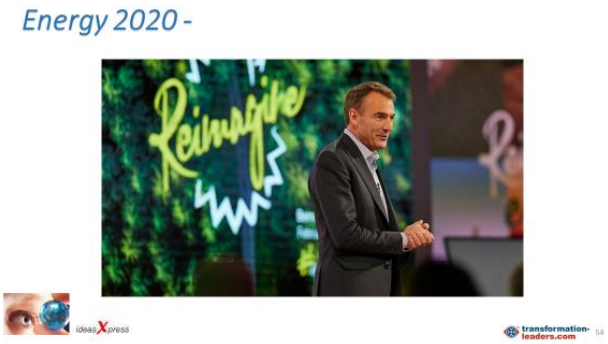
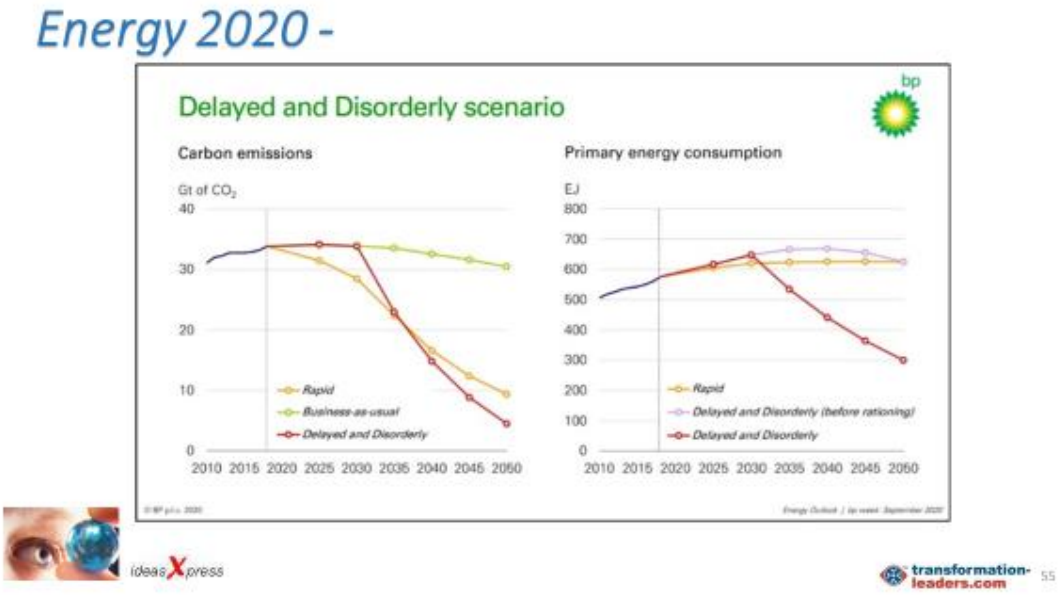


This month, BP presented their 2020 energy outlook. It didn't focus on technologies although much of what I have said featured in their forecast. They talked about a 40% reduction in oil production, a new business model and 10,000 redundancies.
BP is betting the business on partnerships with renewable companies, on carbon capture and a hydrogen economy.
During my research for this presentation, I have come across some startling statistics some of which I have shared with you.
BP have provided me with the most startling forecast and one which all to likely to play out.

Slide 55



BP is fond of proposing multiple scenarios for future projection. Here they suggest that business as usual carries forward to 2030 and then the world wakes up and implements drastic action to recover lost ground.
I fear that business as usual will be the rule for a few years yet. But radical investments need to be put in place and government policies enacted, this year or next.
The longer the delay, the steeper the curve to catch-up and the less likely will be the outlook.
But BP are changing and so are many other energy firms.

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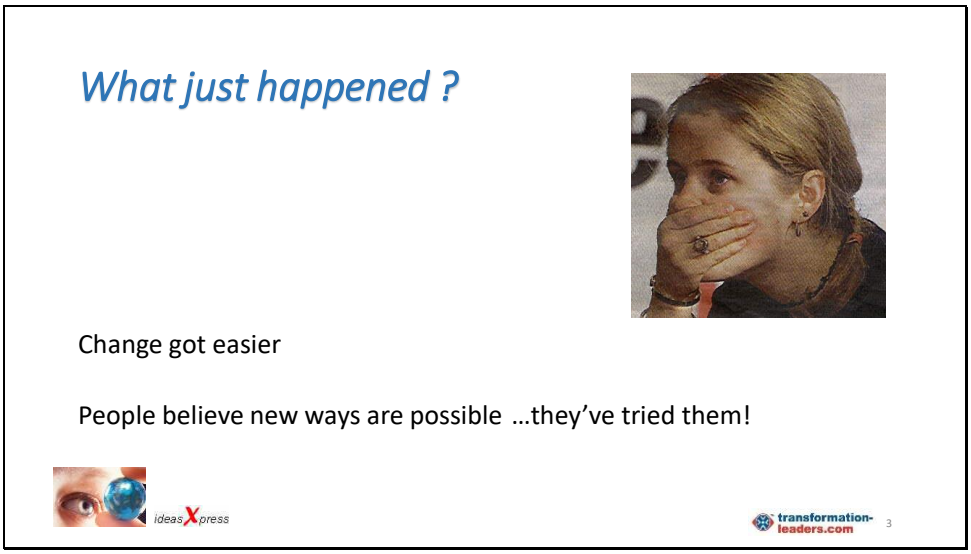
Keeping the lights on in Europe and meeting climate change commitments involves a planned transition which is already underway.
Any one of these is a game-changer. All together they will reshape our energy future.

Slide 57



This was the reaction of Martha Lane-Fox when she realised the listing of Lastminute.com had made her a millionaire.
What we have recently seen is equally jaw-dropping.
People have found news ways of working; behaviour and expectations have changed.
Trends already in place will accelerate and open new opportunities.
Many people will see the future for energy in a wholly different light.

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