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Hydrocarbons, Geoscience & The Energy Transition

Andy Davies & Mike Simmons*

Good morning all,

My name is Andy Davies and I am a principal geoscience advisor at Halliburton.

Halliburton are one of the largest oil and gas field service companies in the world employing around 50,000 people across the globe

I work in a part of Halliburton called Landmark where we generate software and geological products to help companies explore and produce hydrocarbons

I am also a senior visiting research fellow at the university of Leeds

The talk I want to give you today is entitled “Who Needs Geoscientists? Career Options Through The Energy Transition”

It stems from some work I have been doing with my colleague Mike Simmons to provide insights into the value of geoscientists to society, especially in light of the ongoing energy transition

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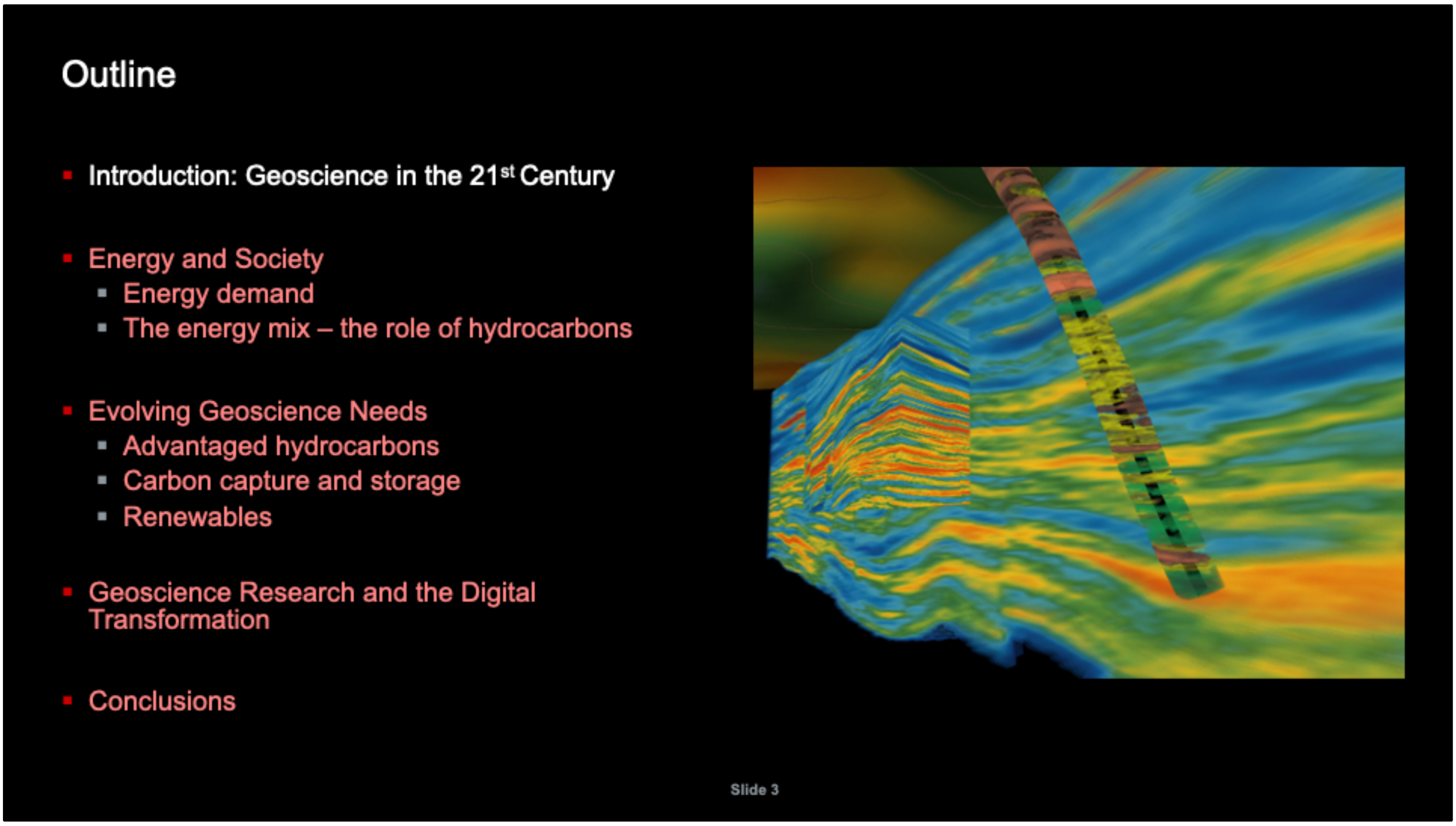


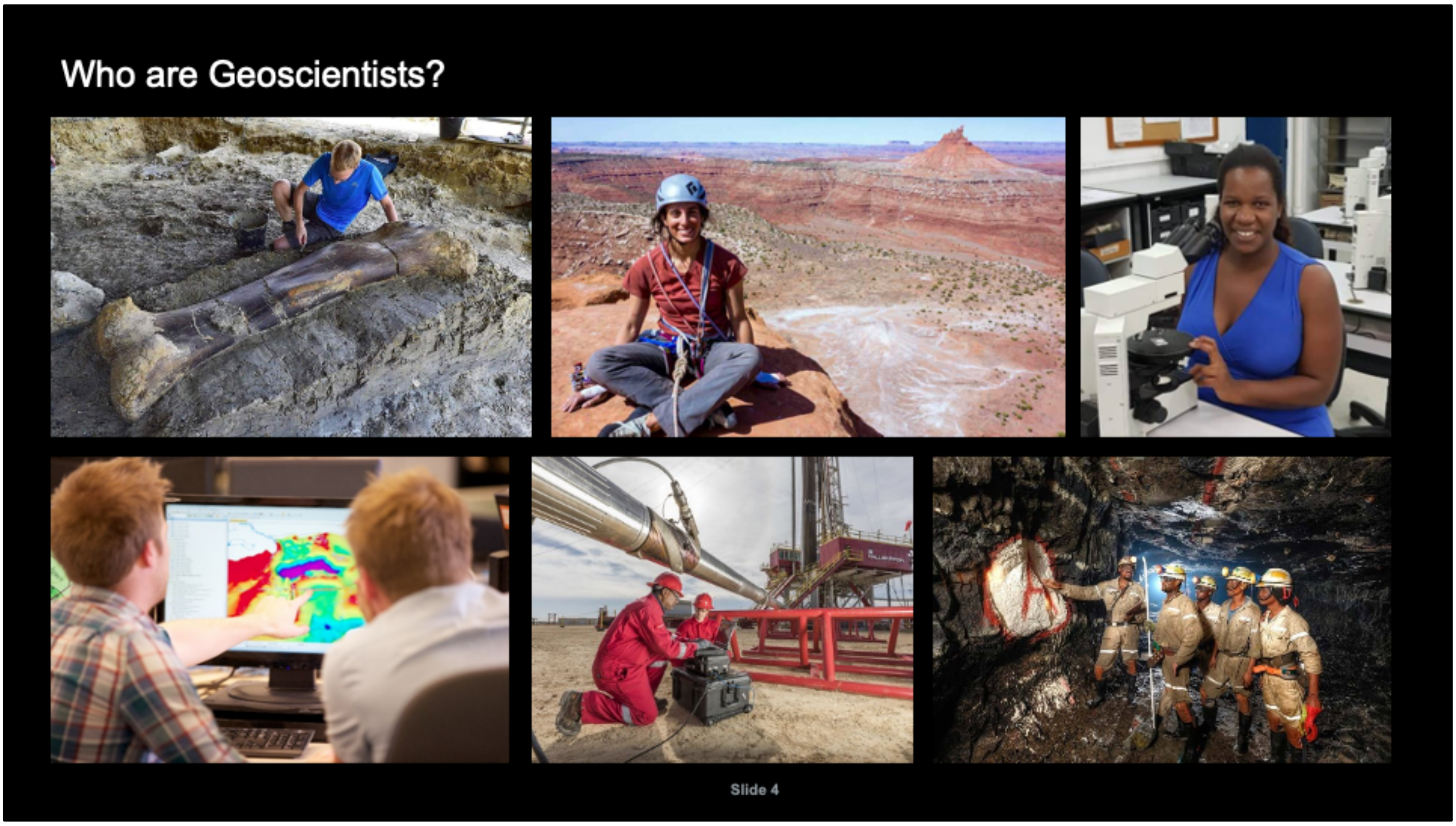
Let me begin by giving you an overview of the talk

I'll start with an introduction to set the scene, then look at energy and society.

This will lead us into assessing future Geoscience Careers in relation to the energy transition

I'll then assess some aspects of future geoscience research and the digital transofrmation

Before wrapping up with some conclusions

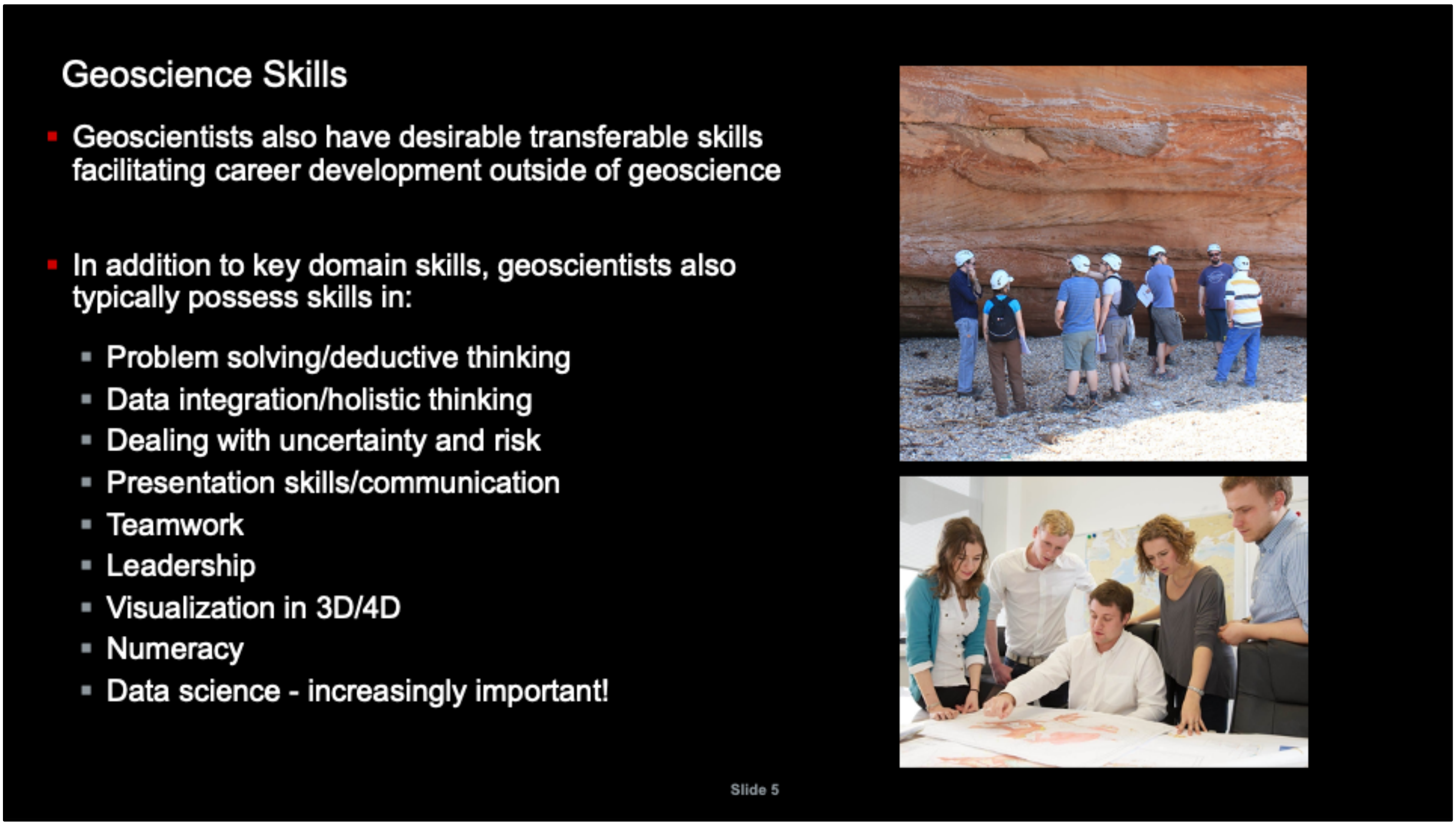


Who are geoscientists and what do they do?

The world of geoscience is hugely varied and this is reflected in where geoscientists work

This can range from the field, the lab, the office or onsite - at a rig or mine.

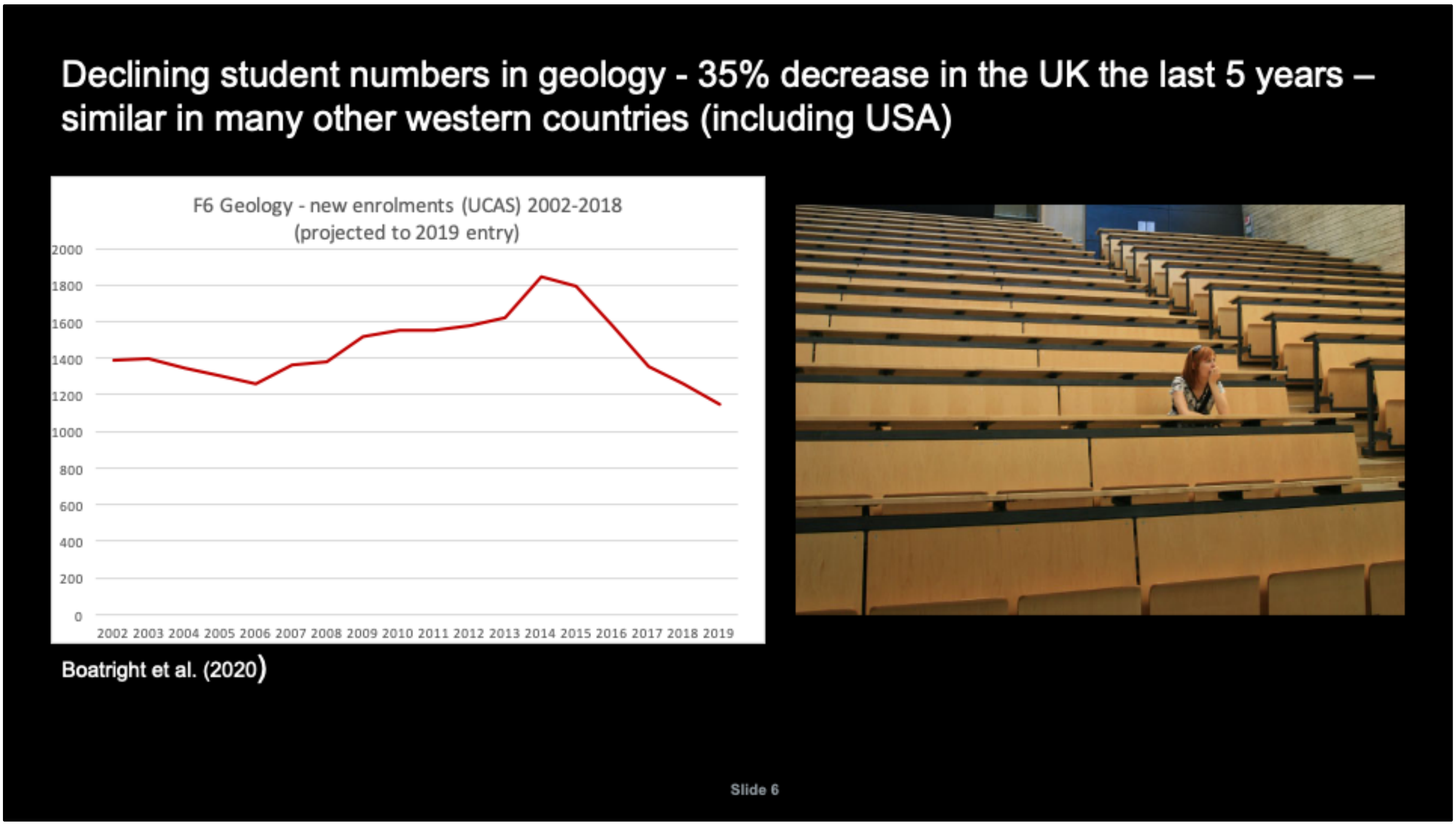
My work is routinely done in the office (which of course now means “at home”) with occasional research and teaching trips into the field



Geoscientists also gain desirable transferable skills facilitating career development outside of geoscience

So along with your domain knowledge, you will also develop skills in

Problem solving or deductive thinking

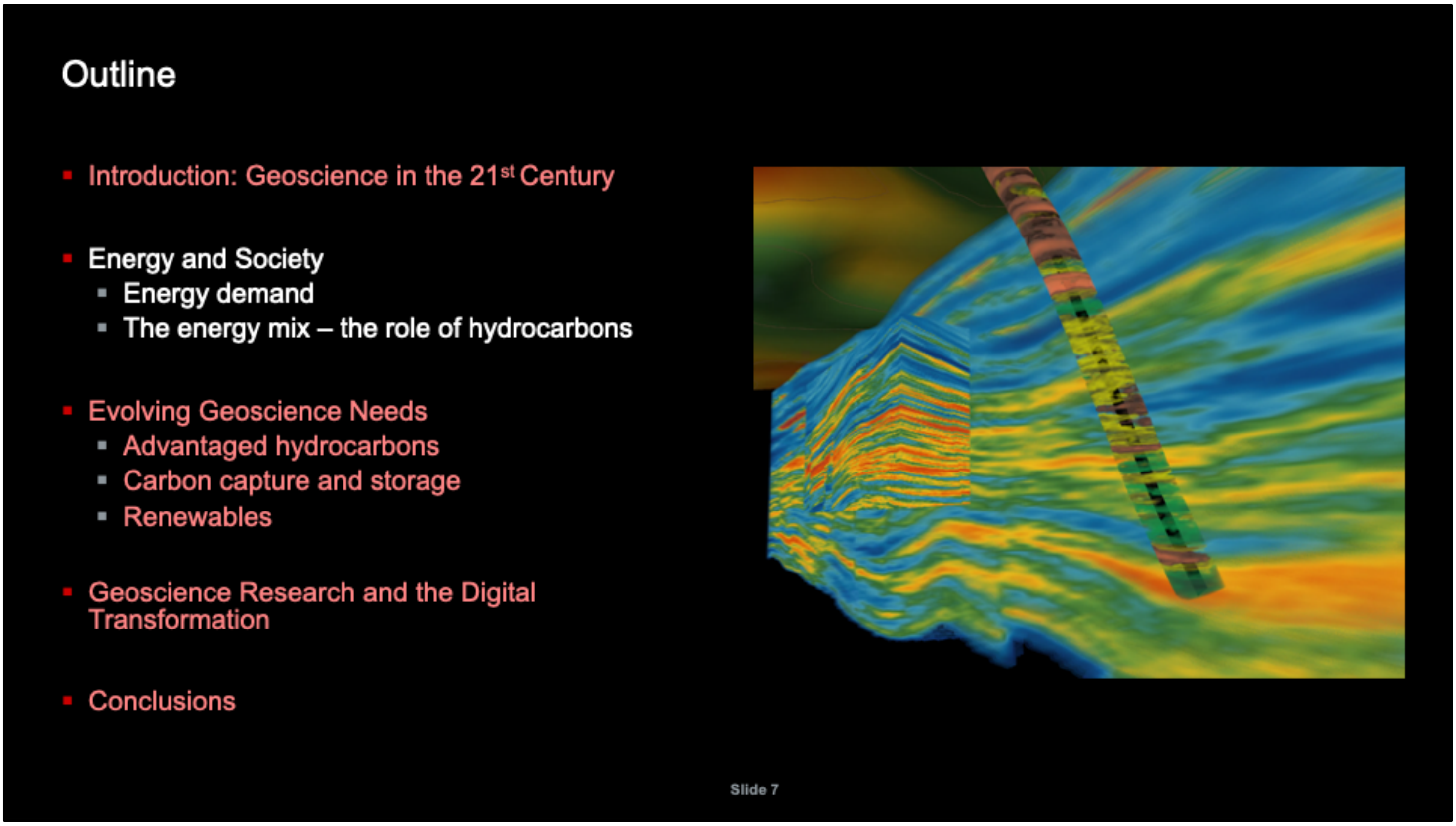


However we know in recent years that less students want to study geoscience

The graph on the left shows that over the past few years there has been a 35% drop in the number of geoscience students in Uk universities

There are lots of reasons behind this, including the public perception of geoscience, and the industries it is associated with, when seen through the lens of climate change

but I'm sure another reason is the perception of reduced career opportunities within the field



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Poll Question 1

Compared to 2019, by how much has global energy demand (from all energy sources) dropped in 2020 because of the pandemic and its socio-economic consequences?

a. Less than 10%
b. 10-25%
c. 25-50-%
d. More than 50%

Slide 8

To further highlight this, take a look at this graph showing the fluctuations in energy demand since 1900

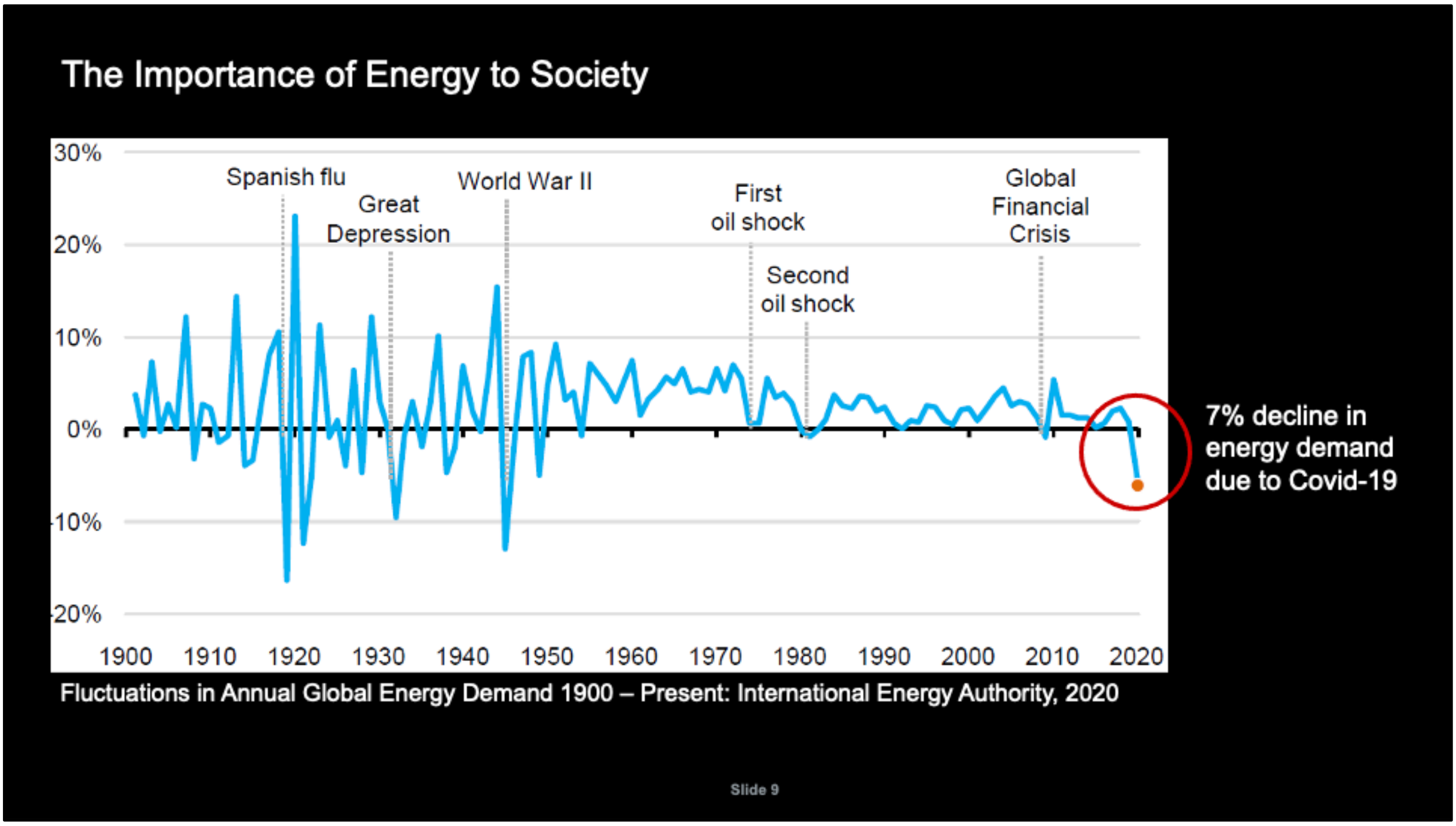
You can see that most of that time, energy demand has been positive – year on year society has used more energy.

The only times energy demand has been negative is during major recessions and global events, including the Spanish Flu pandemic, the great depression, WW2, the oil shocks, the 2008 financial crisis and the COVID pandemic we are currently going through

However, note that despite month long lockdowns across the globe and the collapse of international air travel, energy demand is only down ~7% due to COVID.

Its therefore very difficult for us to reduce energy demand without major impacts on or lives.

Therefore access to affordable energy is crucial for many of the UN goals, including reducing poverty, ending hunger and improving health



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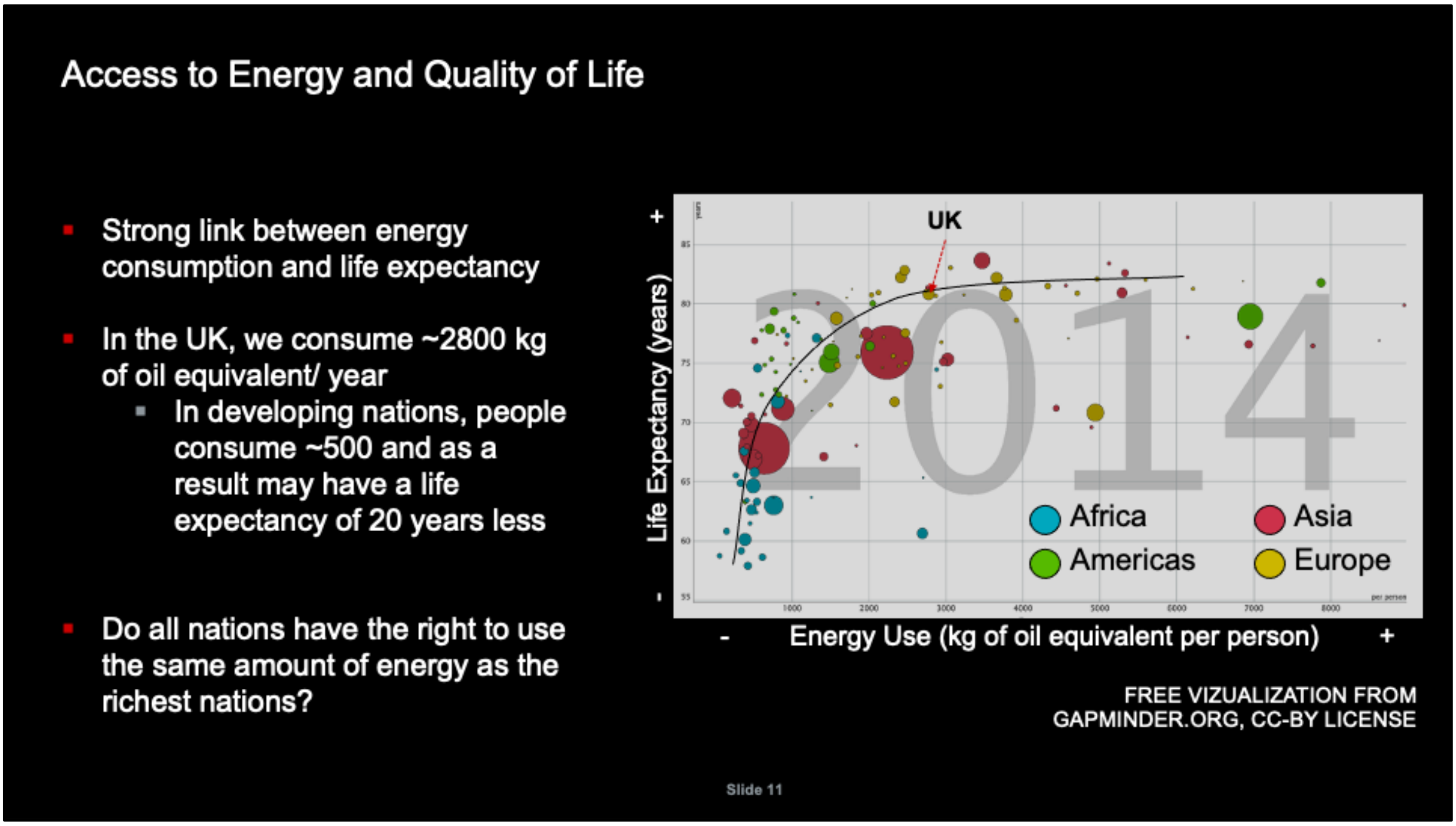
These are the United Nations sustainable development goals which are the blueprint for us to achieve a better and more sustainable future

The goals include eradicating poverty and hunger, improving health and wellbeing, ensuring all get access to quality education and clean water and ensuring gender equality

You can see that at number 7 we have affordable and clean energy.

For me it should be number 1 because as you'll see in the next section, without affordable energy its difficult to achieve may of these other goals.



This chart, **modified from Gapminder,** shows the average energy consumed per person, versus life expectancy for every country in the world

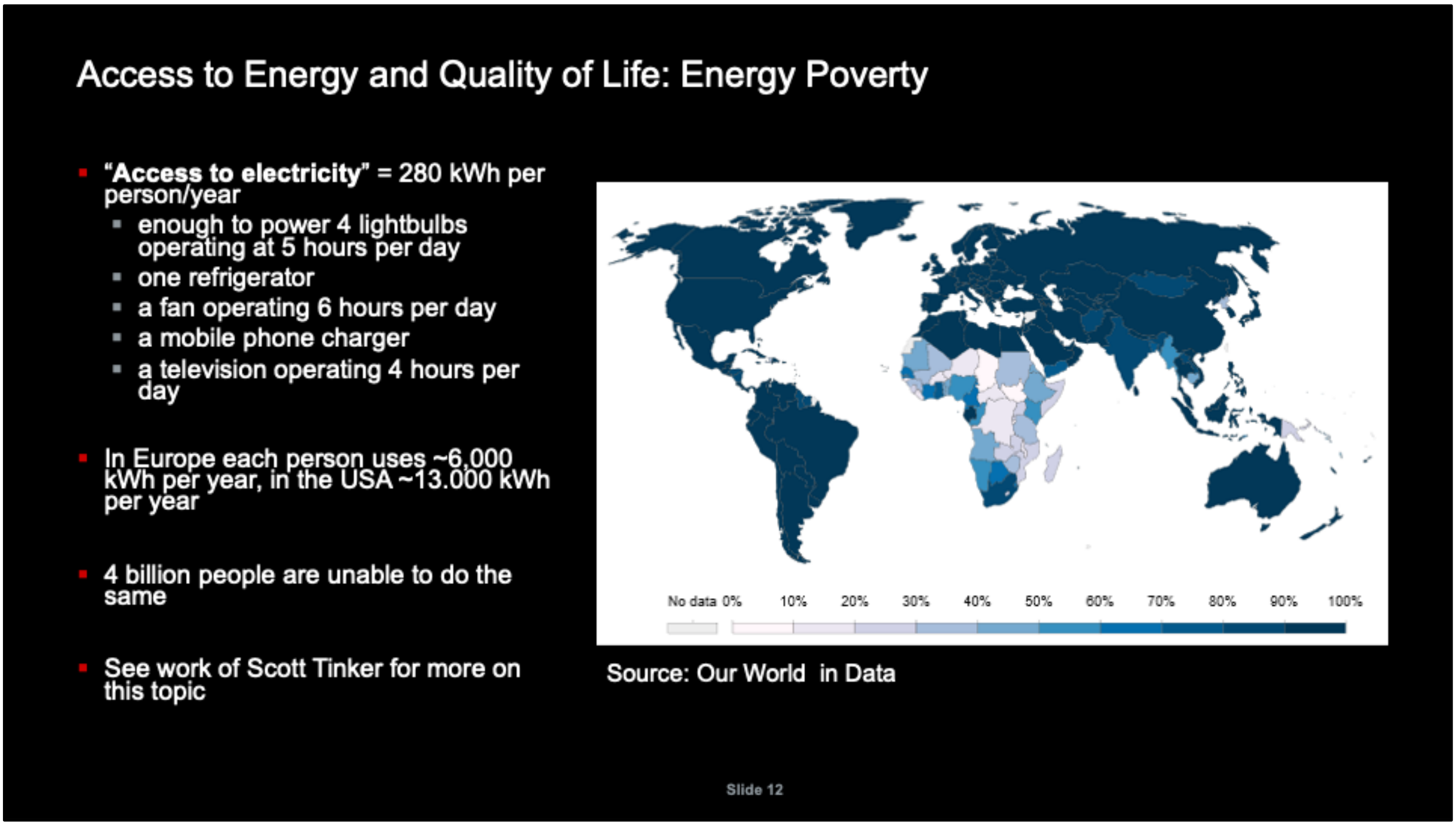
Each dot represents a country and the size of the dot reflects the total population. The different colours reflect different continents.

You can see that there is a clear link between energy use and life expectancy

I've highlighted the UK, where each person consumes ~2800 kg of oil equivalent/ year

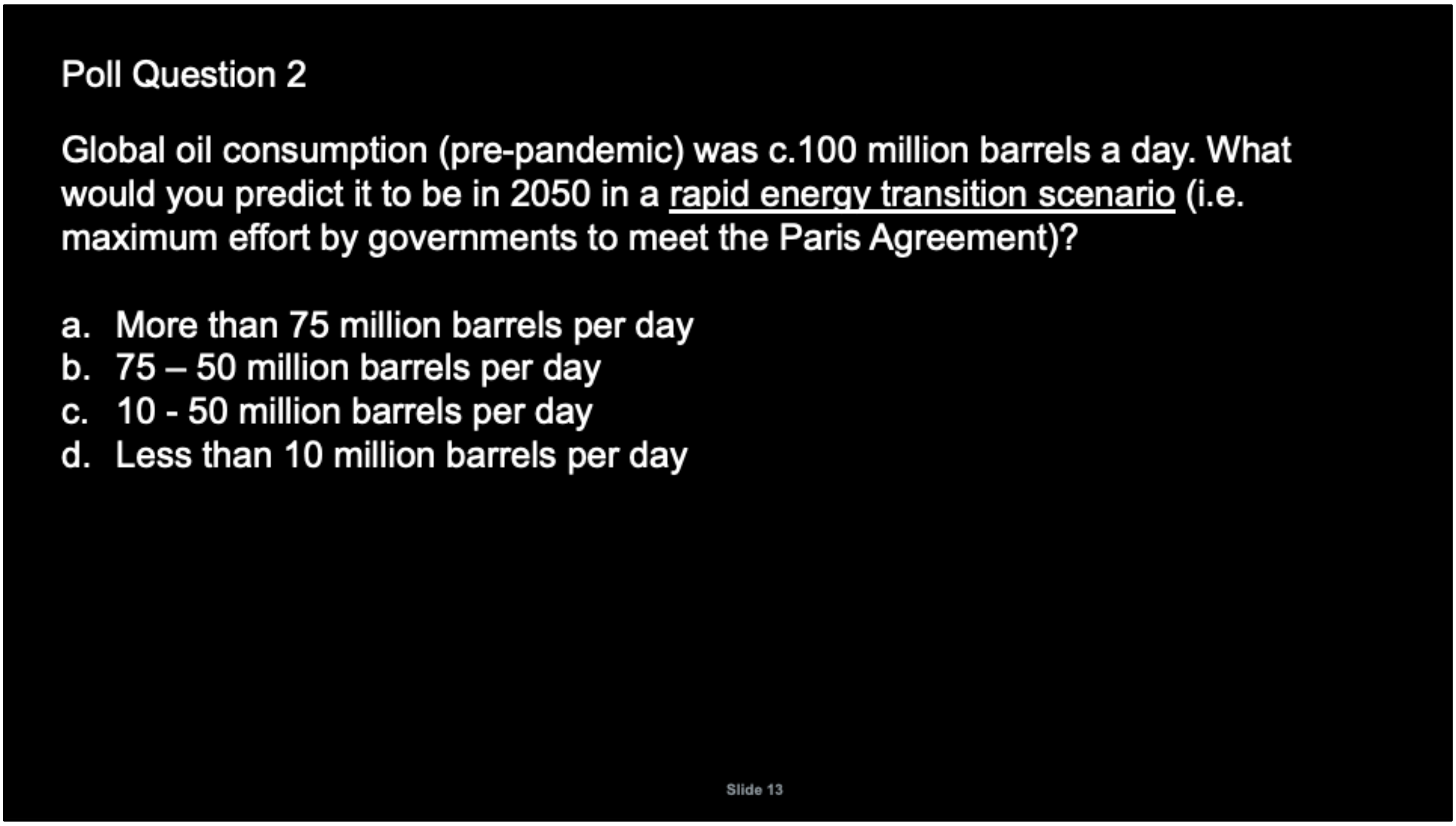
In many developing nations, people consume just 500 – 5 times less and as a result may have a life expectancy of 20 years less

This raises important moral questions, such as do all nations have the right to use the same amount of energy as the richest nations?



The uneven access to energy is highlighted in this map, showing the share of population of each country with access to electricity

Access to electricity may not be what you imagine



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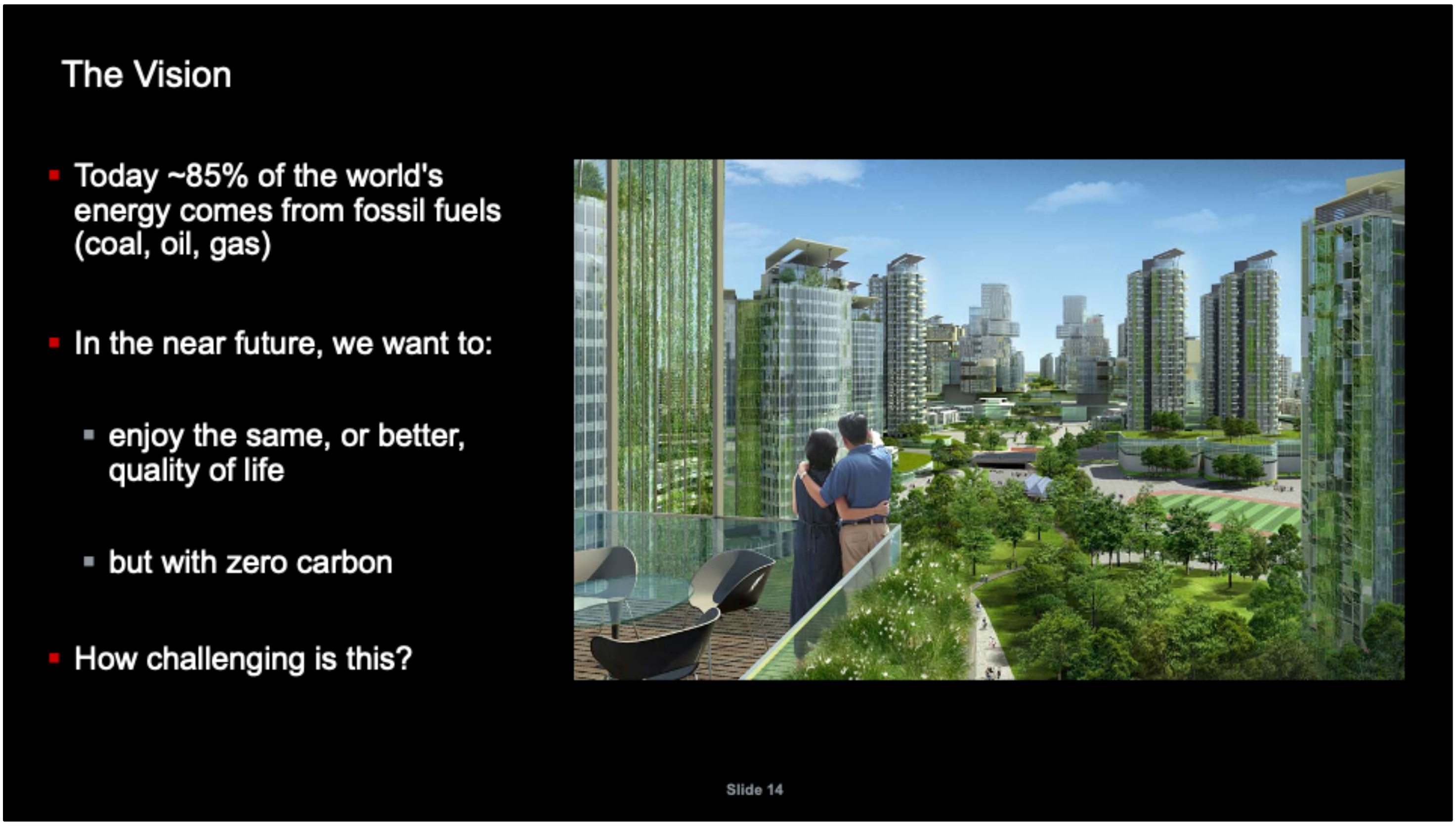
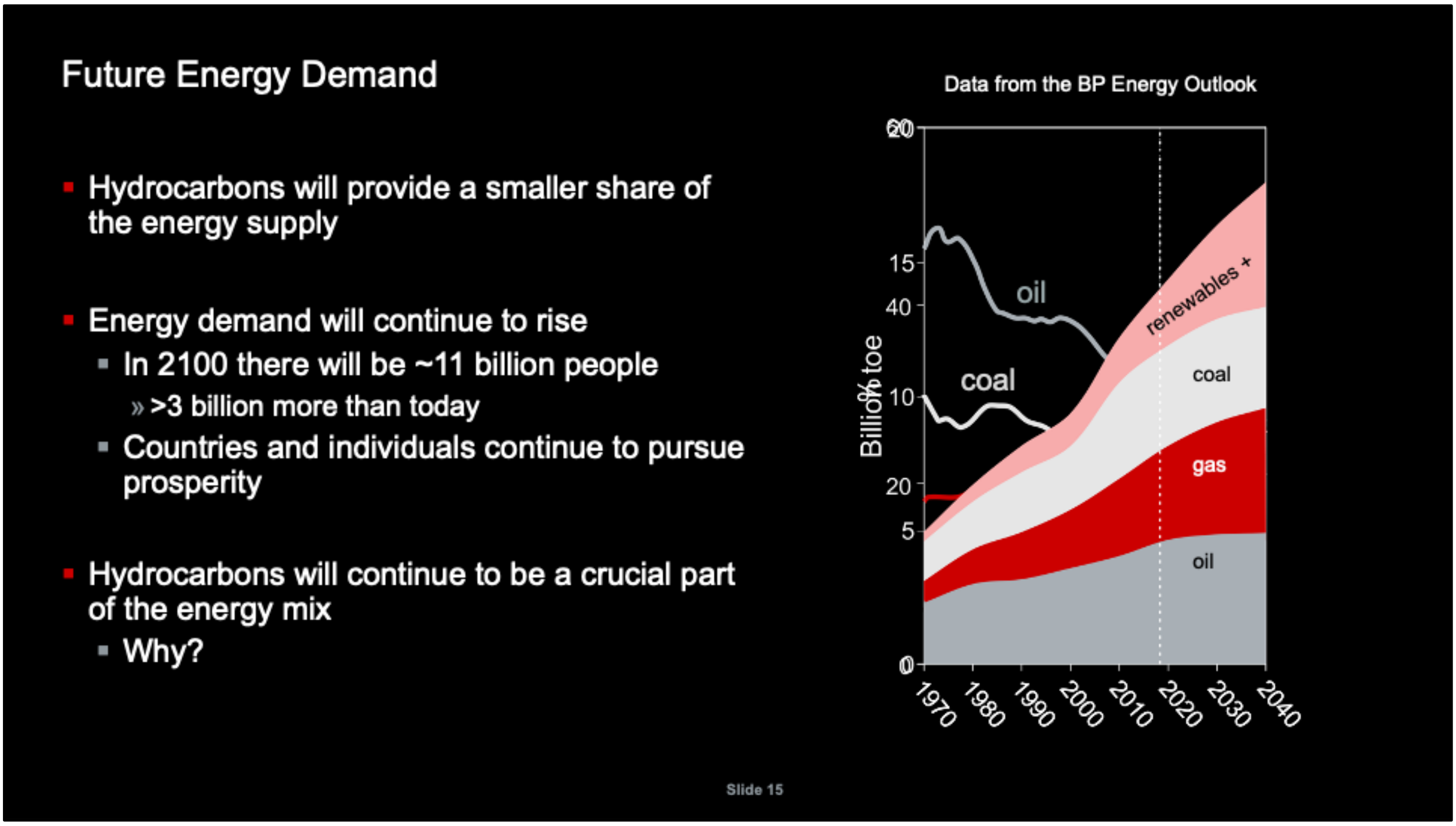


Therefore, most of the public share a collective vision whereby we move from the situation of today, where 85% of the worlds energy comes from hydrocarbons,

To a world where we enjoy the same, or better quality of life, but with zero carbon emissions.

And it sounds simple doesn’t it? It just takes political will, right?

In this talk we’ll explore the practicalities of this vision



So what does this mean for the future?

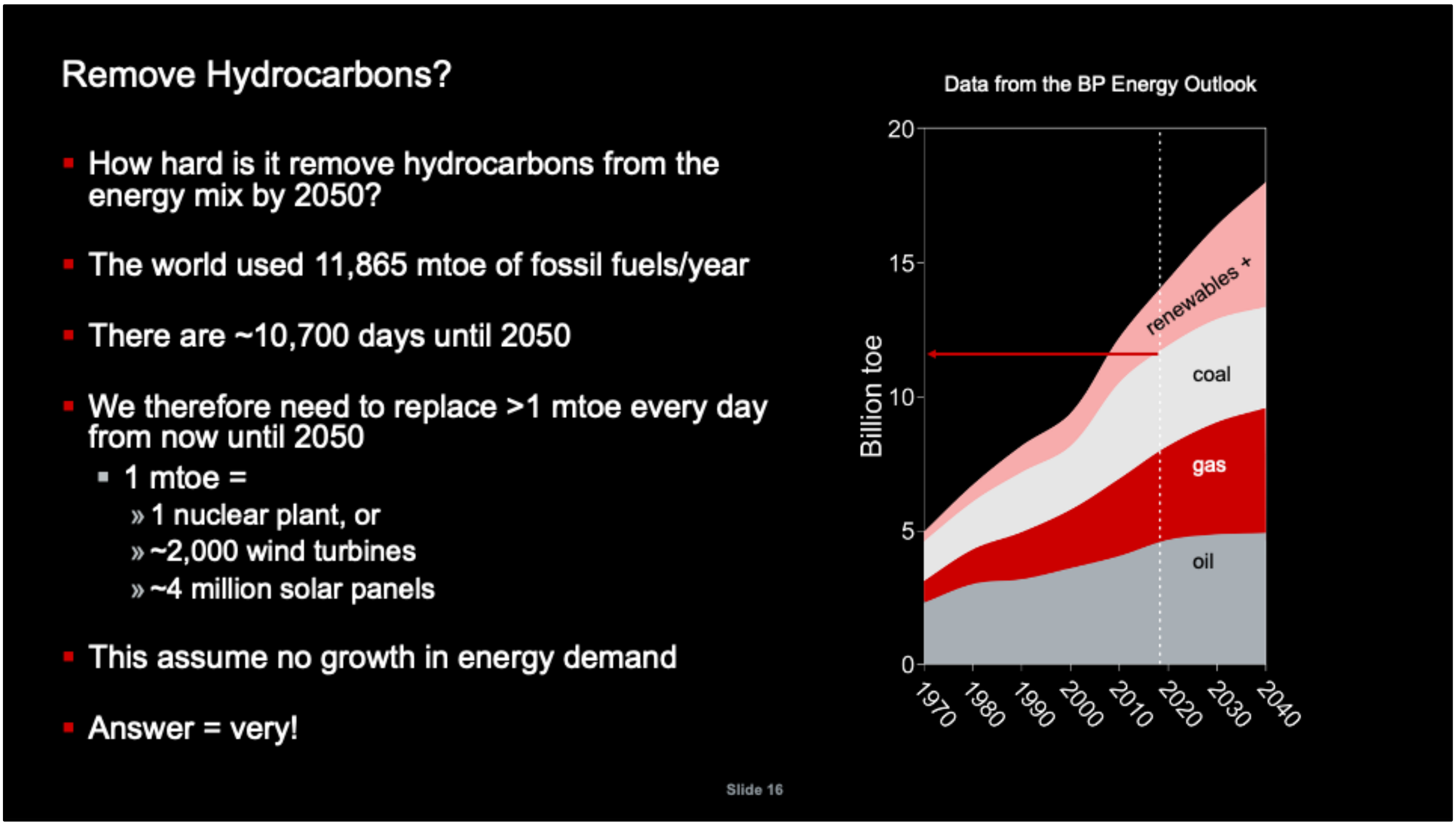
Well, we know that hydrocarbons will provide a smaller share of the global energy supply in future. This is **the continuation of a trend that's has been playing out for some time**.

However Energy demand will continue to rise as the **global population becomes wealthier and grows in number**.

The **UN forecast** is that by 2100 there will be ~11 billion people on the planet; 3 billion more than today

As such, even in light of climate change, hydrocarbons are predicted to be a crucial part of the energy mix for decades to come

Why is this?



We can therefore ask the question; how hard is it remove hydrocarbons from the energy mix by 2050?

Currently, the world used 11.8 billion tons of oil equivalent energy from fossil fuels per year

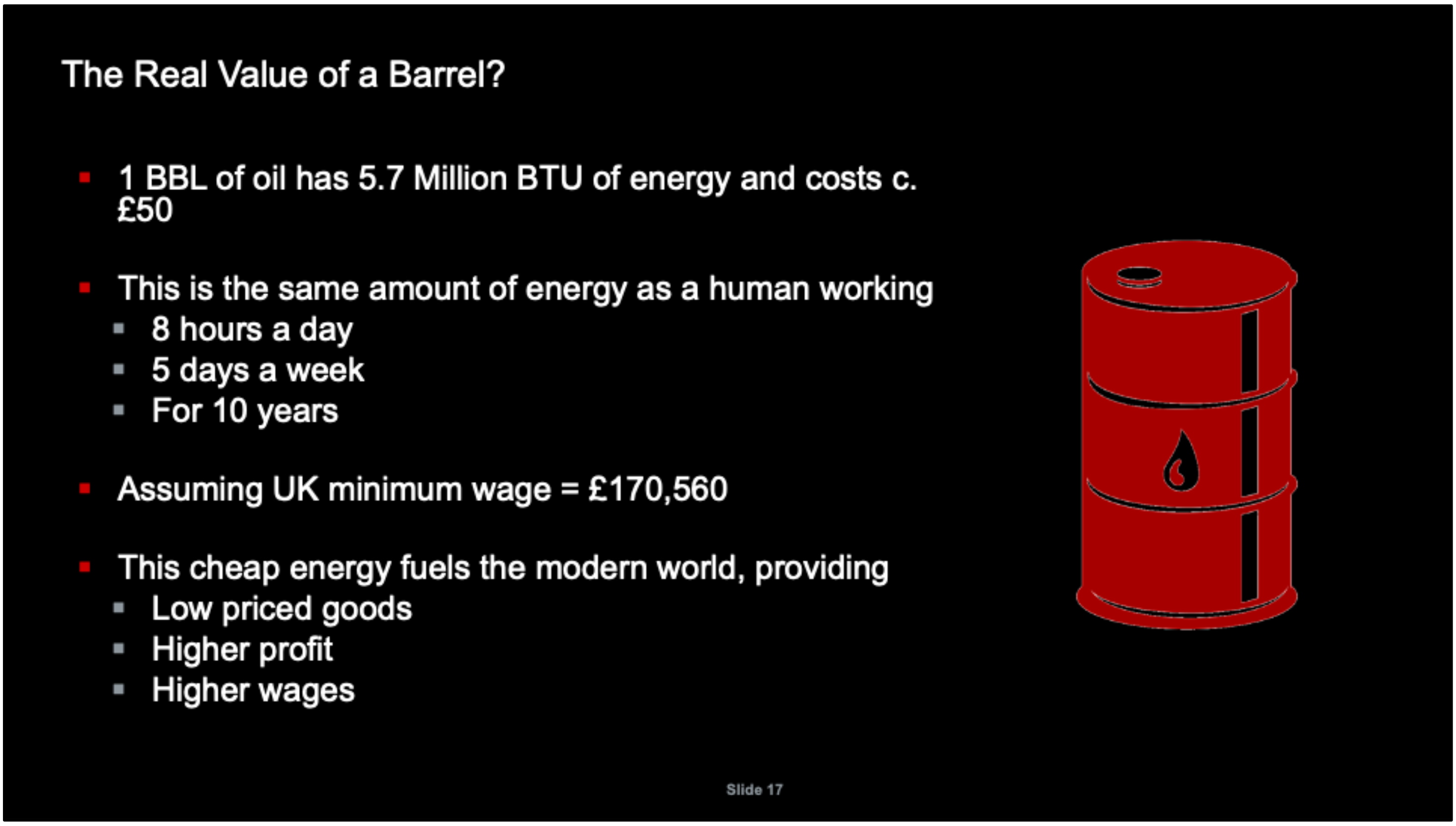
There are ~10,700 days between now and 2050, and so we need to replace >1 million tons of oil equivalent energy every day between now and then

But what does 1 million tons of oil equivalent energy represent?

1 nuclear plant, or
~2,000 wind turbines
Or 4 million solar panels

This assume no growth in energy demand

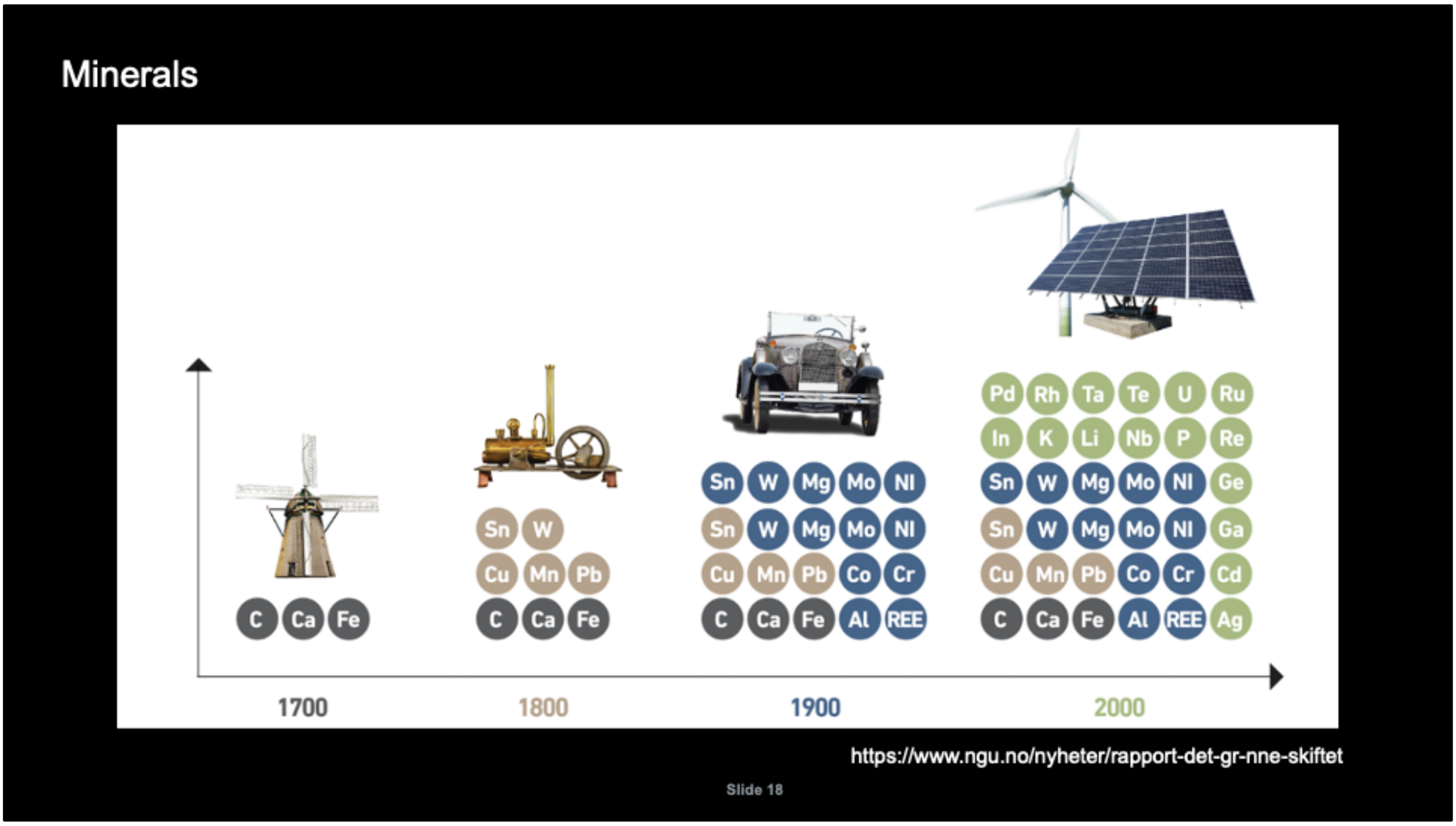
Answer to the question is = very!



So how much energy is there in a barrel of oil?

1 barrel of oil, which can be bought for ~£35, contains 5.7 Million BTU of energy

This is equivalent to a human working

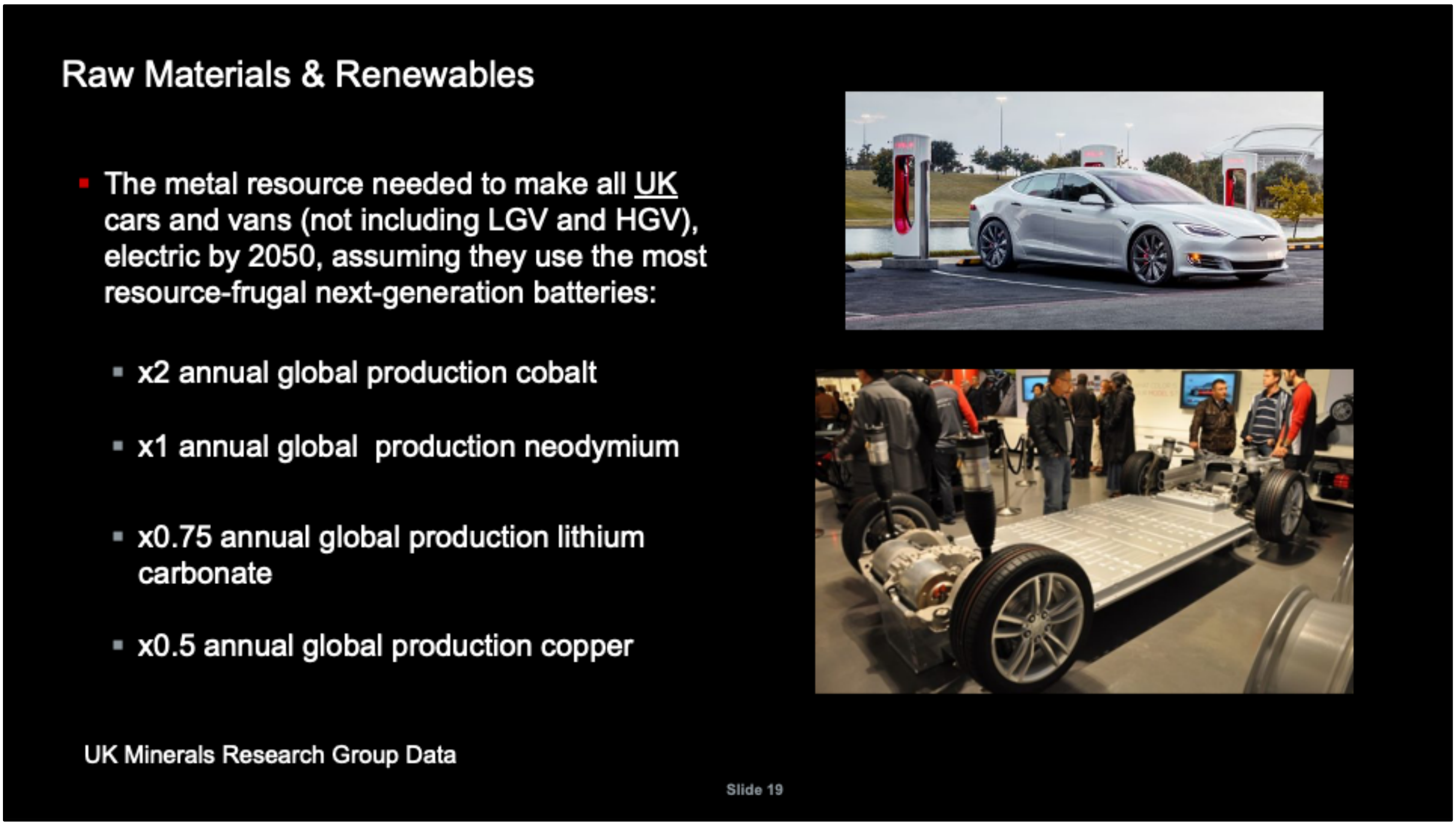


The energy transition will also be associated with an unprecedented demand for mineral resources and hence mining geoscientists

Not only will there be a growing demand, but the demand will be for a larger range of minerals than ever before.

As can be seen in this graph, the digital revolution and energy transition mean we now need to source an ever growing list of elements from the periodic table.

The mining industry is going through its own paradigm shift. Resources have been traditionally found close to surface, but increasing the mining industry will need to use techniques from the hydrocarbon industry, such as the use of seismic and an understanding of geological processes to map fairways, to find more deeply buried reserves.



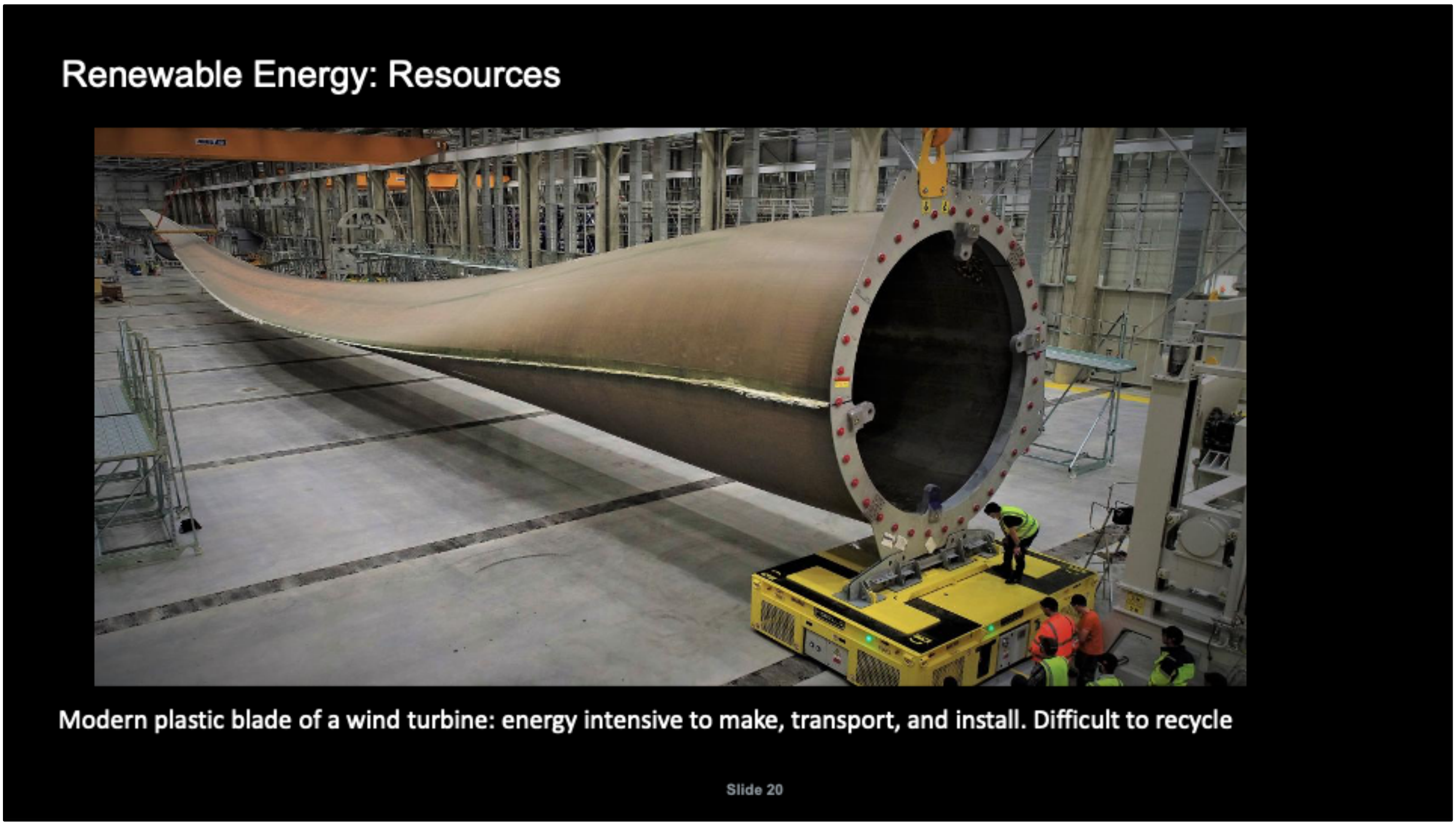
However, mineral demand itself is a barrier to the rapid transition and is a further demonstration that becoming net zero is not simply a case of political will

If we look at the metal resource needed to make all UK cars and vans (not including LGV and HGV), electric by 2050 we get some staggering statistics

To do this we need to use

x2 annual global production cobalt
x1 annual global production neodymium
x0.75 annual global production lithium carbonate
x0.5 annual global production copper

Clearly this is a difficult ask!



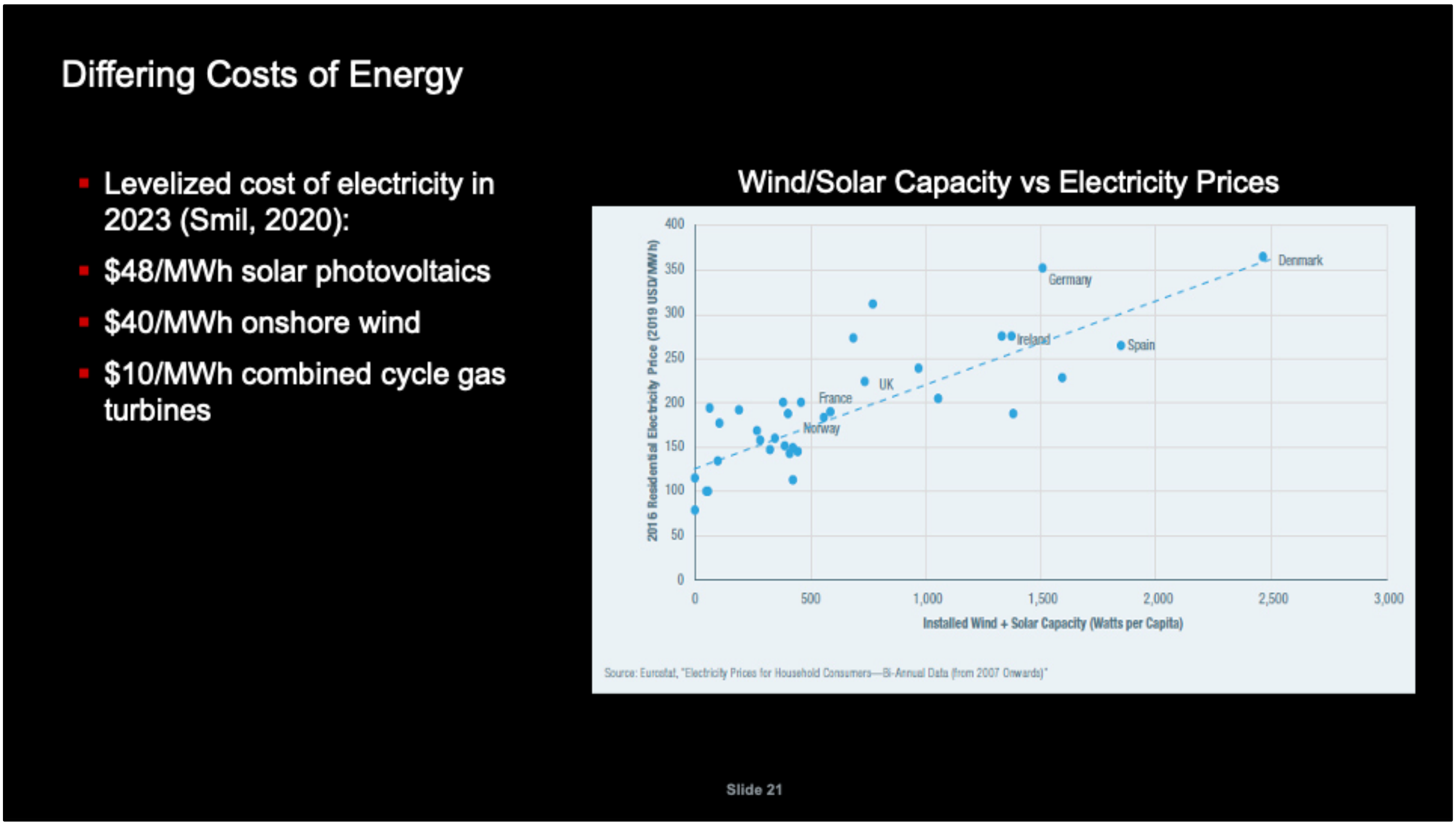
The successful deployment of wind turbines also requires expert geoscience input.

As an example, in the North Sea, the Quaternary glaciations have left a buried landscape of glacial and fluvial channels, as can be seen in the shallow seismic image and geological map

These pose a risk to the foundations of wind turbines

Geoscientists are therefore needed to interpret seismic data to help plan wind turbine placement and foundations

If this isn't done correctly there can be very costly mistakes!



All of this, plus things like building missing infrastructure, means the cost of the transition is huge

Most emissions reductions will not be profitable to society.

For instance, CCS may be profitable to some companies but you can think of it as “waste disposal”. Waste disposal is a good thing but it has to be paid for.

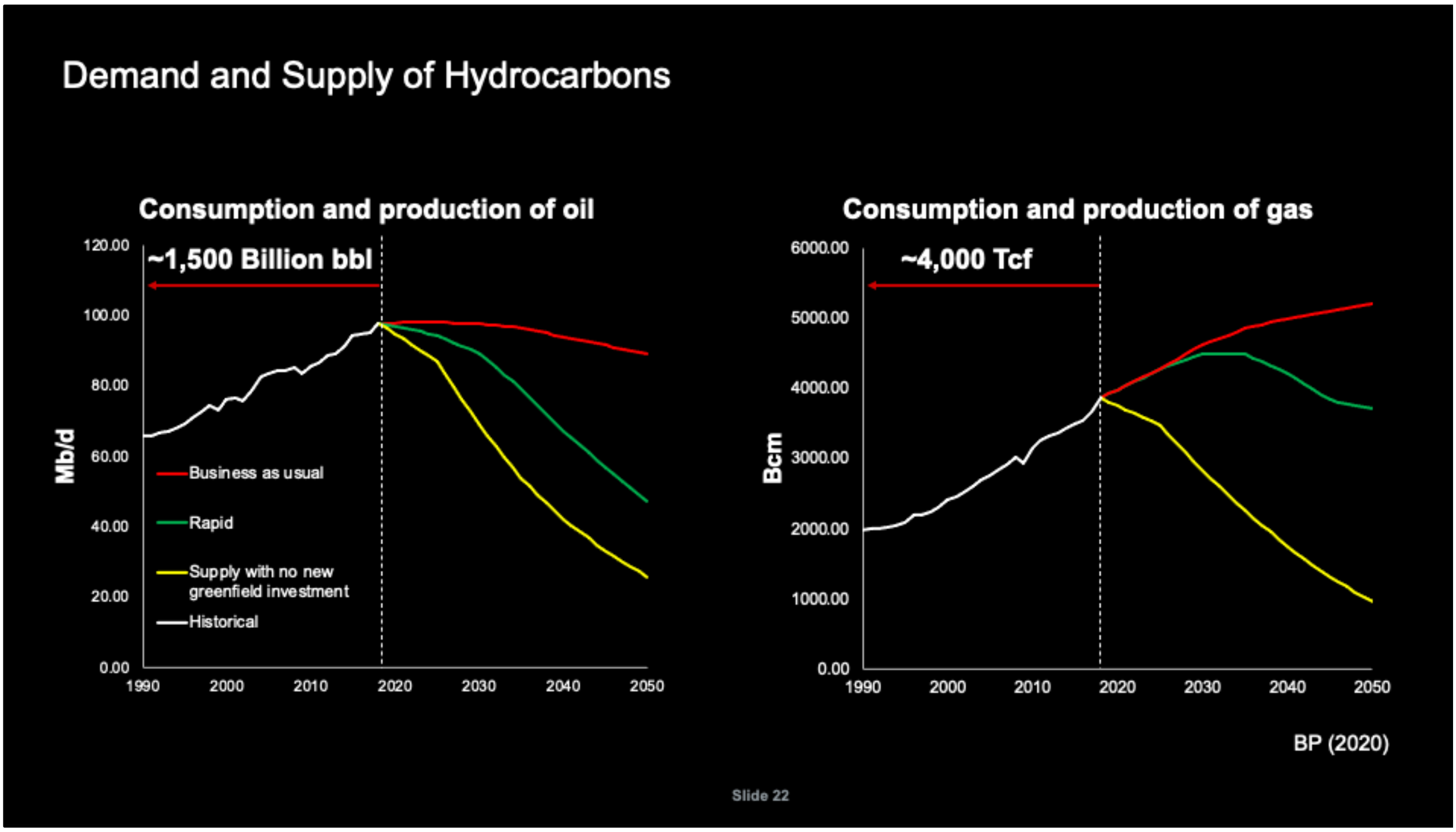
CCS will therefore act as a tax on energy. This cost acts as a brake on the speed of the transition.

Who will pay for this? Ultimately all of us.

We can see this playing out already. The graph on the right shows the Wind/Solar Capacity of each country in Europe vs Electricity Prices for each country in Europe

It clear that a higher reliance on renewables equals higher prices.

What may be the consequences of these rising energy costs?



So what does this mean for those seeking careers in the hydrocarbon industry?

These graphs show the consumption of oil and gas

The vertical dashed line is today and left of that the white line shows historical consumption going back to 1990.

In the whole of human history, we have produced and used 1.5 trillion barrels of oil and ~4,000 Tcf of gas

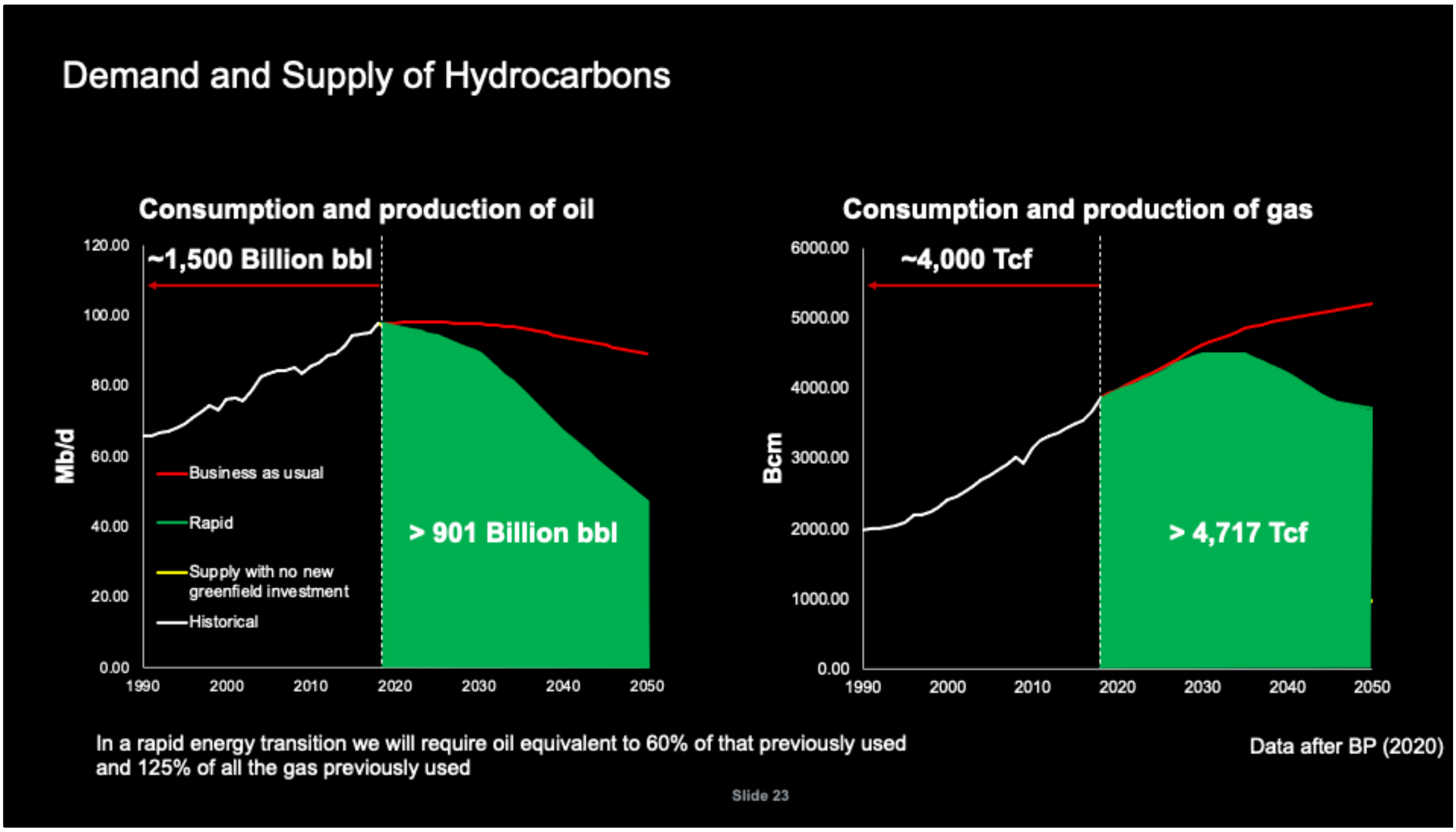
To the right of the dashed line are future projections

The red line shows business as usual demand with moderate CO2 reduction policies equalling a 10% on modern outputs by 2050

The green line shows demand that will be required in an ambitious rapid energy transition scenario where CO2 emissions fall by 70% compared to current – this roughly equates to the Paris agreement

The yellow line is the supply with no new exploration.

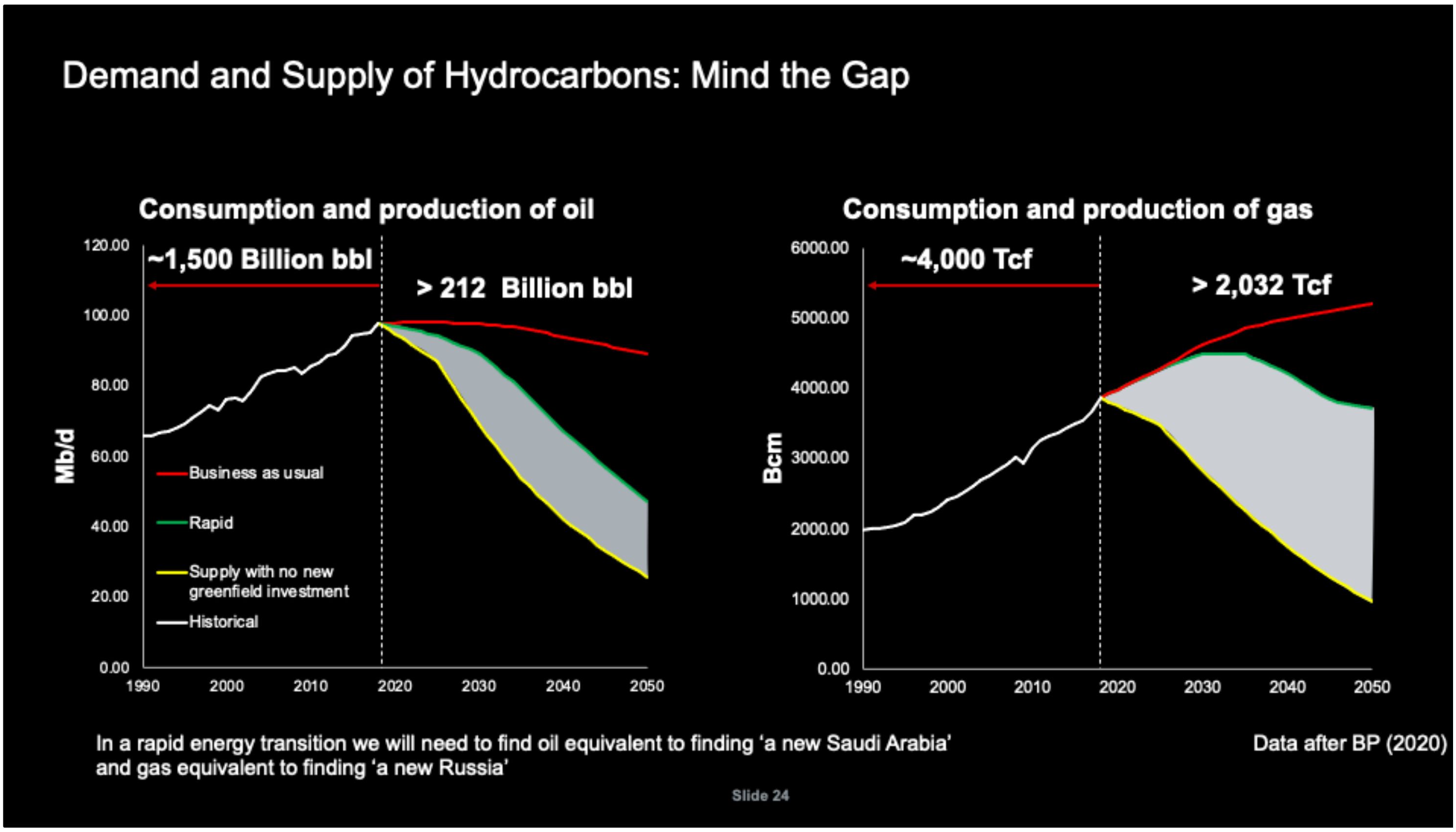
Lets look at what the rapid scenario may mean for our industry



In this scenario we will need to produce over 900 billion barrels of oil and over 4700 Tcf of gas in next 30 years

This equates to two thirds of all the oil we half ever produced and used and all the gas we have used to date plus another quarter – a really big ask

Of course, some of this will come from current oil fields. So what do we need to actually find?

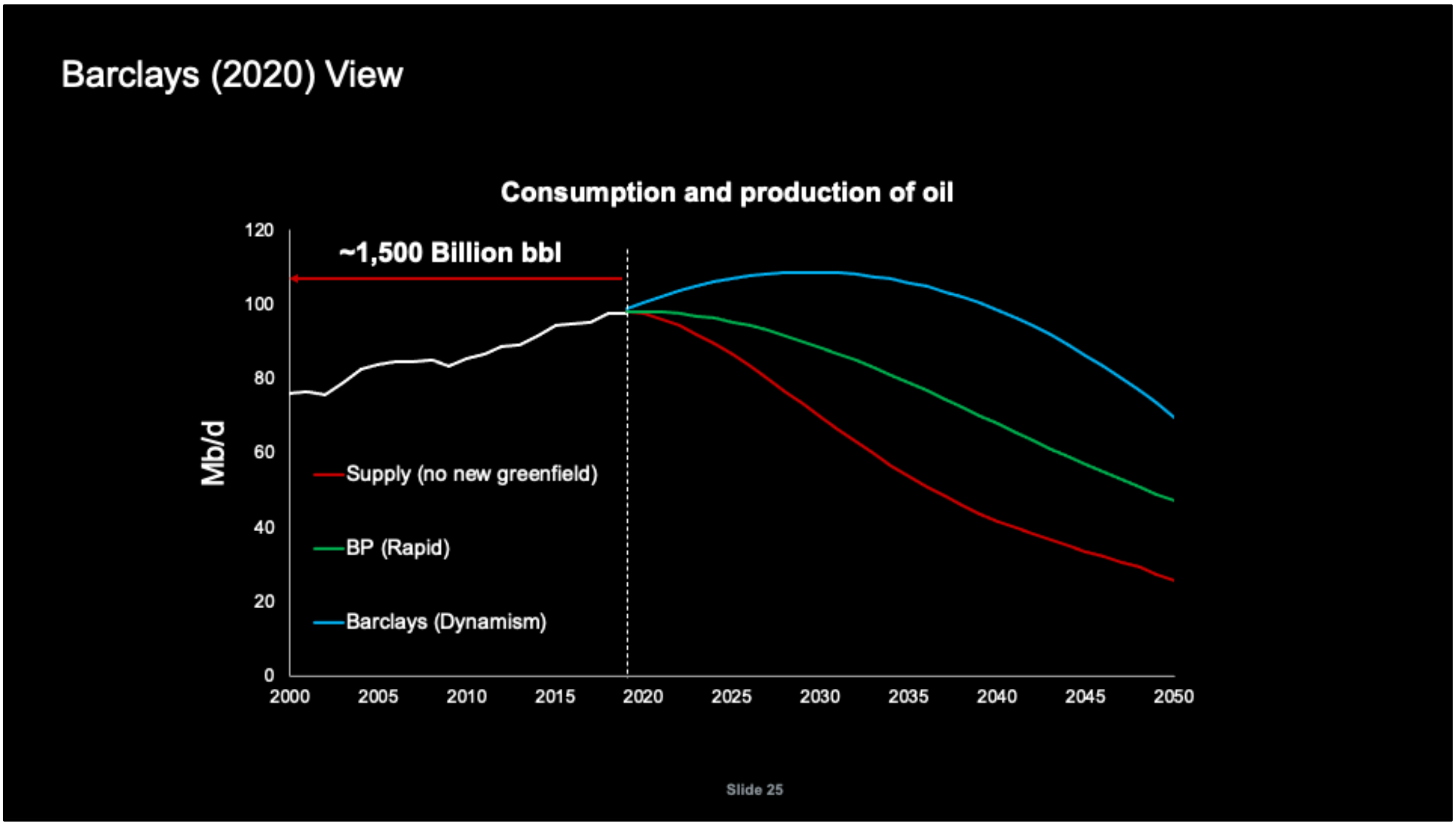


If we look at the gap between production from existing fields and demand, we will need to find and produce >212 billion barrels of oil and 2,032 TCF of gas in the next 30 years

So, about a fifth of ALL the oil we have ever used and half of all the gas we have ever used.

Put another way, at minimum we need to find another Saudi Arabia for oil and another Russia for gas

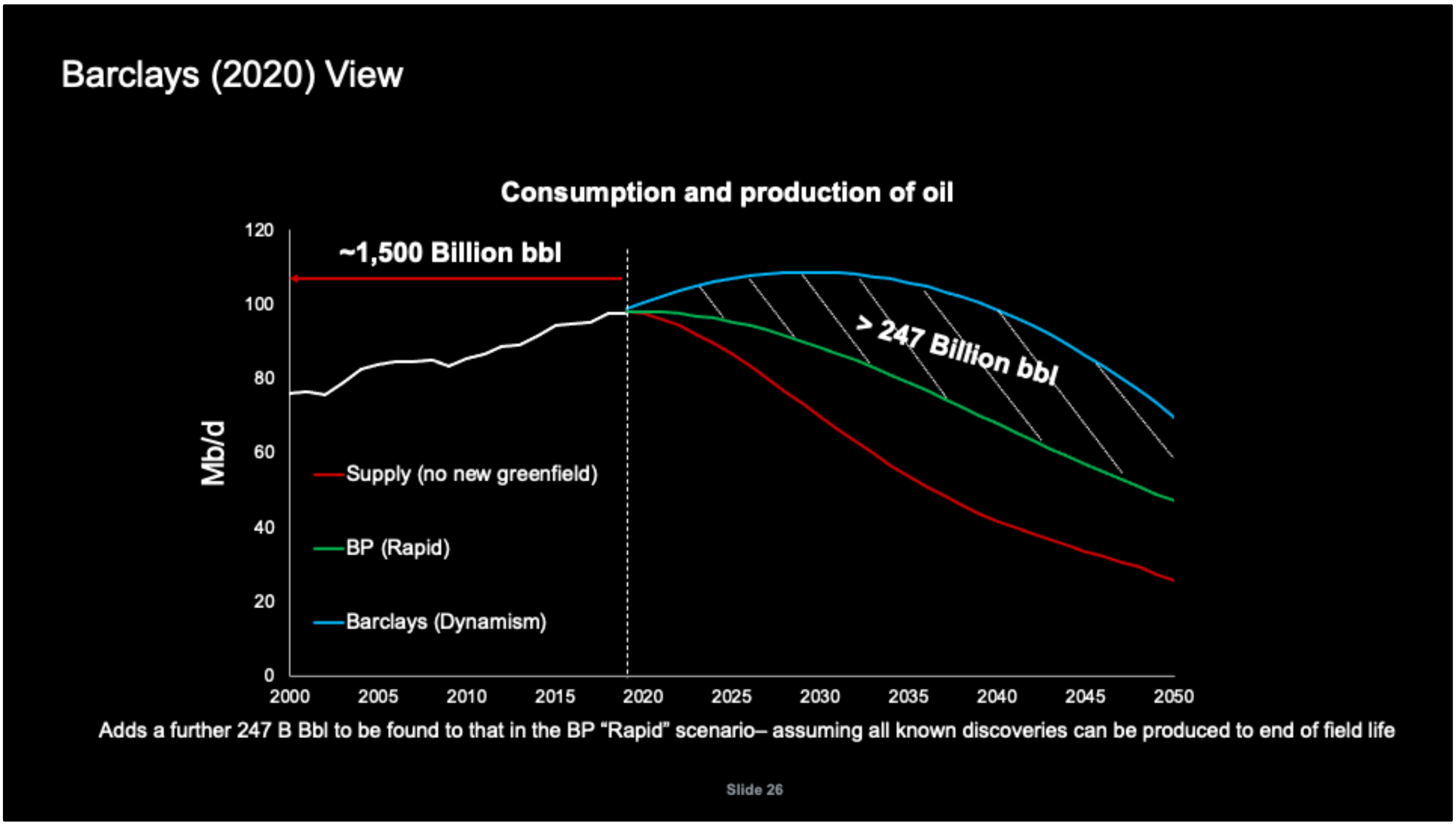
Therefore there is still a huge amount of work that needs to be done over the next 30 years at least



This might be reflected in other future projections which often show a greater hydrocarbon demand than BP in rapid energy transition scenarios

In this graph you can see the oil demand in the BP rapid scenario, in green, compared against the rapid energy transition scenario of Barclays Bank in blue

You can see that the Barclays are forecasting a far higher demand for oil in the next 30 years than BP

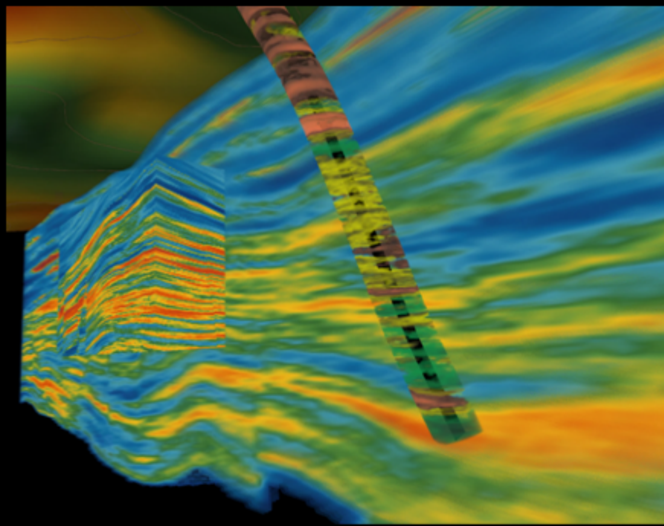


This demand forecast by Barclays amounts to an additional 247 billion barrels comapred top BP's forecast

And indicates a need to produce 1.1 trillion barrels of oil and find almost 500 billion barrels in the next 30 years

Outline

- Introduction: Geoscience in the 21st Century
- Energy and Society
  - Energy demand
  - The energy mix – the role of hydrocarbons
- Evolving Geoscience Needs
  - Advantaged hydrocarbons
  - Carbon capture and storage
  - Renewables
- Geoscience Research and the Digital Transformation
- Conclusions



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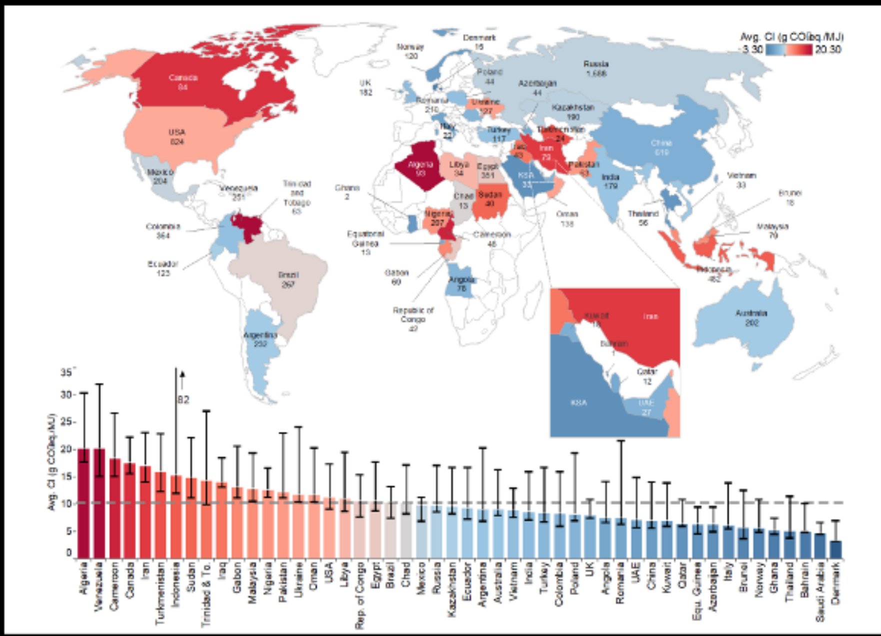
The Search for Hydrocarbons: Focus on Carbon Intensity

- We need to be more efficient
- Finding oil and gas by using the least amount of energy & carbon intensity
- Exploration projects are now being risked and sanctioned based on carbon intensity
- Carbon intensity not only relates to efficiency, but the type of hydrocarbons produced



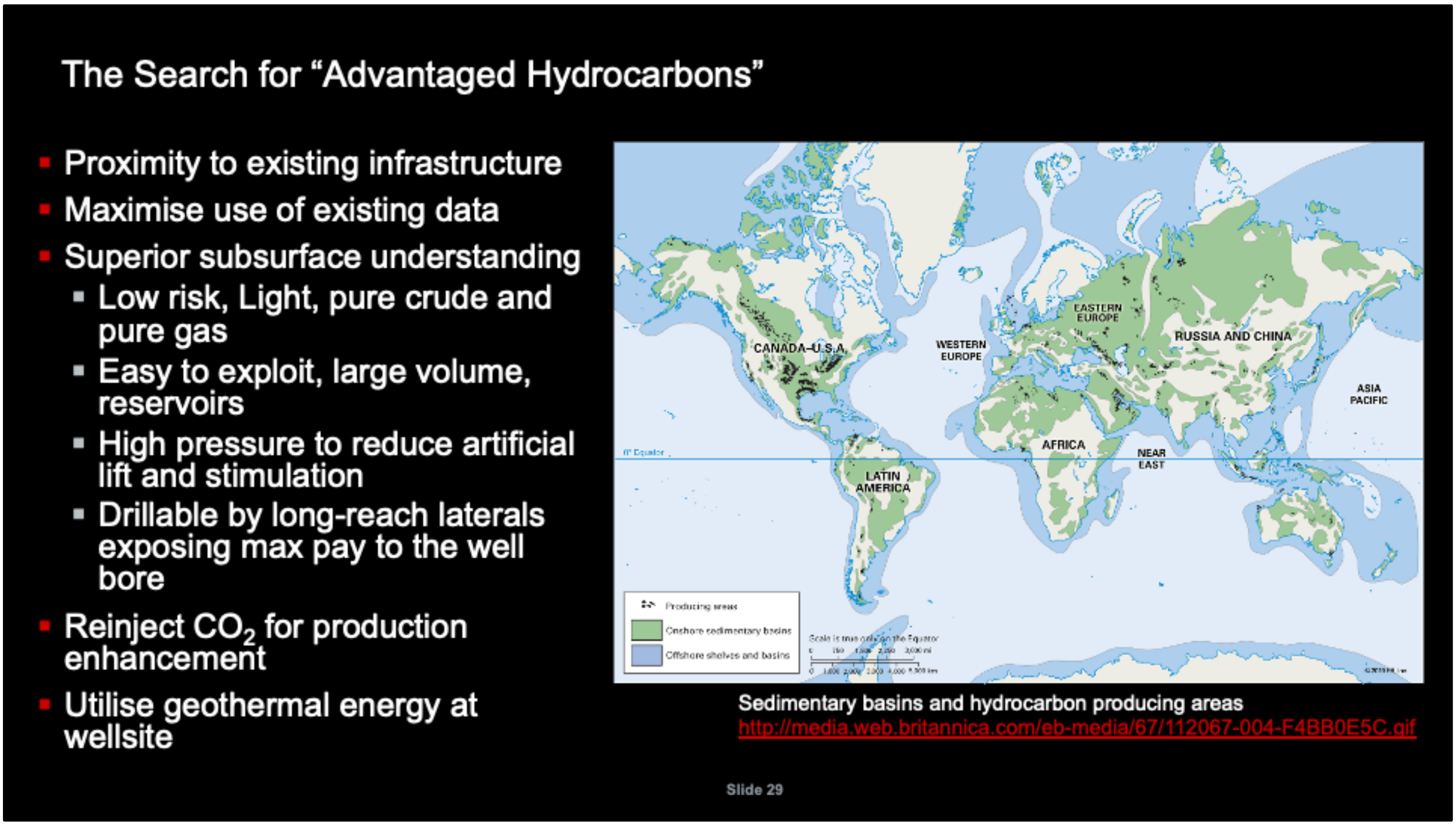
Masnadi et al. (2018)

Slide 28

Carbon intensity not only relates to efficiency, but also the type of hydrocarbons produced

This map shows the carbon intensity to produce hydrocarbons in different countries

We’ll need to employ some clever approaches to help target low carbon intensity reserves



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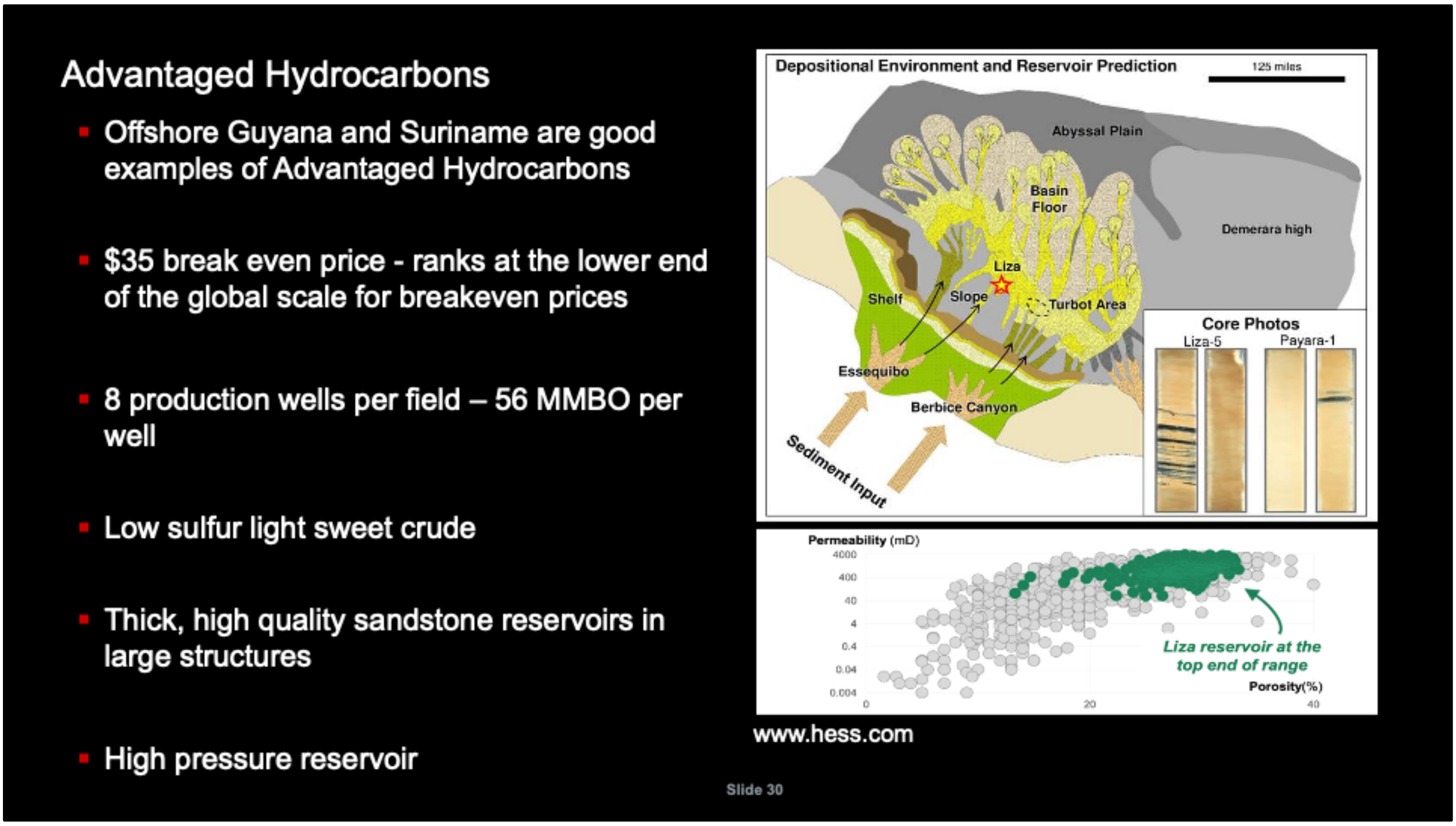


Offshore Guyana and Suriname are good examples of Advantaged Hydrocarbons

The oil offshore Guyana and Suriname's are low sulfur, light sweet crude with API's of 32 and higher

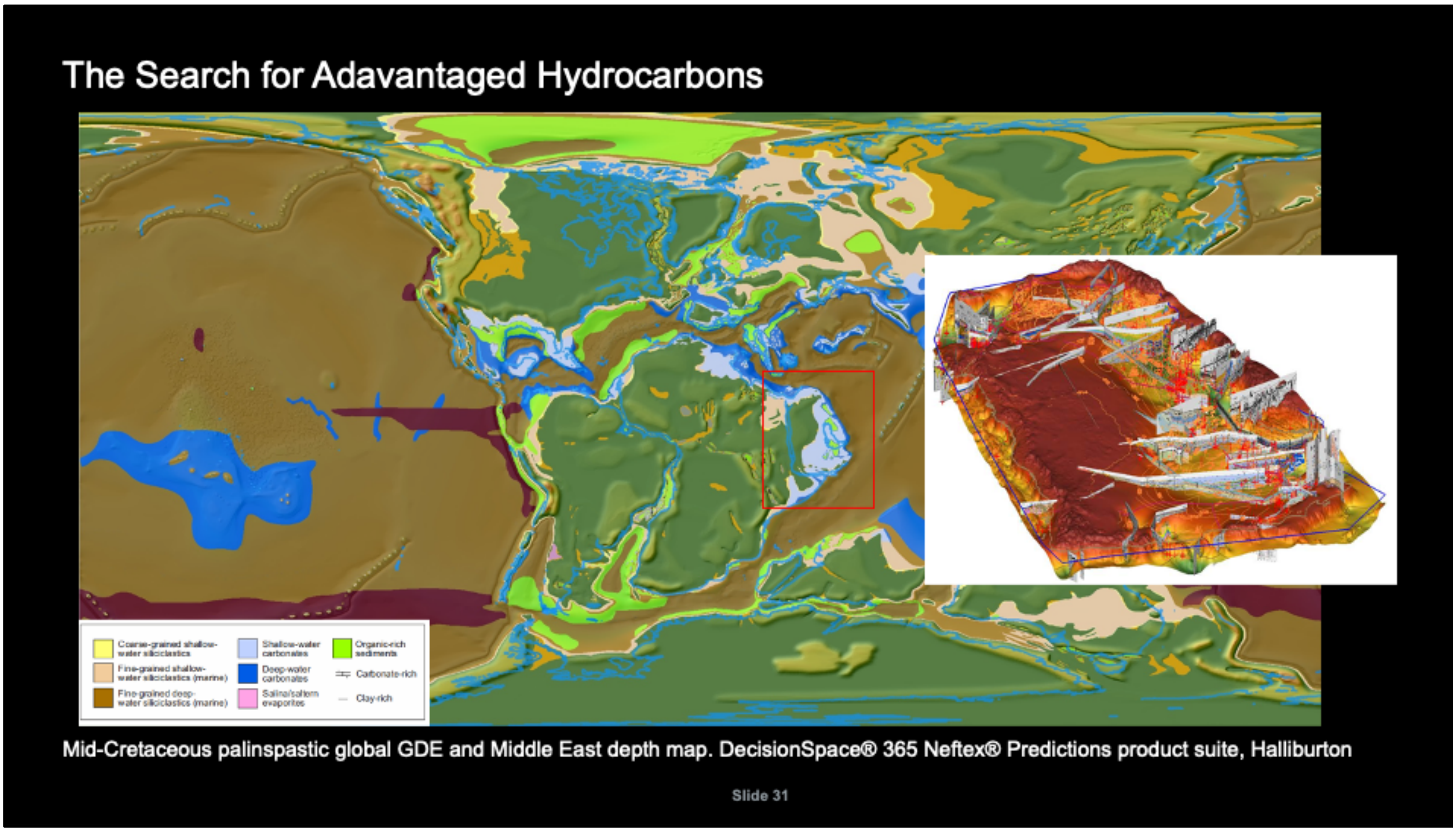
The reservoirs are thick, high quality sands that are easy to exploit, and occur in large structures. As such there are large volumes of hydrocarbons in each field.

This, along with high reservoir pressures, means that the hydrocarbons can be easily produced from a small number of well – in Liza-phase 1, 8 wells, with 6 water and 3 gas injections wells.

Despite exploration being in deep water, the breakeven even price in the Stabroek block is $35 per barrel and the price is expected to fall further as infrastructure is developed, and knowledge and technology improves.

Guyana therefore ranks at the lower end of the global scale for breakeven prices

Petronas is already employing an advantaged hydrocarbons strategy with its recent spudding of the Sloanea-1 well Offshore Suriname

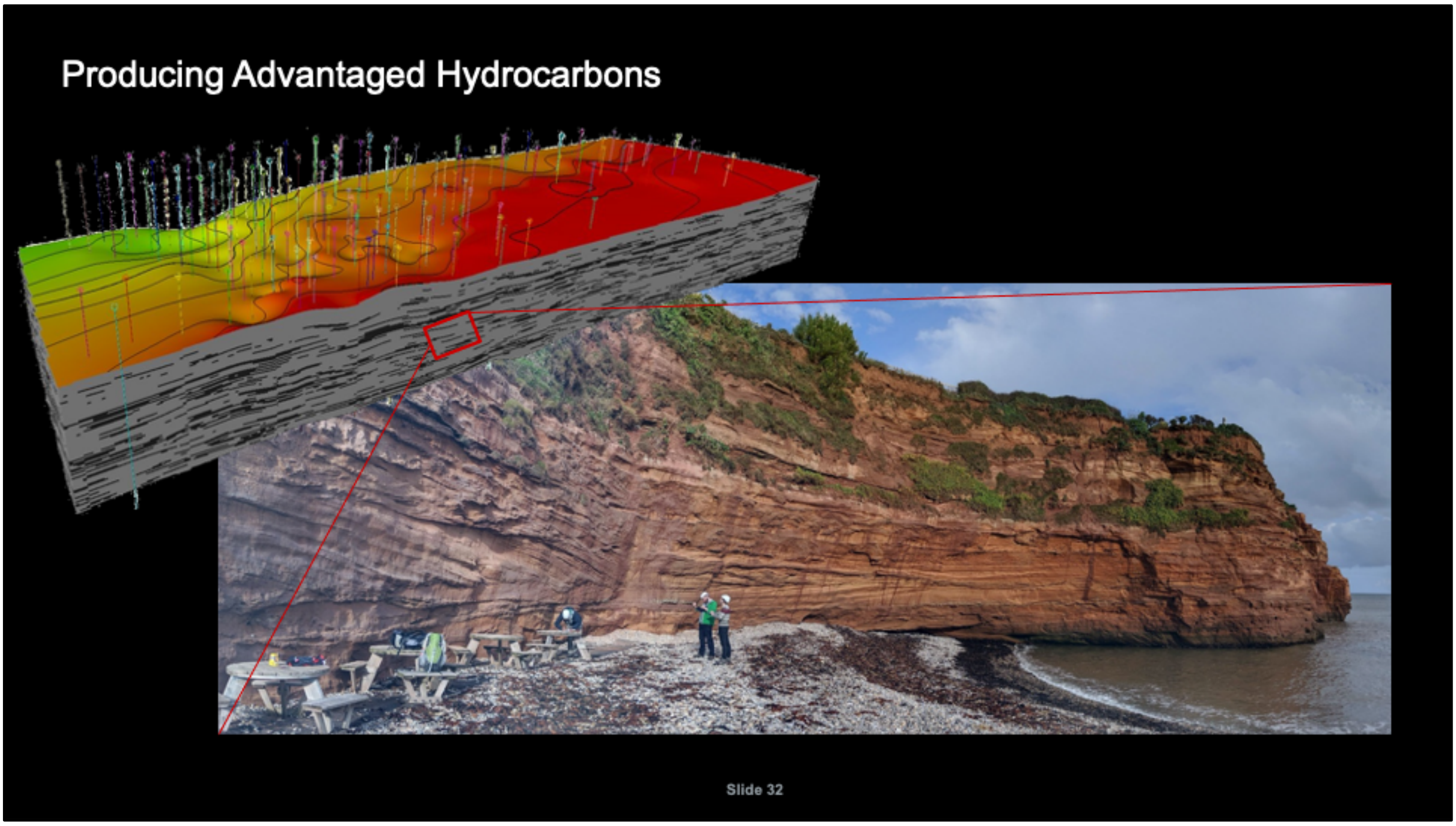


Well, as I just showed, there is a lot of work to in the exploration of hydrocarbons

There will therefore be continued demand for exploration geologists and for exploration geoscience products and software, such as those shown here, to help with this task

We will need to be as efficient as we can at finding new reserves, so that it is done with the lowest carbon intensity

Exploration projects are now being risked and sanctioned based on the carbon intensity to find and produce new reserves

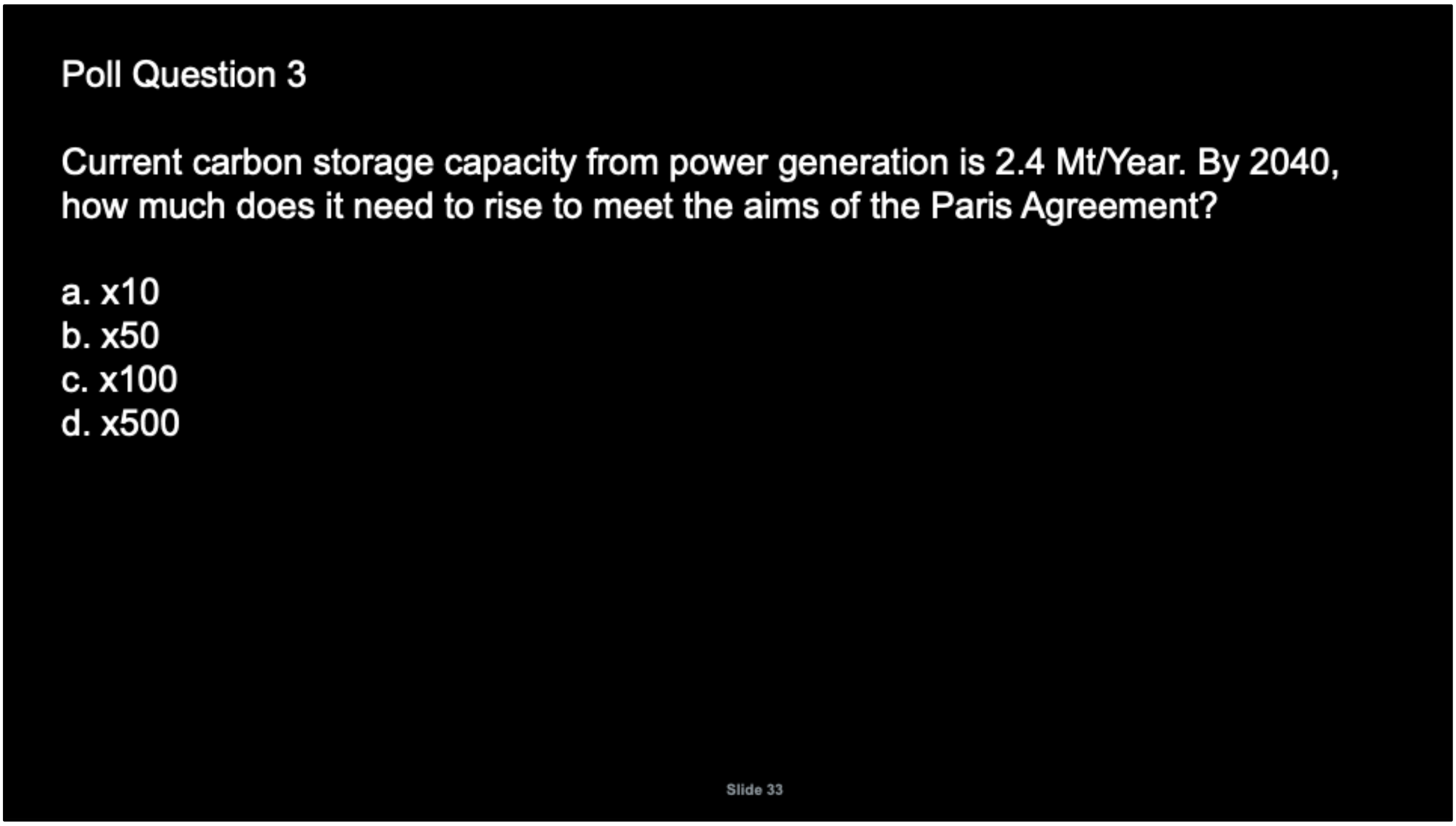


We need to continue to improve our solutions to help customers characterise and model reservoirs

This is needed for more efficient production of hydrocarbons

To help assess potential CCS sites

And to assess opportunities for geothermal



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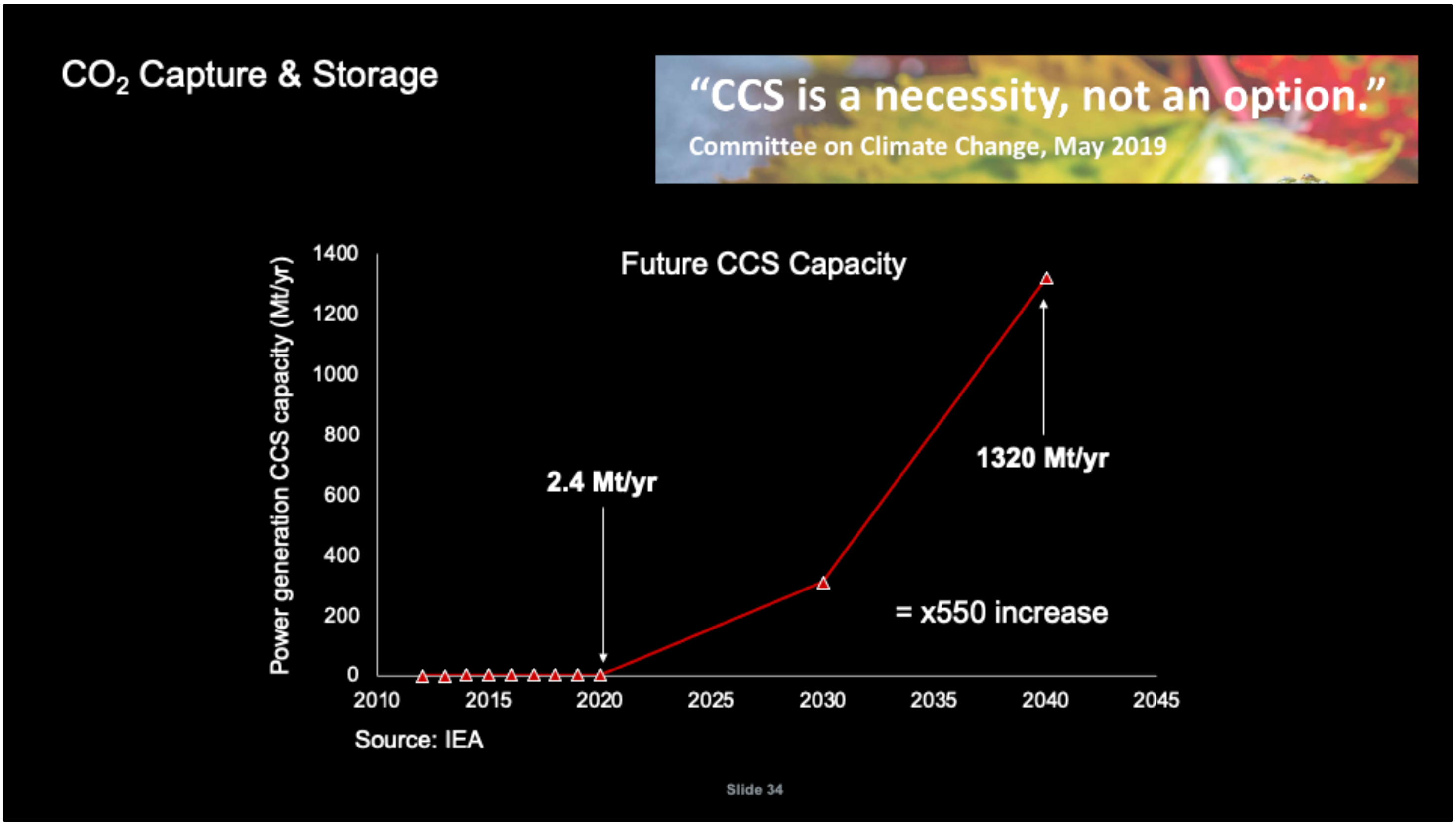
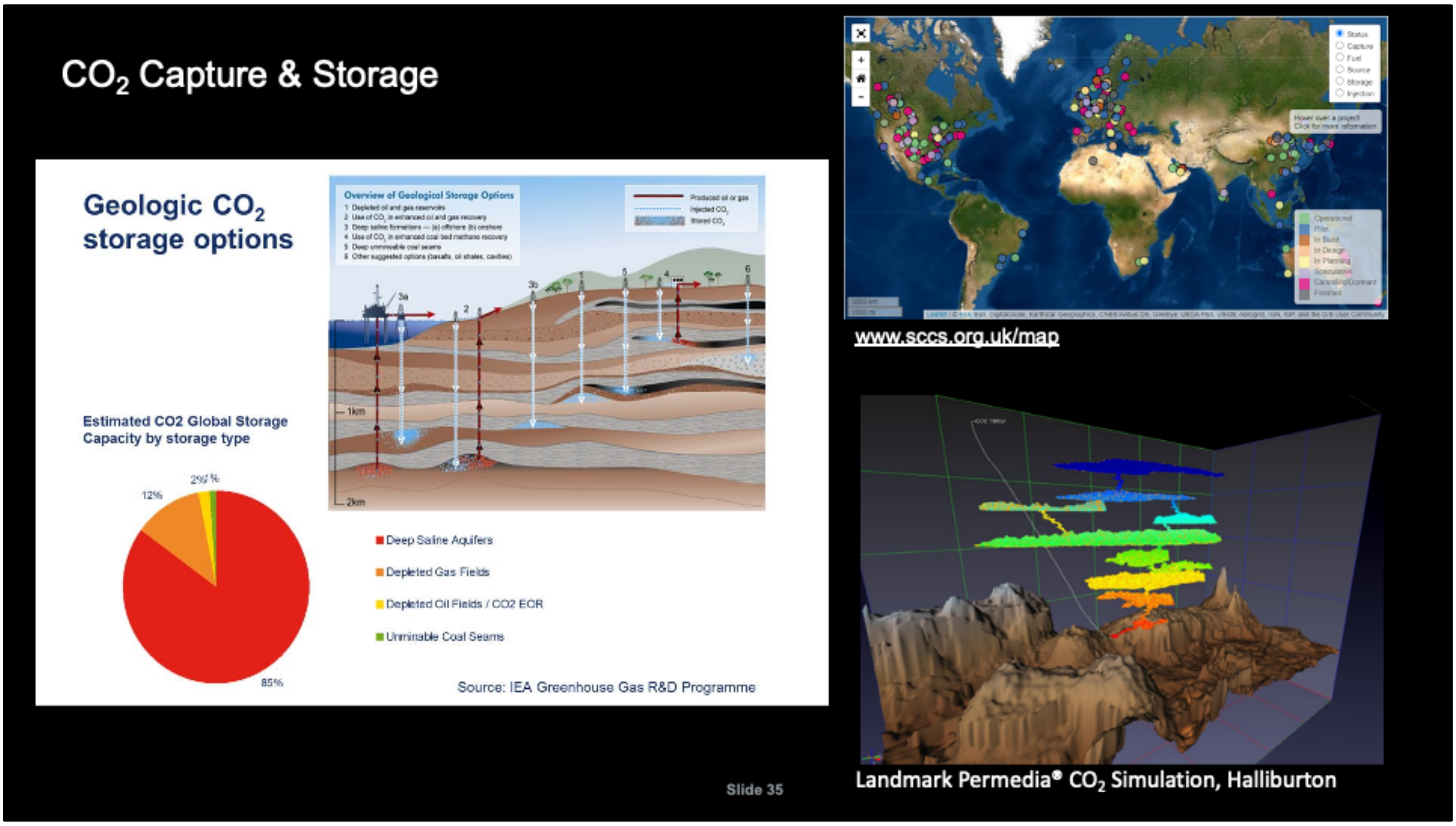


Ok, so we've tackled hydrocarbons but what other opportunities will there be for geoscientists as a result of the energy transition?

Clearly CCS will be part of the solution

This not only reflected in what I have shown you so far, but is also the opinion others, including the committee on climate change.

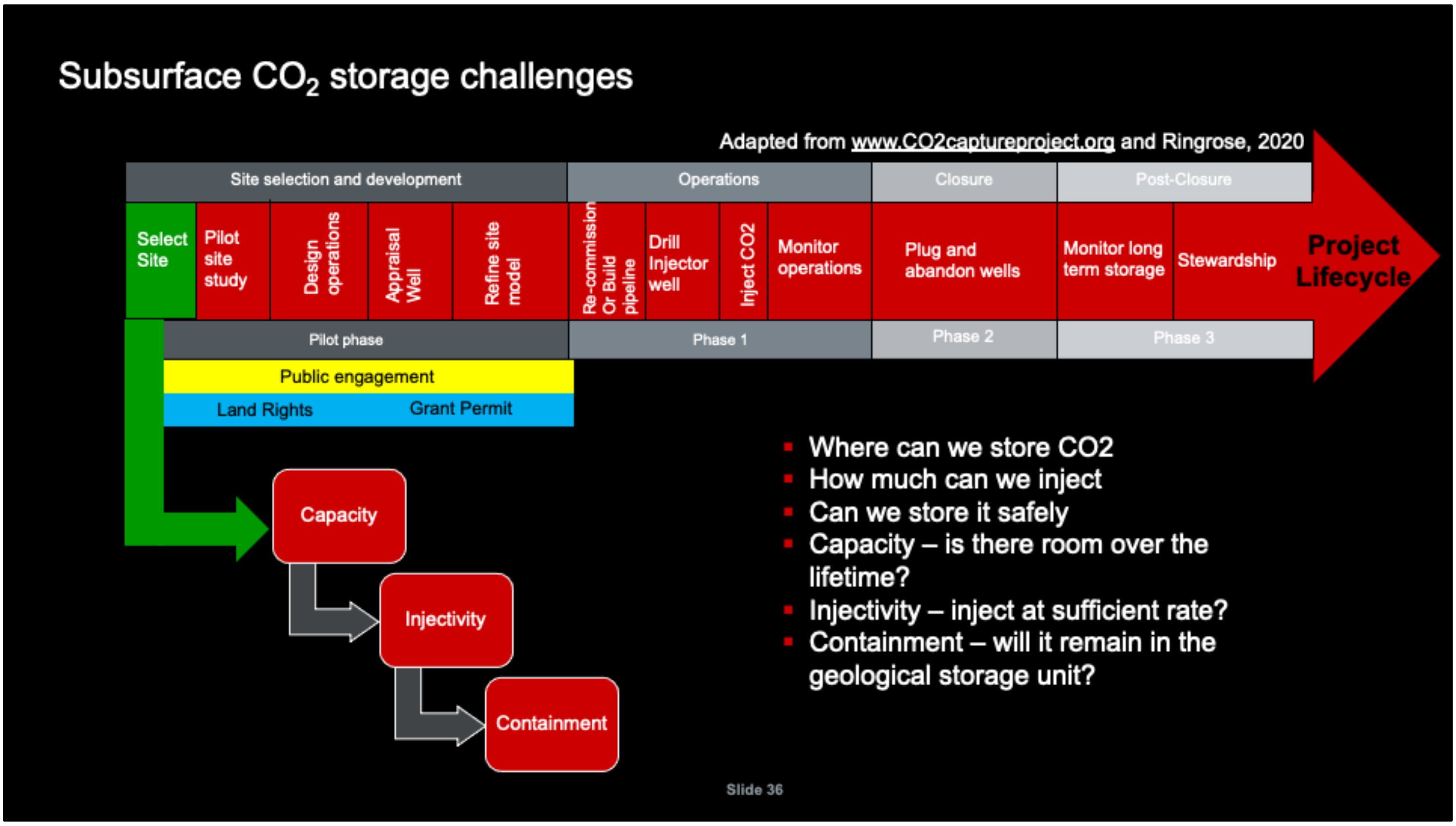
Using renewables alone is unlikely to give society the energy density it needs



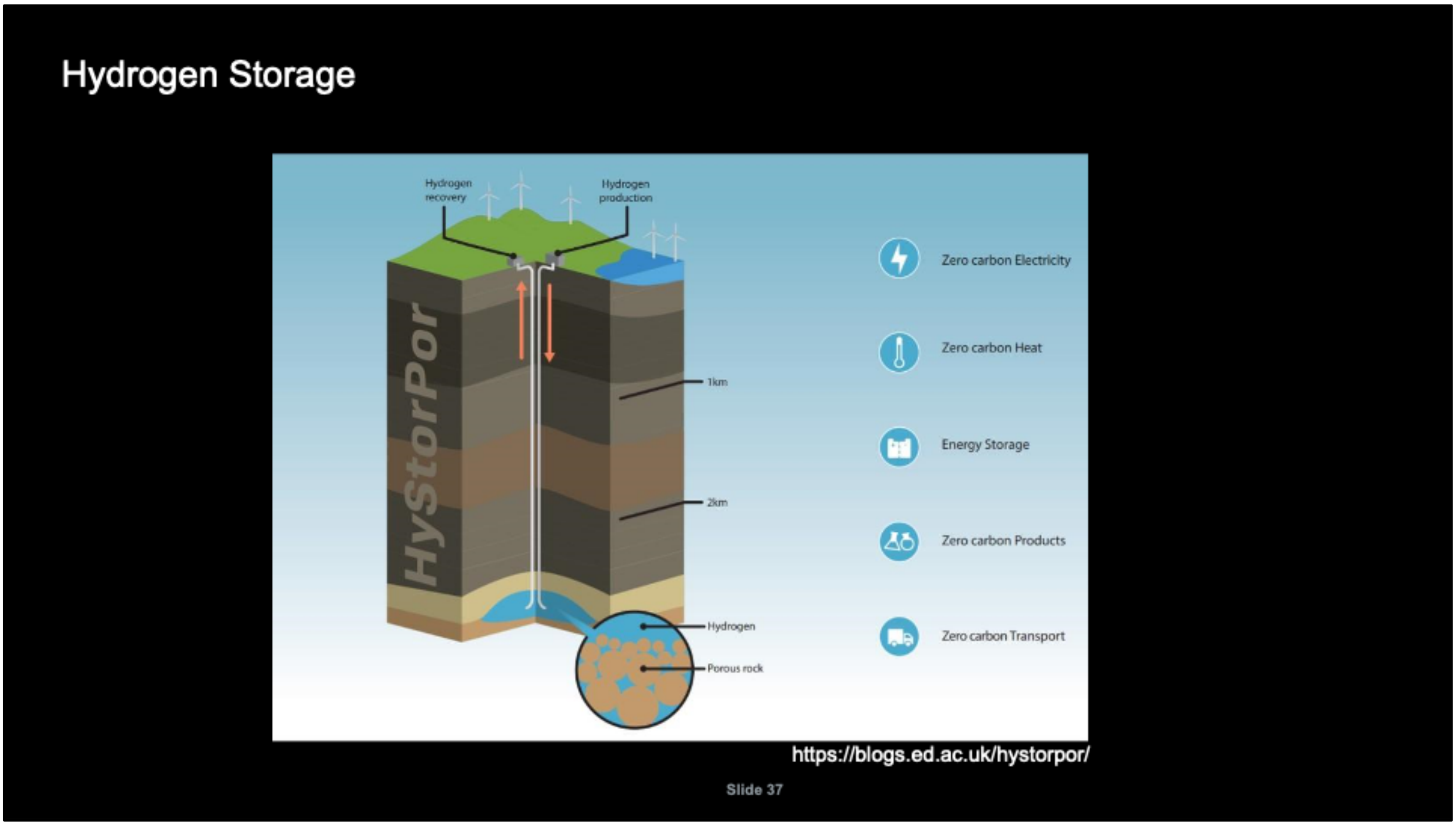
Halliburton already has CCS projects in all continents as can be seen in the map in the top right

However, we know that much of the storage will likely be taken up in previously ignored saline aquifers.

Geoscientists will be needed to help identify suitable CCS sites, create models of potential carbon reservoirs and use basin modelling software, such as Permedia, to explore the suitability of different storage sites



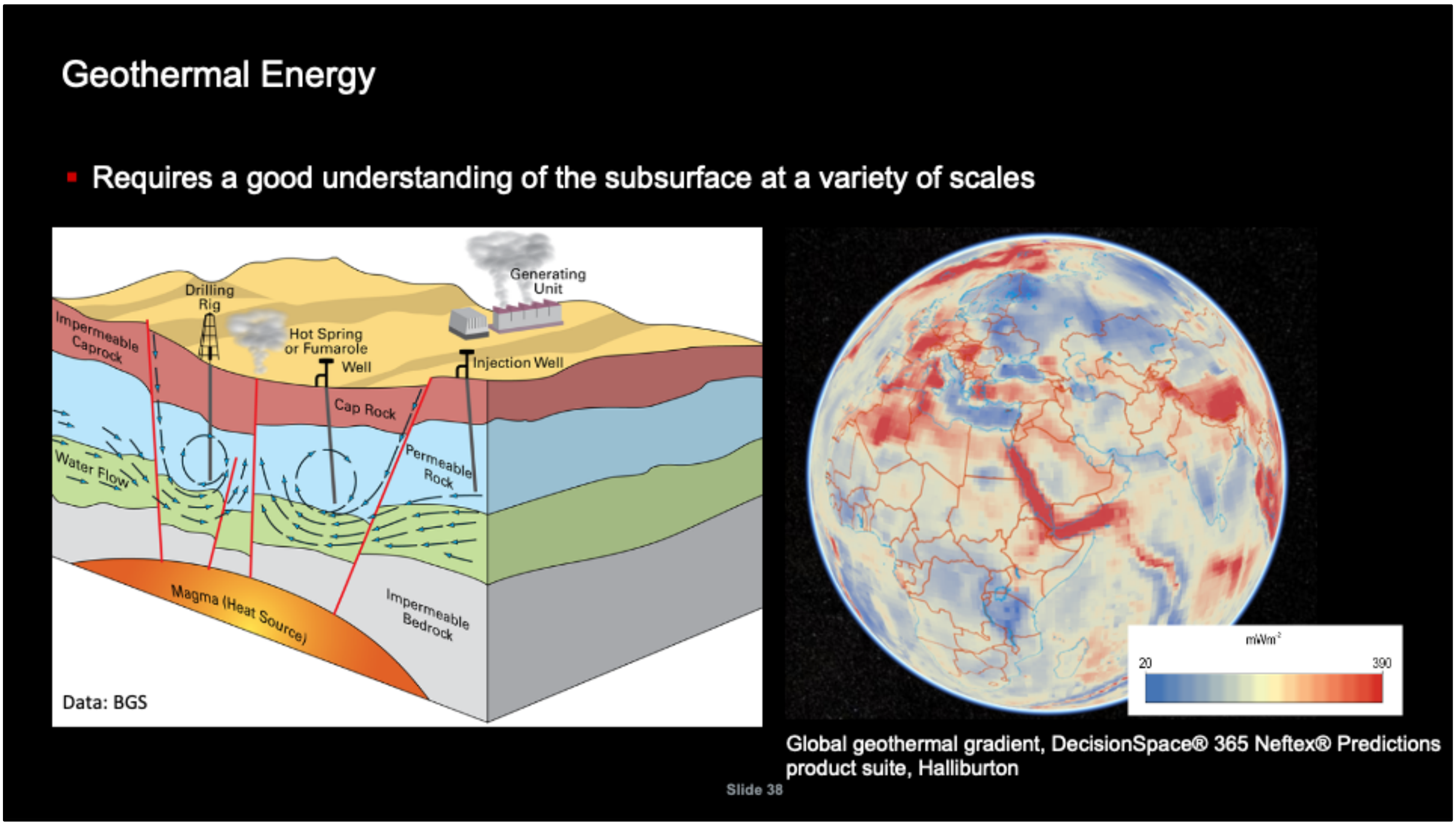
At the beginning of a carbon sequestration project it is important to address the following questions: Where can we store CO2, how much can we inject, can we store it safely, is there enough capacity over the lifetime? can we inject at sufficient rate? and will it remain in the geological storage unit? Permedia CO2 software can help reduce considerable risk and uncertainty over these questions and enable subsequent decision making on site selection more cost effective and ensure the critical elements of the subsurface are understood with more confidence.



There may be further opportunities for geoscientists in the near future relating to subsurface storage.

Hydrogen is seen as a green replacement for liquid fuels and, as it can be stored for later use, it is seen as a way to fill the energy gap from renewables when the sun isn't shining, or the wind isn't blowing

Studies are already underway to explore the geological storage of hydrogen in salt caverns, depleted oil and gas fields, and deep saline aquifers

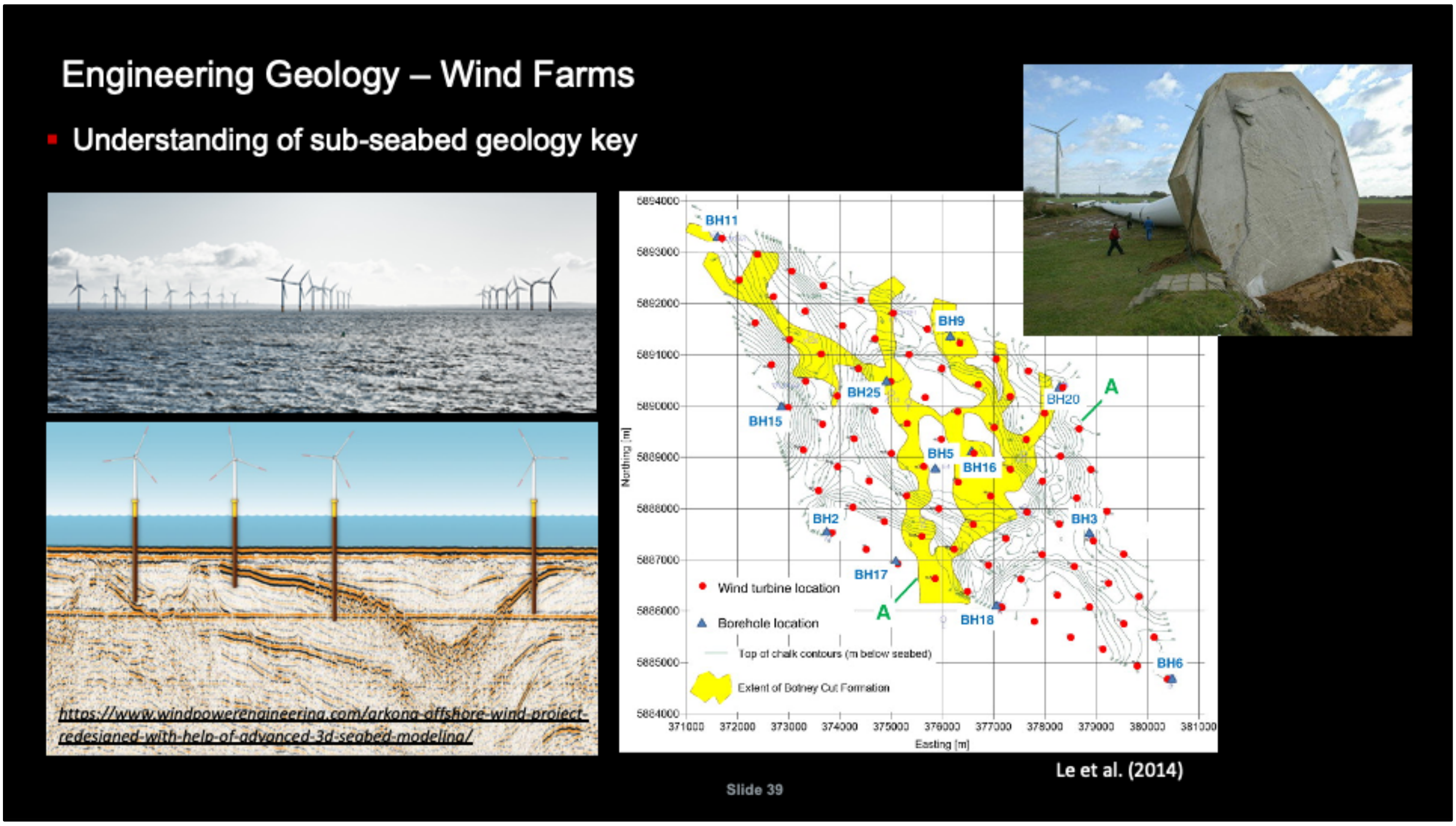


The focus on reservoir scale geology will not only be useful for hydrocarbons and CCS, but also for emerging geothermal opportunities

As a business, Halliburton already has significant geothermal experience with many projects already completed around the globe – but the interest in geothermal is certain to increase in the coming years

Whilst much of the G&G work on geothermal will be reservoir scale, the successful use of geothermal energy does require a good understanding of the subsurface on a variety of scales

For instance, the Neftex heatlfow map can be used to provide valuable screening for opportunities



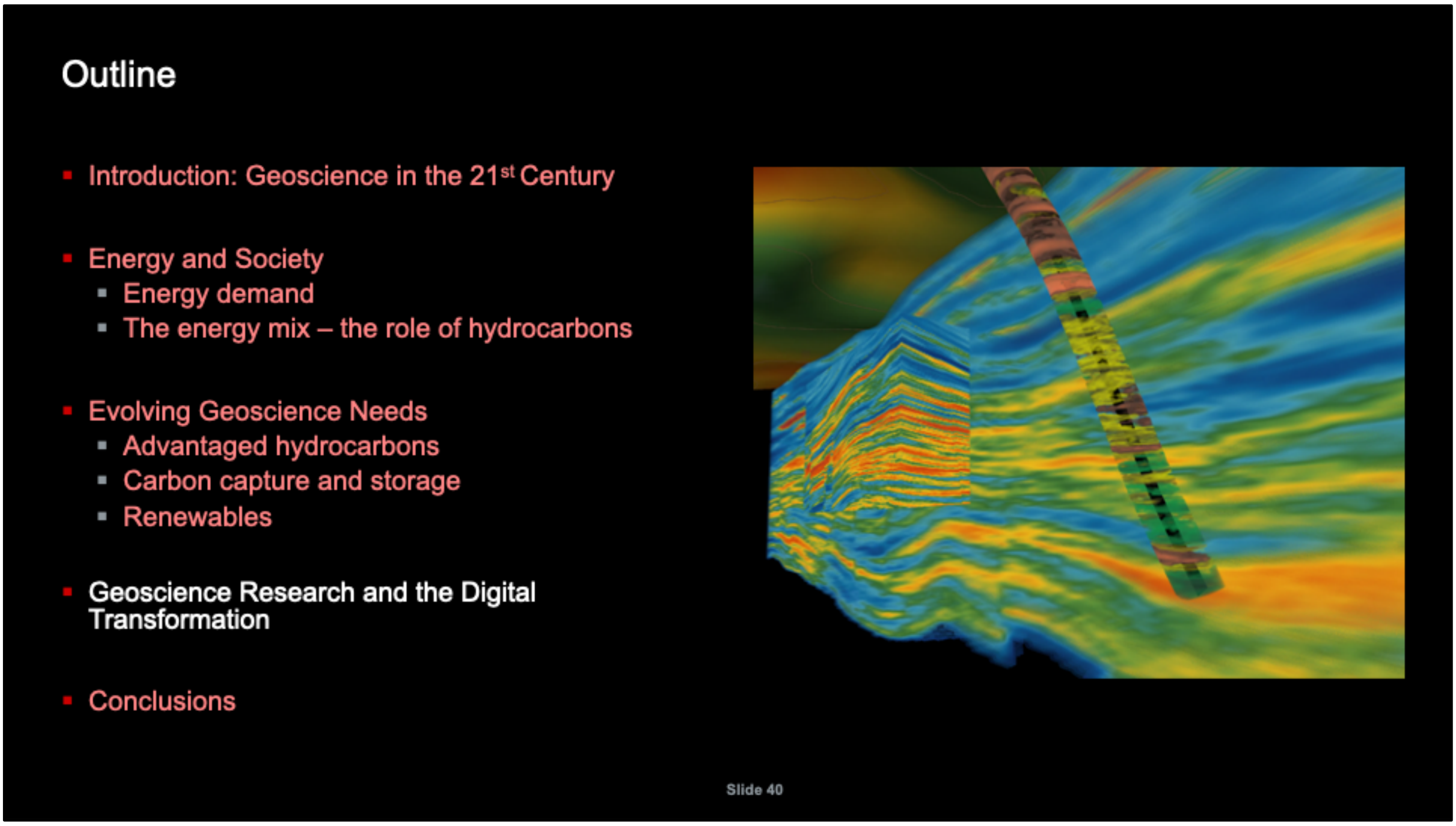
The successful deployment of wind turbines also requires expert geoscience input.

As an example, in the North Sea, the Quaternary glaciations have left a buried landscape of glacial and fluvial channels, as can be seen in the shallow seismic image and geological map

These pose a risk to the foundations of wind turbines

Geoscientists are therefore needed to interpret seismic data to help plan wind turbine placement and foundations

If this isn't done correctly there can be very costly mistakes!



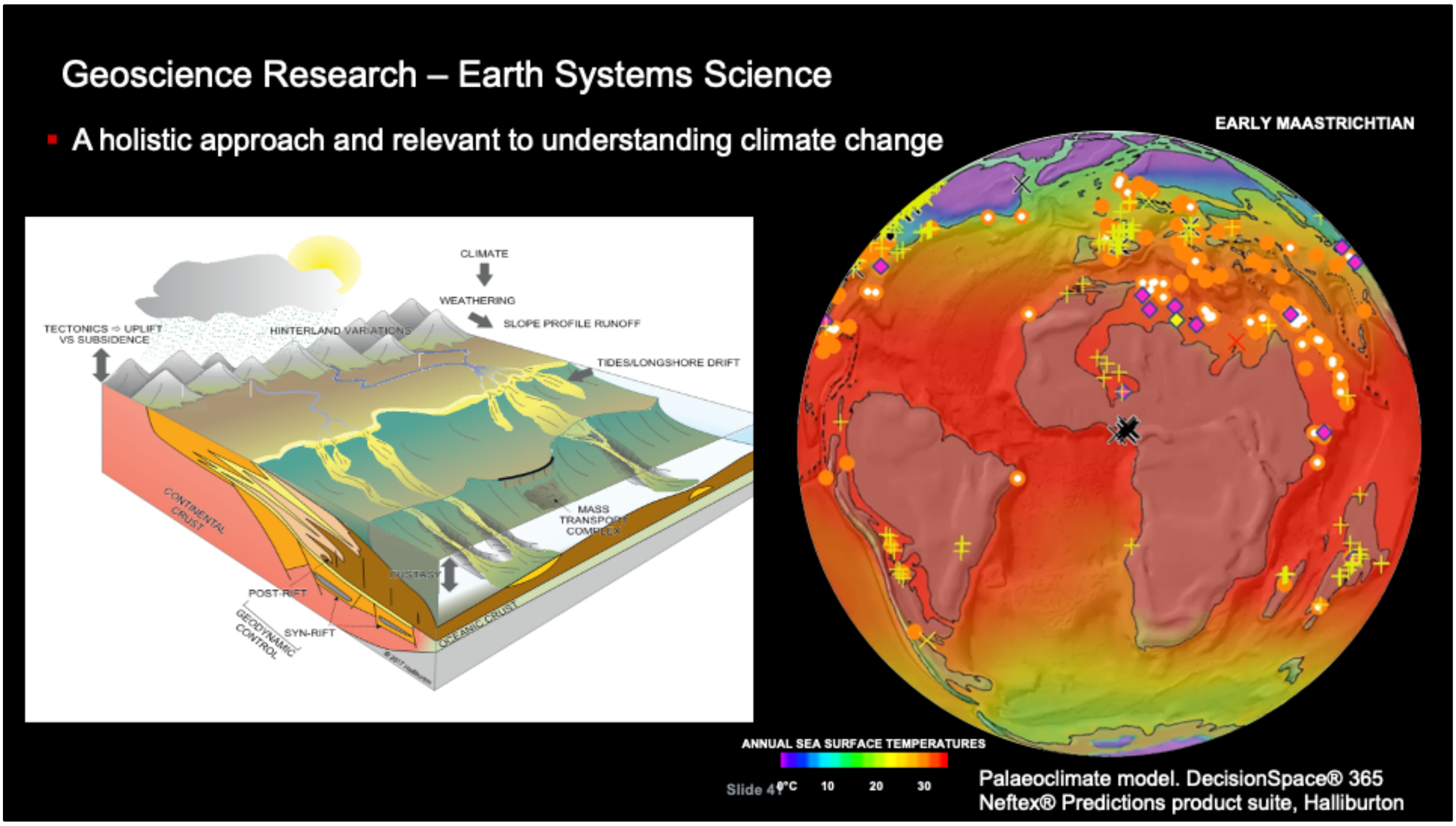
Let me begin by giving you an overview of the talk

I'll start with an introduction to set the scene, then look at energy and society.

This will lead us into assessing future Geoscience Careers in relation to the energy transition

I'll then assess some aspects of future geoscience research and the digital transofrmation

Before wrapping up with some conclusions



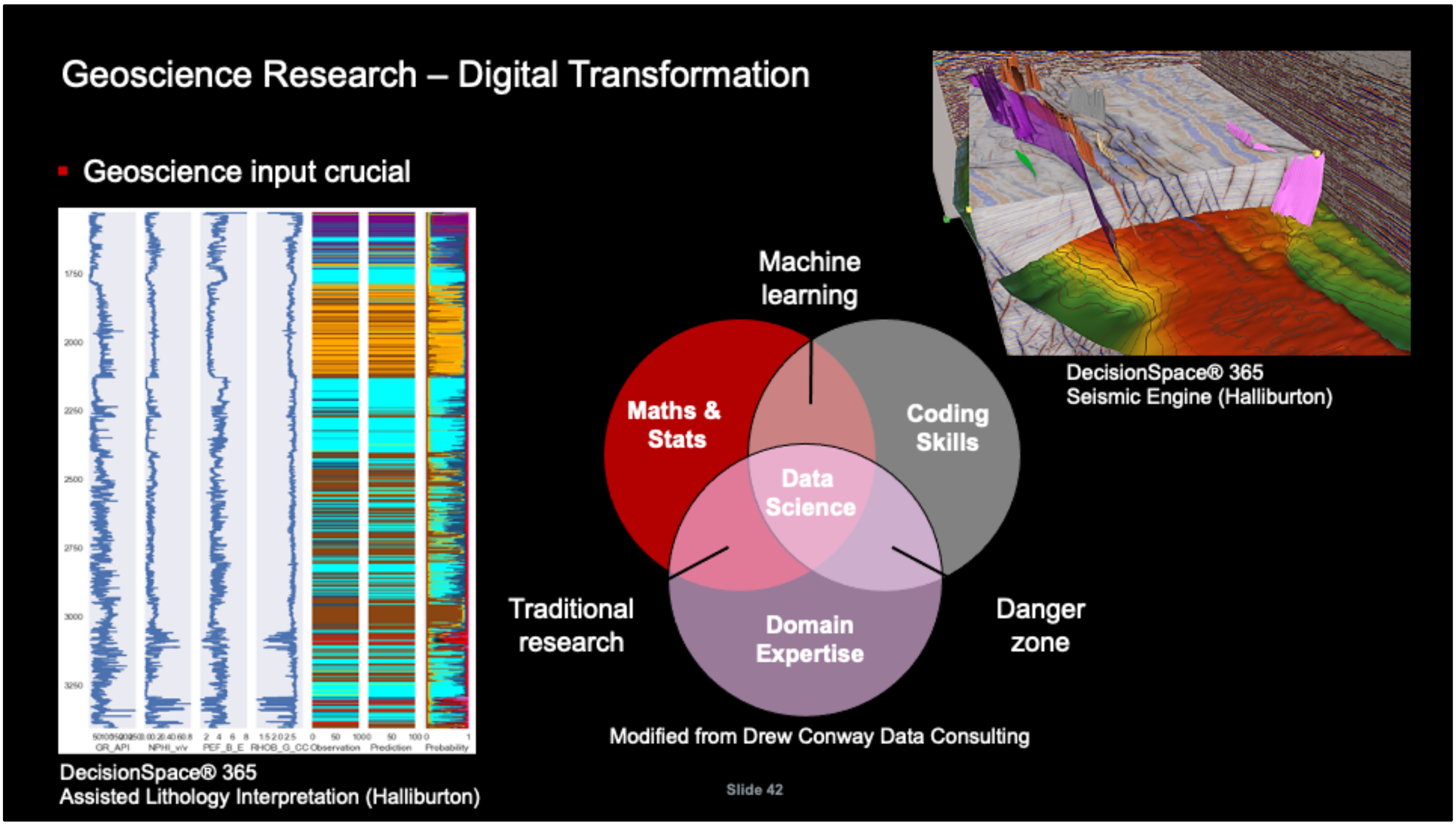
To put it bluntly, there is still an awful lot we don't know about the Earth system

The fundamental research, undertaken at Universities like Leeds, must therefore continue.

It not only benefits pure scientific curiosity, but is needed to help with all of the industrial challenges I outlined in the previous section.

One aspect of geoscience I have been involved with over the past few years is the development of a holistic Earth systems approach to understand depositional systems and petroleum systems elements

This involves the use of paleoclimate models, as seen on the right, which the university of Leeds help us to create.

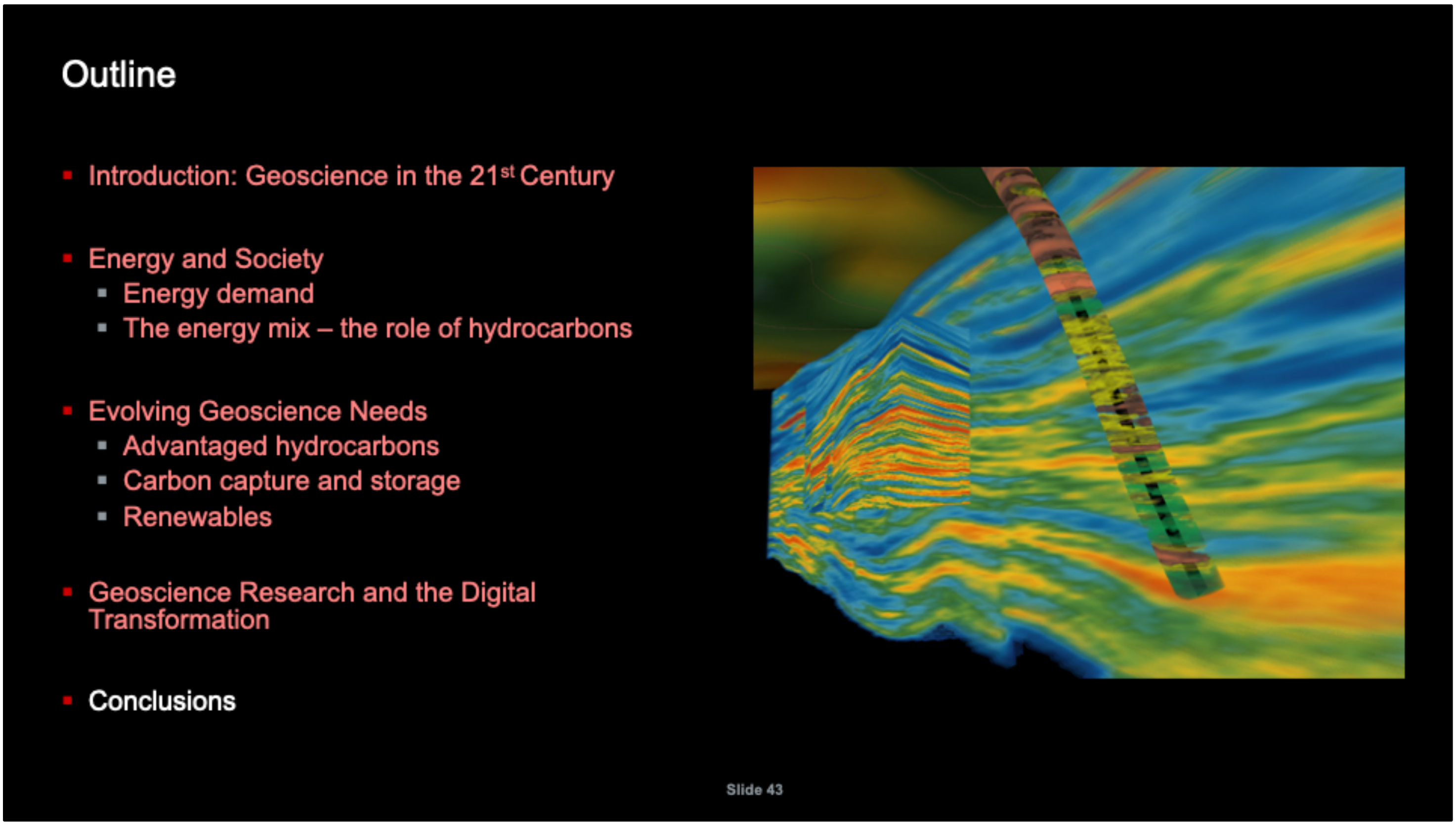


To support all of this, geoscience needs to further embrace the use technology and AI

At Halliburton we have multidisciplinary teams that include maths expertise, coding skills and geoscience domain knowledge that work to generate our next generation tools

These tools use techniques like machine learning to conduct geological interpretations automatically

As an example, we now use machines to automatically interpret lithology in wells, as shown in the image on the left, and automatically interpret faults in seismic data, as shown in the top right image



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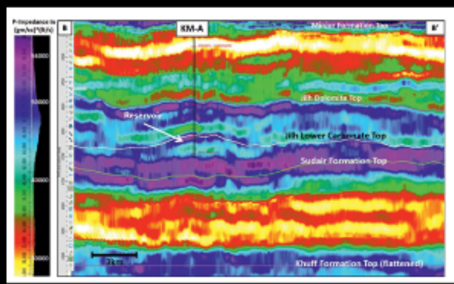
Key Take Home Messages

- Geoscientists have a crucial role to play through the energy transition
- Hydrocarbons will continue to be a major part of the energy mix for decades to come
- Needed to sustain the energy demands of a growing, healthier and wealthier global population
- Produce >900 billion barrels and >4,700 Tcf by 2050, including finding significant new resource
- With minimal carbon intensity (“advantaged hydrocarbons”), augmented by CCS
- Other renewable energies require geoscience know-how
- Data science required to allow geoscientists to focus on higher-value tasks

https://www.pinterest.co.uk/pin/176555247869320740/



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So at this point I’ll give you my take away messages for the talk

Key Take Home Messages

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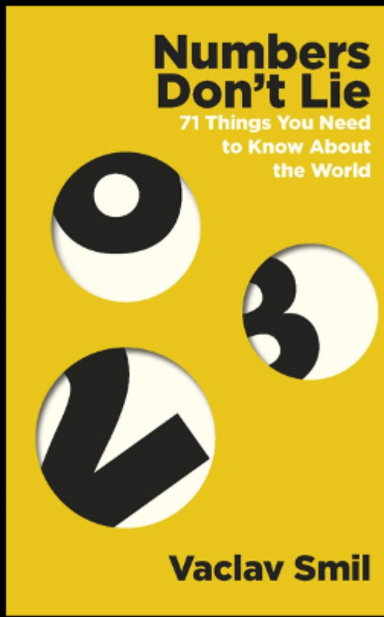

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THANK YOU