The future of the oil and gas industry

YP Simplified Series

Ian Phillips
CEO – OGIC (The Oil and Gas Innovation Centre)
Chair – SPE Aberdeen Section
4th April 2018

Outline

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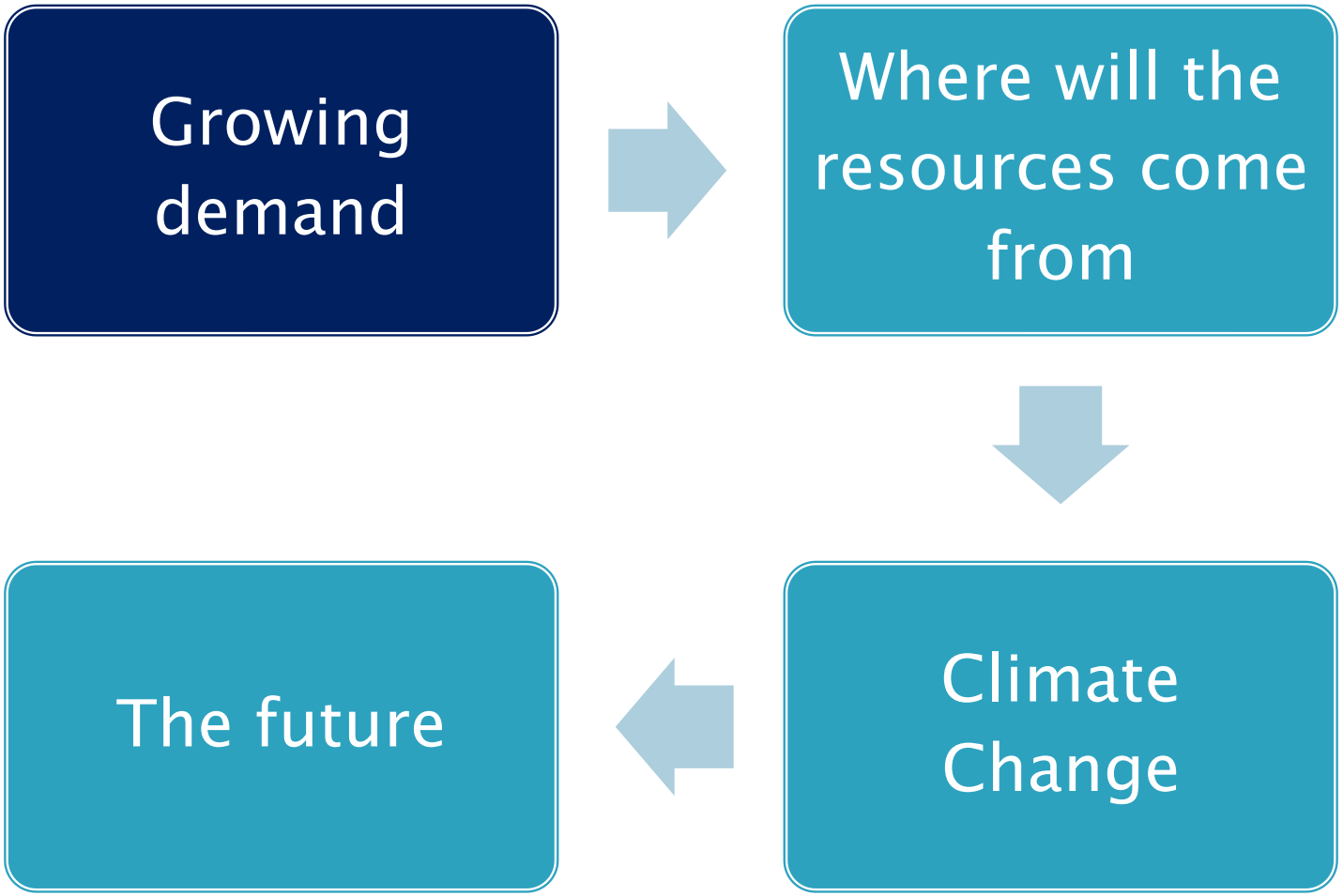

Growing Demand

Global Population Growth

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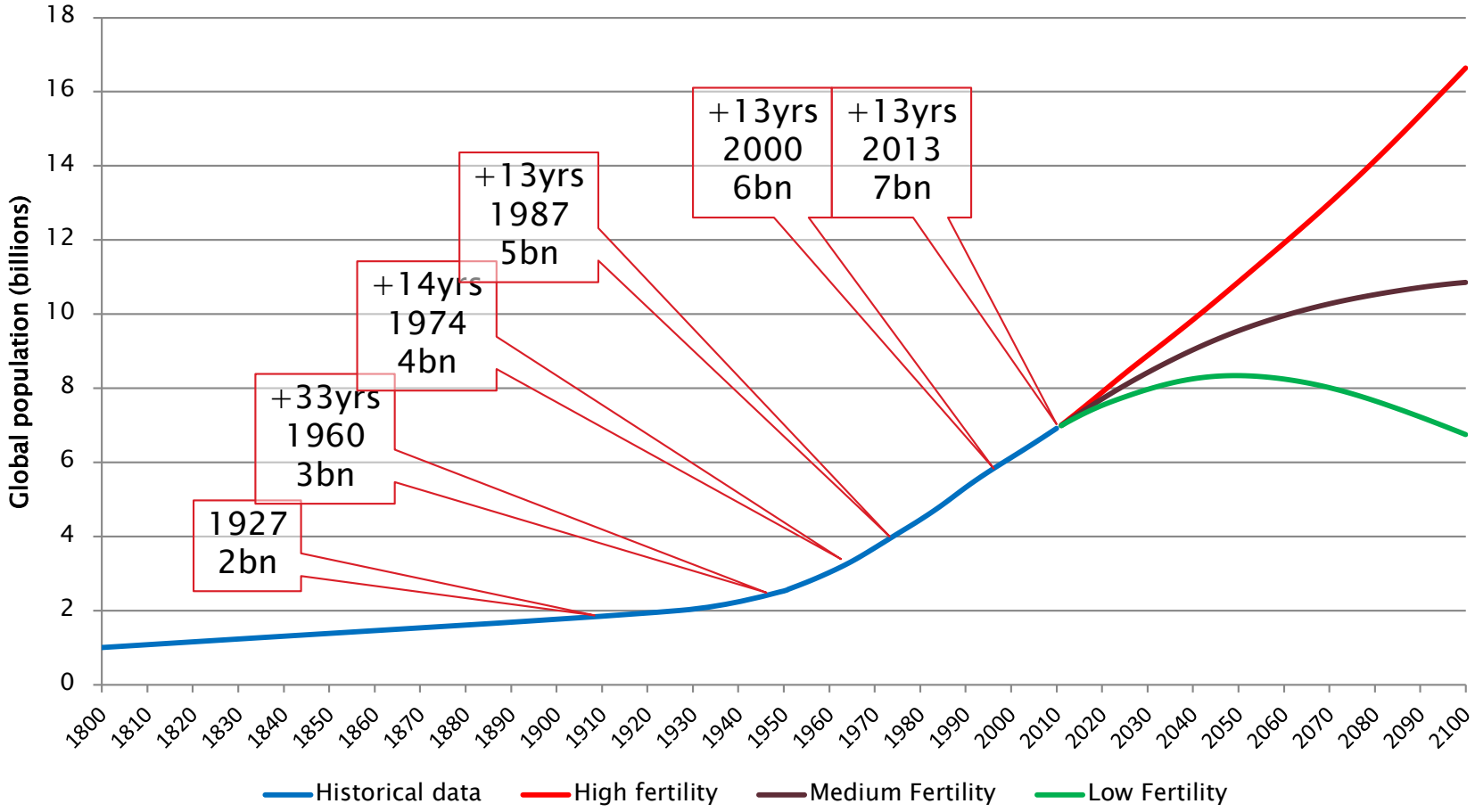

Source – UN Department of Economic and Social Affairs, Population Division – World Population Prospects: The 2012 Revision

Growing Demand

People want to climb the Energy Ladder

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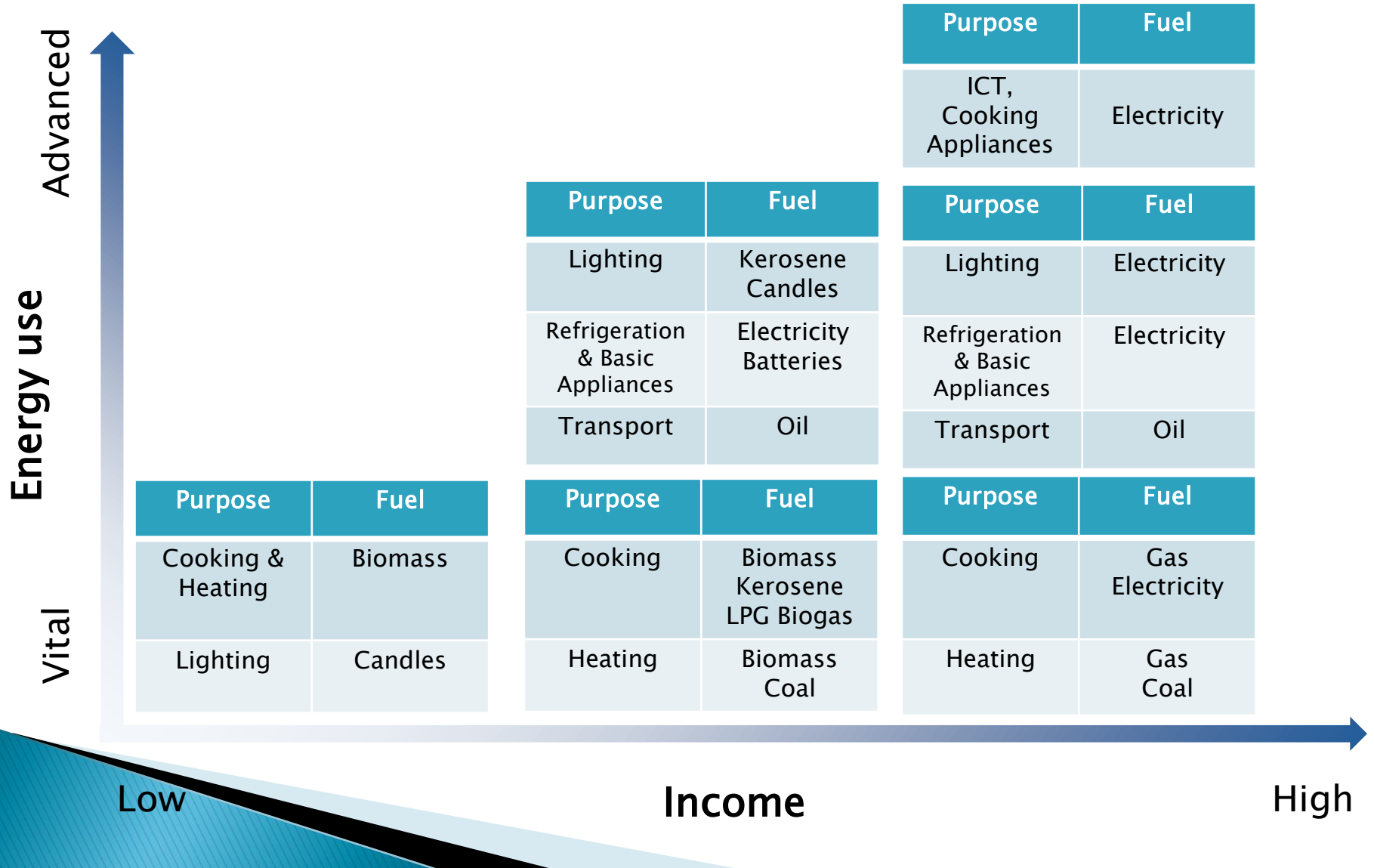

Growing Demand

BP Outlook - 2018

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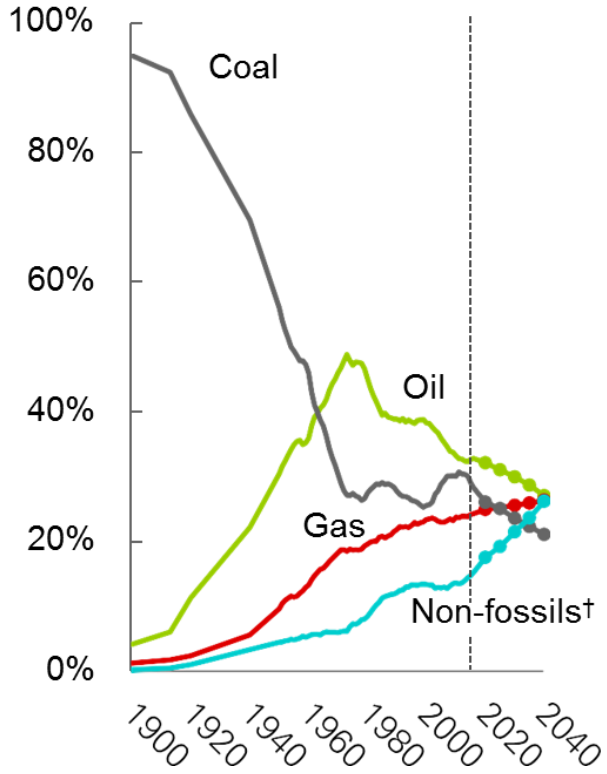

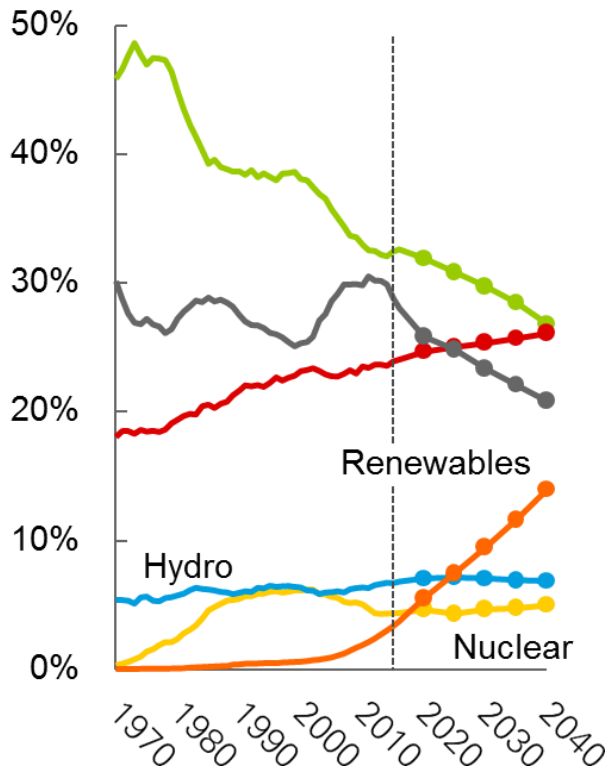

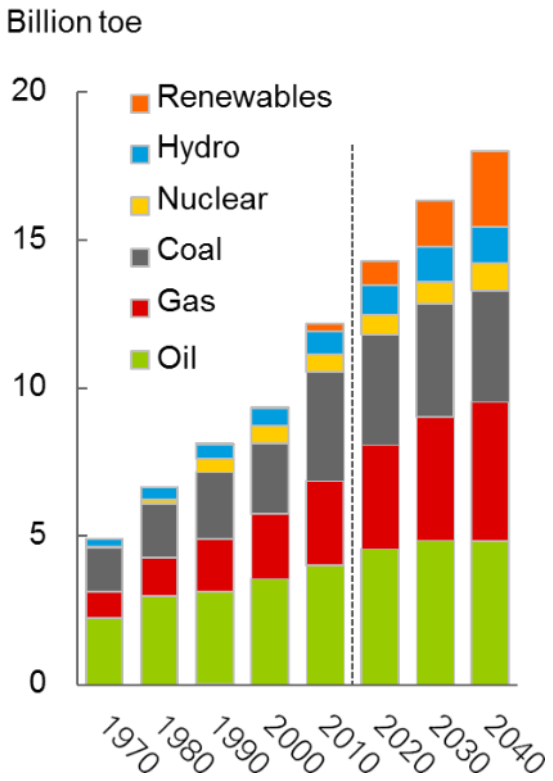

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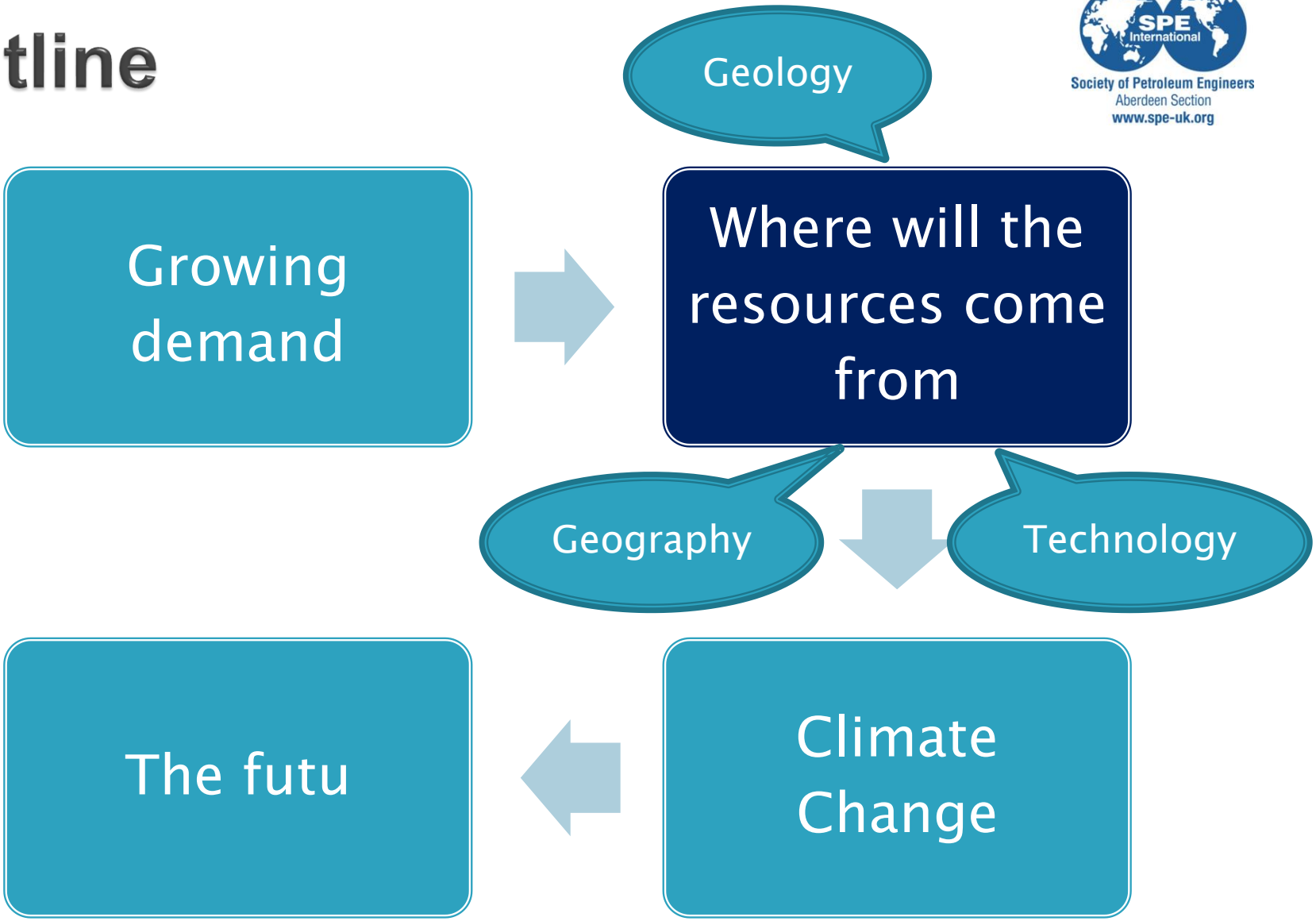

Where will the resources come from?

Distribution of proven oil reserves

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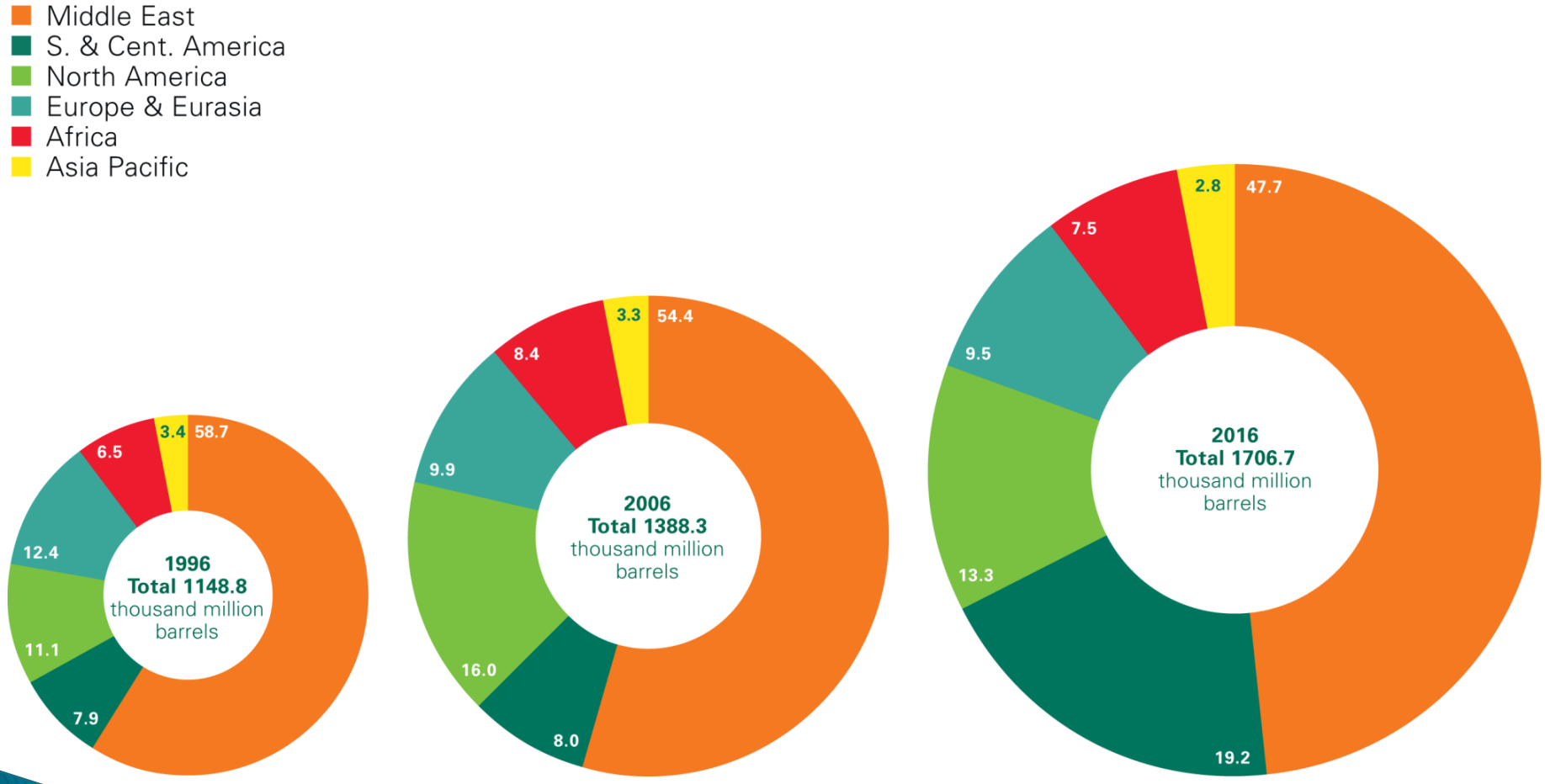

……reserves increase despite growing consumption!!

BP Statistical Review of World Energy
June 2017

Where will the resources come from?

Distribution of proven gas reserves

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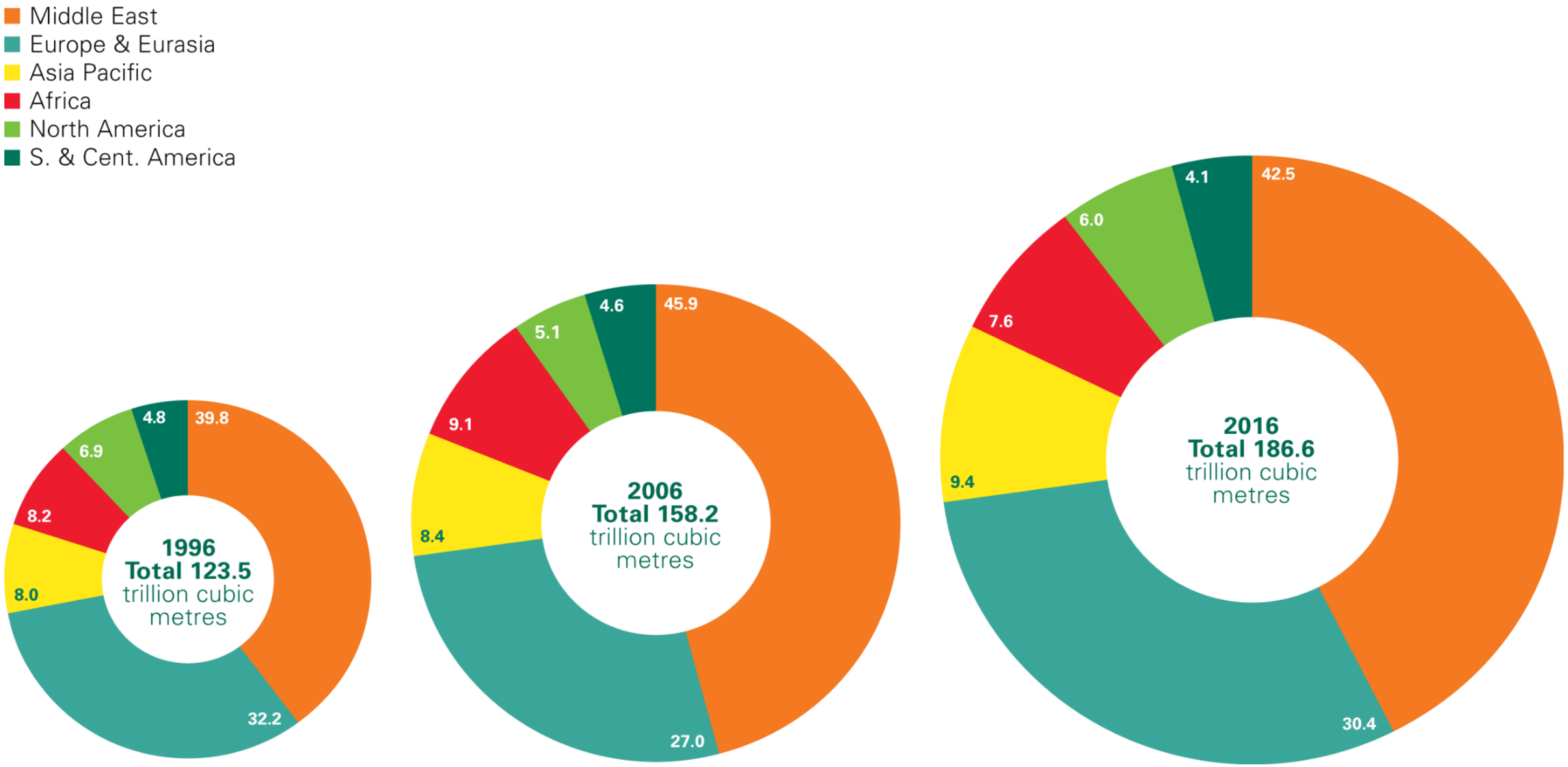

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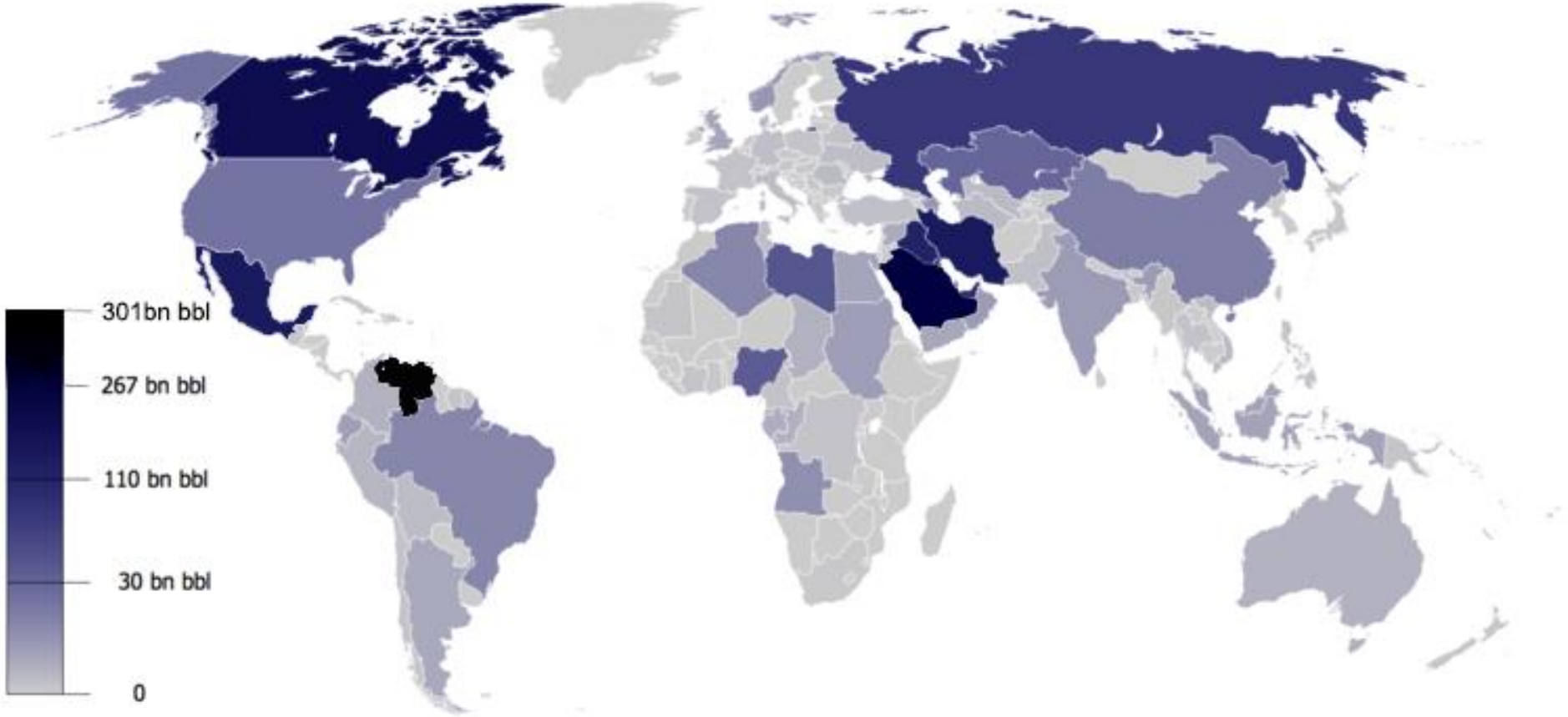

Where will the resources come from?

Technically challenging sources

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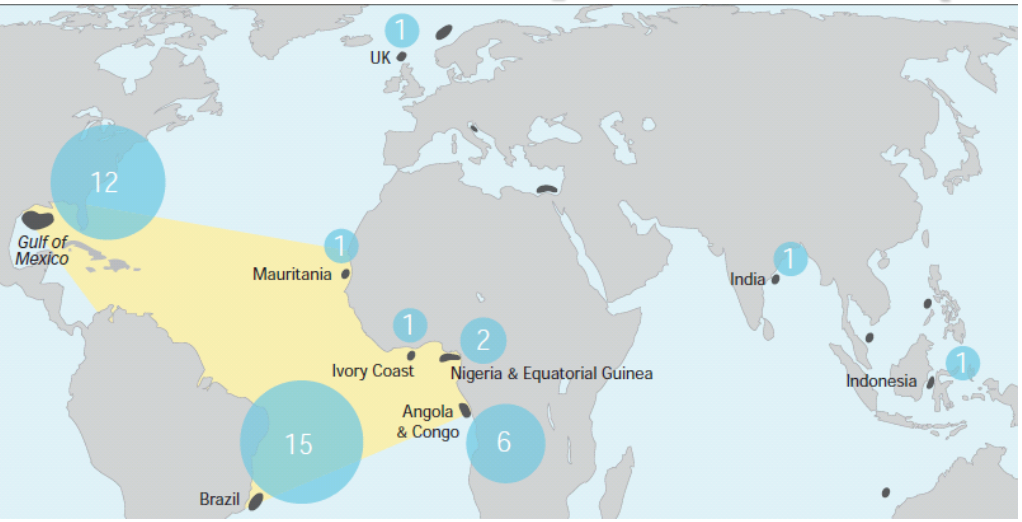
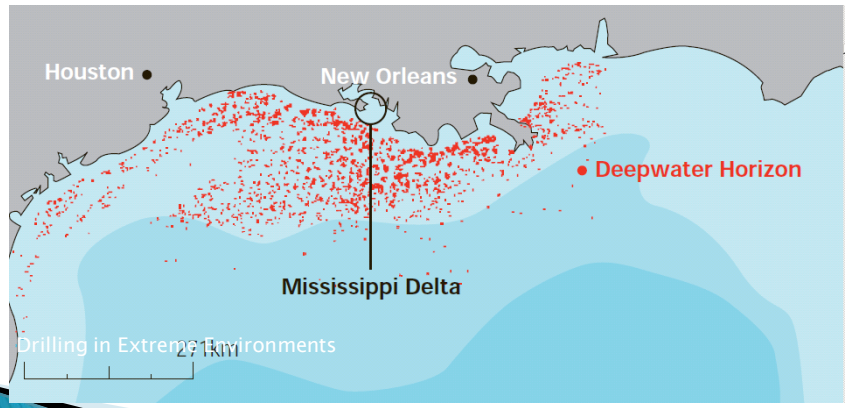
- Ultra-deep water
- High Pressure / High Temperature reservoirs
- Very Heavy Oils
- Tar sands
- Shale Gas and Shale Oil
- Bio-Fuels
- Carbon Capture and use (for EOR)

Where will the resources come from?

Ultra-Deep Water (UDW)





- UDW is arbitrarily classed as water depths >500m
  - North Sea typically 100-300m
- Depth records held by Transocean
  - drilling in 3,088m (10,190') of water
  - deepest well drilled is 12,200m (40,320')
- UDW reserves are relatively small
  - circa 0.025 trillion barrels
  - Compared with world reserves of 1.7 trillion barrels
- Technology largely understood
  - Incremental step out from the shallow water Gulf of Mexico technology
  - Some unique challenges
    - Well completion technology - flowing oil in cold deep water
    - Regulatory regimes.
    - Insurance market nervous after the Macondo incident

Where will the resources come from?

HPHT fields

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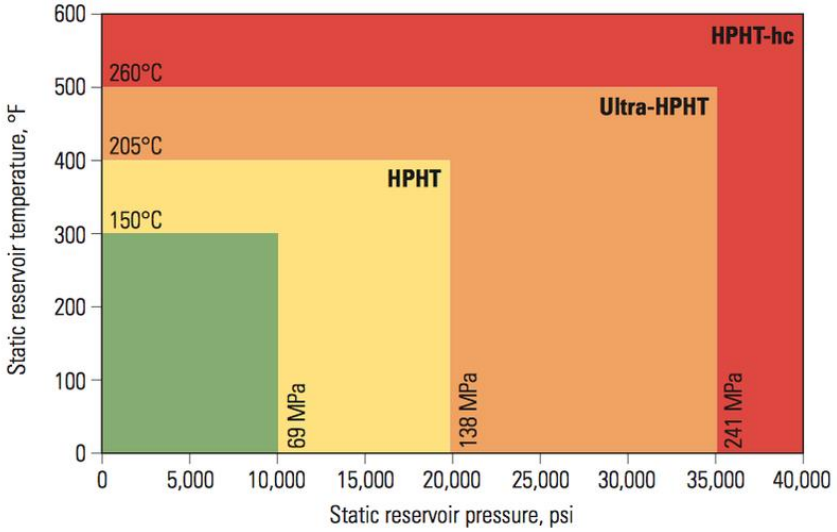
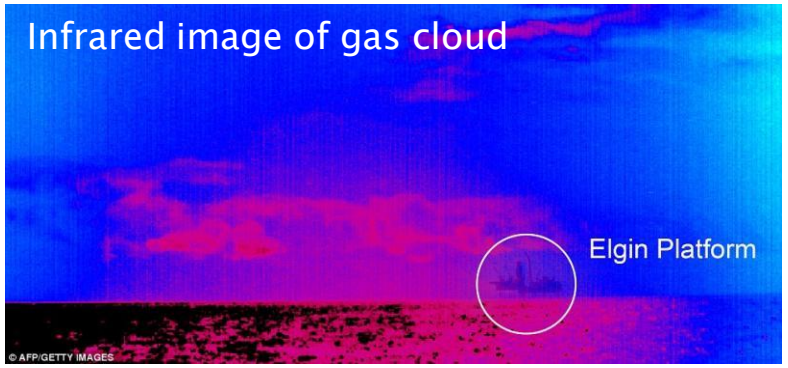
- HPHT = Over 150°C / 10,000psi in the reservoir
  - requiring 15,000 psi rated BOP at the surface
- Challenges compared with 'normal' wells
  - High stresses
  - High operating temperatures
  - High-end metallurgy susceptible to specific environments
  - Massive initial flow rates of most wells
  - Narrow margin
- Challenging environment
  - Ocean Odyssey loss
  - BP Macondo blowout





Where will the resources come from?

Very Heavy Oil

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- World reserves of very heavy oil not widely reported
- Extensive deposits in Venezuela
  - 2.0 trillion barrels
  - compared to world conventional crude proved reserves 1.7 trillion barrels
- Heavy oil
  - Extracted by steam injection
  - then needs extensive treatment (thermal cracking) to produce a synthetic oil
- Production in 2008 was 640,000 bpd
  - compared to world 82,120,000 bopd
- “Orimulsion” is a water / heavy oil mixture
  - Environmentally challenging

Where will the resources come from?

Tar Sands

- Potential Canadian tar sand reserves
  - 1.8 trillion barrels (compared with conventional crude proven reserves 1.7 trillion barrels
- 2008 production of 700,000 rising to 3 million bpd by 2018
  - Compared to world ~96 million bpd
- Extracted by
  - mining plus hot water treatment
  - steam injection for deposits below 250' - some 80% of reserves.
  - Recovery factors - 80% for mining - 5-50% for deep extraction

Where will the resources come from?

Shale oil

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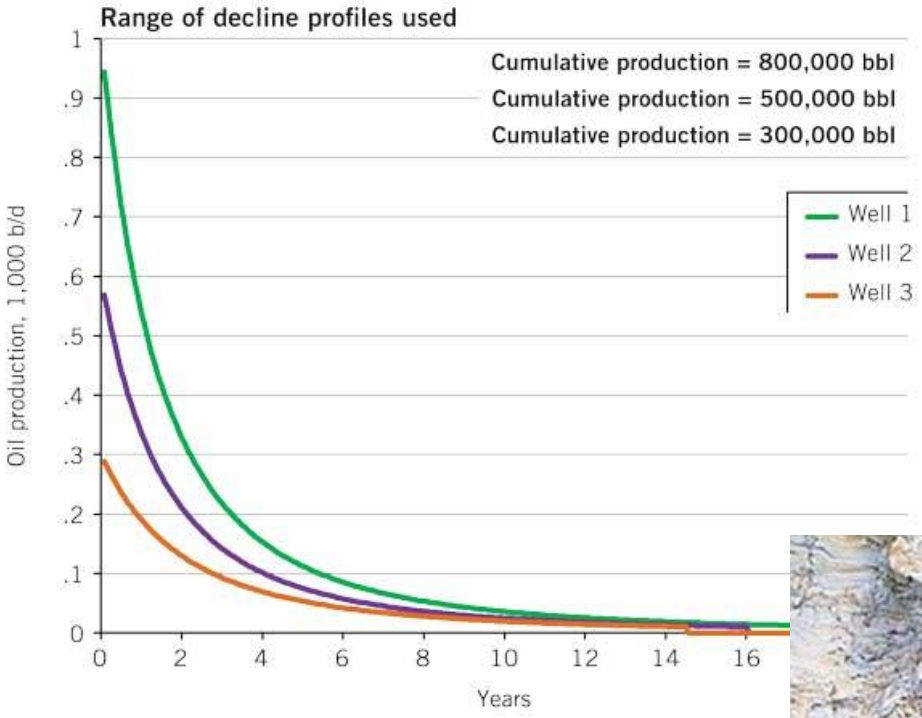
TYPE PRODUCTION PROFILES AND PRODUCTION USED IN MODELING FIG. 1



Where will the resources come from?

Oil Shale

- Organic rich rock
  - mined using open-cast mining
  - heated to 450^{o}C to produce oil
  - Oil further refined to middle distillates (kerosene)
- Extensive deposits in USA
  - 3.0 trillion barrels - 62% of world proven oil shale reserves
  - Compared with world crude oil reserves of 1.7 trillion barrels
- Growing industry, behind tar sands
- Significant environmental concerns - mining, transport, waste, CO_2 emissions

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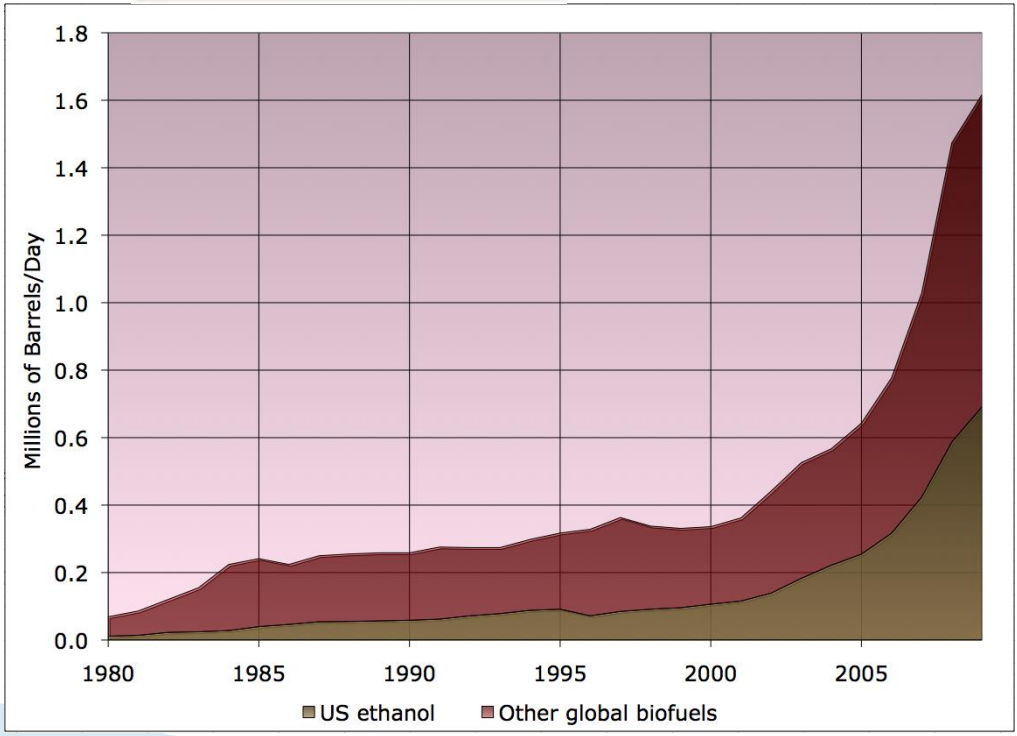
Where will the resources come from?

BioFuels

- Biofuels are
  - Made from biomass materials
  - Mostly transport fuels like ethanol and biodiesel
  - Usually blended with gasoline and diesel fuel, but they can also be used on their own
- Compete for agricultural land for food use



Where will the resources come from?

Enhanced Oil Recovery (EOR)

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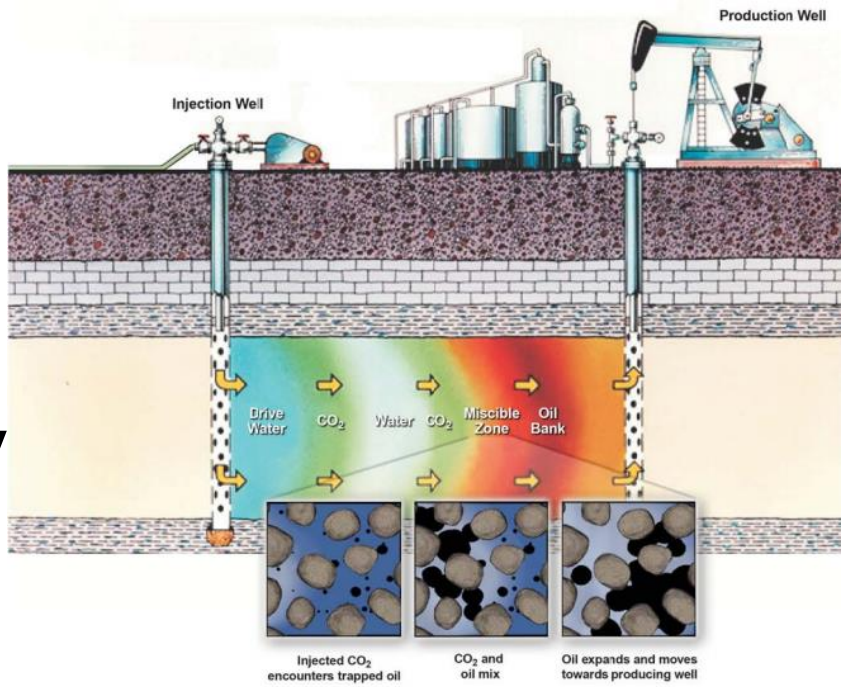
- EOR encompasses a range of techniques
  - Injecting CO2
  - Injecting heat (steam)
  - Injecting water (sometimes with chemicals to make the water more viscous)
- Can improve oil recovery by 5-20%
  - Depending on what techniques were applied previously



CO_2 EOR – CO_2 dissolves in oil making it mobile

Where will the resources come from?

The impact of Technology

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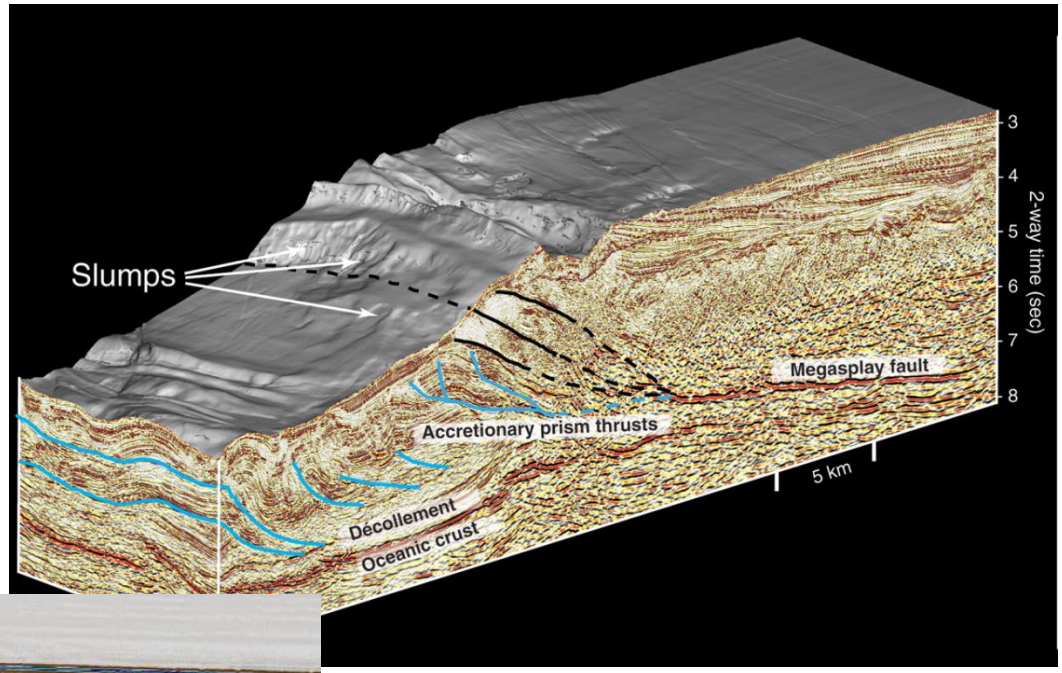
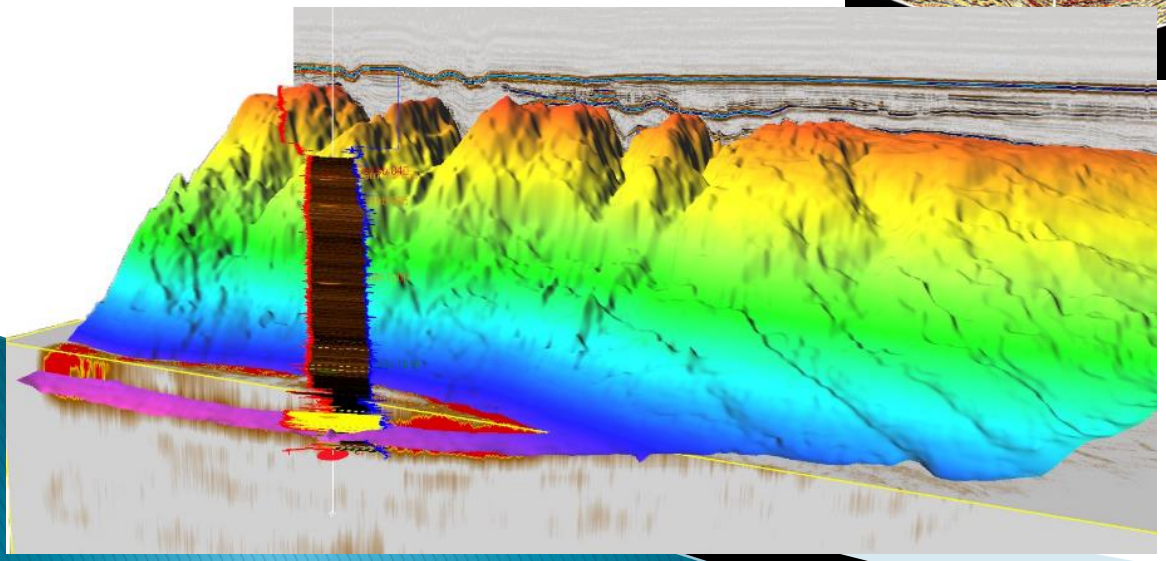
- **Exploration**
  - Allowing for more accurate exploration, targeting reserves with guaranteed high production volumes.





Where will the resources come from?

The impact of Technology

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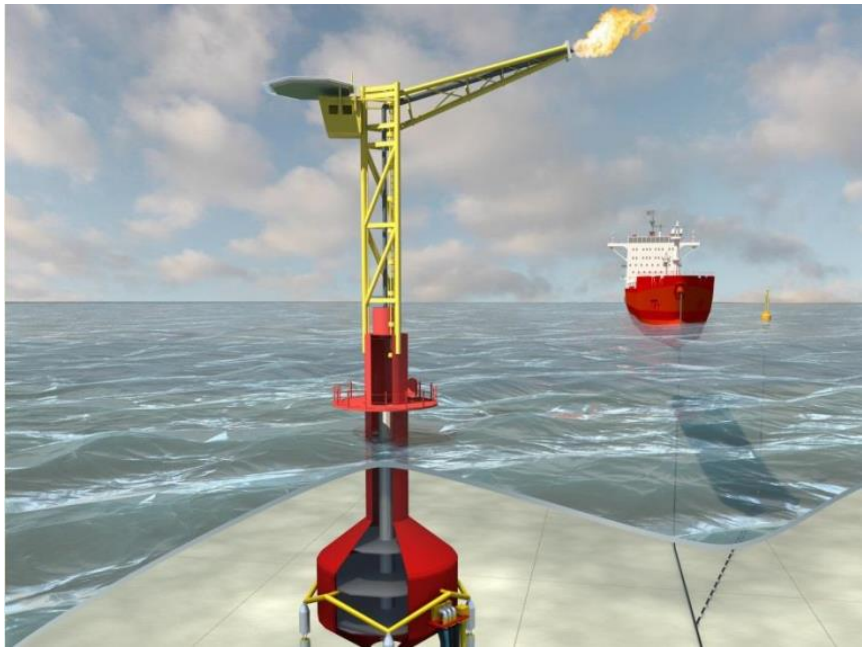
- **Development**
  - Reducing the surface impact of oil and gas operations, while allowing for optimum recovery of reserves
  - Facilitating access to deep water and remote reserves
  - Make alternative sources like oil sands and shale gas acceptable from financial and sustainability perspective
  - Optimising construction costs



Where will the resources come from?

The impact of Technology

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- **Production**
  - Reducing environmental impact of operations
  - Reducing unit cost of operations
  - Increasing efficiency and reliability of operations
  - Maximising recovery from existing reservoirs
  - Reducing HSE risk in operations

Shale gas

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- Shale gas is the same gas we find everywhere else
  - Predominantly methane
- The reservoir is a shale
  - Rather than a sandstone
  - Porosity higher due to small grain size
  - Permeability almost nil
- To access the gas you “shatter” the rock
  - Technology known as “fraccing”
  - Gas flows out along fractures which are packed with sand

A typical shale

Where will the resources come from?

A shale gas fracture "spread"

- "Frac" fluids stored in the green tank trailers (to bottom left)
- "Frac" sand stored in the five white trailers (to rear)
- "Frac" fluids and sand mixed in plastic cube tanks on 7 flatbed trailers to (bottom right)
- Pump equipment (red) linked to create 14,000 psi fracking pressure and inject the "frac" fluids
- Orange tower is a flare stack for flaring the initial gas following fraccing.

Where will the resources come from?

Major global shale gas “plays”

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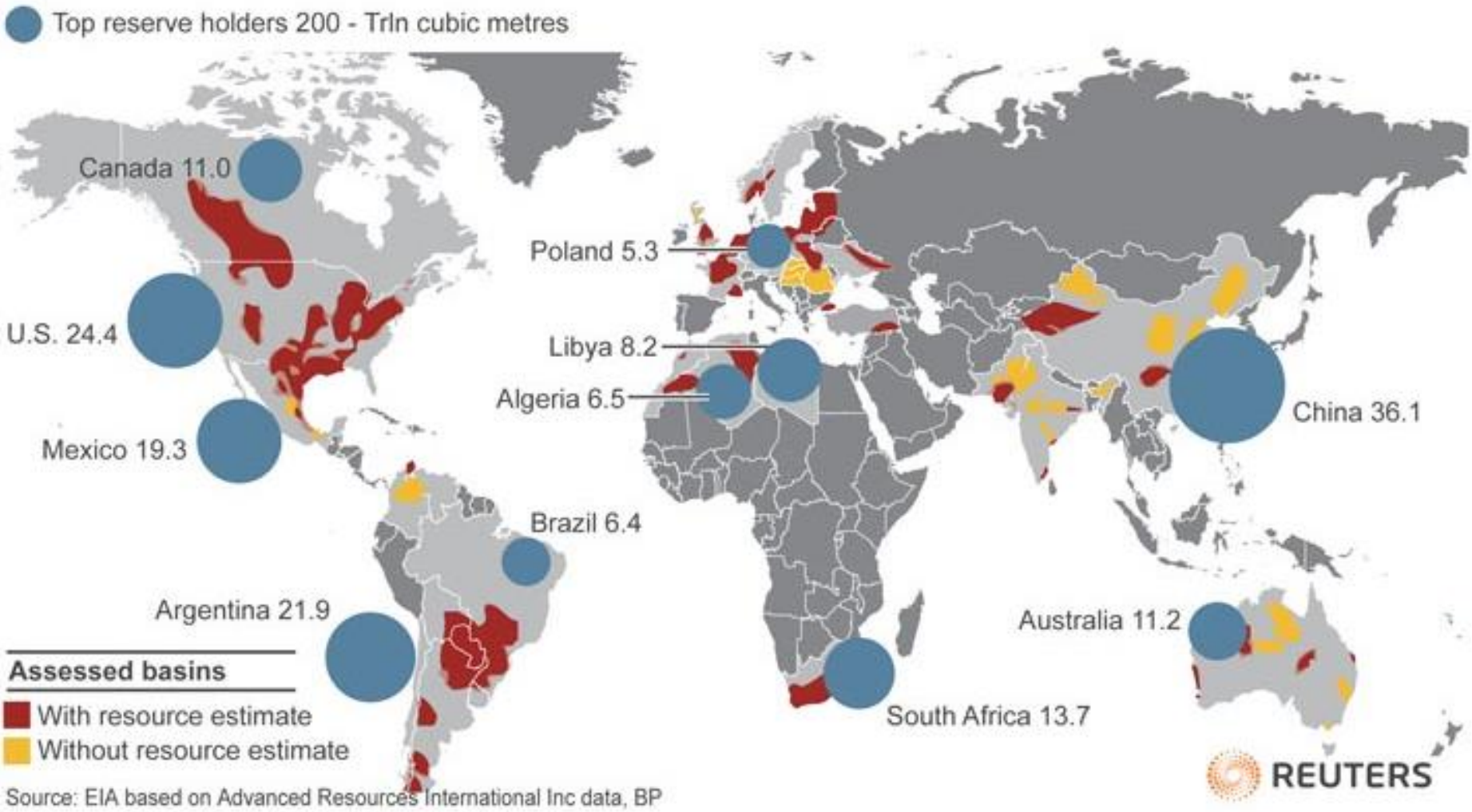

Where will the resources come from?

But it has its detractors!!

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Staged and not real – but it went viral

Where will the resources come from?

We know where a lot of oil resides

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- Ultra-deep water – 0.025 trillion bbl
- HPHT reservoirs – 0.025 trillion bbl
- Very Heavy oils – 2.0 trillion bbl
- Tar sands – 1.80 trillion bbl
- Bio-Fuels – competition with agriculture
- EOR - +5% on current fields – 0.1 trillion bbl
- Technology - +5% - 0.1 trillion bbl
- **We know where there is >4.0 trillion bbl**
  - **More than twice current proven reserves**
- Plus Shale Gas and Shale Oil – vast and difficult to quantify

Outline

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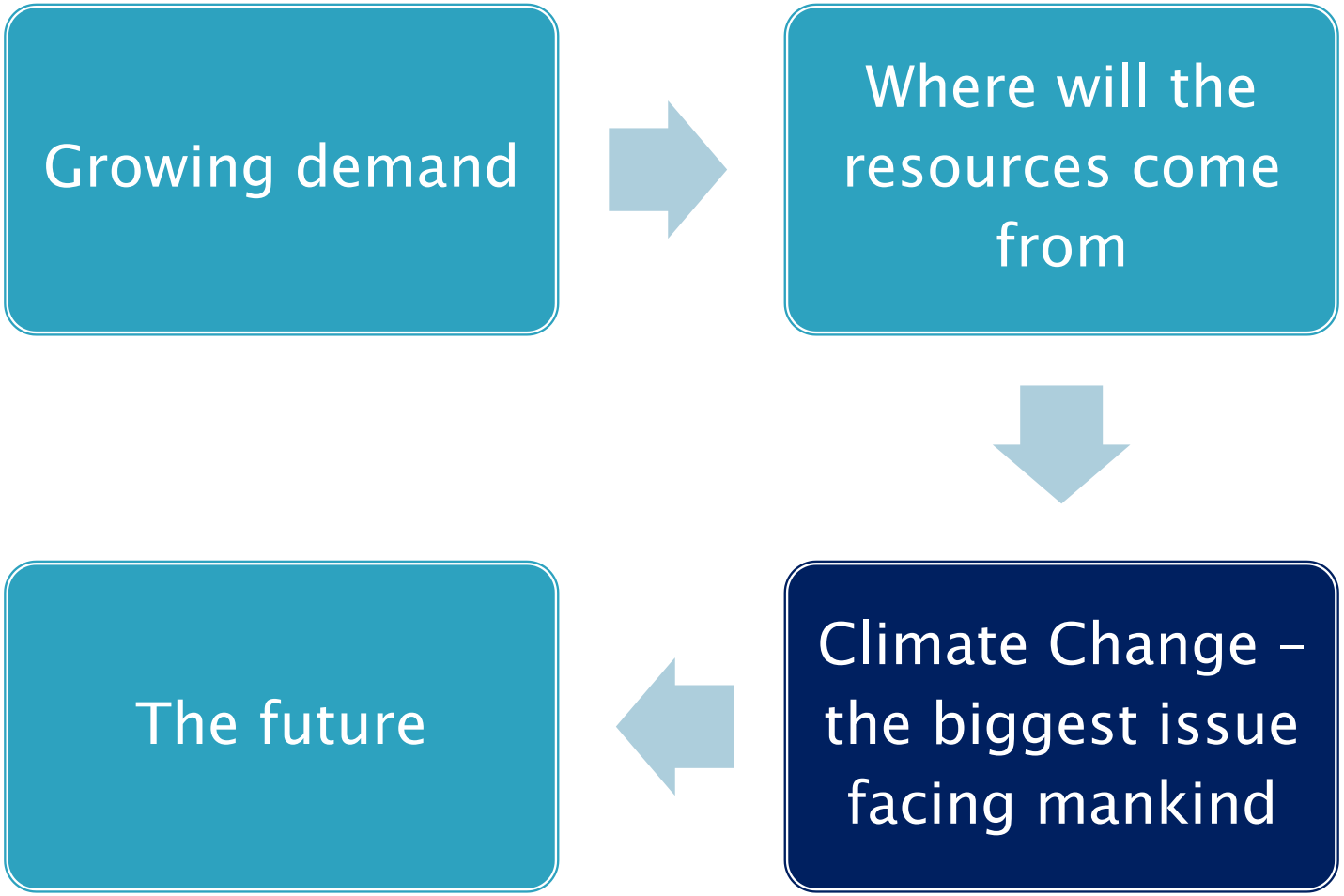

Climate Change

CO_2 concentrations rising

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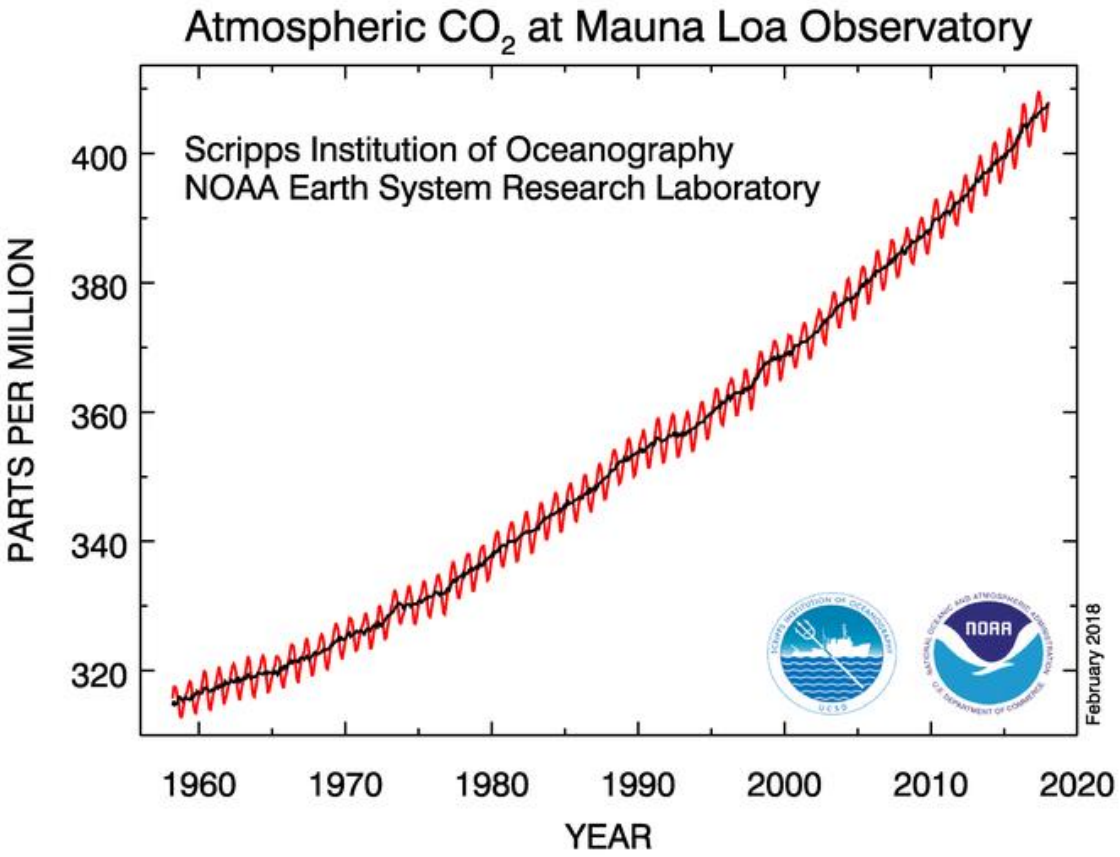
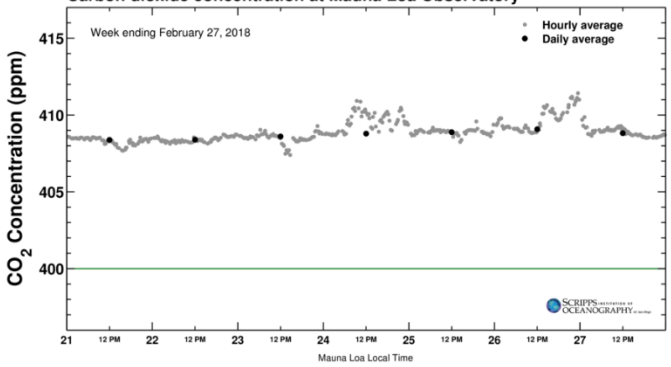


Latest CO_2 reading
February 27, 2018

408.82 ppm



Source – NOAA February2018

Climate Change

Linkage – CO_2 and temperature

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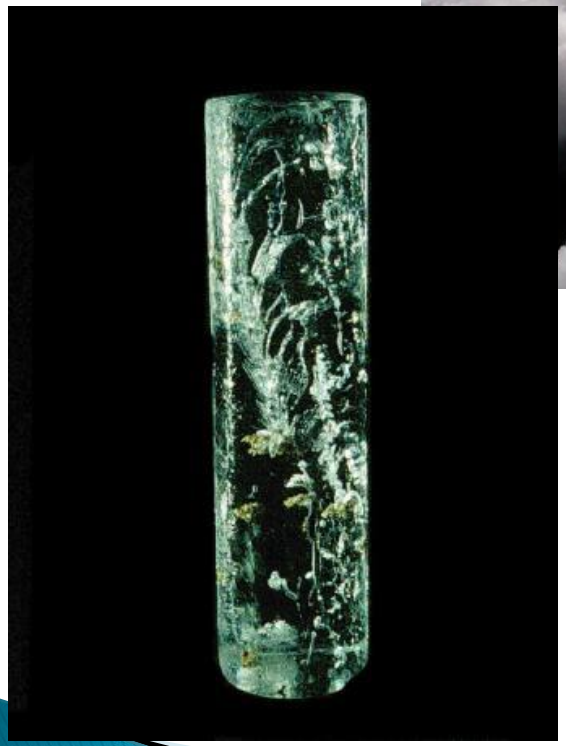
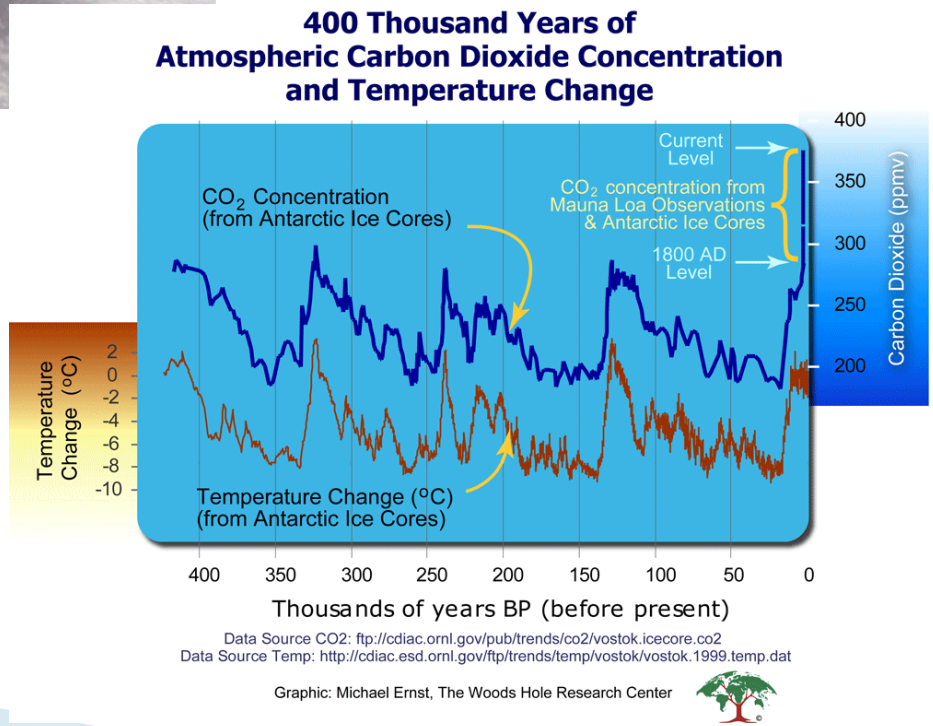
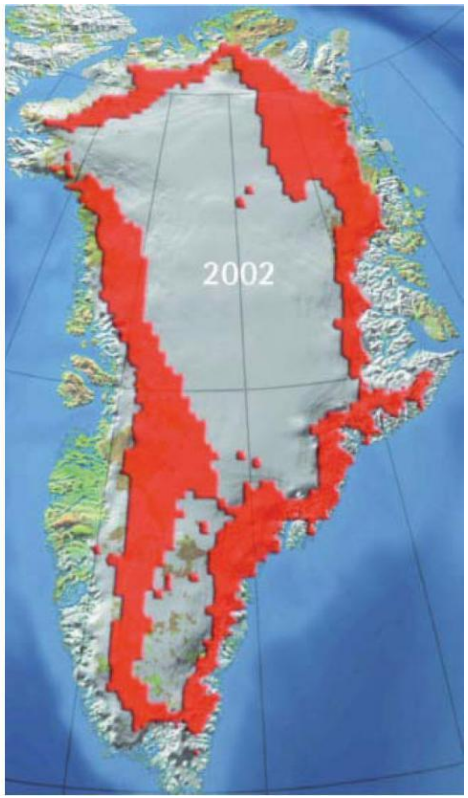




Sources – IPCC 4th Synthesis Report – November 2007 / Vostok Ice core data January 2003 / Mauna Loa

It's happening now !!

- NASA study of Greenland (2005)
  - +20cm in centre
  - -60cm at edges
- Net loss 51 km^3
  - 7% of total rise in sea level in 2005
- If all Greenland ice melts
  - 7-8 m rise in sea levels



Climate Change

A tipping point?

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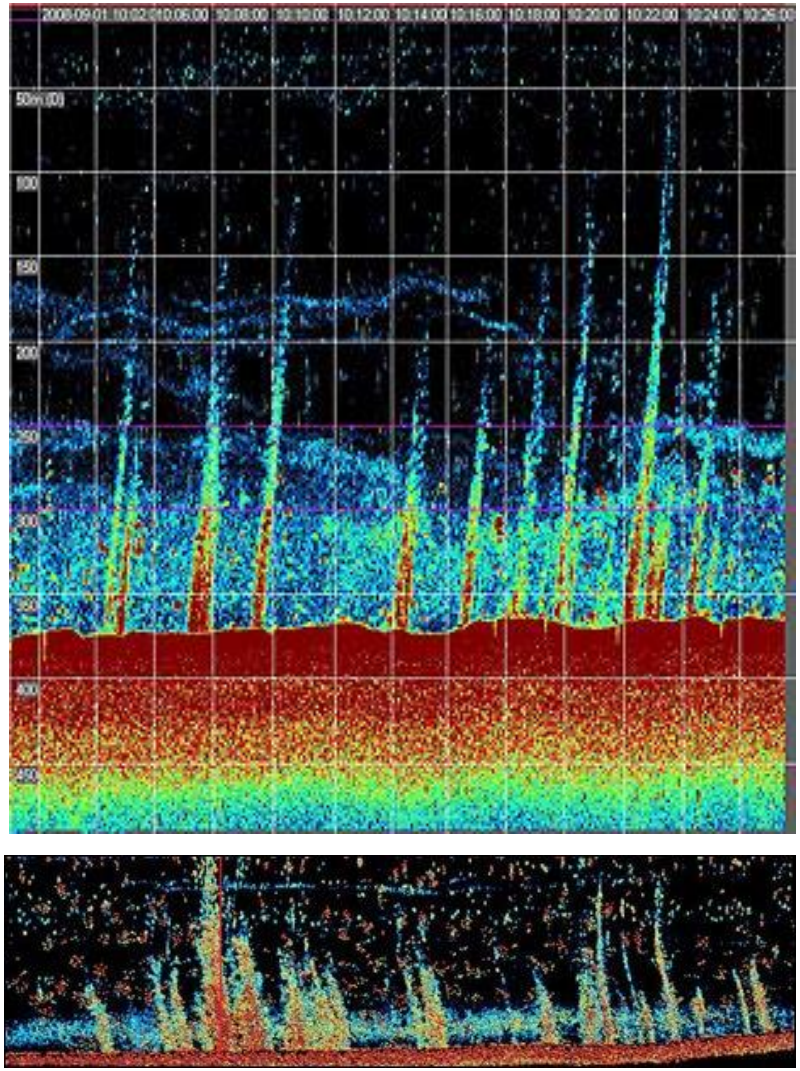
- As temperatures rise
  - Sea-bed grows warmer
  - Methane hydrate crystals in the sediment break down, allowing methane trapped inside them to escape
- Potentially evidence of the predicted positive feedback effect of climate change
- Have we reached the “tipping point” ?



Source: National Oceanographic Research Centre, Southampton, in “Geophysical Research Letters”, August 2009

Climate Change

Palaeocene-Eocene Thermal Maximum

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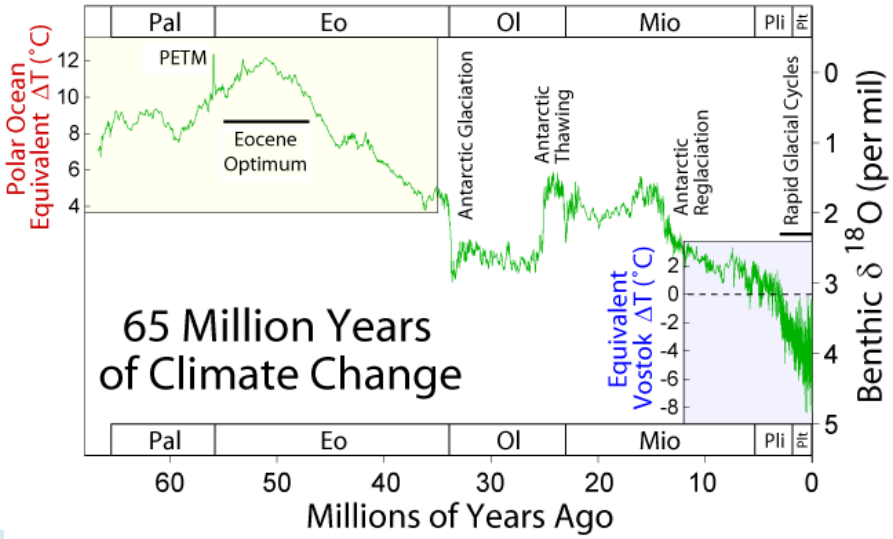
- Known as PETM
  - 55 million years ago - lasted 2 million years
  - Massive release of greenhouse gas - CO_2 or methane – cause not clear (probably volcanic)
  - ~5°C rise in temperature
    - rapid alternations of marine- and land-derived organic matter
    - storms lasting 1100 to 1400 years
- We are heading for 1.1-6.4°C rise in temperature



Source – Wikipedia and British Geological Survey paper in preparation

Climate Change

GHG Emissions Scenarios

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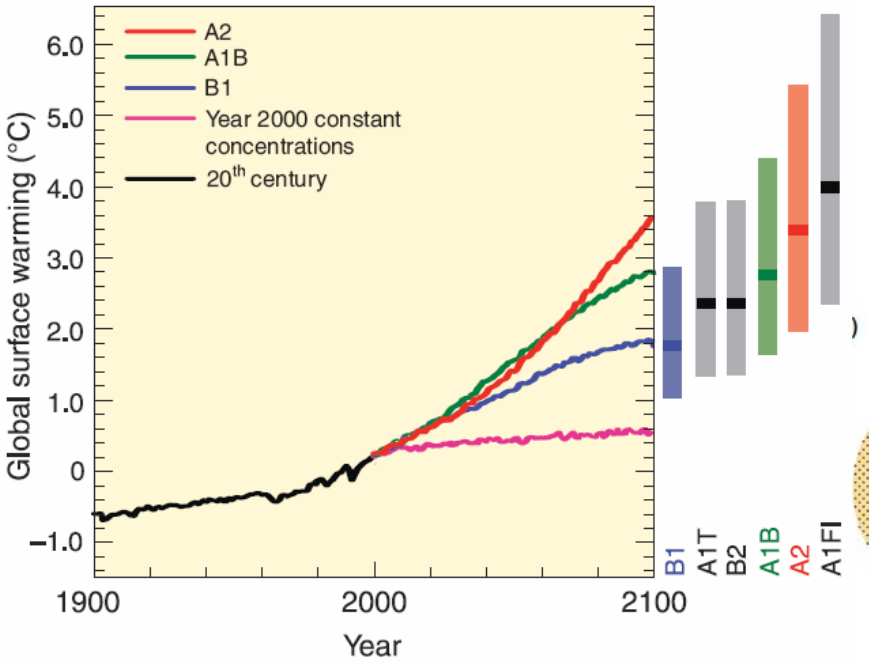

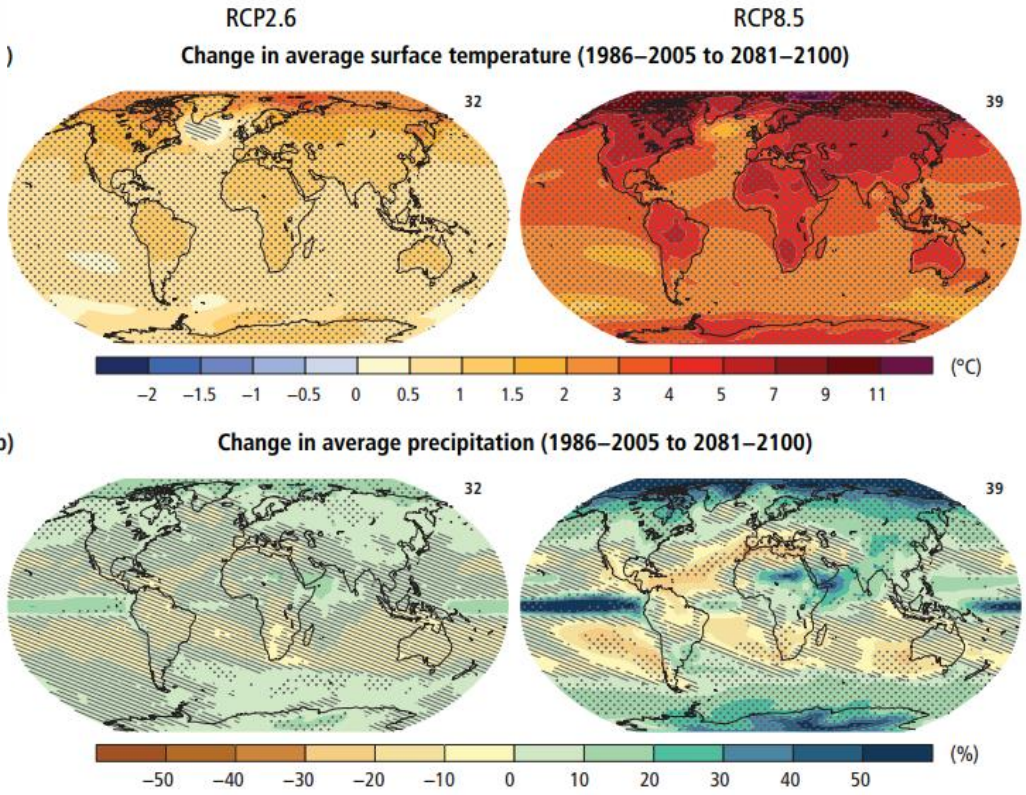

Source – IPCC 4th Synthesis Report, November 2014

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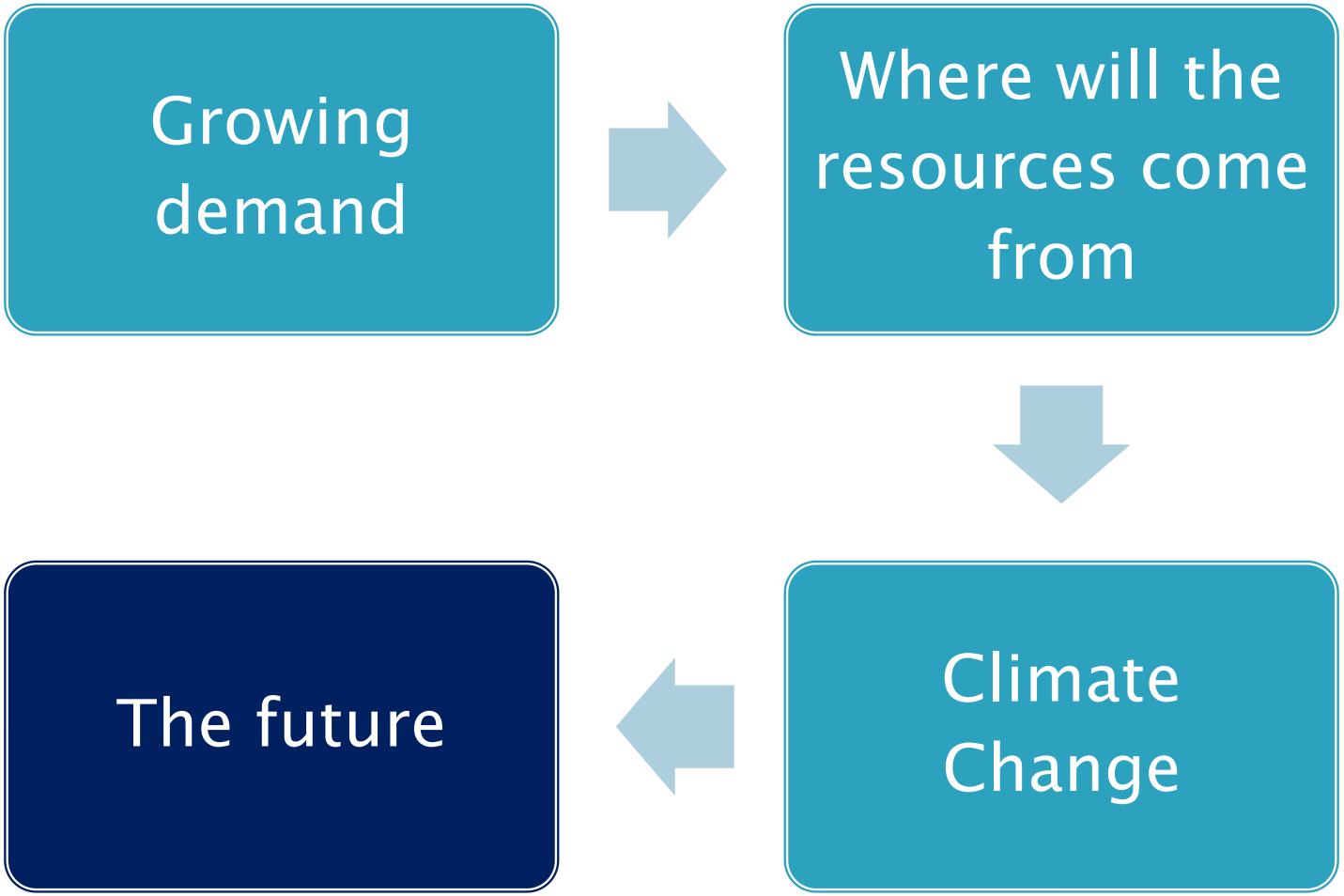

The Future

Carbon budget – 20-40 years

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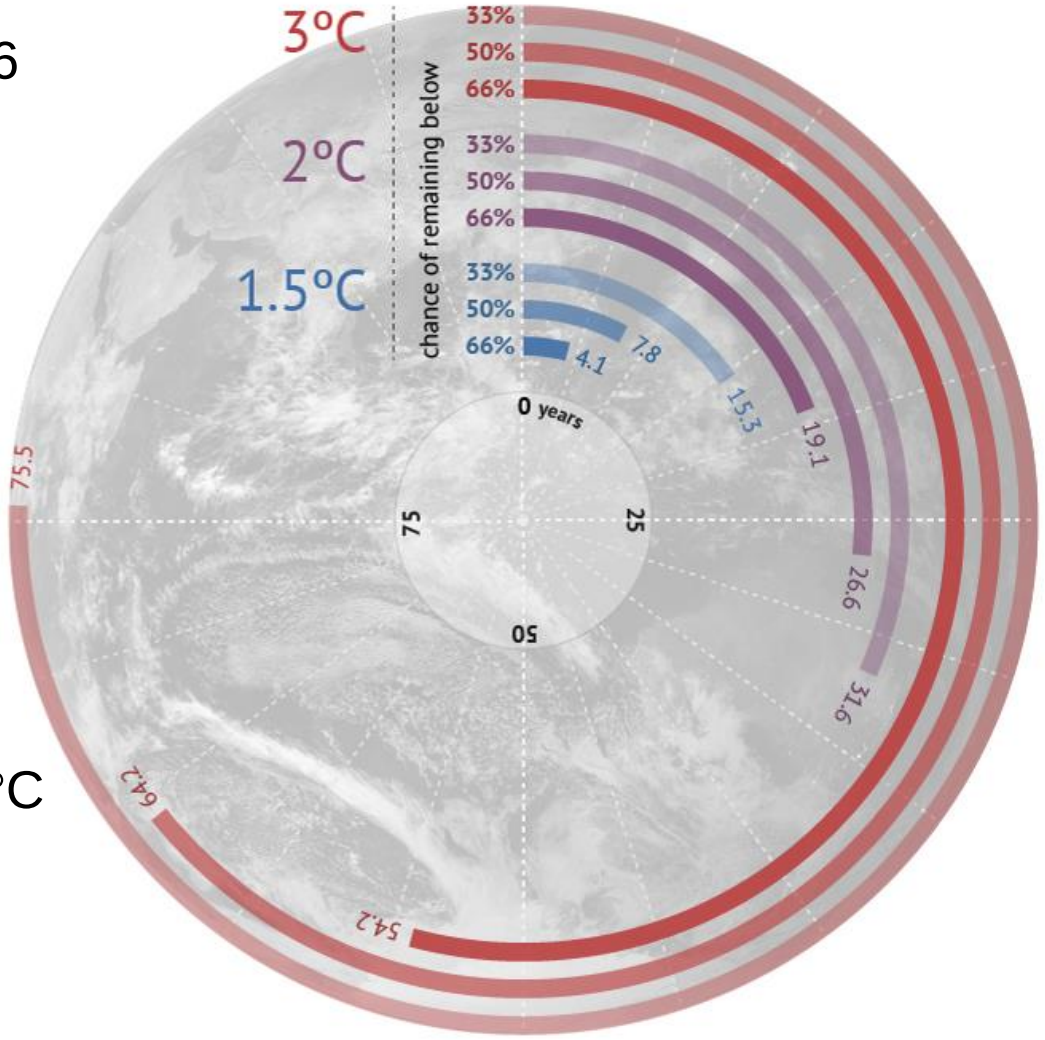
- 39.9 gigatonnes emitted in 2016
  - 36.4 Gt due to fuel use
  - 3.5 Gt due to land use
- We have access to 2795 Gt of CO_2 from in current proven reserves
  - Worth ~US$27 trillion
  - Producing it is factored in to every oil and gas company share price
  - Need to leave 80% in the ground to avoid exceeding 2°C – writing £20 trillion off !!



CarbonBrief
CLEAR ON CLIMATE

The Future

Energy is changing - wind

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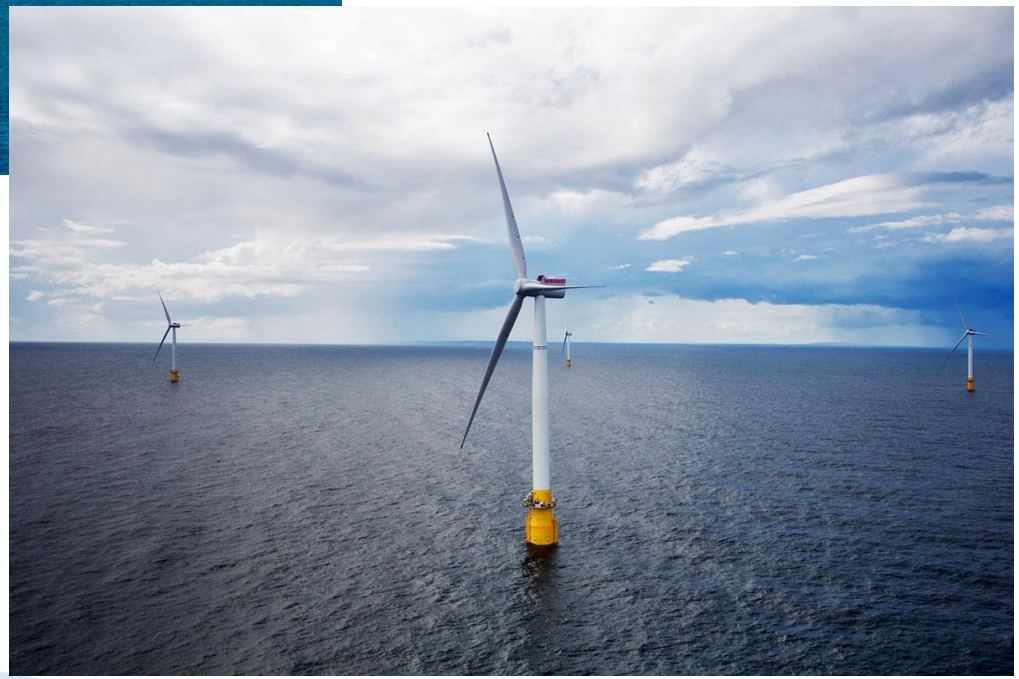

The Future

Energy is changing - solar

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The Future

Energy is changing - storage

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The Future

Energy is changing - tidal

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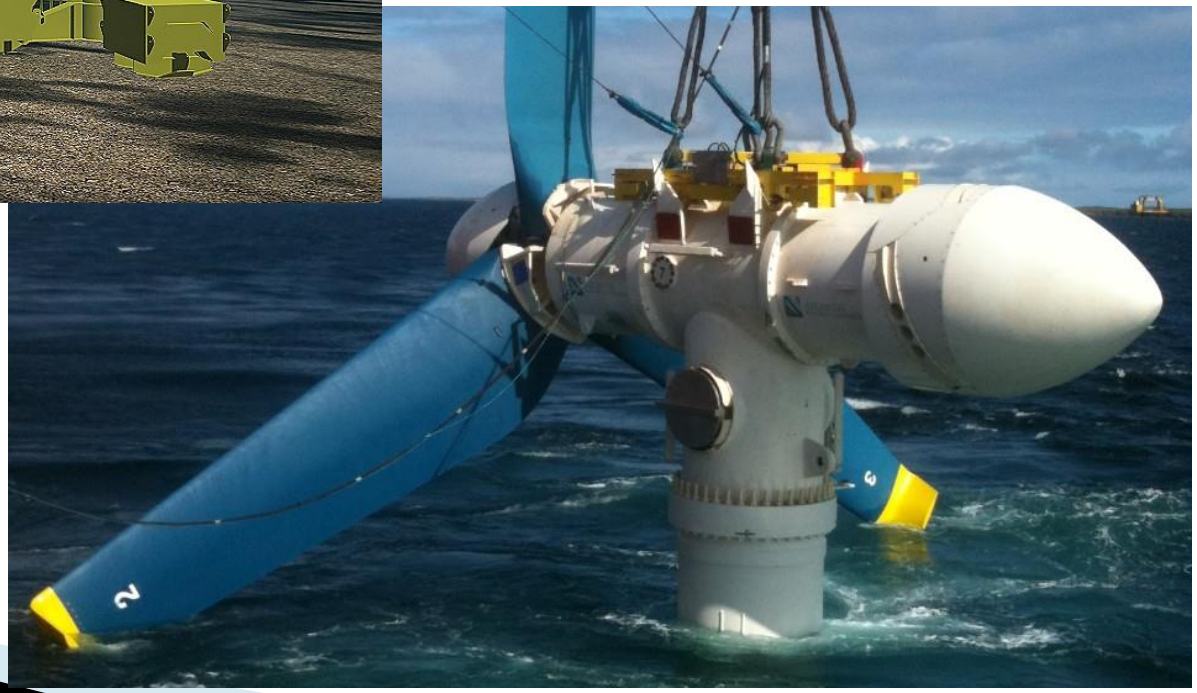

The Future

Energy is changing – road transport

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The Future

Energy is changing – aeroplanes

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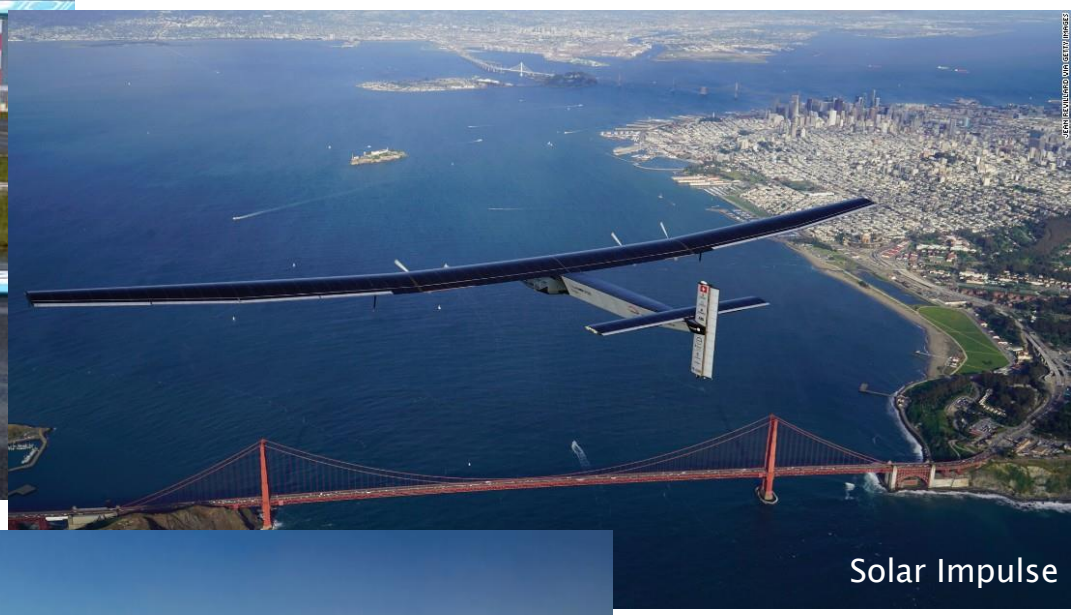
Solar Impulse

The Future

Energy is changing – transport

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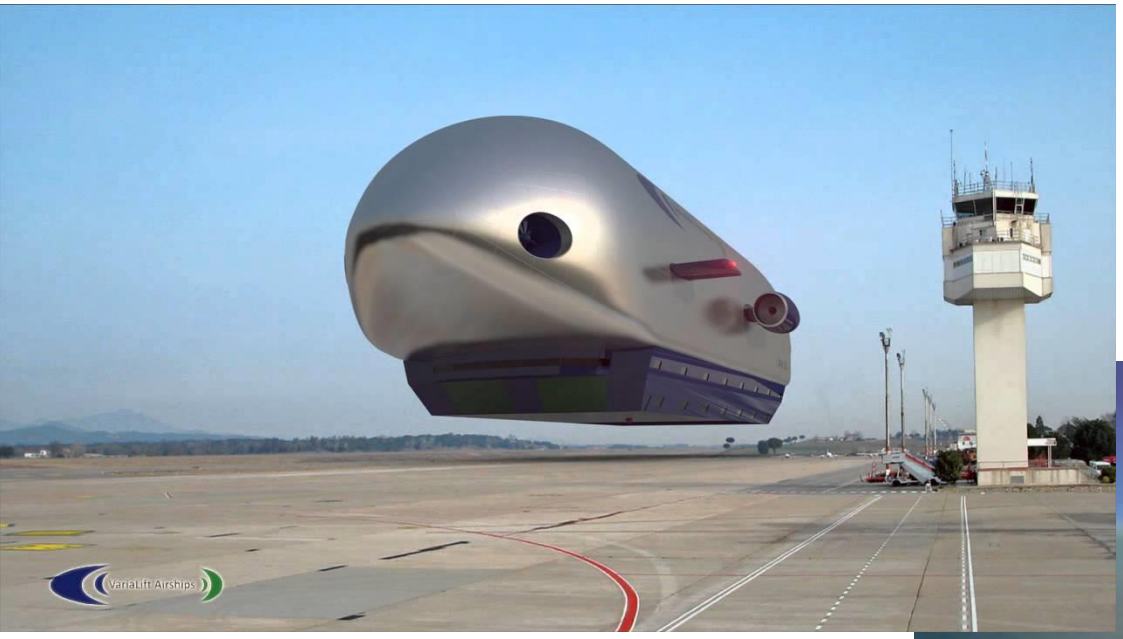

The Future

Renewables rapid growth

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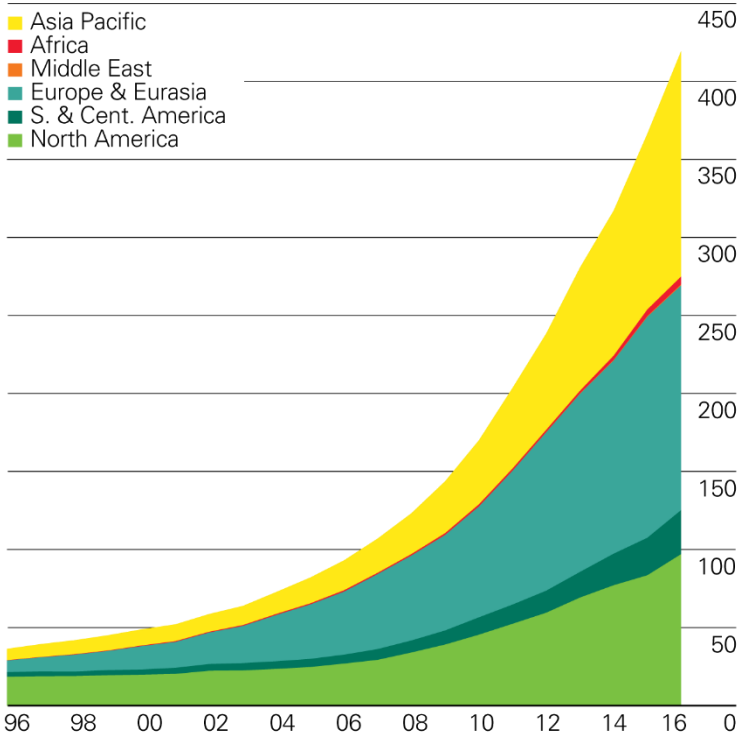
Other renewables consumption by region

Million tonnes oil equivalent



2015 saw a record breaking $367 billion invested in renewable power

BP Statistical Review of World Energy June 2017

The Future

Decarbonising oil and gas

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- Oil and gas and coal provides ~80% of the worlds energy
  - and we know where it is
- It contains Hydrogen
- Could we split the hydrocarbon into
  - Hydrogen – for use as a fuel
  - Carbon – lots of it
  - In the reservoir
  - At the coast

Conclusion

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- The oil and gas industry has a future
  - but it will look very different
- 92% of current oil and gas production is for energy
  - Electricity / cars / trucks / trains / planes / ships / space heating
- 8% of oil and gas production is used as raw material for plastics and fertiliser
- Renewables are coming
  - Currently ~5% of supply
  - Accelerating dramatically
- There is an energy transition – and it's happening now
  - The future is low carbon

The future of the oil and gas industry

Question? Thoughts?

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