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Shale gas: a Golden Age or a Gilded Cage?

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Quick overview of shale

- Shale gas is identical to natural gas (methane CH₄)
- Natural gas is a high carbon energy source

75% of its mass is carbon

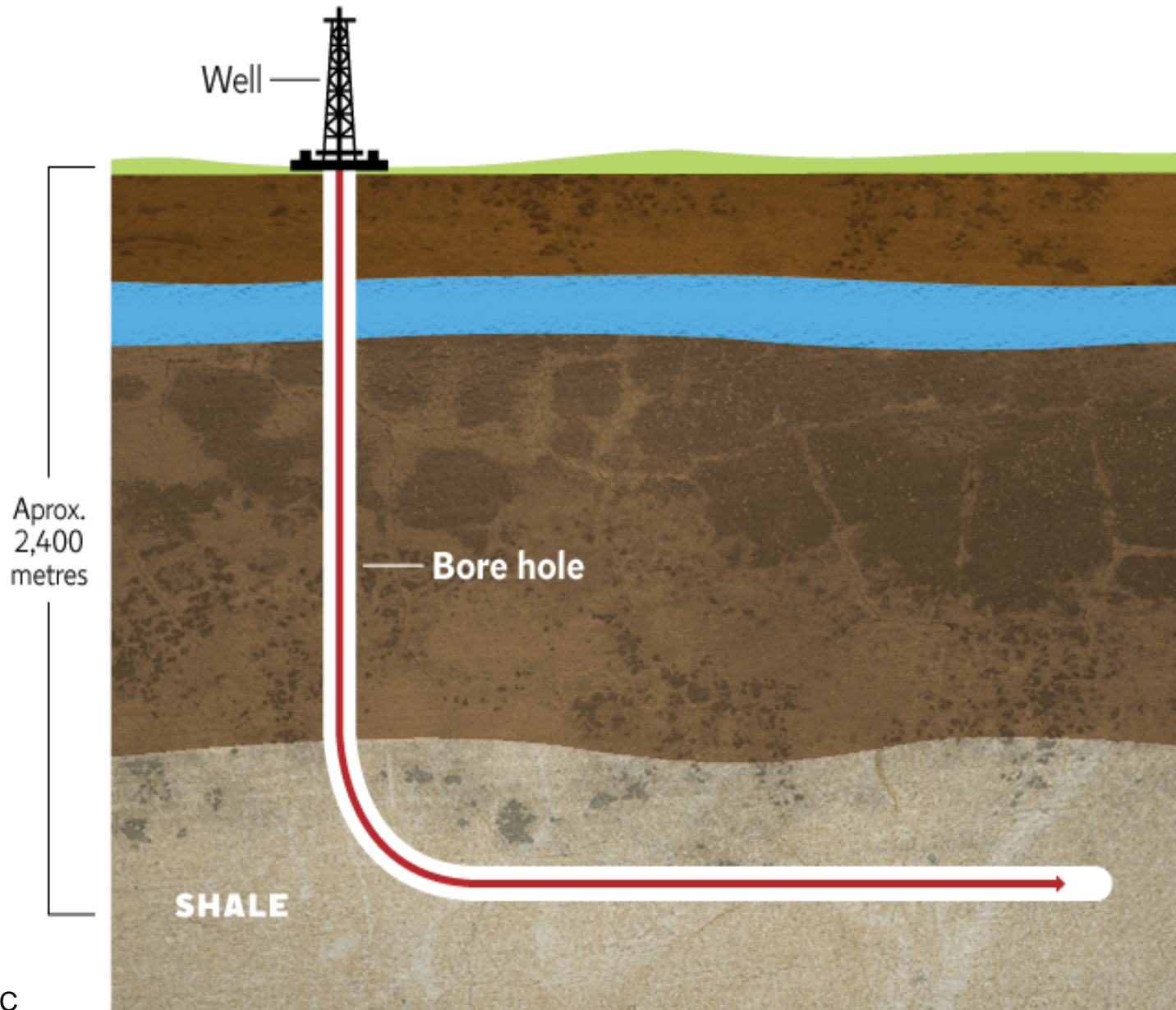
burn it and lots of carbon dioxide (CO₂) is emitted

- Shale gas is liberated from shale rock using a fracturing process
- The elements of the production process are not new

Why the new focus on shale gas?

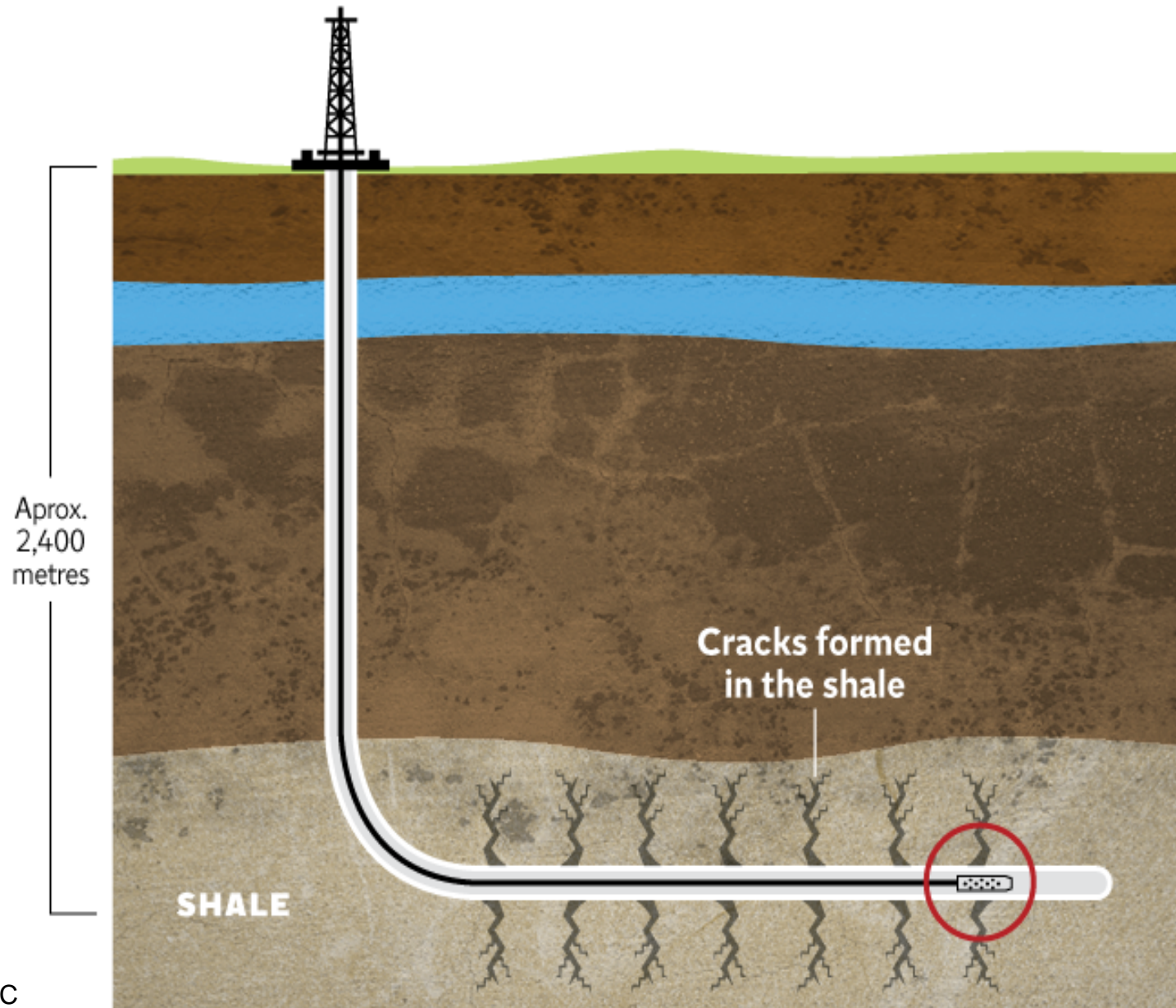
- Novel combination of existing technologies permit gas trapped in shale rock to be commercially available:
 1. Horizontal drilling
 2. 3D Seismic surveying
 3. Hydraulic fracturing
- Each has been used previously and collectively are now driving rapid expansion in the USA

Drilling the well

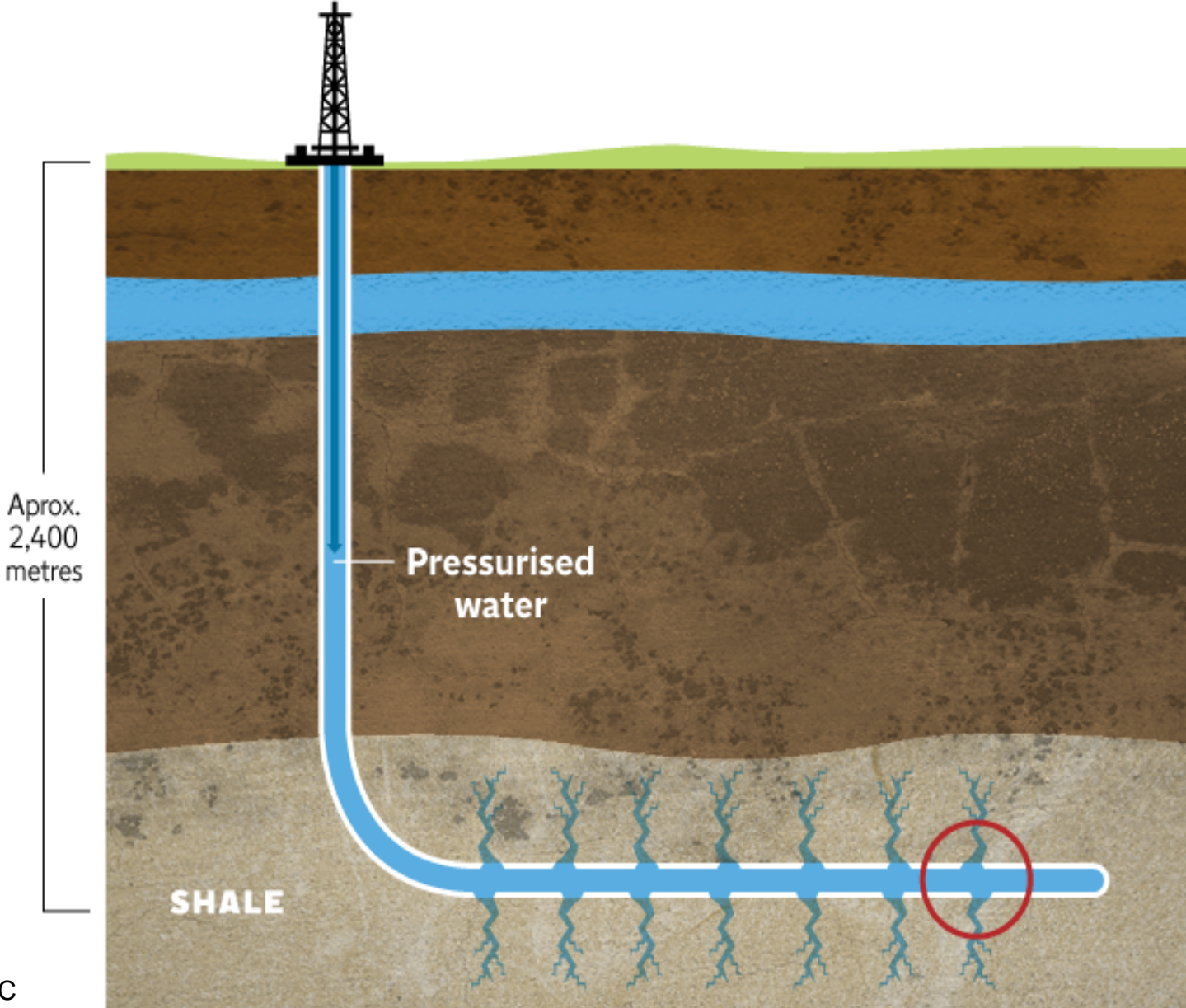


Source: DECC

Jet perforation

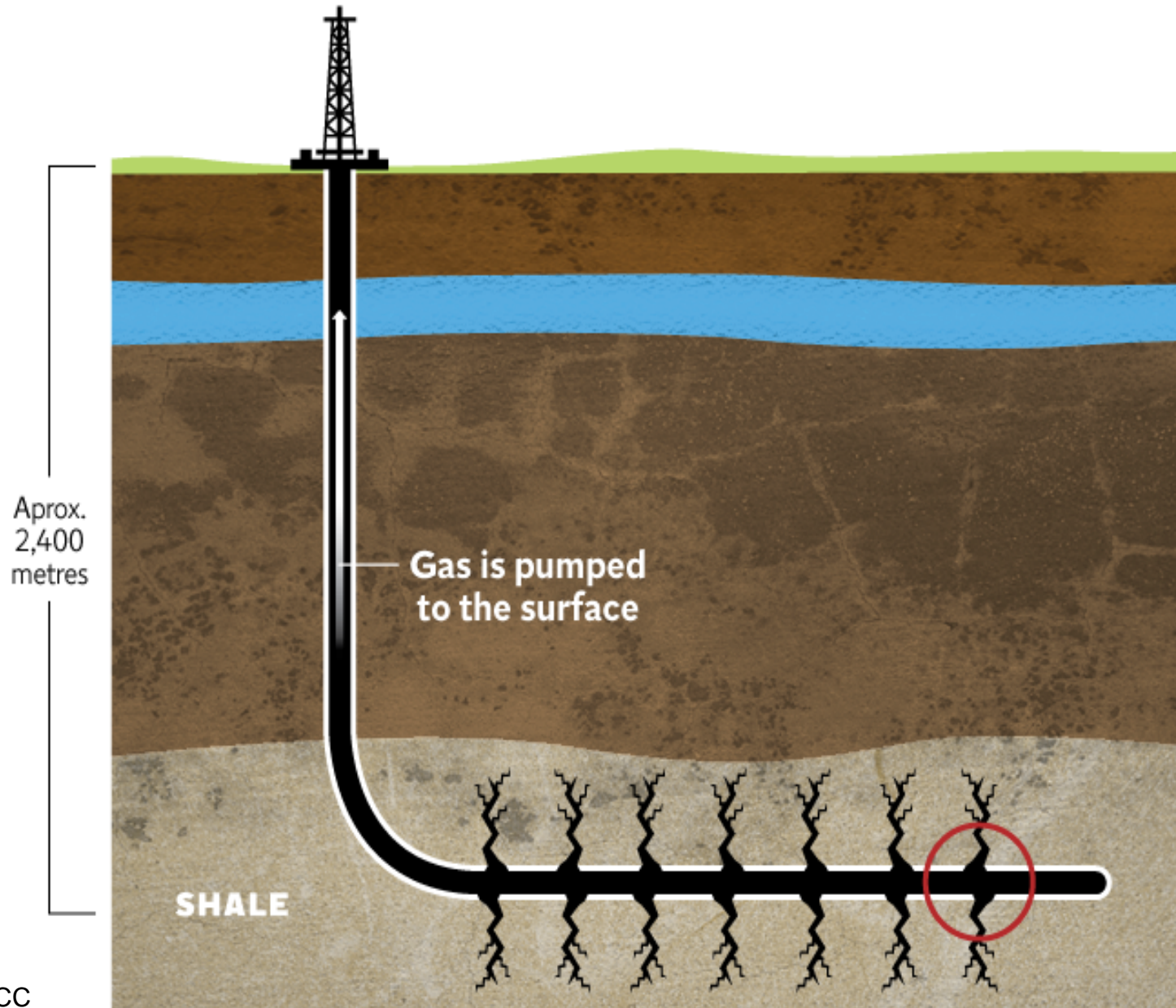


Fracturing fluids



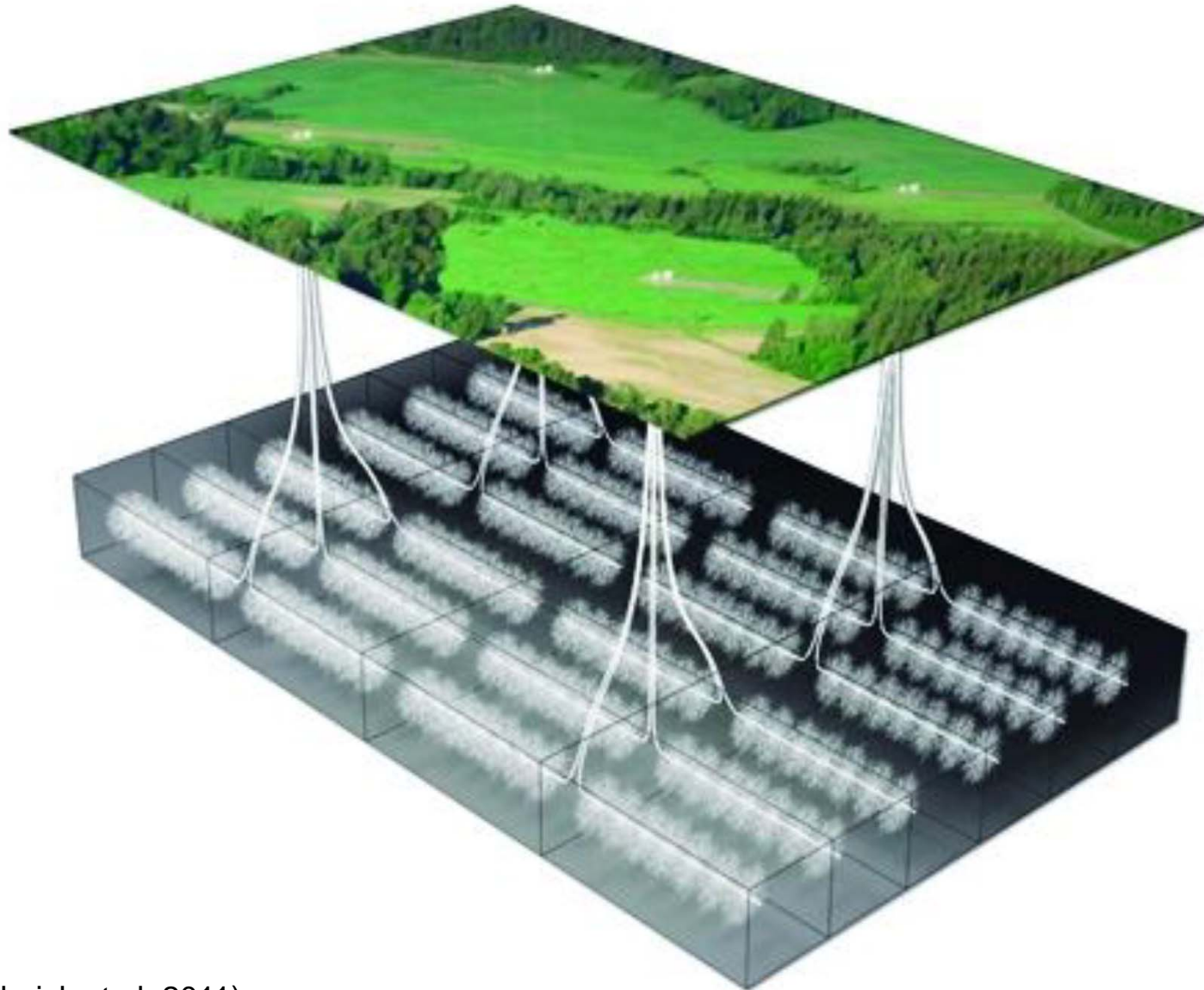
Source: DECC

Gas extraction



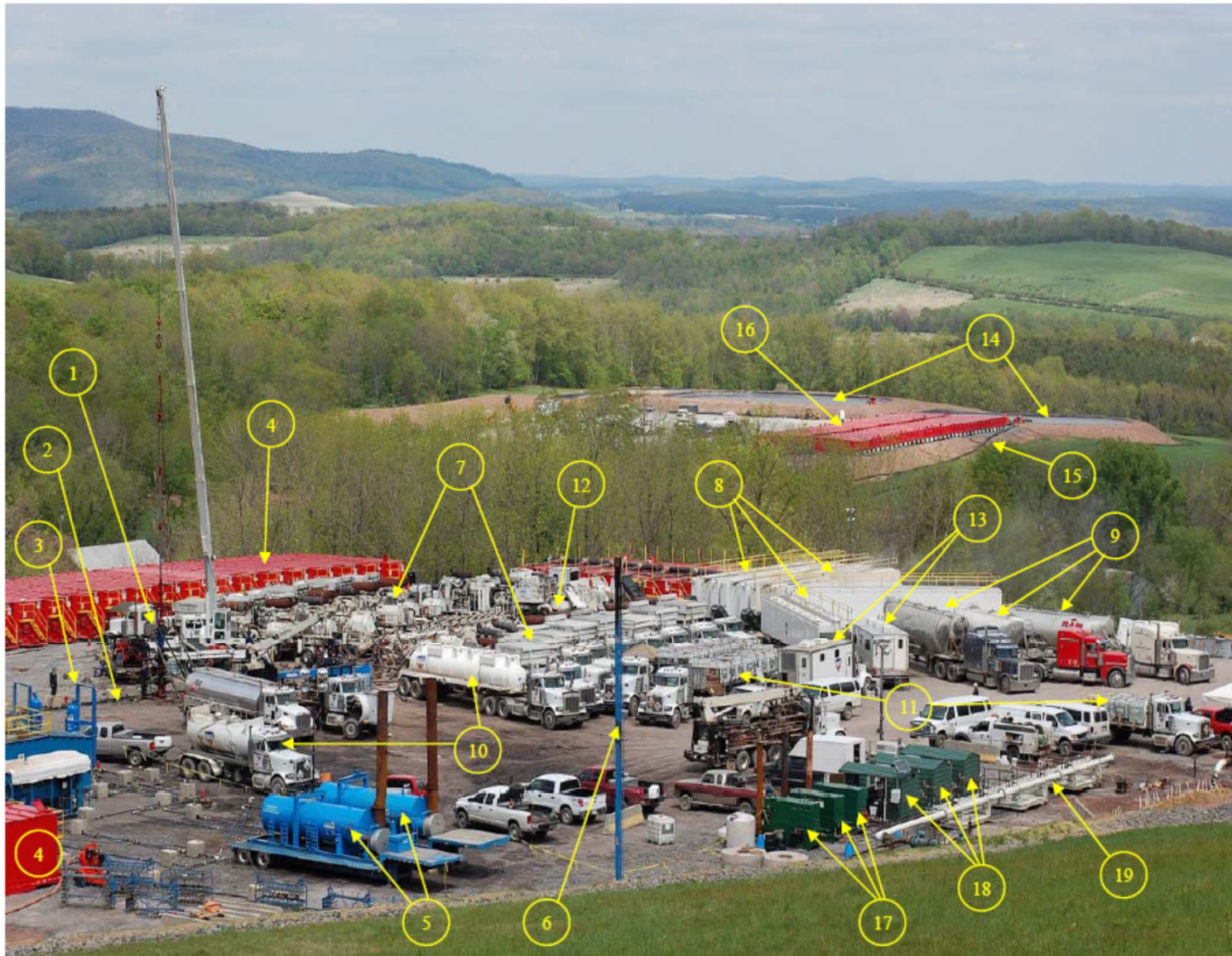
Source: DECC

Illustration of the arrangement of arrays of multi-well pads over target formations (New York State, 2009)



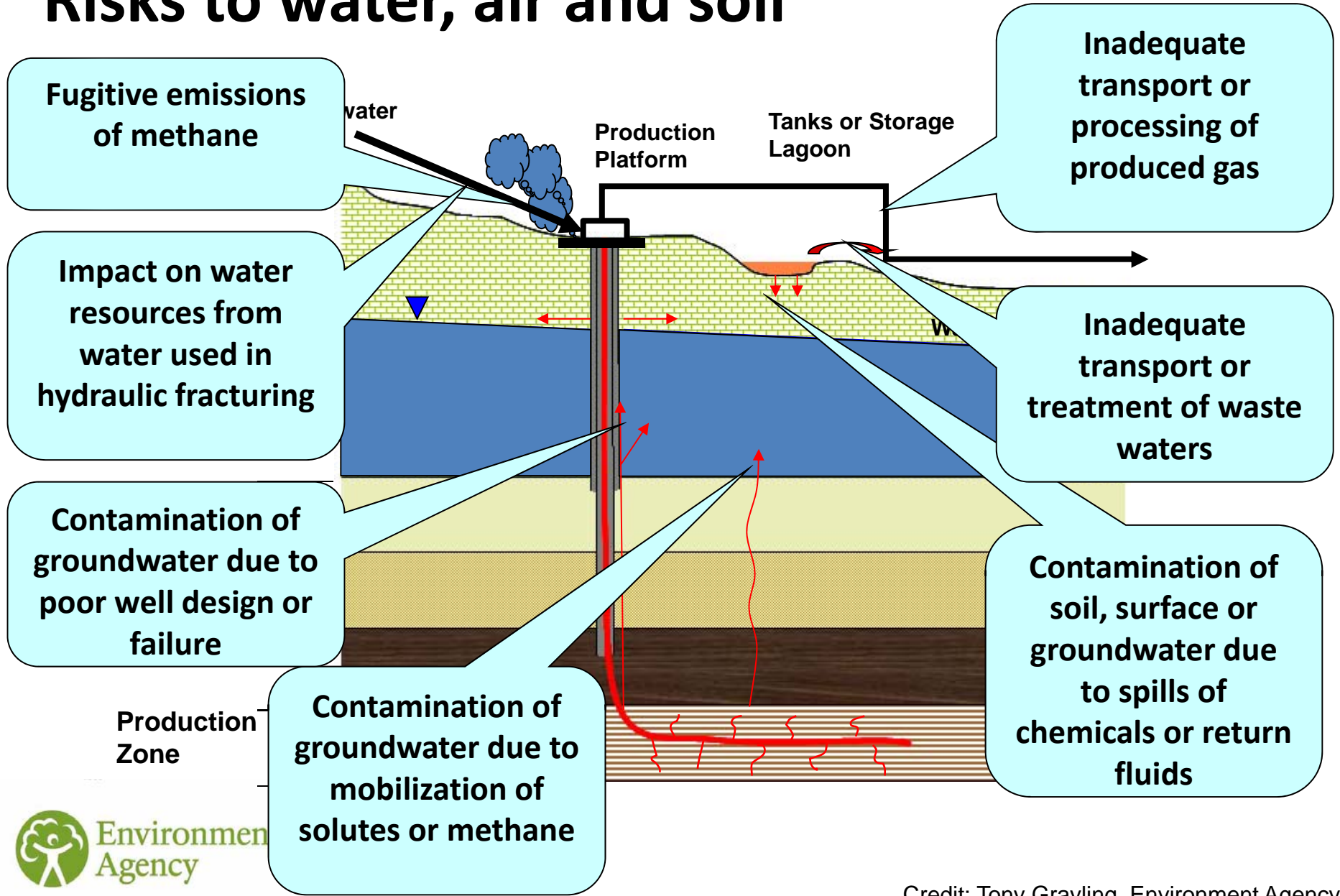
(Cited in Broderick et al. 2011)

A well site during a single hydraulic fracturing operation (New York State, 2009)



(Cited in Broderick et al. 2011)

Risks to water, air and soil



Other environmental impacts

- Traffic, noise and community disruption
 - » substantial above-ground infrastructure delivered by road
 - » Potentially also water and waste water transport



Exxon Mobil CEO welcomes fracking, but not water tower in his backyard

BY MARICE RICHTER

DALLAS | Wed Feb 26, 2014 10:36pm GMT

0 COMMENTS | Email Print

Feb
26

(Reuters) - It's not every day that the chief executive of the largest U.S. energy company joins a lawsuit opposing a new water tower planned in his neighborhood that could support fracking.

*...‘the tower could encourage the town of Bartonville to sell "water to oil and gas explorers for fracking shale formations leading to **traffic with heavy trucks... creating a noise nuisance and traffic hazards**"*

From the lawsuit filed in Denton County District Court

Other environmental impacts

- Traffic, noise and community disruption
 - » substantial above-ground infrastructure delivered by road
 - » Potentially also water and waste water transport

- Induced seismicity and subsidence
 - » Induced seismicity (*manageable risk Royal Society, RAEng, 2011*)
 - » Potential for voids created in gasification process
(as per existing mineworkings)

Personal view on environmental impacts

“with a stringent & appropriate regulatory and monitoring regime the environmental implications of shale gas extraction could be brought to levels similar to those considered acceptable with regards to the extraction of conventional natural gas”

3 exceptions

- traffic (ongoing drilling/refracturing)
- aggregate well integrity (more wells per unit of gas)
- climate change from an additional fossil fuel

Focussing in on climate change

Sequential approach

- *What levels of climate change are we committed to avoid?*
- *How does this translate to carbon budgets/emission pathways?*
- *How do budgets divide between nations?*
- *What is the carbon footprint of shale gas (electricity & heating)?*
- *Is shale gas a substitute for or additional to other fossil fuels?*
- *If it's a substitute, can it fit within emission pathways?*
- *Conclusions for wealthier (Annex 1) & less-wealthy (non-Annex 1) nations*

UNFCCC to Copenhagen & Camp David

- *“stabilization of greenhouse gas concentrations ... at a level that would prevent dangerous anthropogenic interference with the climate system”*

Article 2 of UNFCCC

- *‘To hold the increase in global temperature **below 2 degrees Celsius**, and take action to meet this objective consistent with **science** and on the basis of **equity**’*

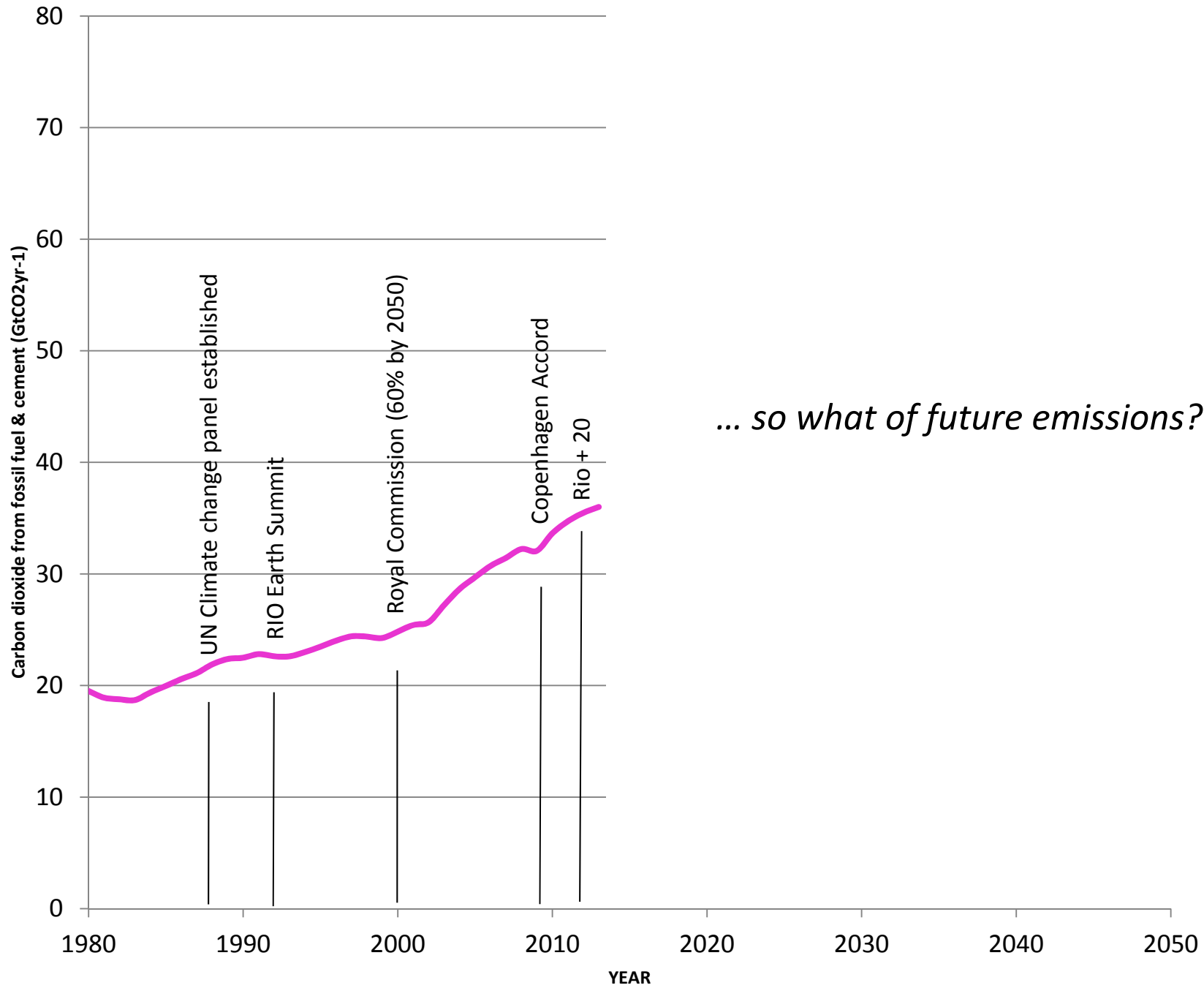
Copenhagen/Cancun/Doha/Camp David declarations

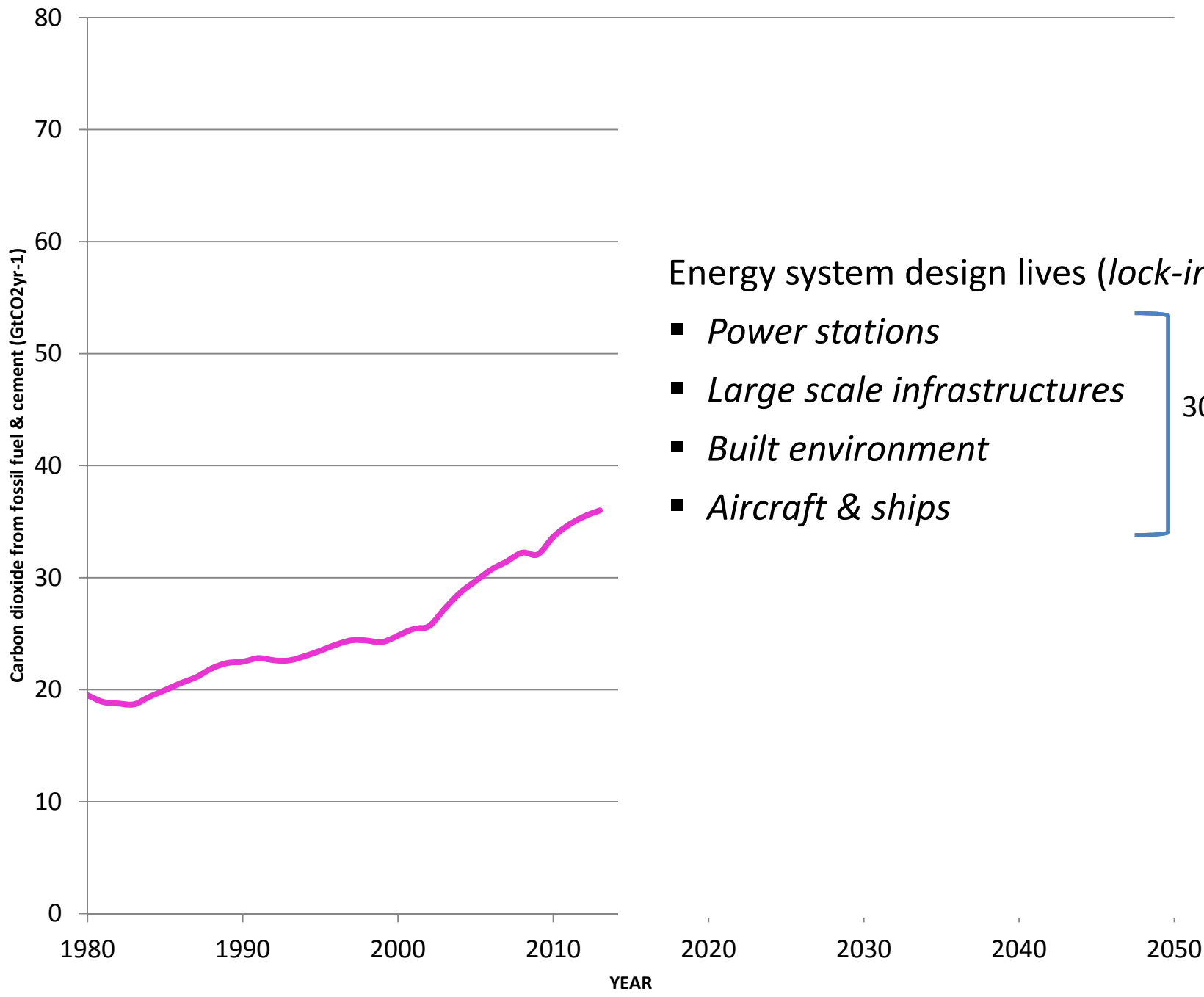
- *‘... **must** ensure global average temperature increases **do not exceed** preindustrial levels by more than **2°C**’*

European Commission’s annual communication

What emissions pathways fit with 2°C?

- In 2014 it is too late for a high probability of staying below 2°C
i.e. already blown the budget for our existing commitments
- So with a 60% chance of ‘avoiding dangerous CC’
- ... and with reductions in deforestation & halving food-related emissions
- What is left for emissions from energy?
i.e. a pathway for 60% chance of avoiding dangerous climate change

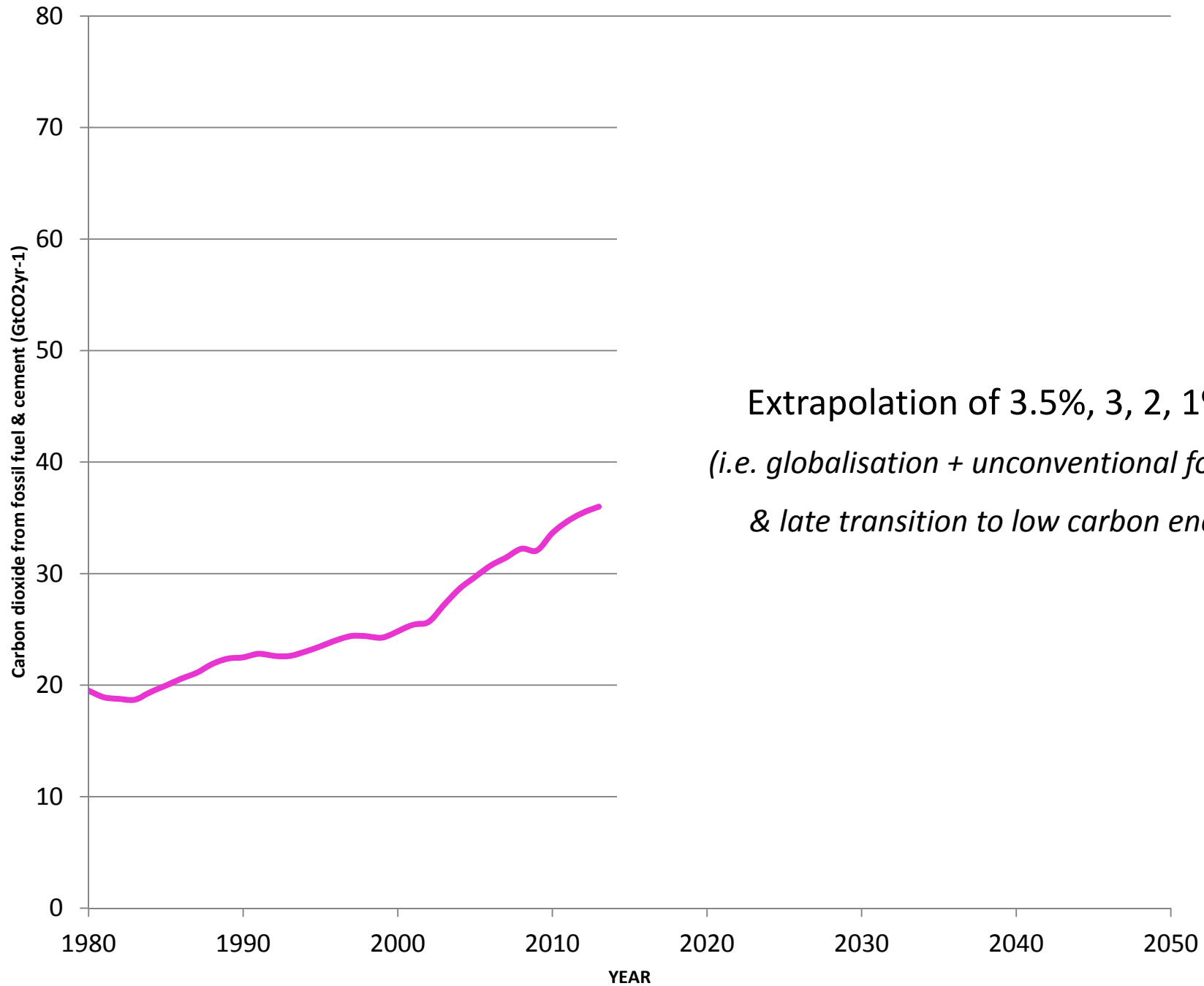




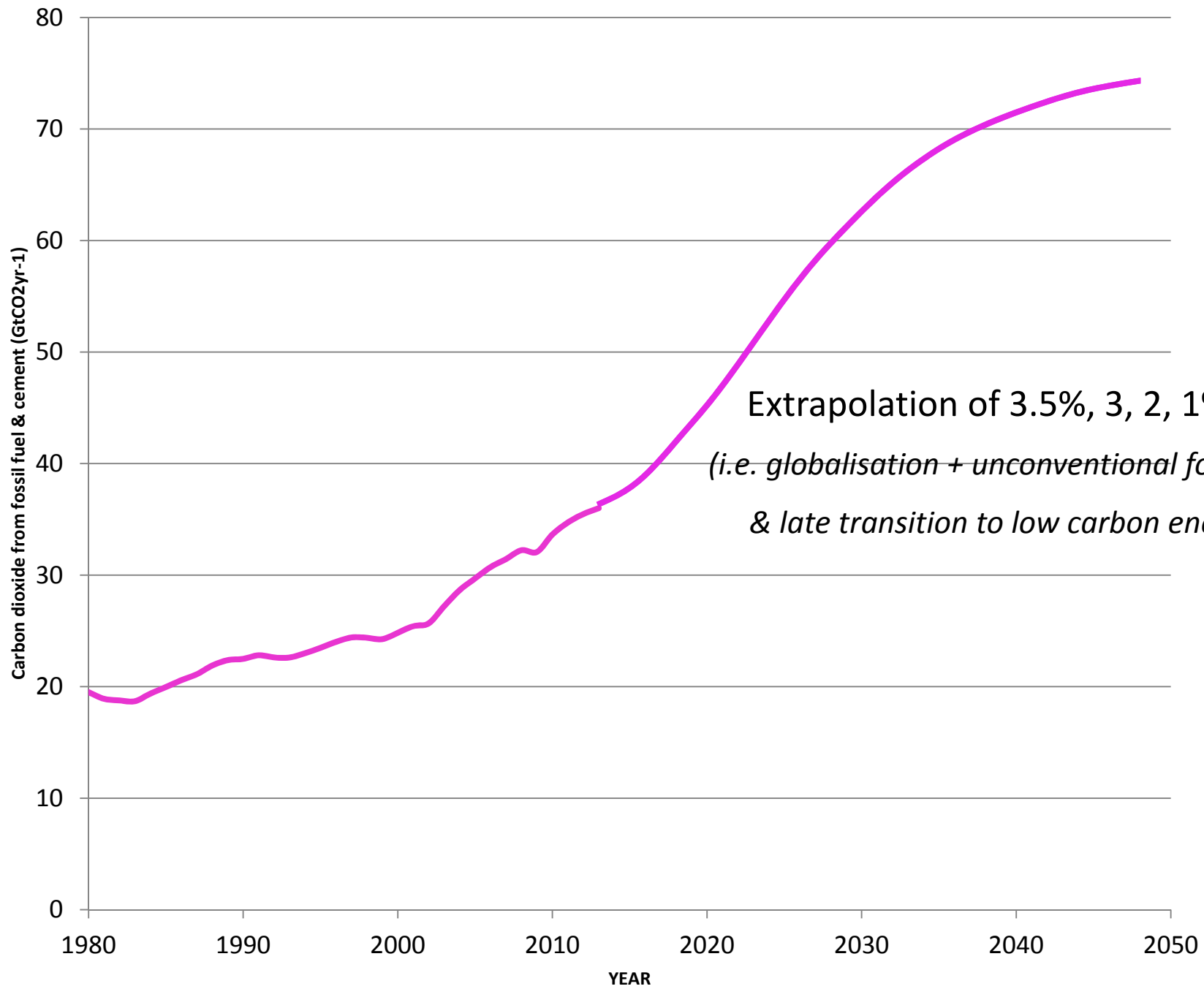
Energy system design lives (*lock-in*)

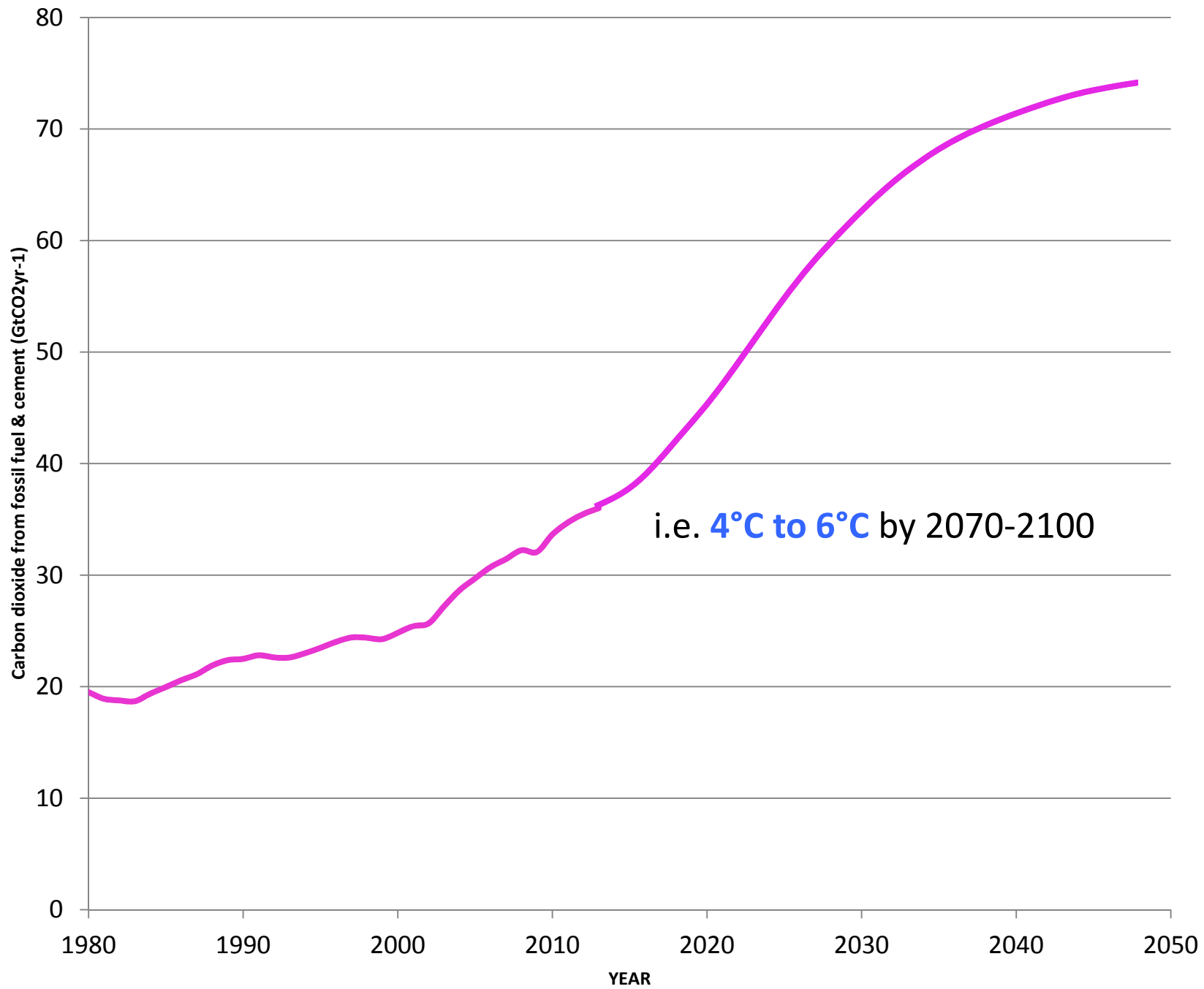
- *Power stations*
- *Large scale infrastructures*
- *Built environment*
- *Aircraft & ships*

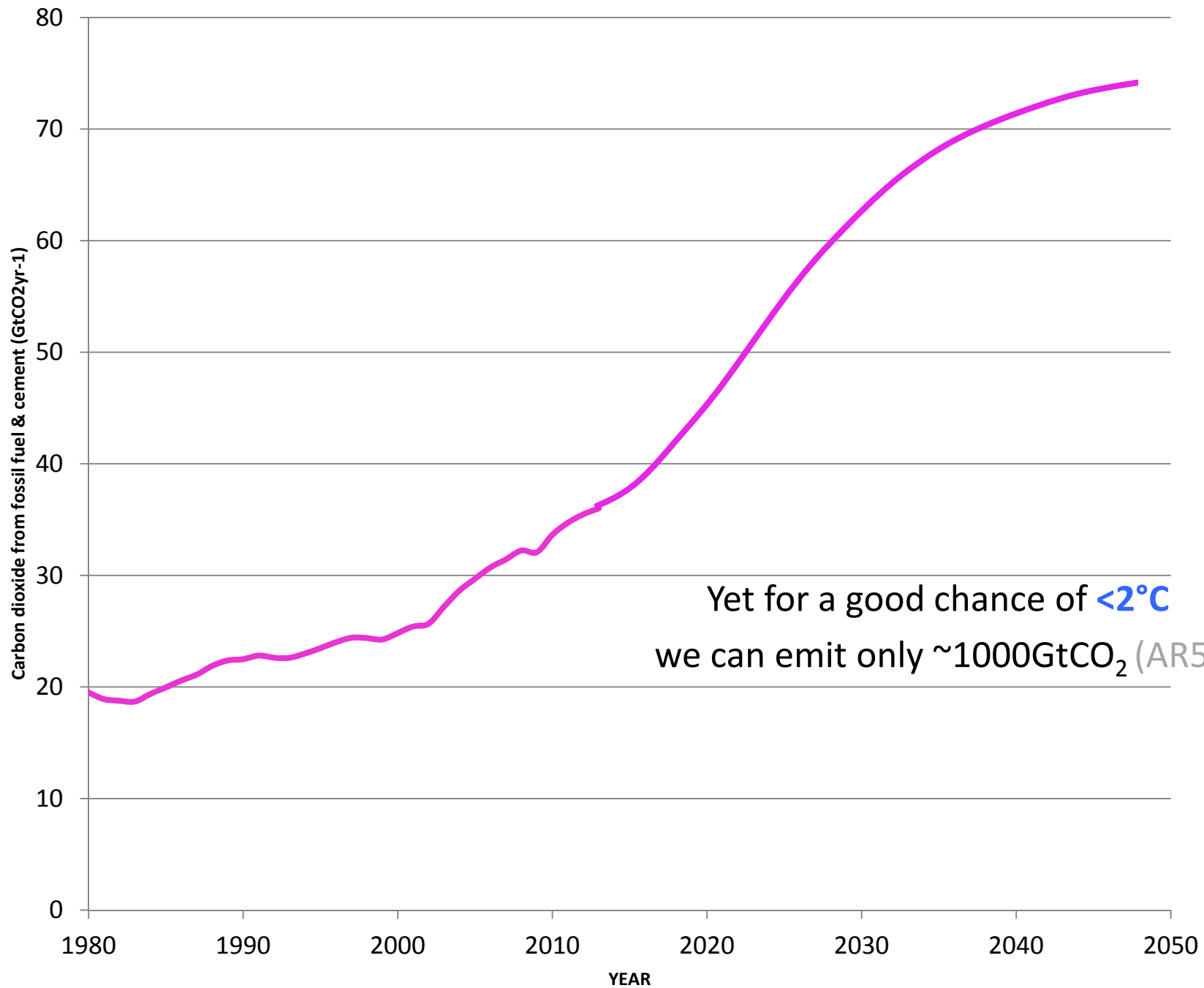
30-100 years

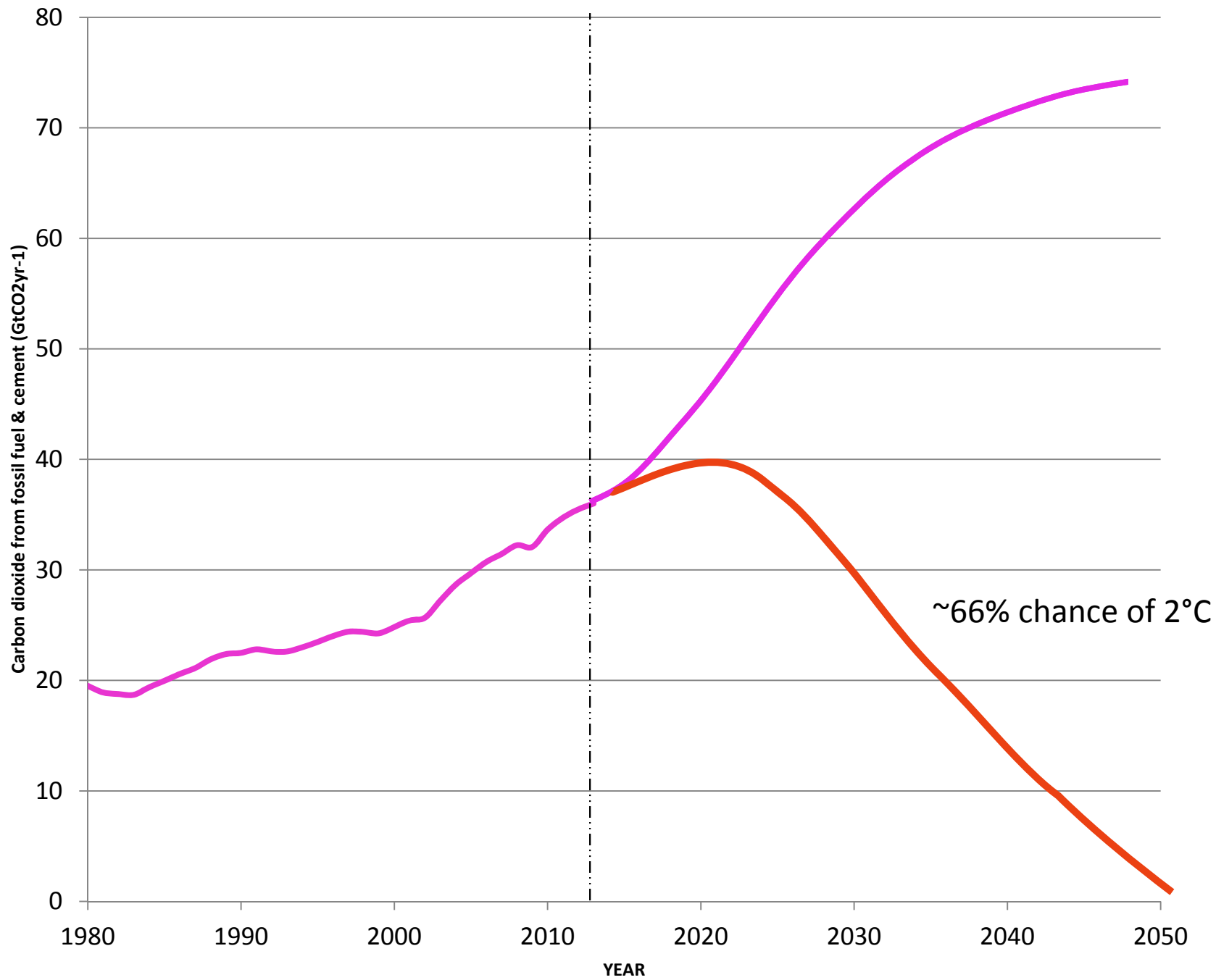


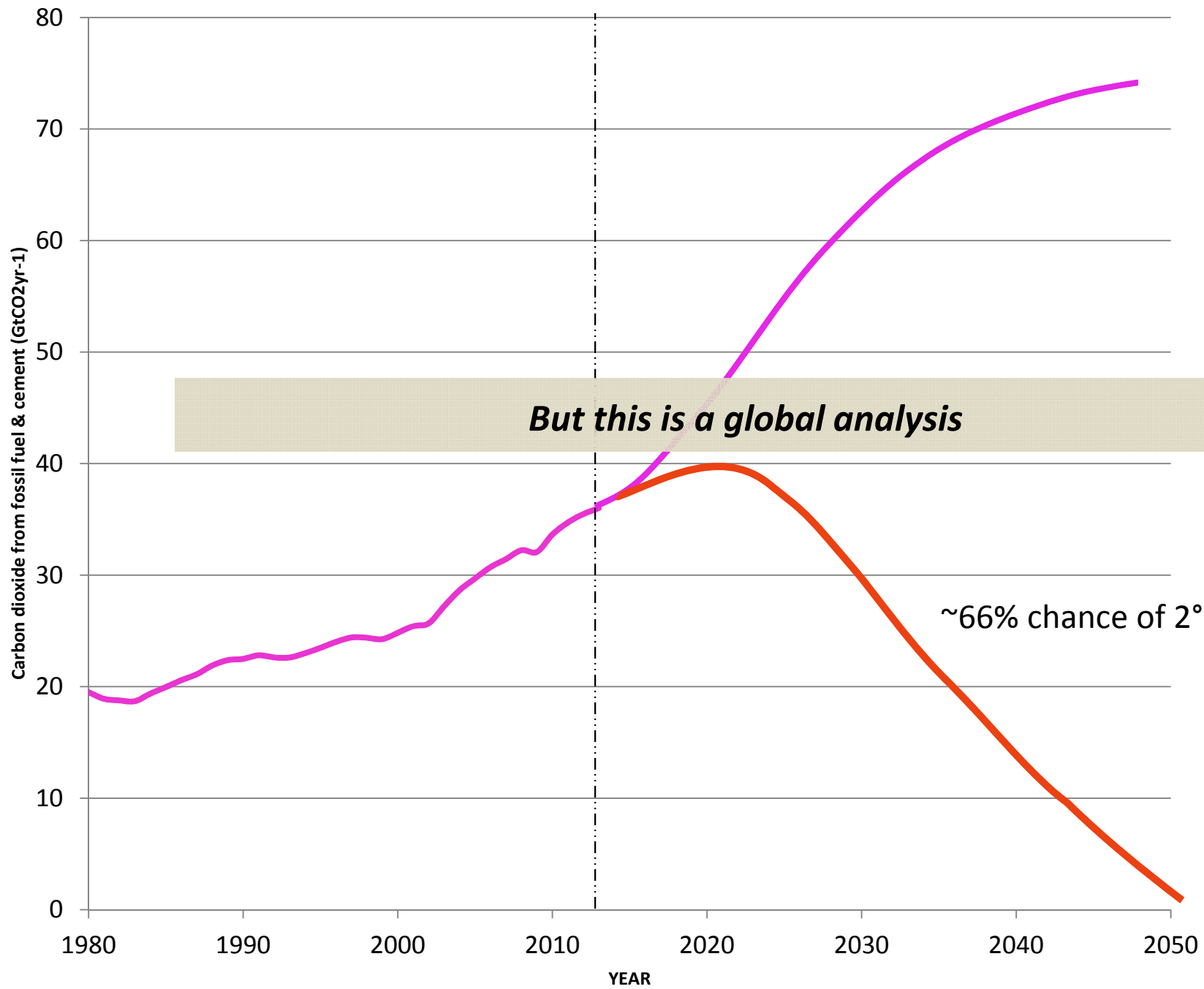
Extrapolation of 3.5%, 3, 2, 1% ...
(i.e. globalisation + unconventional fossil fuel
& late transition to low carbon energy)

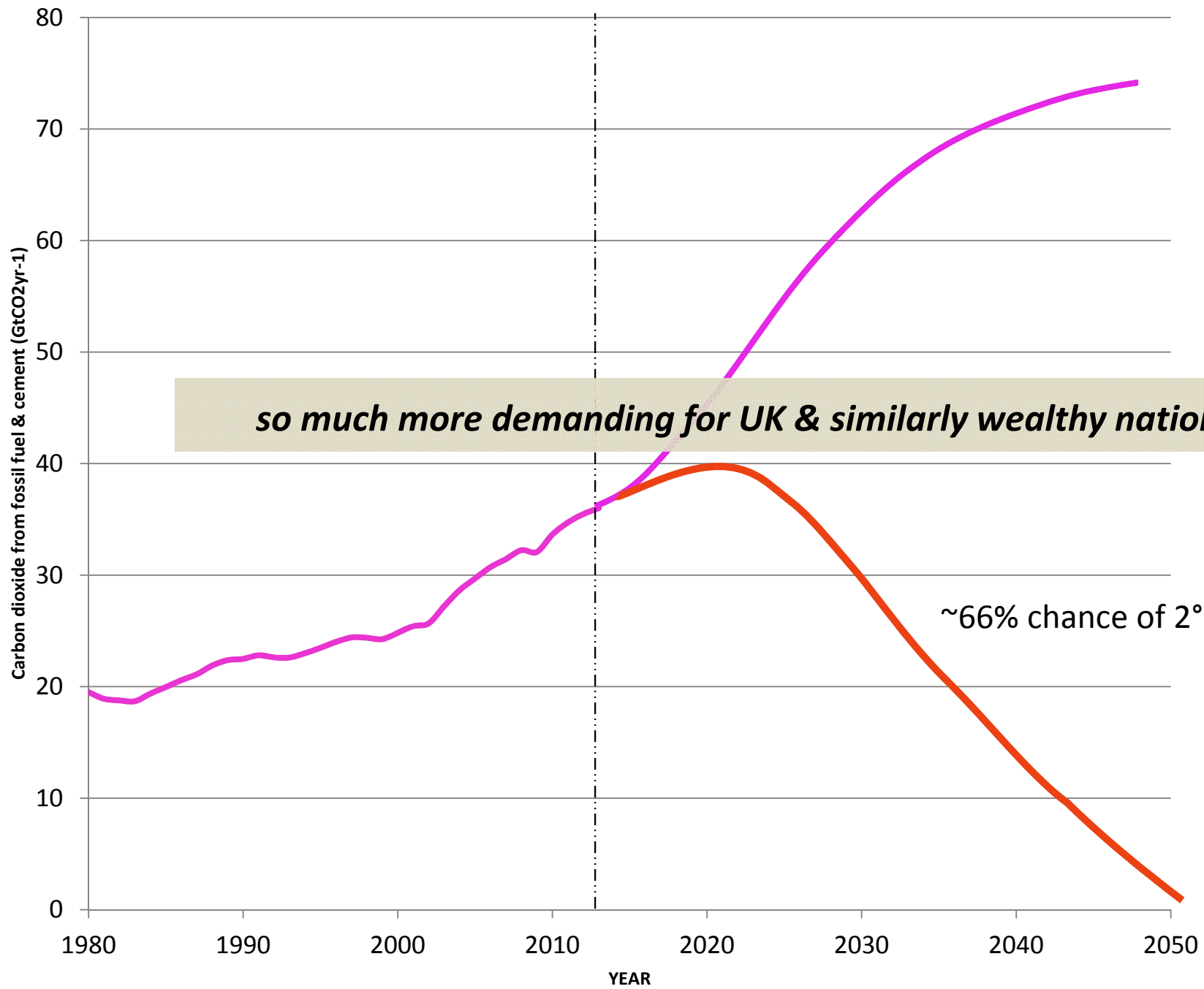












So what of (shale) in avoiding dangerous climate change (2°C)?

Many misunderstand the difference between *Emissions Intensity* and *Cumulative Emissions*, for example:

*“Gas, as **the cleanest fossil fuel**, is **part of the answer** to climate change, as a bridge in our transition to a green future, especially in our move away from coal... This report shows that the continued use of gas is **perfectly consistent with our carbon budgets** over the next couple of decades.”*

Secretary of State for Energy and Climate Change, Rt Hon Edward Davey

So what of (shale) in avoiding dangerous climate change (2°C)?

- Gas is a high carbon energy source (comprising 75% carbon)
- *“If a country brings any additional fossil fuel reserve into production, then in the absence of strong climate policies, we believe it is likely that this production would increase cumulative emissions in the long run. **This increase would work against global efforts on climate change.**”*

DECC: MacKay & Stone shale gas review (2013)

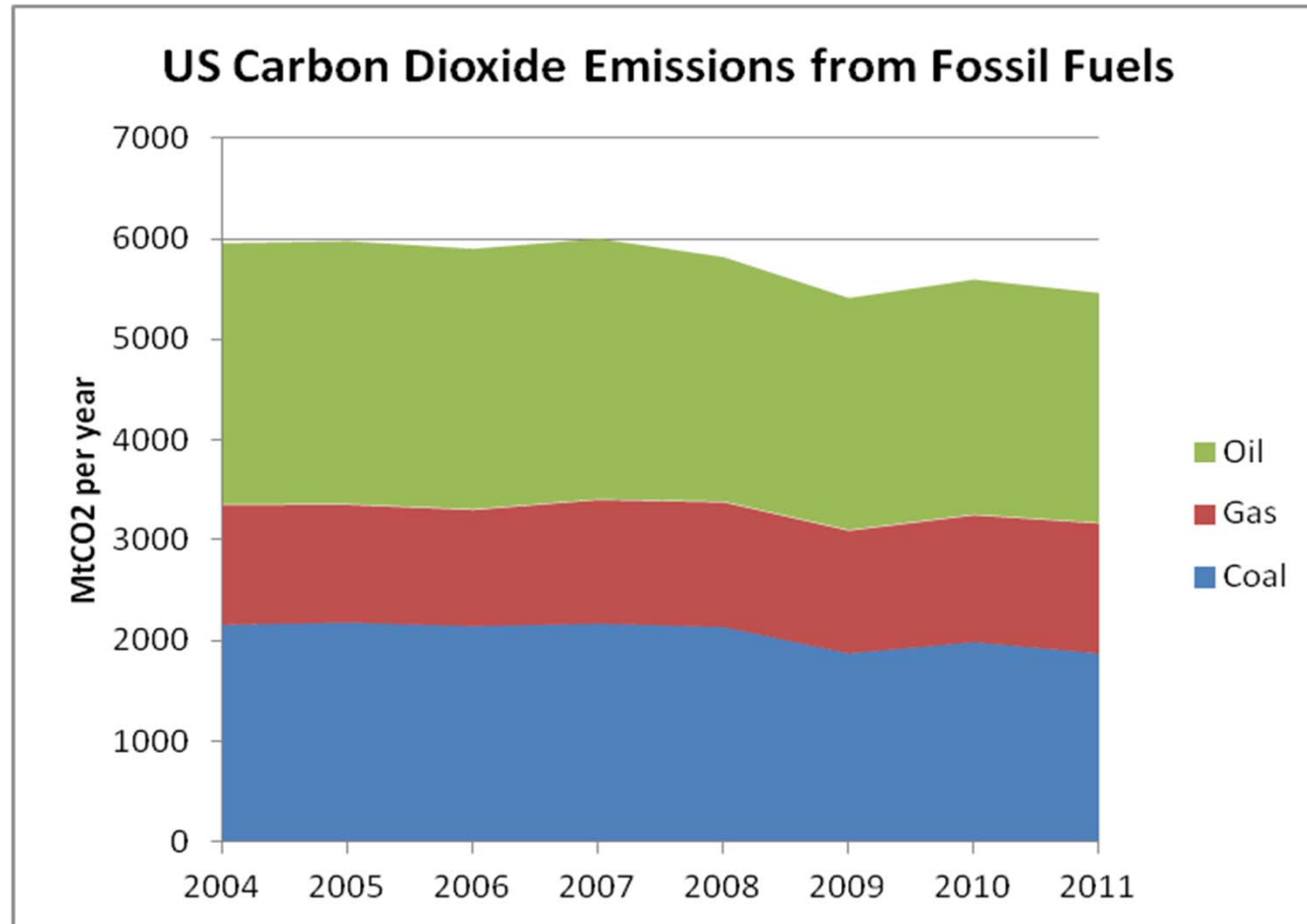
- In an energy-hungry world without stringent carbon caps shale gas is likely to be used in addition & not as a substitute for coal or oil.
(other than for peat, has a fossil fuel ever substituted for another?)

So what of (shale) in avoiding dangerous climate change (2°C)?

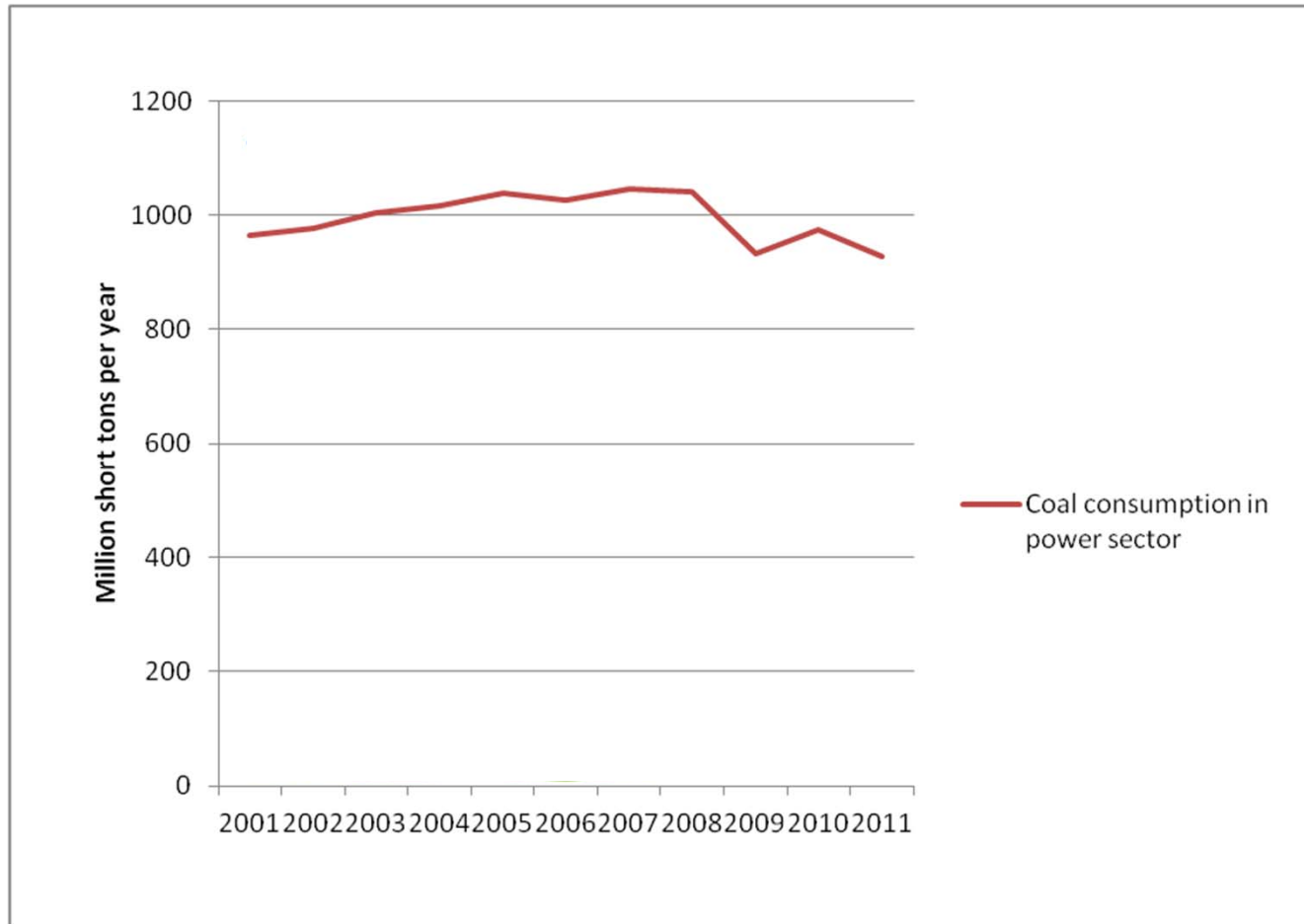
- *“...if a significant amount of shale gas enters the UK market (whether from domestic sources, imported from another European country, or from the global market via LNG) it will probably discourage investment in more expensive—but lower carbon—renewables.”*

The House of Commons Energy and Climate Change Committee (2011)

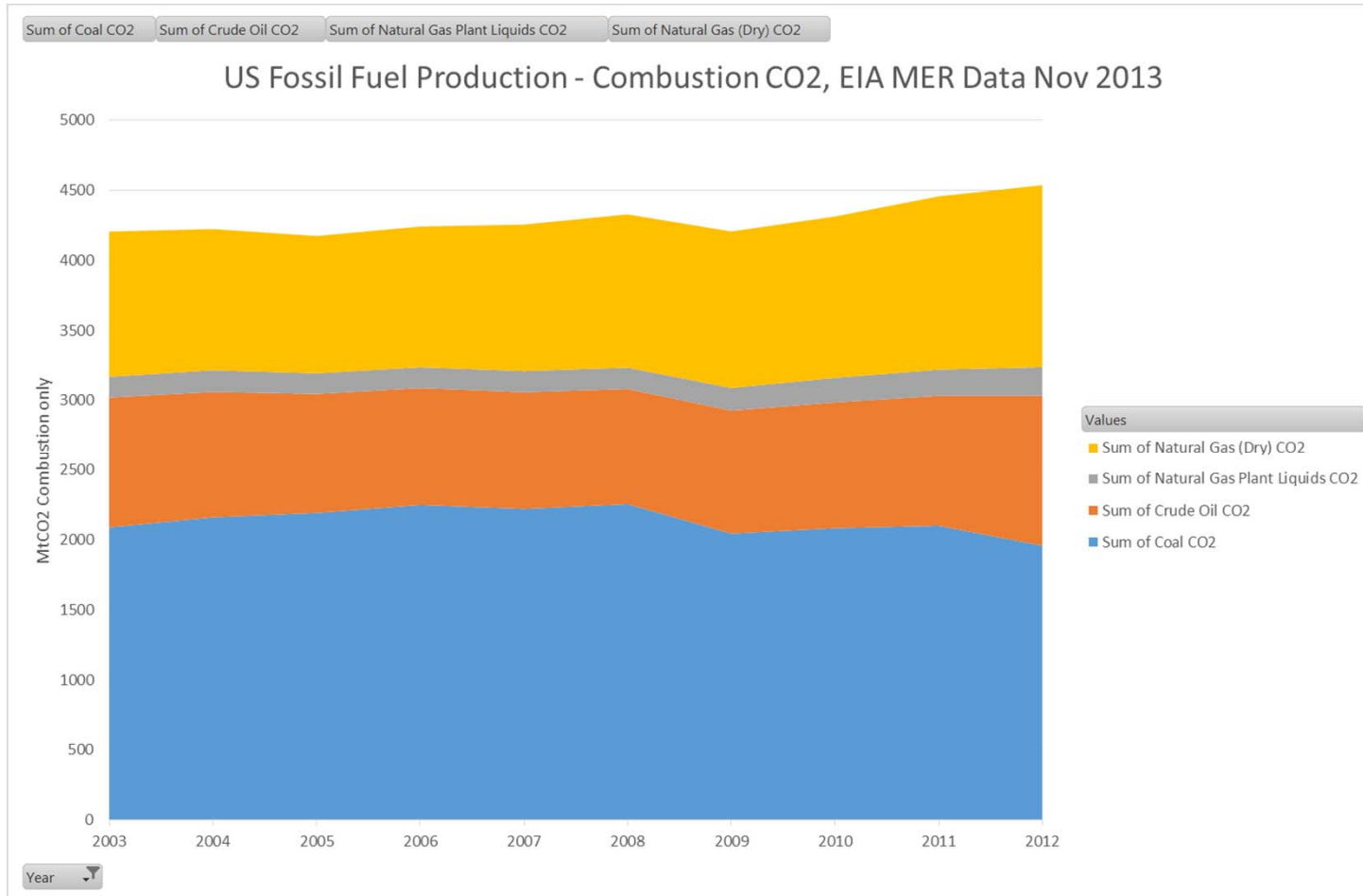
... what does the evidence from the US suggest?



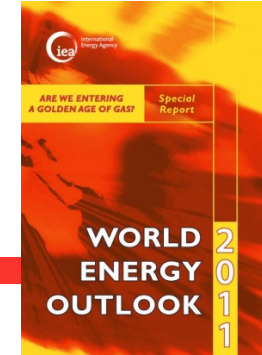
... but is the coal really staying in the ground?



... & what of total US fossil fuel production



So is this really The Golden Age of Gas?



- Shale gas with CCS can't be major component of energy system – lifecycle emissions projected to be $\sim 80\text{-}120\text{gCO}_2/\text{kWh}$
(c.f. renewables & nuclear at ~ 5 to $20\text{gCO}_2/\text{kWh}$)
- If poorer (non-Annex 1) nations peak by 2025 before reducing at 5-8% p.a. then 2°C obligation requires wealthier (Annex 1) nations to be very-low carbon by $\sim 2030\text{-}35$
i.e. no emission space for shale in Annex 1 nations
- Even DECC's UK position is for the 2030 grid to be under $50\text{gCO}_2/\text{kWh}$ with heating & cars on the electric grid
...so why invest in 'unusable' new shale-gas reserves?

Conclusions

Absolute emissions + knowledge of time constraints =>

Poorer (non-Annex 1) nations

Shale gas as part of rapid carbon intensity reduction

if upstream emissions are managed

... but must lock out other fossil fuel infrastructures & enable CCS

Wealthier (Annex 1) nations

Shale gas incompatible with even weak version of 2°C commitments

- » Need a *rapid reduction* in energy demand; and
- » and an increase in *very low/zero energy supply* necessary

Why such different conclusions?

Context

- Take science-based view of 2°C (*i.e. cumulative emissions not 2050 targets*)
- ‘Fair’ division of emissions between Annex 1 & non-Annex 1
- Explicit account of global deforestation and food emissions

NB: decarbonising power sector is not the same as “avoiding dangerous climate change”

Implications

- Timeframe of transition to low/zero carbon **energy** system significantly reduced
- Gas not compatible with such a science-based timeframe
- Gas with CCS only compatible (in non-Annex 1) with very high capture (over 95%)

NB: investment & planning priorities should centre on genuinely low or zero carbon energy

20th century fuel out of place in the 21st century?

- *“If a country brings any additional fossil fuel reserve into production... it is likely that this production would increase cumulative emissions in the long run. This increase would work against global efforts on climate change.”*

DECC: MacKay & Stone shale gas and climate review (2013)

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Opportunity cost of gas investment

- *“...if a significant amount of shale gas enters the UK market (whether from domestic sources, imported from another European country, or from the global market via LNG) it will probably discourage investment in more expensive—but lower carbon—renewables.”*
 - » The House of Commons Energy and Climate Change Committee (2011)
- Capital cost comparison
 - » Gas equiv 10% UK consumption (9bcm)
 - » Wells at £9m, series over 20 years
 - » No operational costs or rent on gas

Opportunity cost of gas investment

- *“...if a significant amount of shale gas enters the UK market (whether from domestic sources, imported from another European country, or from the global market via LNG) it will probably discourage investment in more expensive—but lower carbon—renewables.”*
 - » The House of Commons Energy and Climate Change Committee (2011)

Table 3.9: Capital costs of generation technologies	
Generation technology	Capital cost (£m/GW)
Gas CCGT	669
Gas CCGT with CCS	1,634
Onshore Wind	1,524
Offshore Wind	2,722