CCUS for net zero: overview

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CCUS for Net Zero Seminar Series
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Acknowledgements: Jon Gibbins, Mathieu Lucquiaud, Stuart Haszeldine and many others

Outline

- Why consider CCS?
  - Cumulative CO_2 emissions matter
  - Options for keeping fossil carbon in the ground
  - Tackling ‘hard to reach’ sectors
- Technology 101

Cumulative CO_2 emissions matter

The case for mandatory sequestration

Myles R. Allen, David J. Frame and Charles F. Mason

The fact that cumulative carbon dioxide emissions are more important than annual emission rates calls for a fresh approach to climate change mitigation. One option would be a mandatory link between carbon sequestration and fossil fuel extraction.

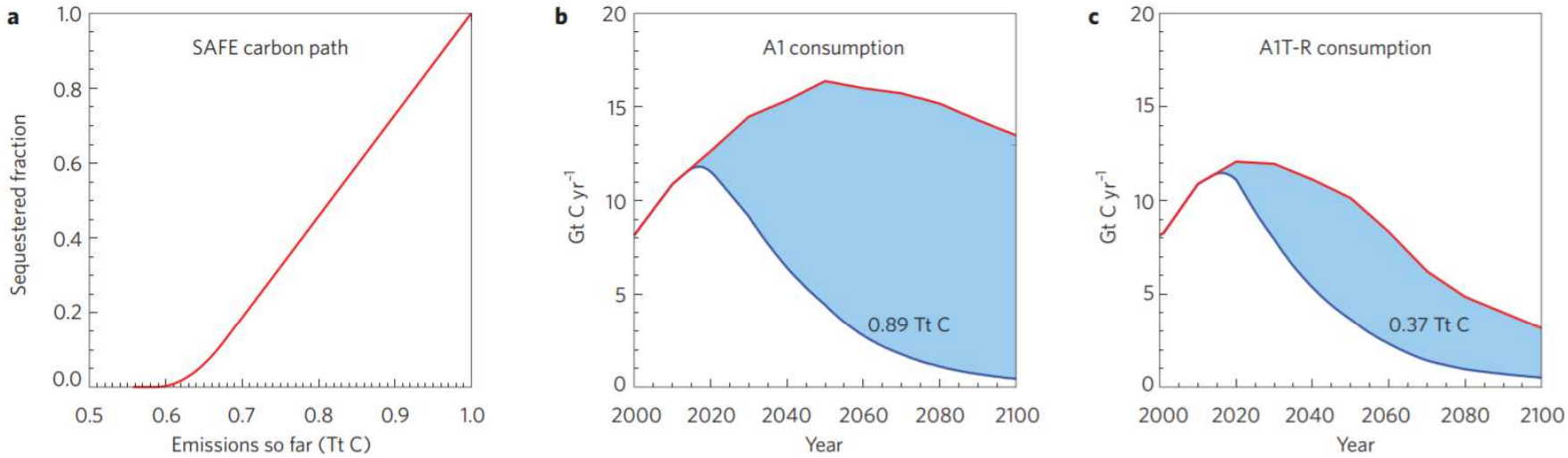


Figure 1 | SAFE carbon futures. **a**, Under a policy that avoids releasing, for example, more than one trillion tonnes of carbon in total, the sequestered adequate fraction of extracted (SAFE) carbon needs to approach 100% as the cumulative carbon emissions approach this total. **b**,**c**, This gives similar atmospheric emissions (blue lines) under very different scenarios for future fossil fuel consumption (red lines), at the price of very different levels of sequestration (blue regions). IPCC scenario A1 (**b**) assumes continued dominance of fossil fuels[15], whereas IPCC scenario A1T-R (**c**) assumes even higher rates of growth in renewable and nuclear energy than IPCC scenario A1T.

Nature Geoscience 2, 813–814 (2009)

Effective options to keep fossil carbon in the ground?

Renewables/Nuclear

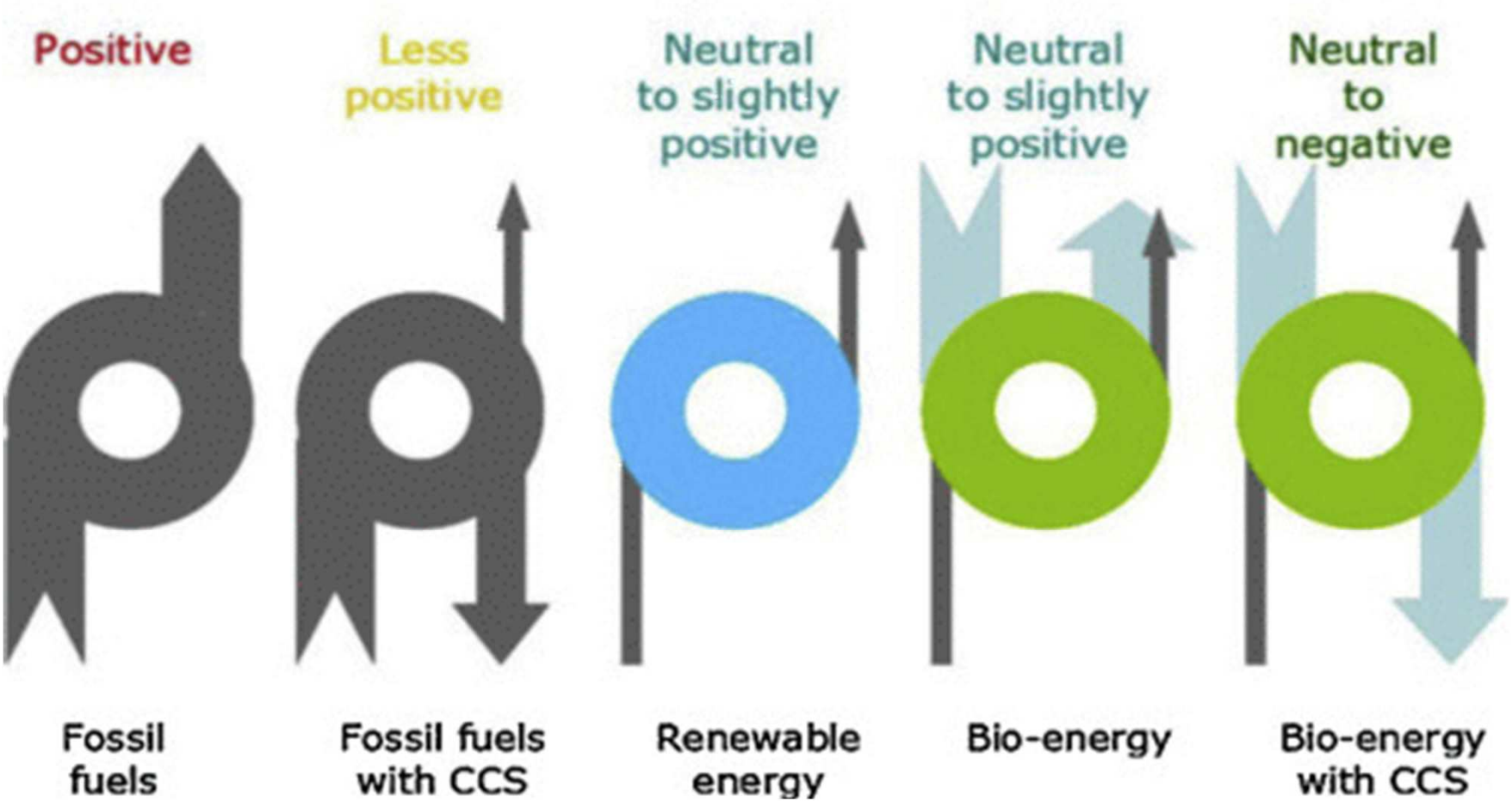
Low carbon energy
+ Fossil C in the ground as fossil fuel

How long will unused fossil fuel stay in the ground?
Can achieve <1% use per century over millenia?

Effective options to keep fossil carbon in the ground?

Renewables/Nuclear	CCS
Low carbon energy	Low carbon energy
+ Fossil C in the ground as fossil fuel	+ Fossil C in the ground as CO_2
How long will unused fossil fuel stay in the ground? Can achieve <1% use per century over millenia?	How long will geologically-stored CO_2 stay in the ground? Want <1% leakage per century over millenia.

Tackling ‘hard to reach’ sectors



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  - Cumulative CO_2 emissions matter
  - Keeping fossil carbon in the ground
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Outline

- Why consider CCS?
- Technology 101
  - CO_2 capture
  - CO_2 storage
  - CO_2 transport

‘Conventional’ CCS overview

1. Capture carbon dioxide (CO_2) arising from using a fuel that contains carbon to make:
    a) Electricity (extra ~0.5-2p/kWh for capture?)
    b) Hydrogen (minimal extra cost)
    c) Unconventional oil/coal to liquids (reduces CO_2 only)
    - Products can be exported or used for an industrial process
    - Wide range of methods, some commercially available
2. Compress CO_2 to ~100 atmospheres (dense phase)
    Transport using pipeline or ship
3. Inject CO_2 > 1 km underground into secure storage
    a) Oil or gas reservoir - proven geological trap for light fluids
    b) Geological trap containing only water (saline formation)
    c) Store for >10,000 years

Class 1 – Class 2 – Class 3 CCS projects

Class 1 = carbon positive CCS
Class 2 = (near) carbon neutral CCS
Class 3 = carbon negative CCS

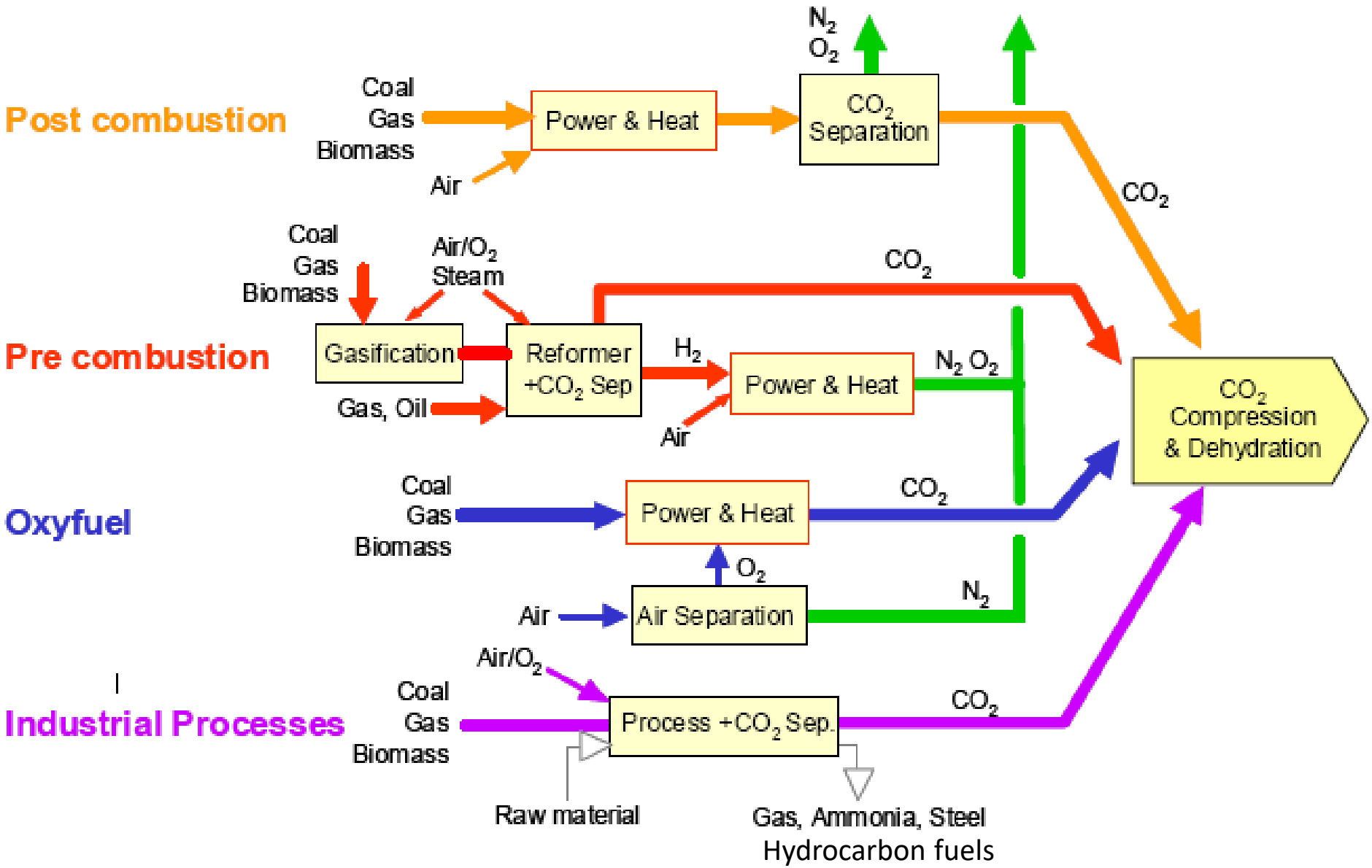
Class 1: Usually producing hydrocarbons, CCS gets the carbon footprint down to conventional hydrocarbon levels
e.g. LNG, coal-to-liquids, oil sands

Class 2: Producing carbon free energy vectors: electricity, hydrogen or heat

Class 3B: Biomass plus CCS (takes CO_2 from the air)
Class 3A: Technology to process air directly to capture CO_2

Enhanced oil recovery (EOR) and replacing natural gas reinjected in oil fields are grey areas.

Types of Carbon Capture Technology

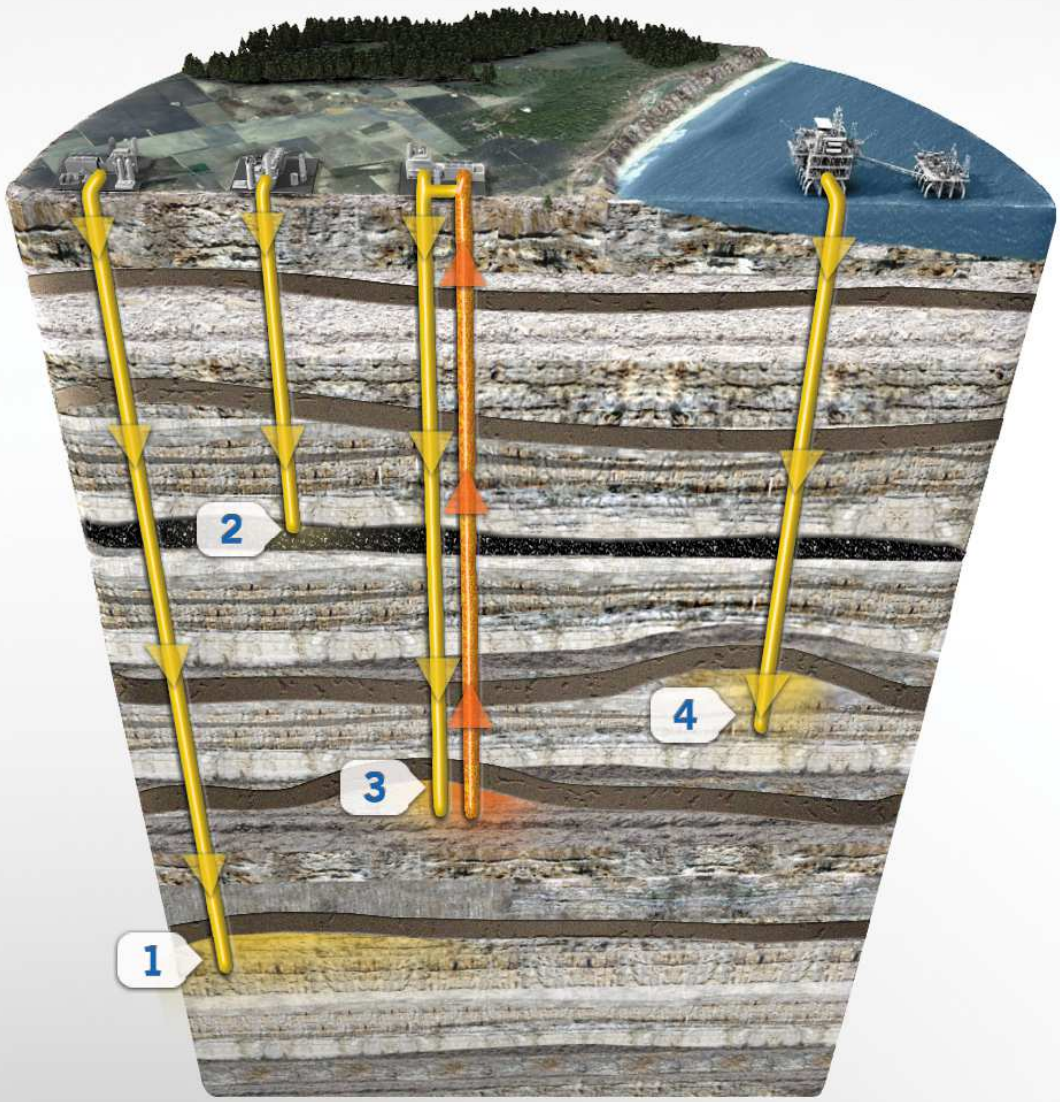


Source: IPCC Special Report on CCS, www.ipcc.ch

STORAGE OVERVIEW

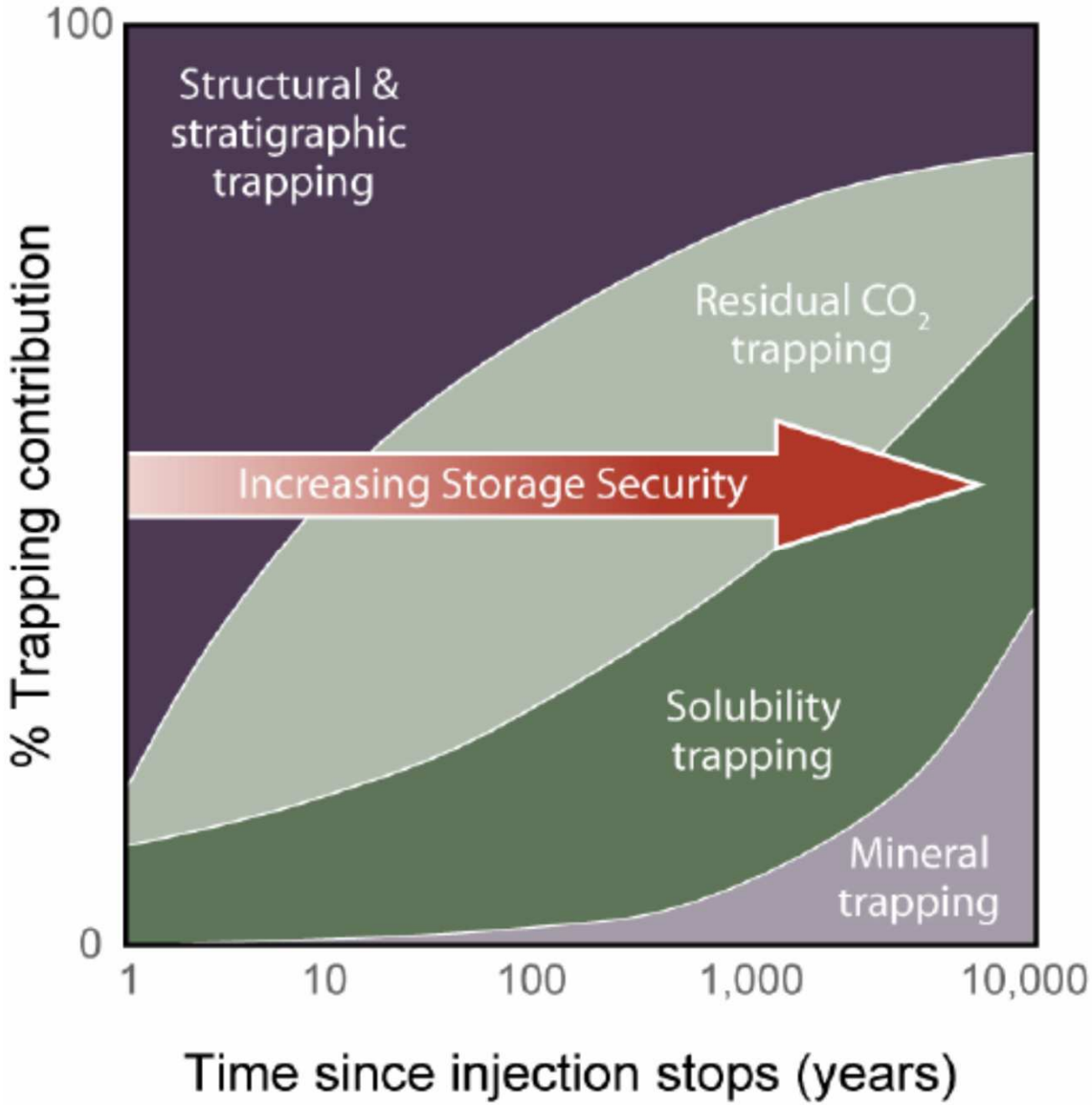
SITE OPTIONS

1. Saline formations
2. Injection into deep unmineable coal seams or ECBM
3. Use of CO_2 in enhanced oil recovery
4. Depleted oil and gas reservoirs



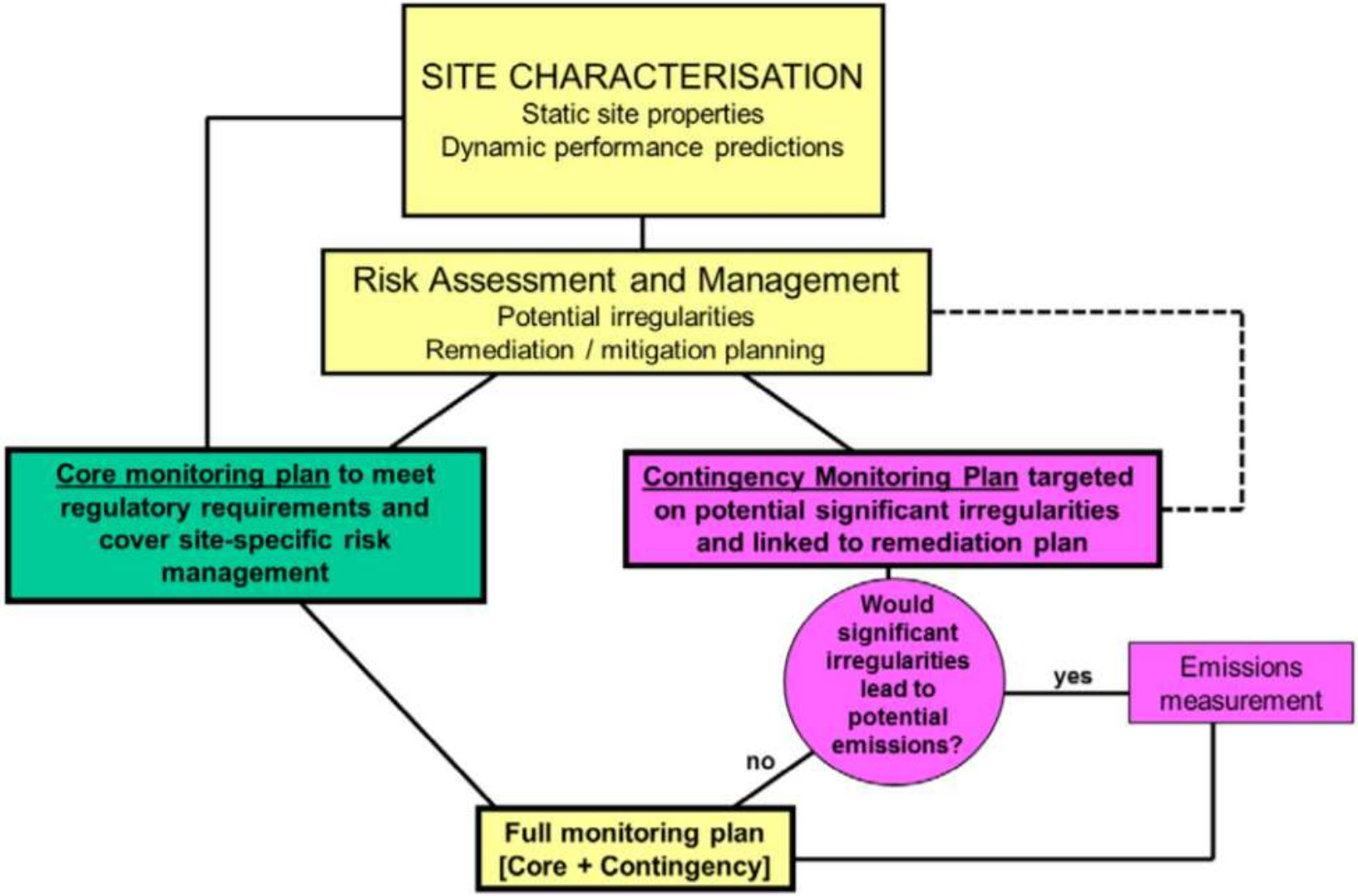
Provided by the Global CCS Institute

CO_2 storage security



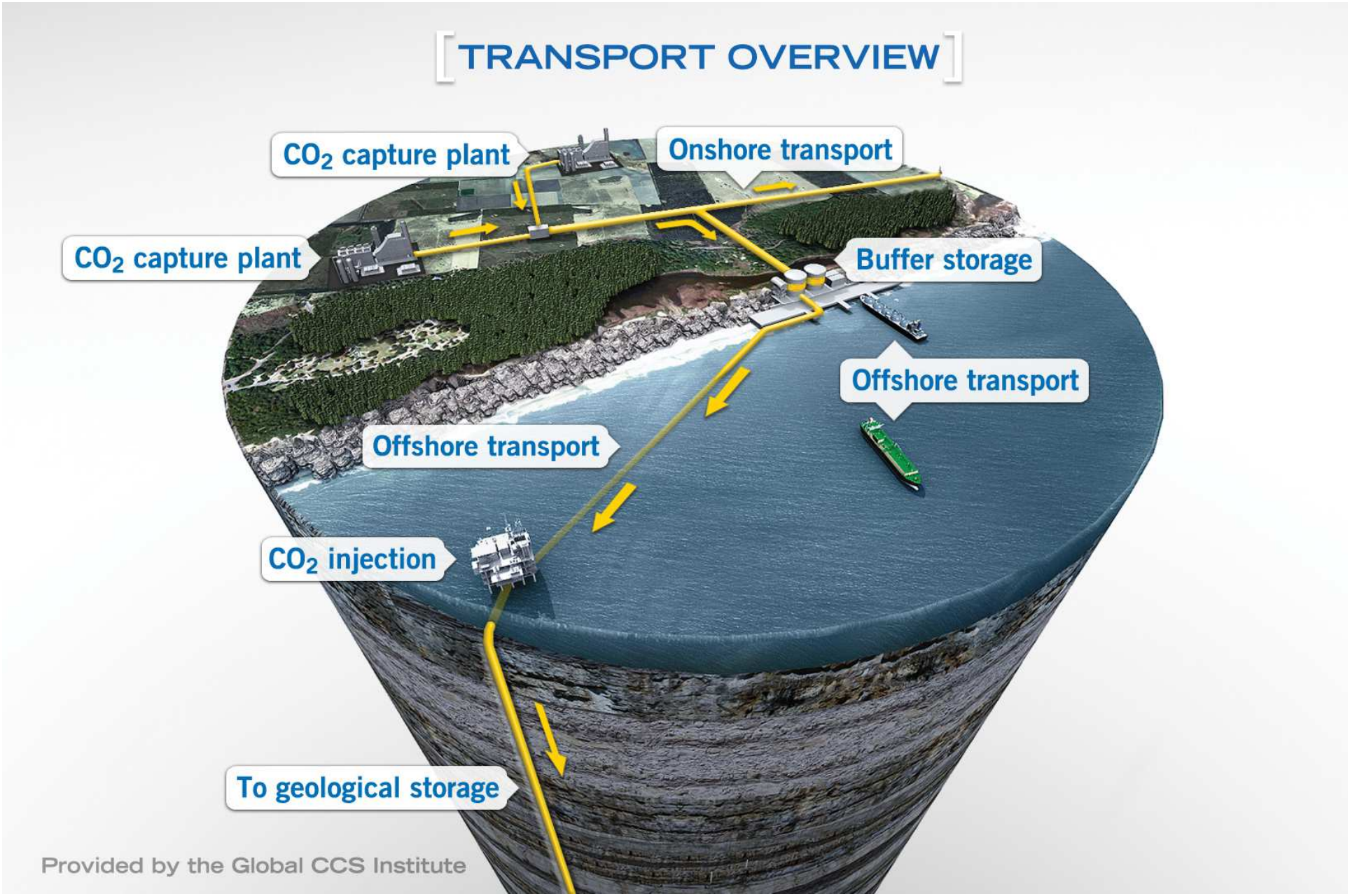
From IPCC (2005) Special Report on Carbon dioxide Capture and Storage, www.ipcc.ch

Major elements of CO_2 storage monitoring



https://ieaghg.org/docs/General_Docs/Reports/2015-02.pdf

TRANSPORT OVERVIEW



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Key issues to consider for pipeline planning

- Limited (but growing) experience of offshore CO_2 pipelines
- More experience with onshore pipelines, but often in places with little/no population
- Need to get clarity on how supercritical CO_2 will be regulated and which authorities involved
- Can existing infrastructure be adapted to a new use?

Outline

- Why consider CCS?
- Technology 101

Further detail at

Climate Change: Carbon Capture and Storage MOOC

https://www.edx.org/course/climate-change-carbon-capture-and-storage