



Edinburgh: 1770 CO₂ discovery

Creating Net Negative carbon storage

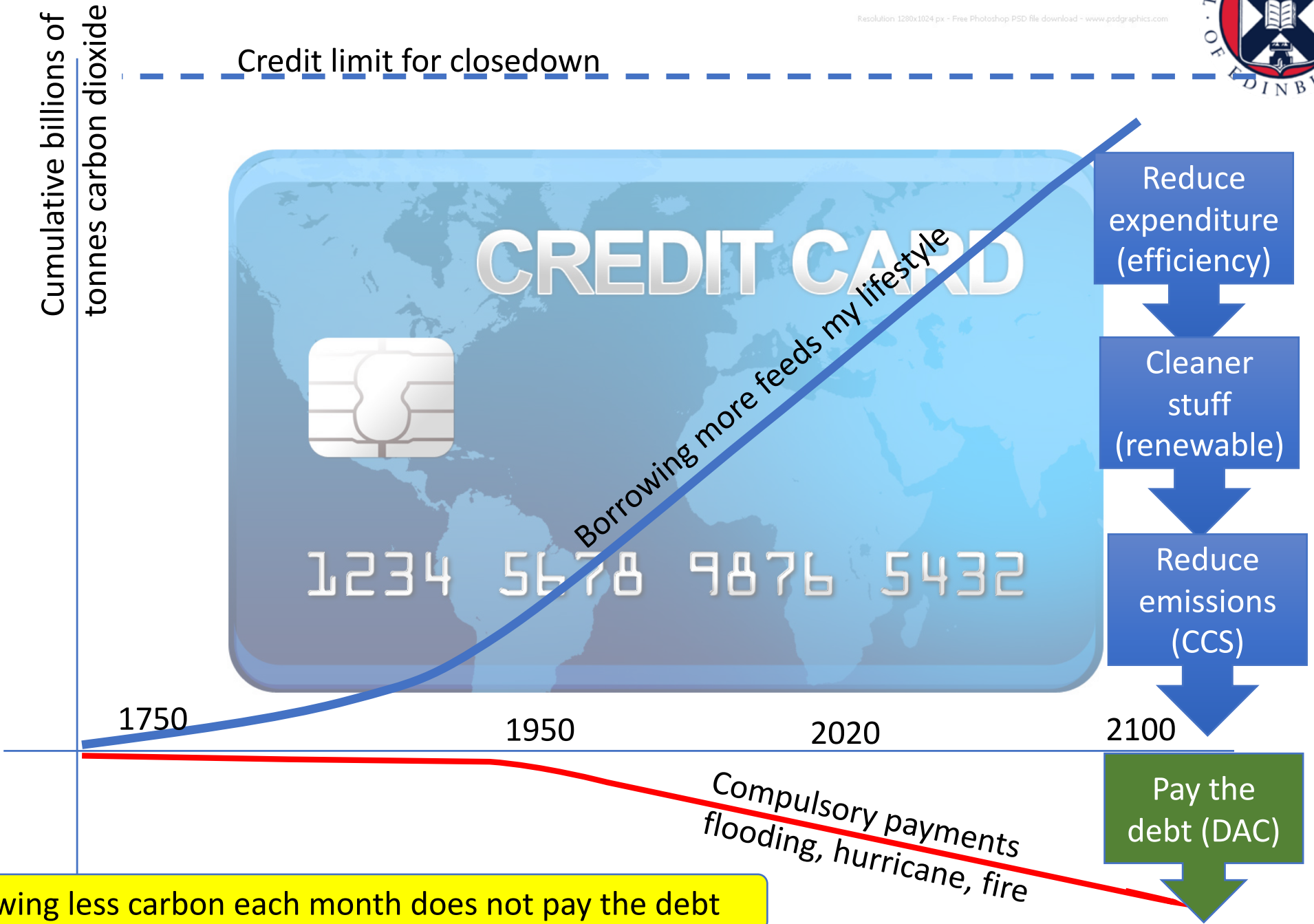
How much and how ready?

Professor Stuart Haszeldine
GeoSciences, University of Edinburgh

Carbon on credit

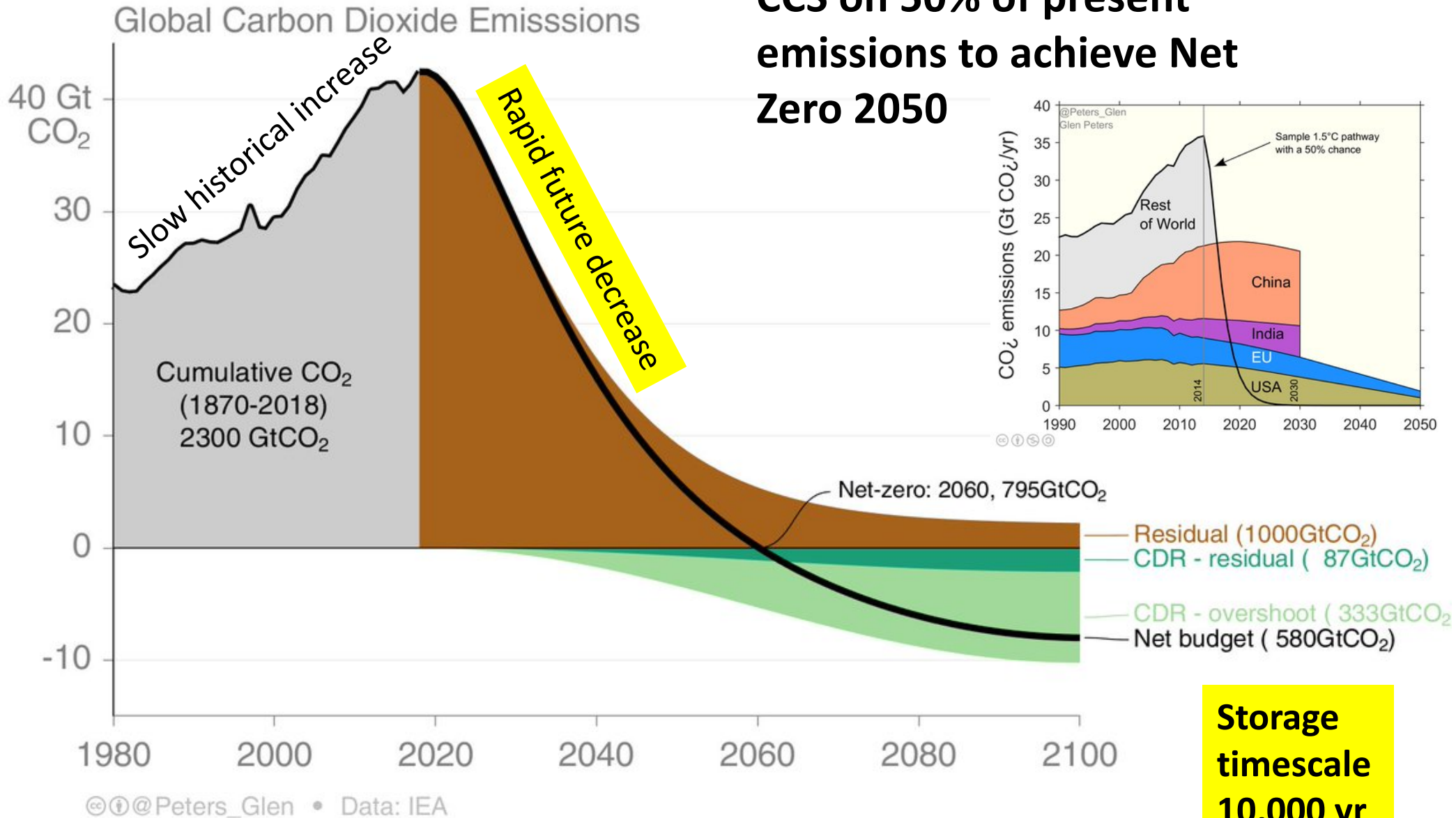


Resolution 1280x1024 px - Free Photoshop PSD file download - www.psdgraphics.com



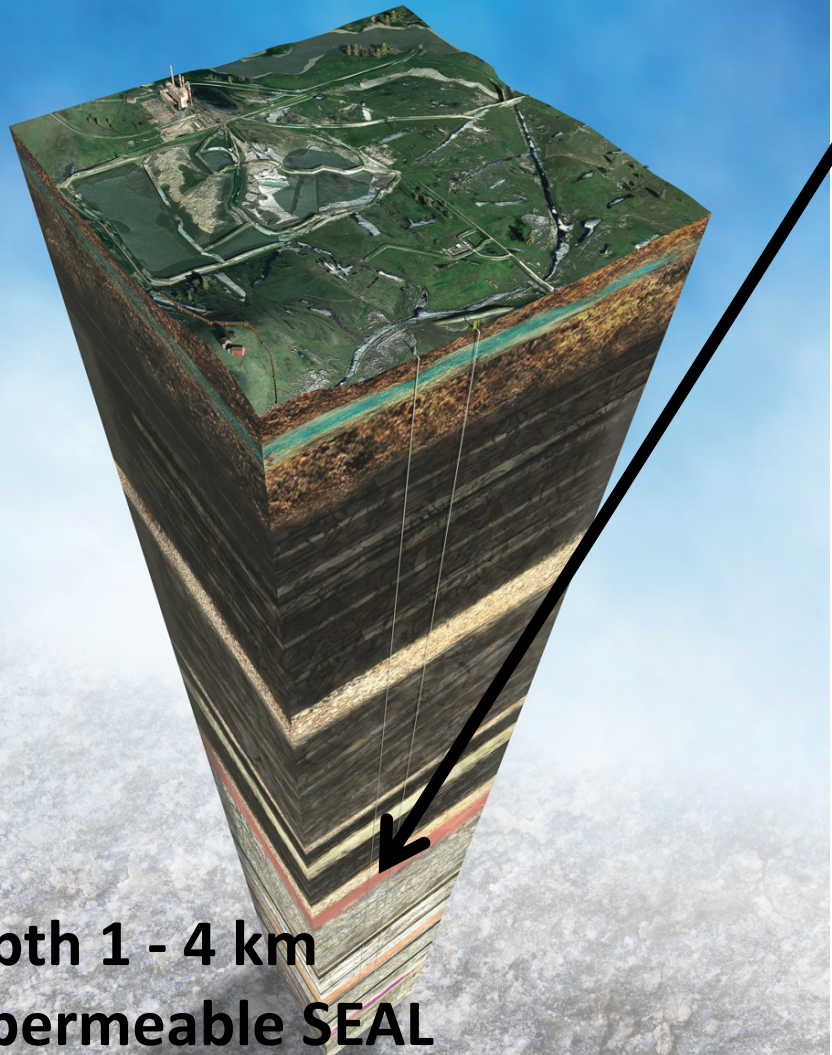
Pathways to Net Zero

International Energy Agency (2020) calculates CCS on 50% of present emissions to achieve Net Zero 2050

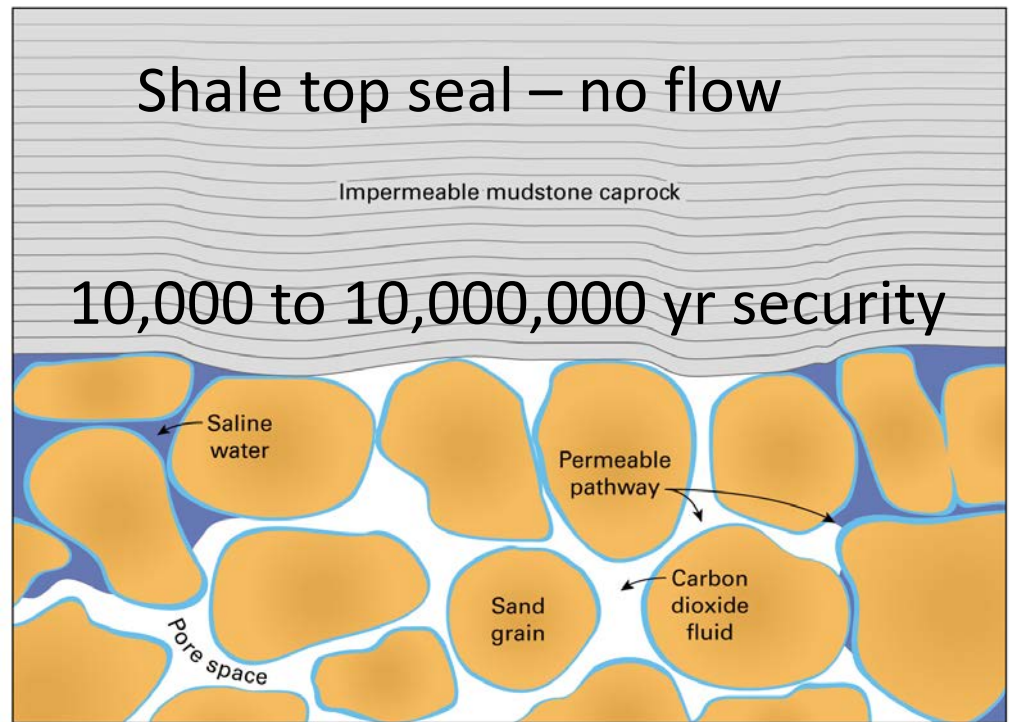


Storage timescale 10,000 yr

CO2 storage is a long way down



Depth 1 - 4 km
Impermeable SEAL
Overlies
Porous RESERVOIR



Boundary Dam coal CCS

CCS \$140/ton

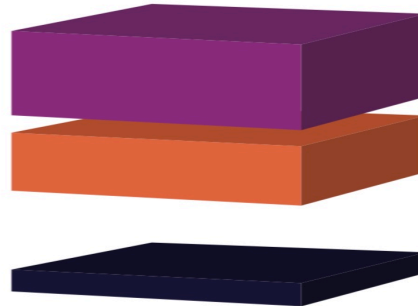


BD 3



SHAND
Shand coal power plant (1992),
Retrofit 300 MW, 2Mt CO₂/yr

\$45 /tonne CO₂



<https://ccsknowledge.com/news/cost-of-capturing-co2-drops-67-for-next-carbon-capture-plant>

Valero refinery H₂

Coal: Amine post-combustion
Gases: Pressure swing adsorption



Air Products 2 x units vacuum swing solid adsorption, 90% capture, 97% purity.

1 Mt CO₂/yr 159km pipe to Hastings field
EOR 1.6 – 3 Mbbbl/yr.

28 MWe steam and operations. Upscale potential 56 Mt CO₂/yr in USA

\$60 /tonne CO₂ ?

Nature Based Forest



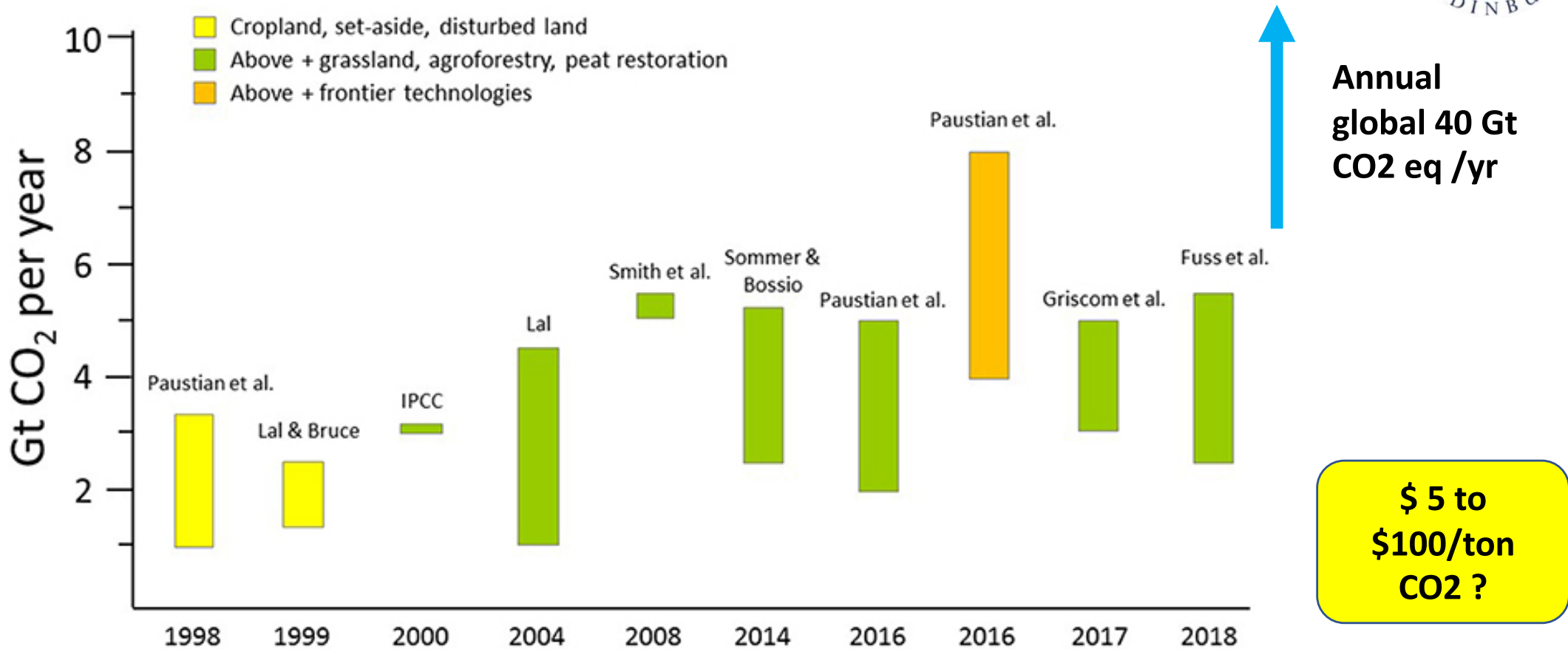
**\$ 100 or
\$50/ton CO2 ?**

**Each European
needs 3 football
pitches of trees
during their
lifetime, continually.
= 2 x India land area**

Permanence?? Fire ??



Size scale - materiality, global soil

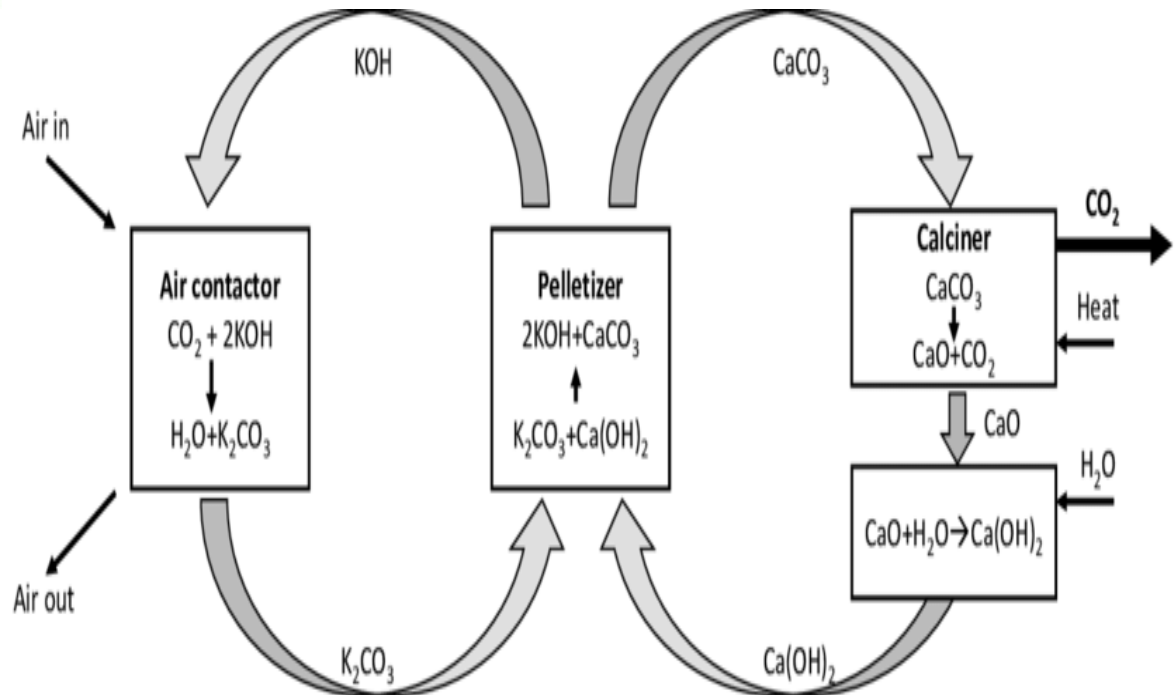
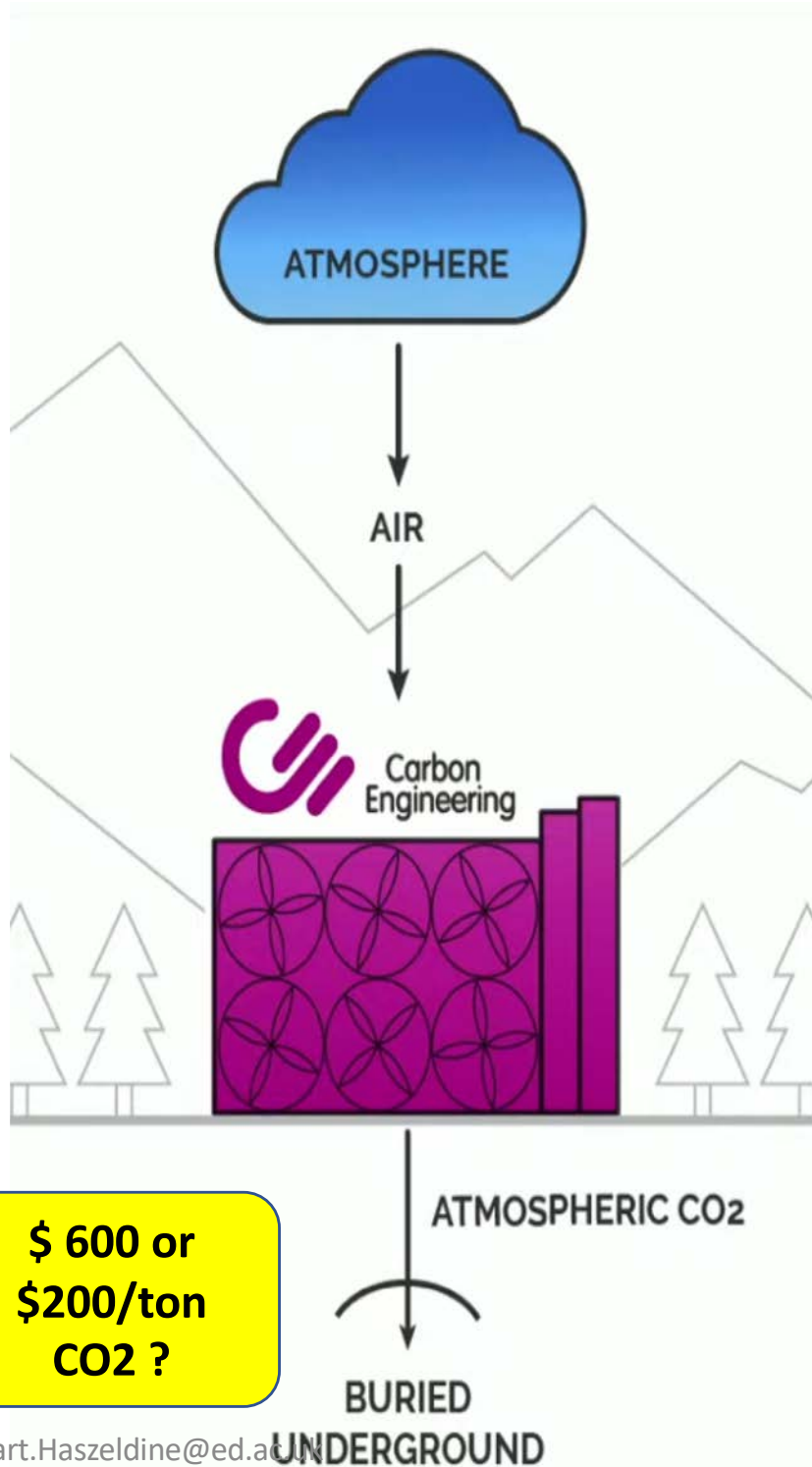


Global soil stock 2020 1,500 Gt C at 1 metre; 2,400 Gt C (8,640 Gt CO₂ eq) to 2 metres
 Most minerals soils have lost 50% of organic components

Changed management to restore carbon to soil : rotation, tillage , grazing, biochar

Time to gradual introduction 10-40yr, How to monitor and verify ?

DAC: Carbon Engineering



Utilisation: Carbon8 aggregate CONCRETE



Demolition
Concrete
Iron slag
Sand
Glass aggregate
Fly Ash

**\$ 50 or
\$20/ton CO2 ?**

Spinout Univ Greenwich 2006
Employs 90 people, 3 UK plants
£ 15 M /year turnover
Makes 300,000 tonne/year aggregate
LCA - carbon negative

Waste based Accelerated CO2 Utilisation



HOW

to get paid ?

**Regulation
& Verify**



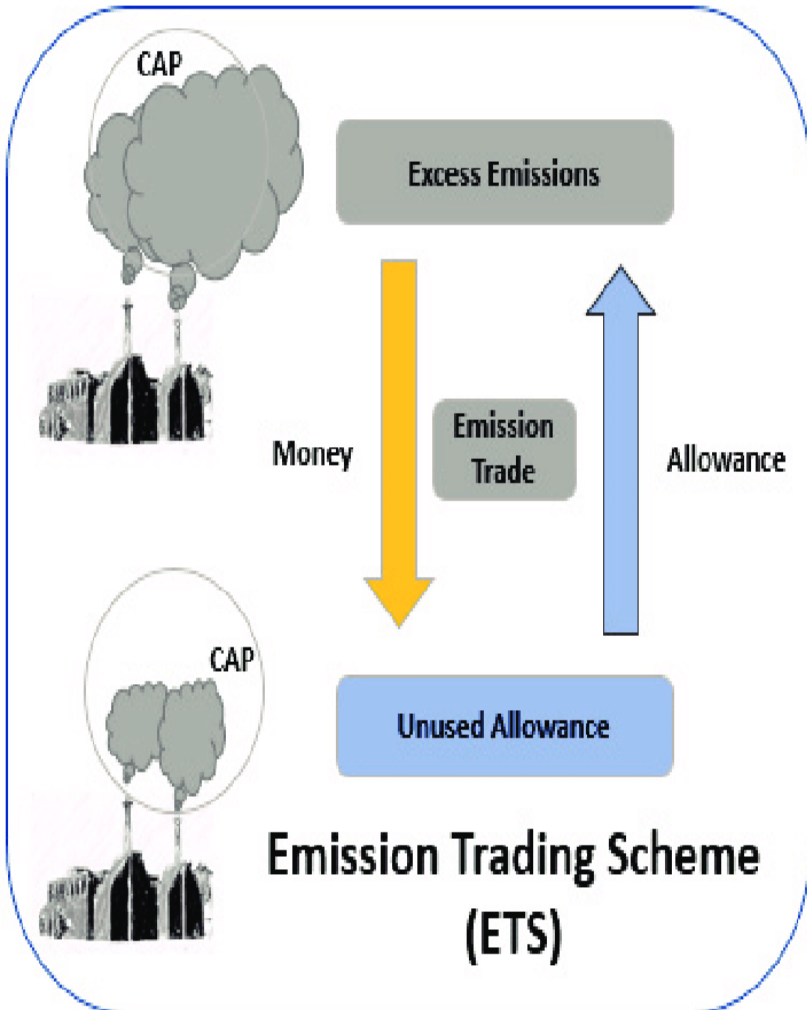
Cost



**Market &
Revenue
X**

**Price or
mandate ?**

Pricing of emissions : polluter pays



The Economist

Price (much) too low; Price unstable, un-bankable

**Treating the symptoms (emissions)
Or tackling the causes (vaccinations)
High carbon prices are NOT politically reliable**

Focusing on emissions is incomplete

BUT needs a discussion about BALANCE of accounting

Extraction = Storage

ALL reliable technologies needed, rapidly

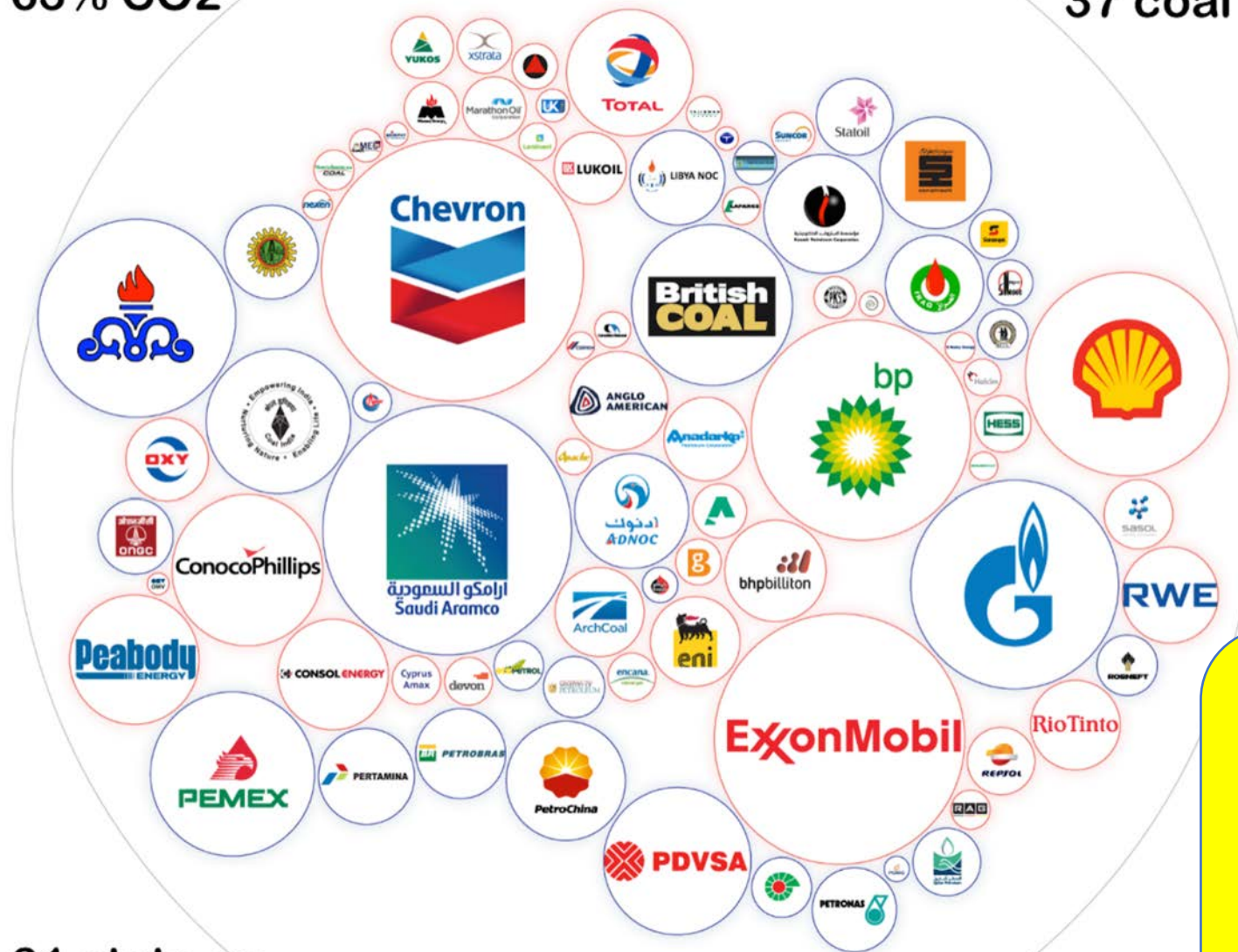
Fossil fuel use can continue, but balanced

Focusing on storage is correct

90 companies
1751 - 2010
63% CO2

56 oil and gas
7 cement
37 coal

Target 9 billion consumers DEMAND, or 90 corporates SUPPLY ?

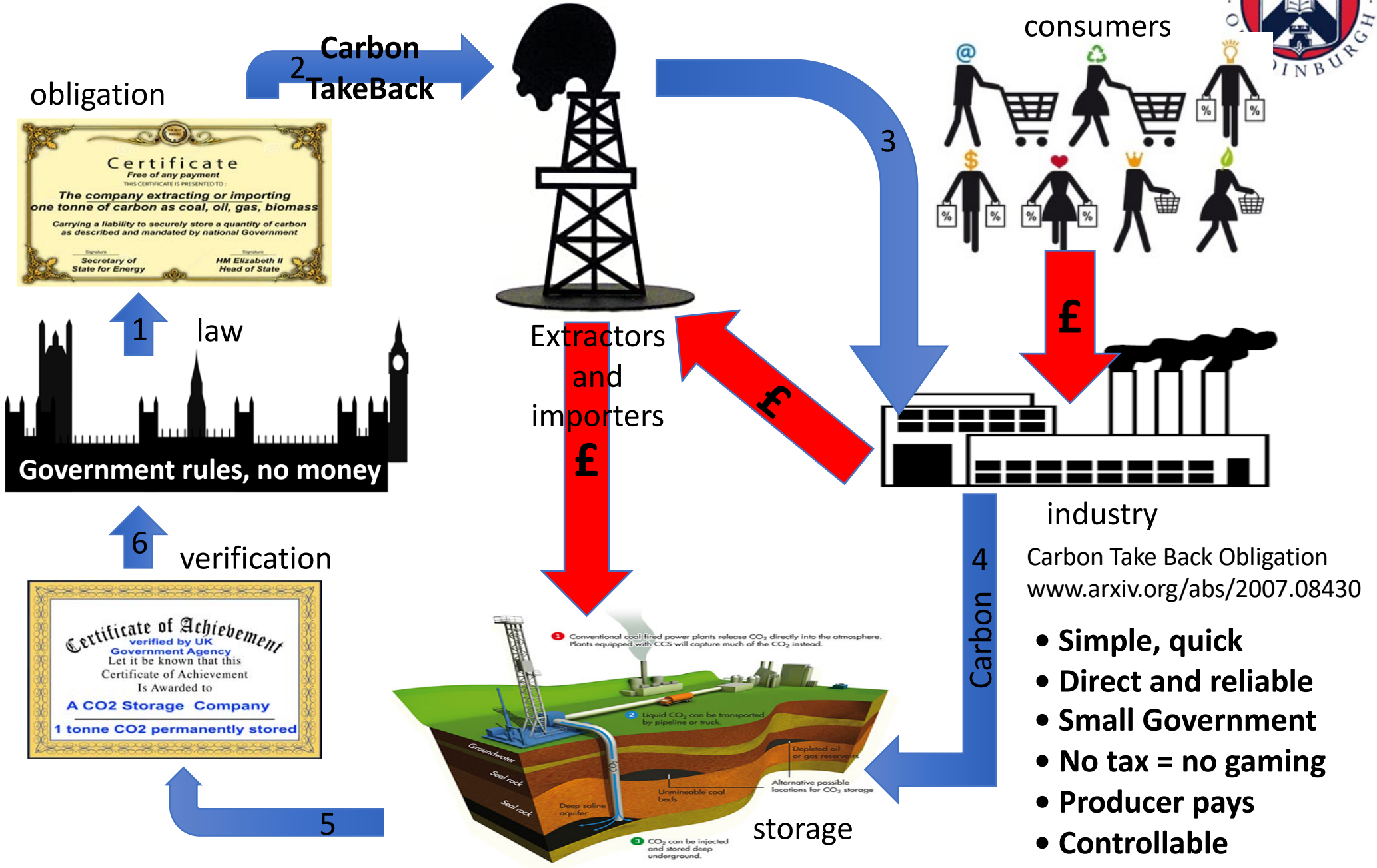


31 state co.
50 public co.
9 government

www.carbonmajors.org

Continued fossil fuel production depends on about 90 organisations and nations

Carbon TakeBack Obligation, cancelled by Storage



consumers

Extractors and importers

industry

Carbon Take Back Obligation
www.arxiv.org/abs/2007.08430

- Simple, quick
- Direct and reliable
- Small Government
- No tax = no gaming
- Producer pays
- Controllable

Summary

- **Need** to reduce emissions is vast, and urgent, together with storage
- **Continuing** need beyond 2050
- **CCS** and many GGR are TRL 4 - 6 - accessible cost and verifiable
- **NBS** can be TRL 8 and 9 - but short duration, insecure, hard to verify
- **Emissions** markets are unreliable, **Utilisation** = profit, **Storage** = climate
- **CTBO** - **storage obligation** on producer,
 - **competence** to store with producer
 - **provides certainty**, creates Oil and Gas efficiency and low cost
 - **reliable pathway** to and beyond Net Zero
- **ALL** the solutions are needed, all the time. Business, government and public