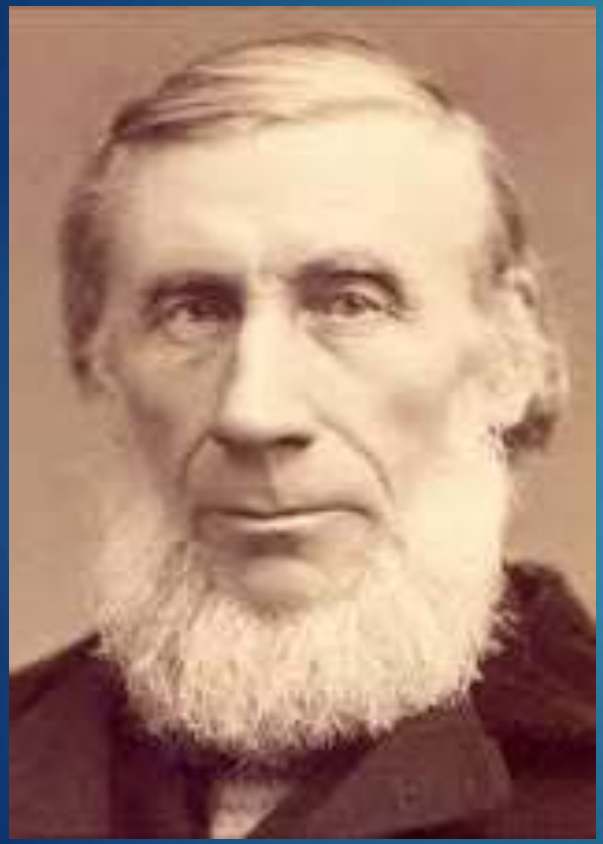
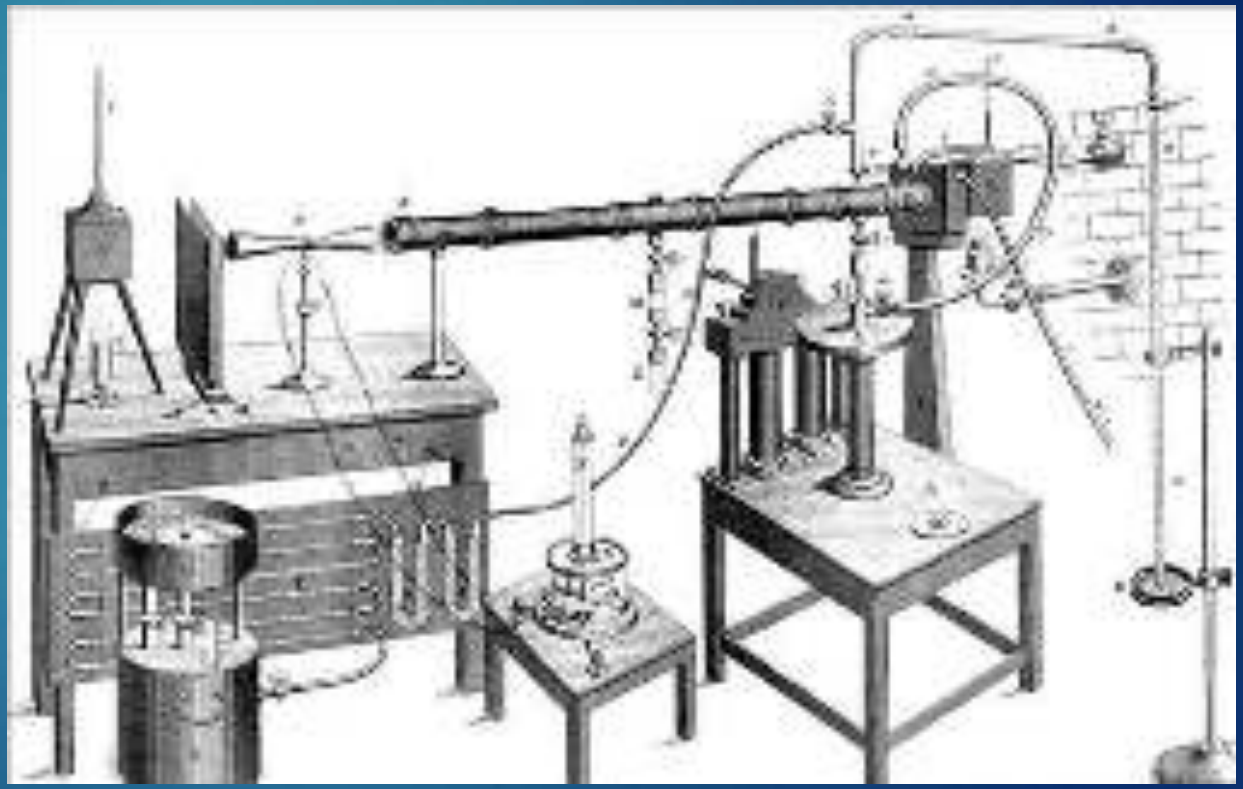
The Governed Planet? Climate Change Targets and Carbon Negative Technologies

LUTHERAN EDUCATION AUSTRALIA

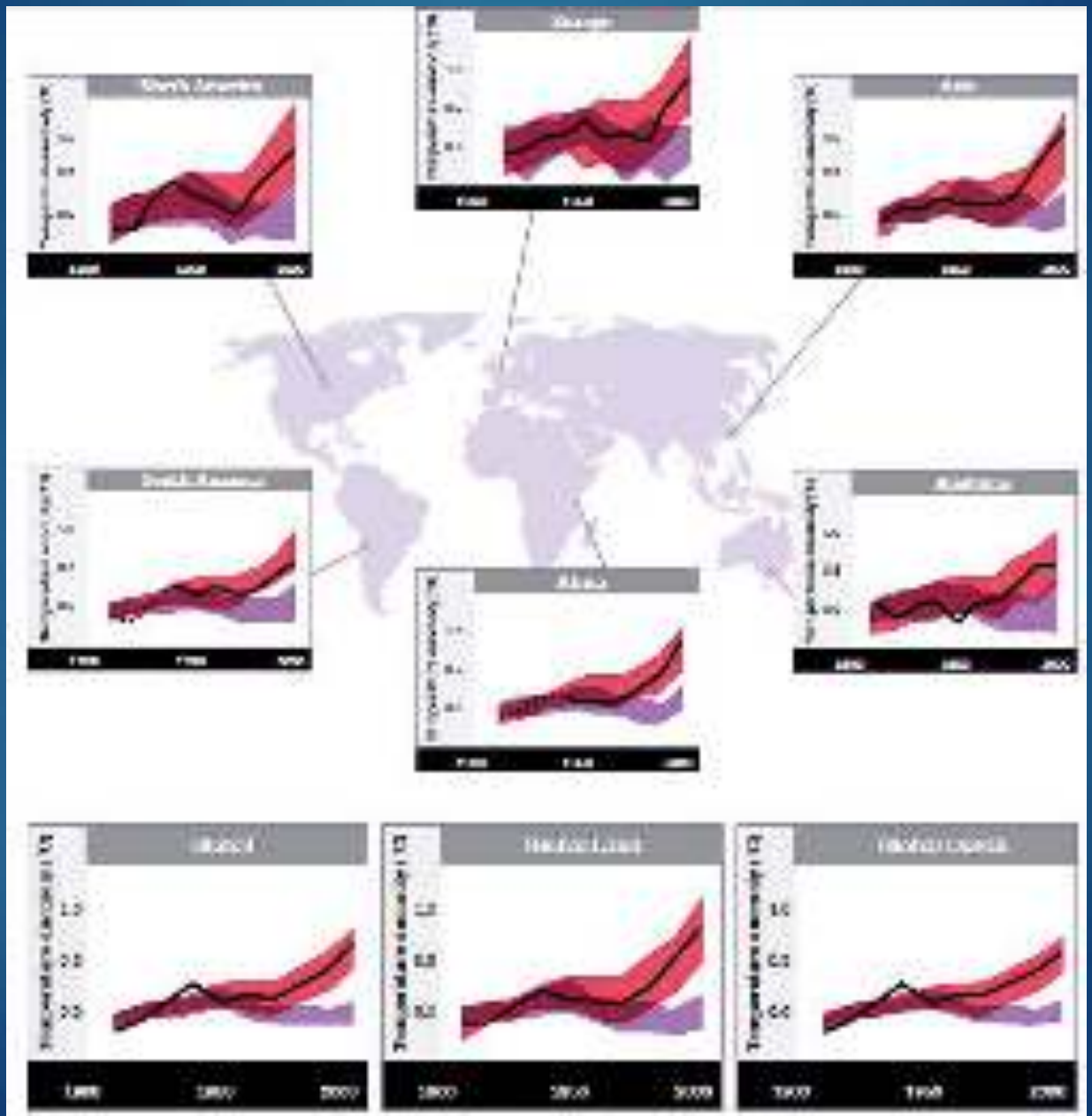
Professor Tim Flannery
Melbourne Sustainable Society Institute
University of Melbourne

John Tyndall, 1859





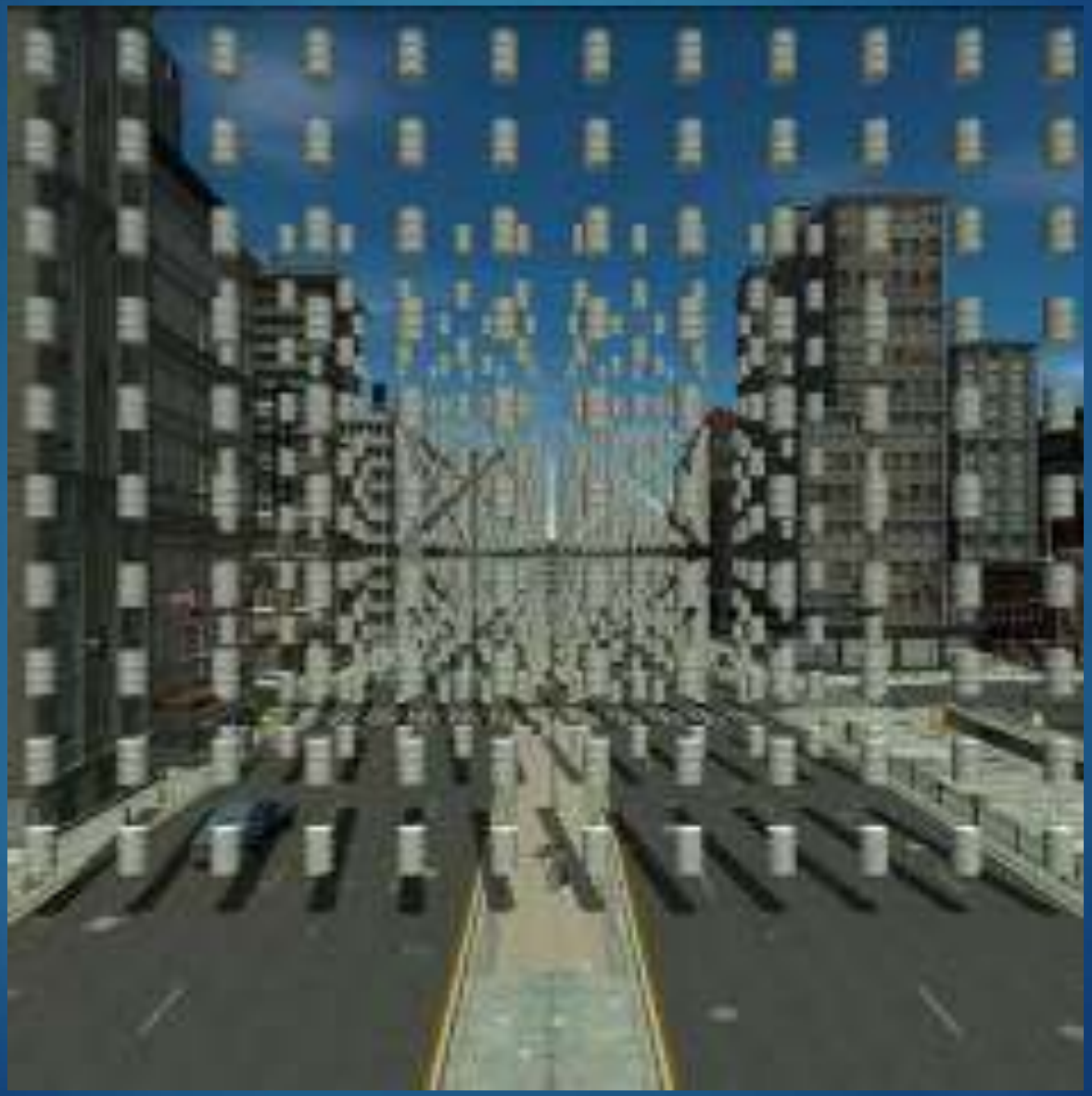
The Human Influence



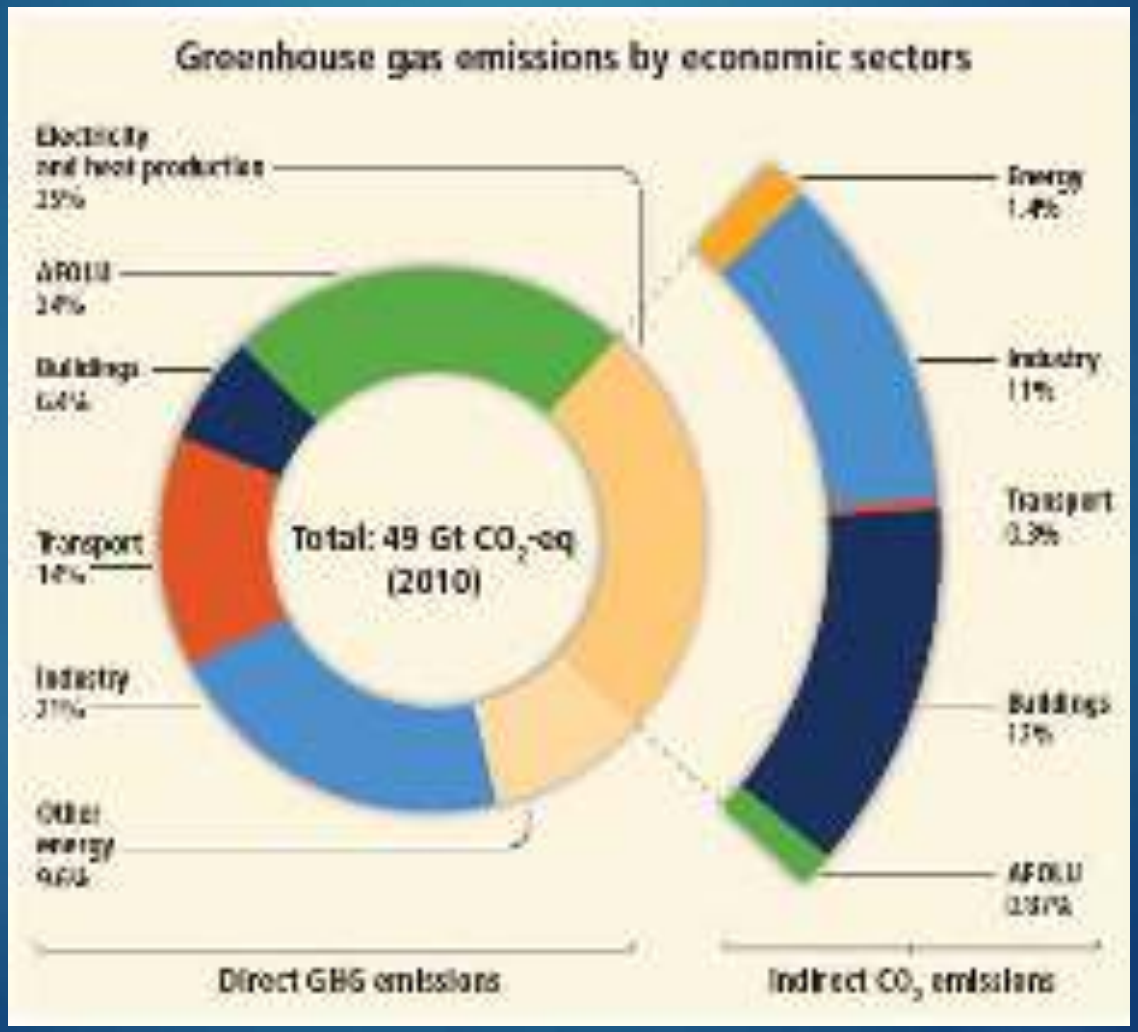
Source: IPCC, 2007

The Anthropocene Equation

Steve Halley: One Second

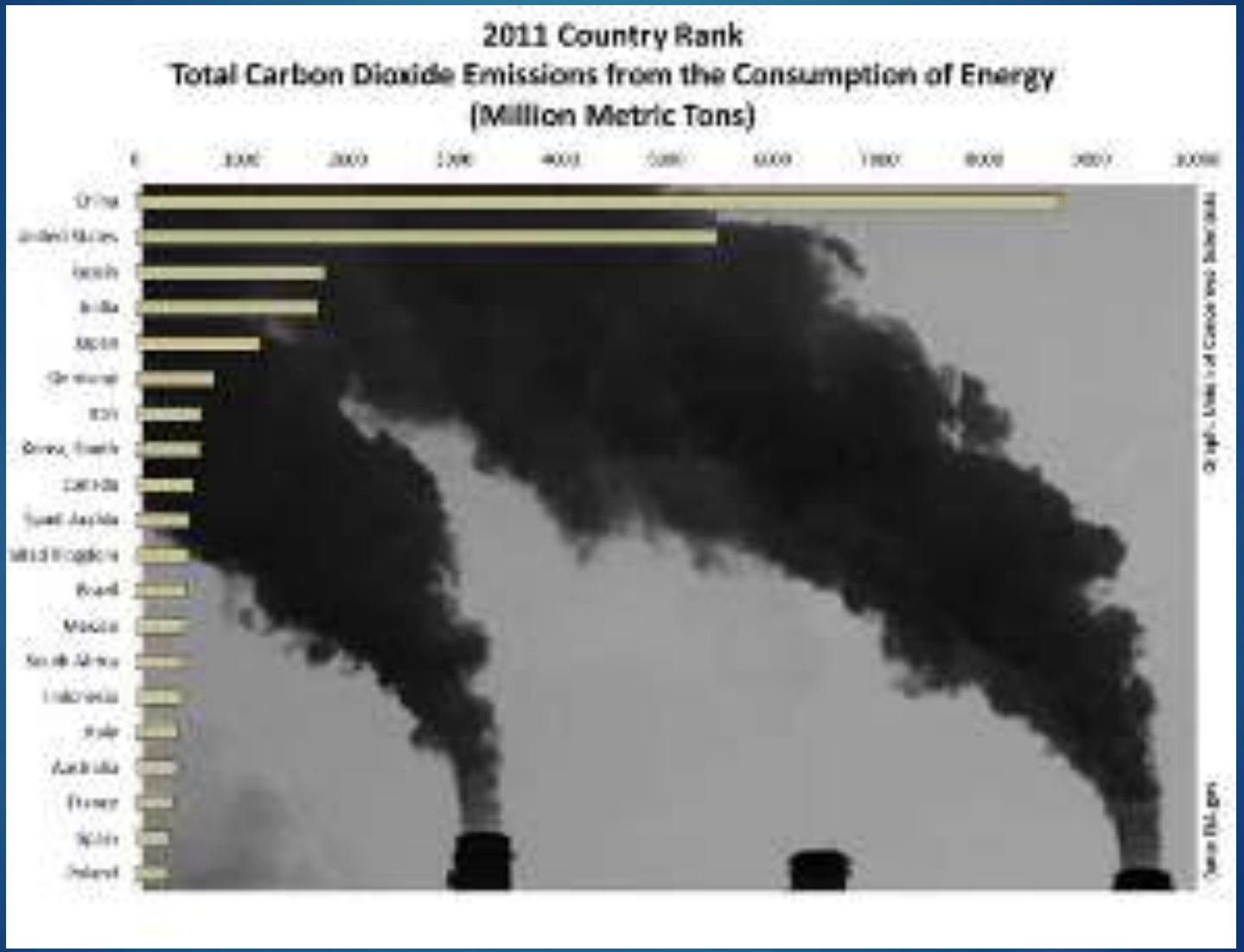


Global Greenhouse Gas Emissions by Sector



*https://www.**ipcc**.ch/pdf/assessment-**report**/ar5/syr/SYR_AR5_FINAL_full.pdf*

Who is Responsible?



Which ecosystems are effected?

- *' Climate change **impacts** have now been documented across **every ecosystem** on Earth'*

Coral reefs: doomed to extinction?

Alpine ecosystems

- In New Guinea, tree-lines rise by 300m per 1C temperature increase.

Are the fish shrinking?

Source: https://www.abdn.ac.uk/news/5731/

YES

- Up to eight **commercial fish** species in the North Sea (haddock, whiting, herring, Norway pout, plaice, sole) have **shrunk** in size….
- This is over a **40 year** period
- Coincides with a **1-2 °C** increase in temperature
- Resulting in a **23%** decrease in yield

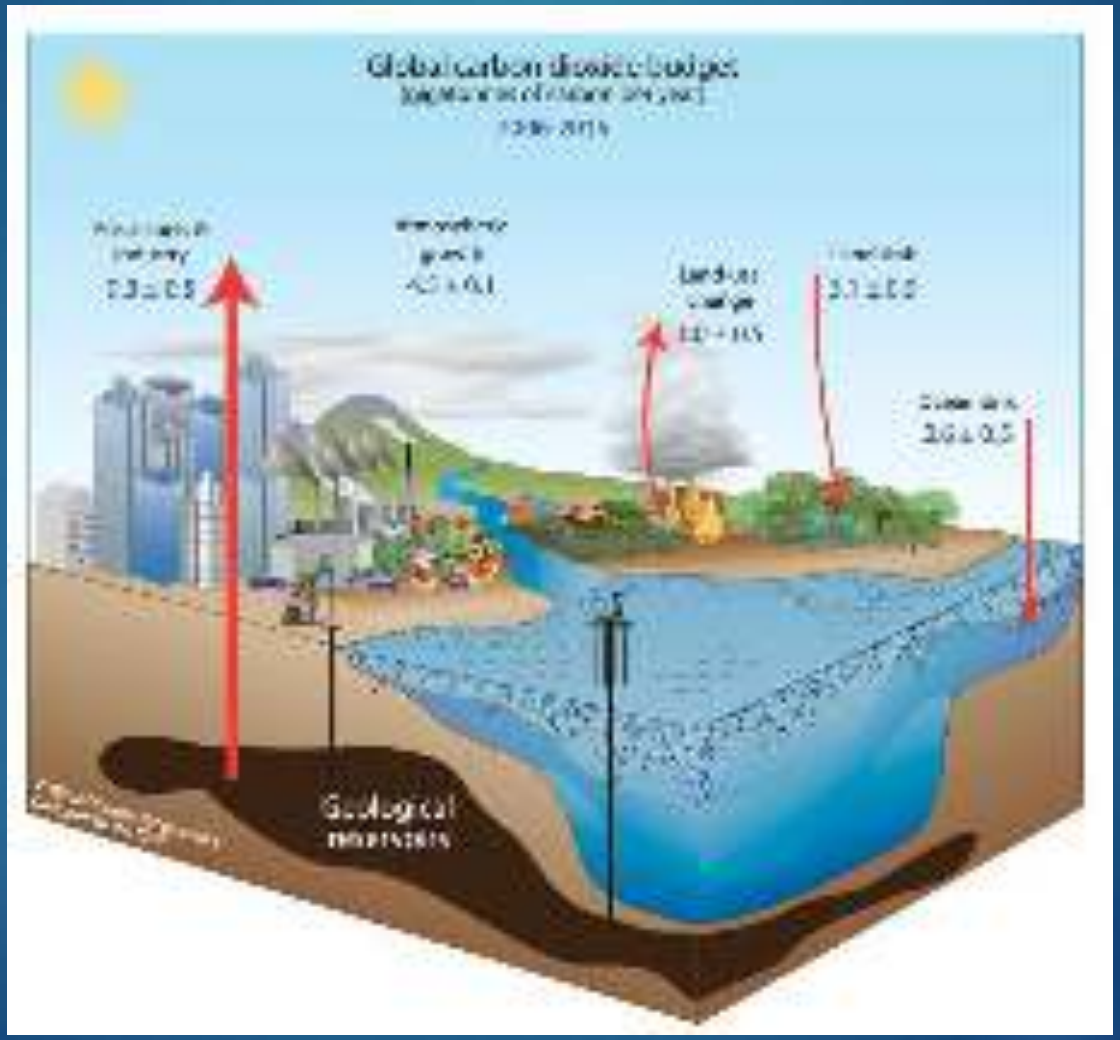
Wine Anyone?

Global food security?

The Paris Agreement

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

The Global Carbon Budget



Source: Climate Council Global Carbon Budget Report

Biosphere Feedbacks

Biosphere climate-carbon cycle feedbacks that could be activated by a ~ 2°C increase in global average temperature.

Biosphere climate-carbon cycle feedback process	Additional carbon emitted by 2100 (GtC)[1]	Corresponding global temperature increase (°C)[2]	References/notes (see SI for details)
Relative weakening of land and ocean C sinks	125 (65-185)	0.25 (0.13-0.37)	Rescaling of results from RCP4.5 "compatible emissions" scenario (Ciais et al. 2013).
Permafrost thawing, CO_2 and CH_4 release	45 (20-80)	0.09 (0.04-0.16)	Estimates based on Schaefer et al. (2014), Schneider von Deimling et al. (2015), Koven et al. (2015).
Amazon forest dieback	25 (15-55)	0.05 (0.03-0.11)	Based on extrapolation of observed changes and model projections of dieback (Jones et al. 2009).
Boreal forest dieback	30 (10-40)	0.06 (0.02-0.10)	Based on extrapolation of observed changes and model projections of dieback.
Increased bacterial respiration in the ocean	10	0.02	Rescaling of RCP8.5 results (Segsneider and Bendtsen 2013, Bendtsen et al., 2015)
Total	235 (120-380)	0.47 (0.24-0.76)	

[1]Rounded to the nearest 5 GtC

[2]To convert the climate-carbon cycle feedbacks from amounts of carbon emitted to an equivalent temperature rise, we assume a 2°C temperature rise per 1000 GtC added to the atmosphere.

Source: Rockström et al., 2017, **Biosphere climate-carbon cycle feedbacks and the 2°C Paris guardrail**

CO_2 is Not The Only Greenhouse Gas

- **Methane** and **nitrous oxide** are not included in the carbon budget because their warming impact is offset by particulate pollution

- Both China and India are clamping down on **particulate pollution**

- Carbon Dioxide ~81%, Methane ~11%, Nitrous Oxide ~6% (https://www.epa.gov/ghgemissions/overview-greenhouse-gases)

Out of Carbon Budget

"Our central estimate gives a total loss of **235GtC** equivalent…[This] would consume the entire remaining carbon budget of **225GtC** and generate a slight deficit, **thus requiring negative emissions technologies to respect the 2C Paris guardrail.**"

Biosphere climate-carbon cycle feedbacks and the 2°C Paris guardrail

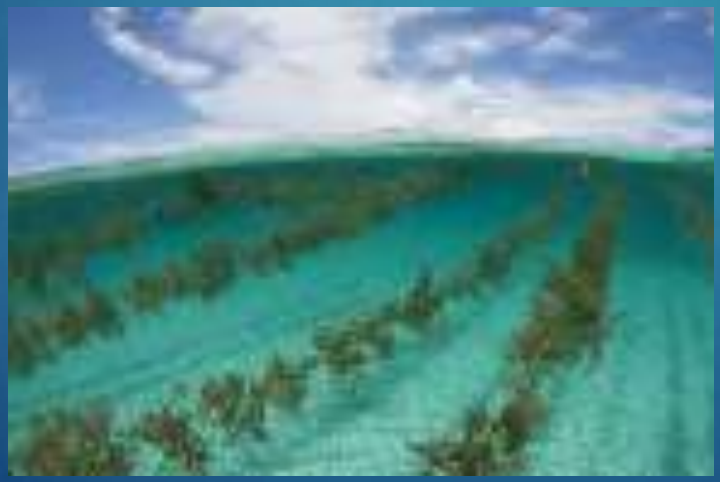
Johan Rockström[1], Will Steffen[1,2], Katherine Richardson[3], Timothy M. Lenton[4]

Submitted Nature

The Virgin Earth Challenge

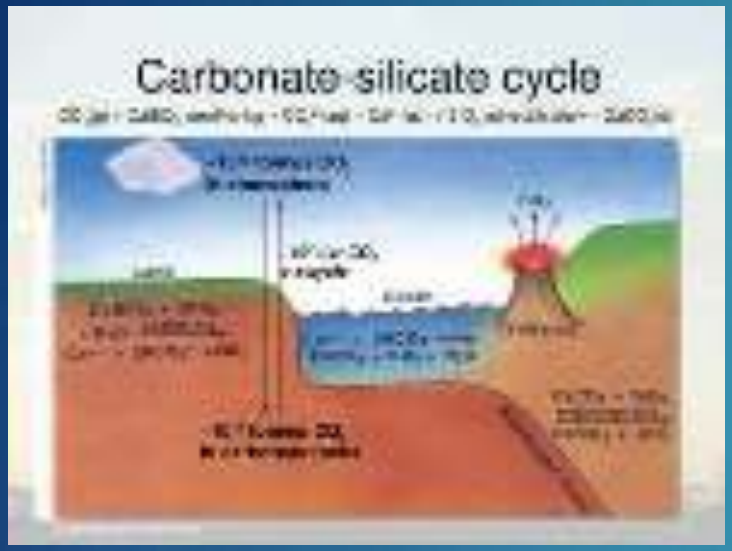
Biological and Chemical Pathways to remove CO_2

Reafforestation



Seaweed Farming

Biological and **Chemical** Pathways to remove CO_2



Silicate Rocks

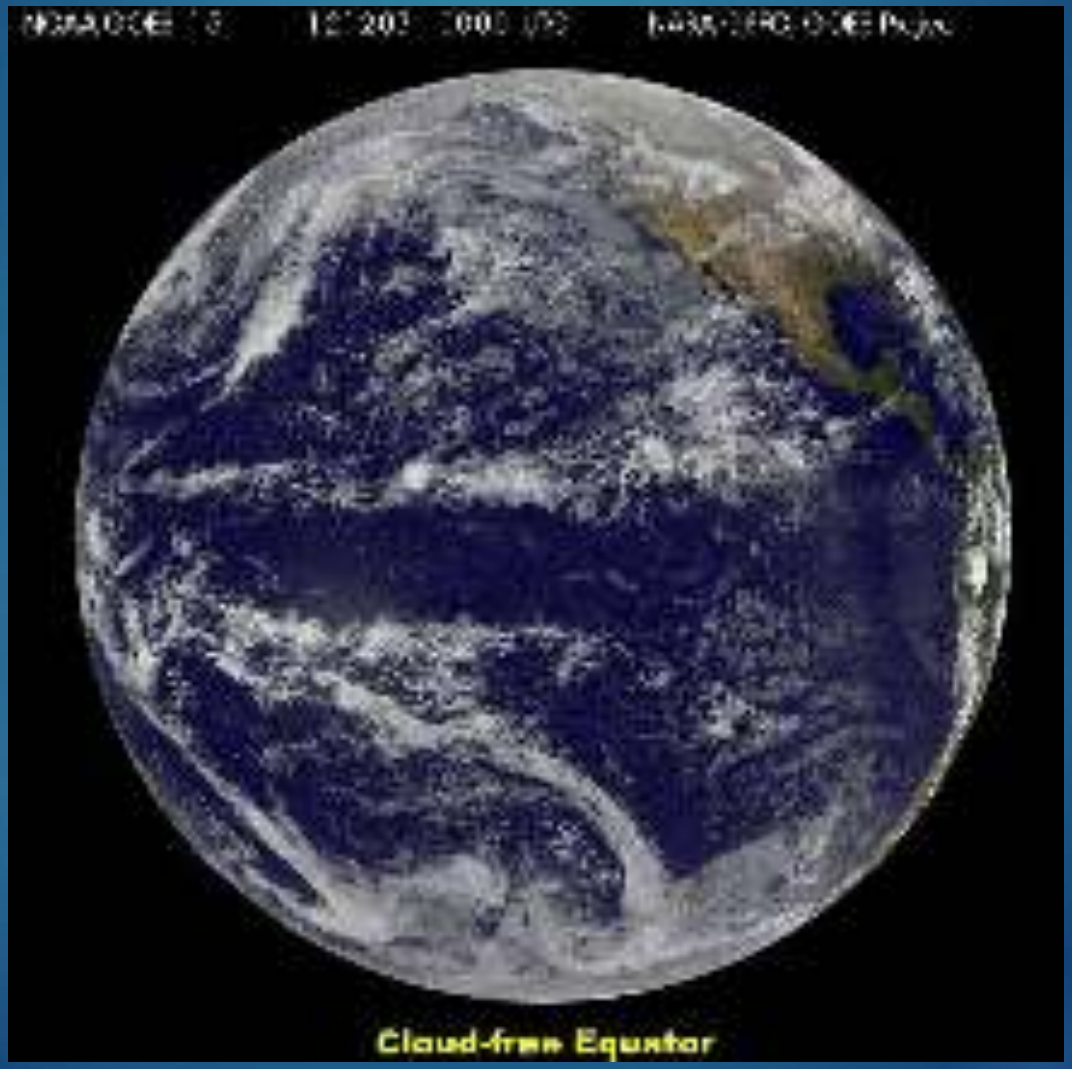
Carbon Negative Concrete

Direct Air Capture to make plastics, carbon fibres

North America

Kelp Farm

Mid Pacific Ocean



Only mid-ocean kelp farming offers storage

- If **9%** of the ocean could be covered in seaweed farms, the farmed seaweed could produce 12 gigatonnes per year of biodigested methane for use as natural gas, while storing 19 gigatonnes of CO_2. A further 34 gigatonnes per year of CO_2 could be captured if the methane is burned to generate electricity.
- This would produce sufficient biomethane to replace all of today's needs in fossil fuel energy, while **removing 53 billion tonnes of CO_2 per year from the atmosphere**...This amount of biomass could also increase sustainable fish production to potentially provide 200 kilograms per year, per person, for 10 billion people. Additional benefits are reduction in ocean acidification and increased ocean primary productivity and biodiversity.
- N'Yeurt, A. *et al.*, (2012). 'Negative Carbon via Ocean Afforestation', *Process Safety and Environmental Protection* 90, 467–74, 2012.

The Deep Sea

Wind Turbines in the Antarctic

Carbon negative concrete

Silicate Rocks

International Journal of Greenhouse Gas Control

Coastal spreading of olivine to control atmospheric CO_2 concentrations: A critical analysis of viability

nature

Rock's power to mop up carbon revisited

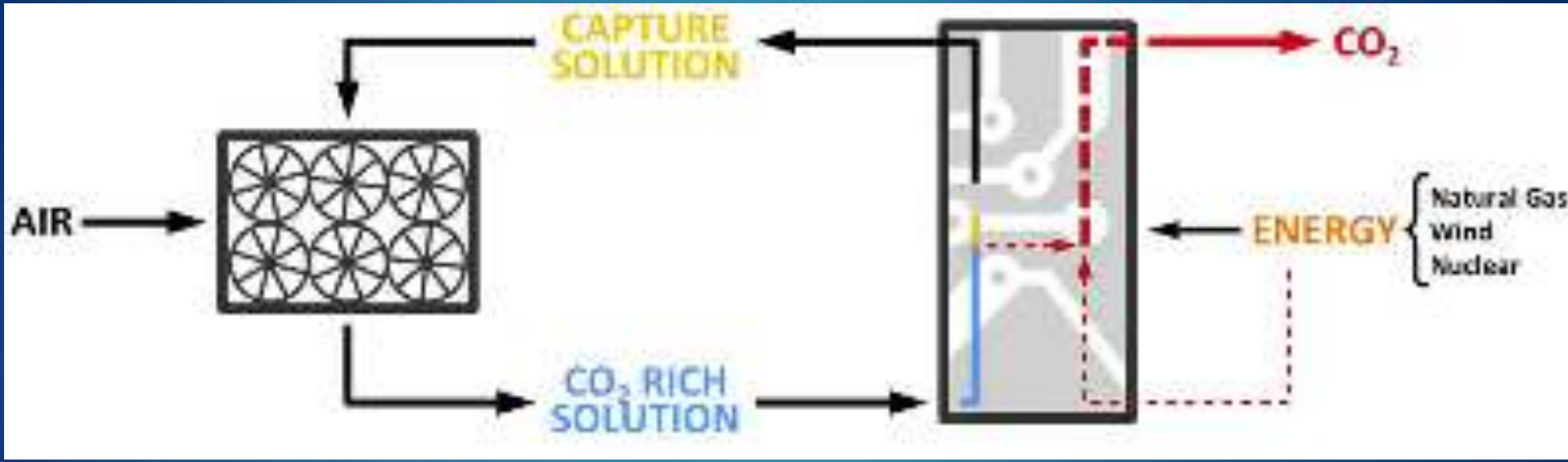
Experts push for more research into olivine weathering.

James Hanson et al. see a solution

Enhanced weathering could lower atmospheric CO_2 by 30–300 ppm by 2100, depending mainly on silicate rock application rate (1 kg or 5 kg m^{-2} yr^{-1}) and composition. At the higher application rate, end-of-century ocean acidification is reversed under RCP4.5 and reduced by about two-thirds under RCP8.5. Additionally, surface ocean aragonite saturation state, a key control on coral calcification rates, is maintained above 3.5 throughout the low latitudes, thereby helping maintain the viability of tropical coral reef ecosystems

Layla et al (2016). Enhanced Weathering strategies for stabilising climate… Nature Climate Change 6:204-6

Direct Air Capture CO_2



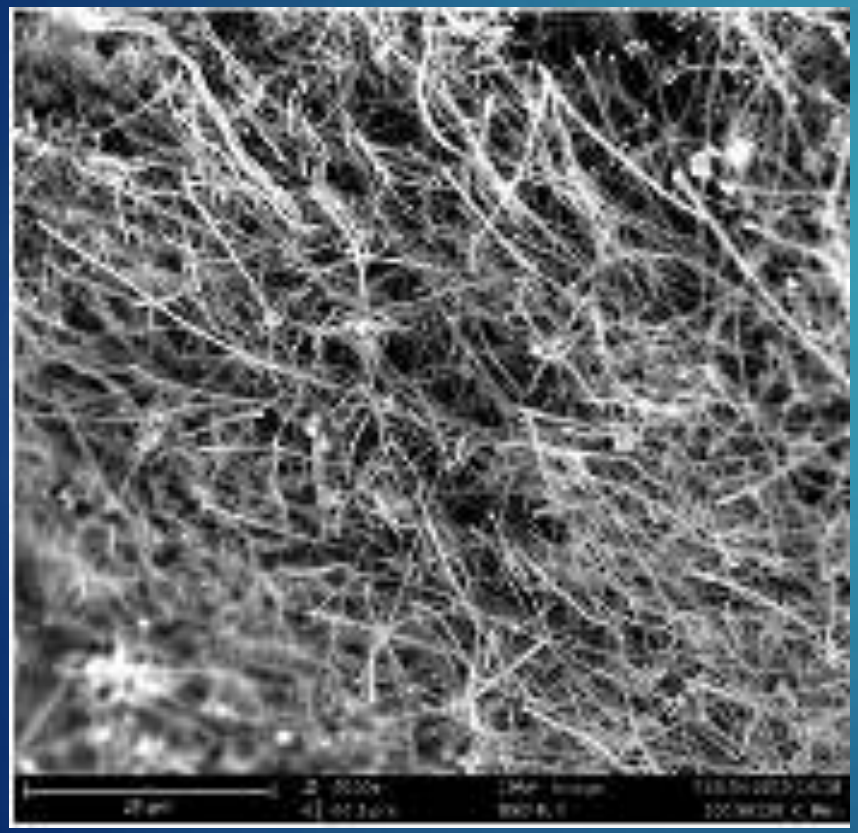
Source: http://carbonengineering.com/air-capture/

Bioplastics (Plastics from CO_2)

Source: http://bioplasticolor.blogspot.com.au/2011/03/polymers-from-carbon-dioxide.html

Source: http://www.climate-kic.org/case-studies/plastics-project-potential-co2-reduction-of-2-9m-tons-

Sahara CST Licht Technologies: CO_2 and **Nanofibres**



Source: **One-Pot Synthesis of Carbon Nanofibers from CO2**
Jiawen Ren, Fang-Fang Li, Jason Lau, Luis González-Urbina, and Stuart Licht, *Nano Letters* **2015** *15* (9), 6142-6148

Artificial photosynthesis?

REPORT

A synthetic pathway for the fixation of carbon dioxide in vitro

- Optimised in vitro photosynthetic pathway using 17 enzymes (3 engineered)
- 5 times more efficient than existing pathways

London 1917


FEDERATION

Image Geneva 1950

Electrification of the Home 1950

Jet Aircraft 1950

Nuclear Blast 1950

What will 2050 be like? We are all connected…