

Coal, Quartz, and Climate Change

Anthony Seaton

Farewell, King Coal

From industrial triumph to climatic disaster

Anthony Seaton

DUNEDIN

"timely, relevant and of universal interest..." PROFESSOR SIR ANTHONY NEWMAN TAYLOR

The discovery of coalworkers' pneumoconiosis by Gregory (1831) and its recognition by Laënnec (1837).





NELANON DE POUNDY.

paint de matiné unéchés. Au cété genche ; la foise surdplanme faint de matiné unéchés. Au cété genche ; tot de la faire poutéchene de ce cété de la polities d'oranit ; dus les lampieutiess professée ; un cété cépitant sec à builles un pou gronnes ; une modification annues de la veix . Au cété d'anit , la requiration solitient dans la foise un-dpineme les minues caroctions ; une modification annues de la veix . Au cété d'avie ; la requiration solitient dans la foise un-dpineme les minues caroctions qu'a gambe ; anni que dans tout la rente du poumes s' soulement ; dans la goutière veriébrede , un uireau de l'imple de l'onneplate ; en tenuer le bouit de souffat et une besochophanie marquée.

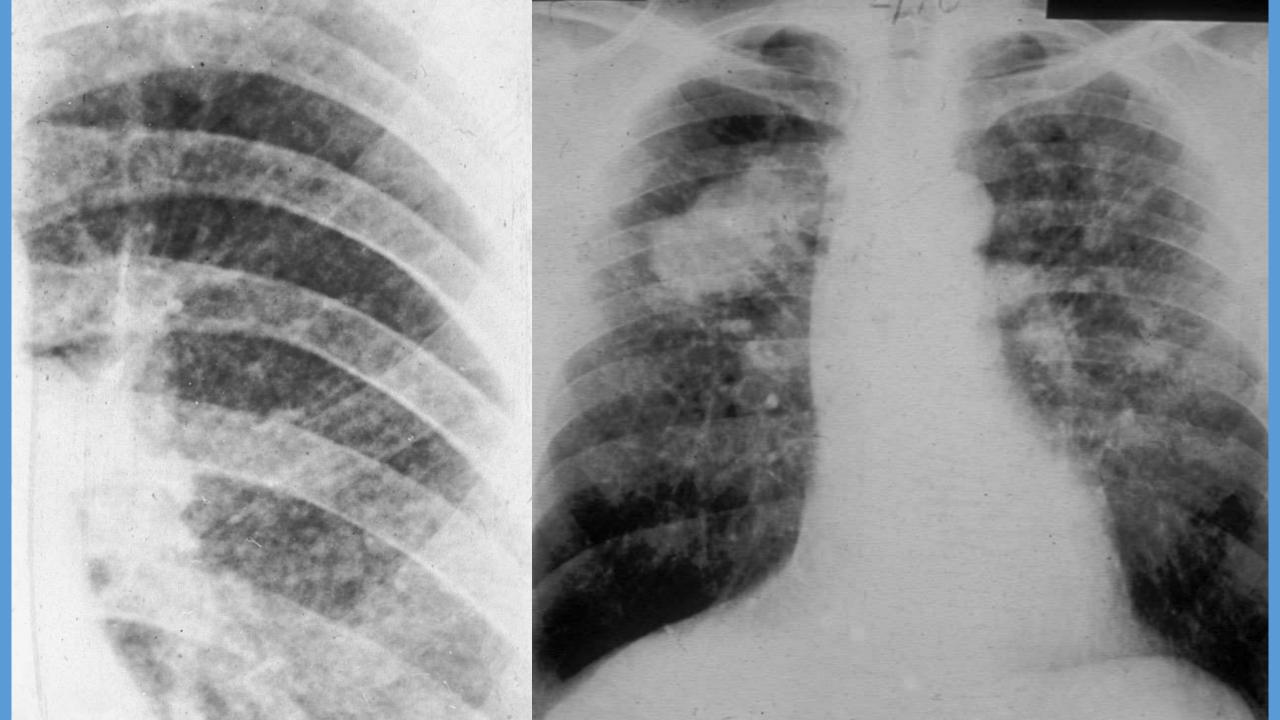
Le malade successive le mitese joue à midi.

L'hompsie farfaite le lendemaint du honore du matte. (Voy, la PZ- 8 et centre,) Paint de vergeturer, point de vigiblie morpsie, un peu d'adima des malitaire des obles.

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Simple pneumoconiosis



Emphysema



Massive fibrosis



Nationalisation of UK coal industry 1946

- 55 coke works, 850 mines, 30 smokeless fuel plants
- 800,000 workers
- Set up a medical service (pre-NHS) and regular health checks
- How much and what sort of dust was causing pneumoconiosis?
- What dust levels would ensure workers would not become disabled by lung disease?

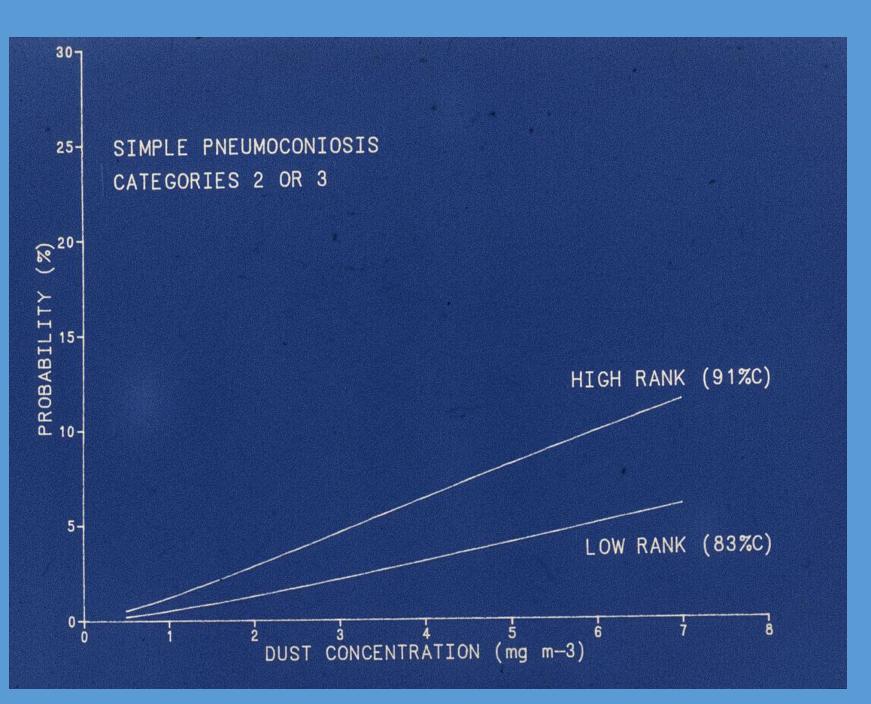


Coal, pneumoconiosis and emphysema The pneumoconiosis field research 1953-89

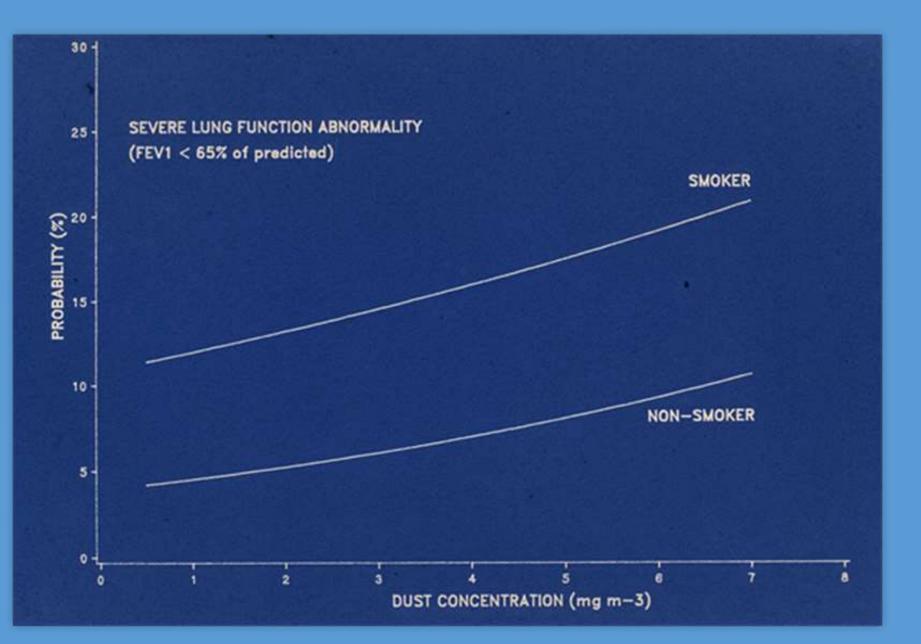
- Sample of c50,000 miners from 25 pits studied over 30 years
- symptoms, smoking, spirometry, chest x-ray every 5 years
- detailed estimates of lifetime dust exposure
- collection of lungs post mortem

The key to measuring risks of lung disease – the MRE 113a dust sampler, 1967

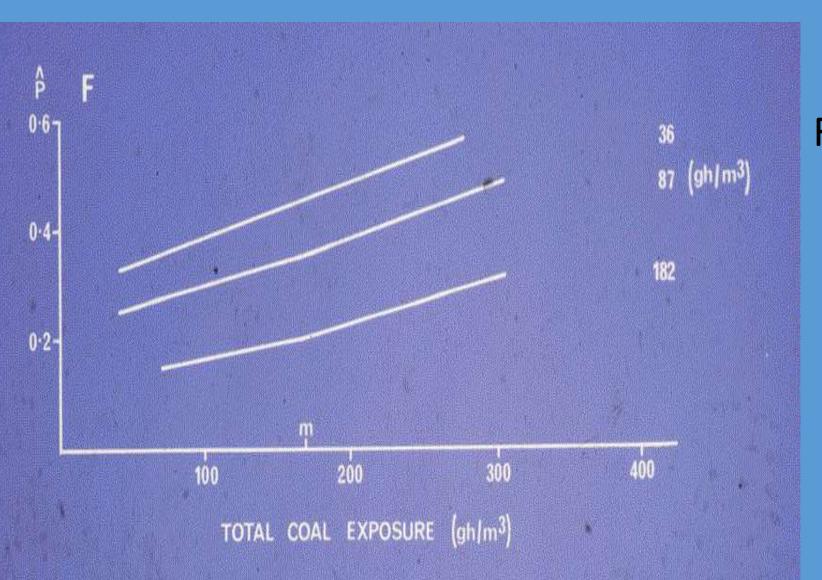




Risks of simple pneumoconiosis in relation to mean coal dust exposure over a working lifetime, in mg/m³



Risks of COPD (FEV1 <65% predicted) in relation to mean dust exposure mg/m^3

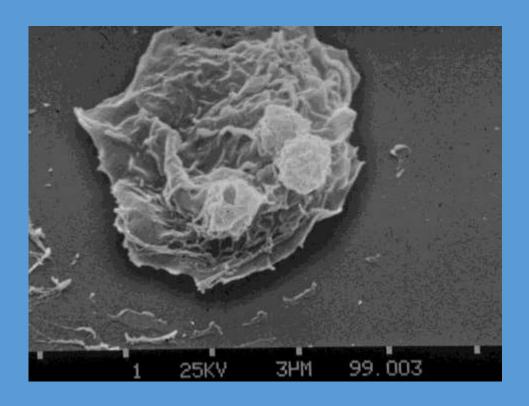


Relationship between risk of >30% centriacinar emphysema and cumulative exposure to coal dust and its silica content ghrs/m³

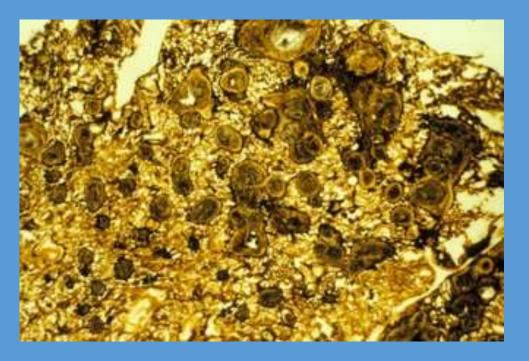
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Macrophage is the key, the first line of alveolar defence

- Inflammation
- Release of cytokines fibrosis
- Recruitment of leukocytes elastolysis
- Sometimes carcinogenesis





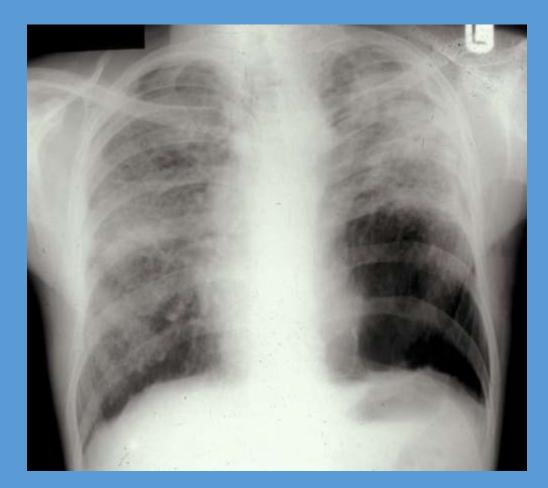


Nodular lung fibrosis caused by inhalation of crystalline silicon dioxide (quartz)



Coal miner with silicosis

Two stone masons with chronic low level, then acute high level, exposures – died from respiratory failure

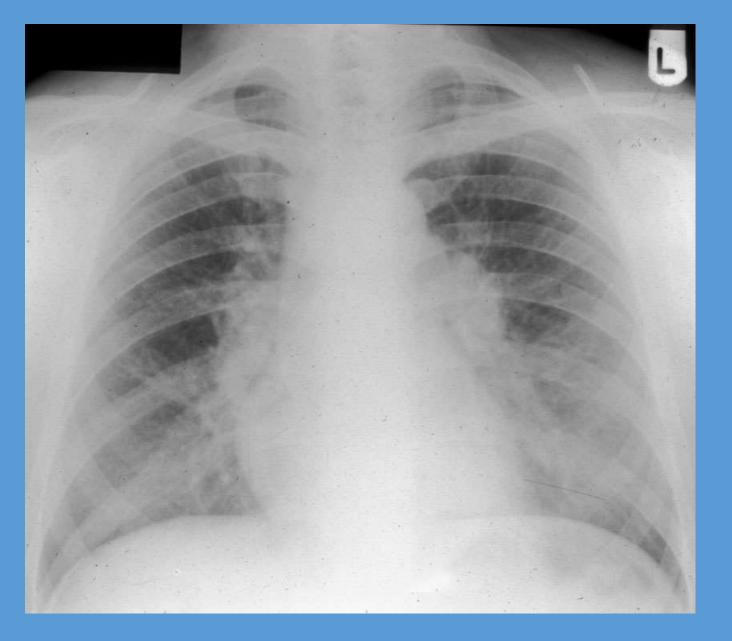




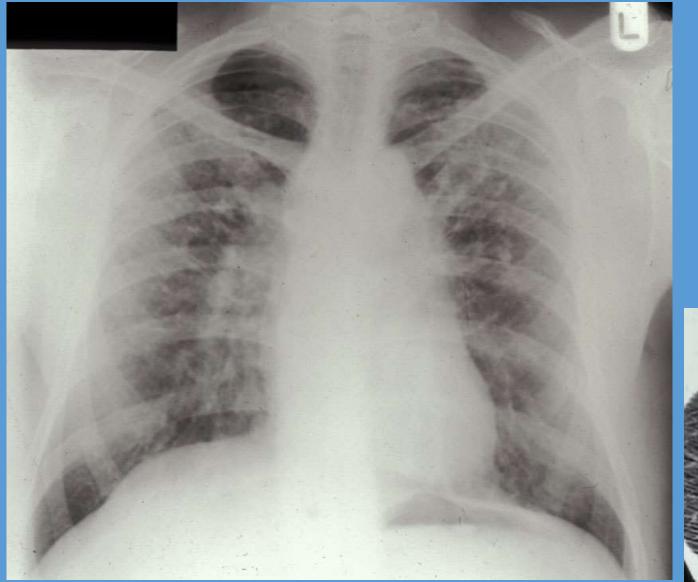
Elgin Cathedral 1991



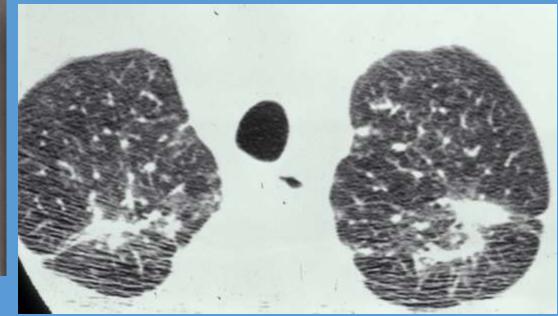




Apprentice stone mason with same acute exposure – large hilar nodes ?sarcoidosis.



Three years later with no further exposure... silicotic massive fibrosis.



Indirect consequences of quartz exposure

- Tuberculosis macrophage impairment
- Renal tubular disease ?direct quartz toxicity
- Increased risk of lung cancer ?inflammation



The nail in the coffin of King Coal: climate change

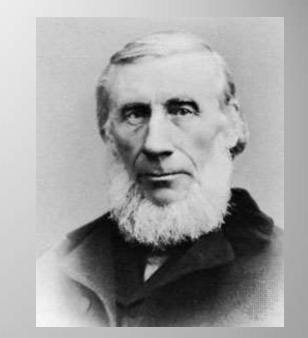


Main greenhouse gases

Carbon dioxide

Methane

- Combustion of fossil fuel
- Animal respiration
- Microbial respiration in soil



John Tyndall 1860

- Agriculture, including rice, from soil and livestock
- Fossil fuel production
- Landfill, biomass burning
- Melting permafrost



The changing atmosphere

Where is carbon dioxide distributed?

- 750 billion tonnes (Gt) in atmosphere
- Uptake by the oceans
 - Lots of water contains 39,000 Gt carbon
- Uptake by vegetation
 - Lots of plants contain 2,500 Gt carbon

CO₂ - Mauna Loa (Jan 2024 420ppm)

Charles David Keeling (1928-2005)



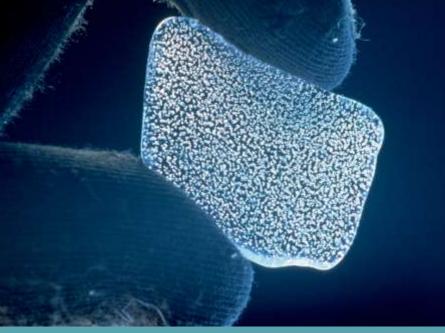


ATMOSPHERIC CARBON DIOXIDE Amount of carbon dioxide (parts per million)

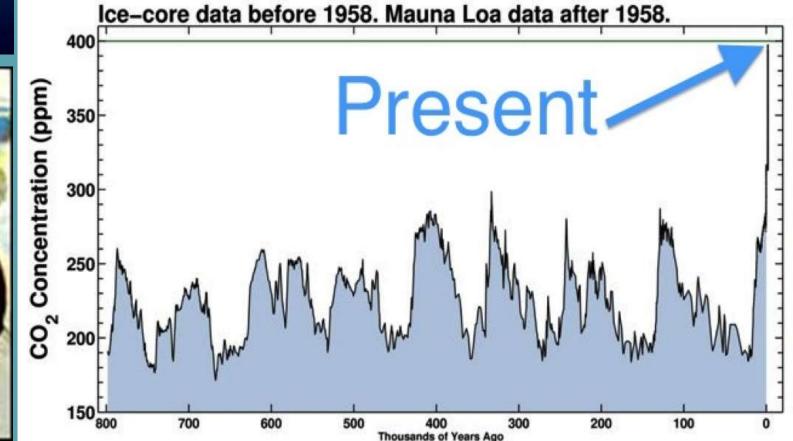
Years

An ice core from the Greenland glacier



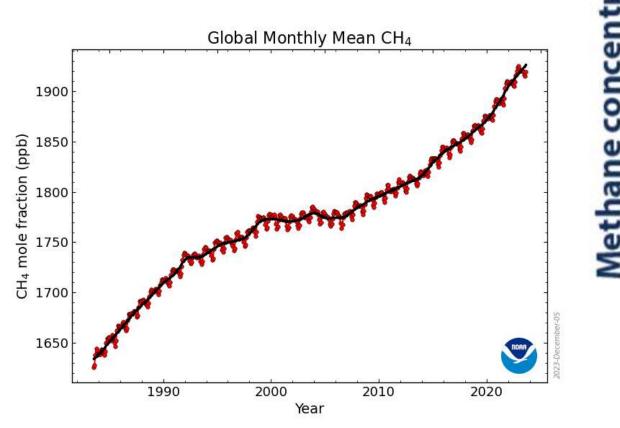


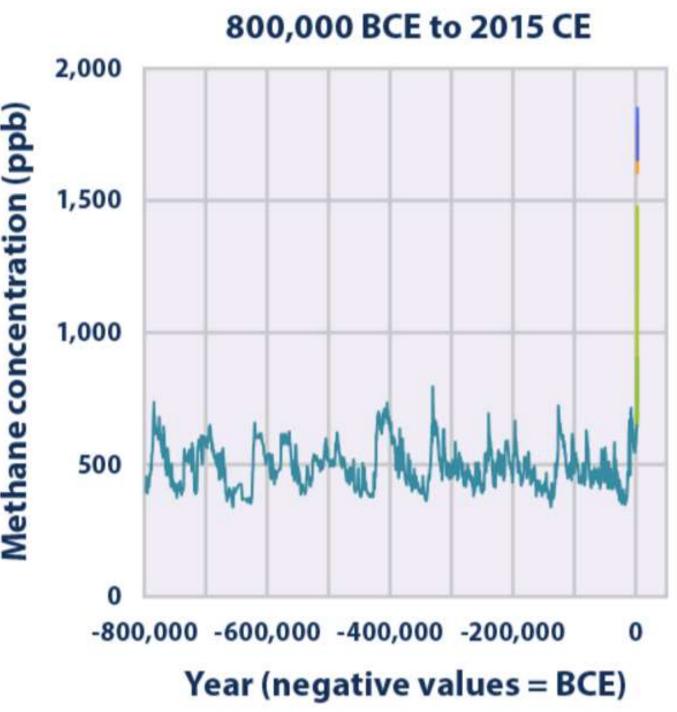
The atmosphere is hidden in the ice





Atmospheric methane 2023: 1920 ppb 1960: 1211 ppb





What are the consequences?

- Rising temperatures
 - heatwaves
- Flooding
 - Increased rainfall and raised sea level
- Drought
 - Decreased rainfall and increased evaporation
- Increasingly violent storms
- Migration



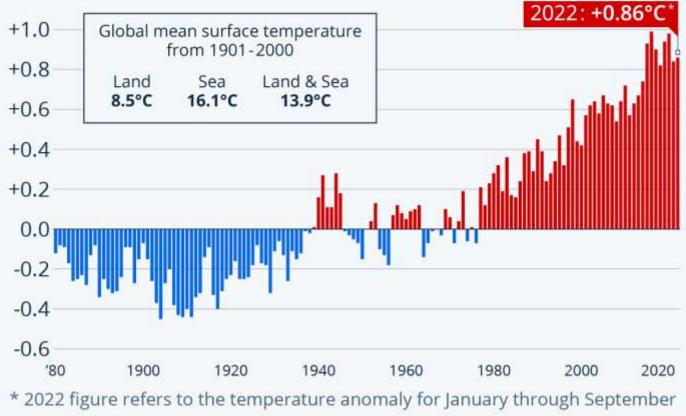






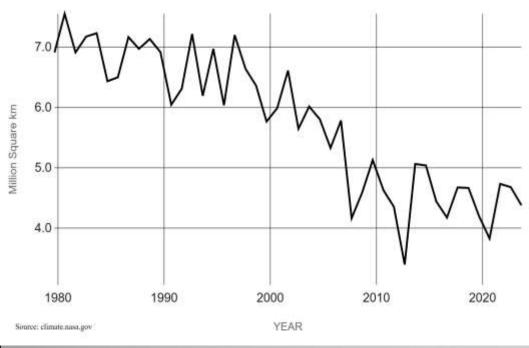
The Last 8 Years Have Been the Warmest on Record

Global land and ocean surface temperature anomalies (degrees Celsius compared to the 20th century average)



Source: NOAA

statista 🗹



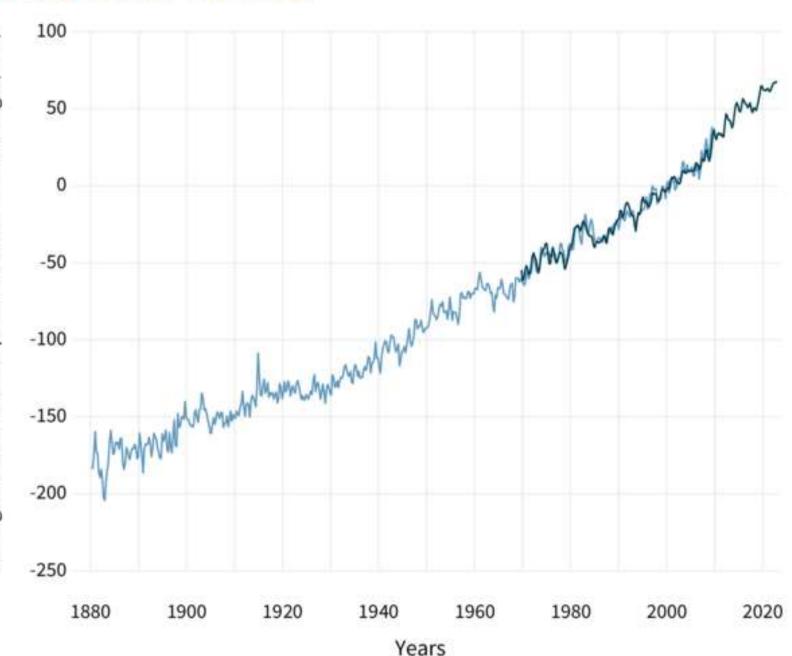


Melting of polar ice: reduced albedo increases temperature rise.

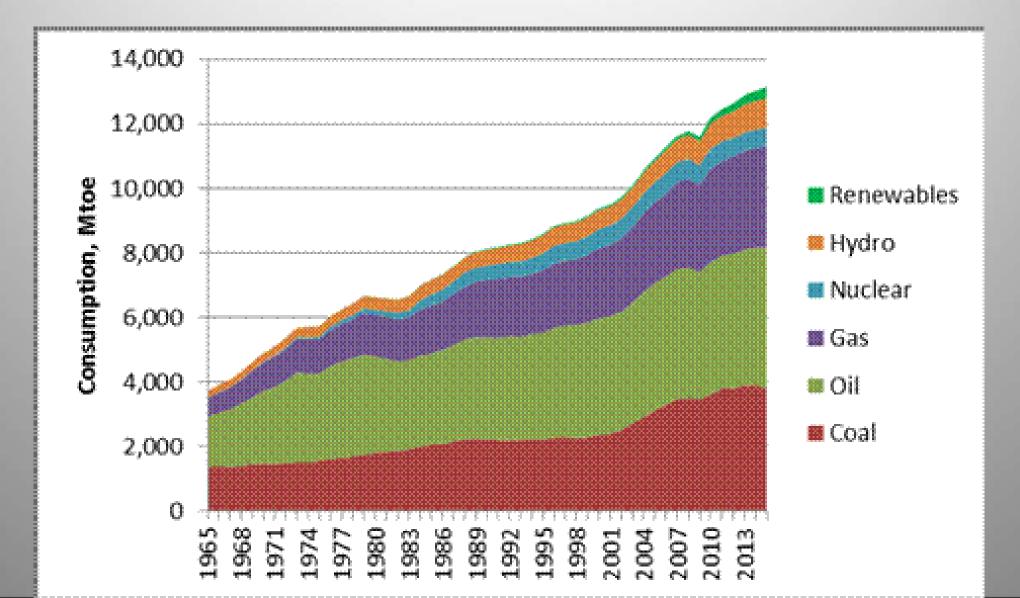
Melting of the Greenland glacier: I metre sea rise by 2100, potential 7 metre rise when it all melts. Acceleration in sea level change since Industrial Revolution. (NOAA data)



GLOBAL SEA LEVEL



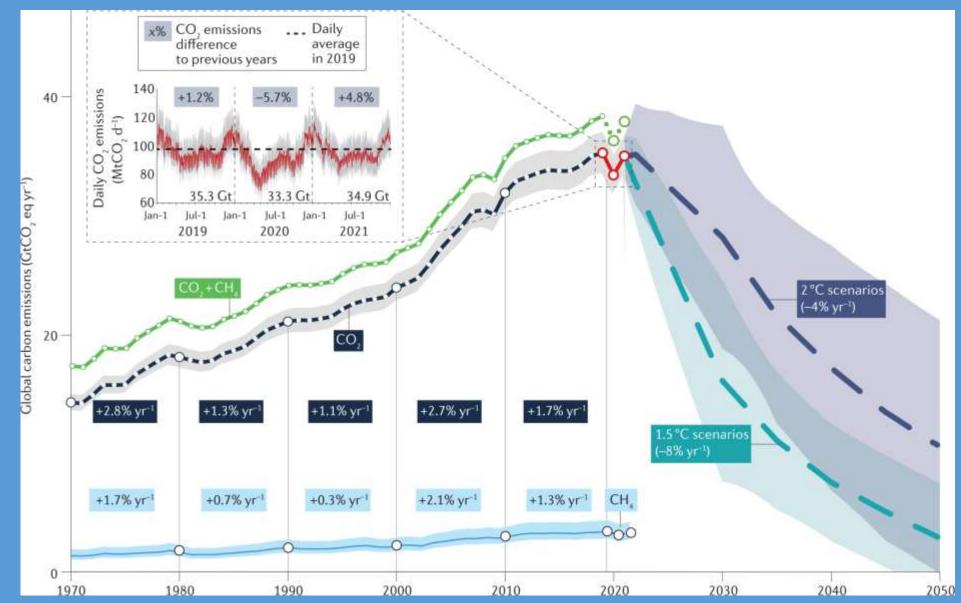
Global energy consumption 1965-2015



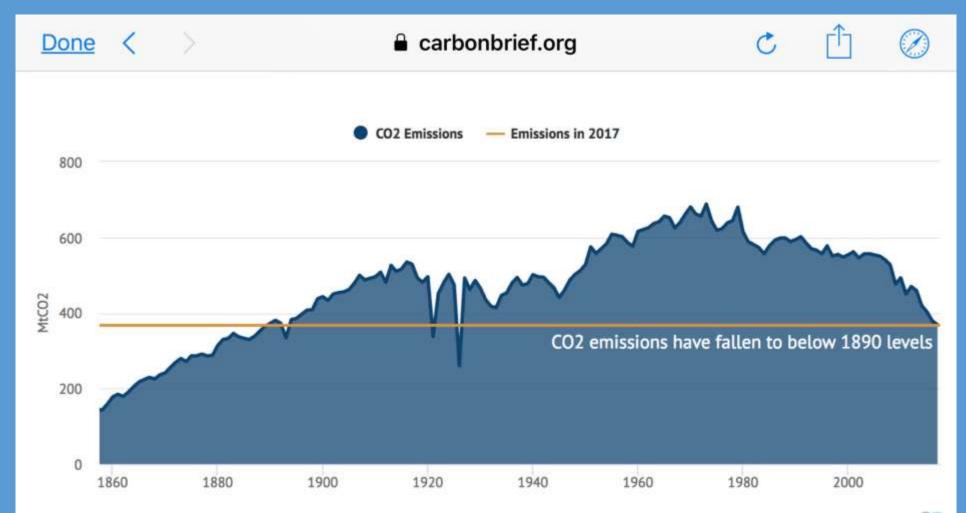
Are there any solutions?

- International agreement is essential (28 CoPs so far).
- Divest from all fossil fuels.
- Reconsider the role of economic growth and free trade.
- Massive investment in renewables, with nuclear as a backup.
- Change farming and food distribution practices.
- Improve energy distribution and storage.

Global greenhouse gas emissions 1970-2022



UK CO₂ emissions 1860-2022



Renewable energy generation, United Kingdom Our World in Data 80 TWh Wind 70 TWh 60 TWh 50 TWh 40 TWh Other renewables 30 TWh 20 TWh 10 TWh Hydropower 0 TWh 1980 1990 2000 2010 2022 1965 Data source: Energy Institute - Statistical Review of World Energy (2023) OurWorldInData.org/renewable-energy | CC BY

Note: 'Other renewables' refers to renewable sources including geothermal, biomass, waste, wave and tidal. Traditional biomass is not included.

How to make matters worse: the world's wealthiest 1% (income >£80k pa) produce 50% of the greenhouse gases

- Drive on fossil fuel average car produces 1.5 kg CO₂ per 100 miles
- Have large (or more than one) cars
- Fly London to Rome = 240 kg CO_2 London to New York = 1000 kg CO_2
- Travel to multiple conferences
- Overheat the house and consume more than needed

UK total and individual annual energy consumption and renewable production 2022

Total UK consumption: 1.512 million MWatt hours Total UK renewable production: 224 million MWh Total UK nuclear production: 44 million MWh Mean individual consumption: 22.5 MWh My personal consumption: 9 MWh My solar generation: 3 MWh (average over 11 years)

In the UK, households are now the main contributors to fossil fuel emissions

Figure 1: Households remain the highest contributors to overall UK greenhouse gas emissions in 2021

Trend for greenhouse gas emissions for the three highest-emitting industries and households in 1990 to 2021 (residence basis)

Mass of air emissions per annum in thousand tonnes of carbon dioxide equivalent (CO2e) 300,000 200,000 100,000 2015 201 201 Manufacturing Consumer expenditure Energy Sector Transport

Source: UK Environmental Accounts from Ricardo Energy and Environment, and the Office for National Statistics

Civilisations fall; the writing on the wall?



The human species

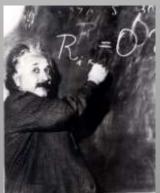
Homo erectus

1.9 million – 50,000 ybp

- Homo neanderthalensis
 250,000 40,000 ybp
- Homo sapiens
 200,000 ybp present







Or will our grandchildren think of us as Homo stupidus?





It's up to us – you and me.

Thank you.

What we should do locally and as individuals.

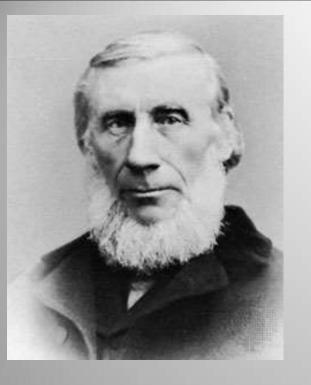
- 1. Insulate houses and turn down heating
- 2. Reduce gas and electricity use. Get heat pump.
- 3. Use renewable energy where possible. Local networks.
- 4. Walk, cycle, bus, drive economically. Go electric.
- 5. Train rather than aeroplane.
- 6. Cut foreign holidays and conferences.
- 7. Reduce meat intake and source food locally.
- 8. Think what we buy where from? Recycle and avoid plastic.
- 9. Invest in renewables and divest from fossil fuel.
- 10. Spread the word

Svante Arrhenius (1859-1927) "On the influence of carbonic acid in the air upon the temperature on the ground" (1896)

Predicted 50% increase in CO₂ would raise temperature c3.5°C, that is from c225 to c336ppb.



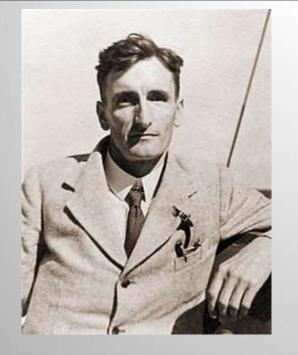
Should Increase agricultural productivity, allow population growth and prevent another ice age.



John Tyndall (1820-93)

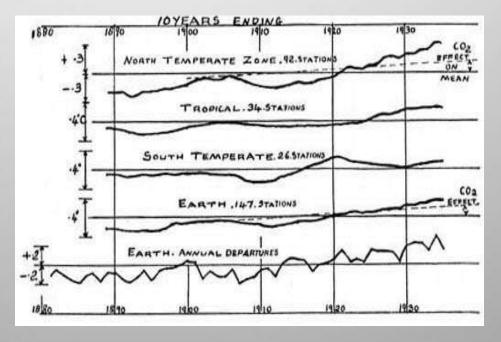
His experiments showed that compound gases absorbed emitted (infra red) radiation, notably CO2, water vapour, and hydrocarbons, thus reducing heat loss into space.

In 1860, when he showed this, atmospheric CO_2 was about 225ppb.



The oceans

Guy Callender (1898-1954)



In 1938 noted the rise in air temperature and CO2, and suggested the ocean's capacity to absorb it was limited.



Roger Revelle (1909-91)

Showed in 1957 that the oceans had not been absorbing the CO2 at a sufficient rate over a few decades; recruited Keeling who had invented apparatus to measure it in the atmosphere

Taught AI Gore at university.

Understanding of climate change

- 1754 Joseph Black discovered CO₂
- 1776 Alessandro Volta discovered methane
- 1827 J-B Fourier described the greenhouse effect
- 1859 John Tyndall showed compound gases to be responsible
- 1896 Svente Arrhenius showed the relation between rise in $\rm CO_2$ and the Earth's temperature.
- 1938 Guy Callender showed that the oceans were not absorbing CO₂ at a fast enough rate
- 1957 Roger Revelle started his research on ocean acidification

Solar energy

- Current solar panel arrays will produce on average 3-4MWh per annum.
- 250,000 new houses were built in UK in 2022
- This represents an annual opportunity to produce up to a million MWh (1 terawatt hour) of power from new builds alone.
- Why is this not in building regulations?
- One Edinburgh Co-op has put panels on all primary Schools.