TIPPING POINTS & CLIMATE CHANGE
Ian Hawker

Climate change is the major issue of our time

Tipping points are temperature thresholds that, if crossed, trigger large scale rapid & irreversible changes in the climate system

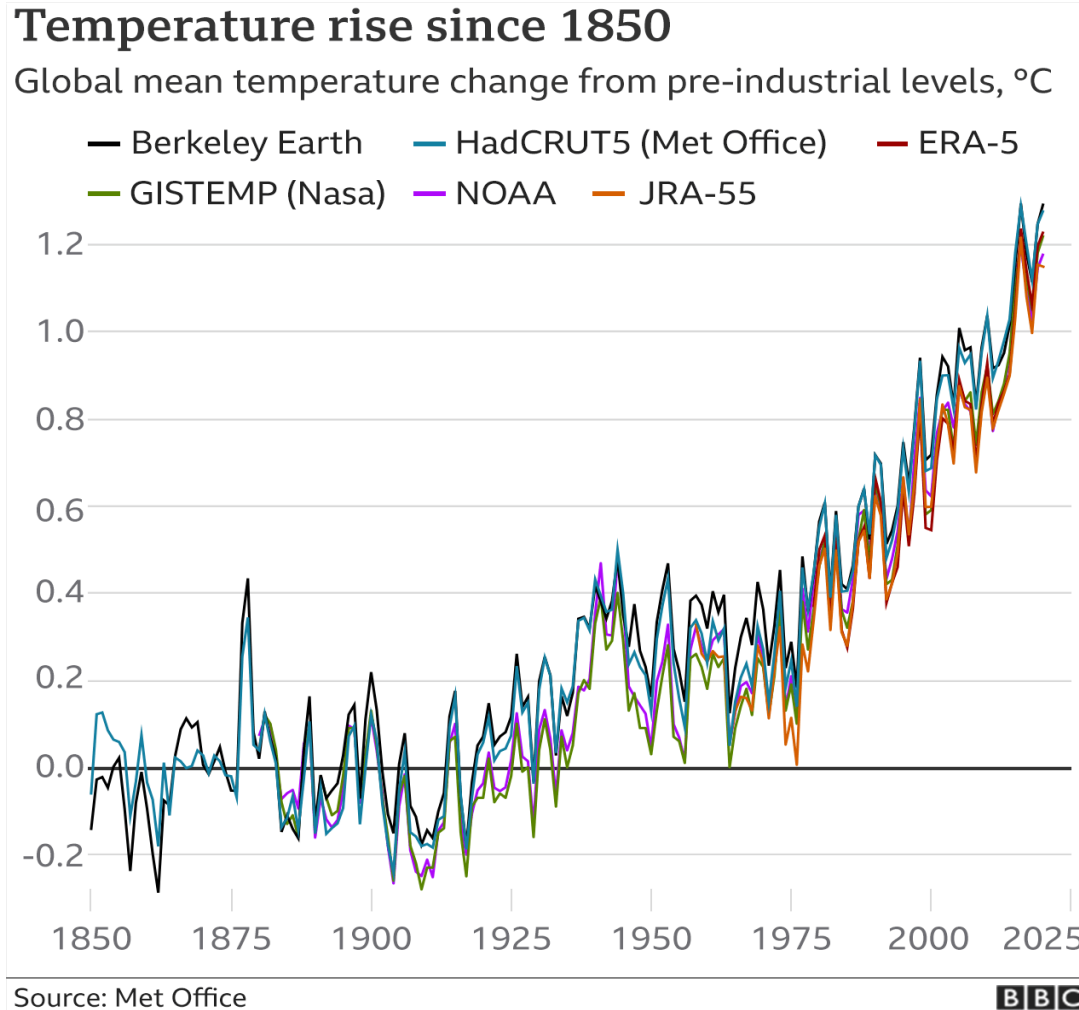Includes Arctic ice melting, loss of Amazon & Boreal forests & reduction of ocean circulation

About 16 tipping points have been identified and 4 have already been passed
Passing all tipping points leads to rapid warming to 3C & beyond
This would produce a Warm House or even a Hot House Earth
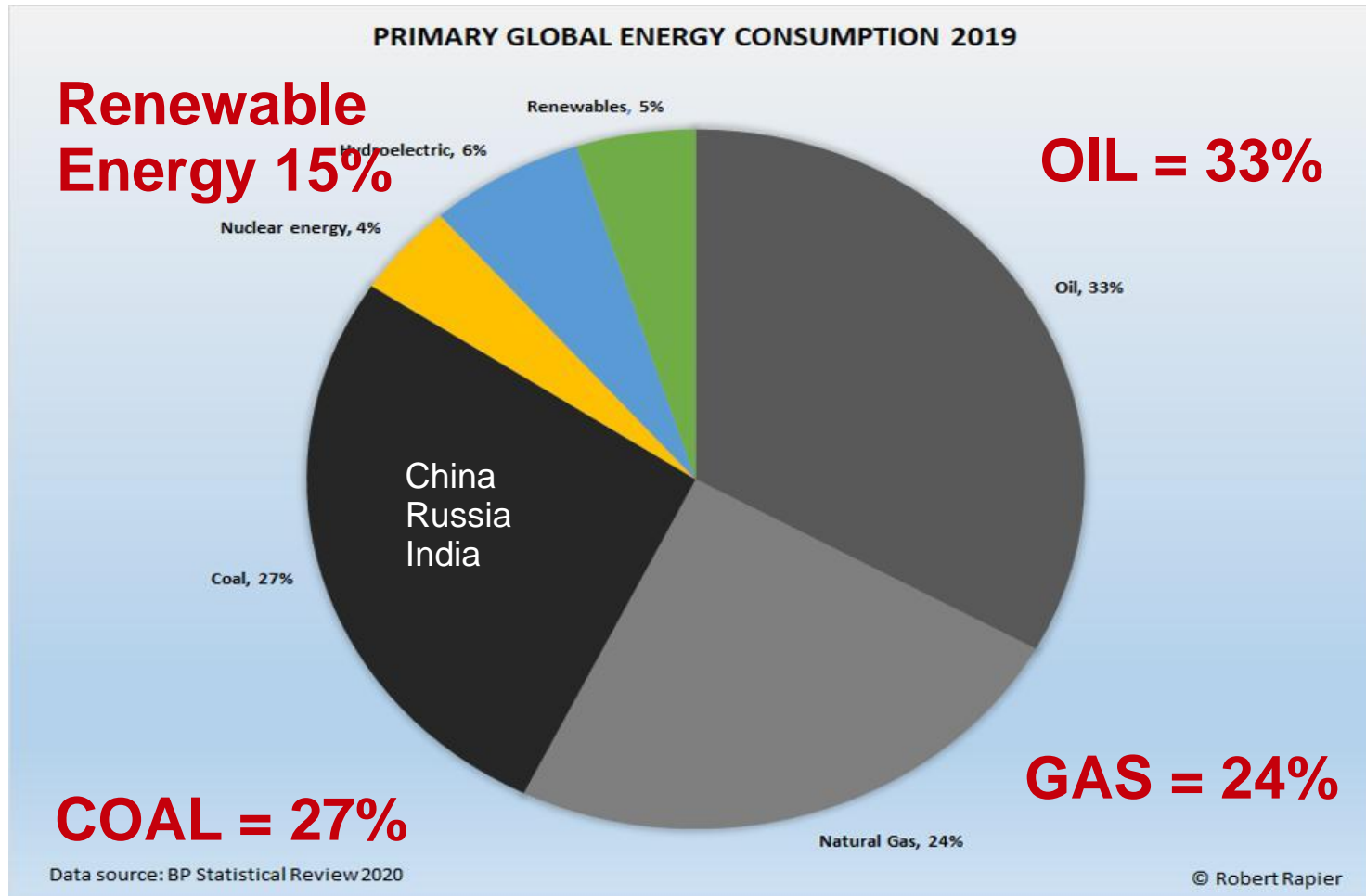
Can we avoid Hot House Earth?
Accelerate adoption of green technology?
Speed up social, political & technological change?
Remove excess CO_2 from the atmosphere?

GLOBAL TEMPERATURE RISE

Temperature rise since 1850

Global mean temperature change from pre-industrial levels, °C

— Berkeley Earth   — HadCRUT5 (Met Office)   — ERA-5

— GISTEMP (Nasa)   — NOAA   — JRA-55

Source: Met Office

BBC

Temperatures are predicted to rise by average 2.6 – 2.9C by 2100
Climate Action Tracker

BURNING OF FOSSIL FUELS

PRIMARY GLOBAL ENERGY CONSUMPTION 2019

Renewable Energy 15%

Renewables, 5%

Hydroelectric, 6%

Nuclear energy, 4%

OIL = 33%

Oil, 33%

China
Russia
India

Coal, 27%

GAS = 24%

Natural Gas, 24%
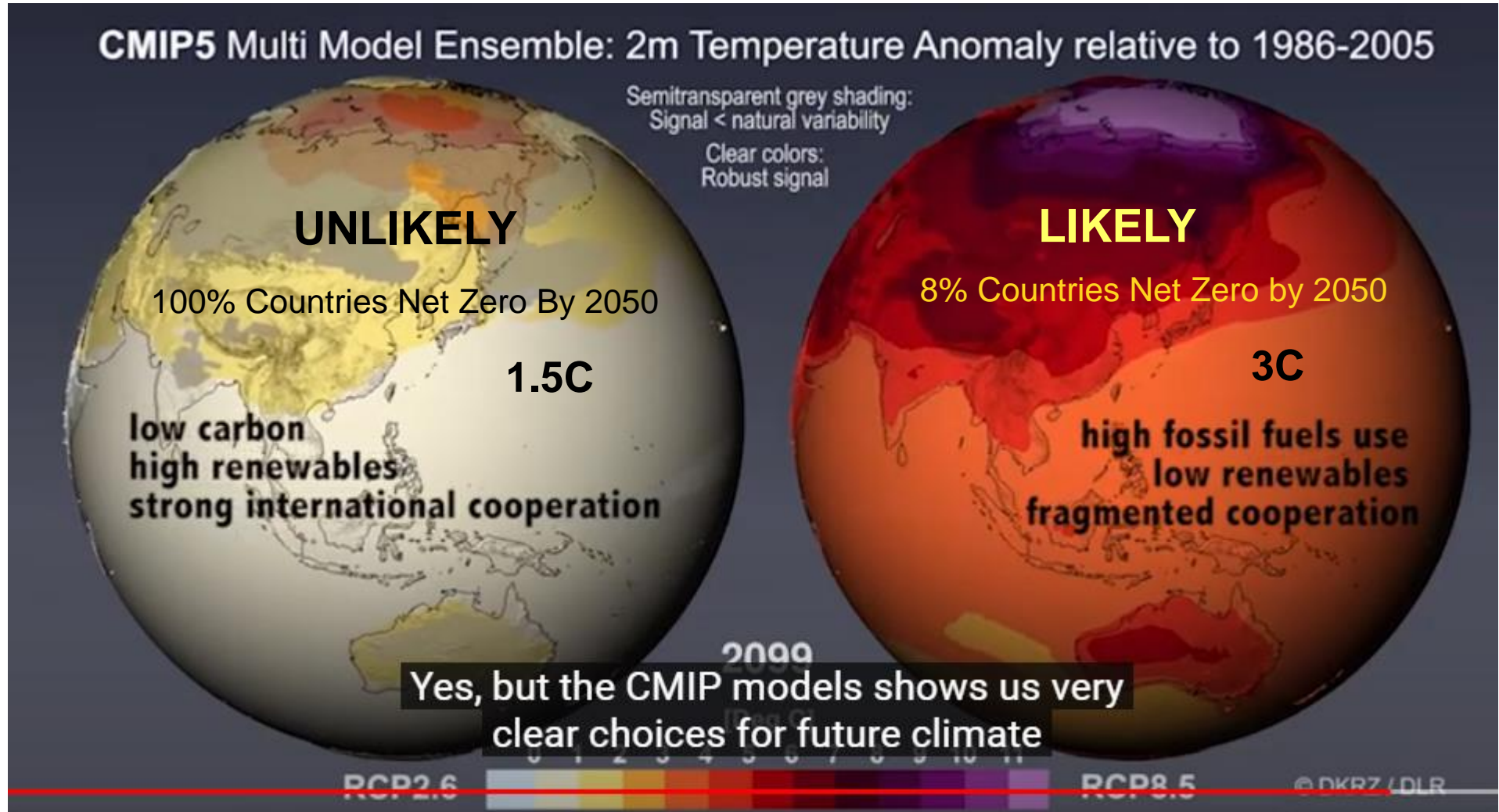
COAL = 27%

Data source: BP Statistical Review 2020

© Robert Rapier

Need to eliminate fossil fuels worldwide to reach Net Zero emissions by 2050

The Speed Of Transition to Net Zero Emissions Is Critical

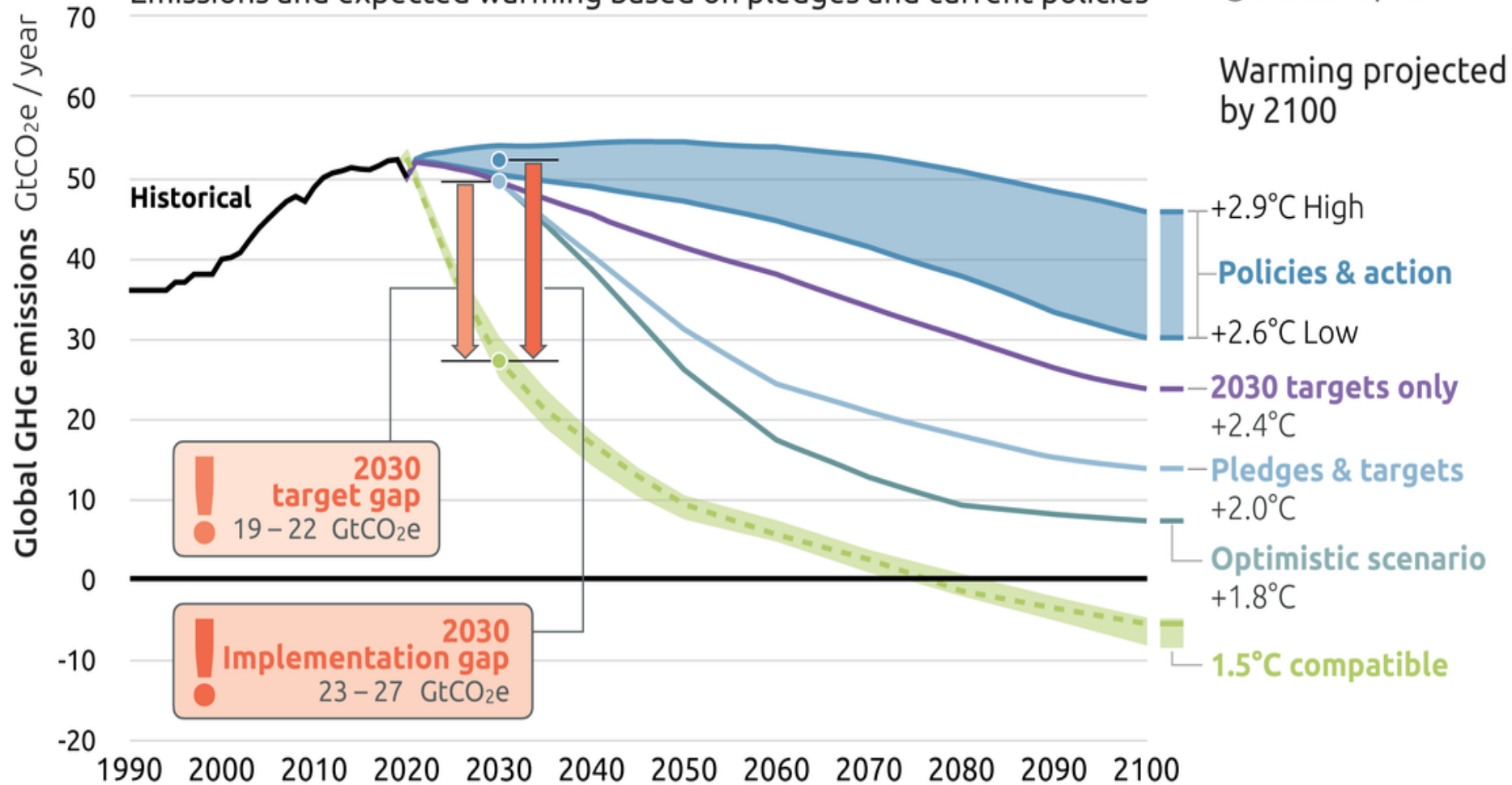# COMPUTER MODEL TEMPERATURE RISE PREDICTIONS 2100

THE CHOICE IS CLEAR

2100 WARMING PROJECTIONS

Emissions and expected warming based on pledges and current policies

Climate Action Tracker

Nov 2022 Update

Warming projected by 2100

Global GHG emissions GtCO₂e / year

Historical

2030 target gap
● 19 – 22 GtCO₂e

2030 Implementation gap
● 23 – 27 GtCO₂e

+2.9°C High

Policies & action

+2.6°C Low

2030 targets only
+2.4°C

Pledges & targets
+2.0°C

Optimistic scenario
+1.8°C

1.5°C compatible

WHAT ARE TIPPING POINTS?

Complex systems can remain 'stable' for long periods resisting external change
Our climate has been relatively stable since last ice age 10k years ago

This is because the effects of positive & negative feedback loops are 'balanced' resulting in only minor fluctuations in the overall system
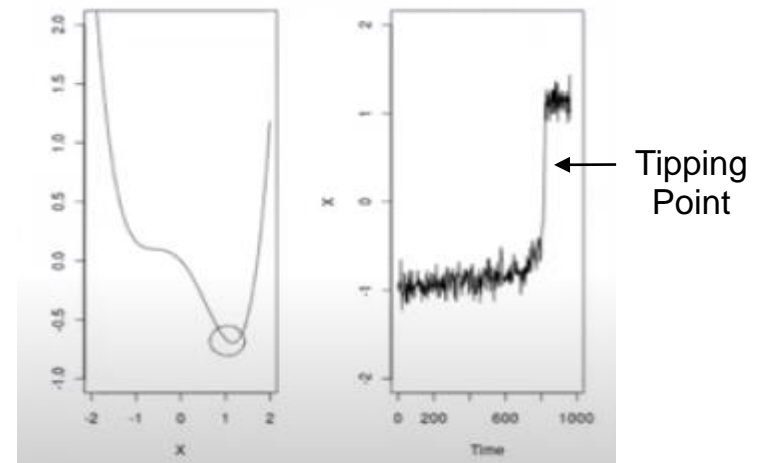
Small
Changes
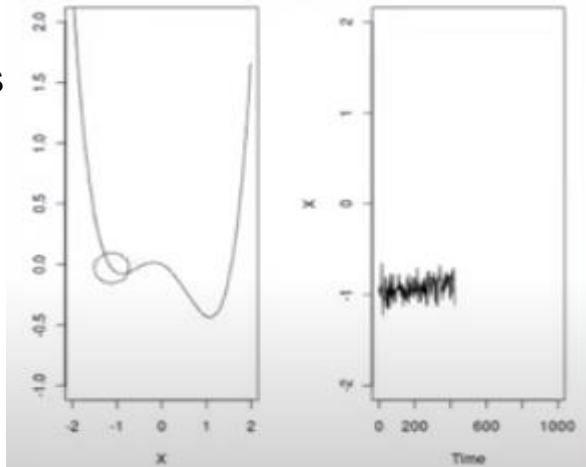
INPUTS   OUTPUTS

Large
Changes

Tipping
Point

INPUTS   OUTPUTS

Once a Tipping Point is reached the system rapidly flips into a new stable state

Stressing the climate system beyond certain limits will flip it into a new state

CLIMATE STATES

Historical records indicate 4 distinctive climate states Hot House, Warm House, Coolhouse & Icehouse Earth

Driven by build up/removal of CO_2 by continental drift, volcanic activity & sequestration by rocks, sea & plants,
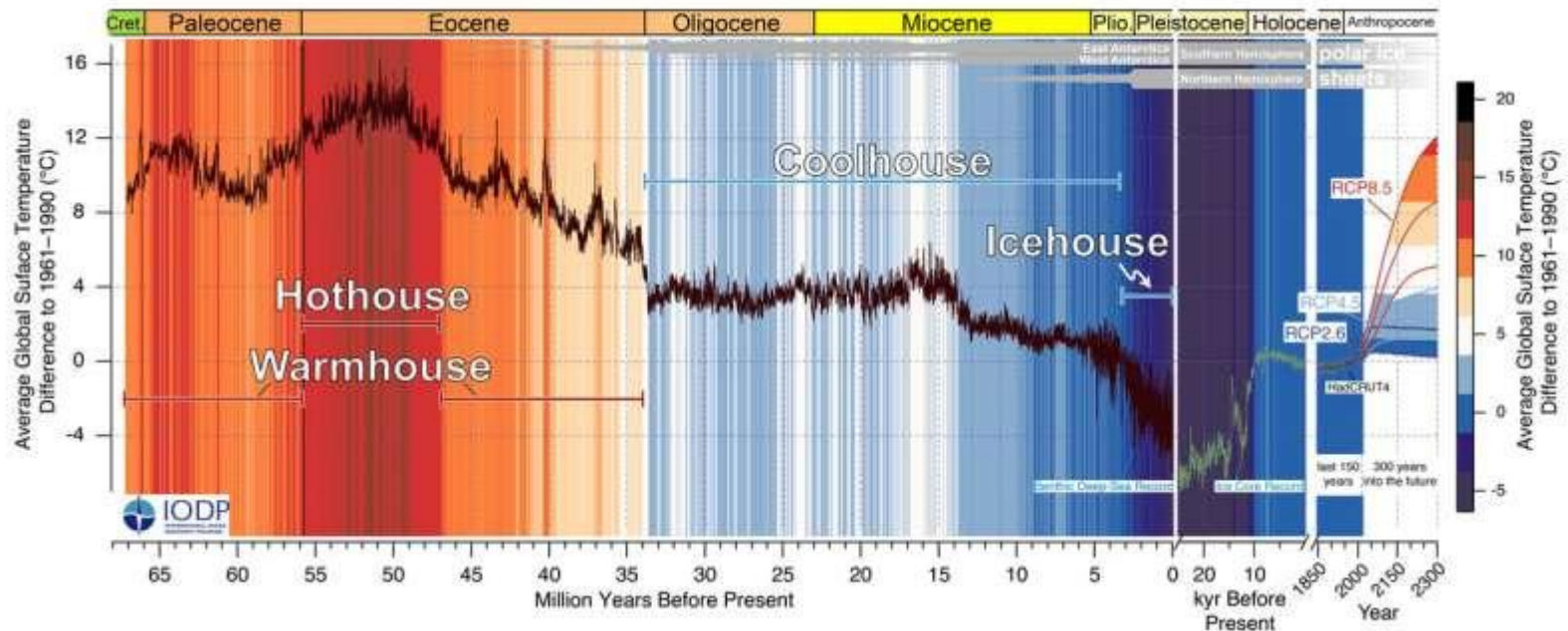
These climate states can persist for millions of years
Within each climate states are smaller cycles driven by changes in Earth's orbit, axis tilt & precession
Milankovitch Cycles 100k/41k/26k years

With rising temperatures could we flip into a Warm/Hot House Earth?

TIPPING POINT INDICATORS
Which Tipping Points Have We Passed?

In summer 2020 Arctic sea ice was 50% less than in 1980

As the ice melts warming accelerates x4 compared with lower latitudes (albedo effect)

Arctic sea ice minimum extent
1980
7.5 million sq km

RUSSIA

CANADA

UK

Source: National Snow and Ice Data Center

BBC

Arctic sea ice minimum extent
2020
3.7 million sq km

RUSSIA

CANADA

UK

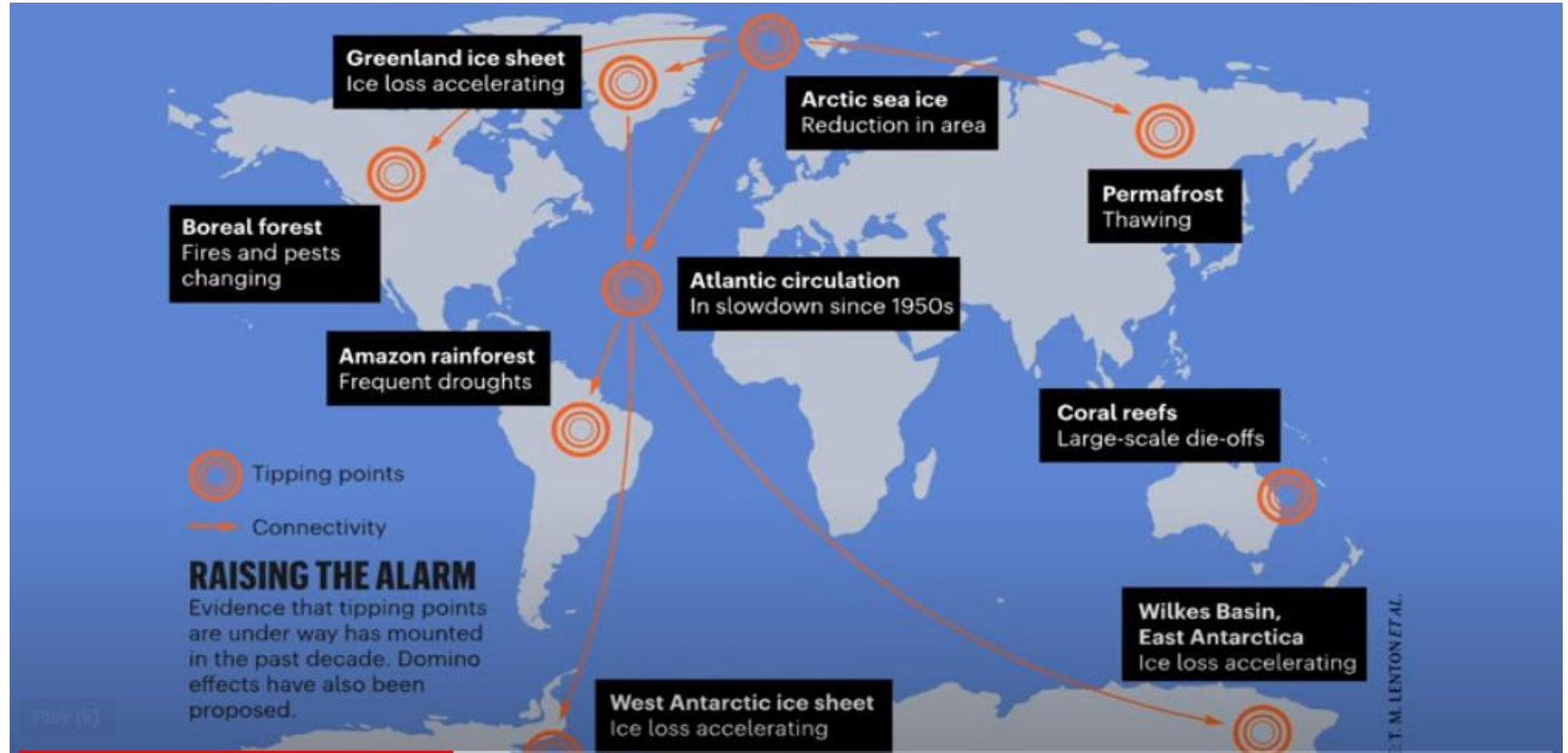Source: National Snow and Ice Data Center

BBC

Summer ice expected to disappear by 2035

Arctic ice melt is a Tipping Point (likely irreversible)

CLIMATE TIPPING POINTS

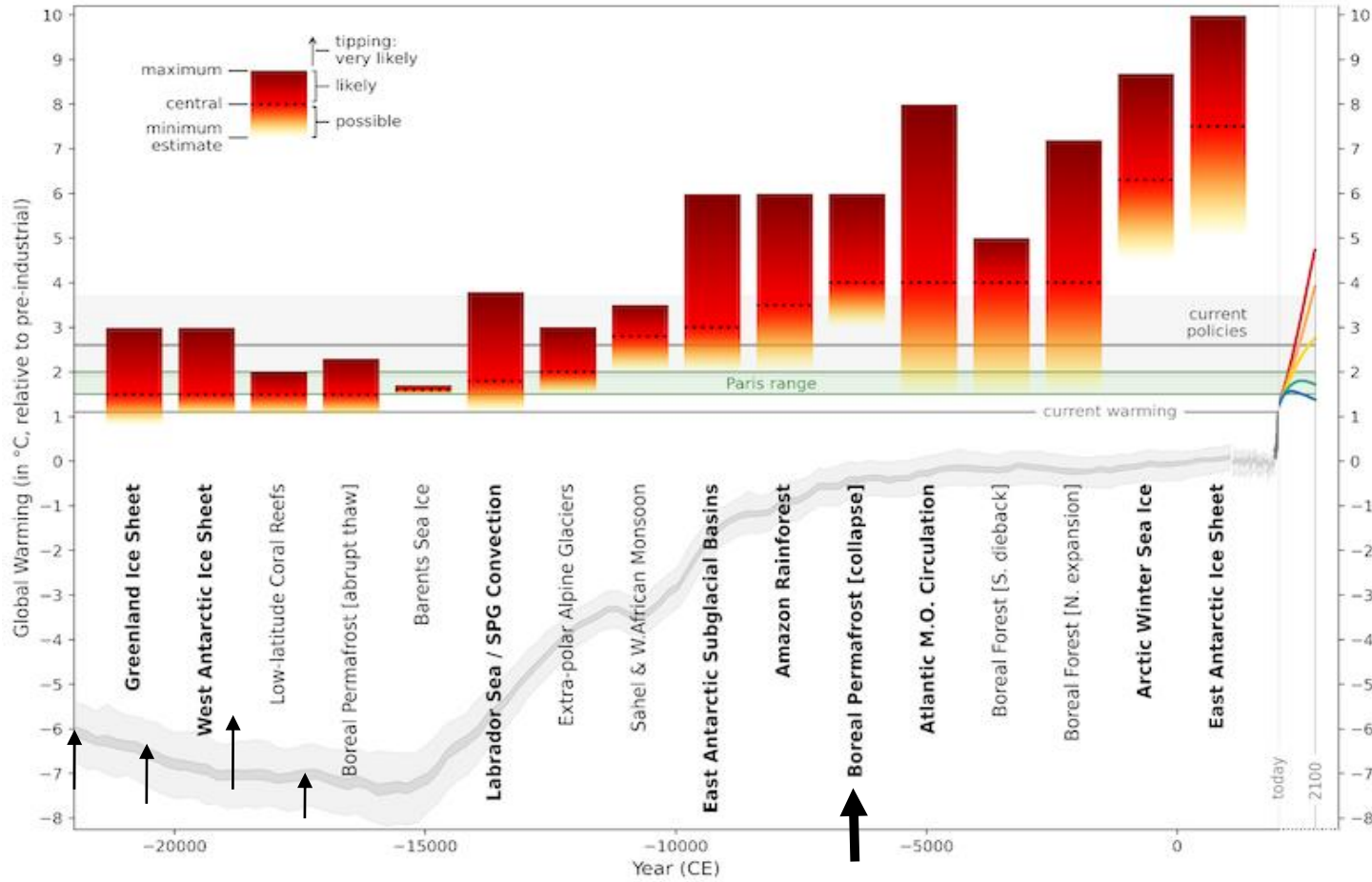Arctic ocean warming affects other tipping points

This produces a <u>domino effect</u> where tipping points are triggered one after the other

Leading to accelerated climate change

TIPPING POINTS

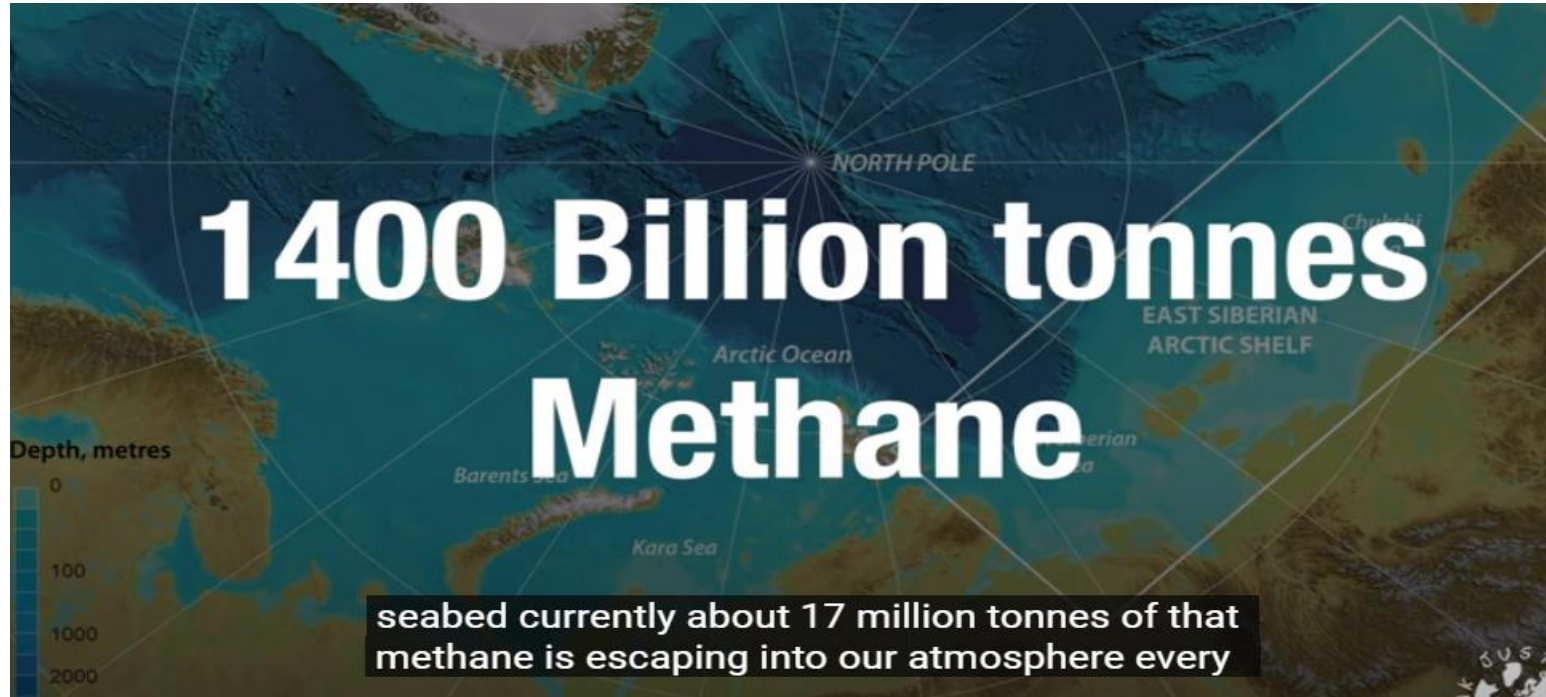18 Tipping Points Identified so far

Human-caused warming of 1.1C has made passing 4 tipping points highly likely

A 3C rise would trigger most of the remaining tipping points

PERMAFROST MELTING

More than 80% of the worlds subsea permafrost exist in the East Siberian Arctic shelf

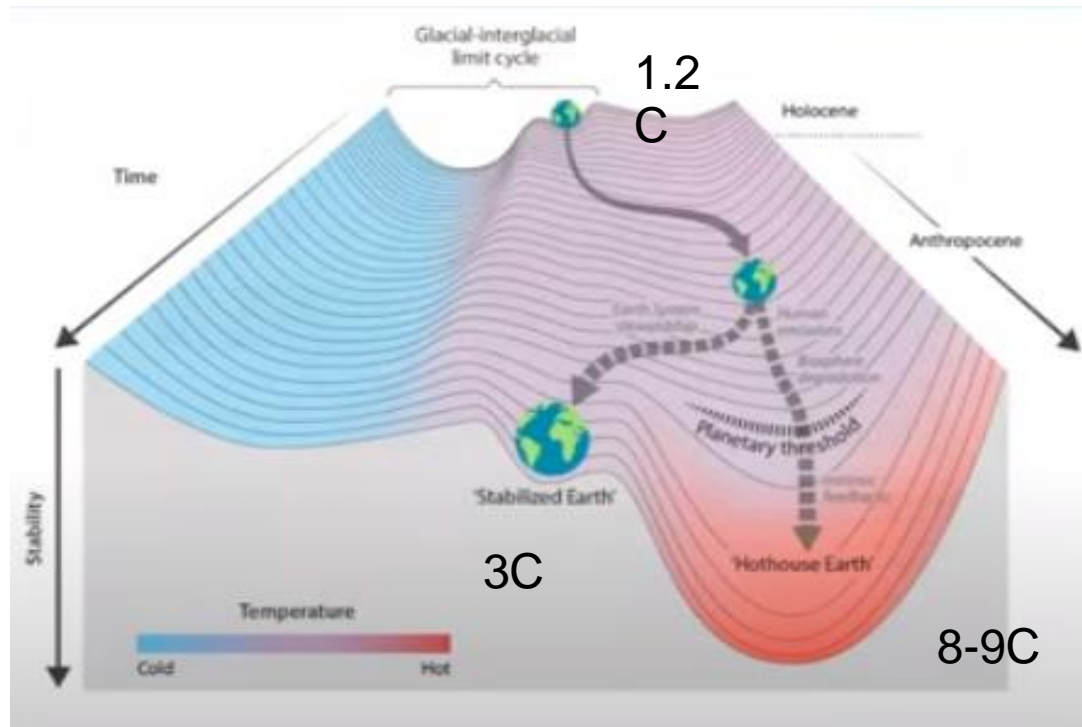Estimated 1400 Billion tonnes methane stored

Methane escaping at ~ 17 million tons each year accelerating as temperatures rise

Over 5-10 years methane is 80x potent than CO_2 (x23 over 100 years)

Release of all this methane would generate a large temperature spike

COOL, WARM OR HOT HOUSE EARTH?

Domino effect could lead to 'Warm House Earth' <u>or</u> 'Hot House Earth'

WHAT WOULD WARM HOUSE 3C EARTH LOOK LIKE?

Parts of the Earth likely become uninhabitable due to heat & water scarcity

What about world food production?   What about sea level rise?

What about migration from equatorial regions?   What about migration from coastal cities?

GLOBAL FOOD PRODUCTION

Globally we currently rely on limited genetic diversity ~ 50% food from rice, maize & wheat
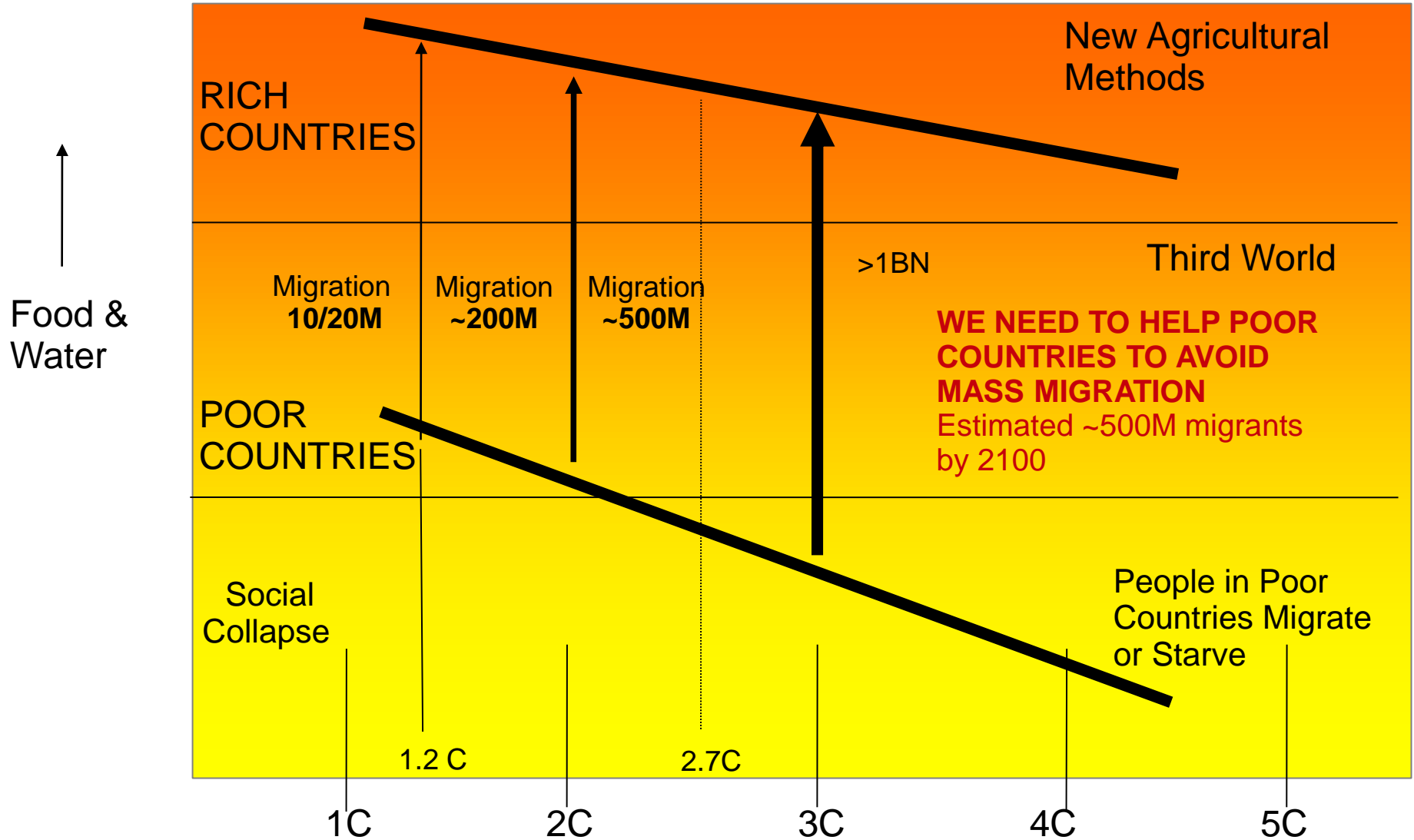

In a hotter world food production must change

Diversify, intensify, genetically engineered crops, synthetic food (?)

MASS MIGRATION FROM POOR COUNTRIES

Agriculture failure could generate billions of climate migrants

New Agricultural Methods

RICH COUNTRIES

>1BN

Third World

Food & Water

Migration **10/20M**

Migration **~200M**

Migration **~500M**

WE NEED TO HELP POOR COUNTRIES TO AVOID MASS MIGRATION
Estimated ~500M migrants by 2100

POOR COUNTRIES

Social Collapse

People in Poor Countries Migrate or Starve

1.2 C

2.7C

1C   2C   3C   4C   5C

SEA LEVEL RISE

2100
0.3 – 2.0 metres sea level rise
Displaces 150-200M people

2100+
Greenland Ice Sheet Melted + Western Antarctic = 13 Metre Rise
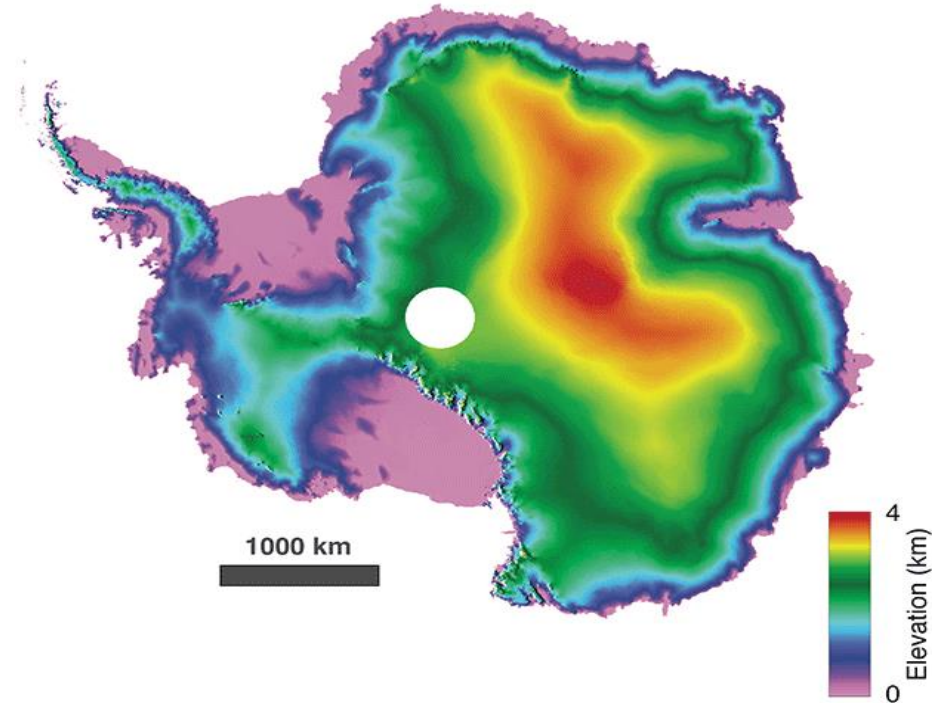Displaces 2 billion people

2200+
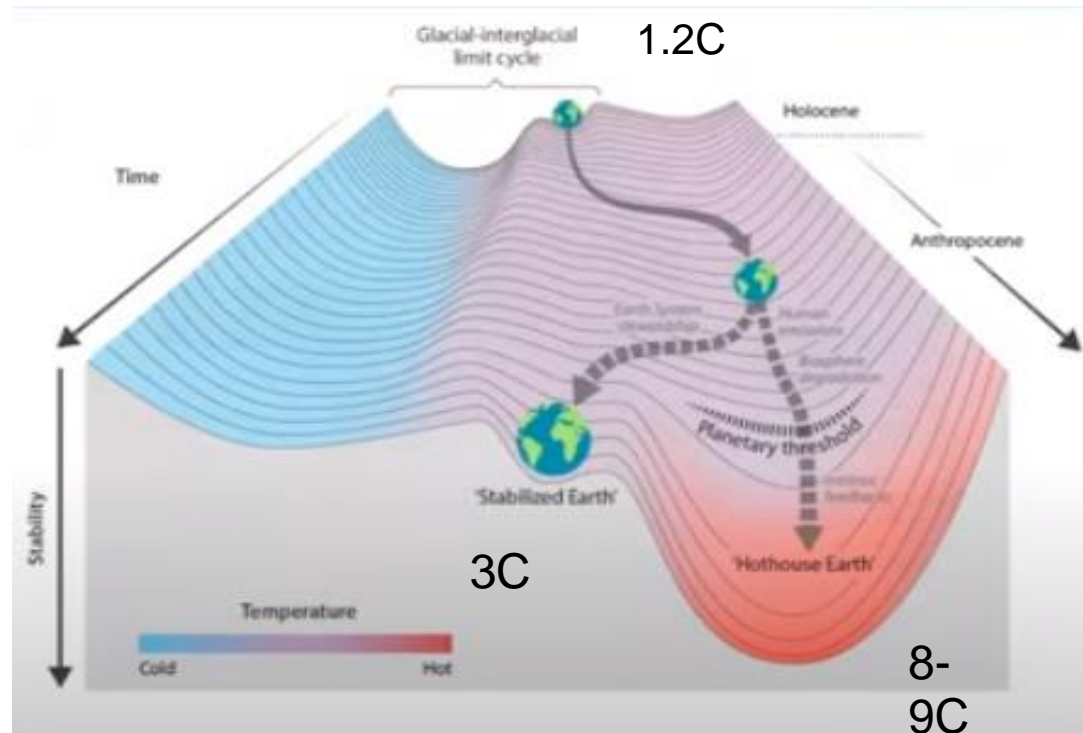Eastern Antarctic Ice Sheet Melted = 70-80 Metre Rise
Coastal cities relocated
Displaces 4 billion people

Tipping points accelerates global temperature rise & ice melting

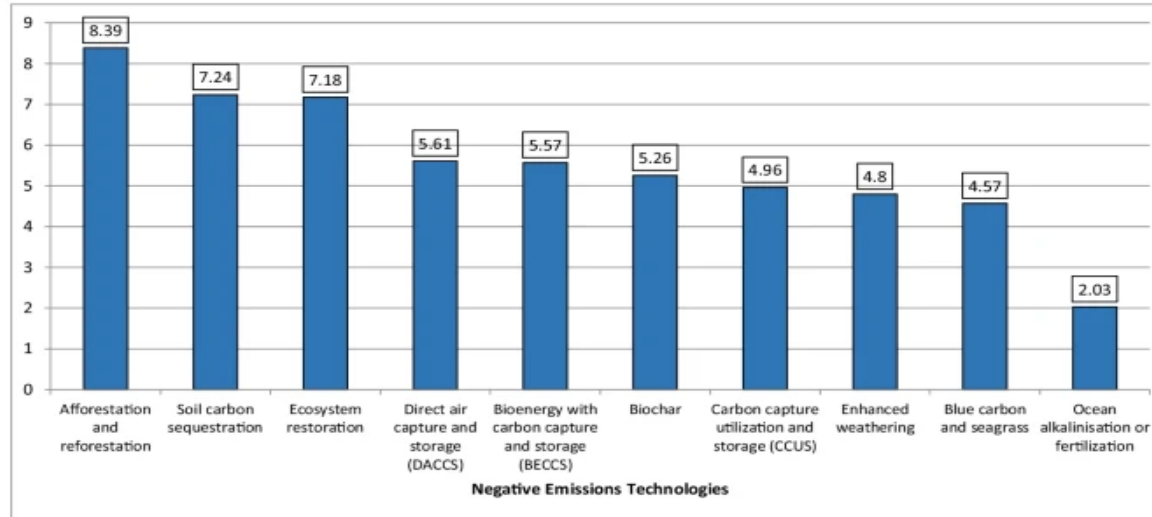# IS THERE AN ALTERNATIVE PATHWAY TO A STABLE EARTH CLIMATE?

Can we avoid Warm/Hot House Earth?

Are there geo-engineering fixes such as CO2 removal?

Can we reduce GHG emissions through accelerating green technology & social change?
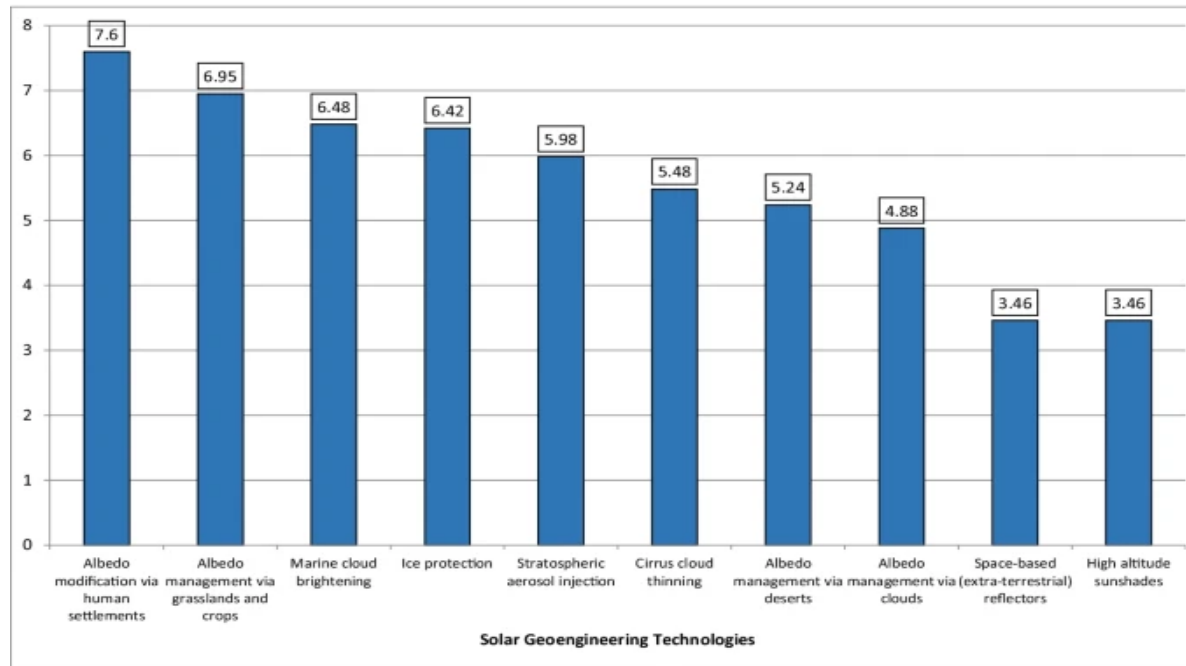
POSSIBLE GEO-ENGINEERING SOLUTIONS

Negative Emissions
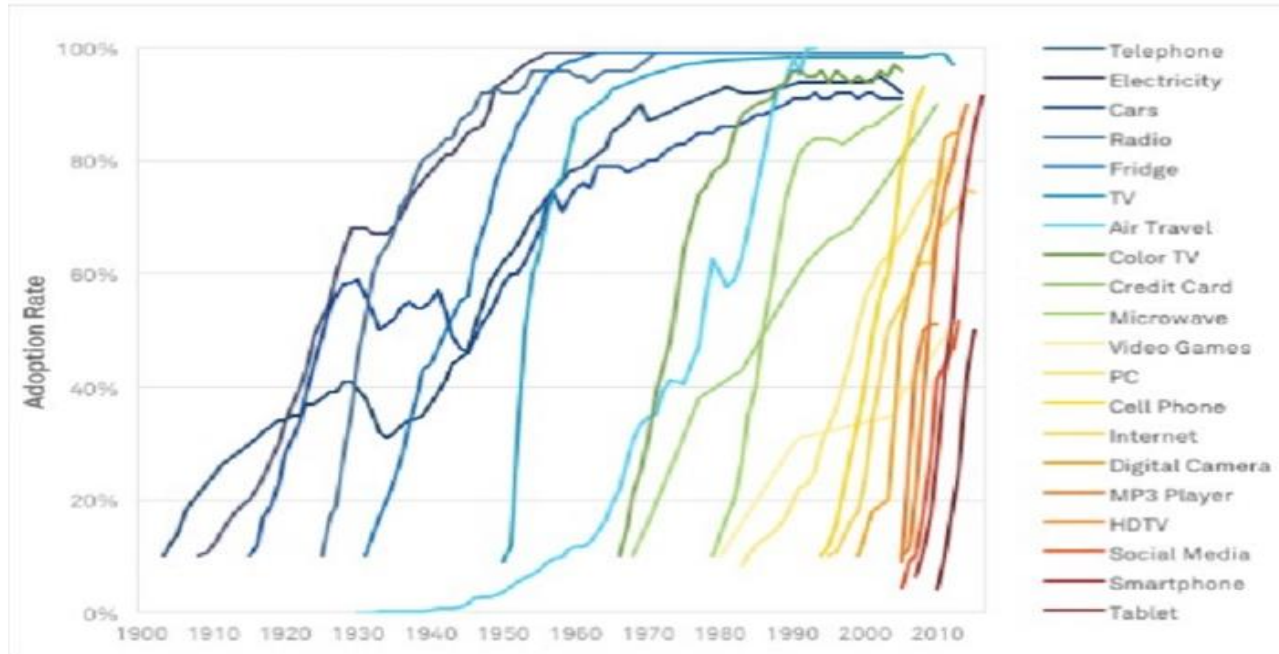Capturing CO2

Solutions rated by experts

Solar
Reflecting Solar radiation Back into space

Questions:
Scalability?
Who pays?
Commercial Opportunity?

WHAT ABOUT TECHNOLOGY TIPPING POINTS?

Technology uptake accelerates as costs fall

Accelerate adaptation of green technology to mitigate climate change?

GREEN TECHNOLOGY & SOCIAL CHANGE

A combination of technology, political, and behavioural change

Technology Solutions

INTERESTS AND INSTITUTIONS

SOCIAL TIPPING DYNAMICS

EXTERNAL SHOCKS

MATERIAL FACTORS

TECHNOLOGICAL TIPPING DYNAMICS

POLITICAL TIPPING DYNAMICS

BEHAVIORAL TIPPING DYNAMICS

IDEAS

Political Support
National & International

Behavioural Change
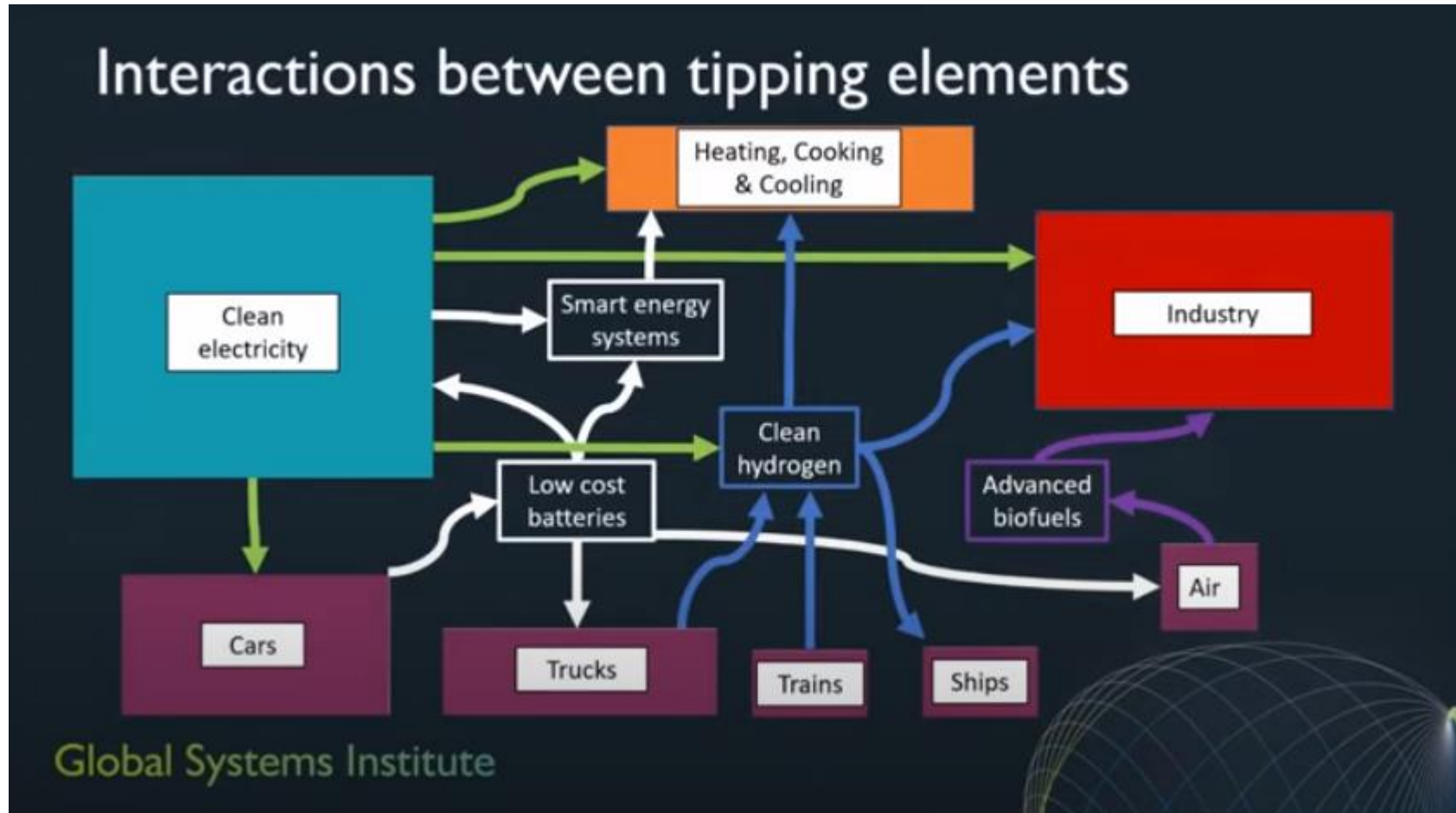Corporates & Individuals
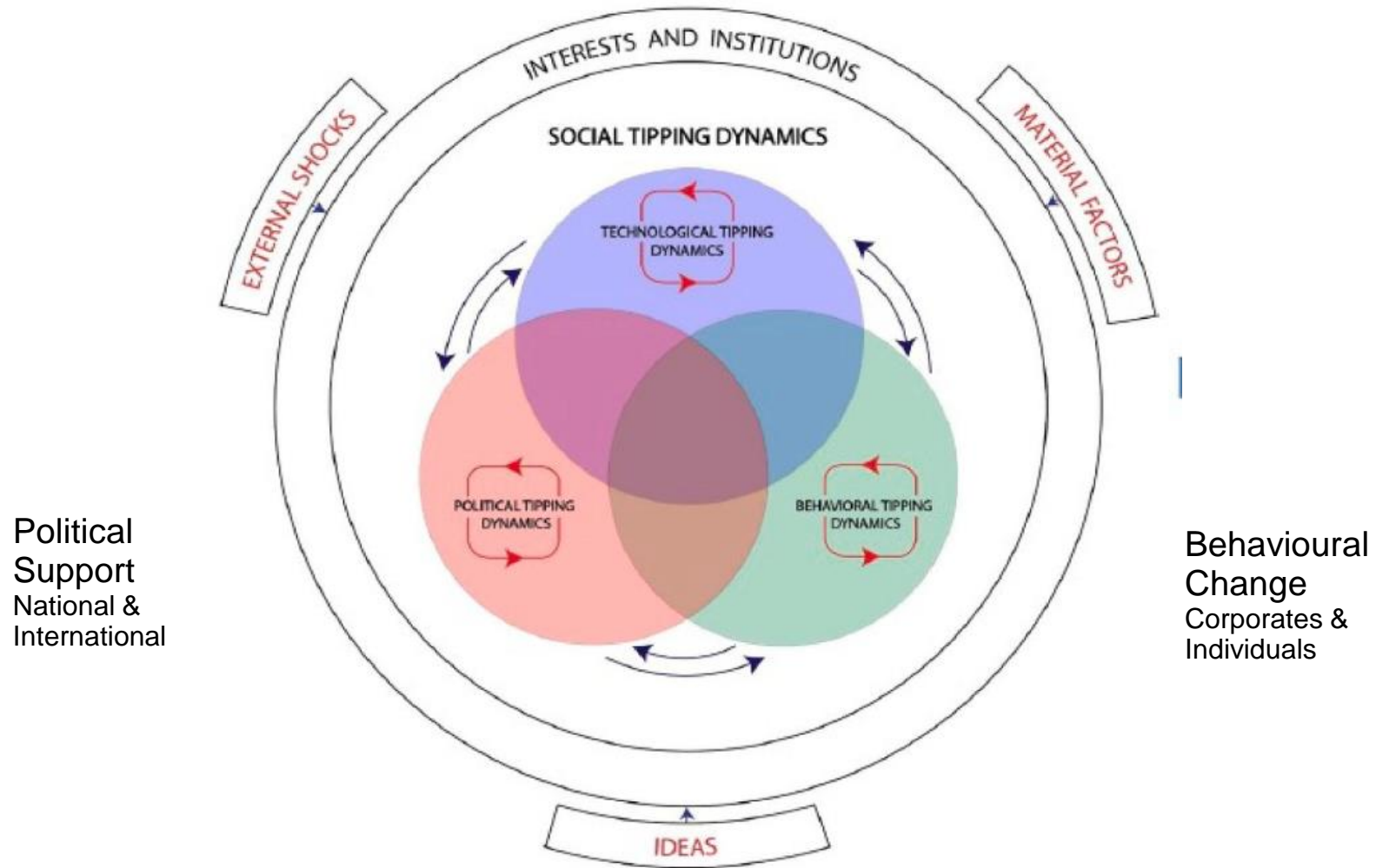
BEHAVIOURAL CHANGE

Average annual carbon footprint by sector
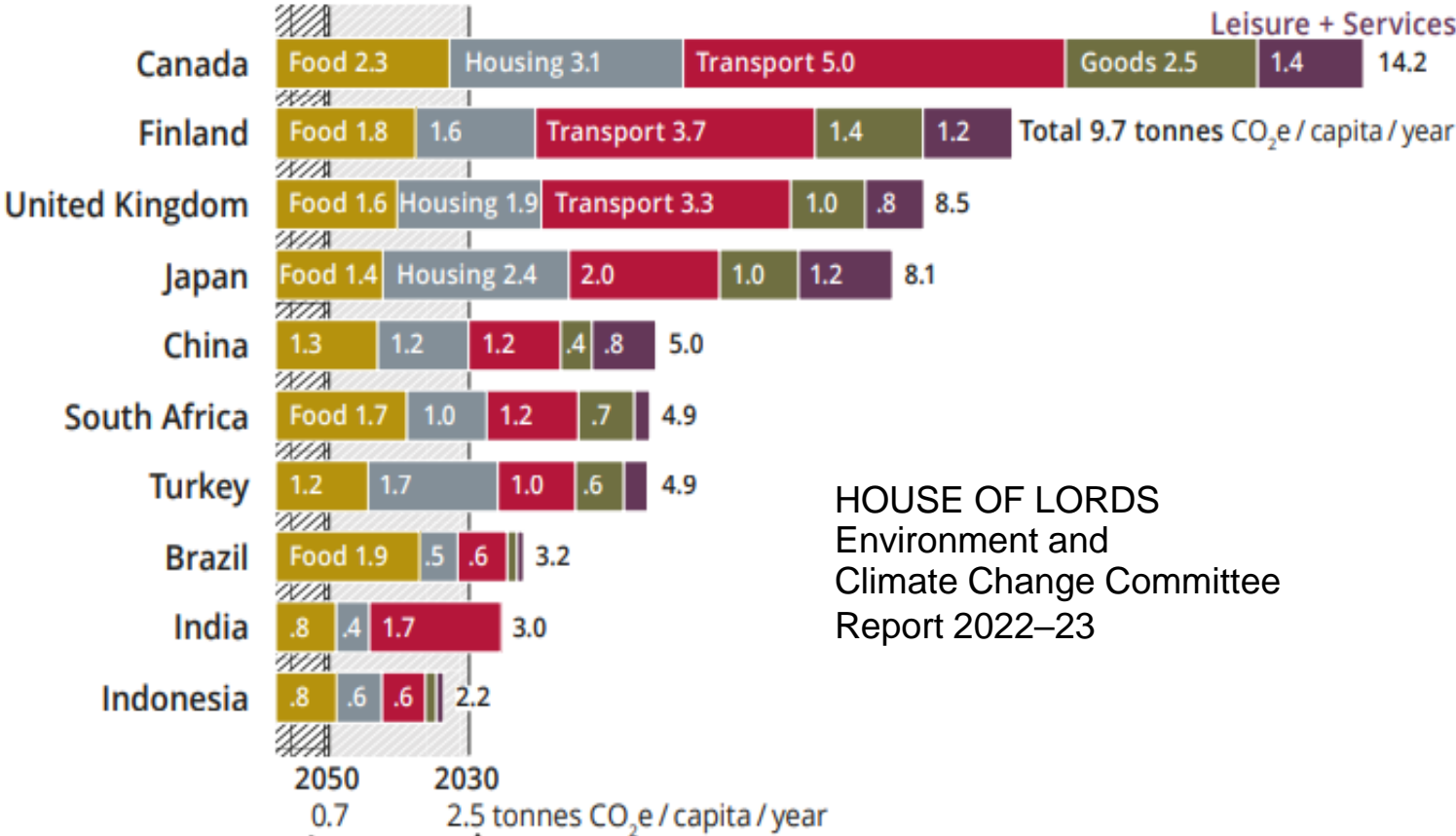
HOUSE OF LORDS
Environment and
Climate Change Committee
Report 2022–23

This is a major challenge - government guidance would help!

TIPPING POINTS ACROSS MULTIPLE SECTORS

Low cost green electricity drives emission reduction across all sectors

LOW CARBON AGRICULTURE
Vertical Farming

Grow food in vertically stacked layers using soil, hydroponic or aeroponic growing methods

Reduced costs, fresher food, increased urban availability, pollution reduction & no chemical use

Crops include lettuce, micro-greens, kale, basil, chives, mint, and strawberries (not rice & corn)
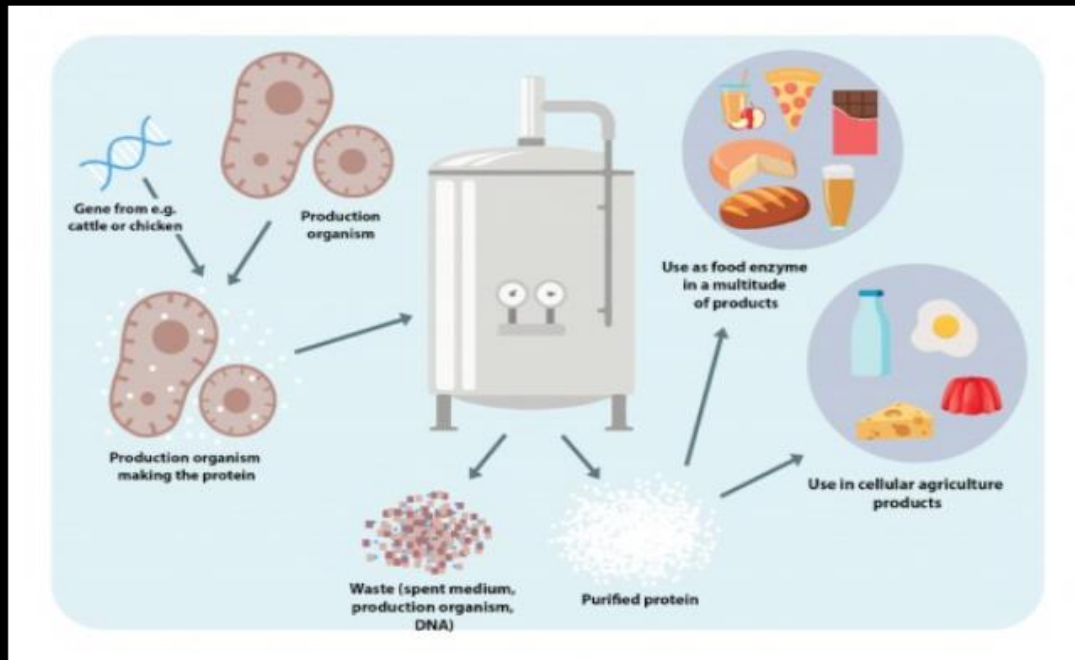
Produce average x500 times tonnes of food per acre as field farms

SYNTHETIC FOOD
Cellular Agriculture

1. Add a Gene from chicken or cattle to a vegetable substrate to produce protein

2. Ferment to produce purified protein

3. Produce a multitude of products

4. More efficient than agriculture but cost needs to reduce (taste, texture & price point)

Precision Fermentation

Gene from e.g. cattle or chicken

Production organism

Production organism making the protein

Waste (spent medium, production organism, DNA)

Purified protein

Use as food enzyme in a multitude of products
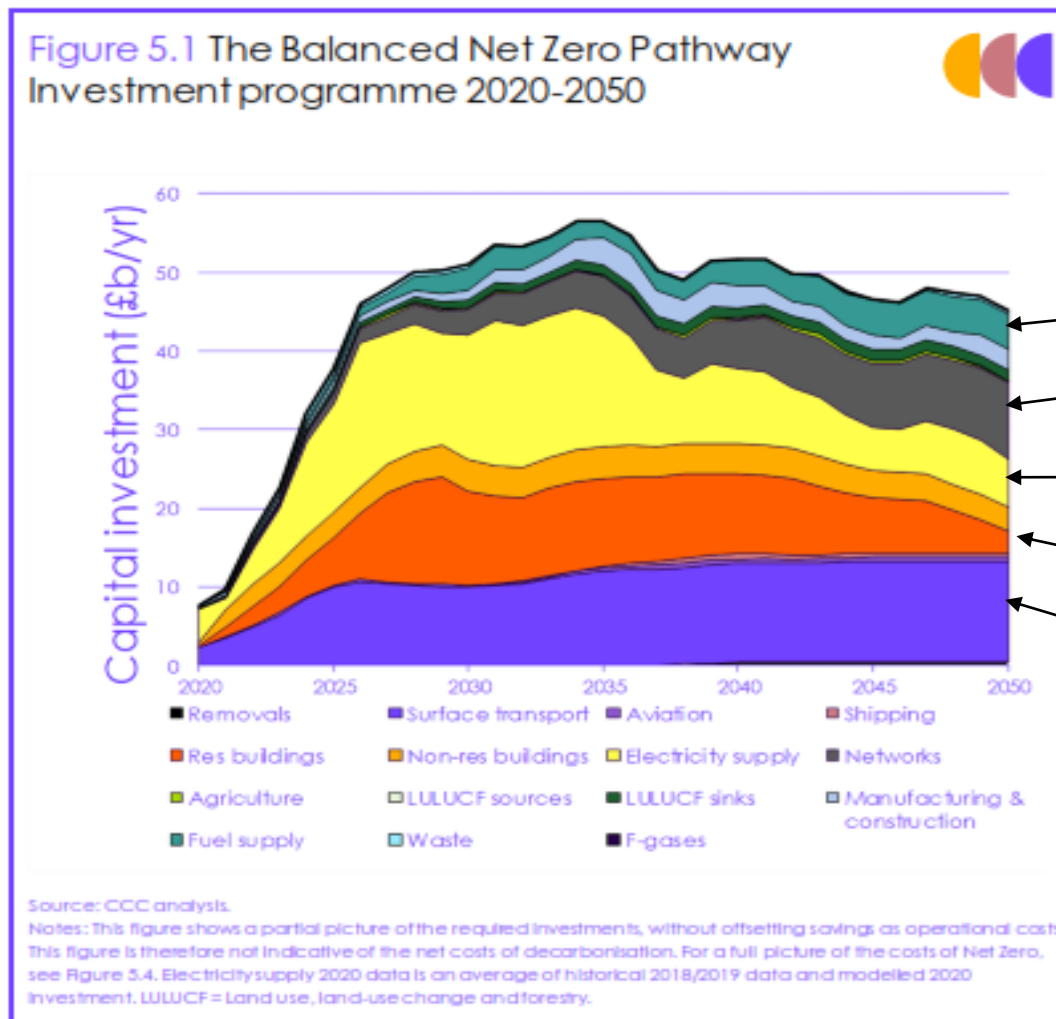
Use in cellular agriculture products

The claim:
- Up to 100 times land efficient
- 10 to 25 times as feedstock efficient
- 20 times as time efficient
- 10 times as water efficient

INVESTMENT NEEDED TO AVOID HOT/WARM HOUSE EARTH?

UK Capital Investment For Net Zero ~ £50 Billion/yr across all Sectors
Government Leadership Needed

Figure 5.1 The Balanced Net Zero Pathway Investment programme 2020-2050

Trees, Bogs

Electricity Networks

Electricity Supply

Buildings

Surface Transport

Source: CCC analysis.

Notes: This figure shows a partial picture of the required investments, without offsetting savings as operational costs. This figure is therefore not indicative of the net costs of decarbonisation. For a full picture of the costs of Net Zero, see Figure 5.4. Electricity supply 2020 data is an average of historical 2018/2019 data and modelled 2020 investment. LULUCF = Land use, land-use change and forestry.

Global investment
£5-10 Trillion/yr

All countries must respond to the challenge