Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

SELFS
Sustainable integrated pathways for carbon-negative energy, land and food systems

Overshoot & implications for national policy

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ENERGY POLICY & MODELLING GROUP

Environmental Research Institute

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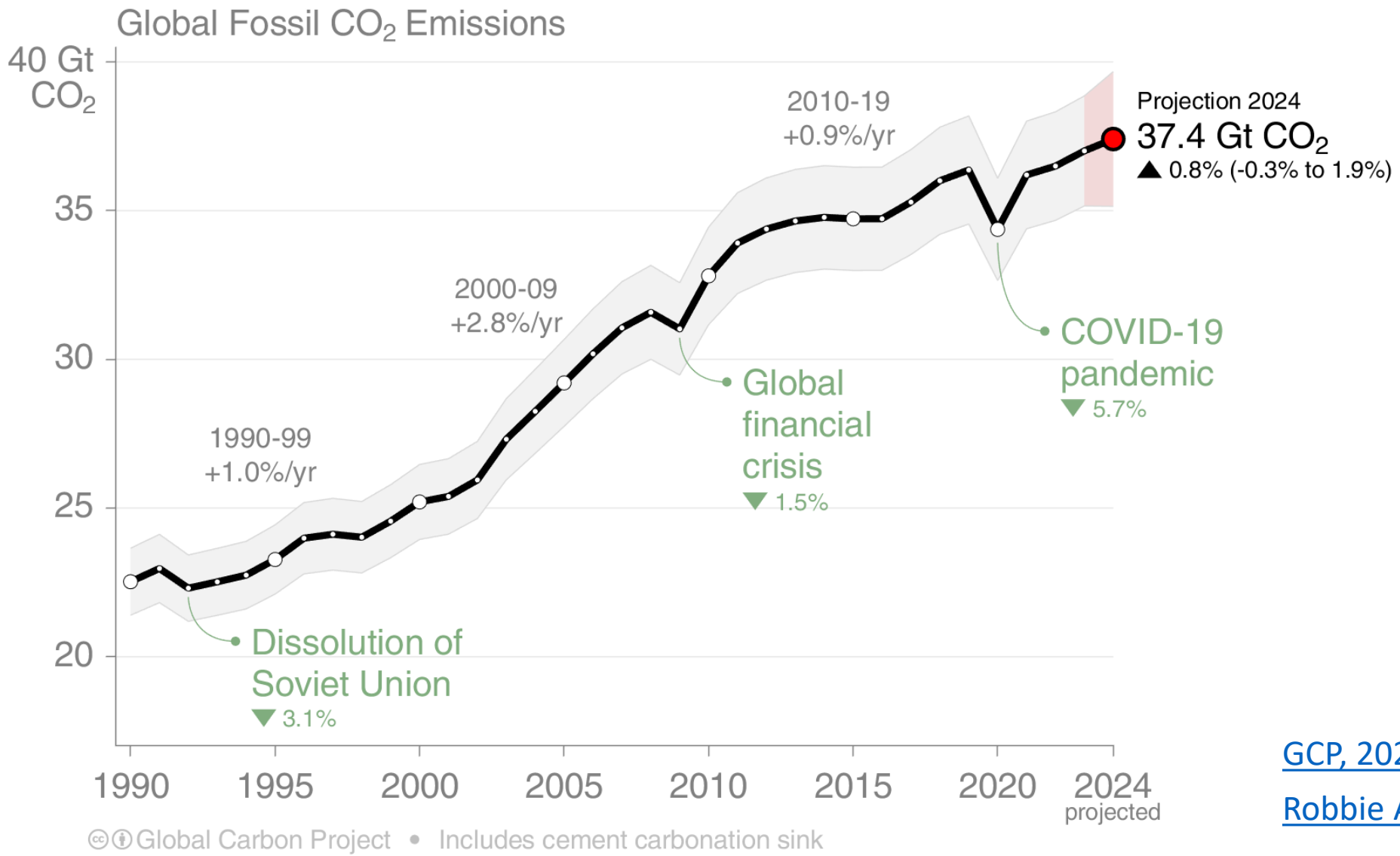
UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

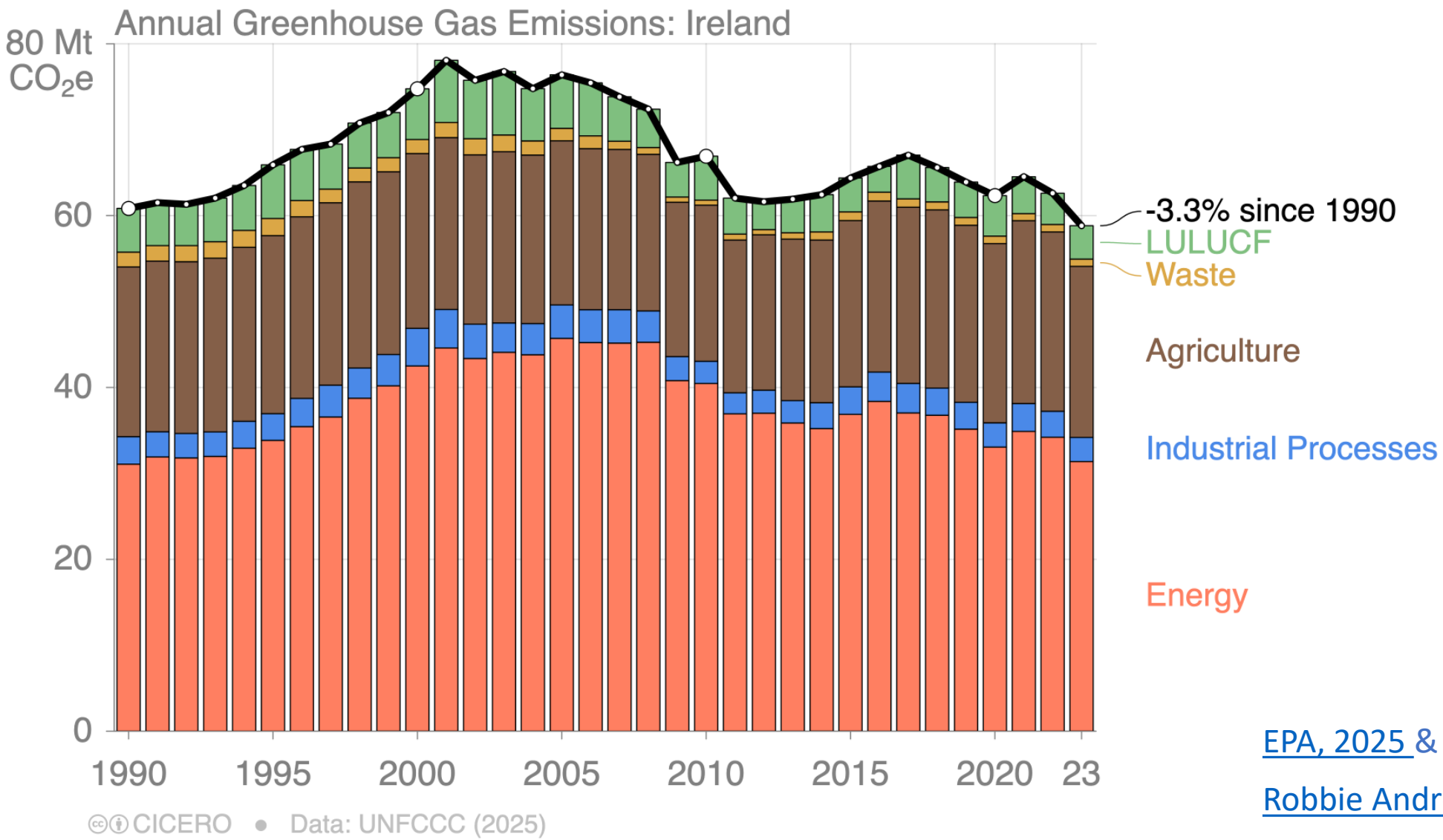
State of play



GCP, 2024 &

Robbie Andrew at CICERO

State of play

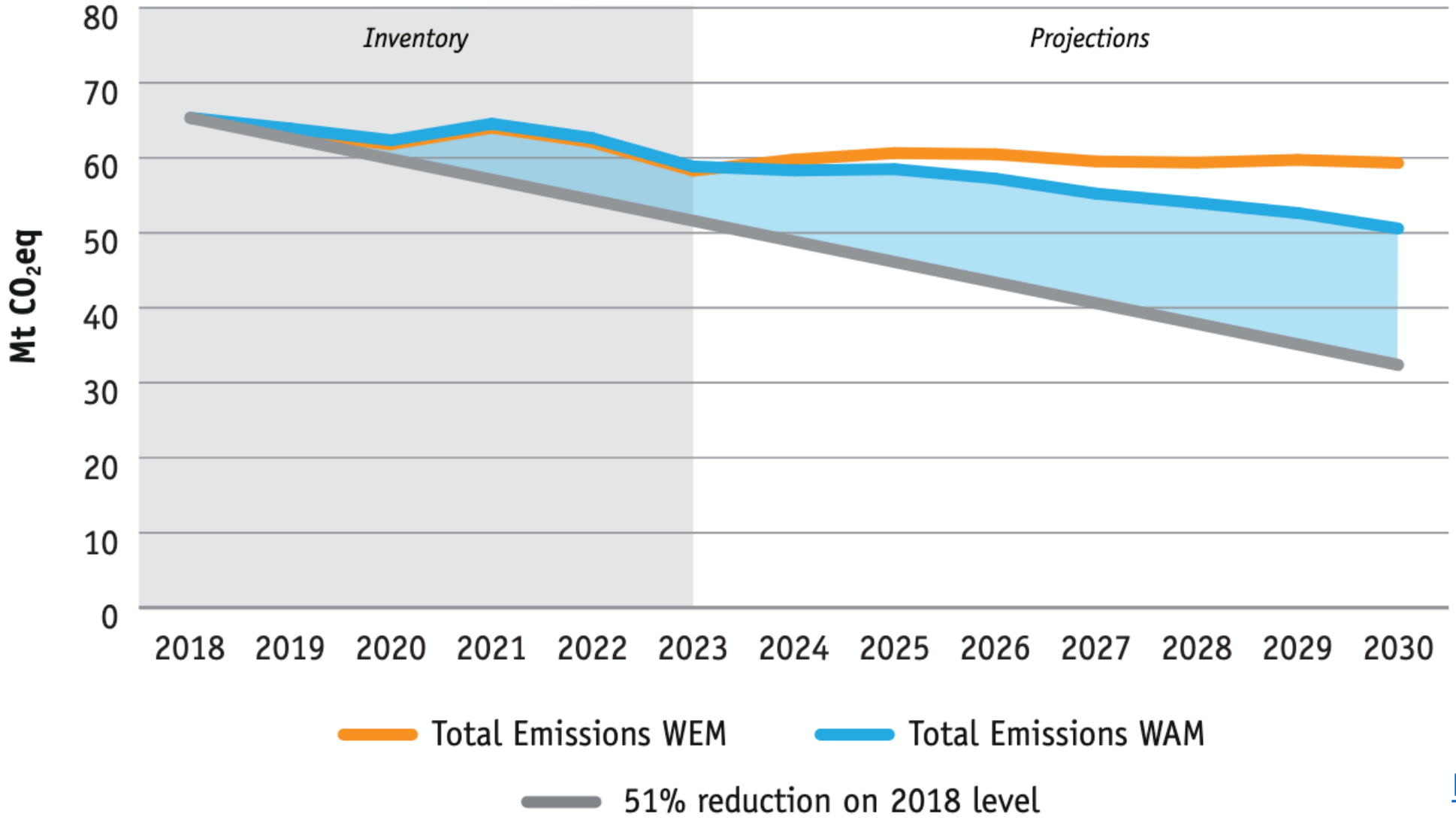


EPA, 2025 &

Robbie Andrew at CICERO

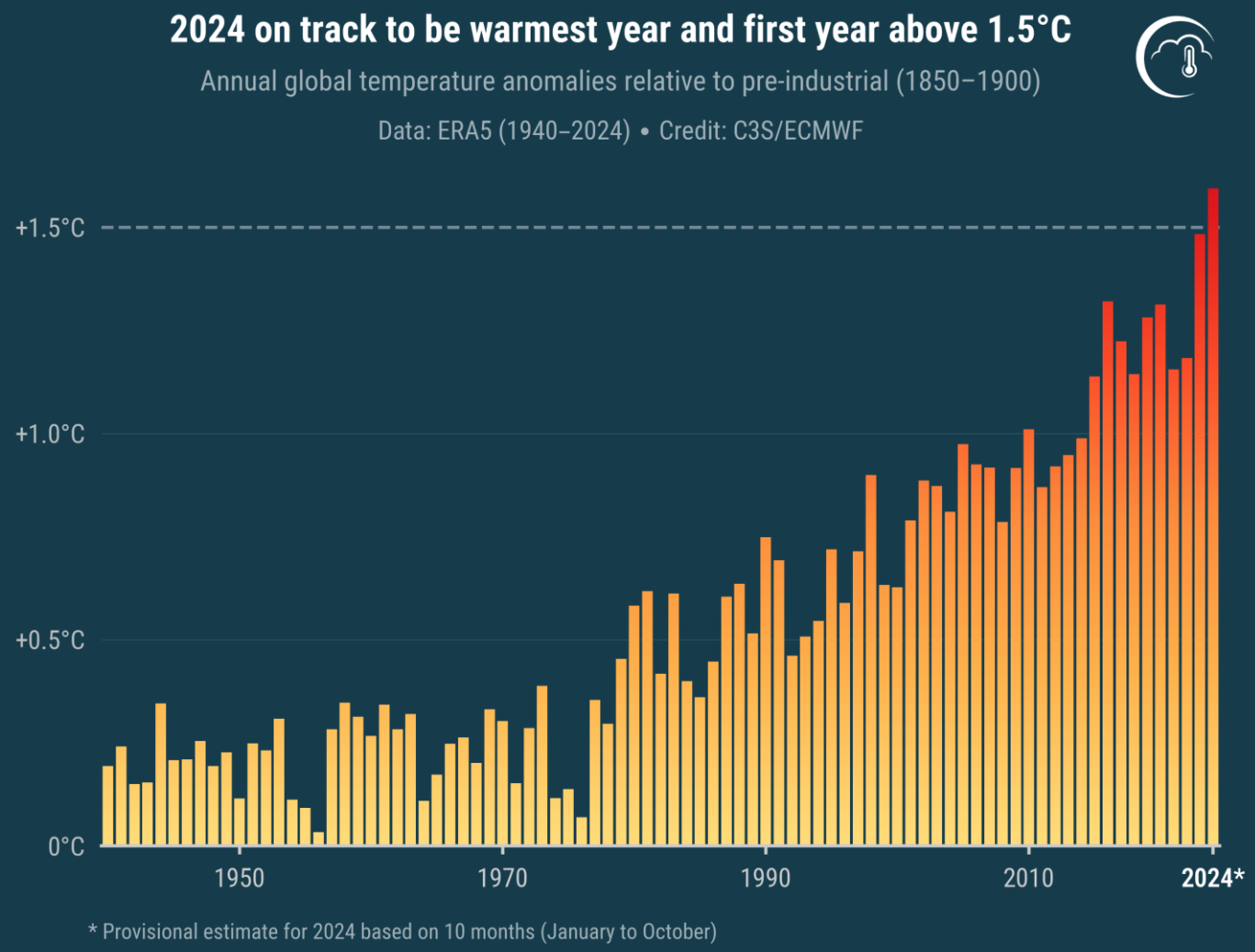
State of play

Annual Greenhouse Gas Emissions: Ireland with LULUCF



EPA, 2025

2024 was the first year above 1.5°C



PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

IMPLEMENTED BY ECMWF

Climate Change Service climate.copernicus.eu

C3S/ECMWF

Have we breeched 1.5°C?

Within this sea of numbers, have we crossed 1.5° C already or is it inevitable? We currently lack clear definitions of what crossing 1.5°C means (Betts et al., 2023), but the day that we are splitting hairs over whether 1.5°C has been crossed, is essentially the day it has been crossed.

–Peters 2024

Next best option–temporary overshoot

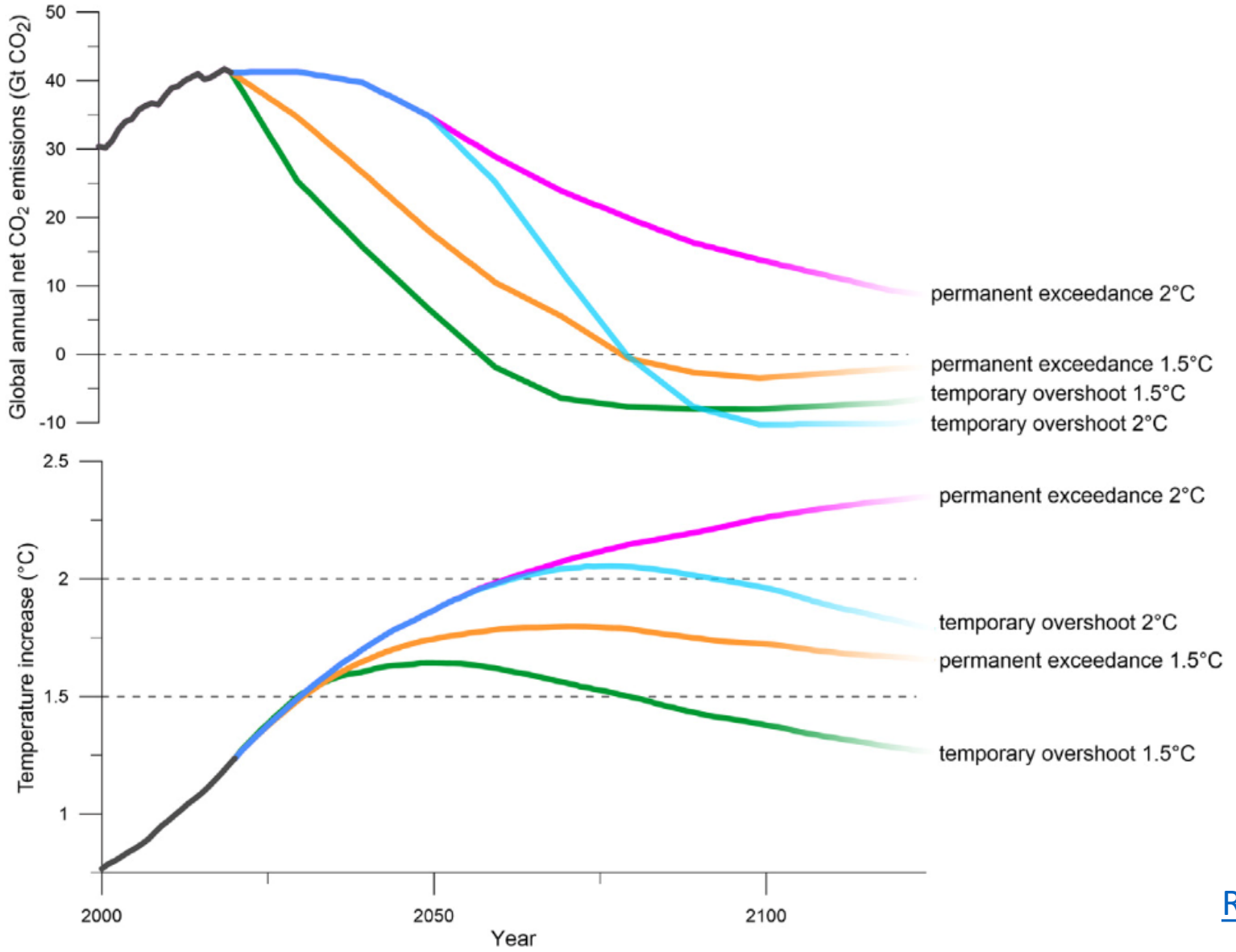
‘temperature trajectories that exceed a specified global warming level and subsequently decline again below that level as temporary overshoot pathways.’

–Reisinger & Geden 2023

IPCC’s terminology

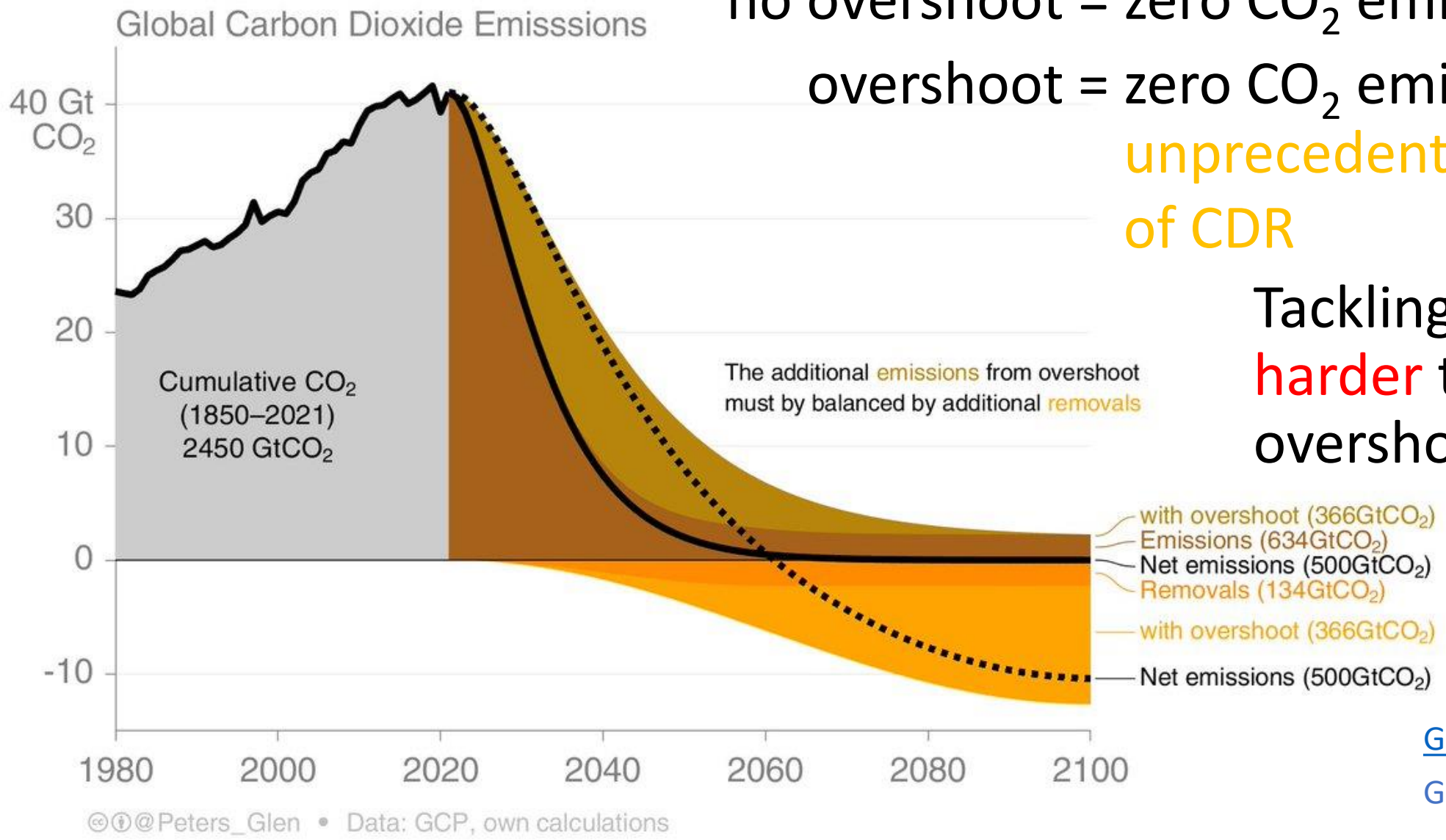
- uses ‘overshoot’ and defines this as only temporary

Next best option–temporary overshoot



Reisinger & Geden 2023

Balancing emissions and removals



no overshoot = zero CO_2 emissions

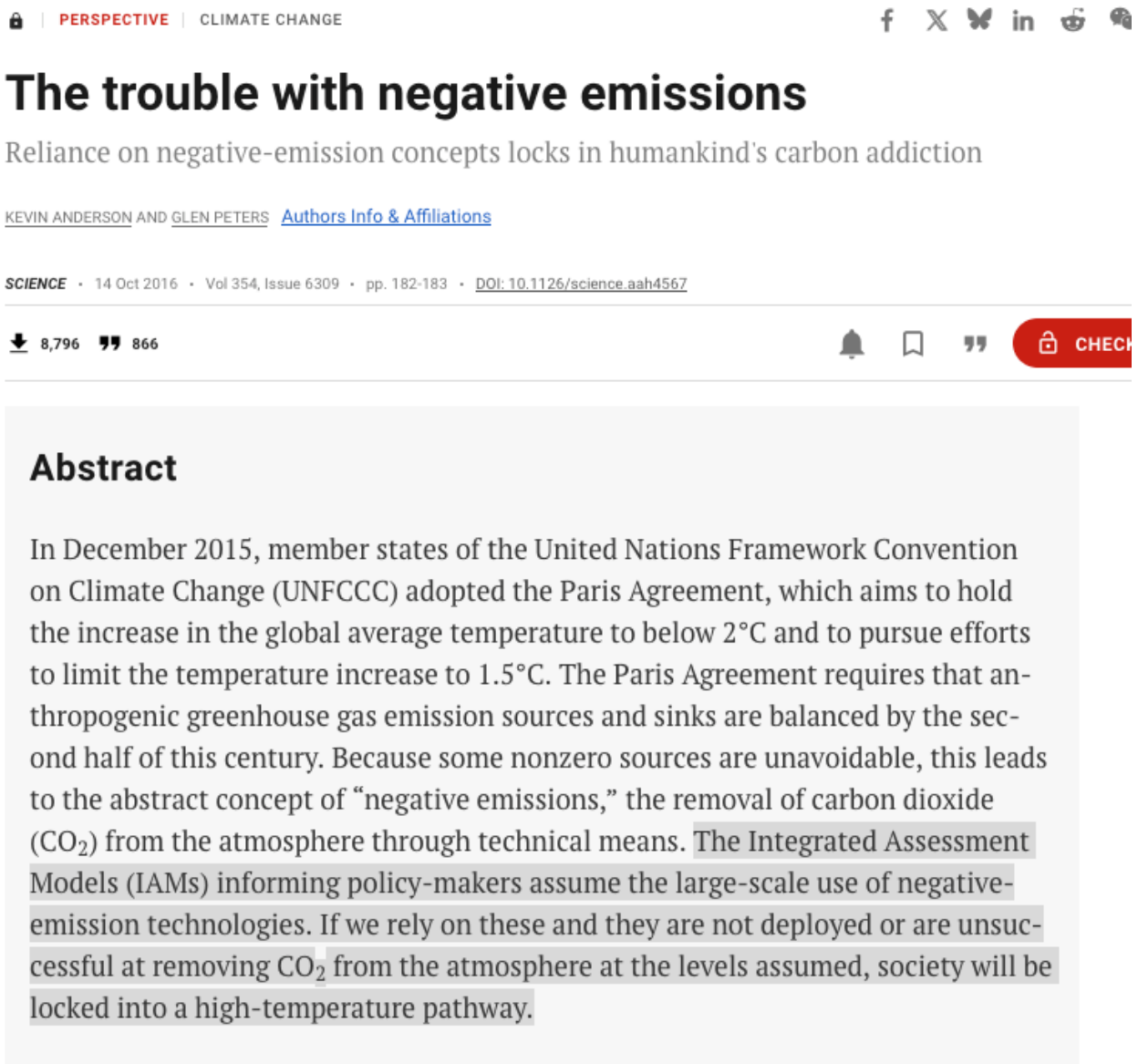
overshoot = zero CO_2 emissions + unprecedented amounts of CDR

Tackling overshoot is harder than no overshoot!!

GCP, 2024 &

Glen Peters at CICERO

Over reliance on carbon dioxide removal



PERSPECTIVE | CLIMATE CHANGE

The trouble with negative emissions

Reliance on negative-emission concepts locks in humankind's carbon addiction

KEVIN ANDERSON AND GLEN PETERS Authors Info & Affiliations

SCIENCE · 14 Oct 2016 · Vol 354, Issue 6309 · pp. 182-183 · DOI: 10.1126/science.aah4567

8,796 866

Abstract

In December 2015, member states of the United Nations Framework Convention on Climate Change (UNFCCC) adopted the Paris Agreement, which aims to hold the increase in the global average temperature to below 2°C and to pursue efforts to limit the temperature increase to 1.5°C. The Paris Agreement requires that anthropogenic greenhouse gas emission sources and sinks are balanced by the second half of this century. Because some nonzero sources are unavoidable, this leads to the abstract concept of "negative emissions," the removal of carbon dioxide (CO_2) from the atmosphere through technical means. The Integrated Assessment Models (IAMs) informing policy-makers assume the large-scale use of negative-emission technologies. If we rely on these and they are not deployed or are unsuccessful at removing CO_2 from the atmosphere at the levels assumed, society will be locked into a high-temperature pathway.

Anderson & Peters 2016

Over estimation of reforestation potential

nature communications

Article

https://doi.org/10.1038/s41467-025-59799-8

Addressing critiques refines global estimates of reforestation potential for climate change mitigation

Received: 12 June 2024

Accepted: 4 May 2025

Published online: 11 June 2025

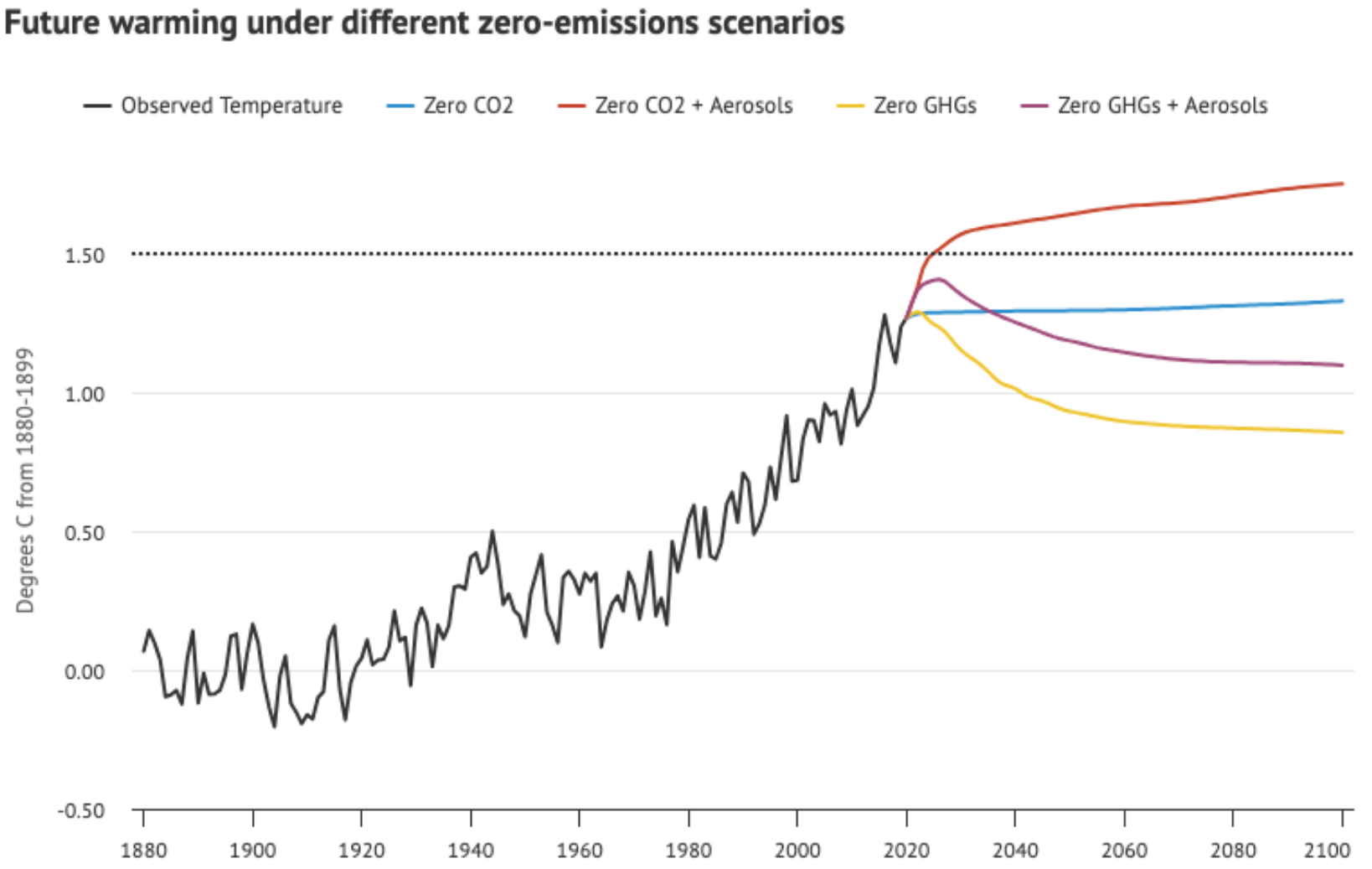
Check for updates

Kurt A. Fesenmyer[1], Erin E. Poor[2], Drew E. Terasaki Hart[3,4], Joseph W. Veldman[5], Forrest Fleischman[6], Pooja Choksi[6], Sally Archibald[7], Mohammed Armani[8], Matthew E. Fagan[9], Evan C. Fricke[10], César Terrer[10], Natalia Hasler[11], Christopher A. Williams[12], Peter W. Ellis[13] & Susan C. Cook-Patton[3]

Reforestation is a prominent climate change mitigation strategy, but available global maps of reforestation potential are widely criticized and highly variable, which limits their ability to provide robust estimates of both the locations and

Fresenmyer et al 2025

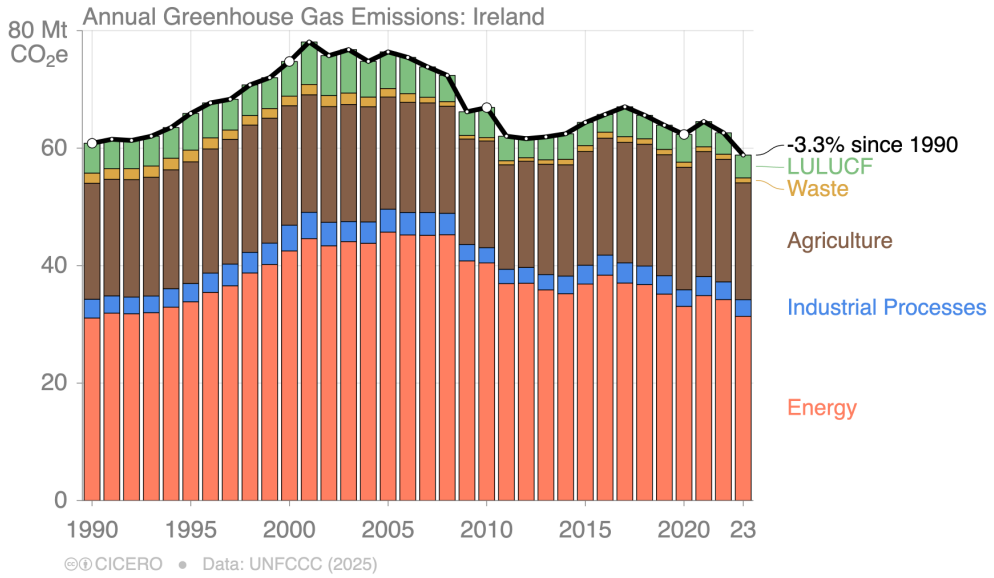
Net-zero GHGs = peak and decline



CB

Carbon Brief 2021

What is clear…



- small, high income country
- high fossil fuel dependence
- high per capita methane emissions << ruminant agriculture for export

- exploitation of peatlands & poorly planted forests << LULUCF is a source
- likely to exceed committed carbon budgets (2021-2030)

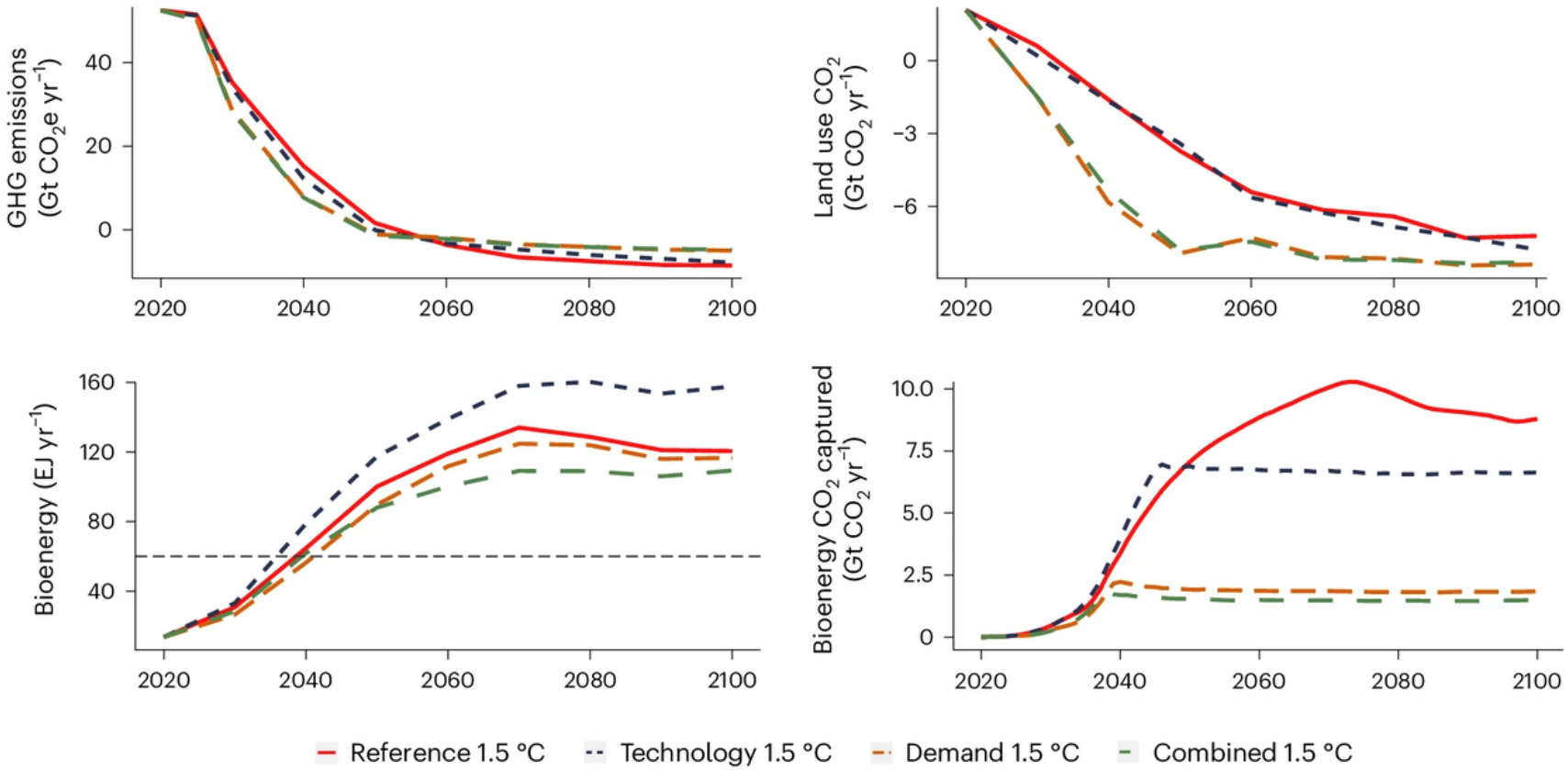
» faster, deeper mitigation

» removals to balance ‘residuals’ + additional emissions from overshoot

What remains to be explored…

Fig. 5: Global GHG emissions, land-use CO_2 emissions, bioenergy use and BECCS.

From: Reducing sectoral hard-to-abate emissions to limit reliance on carbon dioxide removal



The lines refer the SSP2-based scenarios; SSP1 is shown in the Extended Data Fig. 4. For SSP3, the 1.5 °C target is not reached in any of the scenarios and therefore not shown. In all scenarios, annual crop-based bioenergy stays below the sustainable level of 60 EJ yr^{-1}, as identified by Fuss et al.[38], based on ecological and biophysical concerns. However, total bioenergy use exceeds 60 EJ yr^{-1} as it includes residue use, which does not require additional land[46,47].

Edelenbosch et al 2024

Reductions & CDR options across systems

FOOD

Dietary change
Novel proteins
Agri technologies

LAND

Afforestation / reforestation
Peatland restoration
Biochar
Crops for biofuels

ENERGY

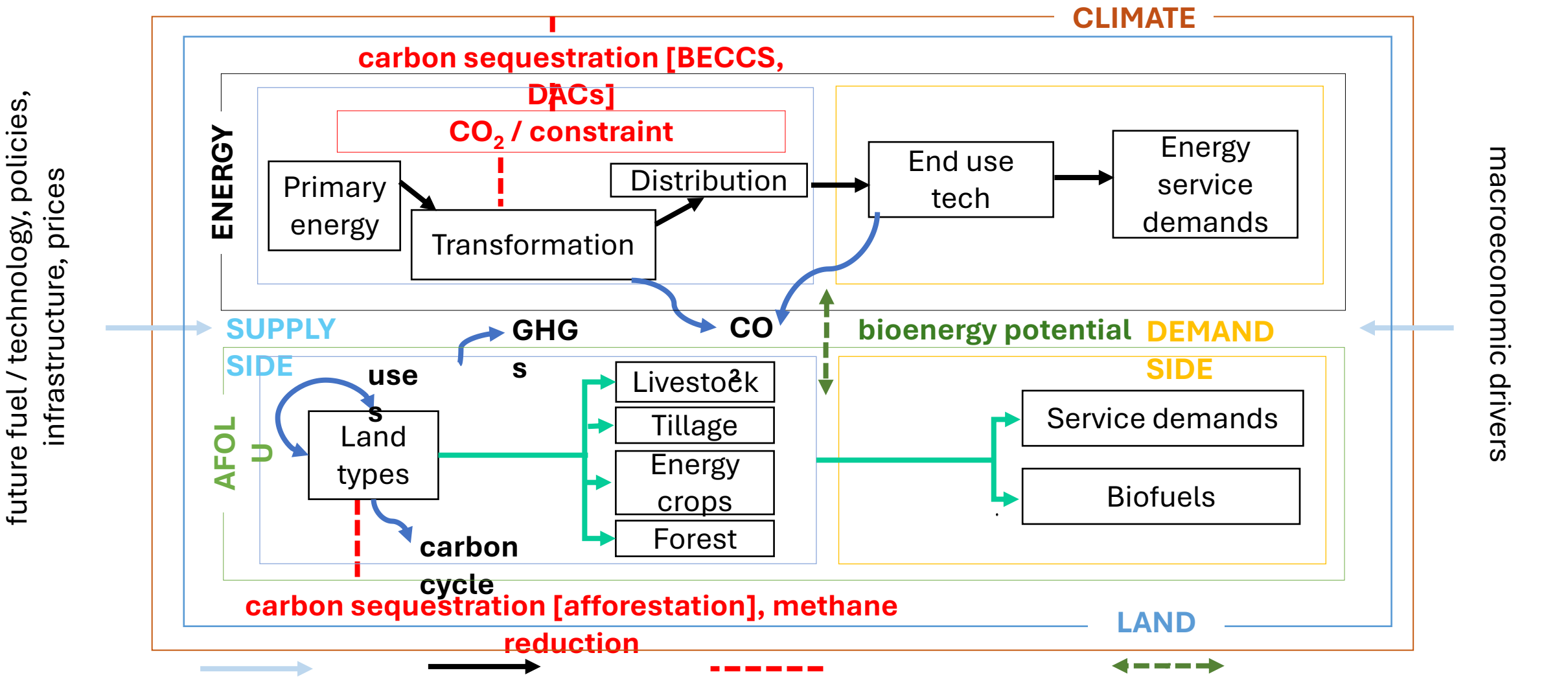
Renewables
Batteries
Electro-fuels
Bioenergy
Biomass with CCS
Direct air capture with CCS
Low energy demand

NATURE

Space for nature

Increasing interaction and interdependencies are not captured in current suite of modelling tools

SELFS: towards an integrated model



Balyk et al 2022 &
Chiodi et al 2016

Aims of SELFS

- Build an integrated model of energy, food and land systems at country level
- Explore the potential and limits of carbon dioxide removal towards 2050 and beyond
- Better understand
  - how powerful levers e.g. dietary change, bioenergy, BECCS, afforestation & low energy demand can be used to enhance reductions and removals
  - Interactions and interdependencies
- What do longer-term limits on removals mean for emissions reductions in the near-term? More reductions ASAP?
- How do we incorporate fairness? Equitable carbon budgets, equitable carbon dioxide removals?

Major references

Reisinger & Geden 2023 Temporary overshoot: Origins, prospects, and a long path ahead. *One Earth*

Peters 2024 Is limiting the temperature increase to 1.5°C still possible? *Dialogues on Climate Change*

Tavoni et al in preparation Futures of overshoot: implications for climate pathways and mitigation strategies

Thank you to SELFS PhD student Neha Jaggeshar for her work on developing the integrated model.

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Questions

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https://www.ucc.ie/en/epmg/research/selfs/

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