Science matters - debunking some myths

Science insights into aviation climate action strategies: NZE, carbon offsets and bio-fuel feedstocks

Aviation Reimagined 2023 webinar series

Session 1: Science matters - debunking some myths

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Shaping a climate ready future

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Overview

- The science-policy gap
- The mitigation gap
- The mitigation imperative
- NZE (what does this mean?)
- Land-based carbon offsets issues
- Problems with & limitations of biological feedstocks for SAF
- The way forward?

Sets the context for aviation emissions

Proposed solutions for the aviation sector

The science -policy gap

United Nations Climate Change

- **Overarching goal** is hold “the increase in the global average temperature to well below 2°C above pre-industrial levels” and pursue efforts “ to limit the temperature increase to 1.5°C above pre-industrial levels”
- Recent COPs have stressed the need to limit global warming to 1.5°C by the end of this century.
- Because IPCC warns that crossing the 1.5°C threshold risks unleashing far more severe climate change impacts and crossing thresholds that lead to irreversible impacts and Earth system tipping points

Nationally Determined Contributions (NDCs)

countries communicate actions they will take to reduce their greenhouse gas emissions in order to reach the goals of the Paris Agreement

Global stocktake

held every five years and is intended to inform the next round of nationally determined contributions to be put forward by 2025.

The science-policy decision making process

- Climate policy is developed through political negotiation, at the international level through consensus decision making
- Then, climate policy is interpretated and implemented by governments at all levels, business, and civil society
- IPCC advises on what the science tell us we need to be doing to doing to meet Paris Agreement mitigation goal and targets
- But, a gap exists between the *realpolitik* of climate negotiations and the *realecologik* of climate science
- The gap is arguably in part wilful ignorance, but also from the science being “lost in translation” which is an ”unintended, good faith” outcome
- So, for aviation sector, some climate implementation policies are not well-grounded in science and some proposed solutions are leaky at best, due to the science-policy gap

The mitigation gap

The mitigation gap revealed by global stocktake

IPCC assessment of emissions reduction to limit global warming to 1.5°C:

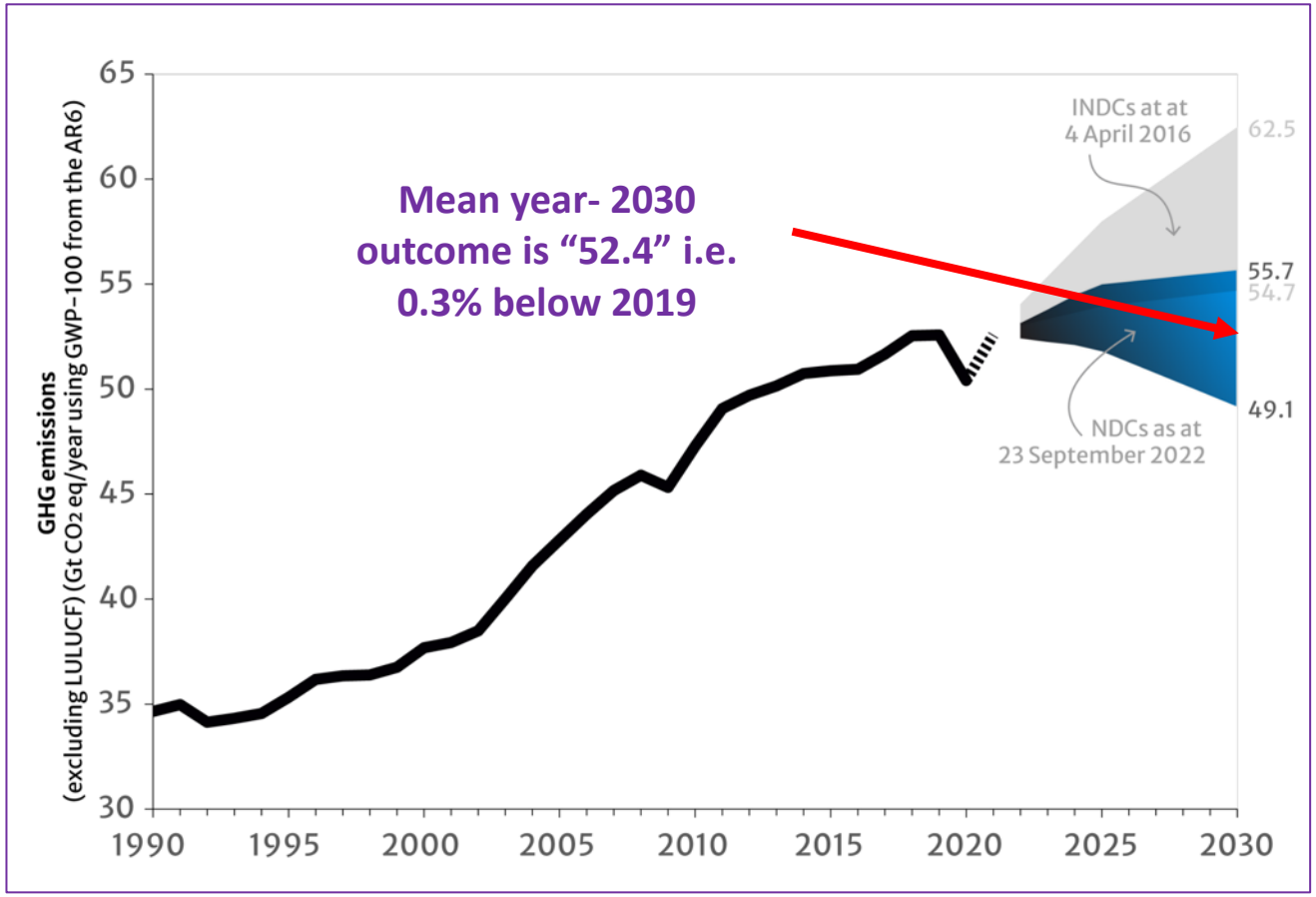
- reduce global GHG emissions by 43% by 2030
- further by 60% by 2035 compared with 2019 levels
- reach net zero CO_2 emissions by 2050 globally

- Full implementation of all latest NDCs (including all conditional elements) is estimated to lead to a 3.6 (0.7–6.6) per cent emission reduction by 2030 relative to the 2019 level

- Implementation of all latest NDCs excluding any conditional elements is estimated to result in 3.1 (0.2–6.0) per cent higher emissions in 2030 than in 2019*

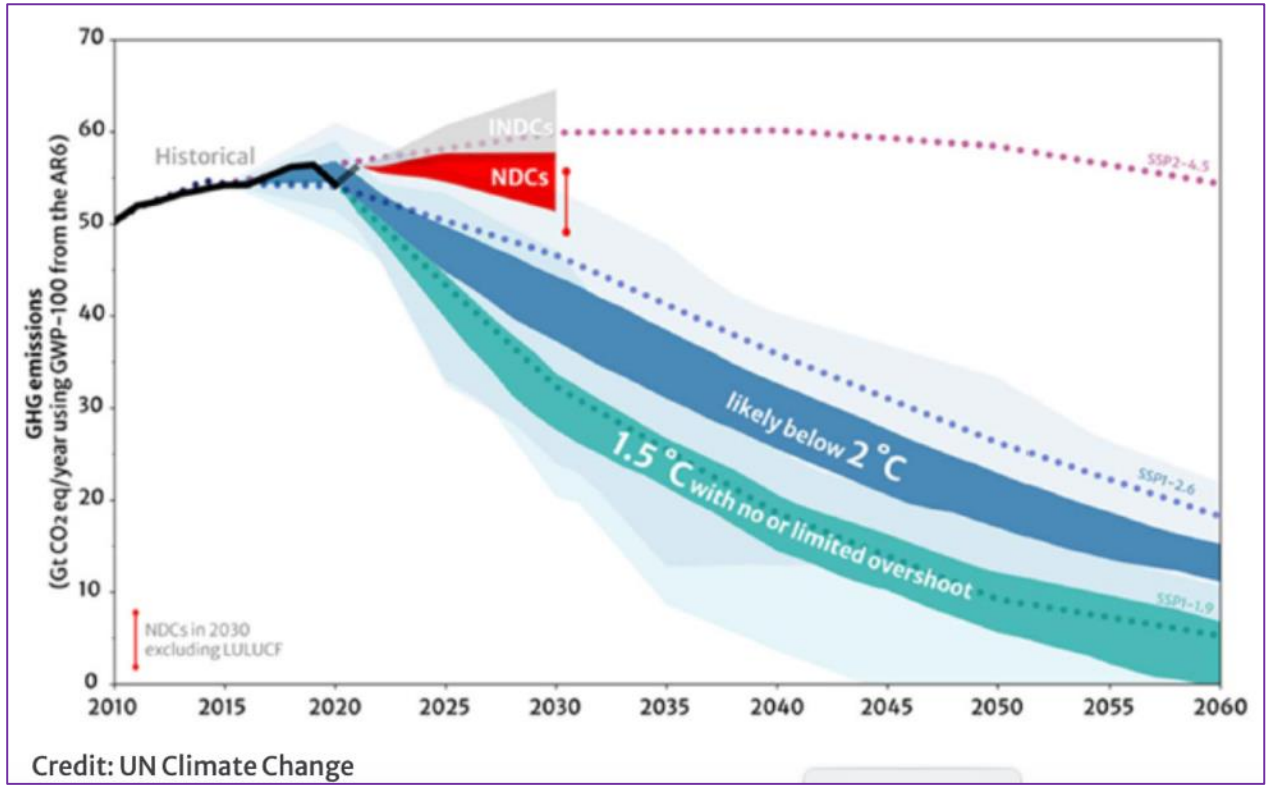
*over 80% of the NDC are attached to international financial and technical support

Projected total global GHG emissions (without LULUCF) taking into account implementation of the latest NDCs



https://unfccc.int/ndc-synthesis-report-2022#Targets

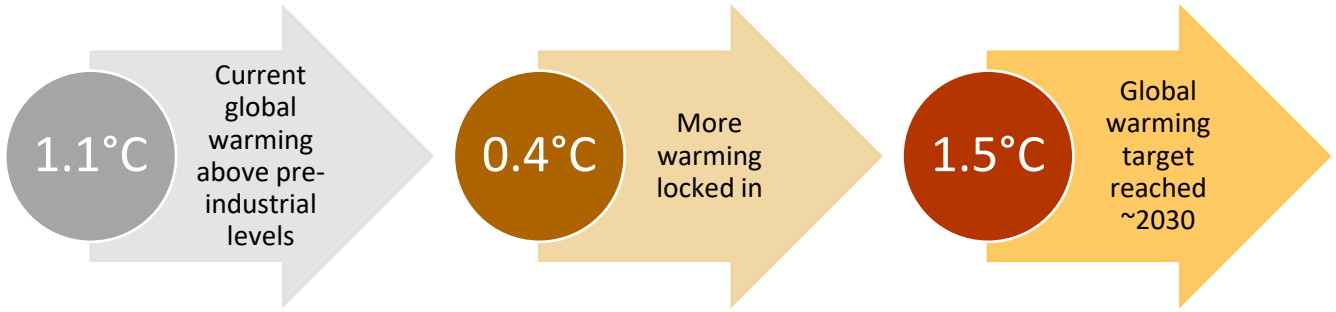
The mitigation gap will yield “catastrophic, irreversible” climate change



Credit: UN Climate Change

- Based on projected NDC outcomes, peak temperature for 2100 is ~2.1–2.9 °C
- Given carbon budget for limiting warming to 1.5 °C (500 Gt CO2, 50% likelihood), cumulative CO_2 emissions in 2020–2030 would use 86% of remaining carbon budget
- Leaving a post-2030 carbon budget of ~70 Gt CO_2, which is equivalent to approximately two years of projected total global CO_2 emissions

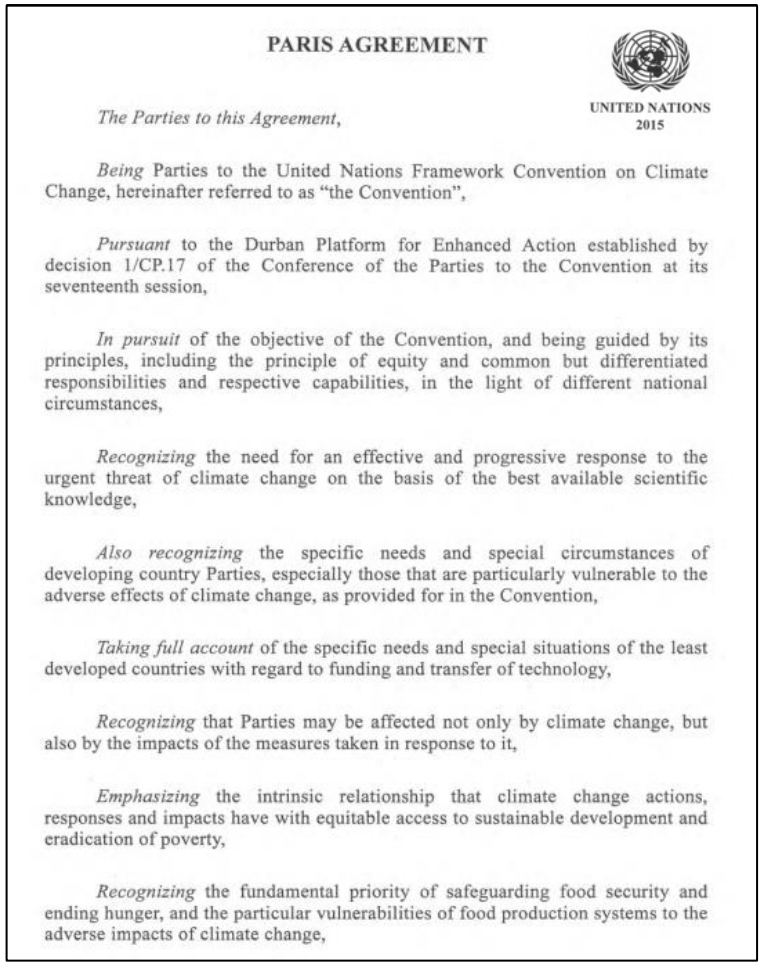
The mitigation imperative



- Fossil-fuel dependent sectors such as aviation are facing pressure to contribute fairly to the goal of limiting the temperature increase to 1.5 °C
- The International Civil Aviation Organization (ICAO, 2022a) has adopted a long-term global aspirational goal (LTAG) for international aviation of net-zero carbon emissions by 2050
- Various pathways proposed to achieve NZE goal including using carbon offsets and SAF


NZE

NZE has both scientific and social-political meanings



PARIS AGREEMENT

UNITED NATIONS
2015

The Parties to this Agreement,

Being Parties to the United Nations Framework Convention on Climate Change, hereinafter referred to as "the Convention",

Pursuant to the Durban Platform for Enhanced Action established by decision 1/CP.17 of the Conference of the Parties to the Convention at its seventeenth session,

In pursuit of the objective of the Convention, and being guided by its principles, including the principle of equity and common but differentiated responsibilities and respective capabilities, in the light of different national circumstances,

Recognizing the need for an effective and progressive response to the urgent threat of climate change on the basis of the best available scientific knowledge,

Also recognizing the specific needs and special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change, as provided for in the Convention,

Taking full account of the specific needs and special situations of the least developed countries with regard to funding and transfer of technology,

Recognizing that Parties may be affected not only by climate change, but also by the impacts of the measures taken in response to it,

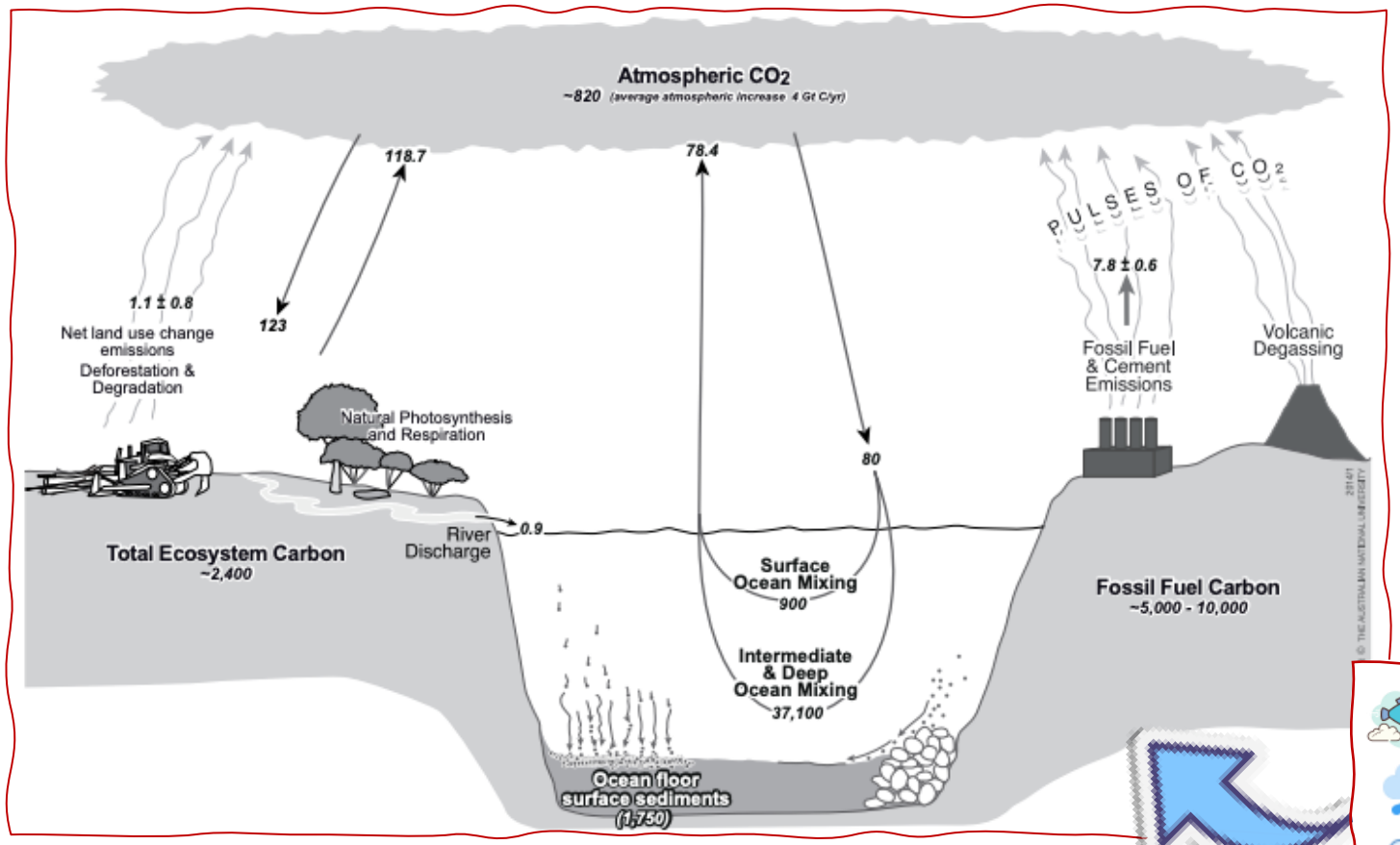
Emphasizing the intrinsic relationship that climate change actions, responses and impacts have with equitable access to sustainable development and eradication of poverty,

Recognizing the fundamental priority of safeguarding food security and ending hunger, and the particular vulnerabilities of food production systems to the adverse impacts of climate change,

The basis for NZE is articulated in Article 4.1 of the Paris Agreement

In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to *undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century*, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty.

The global carbon cycle (simplified)



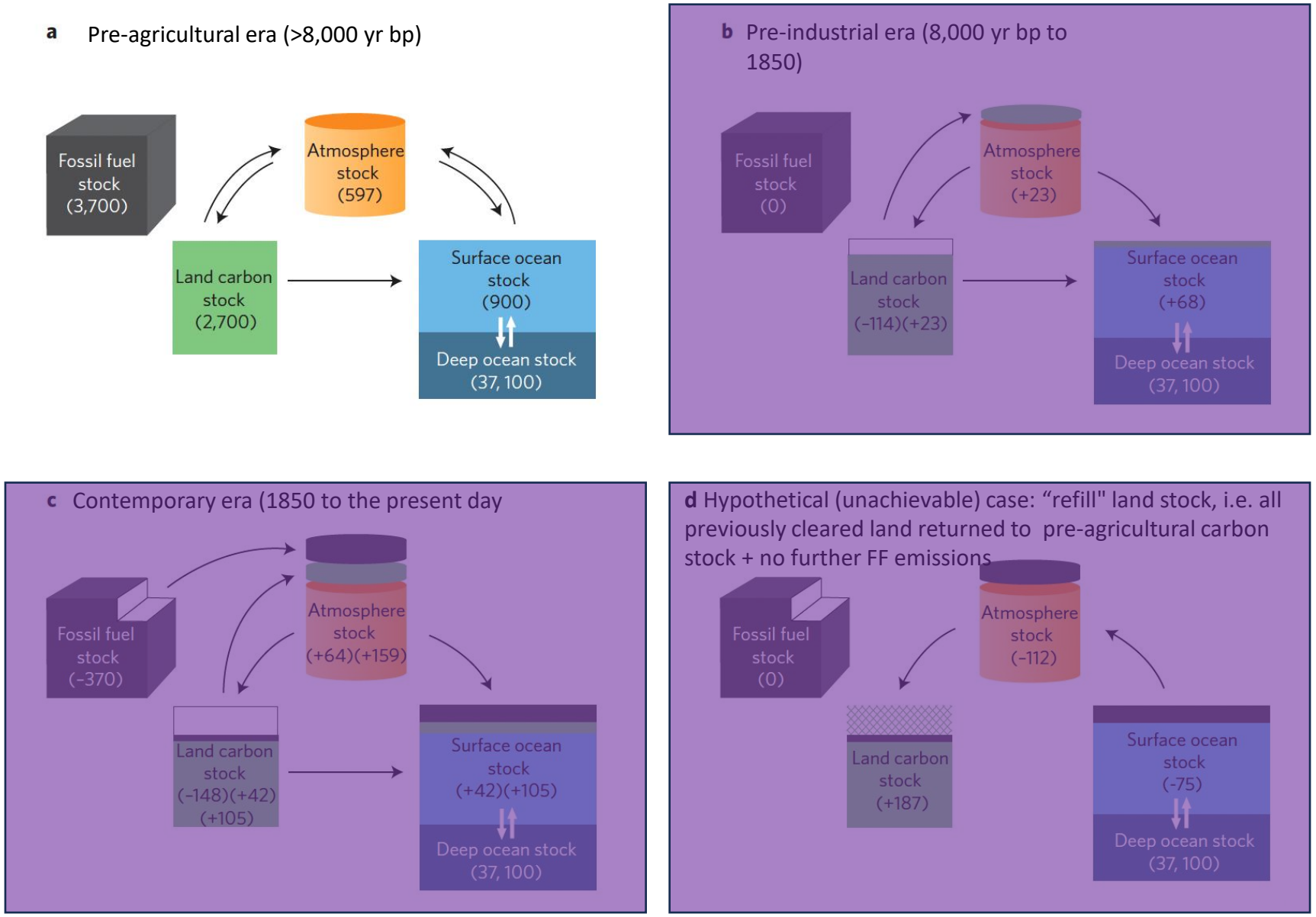
- The numbers represent
- the stock of carbon in the major pools – the atmosphere; terrestrial ecosystems (land carbon); and the ocean (usually depicted as “shallow” and deep” sub-pools plus ocean floor surface sediment which includes the products of weathering and deposition of dead marine biomass) – in billions of tonnes of carbon; and
- annual carbon exchange fluxes in billions of tonnes of carbon per year.
- The numbers associated with the arrows indicate the exchange fluxes between the major pools.

The values are consistent with the IPCC’s 2013 report

- ☆ Biotic-pump
- ☆ Weathering of rock
- ☆ Deposition dead organic matter
- ☆ Sedimentation

Source: Mackey (2014) *Significance.* ww.significancemagazine.org. February 19-23

Human perturbation of global carbon cycle



Source: Mackey et al 2013 Nature Climate Change DOI: 10.1038/NCLIMATE1804

NZE Scientific meaning

○ In the natural global C-cycle

➠ the only sinks were terrestrial ecosystems and the oceans
➠ the only flows were between ecosystems-atmosphere, ocean-atmosphere, and ecosystems-ocean
➠ there was no de-gassing from fossil fuel reserves
➠ there was natural degassing from volcanic activity (including deep ocean ridges)

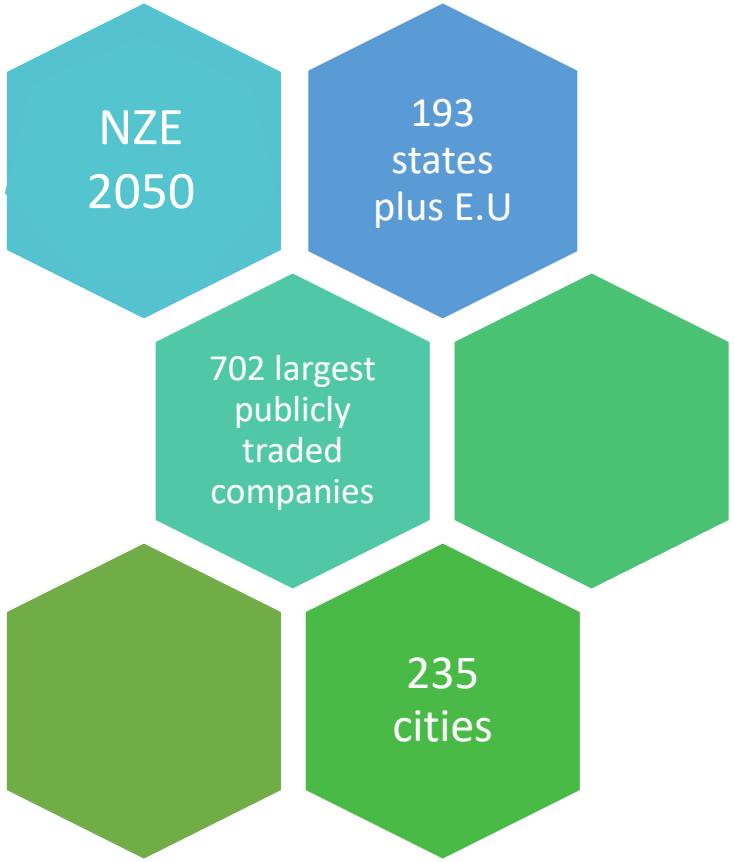
○ Since human perturbation:

➠ human GHG emissions from {burning fossil fuel (oil, coal, gas) for energy, cement production, deforestation and degradation, agricultural} plus natural GHG flows, i.e.

[total human + natural emissions] > natural sink capacity [ecosystems + oceans]

➠ To reach NZE requires reducing human emissions to match the natural sink capacity
- ✓ A collective, global scaled endeavour
- ✓ But, natural sink capacity of oceans decreases with increasing climate change
- ✓ Land sink capacity a balance of ecosystem processes + land use/land use change

NZE socio-political meanings



- UN Political commitment that action is being taken in support of implementing the Paris Agreement
- UN Branding exercise for enhancing green and SER reputation
- UN Public statement that signals fundamental shift in organisation's mission and vision and strategic priorities

- NZE_*scientific* only possible globally and is not possible at a jurisdictional or organisational level
- "Carbon neutrality" (?) ➠ Jurisdictions and organisations mitigation pledges and action are welcomed and needed as essential contributions to the global collective effort for NZE 2050

Land-based carbon offsets

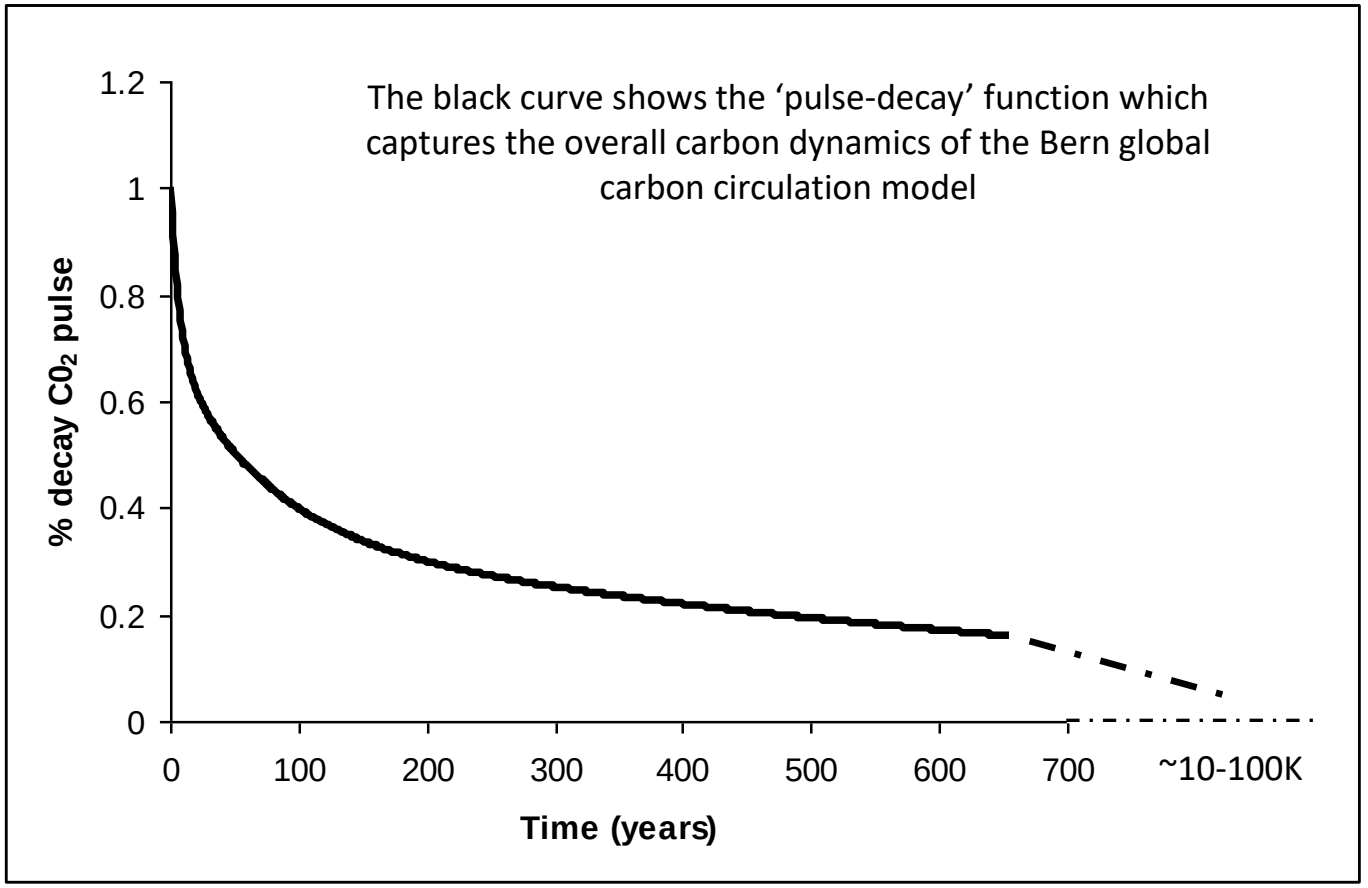
Like NZE, “offsets” has multiple interpretations

Interpretation	Assumed mitigation value	Potential outcome
Like-for-like offset	Sequesters an equivalent quantity of fossil fuel emissions into an comparably long term and stable carbon reservoir	• Neutralizes the additional radiative forcing from the fossil fuel emission
Accounting offset	Annual reporting to track NDC mitigation contributions	• Currently, not a like-for-like offset
SER offset	By invoking the “polluter pays” principles, places a cost on emissions and provides funds for good environmental action elsewhere	• Not a like-for-like offset • Absolves “sins of emissions” (individuals) • Enhances green reputation (corporations)

Offset issue #1: lack of equivalence due atm[CO_2] "long tail"

- Fossil fuel and ecosystems are not equivalent in terms of:
- Longevity of carbon stock/reservoir/pool
- Stability of carbon stock/reservoir/pool

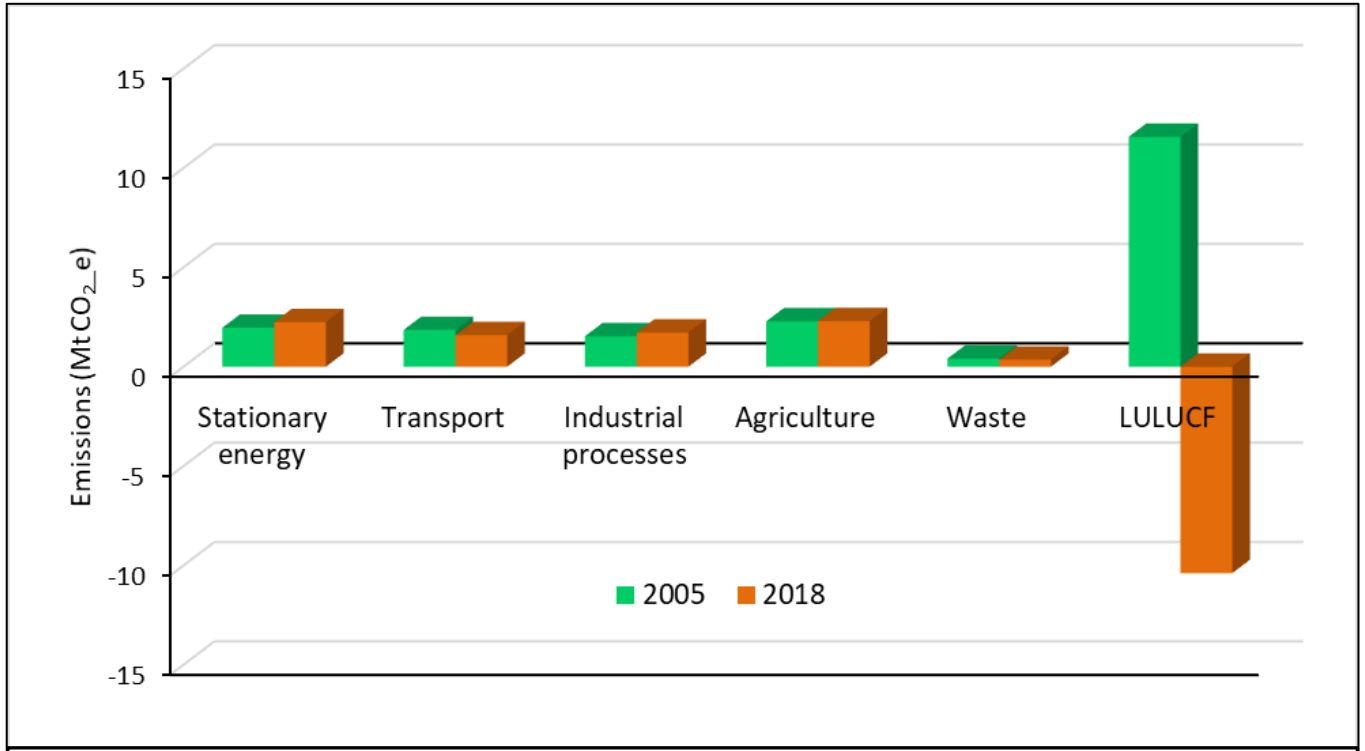
"equivalence" means "forever", otherwise, offset is just a "delayed emission"



The lifetime of the airborne fraction of a pulse of CO_2 is about 300 years for 75% and thousands for the remainder

Offset issue #2: more mitigation avoidance behaviour

- Net accounting undoes the good done by the land sector (i.e. ecosystem) removal
- Deflects scare mitigation resources (capital, time, human) away from sector-based decarbonization action



Source: AUSTRALIAN GOVERNMENT 2020b. State and Territory Greenhouse Gas Inventories 2018. Australia's National Greenhouse Gas Accounts. Department of Industry, Science, Energy and Resources, Australian Government.

- ~10 Mt CO_2_e reduced emissions due to change in forest management around 2012 which resulted in avoided logging emissions
- Plus ongoing removals from forest growth of ~10 Mt CO_2_e
- But, with net accounting, we only see the 10 Mt CO_2 removals in 2018
- Then, this 10 Mt CO_2 is used to net out emissions in other sectors, leaving zero benefit to the atmosphere
- In the absence of net accounting, the total benefit to the atmosphere would have been 20 Mt CO_2

Offset issue #3: carbon competes with other land uses

https://www.landgap.org/

An over-reliance on land removals as offsets for fossil fuel emissions

- The Land Gap Report shows how countries' climate pledges, if implemented, will increase these competing demands made on land. The report quantifies the aggregate demand for land-based mitigation in the climate pledges submitted by Parties to the UNFCCC.Z
- The total area of land needed to meet projected biological carbon removal in national climate pledges is almost 1.2 billion hectares – equivalent to current global cropland. Countries' climate pledges rely on unrealistic amounts of land-based carbon removal
- More than half of the total land area pledged for carbon removal – 633 million hectares – involves reforestation, putting potential pressure on ecosystems, food security and indigenous peoples' rights. Restoring degraded lands and ecosystems account for 551 million hectares pledged.
- Current 'net accounting' methods assume that planting new trees offsets fossil fuel emissions or the destruction of primary forest.

…and risks undermining food security and biodiversity conservation

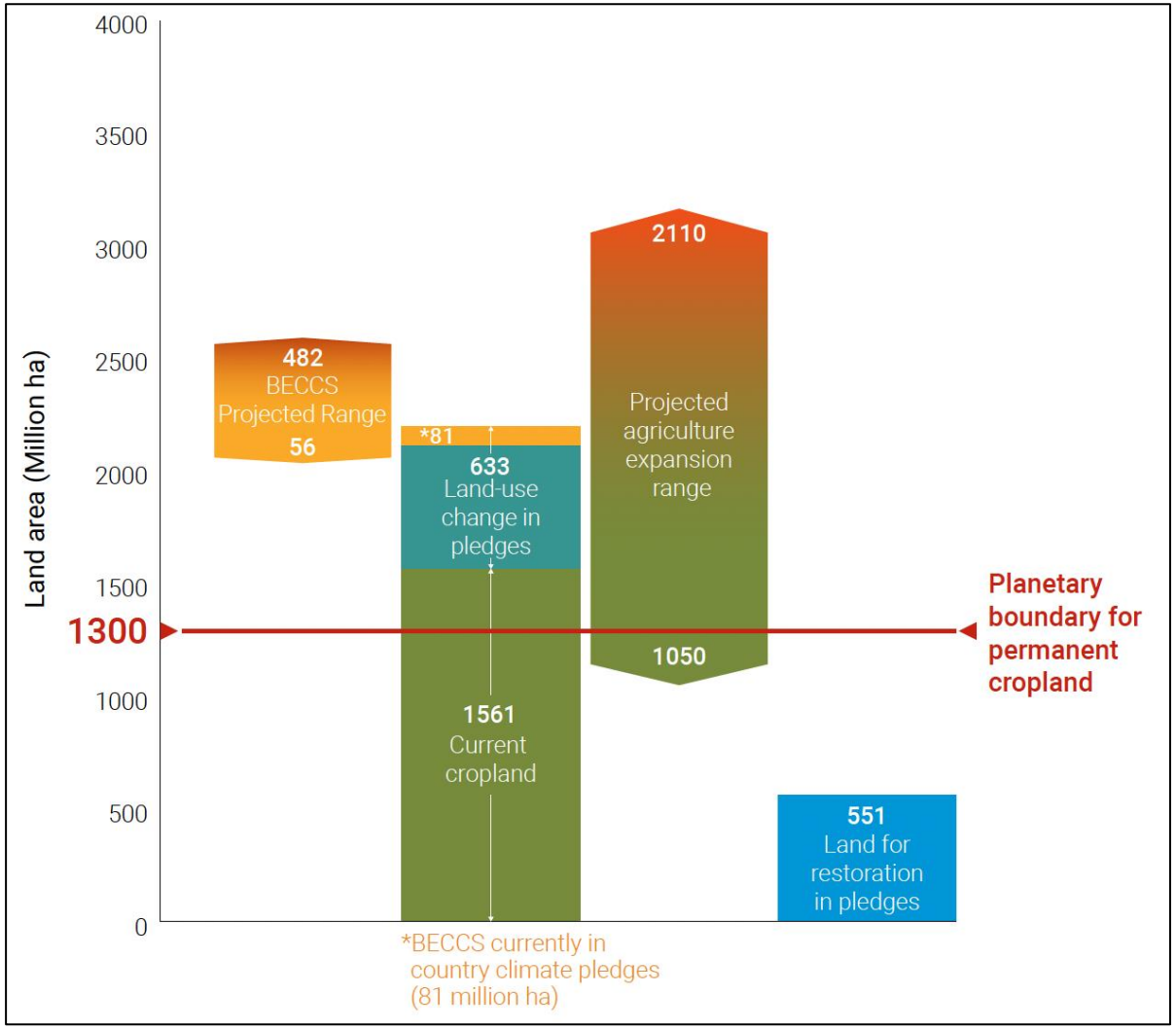
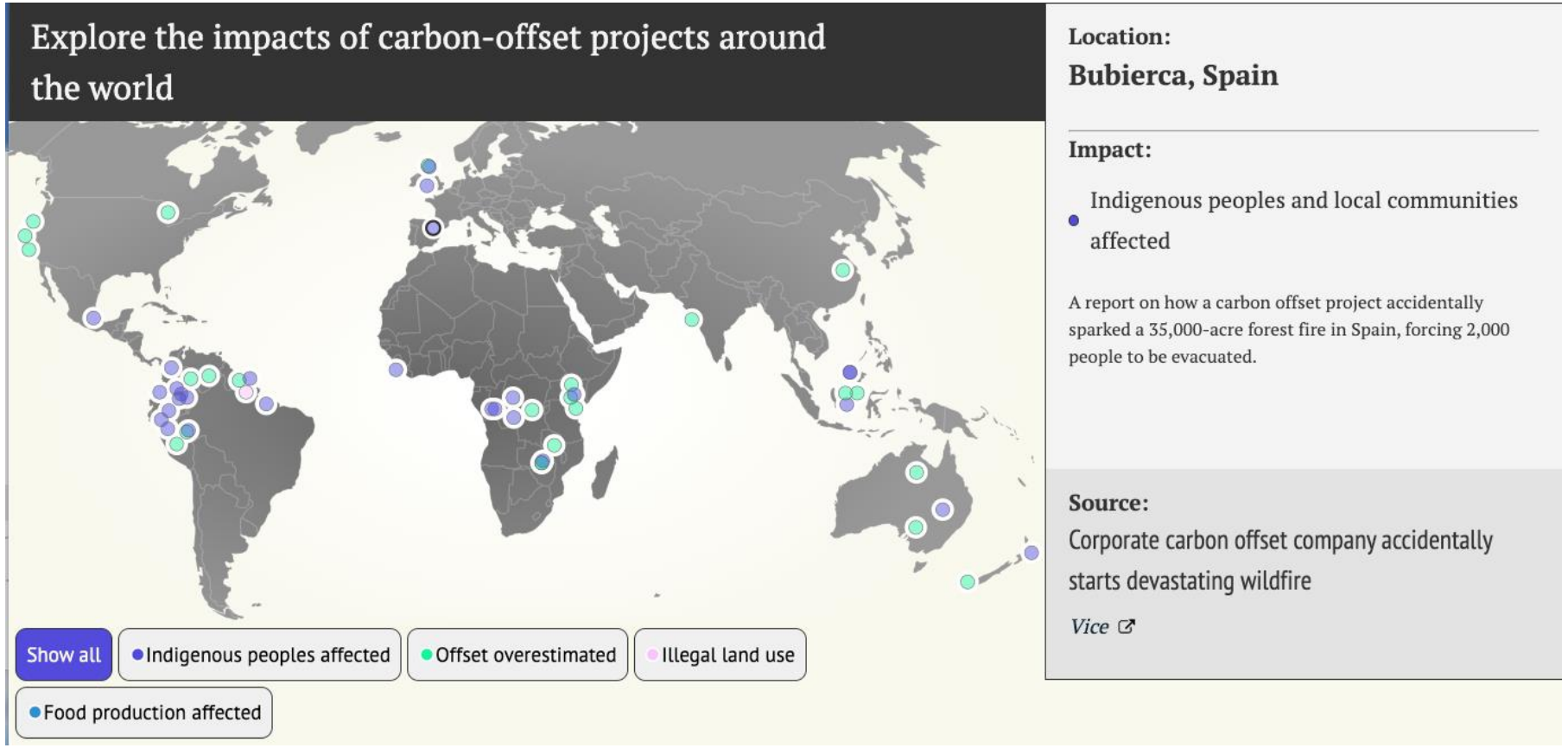


Figure 2.2 Land for mitigation in NDCs. Source: Figure 2.2, Land Gap Report

➥The 633 million ha requiring land-use change found in country climate pledges (including 81million ha for BECCS), adds to demand for land, potentially crossing planetary boundaries if this adds to increased cropland areas.

➥Land for restoration (551 million ha) does not increase demand for land, and can improve biodiversity and socioecological resilience.

…and prioritising short-term carbon removals risks perverse outcomes for people and nature



https://interactive.carbonbrief.org/carbon-offsets-2023/

SAF issues

SAF issues

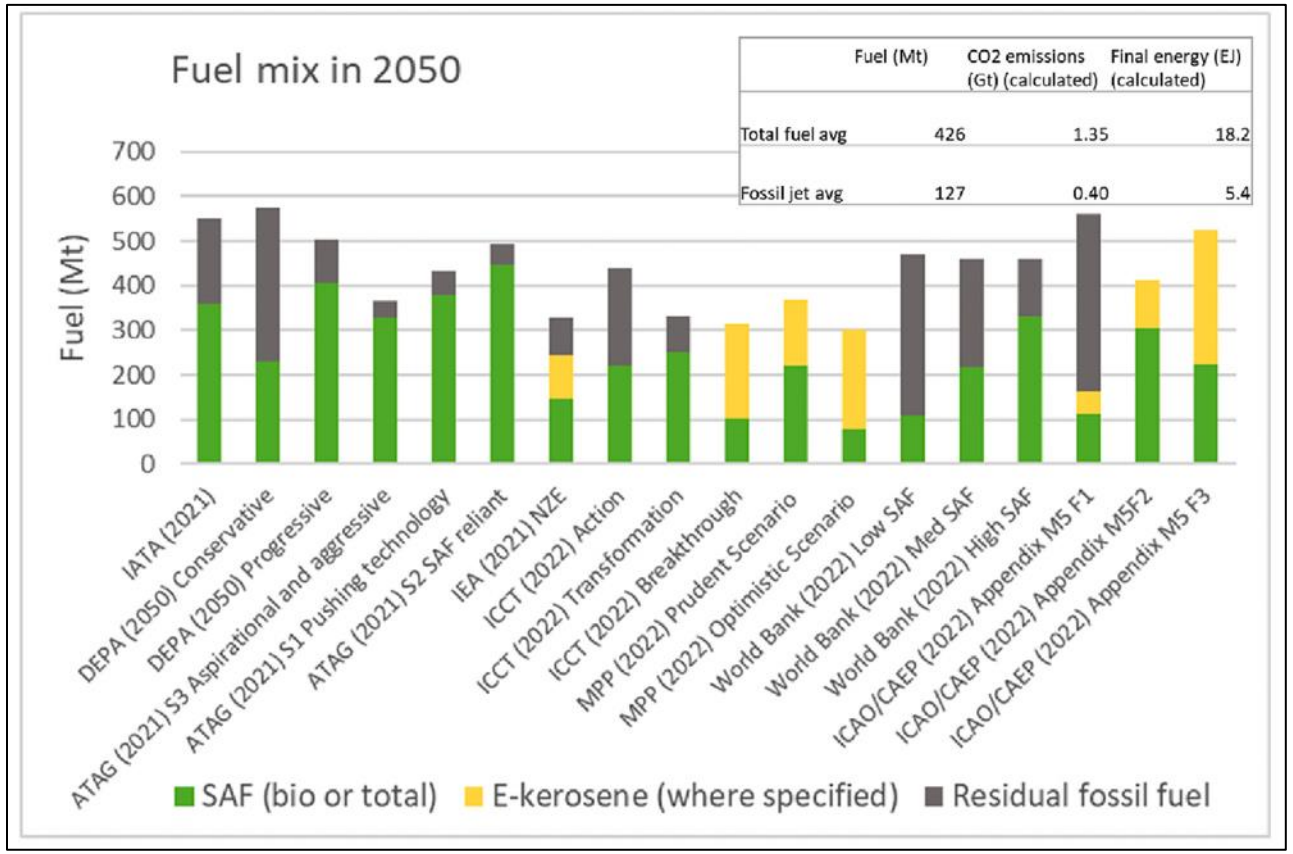


Fig. 2. Fuel volumes (SAF and fossil) for roadmaps where data were available.

Source: Becken, Mackey & Lee (2023) Science of the Total Environment
http://dx.doi.org/10.1016/j.scitotenv.2023.163883

- The production of 'sustainable aviation fuels' (SAF) is being proposed as a solution to removing the fossil carbon component, especially for long-haul flights
- An analysis of 12 aviation roadmaps for net zero 2050 reveals heavy reliance on biogenic SAF in the medium-term and synthetic e-kerosene in the longer term

Energy Return on Investment (EROI)?

“The first law of energy states that the quantity of energy is conserved, while the second law states that the quality of energy, its ability to do work, is not.” D.R. Tilley Ecological Modelling 178 (2004) 121–125

“Entropy rules”: to upgrade energy to useful energy for aviation fuel, a significant proportion of the energy is lost as “waste” heat (i.e. the entropy of the universe increases)

EROIs for bioethanol


1.797


1.040


0.739

Overall plant photosynthetic efficiency of 3 to 6% of total solar radiation

PV conversion efficiency is 15-20%

SAF competes for other uses of clean energy and biomass feedstocks

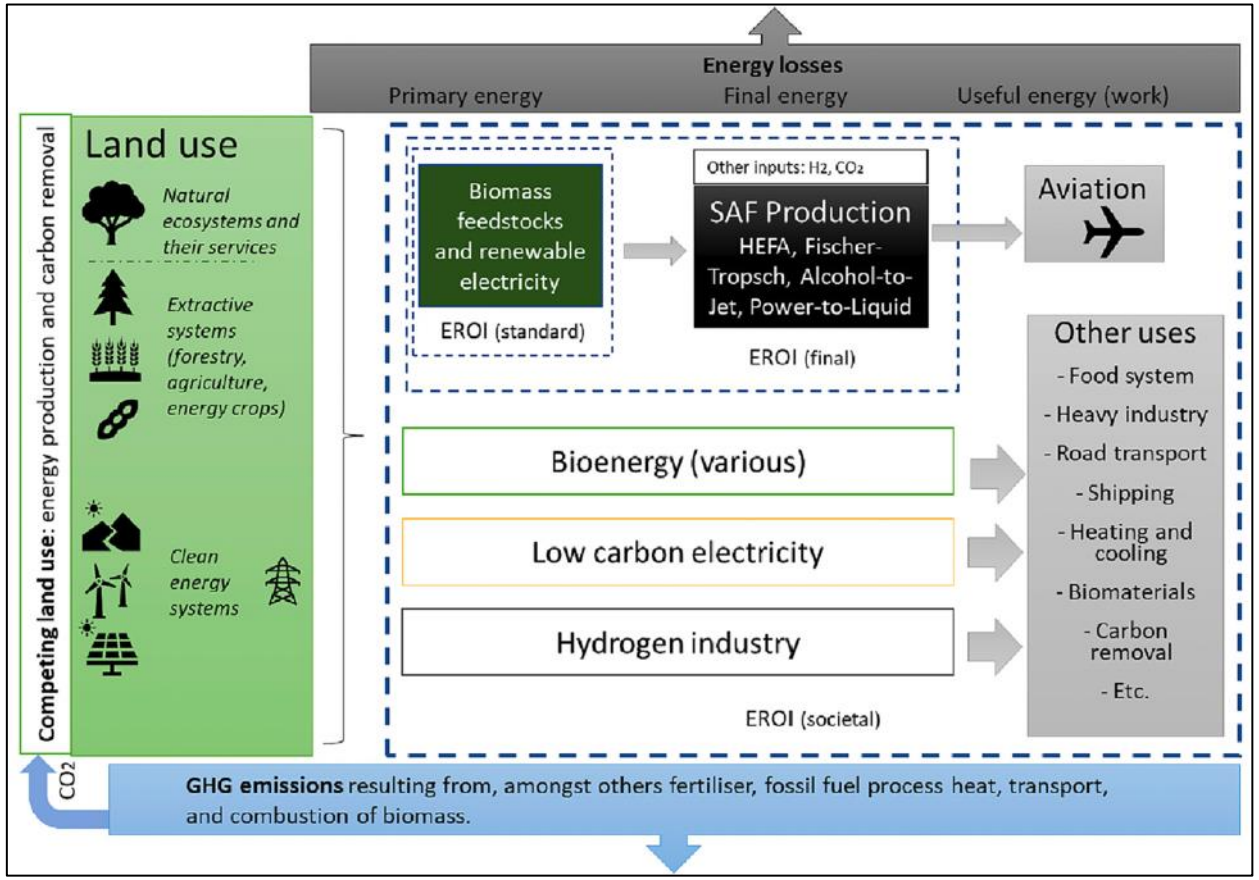


Fig. 1. Energy flows and emissions related to SAF production alongside other users of biomass and low carbon energy in a net zero world.

- Realising these roadmaps could require 9 % of global renewable electricity and will compete for clean energy (still a scarce resource) that could more effectively decarbonise other sectors, on this basis, it can be argued that SAF production could undermines global goals of limiting warming to 1.5 °C

- The scaling up of SAF to not only maintain but grow global aviation would require 30 % of sustainably available biomass in 2050,

- Plus adds to the land gap by competing for land needed for nature-based carbon removal, food production and other uses including nature conservation

Many issues to consider…

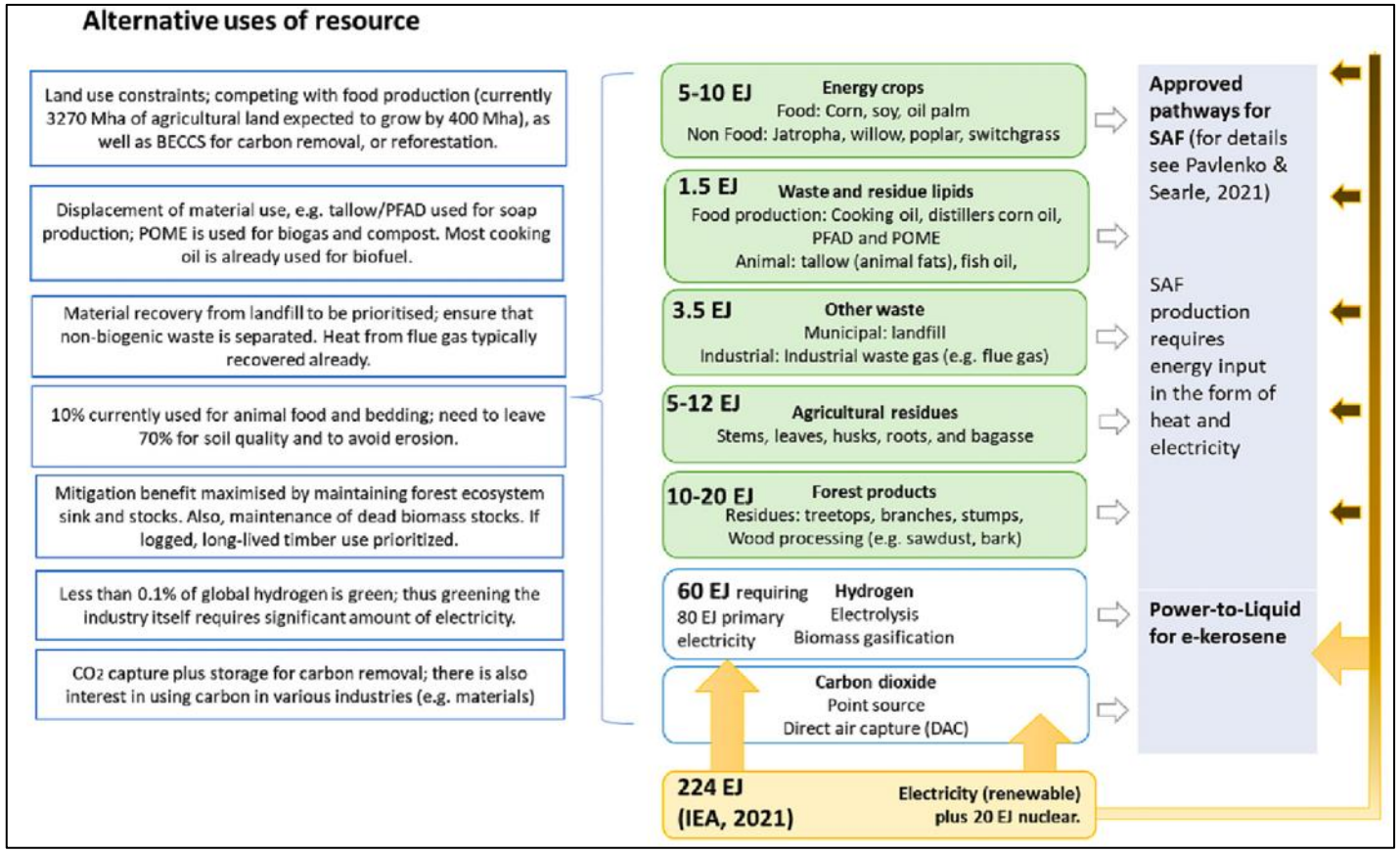


Fig. 3. Biomass and other inputs into SAF, their estimated availability in 2050, and alternative uses.

- Alternative uses of biomass (even “waste”bio-materials have current uses)
- The continued use of hydrocarbon fuel in the roadmaps generates 1.35 GtCO2 in 2050, of which 30% are still from fossil fuel
- The modelled net carbon savings from the 70% depend on the direct and indirect life cycle emissions of producing SAF
- Additional effects that are omitted in most roadmaps relate to decadal to century time lags in re-sequestering biocarbon in the case of forest biomass >> more emissive than coal per unit energy generated

Science-informed climate mitigation action for the aviation sector

- For the aviation sector, we need policies, programmes, mechanisms, markets and innovative technologies that deliver avoided and reduced emissions at their source
- These mitigation actions must also do this in ways that do not cause emissions to increase or continue elsewhere, and are in balance with other socio-economic sectors and goals
- The key question is what mix of new technologies and changed operational and management practices will deliver real avoided and reduced emissions for which components of the aviation sector?
- What (where, when) are the limits to GHG mitigation strategies in the aviation sector and especially for NZE2050?
- Avoid greenwashing through comprehensive, transparent and honest NZE2050 targets and GHG accounting and reporting

Climate Ready Australia National Summit: shaping a sustainable future together

22-23 November at the Brisbane Convention and Exhibition Centre and online

Empower climate action in your field with new knowledge learnt at the Climate Ready Australia National Summit. Hear challenging thought leadership, attend learning labs, and network with climate leaders. By bringing together Australia's peak bodies and members with climate experts, business, and government, we can significantly build capability and accelerate national climate action.

https://www.griffith.edu.au/research/climate-action/climate-ready-australia-national-summit