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LEURE

Towards climate-neutral global aviation:

Less flights, more wellbeing

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Switzerland Innovation Park, Biel/Bienne, 12.09.2023
go.epfl.ch/aviation

Journal of
Risk and Financial Management

MDPI

Article

Towards True Climate Neutrality for Global Aviation: A Negative Emissions Fund for Airlines

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Abstract: What would it take for aviation to become climate-neutral by 2050? We develop and model a trajectory for aviation to reduce its CO_2 emissions by 90% by 2050, down to a level where all residual emissions can be removed from the atmosphere without crowding out other sectors that also need negative emissions. To make emitters pay for the carbon removal, we propose and model a negative emissions fund for airlines (NEFA). We show that it can pay for the removal of all CO_2 emitted by aviation from 2030 onwards, for a contribution to the fund of USD 200–250 per ton CO_2 emitted. In our baseline simulation, USD 3.3 trillion is invested by the fund over 40 years in high-quality carbon removal projects designed for biodiversity and societal co-benefits. While we do propose a number of governance principles and concrete solutions, our main goal is to start a societal dialogue to ensure aviation becomes both responsible and broadly beneficial.

Press Release No: 66

Date: 4 October 2021

Net-Zero Carbon Emissions by 2050

FLY NET ZERO

Translations:

Élimination des émissions nettes de carbone d'ici 2050 (pdf)
Zero emissão líquida de carbono até 2050 (pdf)
Cero emisiones netas de CO2 en 2050 (pdf)
国际航协：2050年实现净零碳排放 (pdf)

Boston - The International Air Transport Association (IATA) 77th Annual General Meeting approved a resolution for the global air transport industry to achieve net-zero carbon emissions by 2050. This commitment will align with the Paris Agreement goal for global warming not to exceed 1.5°C.

"The world's airlines have taken a momentous decision to ensure that flying is sustainable. The post-COVID-19 re-connect will be on a clear path towards net zero. That will ensure the freedom of future generations to sustainably explore, learn, trade, build markets, appreciate cultures and connect with people the world over. With the collective efforts of the entire value chain and supportive government policies, aviation will achieve net zero emissions by 2050," said Willie Walsh, IATA's Director General.

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Countries' support global 'Net-zero 2050' emissions target to achieve sustainable aviation

Ministers and other high-level officials concluded high-level environment talks at ICAO Headquarters in Montréal on 22 July 2022, supporting a collective global goal of net-zero carbon emissions by 2050.

Montréal, 25 July 2022 – Ministers and officials engaged in high level environment talks brokered by ICAO have urged countries to cooperate further through the UN agency toward a collective global long term aspirational goal (LTAG) of net-zero carbon emissions by 2050, in support of the Paris Agreement's temperature target.

The conclusions came Friday evening after four days of deliberations among Ministers and other high-level officials representing 119 countries at ICAO Headquarters in Montréal, with over 700 participants from States and International Organizations attending the hybrid Meeting.

Recognizing that each State's special circumstances and respective capabilities will inform the ability of each to contribute within its own national timeframe, while showcasing a collaborative spirit through constructive dialogue and respect for diversity, the new conclusions will aid a just and green transition for the decarbonisation of international aviation.

NEFA Methodology

1. Analysis
    a. Goals, commitments, and actions of key aviation players incl. CORSIA
    b. Non-CO_2 dynamic climate effects of aviation (today RFI=3)
    c. Lifecycle climate and biodiversity effects of alternative fuels
    d. Alternative power sources and possible efficiency gains: electric, hydrogen
    e. Resource use for aviation and fairness
    f. Credibility and past announcements of key aviation organizations
2. Modeling, simulation, sensitivity analysis of NEFA
3. Policy and governance proposal development

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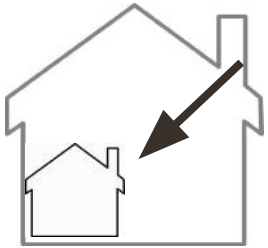
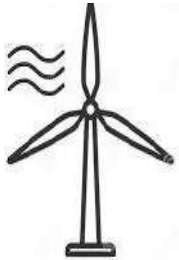
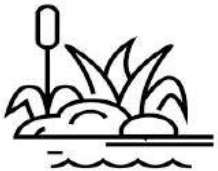
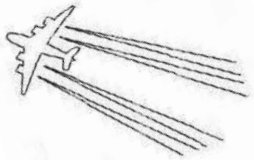
Typology of Climate Action






1 Sufficiency 2 Efficiency 3 Clean Energy 4 CCS 5 NET 6 SRM 7 Adaptation

Stabilize temperature

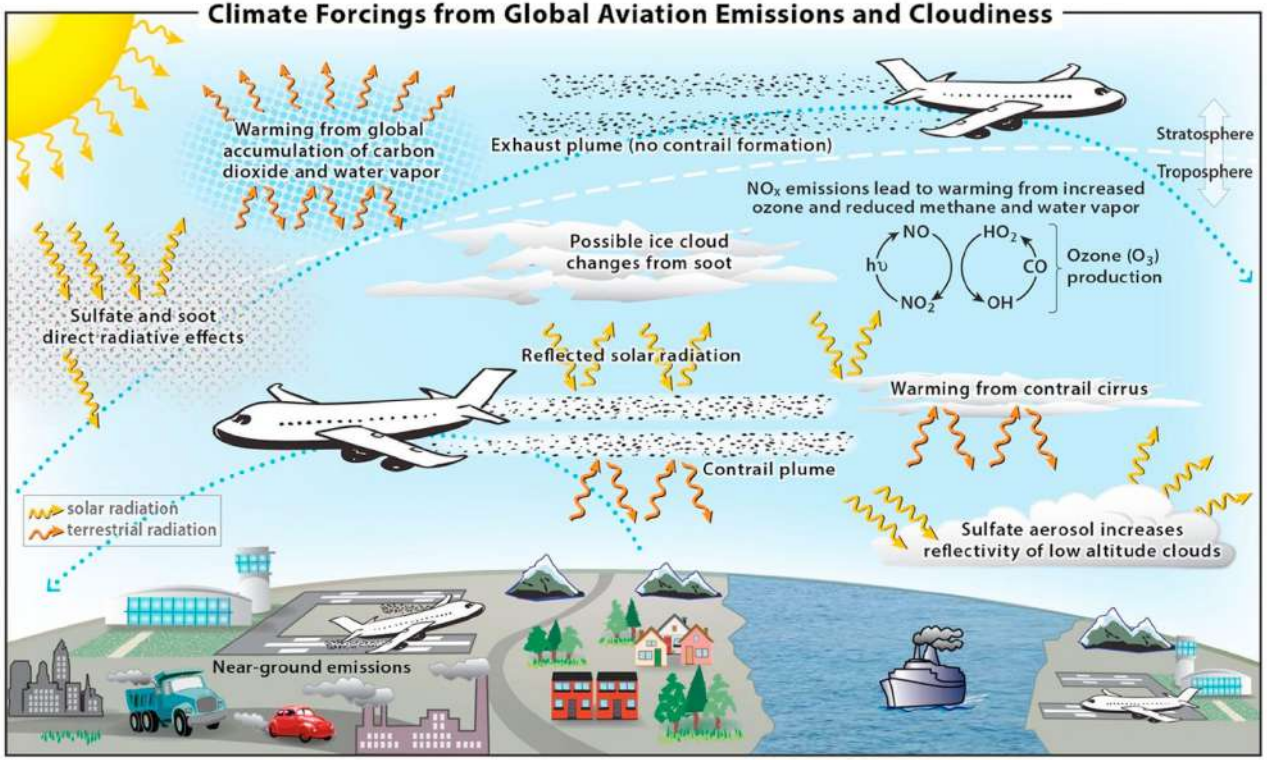
Stabilize CO_2 concentration

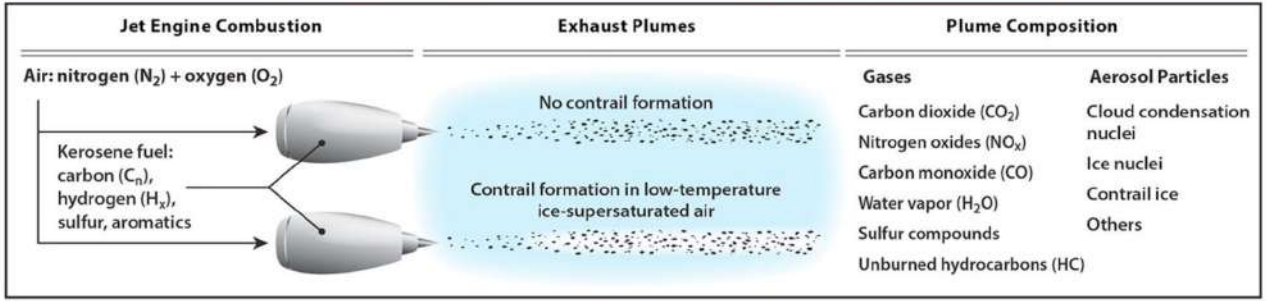
Reduce emissions

Adapt to changed climate

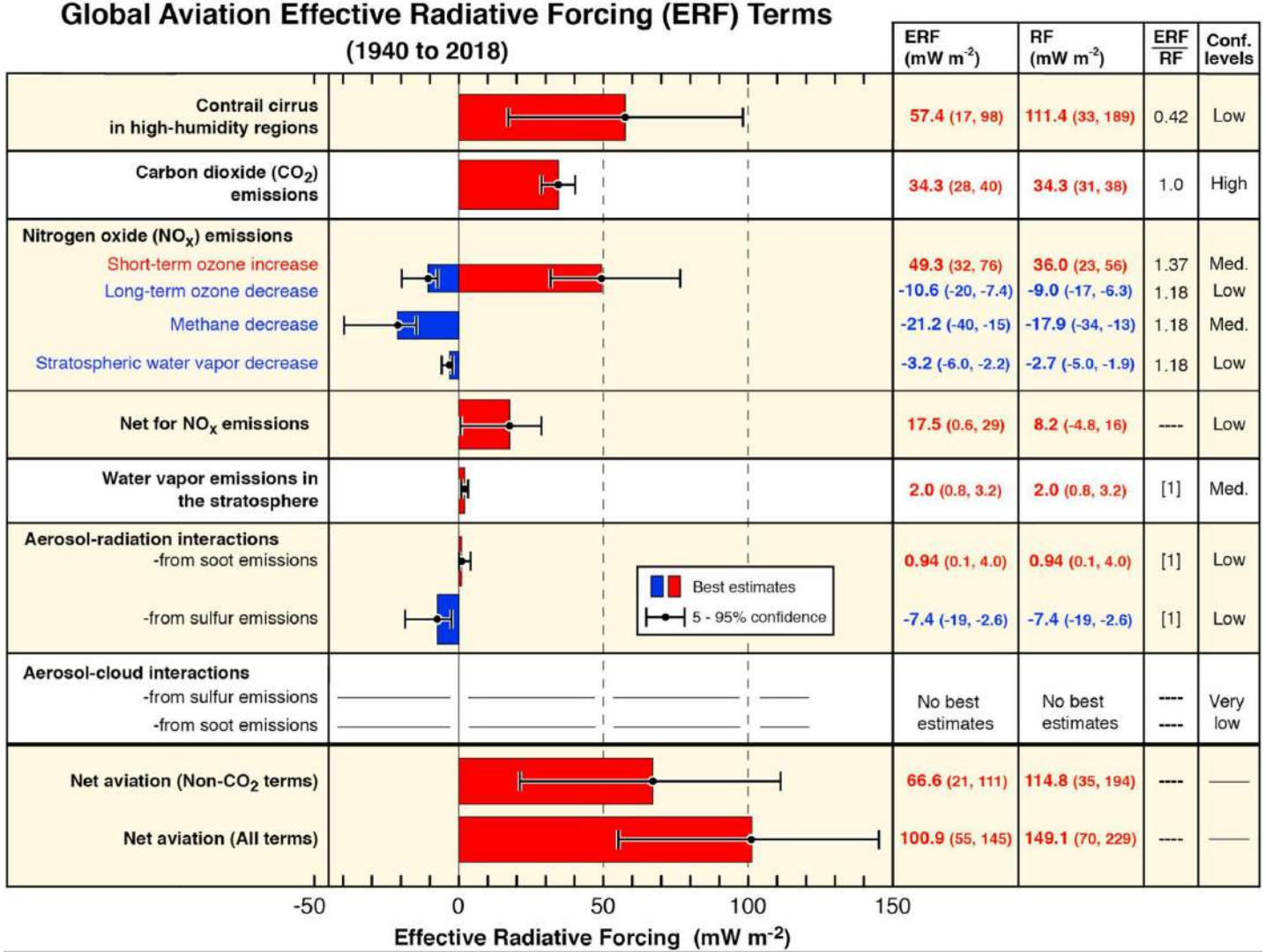
Mitigation (IPCC): reduce sources or enhance sinks

Adaptation: reduce harm





Lee et al 2021

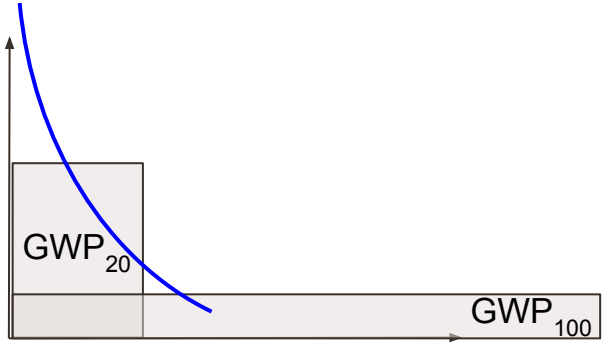


Lee et al 2021

Short-lived and long-lived GHG, example of methane

Nick and Thalmann 2021

GWP_{100} or **GWP_{20}** or **GWP*** ?



For short-lived GHG, especially methane

$$\mathbf{CO_2e^* = (105 \bullet \Delta Em) + (7 \bullet Em)}$$

where Em are current methane emissions and ΔEm is the absolute change in methane emissions over 20 years

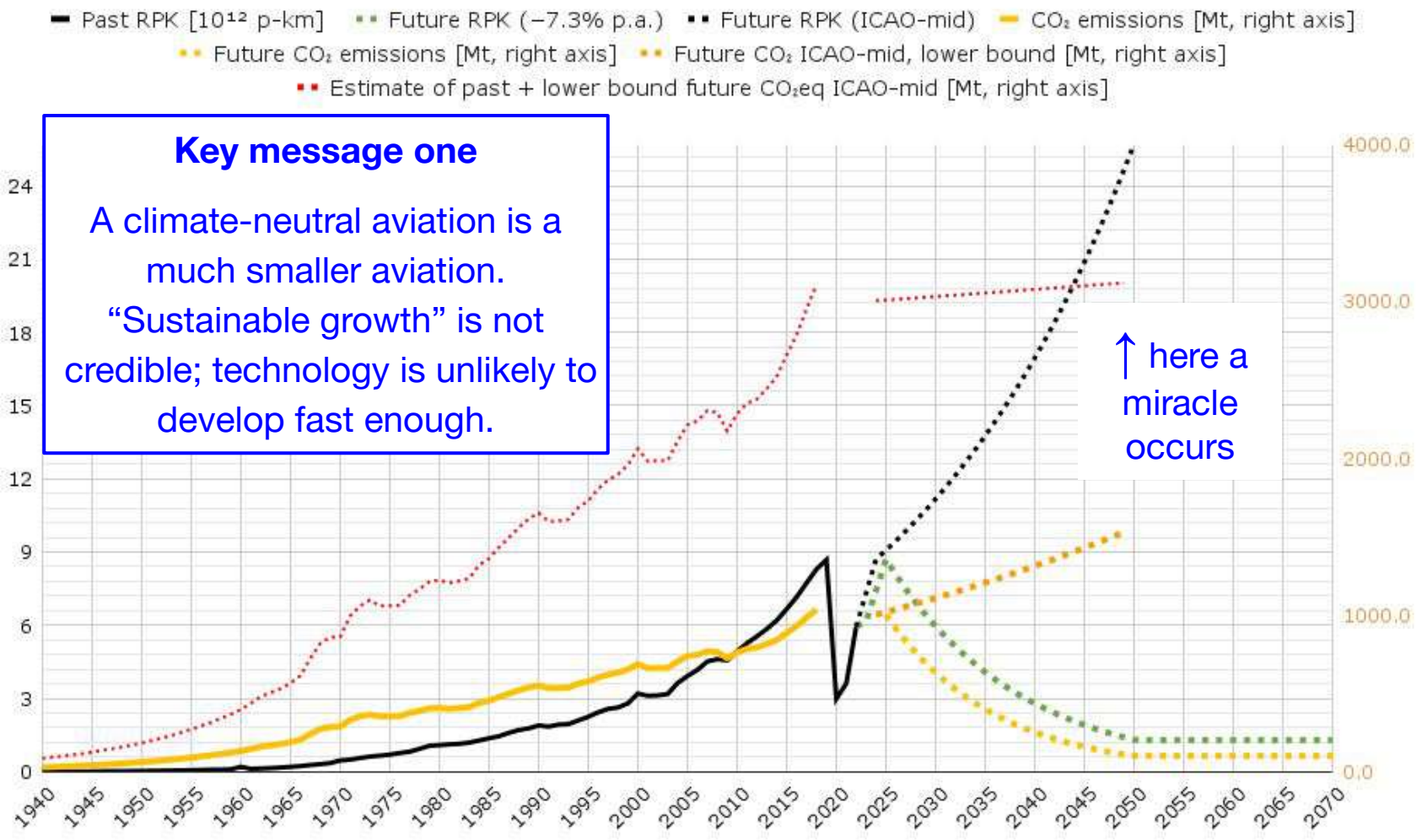
Example: For methane from Swiss agriculture, based on the 1999-2019 period, when emissions slightly decreased from 160 to 155 kt CH_4,

ΔEm is -5 kt CH_4, and equivalent CO2 emissions using GWP* are

$105*(-5)+7*155 = 560$ kt CO_2e

significantly less than the $155*28 = 4340$ kt CO_2e obtained when using GWP_{100}

Simulation parameters	
Emission reduction p.a.	**8.80%**
Initial emissions [Mt/p.a.]	**1000**
Final emissions [Mt/p.a.]	**100**
NE growth 2027-36	**50.0%**
NE growth 2037+	**25.0%**
Max removals |Mt p.a.]	**400**
Removal cost start [$/t]	**400**
in year	**2025**
Removal cost final [$/t]	**250**
from year	**2050**
Interest rate	**2.00%**
Simulation results	
CO_2 price [$/t]	**229.87**
Σ NE payments [$ bn]	**3256.16**
Removed excess CO_2 by	**2072**
Cash flow summary	
Total discounted cash flow [$ bn]	
Paid by fund	**-1816.79**
Paid into fund	**1816.79**
Fund balance in end year	0.00


Past RPK [10¹² p-km]
Future RPK (−7.3% p.a.)
Future RPK (ICAO-mid)
CO₂ emissions [Mt, right axis]
Future CO₂ emissions [Mt, right axis]
Future CO₂ ICAO-mid, lower bound [Mt, right axis]
Estimate of past + lower bound future CO₂eq ICAO-mid [Mt, right axis]
Key message one
A climate-neutral aviation is a much smaller aviation.
"Sustainable growth" is not credible; technology is unlikely to develop fast enough.
↑ here a miracle occurs
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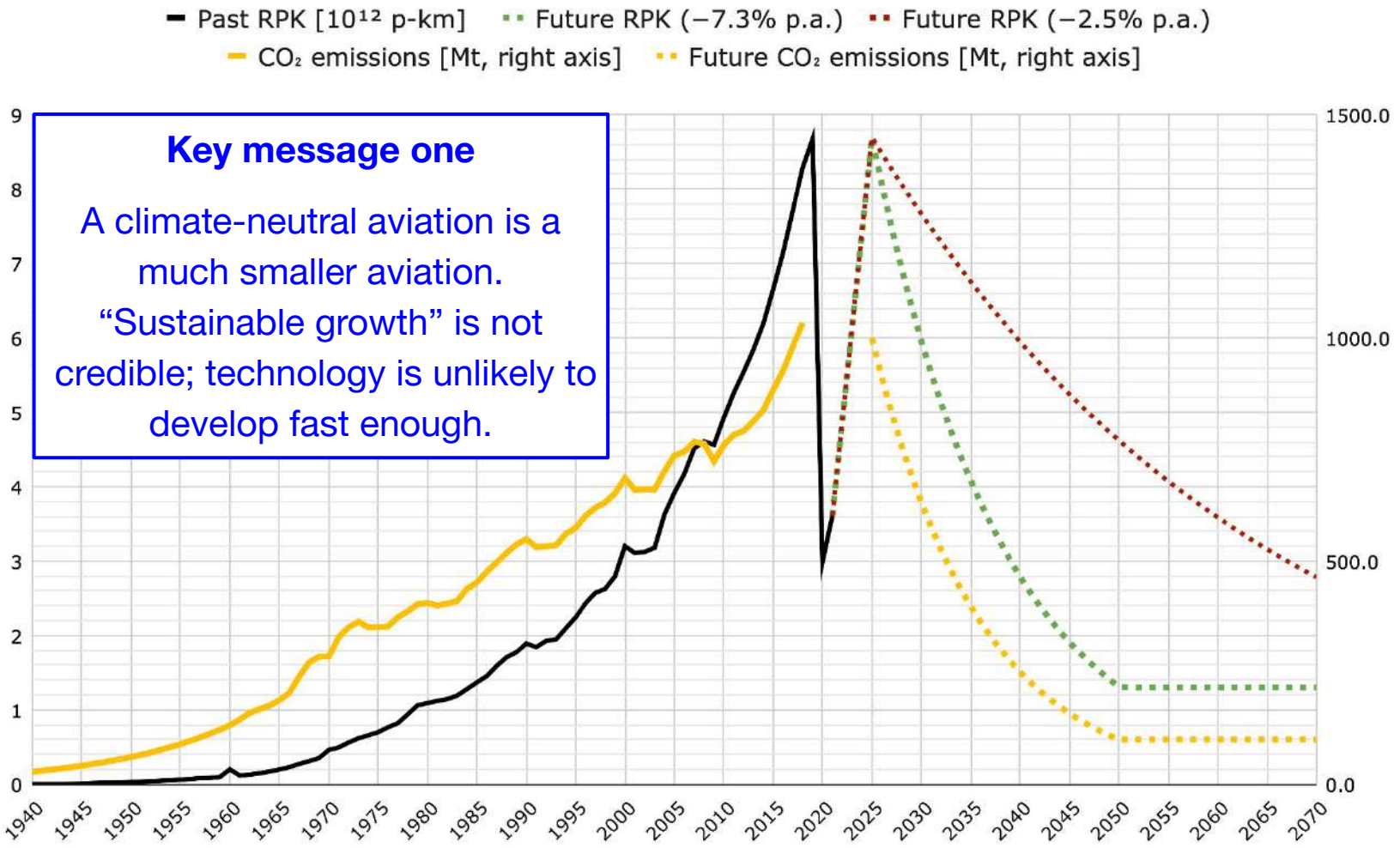
Past RPK [10¹² p-km]
Future RPK (−7.3% p.a.)
Future RPK (−2.5% p.a.)
CO₂ emissions [Mt, right axis]
Future CO₂ emissions [Mt, right axis]
Key message one
A climate-neutral aviation is a much smaller aviation.
"Sustainable growth" is not credible; technology is unlikely to develop fast enough.
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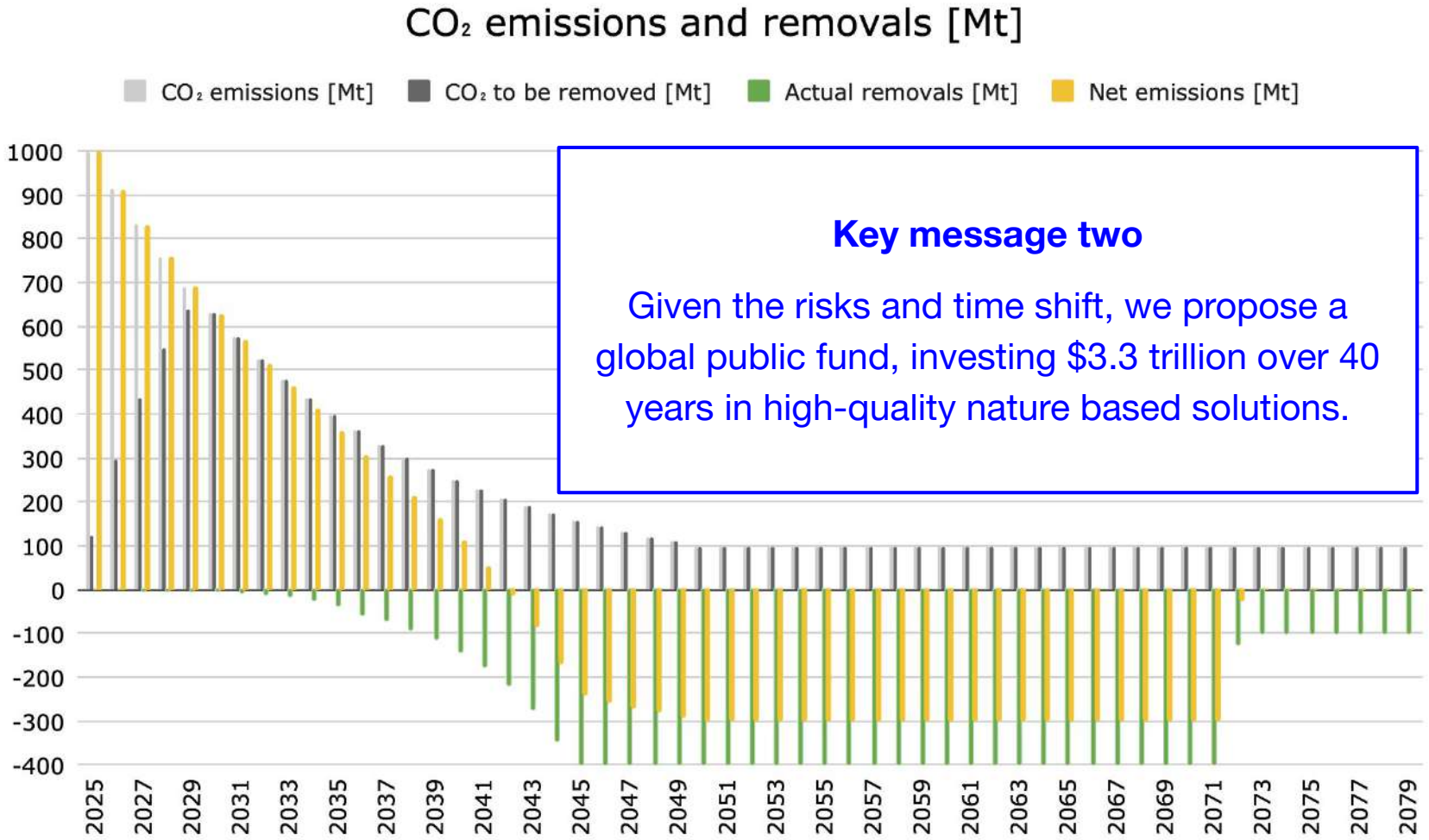
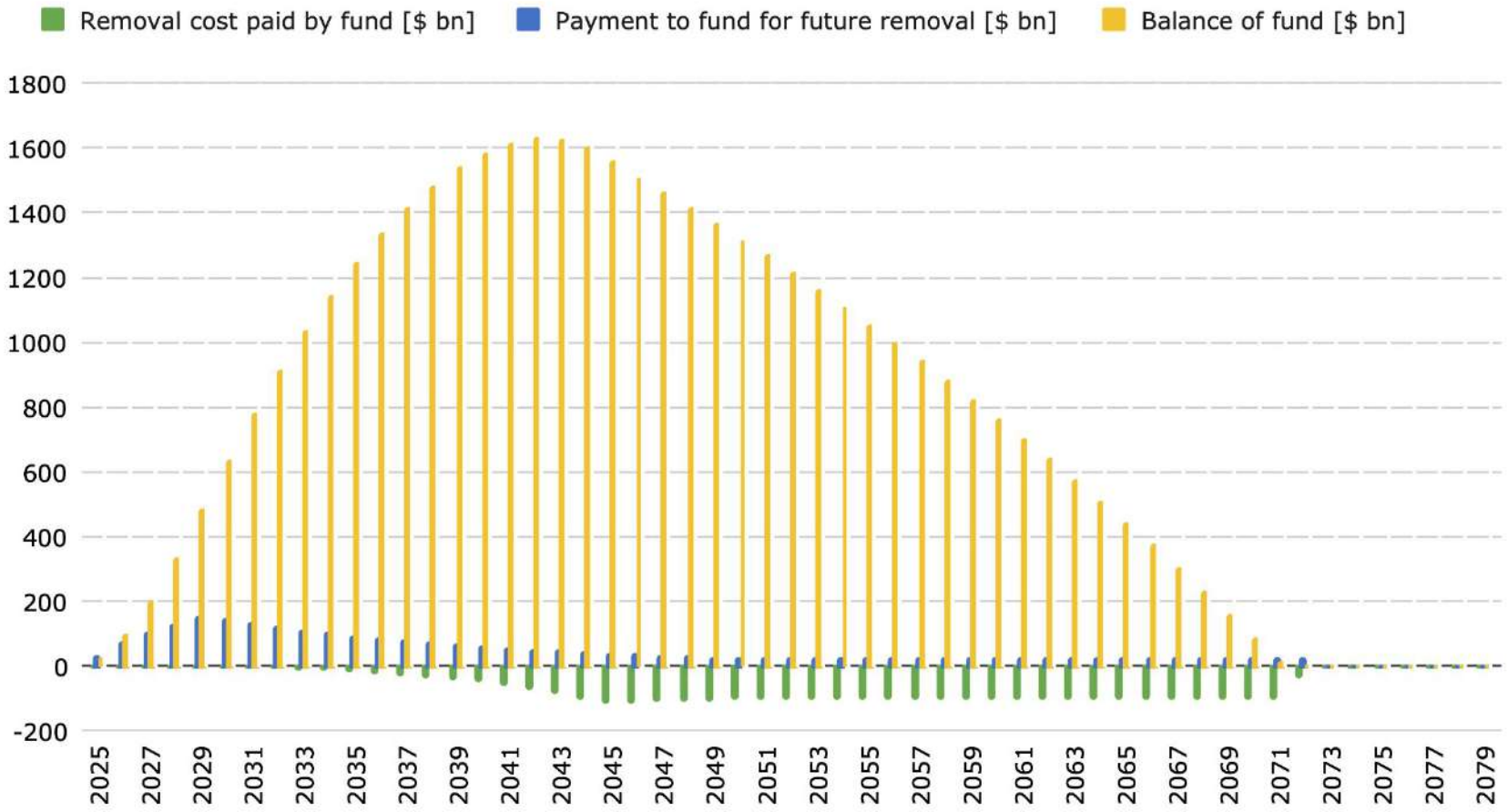


Key message two

Given the risks and time shift, we propose a global public fund, investing $3.3 trillion over 40 years in high-quality nature based solutions.

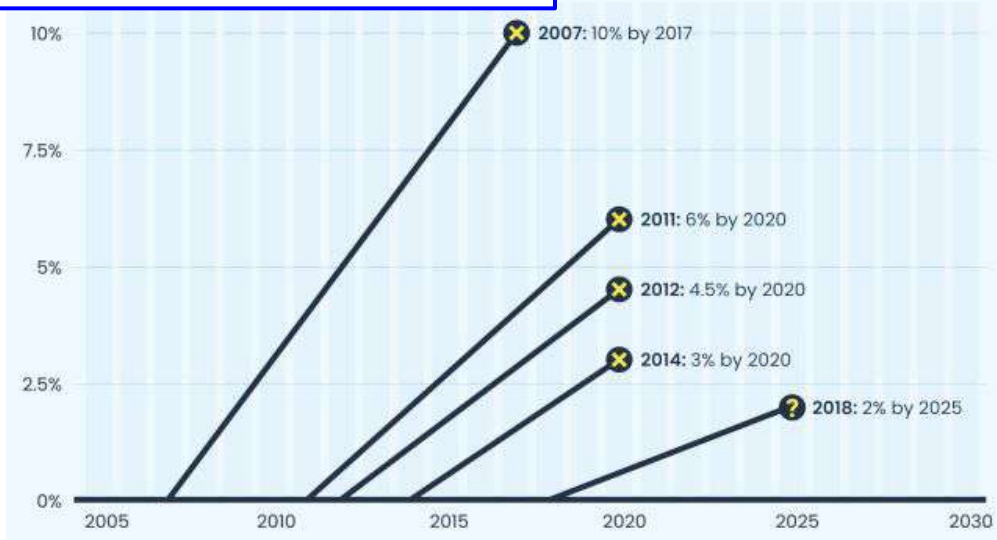
Fund inflows, outflows, balance

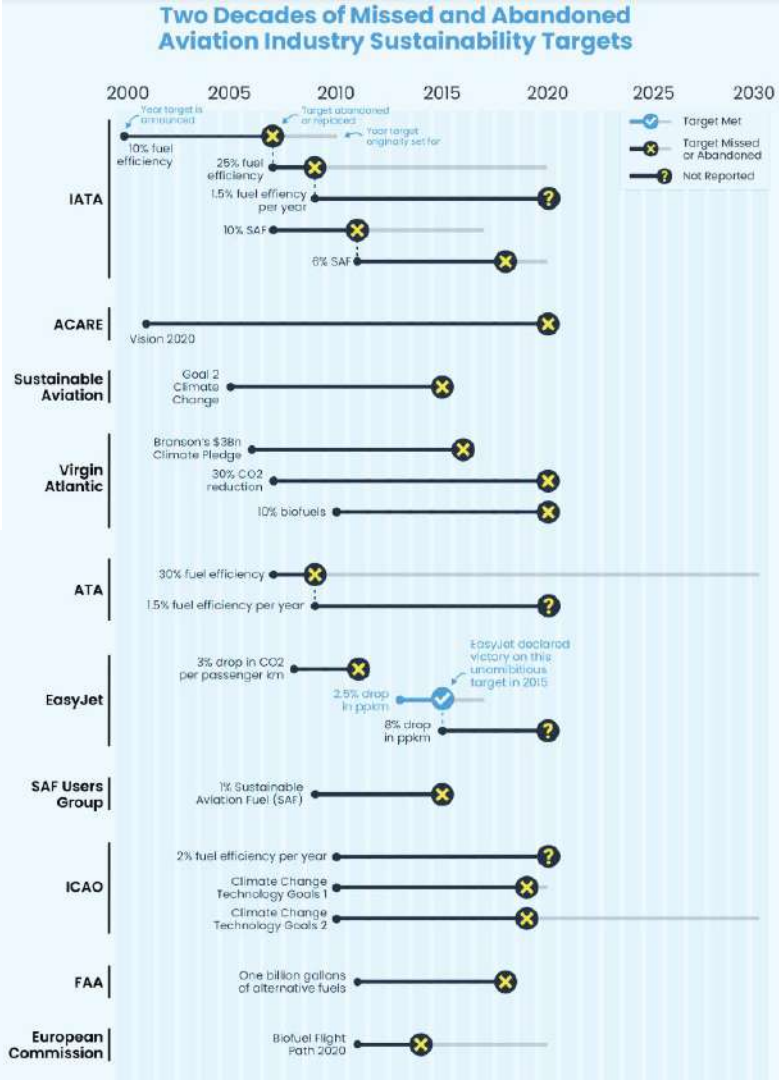


Sensitivity Analysis		Range of Parameter		CO_2 Price [USD/t]		Σ CO_2 Removal Payments [USD bn]		Removed All Excess CO_2 by Year	
Simulation parameters	Baseline	Min.	Max.	Min. param.	Max. param.	Min. param.	Max. param.	Min. param.	Max. param.
Emission reductions p.a.	8.8%	2.5%	10.0%	160	239	9651	2953	2136	2069
Reductions, narrower range, p.a.		5.0%	7.3%	196	218	5177	3772	2091	2077
Final emissions [Mt/p.a.]	100	50	150	231	227	2979	3717	2069	2076
NE growth 2027-36	50.0%	33%	60%	203	246	3326	3217	2078	2068
NE growth 2037+	25.0%	10%	50%	204	243	3401	3228	2080	2069
Max removals [Mt p.a.]	400	200	800	186	249	4629	2897	2128	2057
Removal cost in 2025 [USD/t]	400	300	600	222	245	3173	3422	2072	2072
Removal cost from 2050 [USD/t]	250	200	300	190	270	2671	3841	2072	2072
Interest rate p.a.	2%	1%	3%	269	196	3256	3256	2072	2072
Interest rate, extreme range		0%	4%	314	168	3256	3256	2072	2072
Simulation results-baseline				230		3256		2072	

Key message three

Based on its track record, aviation cannot be trusted to decarbonize voluntarily and must be regulated.





Structure of the proposed Negative Emissions Fund for Airlines (NEFA)

Governance: ICAO or NEFA

Reporting + monitoring
- Report flights, aircraft, fuel, CO_2, contrails
- Monitor payment to NEFA
- UNFCCC: submit NDC as virtual country
- Restrict alternative fuels to low-impact

Annual capacity auction

2025
–7.3% p.a. until 2050
stable from 2050

...

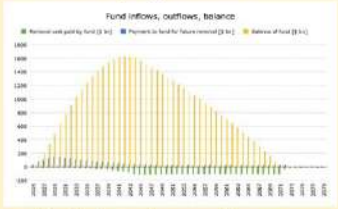
Airline 2

Airline 1

Commitments:
- Reduce RPK >2.5% p.a.
- Buy capacity at auction
- Pay CO_2 price to NEFA
- Report flights and CO_2

Benefits:
- Access to NEFA airports

NEFA
- Collect and invest airline payments



- Build and monitor a portfolio of carbon removal projects
- Int'l fund governance

...

NEFA project 2

NEFA project 1 for carbon removal
- Only in NEFA countries w. credible 1.5°C NDCs
- Designed for co-benefits
  - Biodiversity, restoring ecosystems
  - Societal: investments, jobs, capacity building

Climate Club: EU + other
- Require airline participation
- Participate in the Climate C
- Submit credible 1.5°C NDC
- Ensure NEFA projects are g
- Engage citizens to ensure benefits of a smaller aviation + progressive frequent flyer taxation

Why join the Climate Club?
- NEFA project funding + benefits
- Benefits of 1.5°C climate
- No public funding needed
- Societal benefits + acceptance
- Aviation beneficial for all

Key message four

A well-designed governance ensures compliance, mobilizes significant resources for biodiversity and societal wellbeing, and gives a future to aviation.

Structure of the proposed Negative Emissions Fund for Airlines (NEFA)

Governance: ICAO or NEFA

Reporting + monitoring
- Report flights, aircraft, fuel, CO_2, contrails
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...

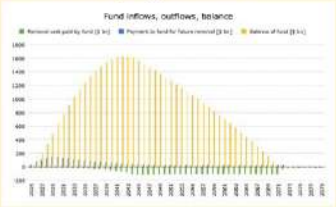
Airline 2

Airline 1

Commitments:
- Reduce RPK >2.5% p.a.
- Buy capacity at auction
- Pay CO_2 price to NEFA
- Report flights and CO_2

Benefits:
- Access to NEFA airports
- Climate neutrality
- Societal legitimacy

NEFA
- Collect and invest airline payments



- Build and monitor a portfolio of carbon removal projects
- Int'l fund governance

Payment to projects
Payment from airlines
Payment from auction

...

NEFA project 2

NEFA project 1 for carbon removal

- Only in NEFA countries w. credible 1.5°C NDCs
- Designed for co-benefits
  - Biodiversity, restoring ecosystems
  - Societal: investments, jobs, capacity building

Climate Club: EU + other countries
- Require airline participation in NEFA as condition to access its airports for international flights
- Participate in the Climate Club as condition to receive carbon removal project funding
- Submit credible 1.5°C NDCs, including domestic aviation
- Ensure NEFA projects are governed for biodiversity and societal co-benefits
- Engage citizens to ensure benefits of a smaller aviation + progressive frequent flyer taxation

Why join the Climate Club?
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- Benefits of 1.5°C climate
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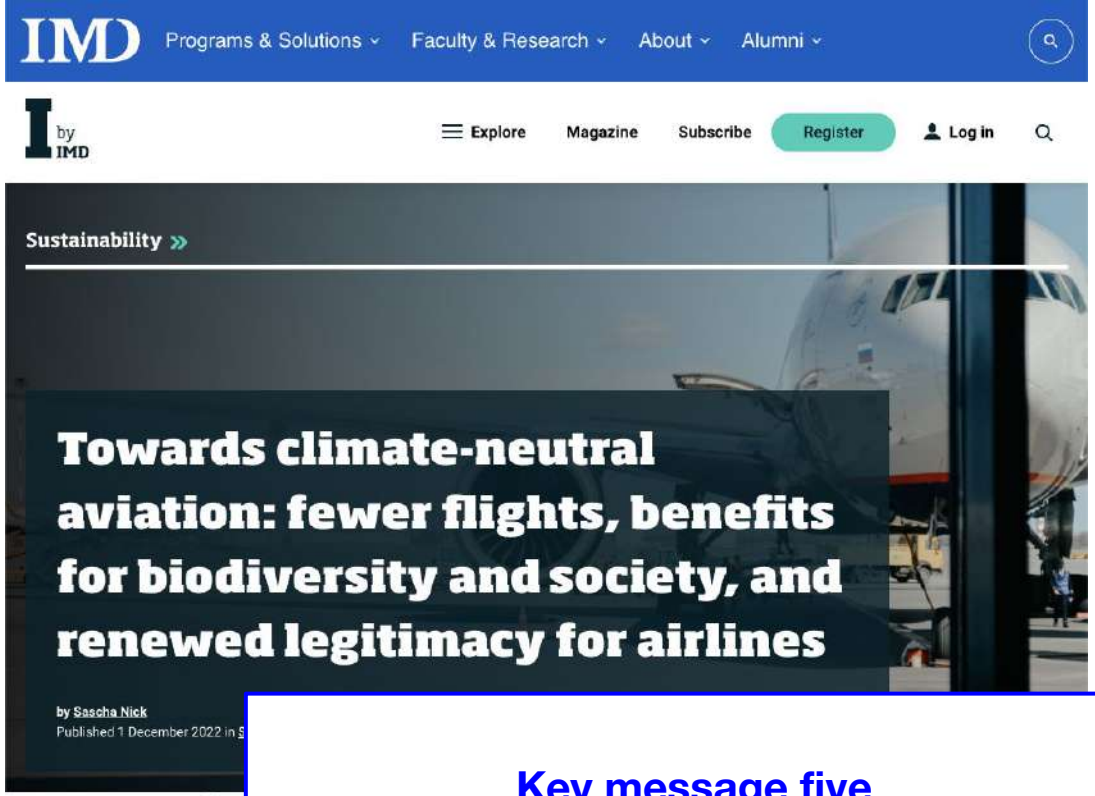


Large companies

Most obviously, the total cost of flying would go down by two thirds, and videoconferencing would be used even more than today. Over time, globalized supply chains might be at a disadvantage and could be reconfigured to become more regional or local, with only a few components truly globally sourced – for example, specialized microprocessors. As this would happen over two decades, there is time to adjust, and in the process make supply chains more resilient, circular, and sustainable. Now is the time to rethink business models, eliminate planned obsolescence, and start curbing extraction, material, and energy use. However, given the time needed to reconfigure supply chains, planning should start immediately, starting with new products and services.

Academia

In terms of operations, reducing academic staff travel would just be the beginning. This would mean more local or regional conferences, with fewer participants, remotely connected to related events elsewhere when needed, but little flying. Executive or other learning programs could be planned in ways that would minimize travel – adjusting schedules, combining events, on-site teams remotely connected to other teams, and longer and more local gatherings incorporating multiple activities. More fundamentally, helping society to rapidly adjust to a post-fossil fuel, limited extraction world could become an essential focus of research and teaching, especially in business education.

Agricultural communities

Any transition towards sustainability will only work if it benefits communities and wins their support. Climate change, biodiversity loss, soil depletion, and very different precipitation patterns are already affecting almost every agricultural community in the world, and they must adapt to these threats in order to survive. A limitation in air transport capacity will also impact global food exports, reducing the markets available to many agricultural communities, which would be extremely challenging, especially for disadvantaged populations. On the other hand, continuing today's agricultural trajectory will lead to a collapse in ecosystem services, including food production, which would disproportionately affect such communities. There is no single solution, but our proposal mobilizes around $100 billion each year for decades to invest in nature-based solutions, with most carbon removal projects managed by and for the benefit of local communities in participating countries. Restoring and protecting wetlands, mangroves, corals, forests, and other ecosystems would all qualify, as would soil health projects, which would also improve food production resilience.

Airlines

Surprisingly, aviation is perhaps the easiest sector to adapt, even though it is the one that will be transformed most by the transition to climate-neutral aviation. Predictable flight reductions would facilitate investments and asset management, hiring and training, flight route planning, ultimately ensuring service quality. Reporting guidelines developed for the current Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) could be adapted. The 25-year transition period is longer than the timeframe airlines had for previous adaptations, even before COVID-19. The 1980s, the reference period for the number of flights, was a profitable and predictable period for airlines. Most importantly, in a world of constrained resources, becoming climate neutral would renew airlines' social license and ensure the future of the aviation sector.

Key message five

From the perspective of main stakeholders, big but not insurmountable changes are needed, many with positive side-effects.

Abo Transport aérien

Voler sur des avions «verts» en 2050 coûtera plus cher

Des chercheurs de l'EPFL ont mis au point un modèle pour financer la décarbonation de l'aviation civile d'ici à trente ans. Il suppose une réduction drastique des vols et une hausse des tarifs.

Ivan Radja
Publié: 14.11.2022, 07h00

L'aviation civile a émis 1 milliard de tonnes de CO_2 en 2019. Le chemin vers le zéro net carbone en 2050 est encore long.
AFP

LE TEMPS EPFL

Analyse

Vers la fin des vols à bas prix?

ENVIRONNEMENT RÉCHAUFFEMENT CLIMATIQUE NEWS
Publié le 17 janvier 2023 à 18:00. Modifié le 18 janvier 2023 à 19:16

A Davos, des jets privés et le mirage de l'aviation verte

par Sarah Sermondadaz

CLIMAT COP27 ANALYSE
Publié le 13 novembre 2022 07:00. Modifié le 15 novembre 2022 14:19.

Zéro carbone dans l'aviation: des promesses dans le vent?

par Sarah Sermondadaz

Deux chercheurs suisses ont calculé à quelles conditions le secteur du transport aérien peut respecter ses promesses de décarbonation. Pour l'instant, le compte n'y est pas.

NOS TABLEAUX BORD

sses

Deux chercheurs suisses ont calculé à quelles conditions le secteur du transport aérien peut respecter ses promesses de décarbonation. Pour l'instant, le compte n'y est pas.

Key message six

Holistically, the proposed approach reverses globalization and deregulation, and shifts resources from the top 1% to the rest of humanity, reducing biodiversity loss, the climate crisis, inequality, and improving resilience.

It also gives a future to aviation and shows the way forward for other “hard to decarbonize” sectors.

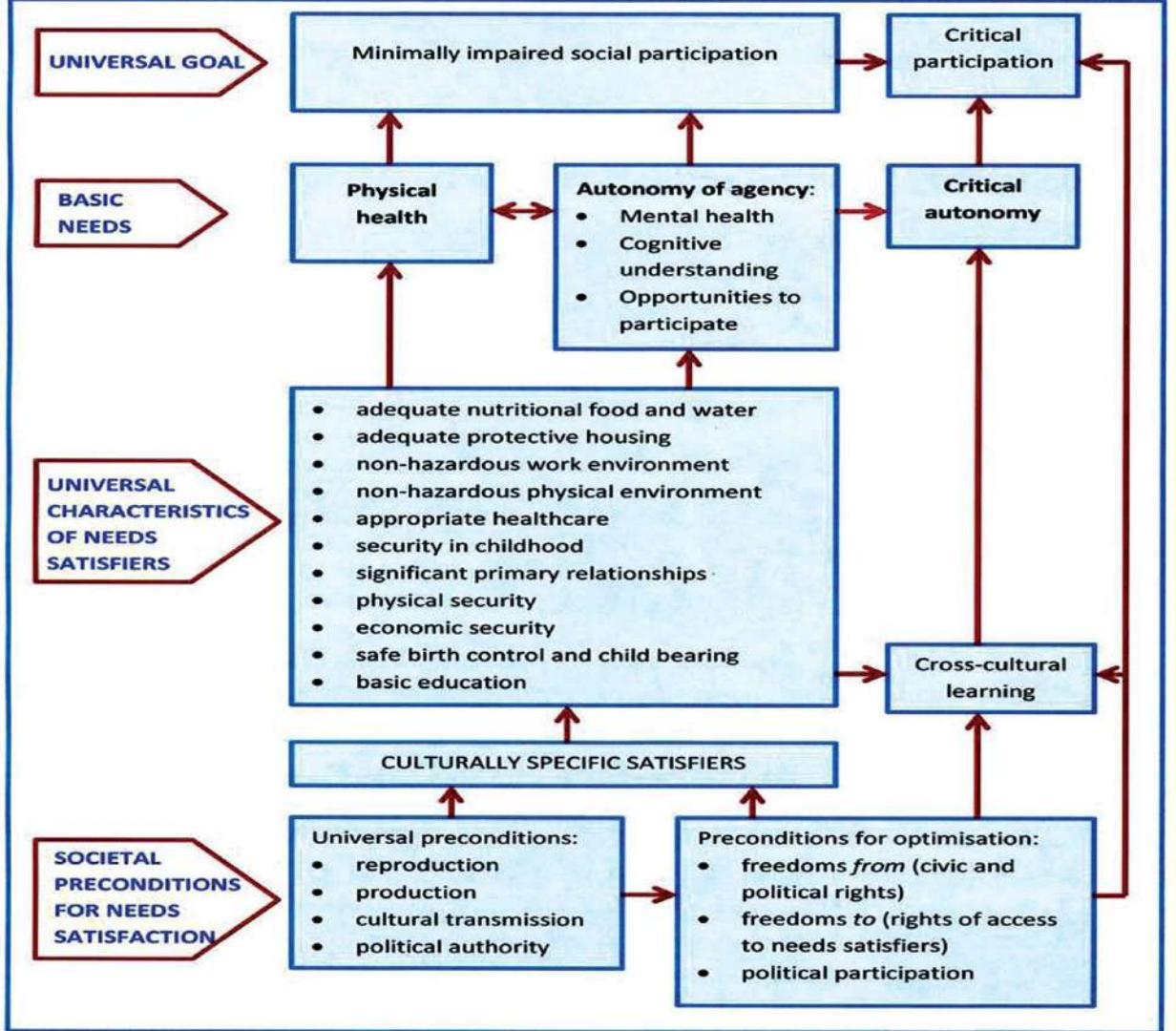
Why is wellbeing central to a sustainable society?

Wellbeing is a state of thriving, which involves full participation in society, a sense of prosperity and of leading a good life, based on the precondition of all needs being satisfied. Sustainable wellbeing extends this wellbeing to future generations.

The concept of human needs is central to wellbeing, and the only approach that can define wellbeing in a broad culturally meaningful way, relevant now and far in the future.

“Preference satisfaction”, or the different but equally subjective concept of hedonic happiness cannot be a basis for wellbeing, for many reasons such as limits to knowledge or rationality, adaptation, lack of moral distinction, or cultural differences (Gough 2015, 2017).

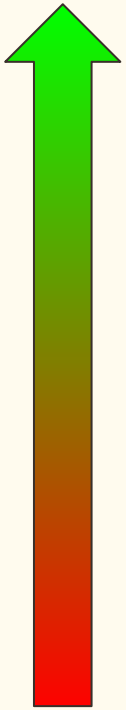
How to analyze wellbeing?



Theory of human need, Doyal & Gough 1991

Sufficiency framework based on satisfier orders

High impact



Low impact

1. **Socio-technical provisioning systems**
   - Examples: redesigning cities, relocalizating+rethinking supply chains, repurposing buildings and neighborhoods, rethinking services, reorganizing working time
2. **Socially and culturally built activities**
   - Examples: cars and non-essential flying become culturally toxic, identity and meaning is linked to human relationships
3. **Energy and material services**
   - Examples: optimized flight management reducing ton and passenger-km, video-conferencing
4. **Specific product or technology**
   - Examples: smaller and lighter car, optimized airframes and engines

Nick 2023, (“satisfier order” adapted from Brand Correa et al 2020).

Systems view, action levers, and leverage points

Action levers

Coordinated action on multiple leverage points

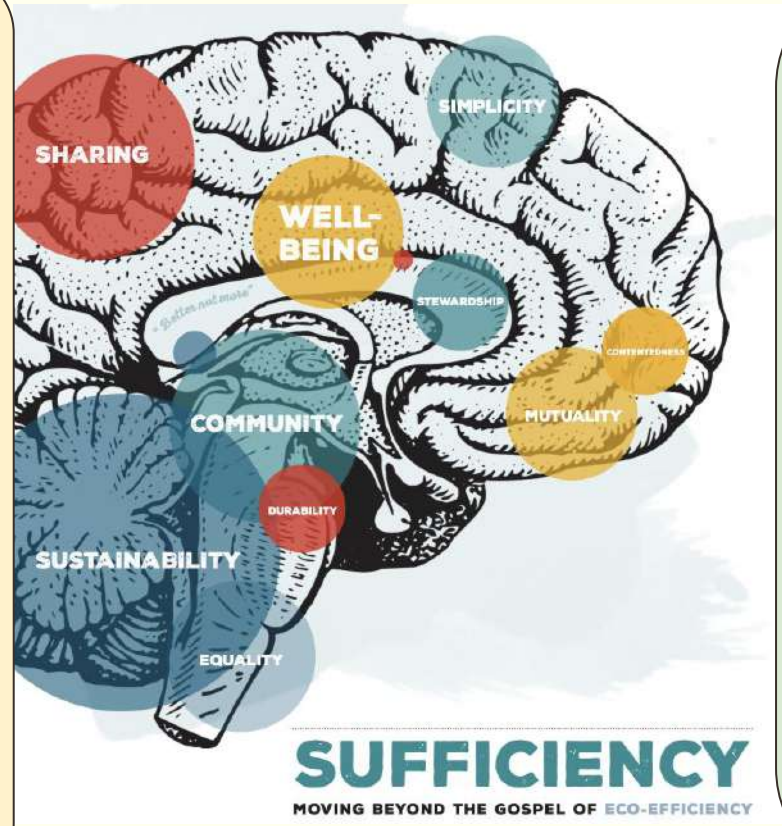
Mindset: post-growth

System goal: wellbeing for all within planetary boundaries

Change system structure: via local deliberative democracy

System rules: resources for public luxury, private frugality

Nick 2023



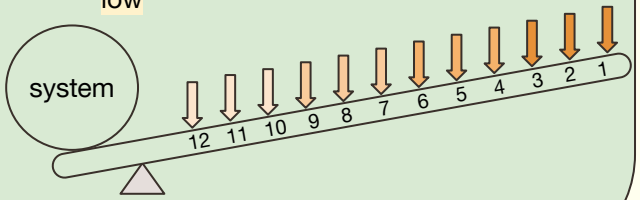
Friends of the Earth Europe 2018

Systems: Leverage points

high

Intent	1. The power to transcend paradigms 2. Mindset, worldview, values 3. System goals
Design	4. Power to change system structure 5. System rules 6. Structure of information flow
Feed-back	7. Gain of positive feedback loops 8. Strength of negative feedback loops 9. Delays
Para-meters	10. Structure of stocks and flows 11. Buffer size 12. Parameters, incentives, standards

low



Adapted from Abson et al. 2017, Meadows 1999