NAVIGATE

Next generation of advanced integrated assessment modelling to support climate policy making

International transport in a world below 2°C

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17 January 2023

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 821124.

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Overview of the presentation

- Below the 2°C target
- International transport (aviation and shipping): specific of these two modes (similarities and differences)
- Mitigations potential: policies and technologies
- Representation of international transport in IAMs (NAVIGATE)
- Analyse the level of decarbonisation potential by international transport in a below 2°C target world

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Paris Agreement (some of its key aspects)

- A temperature goal (Art. 2) – limiting global temperature increase to well below 2 degrees Celsius, while pursuing efforts to limit to 1.5 degrees.
- Global peaking and 'climate neutrality' (Art. 4) – aim to reach global peaking of GHGs as soon as possible to achieve a balance between anthropogenic emissions by sources and removals by sinks in the second half of the century.
- Mitigation (Art. 4) – binding commitments to prepare, communicate and maintain NDC and to pursue domestic measures to achieve them. Successive NDC will have a ratcheting ambition.

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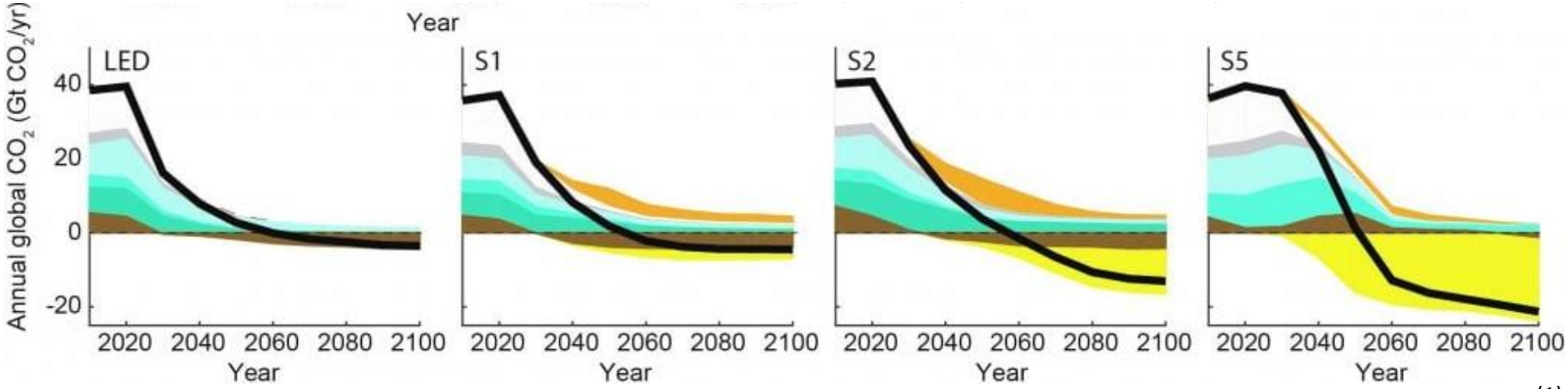

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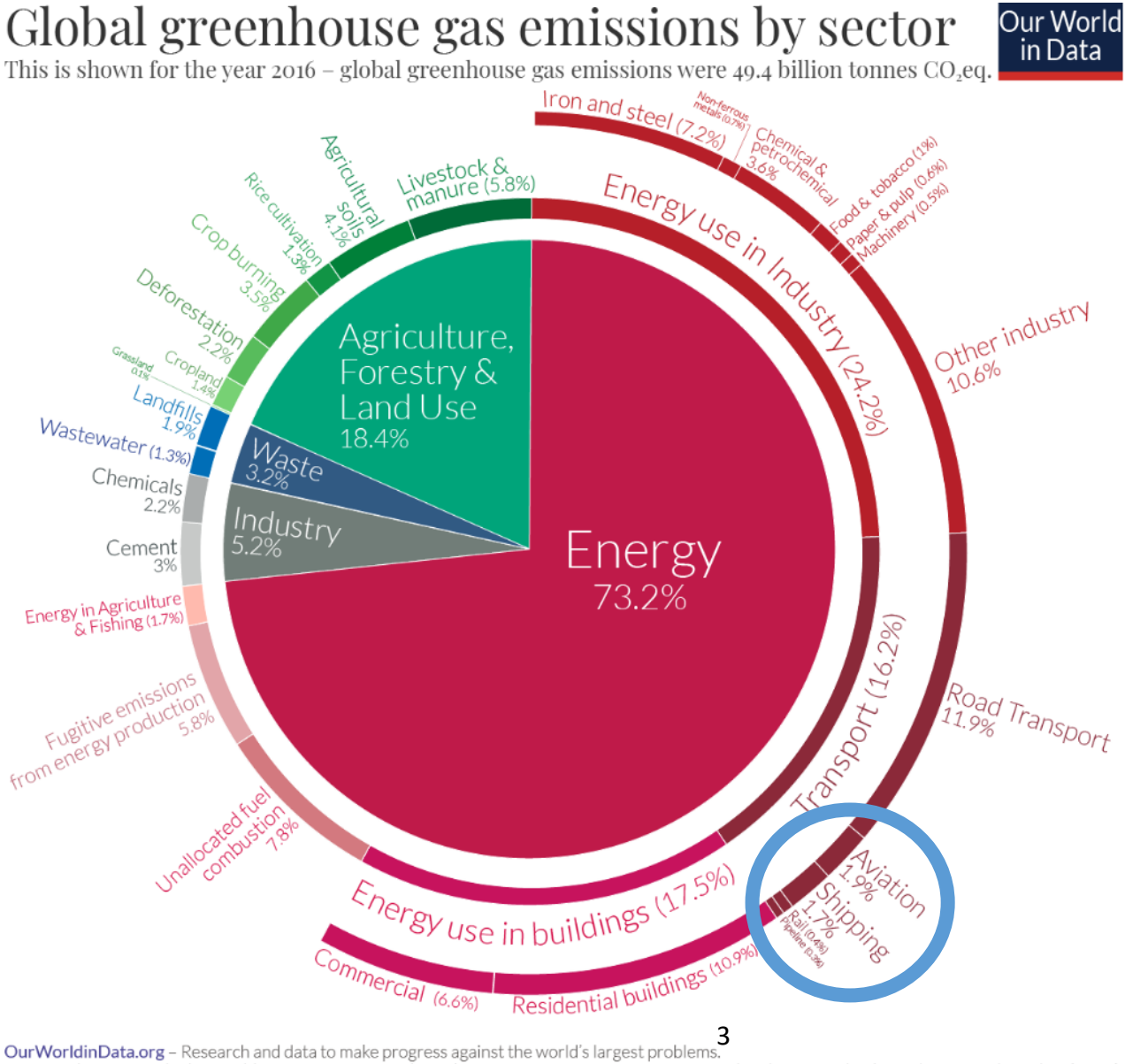
International Transport

- International transport emission out of the main frame of the Paris Agreement
- Regulated by IMO and ICAO
- Emissions 2019: shipping 692 MtCO2; aviation 618 MtCO2 (-10% and -51% for 2020 respectively)
- Increase from 2000: shipping +40% and aviation +75%
- Vessels typically have a very long lifespan (25-30 years) with a fleet age of 10 and 15 yr for aviation and shipping.



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International Transport

- Freight represents 100% of shipping but 20% of aviation emissions [3]
- Climate impact:
  - Shipping: black carbon emissions represent 21% of the CO2 impact [4]
  - Aviation: aerosols, water vapour and NOx emissions at altitude represent 2/3 of the net radiative forcing [5]

- ICAO: CORSIA *Carbon Offsetting and Reduction Scheme for International Aviation* (carbon offset and reduction scheme with goal to have a carbon neutral growth from 2019)
- IMO: EEDI 2011 the *Energy Efficiency Design Index* and *IMO GHG Strategy* 2018 (reduction target of 50% by 2050 compared to 2008)

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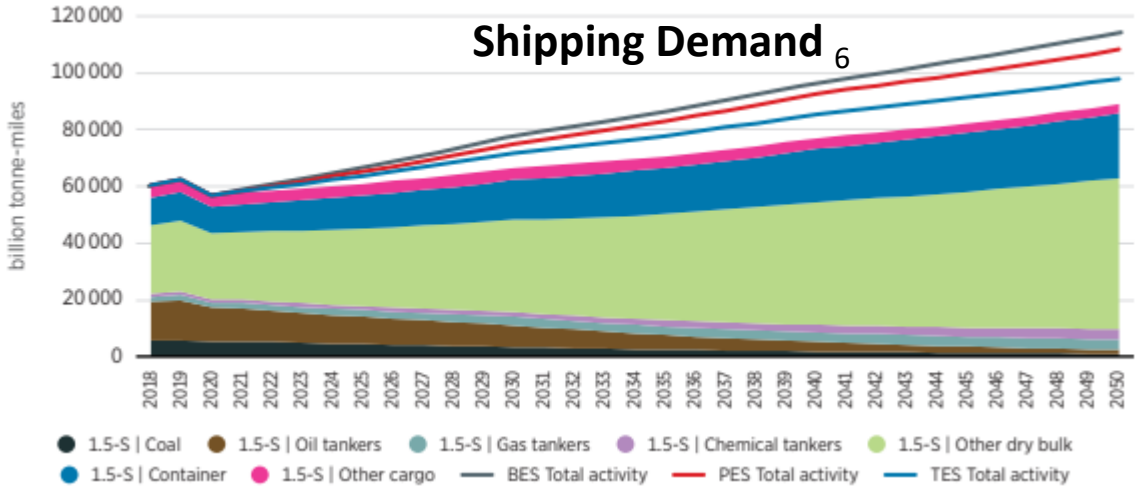
Projecting demand

A number of factors impact demand projection: socioeconomic, behaviour, policy….

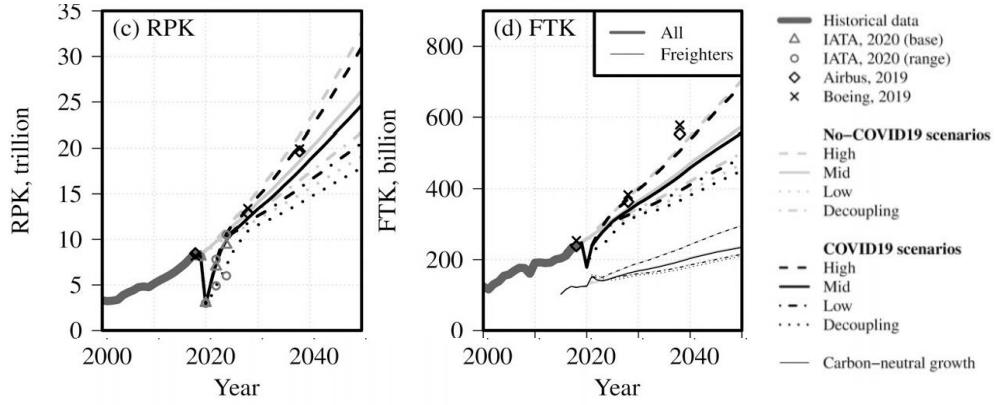
SSP2 projections:

- Shipping (tonne-miles) : 90% (BES) to 56% (1.5C) increase from 2018
- Aviation (RPK): 375% (HD) to 100% (Decoupling) increase from 2018

Shipping Demand [6]



Aviation Demand [7]



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Technologies and Policies for Mitigation

- Shipping: Operational measures and logistic such as slow steaming. Low-carbon fuel (liquefied fossil gases, traditional and advanced bioenergy or renewable electricity processes for synthetic fuels). Demand reduction via regionalisation of production or circular economy development.
- Aviation: Infrastructure and operational efficiencies. New technology to eliminate emissions at the source (SAF, electric and hydrogen). Offsets and carbon capture. Demand reduction policies (carbon tax, frequent flyer levy or escalating carbon tax).

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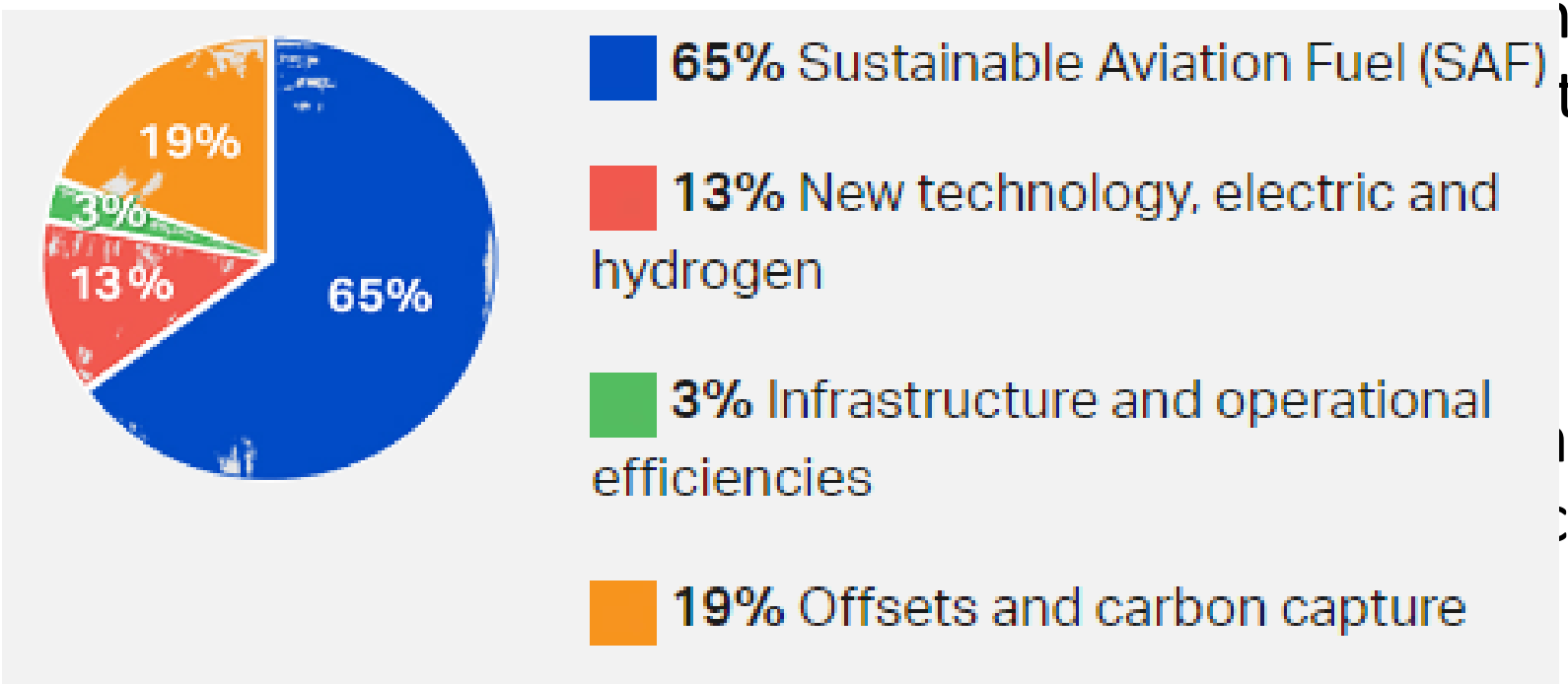
Technologies and Policies for Mitigation

- **IATA NetZero 2050 Strategy** [8]



slow steaming.
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or circular

- New technology
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International Transport and NAVIGATE IAMs

IMACLIM – TIAM-UCL – WITCH – COFFEE – PROMETEUS - IMAGE

Aviation Fuels

	Description	Represented
Conventional	Kerosene and aviation gasoline	All
Bio kerosene	Use a drop-in or total switch	All
Synthetic kerosene	Use a drop-in or total switch	All
Hydrogen	New technology	IMAGE
Electric	New technology	IMAGE, PROMETEUS

Shipping Fuels

	Description	Represented
Conv	Conventional marine fuels	All
Fats	Animal fats- and oilseed-based fuels	All
D-synt bio	Synthetic drop-in biofuels	All
D-synt other	Other drop-in synthetic fuels	All
AG-fos	Fossil alcohol and gases	All
AG-bio	Bio-alcohols and biogases	All
AG-synt	Synthetic alcohols and gases	All
H_2/NH_3	Hydrogen and ammonia	PROMETEUS*, TIAM-UCL, COFFEE, IMAGE*, WITCH*
Elec	Electricity	PROMETEUS

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The model intercomparison:

The goal is to investigate how deep decarbonisation could be achieved, both in terms of technical possibilities and structural changes.
The main objective is to identify the role of international transport in deep mitigation scenarios from a global IAM perspective.

- Under similar SSP2 assumptions, how do different IAMs see the role of international aviation or shipping in deep mitigation scenarios?
- Considering the results from different IAMs, is there a broader response/common conclusion deriving from this modelling exercise?

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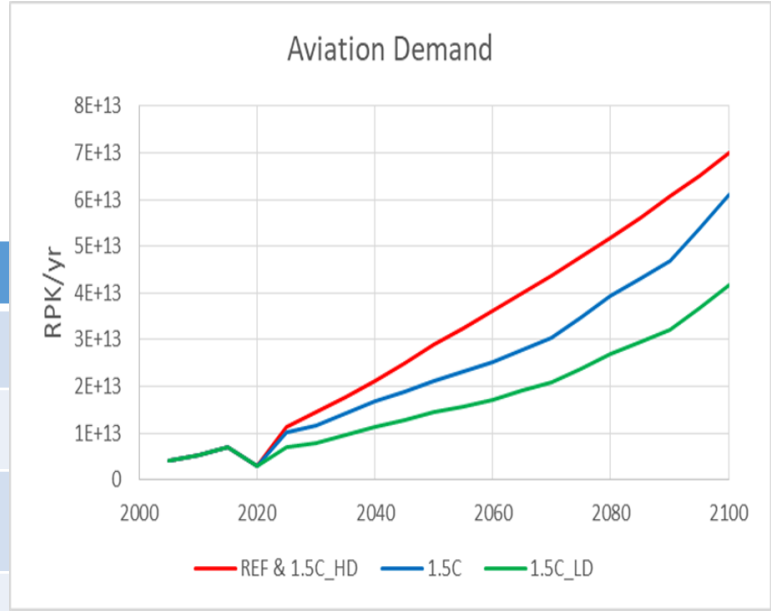
Aviation protocols: Scenarios

UCL: aviation

Aviation scenario name	Climate policy (SSP2)	Aviation sector
REF	**NDCs**	Based on meta-model SSP2
1.5C	**Carbon budget: 700 $GtCO_2$ 2020 onwards**	Based on meta-model SSP2
1.5C_LD	**Carbon budget: 700 $GtCO_2$ 2020 onwards**	Based on reduction relative to meta-model 1.5C SSP2 demand (Kikstra et al., 2021)
1.5C_HD	**Carbon budget: 700 $GtCO_2$ 2020 onwards**	As per REF
1.5C_LCF	**Carbon budget: 700 $GtCO_2$ 2020 onwards**	As per 1.5C + fast deployment of low carbon fuels
1.5C_LDLCF	**Carbon budget: 700 $GtCO_2$ 2020 onwards**	As per 1.5C_LD + fast deployment of low carbon fuels



Fast deployment of low carbon fuels (LCF): is represented as an increase of 50% in the penetration of fuels including bio and electro-fuels in the aviation sector between 2020 and 2050, relative to the 1.5C scenario uptake.

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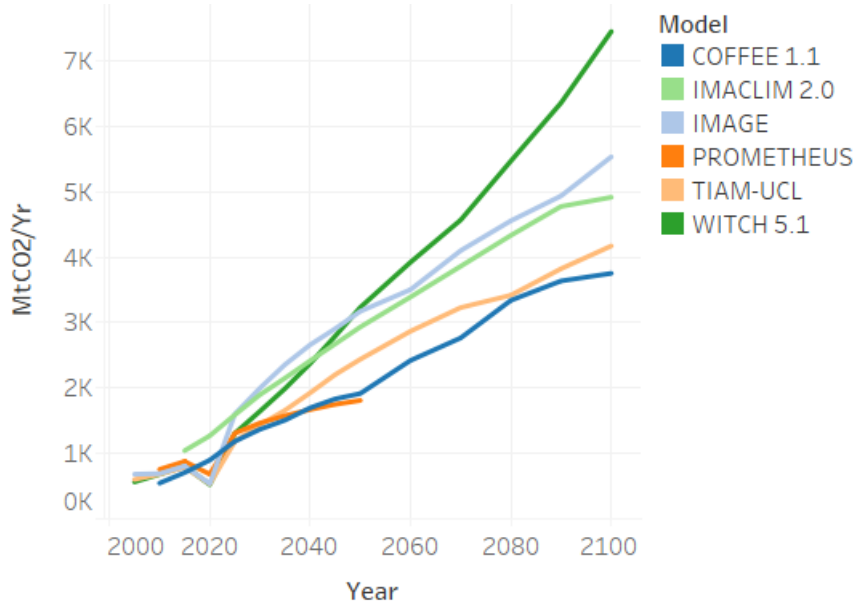
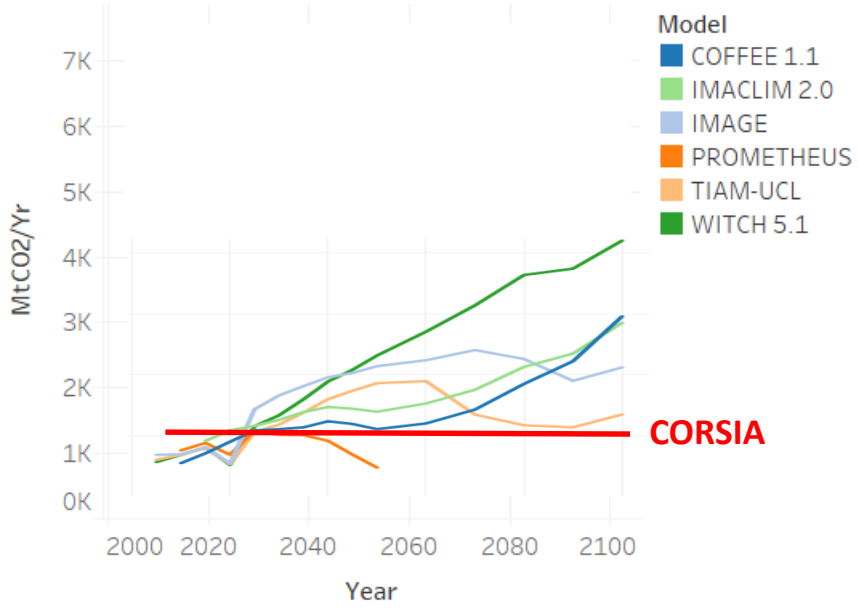
CO2 emissions from International Aviation

- Global carbon budget.
- No specific carbon budget for the sector.
- No specific CDR linked to the aviation industry (offsetting).

NDC aviation emissions



1.5C aviation emissions



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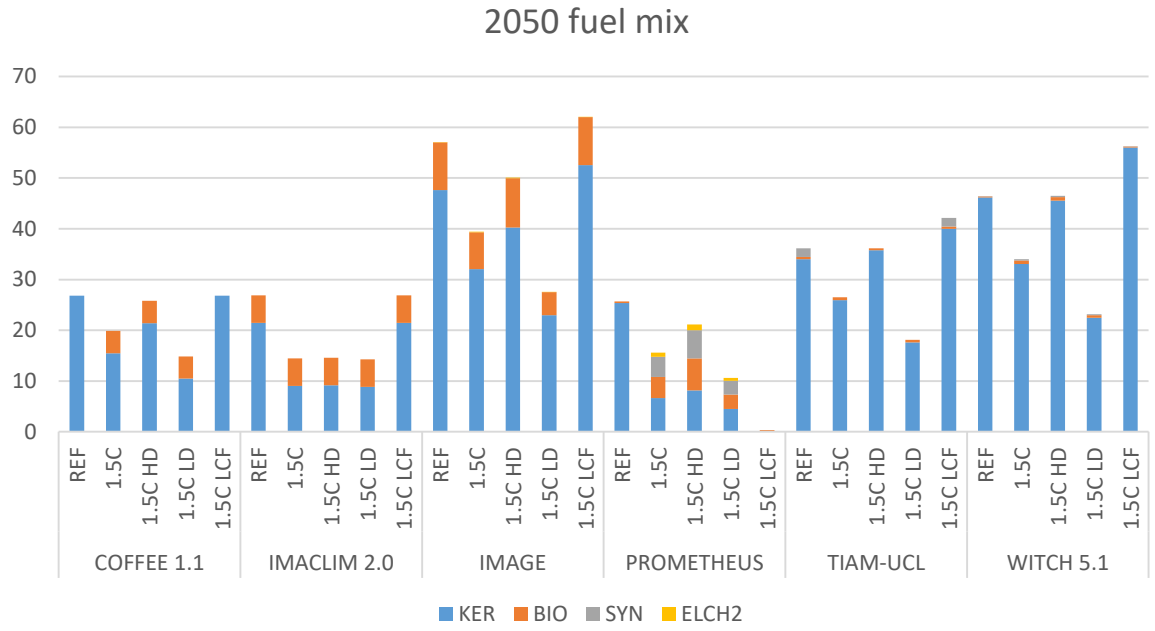
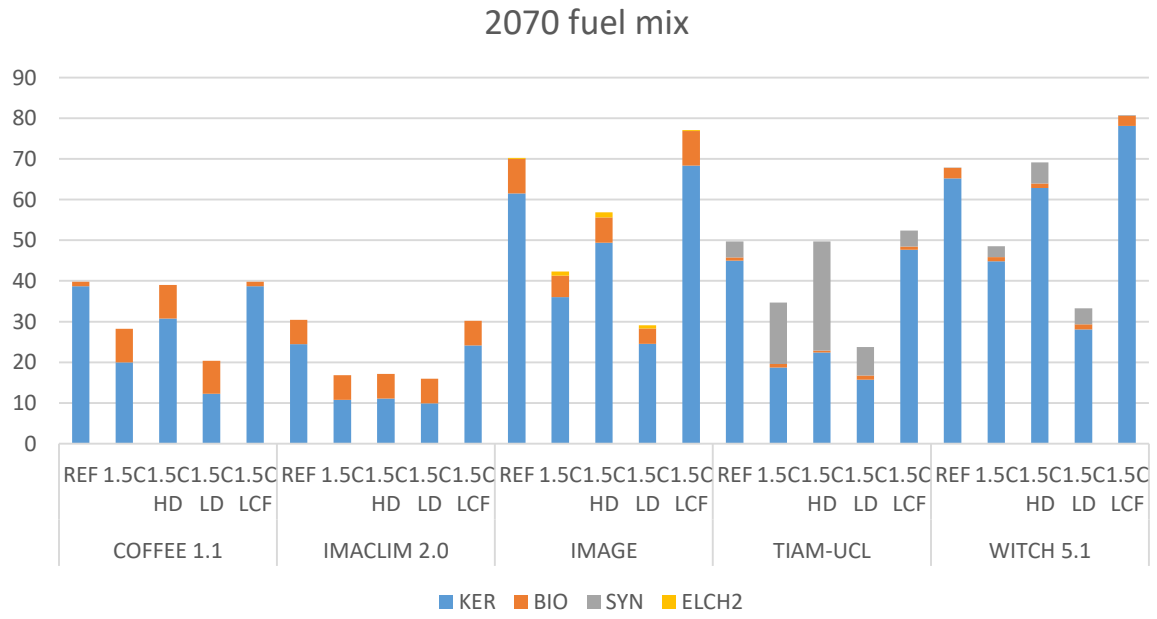
Post 2050 energy carriers for international aviation





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Maritime protocols: Scenarios

- Global carbon budget
- No sectoral storyline (demand harmonized to SSP2)
- No sectoral policy (IMO2050 target not implemented)

Shipping scenario name	Climate policy (SSP2)
NDCi_IntShip	NDCs
NDCi_600_IntShip	Carbon budget: 600 $GtCO_2$, peak
NDCi_600f_IntShip	Carbon budget: 600 $GtCO_2$, full century
NDCi_1000_IntShip	Carbon budget: 1,000 $GtCO_2$, peak
NDCi_1000f_IntShip	Carbon budget: 1,000 $GtCO_2$, full century

The scenario design does not impose any sectoral storyline, but input data are harmonized to SSP2.

The scenarios don't include IMO2050 target. One of our aims is to compare the models' results to this target.

The "f scenarios" are to understand the impacts of allowing overshoot on international shipping emissions.

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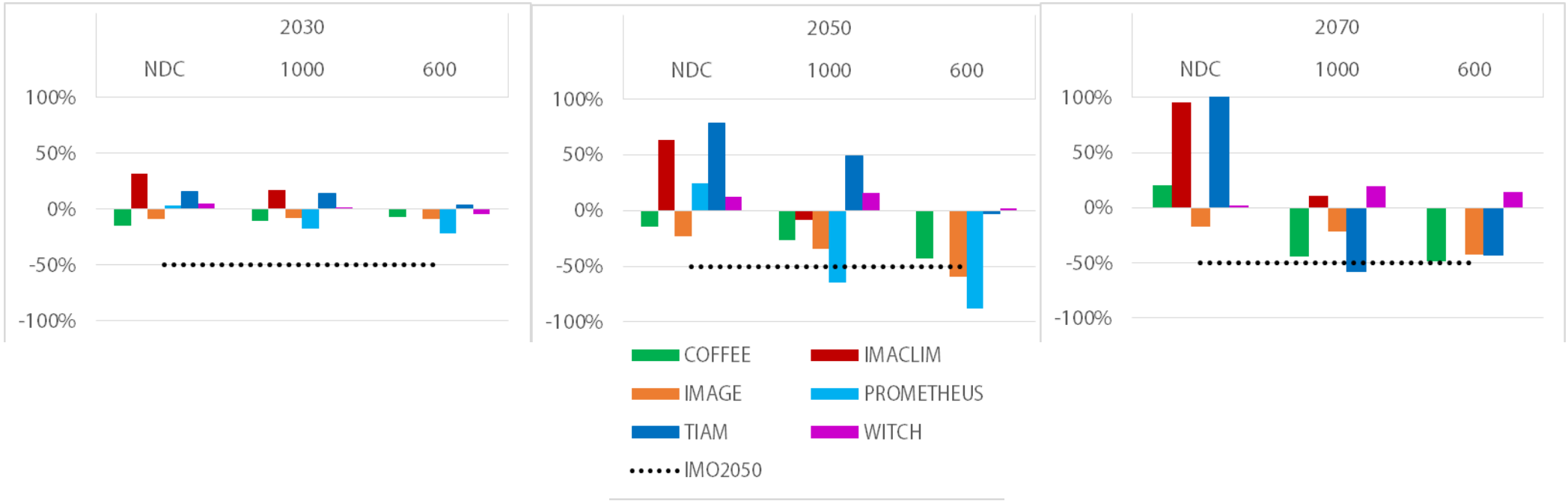
CO2 emissions for International Shipping

In a world below 2C, shipping emissions grow in the short-term and usually plunge by 2050.



International shipping CO2 emissions variation compared to 2020 across 3 principal scenarios

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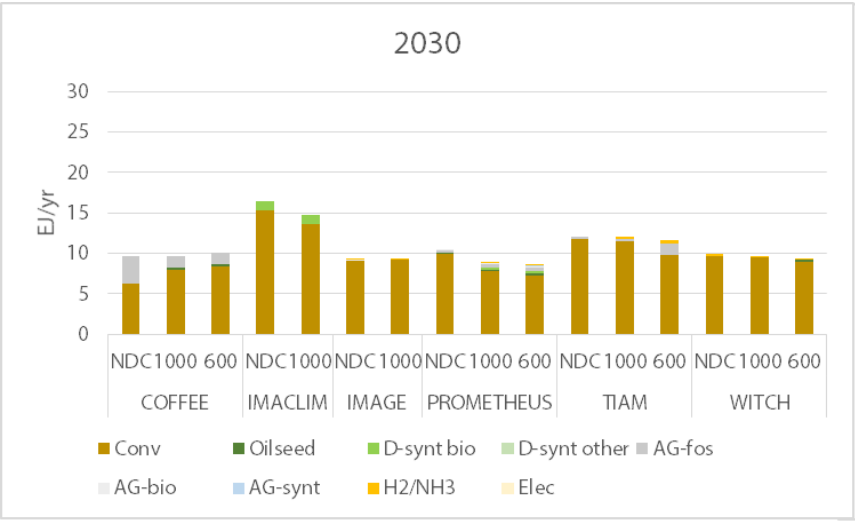
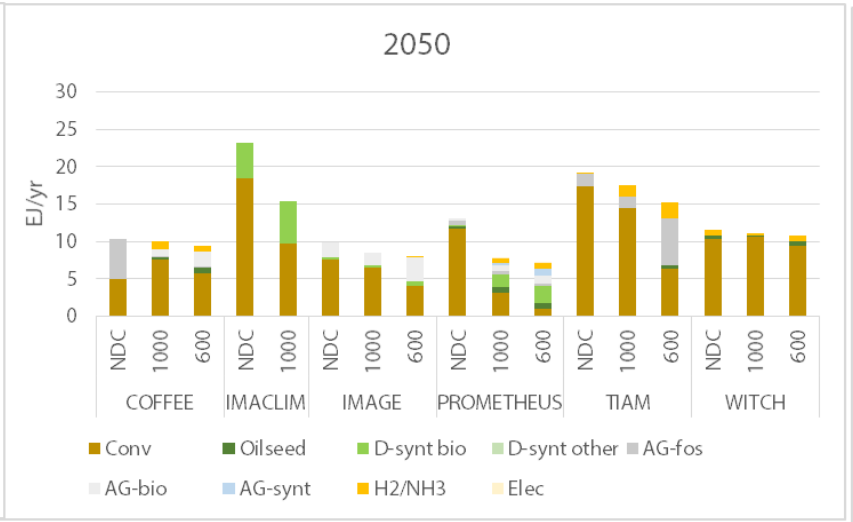
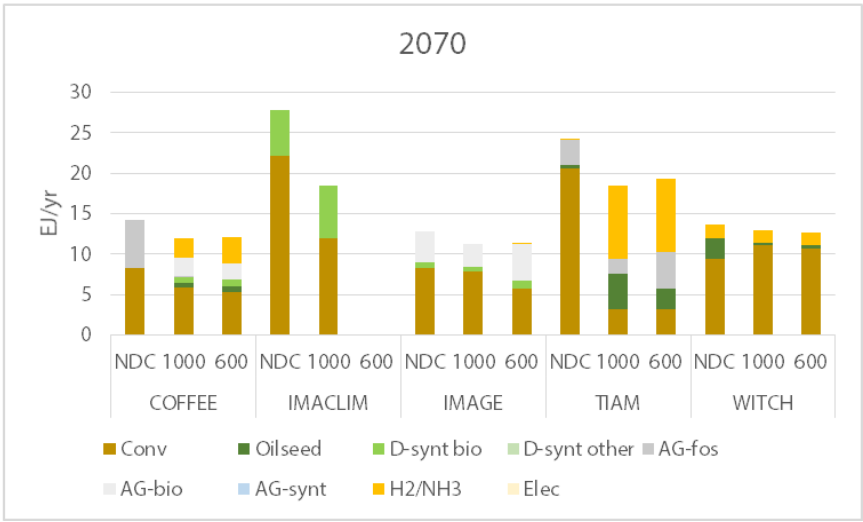
Post 2050 energy carriers for International Shipping

In 2050 and beyond, the marine fuel mixes show different penetrations of low-carbon energy carriers in from 75% in TIAM-UCL to very limited .







International shipping fuel mix in 2030, 2050 and 2070 across 3 principal scenarios

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Concluding remarks

In recent decades the transport sector has seen one of the largest increase in greenhouse gases emissions.
Transport underpins modern economies and ways of life, facilitating international movement of goods and community inter-connectedness.

1.5C global carbon budget:

As seen in the results, without specific sectoral policies, international transport in the second half of the century presents residual emission under 1.5C carbon budget.
These residual emissions can be compensated by CDR technologies.

Sectoral net-zero target:

Non-fuel-based solutions (demand management or operational efficiency) are important but will not to achieve net-zero alone; fuel switch to non-carbon based fuels is needed as well as some offsetting.

Both targets will require comprehensive strategies involving policy decisions, technology choices, infrastructure developments and logistic improvements to support the 1.5C target or achieve a net-zero goal within the next three decades.

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Models and Institutions

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References

1) https://www.ipcc.ch/sr15/
2) https://ourworldindata.org/emissions-by-sector
3) https://ourworldindata.org/transport
4) https://theicct.org/sites/default/files/publications/Global-Marine-BC-Inventory-2015_ICCT-Report_15122017_vF.pdf
5) https://doi.org/10.1016/j.atmosenv.2020.117834
6) https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Oct/IRENA_Decarbonising_Shipping_2021.pdf
7) https://doi.org/10.1177/03611981211045067
8) https://www.iata.org/en/programs/environment/flynetzero/

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