Aviation, shipping & the Paris Agreement

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Why aviation & shipping are interesting..

- Excluded from Kyoto, absent from Paris
- Contribute 4-5% annual global CO$_2$ (equiv. all S America!)
- Slow progress made by bodies mandated to deliver policy
- Sectors face very different mitigation challenges
- Service very different markets/activities

[http://dx.doi.org/10.1080/14693062.2014.965125](http://dx.doi.org/10.1080/14693062.2014.965125)
Global goal – Paris Agreement

... hold the increase in global average temperature to well below 2°C above pre-industrial levels & pursue efforts to limit the temperature increase to 1.5°C.

...rapid reductions in accordance with best science.

...on the basis of equity, and efforts to eradicate poverty.
Global CO$_2$ emission trend

Carbon dioxide from fossil & cement (GtCO₂/yr)

Historical CO₂

4°C CO₂

Challenges lifestyles

Paris trajectory
Carbon dioxide from fossil & cement (GtCO$_2$/yr)

Long term targets less important than carbon budgets (area under the curve)

Steepness of the trajectory important for planning and policy
We argue: mitigation policies need to be delivering change in the short-term because emissions accumulate.
But what are the potential solutions are gaining ground?
To assume emissions can go below zero – “negative emissions” – soon!
IPCC Scenario database:

400 scenarios for 50% or better chance of 2°C, of these:

- **86%** include large scale **negative emissions**
- the remaining **14% peak in ~2010**
- *most use negative emissions & adopt a ~2010 peak*
Negative emissions technologies

Challenges

Never worked at scale

Biodiversity concerns yet to be addressed

Huge technical & economic unknowns

Major efficiency penalty

Limited biomass availability (fuel vs food)

Poorly understood feedbacks
Carbon dioxide from fossil & cement (GtCO₂/yr)
Carbon dioxide from fossil & cement (GtCO₂/yr)

If Negative Emissions Tech. Assumed...

Mitigation can start later...

..as CO₂ goes below zero
Carbon dioxide from fossil & cement (GtCO$_2$/yr)
Relying on either time travel, or future uncertain technologies prioritises longer term solutions over change in the short-term.

If negative emissions ‘fail at scale’ need:

(1) Immediate, deep & sustained cuts in CO$_2$ $\sim$11% p.a.
(2) Complete decarbonisation in wealthy nations before 2050

Larkin et al., 2018, What if negative emissions technologies fail at scale: implications of the Paris Agreement for big emitting nations, Climate Policy, 18(6), 690-714.
Where does that leave aviation & shipping?
High CO₂ intensity & travel further
Shipping - derived demand (freight)

Largely unnoticed by public

Consumption of goods & materials

International trade (e.g. fossil fuels; food)

Just in time logistics & home deliveries
Global trade in fossil fuels

Figure 4.4
Major seaborne trades by commodity
Source: Fearnleys Review

Taken from Stopford, Maritime Economics.
Policy situation...

**Aviation (ICAO)**
- Carbon neutral growth post 2020
- 50% cut in CO$_2$ by 2050
- Delivered through efficiency, biofuels & voluntary off-setting/market based measures

**Shipping (IMO)**
- Energy Efficiency Design Index since 2013
- Mandatory fuel data collection from 2019
- 50% cut by 2050 & phase out by 2100
Growth
Airbus ‘Global Market Forecast’

Traffic doubles every 15 years. Grown at a higher rate than GDP growth – expected by the industry to continue.

World annual traffic (trillion RPKs)

ICAO total traffic
Airbus GMF 2017: \(4.4\%\) growth p.a.

RPK = Revenue Passenger Kilometre
Source: ICAO, Airbus GMF 2017
WORLD SEABORNE TRADE GROWTH FORECAST: 2018–2023

Volume projected to grow
+3.8%

Volumes across all segments set to grow: containerized and dry bulk cargoes projected to grow the fastest

Developed economies
34%

Transition economies
6%

Developing economies
60%

Loaded (outbound/exports)
63%

Unloaded (inbound/imports)
36%

Tanker volumes to grow at a slower pace

## Combined aviation & shipping growth

<table>
<thead>
<tr>
<th>Year</th>
<th>Share of global incl LU</th>
<th>Share of total excl LU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>3.7%</td>
<td>4.6%</td>
</tr>
<tr>
<td>2013</td>
<td>4.2%</td>
<td>4.5%</td>
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**Data:** IEA detailed fuel est.
What does 1.5°C mean for aviation & shipping?

The Future?
## Global CO$_2$ emissions budgets

<table>
<thead>
<tr>
<th>p</th>
<th>$\Delta T &lt;1.5^\circ C$</th>
<th>$\Delta T &lt;2^\circ C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>33%</td>
<td>650</td>
<td>1300</td>
</tr>
<tr>
<td>50%</td>
<td>350</td>
<td>1100</td>
</tr>
<tr>
<td>66%</td>
<td>200</td>
<td>800</td>
</tr>
</tbody>
</table>

Cumulative CO$_2$ budget (2016-2100) in GtCO$_2$

Data from WG1, AR5, removing 2011-2015 est. CO$_2$
Assuming aviation & shipping...

Maintain a proportional share of the budget


What does this mean for CO₂ budgets & intensity change?
Cumulative CO$_2$ budgets for aviation & shipping

Assuming const. ~2% share of global total for each

33-66% chance of <1.5°C – each has

~4-15 GtCO$_2$

33-66% chance of <2°C:

~18-30 GtCO$_2$
Combine with future demand projections

• Typical demand projections for aviation assume 4-5% annual growth in RPK (revenue passenger-km) to 2030+

• Typical demand projections for shipping assume 4-5% annual growth in t-km (tonne-km) to 2030+
Annual CO₂ intensity cuts for aviation & shipping

Constant year-on-year reduction rate from now & demand assumed constant from 2040

The required annual % change in carbon intensity (gCO₂/RPK or g/CO₂/RTkm)...

33-66% chance of <1.5°C:
21% change per year

33-66% chance of <2°C:
~6-8% change per year

Recent CO2 intensity changes: 1-2% p.a.
Near term mitigation options for 2°C?

- Limited by long life-time of aircraft and ships
- If growth & share maintained ~7% CO₂ p.a. intensity reduction
- Slow steaming & retrofit for ships (not planes!)
  » Rigid or soft sails, kites, Flettner rotors
- Aircraft have few options other than a drop-in biofuel
- Electric hybrid aircraft not ready until 2030? (Sugar Volt; Heart aerospace)

Near term mitigation options?

- Demand-management key to both
  - Moratorium on airport expansion
  - Virtual reality/hologram meetings
  - Decarbonisation = less fossil transport
    (Mander et al., *Carbon Management*, 2012;
     Sharmina et al., *Applied Energy* 2016)

- But still scale of change doesn’t stack up under 1.5°C budget
Conclusions (in Paris context)

What works?

Constraining airport expansion in wealthy nations
Some biofuel options viable but issues of competition & tech. spec
Many mitigation options in shipping (slow-steaming)
Decarbonising other sectors reduces shipping demand
Conclusions (in Paris context)

What doesn’t work?

Assuming tech. fixes for aviation fit Paris timeframe
Assuming technical fixes alone can deliver on Paris
Leaving mitigation efforts to own industry bodies
A reliance on global off-setting to incentivise sufficiently rapid innovation
Conclusions (in Paris context)

What needs to be done?

Realistic inclusion of sectors’ CO$_2$ trajectories in the global scenarios

Sectors to deliver Paris-compatible ‘N’DCs

Complimentary policy instruments explored and incorporated in NDCs

Demand management discussed as a realistic element of policy portfolio
Thank you!
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Biofuel?

- Lubricity
- Freeze Point
- Fluidity
- Non-corrosivity
- Microbial growth
- Cleanliness
- Thermal stability
- Storage stability
And tend to fly much further.

grams of CO₂ per passenger kilometre

Note: The figures have been estimated with an average number of passengers per vehicle. The addition of more passengers results in fuel consumption - and hence also CO₂ emissions - per vehicle becomes heavier, but the final figure in grams of CO₂ per passenger is obviously lower. Inland ship emission factor is estimated to be 245 g CO₂/km, but data availability is still not comparable to other modes. Estimations based on TRACCS database, 2013 and EM02 indicator.

Source: EEA report: TEM, 2014