Emerging Policies to Control the Climate Impact of Commercial Aviation

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Overview

- About the ICCT
- Overview of the climate challenge
- A quick look at emerging policies
  - CO₂ standards for new aircraft
  - Measures to promote alternative fuels
  - Market-based measures
- Conclusions
ICCT Background

- The goal of the International Council on Clean Transportation (ICCT) is to dramatically reduce conventional pollutant and greenhouse gas emissions from personal, public and goods transportation in order to improve air quality and human health, and mitigate climate change.

- The Council is made up of leading regulators and experts from around the world that participate as individuals based on their experience with air quality and transportation issues.

- The ICCT promotes best practices and comprehensive solutions to improve vehicle emissions and efficiency, increase fuel quality and sustainability of alternative fuels, reduce pollution from the in-use fleet, and curtail emissions from international goods movement.
International Council on Clean Transportation
ICCT Aviation Activities

- Actively engaged in aviation since summer 2008
- Observer to ICAO Committee on Aviation Environmental Protection (CAEP) since September 2008
  - NGO observer to emissions and technology working group
- Considerable ICAO activity to date this year
  - Feb. 2009: presented at ICAO Workshop on Aviation Alternative Fuels (WAAF), member of conference steering group
  - Feb. 2009: presented to ICAO high-level political group deliberating on climate measures prior to COP-15
  - April 2009: technical working group meetings
- Collaborating with US EPA and FAA on domestic options to curb aviation GHG emissions
Committed warming derived from IPCC Forcing & IPCC climate sensitivity.
Aviation is the second largest transport contributor to climate change

Future temperature change (K) due to transportation with constant 2000 emissions

Source: Berntsen and Fuglesvedt, PNAS, 2008.
Total climate impact of aviation two to four times that of CO₂ alone

Source: Lee et.al. *Atm. Env.* (in publication),
Anticipated two to fivefold increase in aviation CO$_2$ emissions by 2050

Unconstrained growth, or just catching up?

Per Capita Apparent Consumption of Jet Fuel by Country, 2004

## ICAO Action to Date

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Action</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel taxes</td>
<td>Reaffirms opposition</td>
<td>2001</td>
</tr>
<tr>
<td>GHG emission standard</td>
<td>Rules out</td>
<td>2001</td>
</tr>
<tr>
<td>Closed emissions trading</td>
<td>Opposes</td>
<td>2001</td>
</tr>
<tr>
<td>Global ETS</td>
<td>Dismisses in favor of existing schemes</td>
<td>2004</td>
</tr>
<tr>
<td>GHG emissions charges</td>
<td>Three year moratorium</td>
<td>2004</td>
</tr>
<tr>
<td>EU ETS</td>
<td>Attempts to block inclusion of foreign carriers</td>
<td>2007</td>
</tr>
<tr>
<td>Alternative fuels</td>
<td>TBD</td>
<td>2009</td>
</tr>
</tbody>
</table>

Global aviation CO$_2$ essentially unregulated today

Kyoto protocol coverage of global aviation CO$_2$ emissions
assuming no post-2004 growth

Emerging policies to reduce aviation emissions

- CO$_2$/GHG standards for new aircraft
- Measure to promote alternative fuel use
- Market-based measures
Why an aircraft CO$_2$ standard?

- **Industry position:** Aviation is fuel price sensitive --> already a strong driver for efficiency

- **But reduction potential exists:**
  - Airframe duopoly + technological conservatism
  - Race for speed and range impose efficiency penalty
  - Under-optimization of aircraft to allow for general use (stage length, belly freight capacity)
  - Aircraft with low operating costs and high fuel usage (B747, A380)

- **Question:** Can a CO$_2$ standard provide emissions reductions by addressing these issues?
Renewed policy activity around a CO\textsubscript{2} standard

- Request for work from GIACC (ICAO high level political group)

- Interest by member state constituent agencies
  - UK DfT: international work on CO\textsubscript{2} as a mitigation measure for Heathrow expansion
  - US EPA: public comment on preliminary ideas for regulation under Clean Air Act

- Need to revisit previous ICAO work on efficiency metrics to see if it applies to a standard for new aircraft
Criteria for CO$_2$ intensity metrics for new aircraft

- **Carbon intensity metric for new airframe standard *should*:**
  - Accurately characterize emissions per unit productivity --> where proxies are used, should avoid perverse incentives
  - Provide “face” validity (consistent with industry experience)
  - Recognize and reward technological progress

- **Carbon intensity metric for new airframe standard *need not***:
  - Provide a perfect correlation between the intensity of new aircraft and their intensity in use
  - Control for systematic differences in the carbon intensity of aircraft serving different functions
  - Apply universally to all aircraft types (passenger and freight)
Candidate CO$_2$ intensity metrics

- **g/TOW ton-km**
  - Variation of MTOW, a well defined parameter for aircraft
  - MTOW has been suggested as a proxy for payload
  - Assumes very inefficient fueling patterns --> use TOW ton-km instead

- **g/ATK**
  - Similar to CASFE metric, but at 100% load and for individual aircraft
  - Could be used for both passenger and dedicated freight aircraft, or just freight alone

- **g/ASK**
  - Likely require definition of reference seating arrangement
  - May be most appropriate metric if goal is to reduce emissions while maintaining high level of passenger service
g/TOW ton km problematic metric

Figure 1: Block CO$_2$ emissions per TOW ton-km as a function of stage length (mid to long-range)

1. Aircraft carbon intensity improves beyond design range
2. Heavier aircraft perform better: promote belly freight + range, weakened incentive for weight reduction
g/ATK improves on g/TOW ton-km, but concerns remain about belly freight

Figure 5: Block CO₂ emissions per ATK as a function of stage length (mid to long-range)
Block g/ASK intensity particularly flat across most stage lengths for medium to long-range aircraft.

Figure 7: Block CO₂ emissions per ASK as a function of stage length (mid to long-range)

Note reordering of aircraft: most efficient aircraft on g/ATK basis not necessarily most efficient on g/ASK basis --> key question of belly freight!
Application of CO$_2$ intensity metrics to a new airframe standard

- Relative insensitivity of carbon intensity to stage length of a given aircraft + predictable relationship between load factor and carbon intensity point toward simple aircraft “duty cycle”

- Systematic differences in carbon intensity of aircraft can be handled by:
  - Binning (Japan HD FE: 25 bins, IMO: 67 bins?)
  - Corporate average intensity targets for airframe

- Whatever the exact approach, metrics exist to support a new aircraft standard --> could be clarified by ICAO with a reasonable level of effort
Mission profiles could likely be covered by a limited number of standard bins

Representative in-operation aircraft and carbon intensity “bins”
Principles for future CO$_2$ standard work

- Standard needs to be adopted soon
  - BAU ICAO would be enforced from 2017, even 2020?
  - EPA may face 2012 deadline to adopt

- Standard needs to have teeth ("technology forcing")

- Standard should address design variables in addition to technology
  - Speed, range, belly freight, etc.

- Standard should set medium-term signal for aircraft design

- Standard may address interdependencies with non-CO$_2$ forcings
  - NOx through engine efficiencies
  - Contrails/cirrus through cruise speed and altitude
Emerging policies to reduce aviation emissions

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Biofuels in aviation: jumping the gun?

- Much action and interest
  - Numerous commercial trials attracting public attention
  - USAF seeking biofuels for blend certification by 2013

- But...
  - Compelling evidence that GHG emissions from today’s biofuels higher than conventional petroleum fuels
  - Supply constraints severe:
    - Meeting USAF demand for 300,000 gallons (~0.00035% of annual commercial use) “tricky”!

- Little reason to believe that biofuels will significantly reduce GHG emissions in the short to medium term --> need to think broadly about a range of mitigation options

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<table>
<thead>
<tr>
<th>Carrier</th>
<th>Date</th>
<th>Biofuel blend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virgin Atlantic</td>
<td>Feb 2008</td>
<td>20% (coconut and babassu)</td>
</tr>
<tr>
<td>Air New Zealand</td>
<td>Dec 2008</td>
<td>50% (jatropha)</td>
</tr>
<tr>
<td>Continental</td>
<td>Jan 2009</td>
<td>50% (algae and jatropha)</td>
</tr>
<tr>
<td>Japan Airlines</td>
<td>Jan 2009</td>
<td>50% (camelina, jatropha, algae &lt; 1%)</td>
</tr>
</tbody>
</table>
Key hurdles to alternative fuel use

- **Environmental**
  - Should not compete with food production
  - Must provide significant, verifiable GHG emission reductions measured on a lifecycle basis
  - Consider opportunity costs (biomass for electricity generation)

- **Economic**
  - Supply (esp. competition with other transport modes)
  - Cost

- **Operational**
  - Energy density critical
  - Freeze point, engine restart, etc.

- **Infrastructure/distribution**
  - Separate infrastructure for fuel delivery?
  - International use feasible, or domestic only?
Many alternative jet fuels not likely to meet environmental criteria

Comparison of lifecycle GHG emissions from a variety of alternative fuel pathways

Source: GIACC/3 IP/4. US submission.

Life-Cycle GHG Emissions (gCO₂e/MJ)

Source: GIACC/3 IP/4. US submission.
Aviation will compete with other modes and sectors for alternative fuels

US Petroleum Flows, 2007 (million barrels per day)

Without regulatory requirements how will aviation compete for capital and low-carbon feedstocks with other transport modes and sectors?
What is a realistic outlook for the supply of renewable fuels for aviation?

US Ethanol Production, 1980 to 2007

Annual Growth rates
1980 -- 2007: 14%
2000 -- 2007: 22%
Even optimistically, aviation unlikely to reduce emissions significantly in medium term through alternative fuels alone.

Emissions reduction due to fleetwide 10% use of alternative fuels with half the lifecycle CO$_2$ emissions of petroleum jet fuel in 2025.

Source: ICCT, using AERO2K data and linear introduction from 2016.
Summary of alternative fuels

- Nobody knows anything!
- Caution needed, particularly for today’s biofuels
- Industry focus on sustainable fuels acknowledged, but substantial hurdles to overcome
- Alternative fuels may play a part in a comprehensive, long-term strategy to control aviation emissions, but
  - Short-to-medium term potential unclear
  - “Drop-in” constraint limits emissions benefit (part. non-CO$_2$)
  - Will compete with other modes for feedstocks and capital
  - Will not contain emissions growth in the foreseeable future
- Incentives and mandates may help, but only appropriate after environmental benefits have been demonstrated
Emerging policies to reduce aviation emissions

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Scenarios of aviation emissions growth not consistent with climate stabilization goals

Figure 9: Carbon dioxide emission budgets for 450ppmv compared with aviation emissions scenarios based on the UNFCCC data to account for 50% of international flights and all domestic and intra-EU flights.

Relative to other modes, aviation demand is price sensitive.

Elasticity of Demand by Travel Segment

- International business (long-haul)
- International leisure (long-haul)
- Domestic business (long-haul)
- Domestic leisure (long-haul)
- Business (short-haul)
- Leisure (short-haul)

Aviation under EU ETS

- Adopted in 2006 amidst considerable opposition by ICAO
  - US argues binding only through mutual consent (bilateral service agreements)
- Affects all flights to, from, and within Europe from 2012
- Emissions capped at 97% of 2004-2006 levels in 2012, decreasing to 95% in 2013
  - 15% of credits auctioned, with balance grandfathered based upon historical emissions
  - Concerns about windfall profits by industry
- Originally contained 2X multiplier for non-CO₂, but stripped with promise of flanking measure on NOx
- Exceptions for carriers operating under “equivalent” measures abroad
- Establishes cost for growth (~$25/ton for 2012 futures) by route, which de minimis exceptions
Aviation under Waxman-Markey

- Would cover aviation indirectly through two measures
  - Upstream cap on transportation fuels
  - Low carbon fuel standard (2023+)
  - In combination, open trading through 2022, partially closed trading afterward

- Many questions remain:
  - Ultimate stringency of cap
  - Allocation: high levels of auctioning?
  - Domestic vs. international fuel use
  - Treatment of non-CO₂ impacts (if any)

- Depending on how these answered, could be more or less significant than EU ETS legislation
Relatively high carbon prices will be required to impact demand

Impact of $20/ton and $100/ton carbon price on representative airfares

<table>
<thead>
<tr>
<th>Route</th>
<th>Aircraft</th>
<th>Current fare(^1) ($)</th>
<th>CO(_2) emitted (ton)</th>
<th>Carbon price ($/seat)</th>
<th>% of Current Fare</th>
<th>$20/ton</th>
<th>$100/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFO-Salt Lake</td>
<td>Canadair CRJ 200</td>
<td>229</td>
<td>4.6</td>
<td>3.7</td>
<td>1.6</td>
<td>18</td>
<td>8.0</td>
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<tr>
<td>SFO-Minneapolis</td>
<td>Airbus 320-200</td>
<td>259</td>
<td>48</td>
<td>6.4</td>
<td>2.4</td>
<td>32</td>
<td>12</td>
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<tr>
<td>SFO-Newark</td>
<td>Boeing 737-800(^2)</td>
<td>639</td>
<td>78</td>
<td>9.6</td>
<td>1.5</td>
<td>48</td>
<td>7.5</td>
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<tr>
<td>Newark-Heathrow</td>
<td>Boeing 757-200</td>
<td>541</td>
<td>220</td>
<td>17</td>
<td>3.1</td>
<td>83</td>
<td>15</td>
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<tr>
<td>SFO-Tokyo</td>
<td>Boeing 777-200</td>
<td>695</td>
<td>370</td>
<td>25</td>
<td>3.5</td>
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<tr>
<td>SFO-Dubai</td>
<td>Airbus 380-800</td>
<td>1402</td>
<td>1200</td>
<td>42</td>
<td>3.0</td>
<td>210</td>
<td>15</td>
</tr>
</tbody>
</table>

[1] Cheapest non-stop roadtrip fare, 5/25~6/1, kayak.com
Issues for MBM design

- Goal should be to establish a long-term, predictable price on carbon
  - Price helps constrain growth while internalizing social costs
  - Price itself is more important than specific instrument

- For time being, ETS is what we have, but....
  - Tendency to grandfather leads to poor outcomes
  - Price volatility worrying
  - Open trading without consideration of non-CO$_2$ impacts degrades stringency of target

- Key issues moving forward
  - What role will ICAO play?
  - How to link regional/national systems
  - Developing country participation under CBDR
Conclusions

- Undeniable need for GHG action from aviation
  - Large climate impact
  - Fast growth
  - Essentially unregulated by UNFCCC or ICAO

- CO$_2$ standards for new aircraft may help
  - Adopted soon enough to influence next design decisions
  - Need teeth!

- Alternative fuels: jury is still out, but unlikely to be a silver bullet

- MBMs can help constrain/offset growth, but are easy to do wrong