Alternative aviation fuels

Flightpath to 2050?
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About Cerulogy

- Consultancy of Dr Chris Malins, formerly:
  - Fuels lead for the ICCT
  - Communications lead for Renewable Fuels Agency
  - Representative for ICSA on several ICAO committees (AFAHG, SUSTAF, AFTF)
- Experts in alternative fuels policy and sustainability, working for government, business and civil society
Why alternative fuels?

- Aviation industry continues to grow rapidly (~4% annual)
- Climate impact significant now, and growing with industry
- Aviation in general not readily electrifiable
- License to operate requires aviation industry to become consistent with [1.5/2] degree future

![Graph showing CO2 emissions from 2005 to 2045 with three scenarios: Frozen, Baseline, and Best case (~100% alt fuels).]
That's a lot of alternative jet fuel...

The ICAO secretariat has presented scenarios for alternative fuel meeting from 4% to 100% of 2050 alternative fuel demand.
So, what are the options?

- HEFA
- Biomass-to-jet
- Power-to-jet
HEFA

- Hydrotreated oils and lipids
- Pros:
  - demonstrated technology;
  - commercially operational (5 billion litres);
  - cost proposition well understood
- Cons:
  - feedstocks costly (no prospect of being cheaper than jet fuel);
  - Indirect emissions;
  - preferred feedstocks include palm oil and PFAD;
  - food vs. fuel
Biomass-to-jet

- Synthetic jet fuel via pyrolysis and upgrading or gasification and synthesis of ‘generic’ biomass

  Pros:
  - low cost feedstock, potential cost reduction over time;
  - each technology stage has been demonstrated (e.g. in GtL/CtL)

  Cons:
  - Full process not commercially demonstrated;
  - high capital cost;
  - high cost in short term;
  - uncertainty over achievable cost profile;
  - some sustainability issues
Power-to-jet

- Synthesise jet fuel from hydrogen and carbon dioxide
- Pros:
  - low sustainability risk;
  - relatively low land footprint;
  - cost of renewable electricity falling
- Cons:
  - rather inefficient (maybe 50% conversion of electrical energy to chemical energy);
  - process not commercially demonstrated;
  - high cost in short and medium term (cf. bit.ly/e-fuels)
Demonstration phase

- Many airlines have trialled biofuels
- Some airports now offer biofuelling options (e.g. Stockholm, Halmstad, Oslo)
- However, larger scale ambitions have not been fulfilled
  - EU target of 2 million tonnes by 2020 (Flightpath 2020)
  - U.S. target of 2 billion gallons by 2020
Fuel synthesis generally produces mixed molecules
- Petrol range (incl. naphtha)
- Jet/diesel range (mid-distillates)

Achieve up to 85% selectivity of mid-distillates

Molecules suitable for upgrading to jet fuel will also be suitable for upgrading to road diesel
- Developing syn-diesel technologies means developing syn-jet technologies, and vice versa

Aviation ‘needs’ alt-fuels more than road due to chronic reliance on liquids...

... but, there’s no obvious environmental benefit from forcing alt fuels into jets instead of road diesel in the near term (especially while volumes are small)
Policy and neutrality

- In past, fuel supplied to aviation has not been eligible for alternative fuel support (original rules of RED, RFS, LCFS...)
- This has largely been resolved by making aviation fuels eligible for credit
  - Jet fuel suppliers not obligated parties
  - Implicitly subsidy of alt aviation fuel by road fuel consumers
- Aviation may need even larger incentives
  - e.g. multiplier proposal for RED II
  - ...but this could imply even larger cross-subsidisation
- Multiple incentives?
  - e.g. RED II plus CORSIA
CO$_2$ abatement cost

- Alternative fuels expected to need high implied CO$_2$ abatement cost to drive commercial viability
  - Biofuels: 200-400 €/tCO$_2$e
  - PtL: 500+ €/tCO$_2$e
- Implications for cost of aviation
  - Moving to 50% PtL by 2050 could double total aviation fuel spend ([bit.ly/e-fuels](http://bit.ly/e-fuels))
  - Could affect demand growth
Land requirements

- Replacing all EU aviation full with power-to-jet would take up to ~13 million hectares of renewable electricity generation at current typical German areal energy yields (comparable to size of Greece)
  - Compare to 6 million hectares in EU currently devoted to biomass for energy
  - Improved renewable energy yields -> smaller areas required
- Doing the same with biomass-to-liquids (perennial grasses on marginal land) would take something like four times that area (~60 Mha, similar to the size of Ukraine)
  - Rapeseed oil HEFA double that, 120 Mha
- Expanding HEFA use to cover any significant fraction of aviation fuel would have major impact on vegetable oil markets
  - Direct and/or indirect impact on palm oil expansion (see new report from Cerulogy today!)
- Global replacement has proportionately higher resource demands
Lifecycle emissions and indirect land use change – example of palm
Non-CO$_2$ climate impacts

- No demonstrated impact of synthetic fuels on non-CO$_2$ climate impacts
  - At least one paper suggests possibility of reductions
  - Would give an environmental reason to prioritise synthetic fuels into aviation
- Even with 100% alternative fuels, climate impact of aviation could still be large
- Additional solutions are needed for non-CO$_2$
Conclusions

- Three main alt aviation fuel technology families
  - HEFA, BtL, PtL
- All have higher costs than jet
  - PtL and BtL have higher current costs, but prospect of long term cost reduction
- Total replacement of aviation fuel by 2050 would require massive volume (compared to current biofuel industry)
- Massive volumes would mean very large resource/land requirements and cost implications
- Some alternative aviation fuels could have poor climate performance (e.g. palm HEFA)
- Alternative aviation fuels alone cannot resolve non-CO$_2$ climate impact of aviation
Questions?

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