Cerulogy

# Alternative aviation fuels

Flightpath to 2050?

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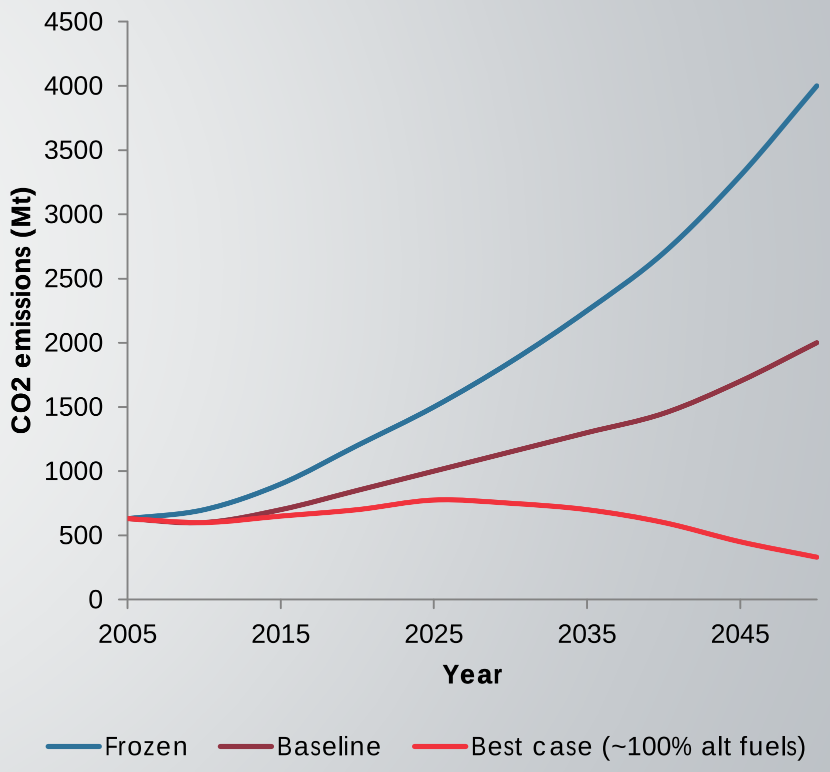
# About Cerulogy


- 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

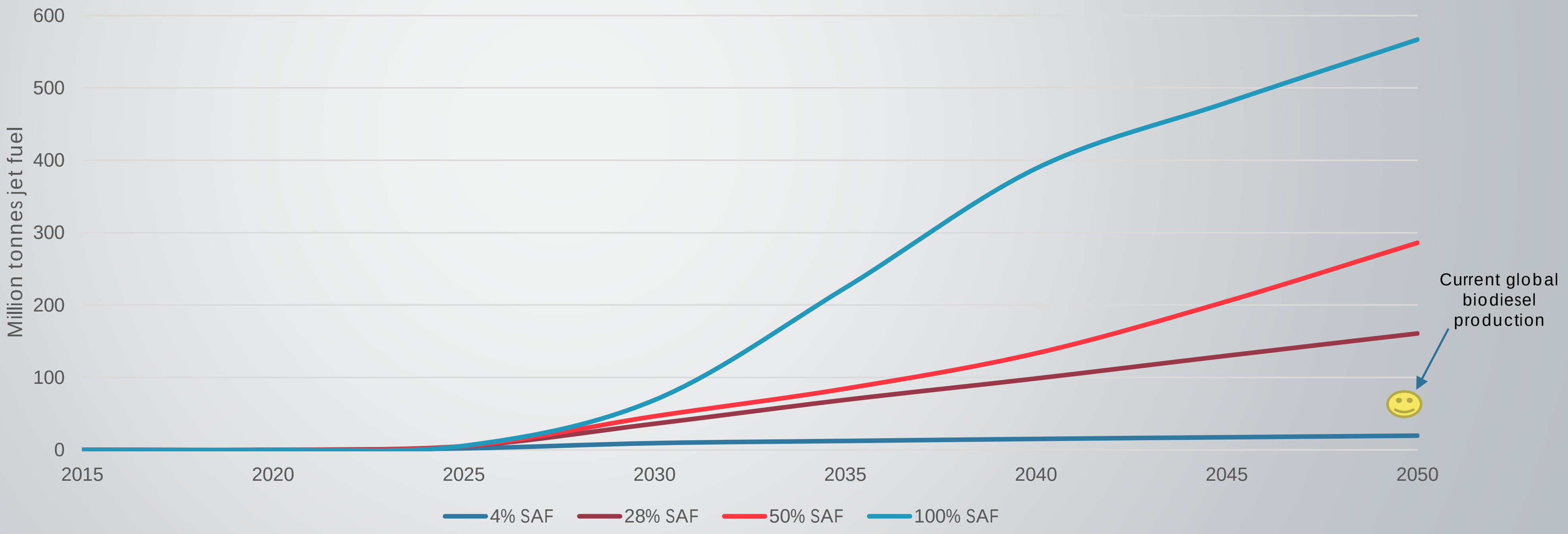
# Why alternative fuels?

- 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



# 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*

# No regrets? Modal priorities...

- 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

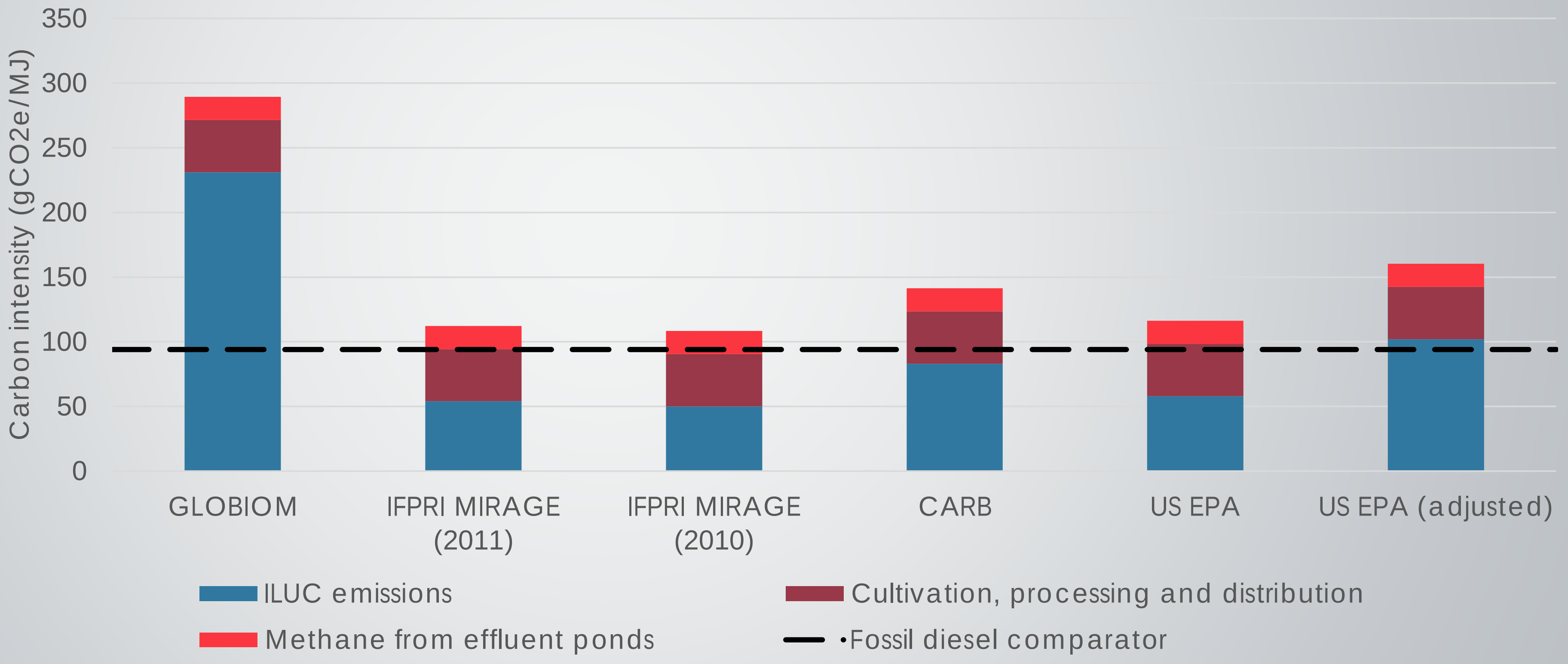
# $CO_2$ abatement cost

- Alternative fuels expected to need high implied $CO_2$ abatement cost to drive commercial viability
  - Biofuels: 200-400 €/t$CO_2$e
  - PtL: 500+ €/t$CO_2$e
- Implications for cost of aviation
  - Moving to 50% PtL by 2050 could double total aviation fuel spend (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

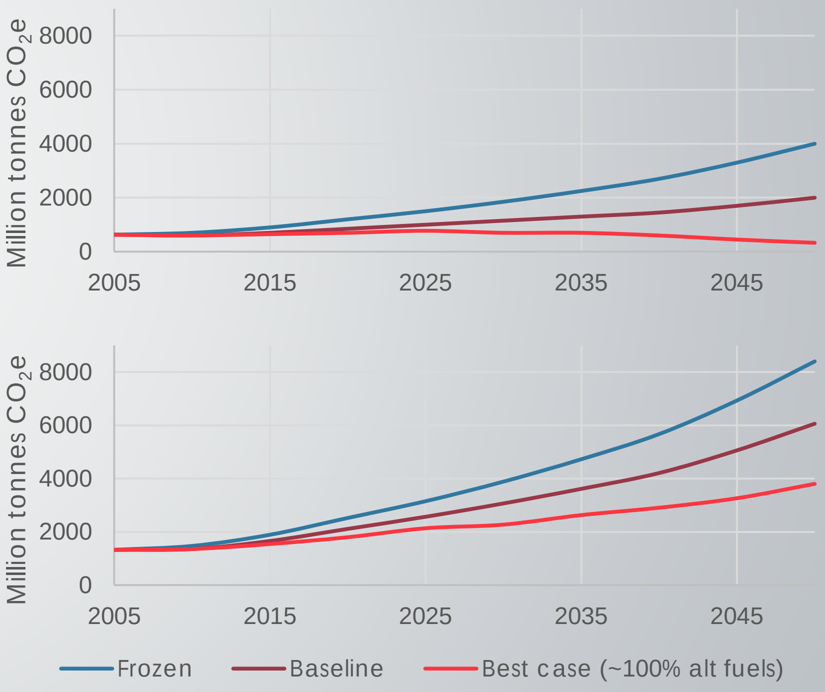
# Lifecycle emissions and indirect land use change – example of palm



# 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-$CO_2$*

With and without estimated non-$CO_2$ ($GWP_{100}$)



# 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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