AVIATION CO_2 REDUCTIONS

STOCKTAKING SEMINAR

TECHNOLOGY · OPERATIONS · SUSTAINABLE AVIATION FUELS

Advanced Aircraft Technologies

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Simple Arithmetic Can Go A Long Way …

… but what about rebound effects, airline competition, etc.?

$$CO_2 = \underbrace{\frac{CO_2}{E}}_{\text{Fuel Composition}} \cdot \underbrace{\frac{E}{RTK}}_{\text{Energy Intensity}} \cdot \underbrace{RTK}_{\text{Air Transport Demand}}$$

CO_2 Emissions — *Fuel Composition* — *Energy Intensity* — *Air Transport Demand*

Rebound effect in US domestic market ≈ 19% (Evans and Schafer, 2013) → a 10% aircraft-level fuel burn reduction leads to a roughly 8% aviation system fuel reduction.

Evans A., Schafer A.W., 2013. The rebound effect in the aviation sector, Energy Economics 36: 158-165.

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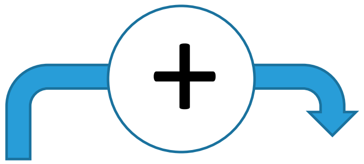

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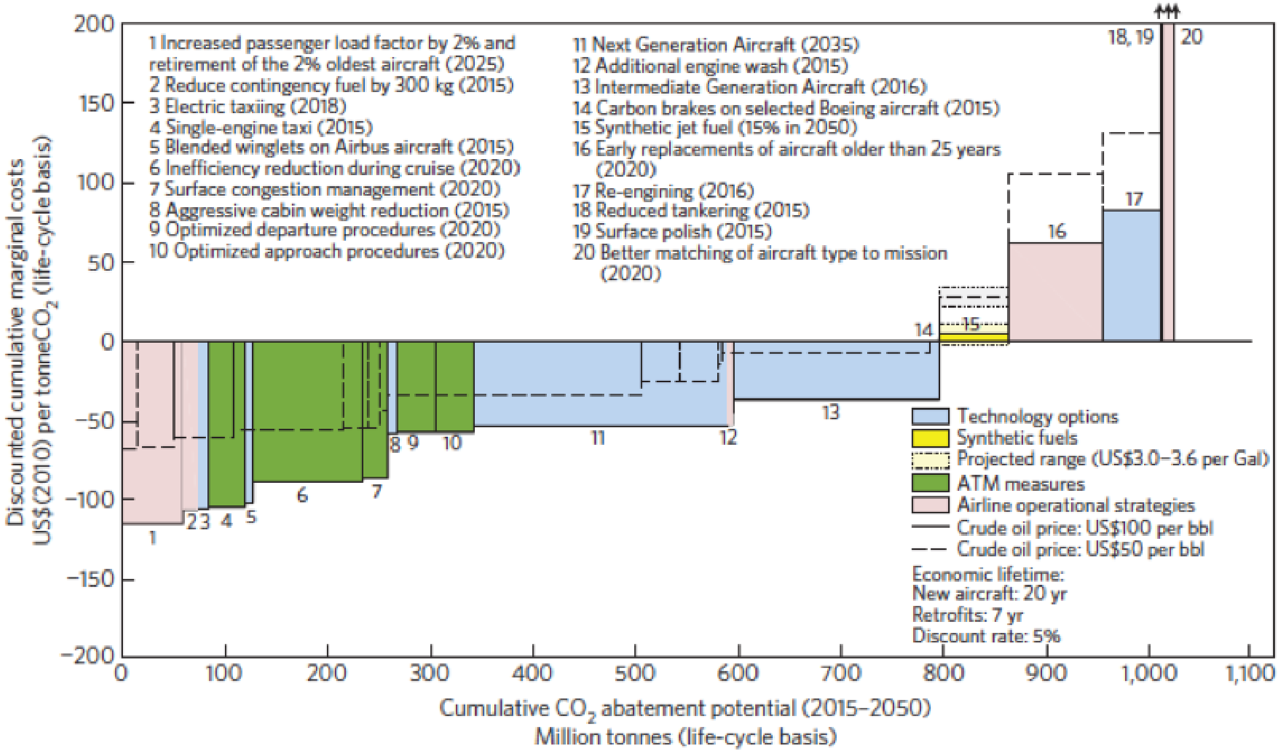
Reducing CO_2 Intensity Via Improvements In Mainstream Technology

Technology, Operations, ATM, Biofuel Blends

US Narrowbody aircraft fleet

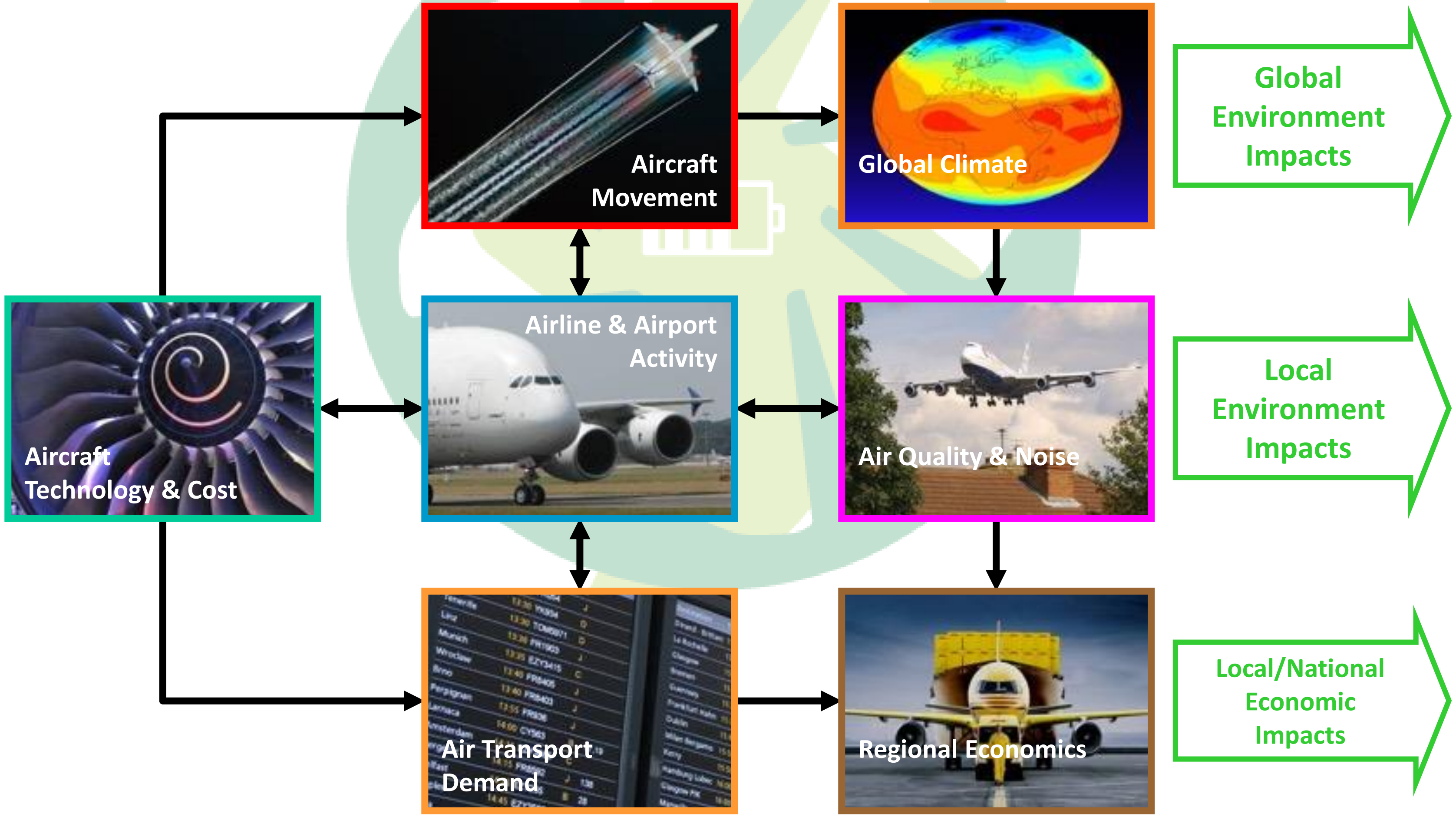


Schafer, Evans, Reynolds, Dray, 2015. Costs of mitigating CO_2 Emissions from Passenger Aircraft, Nature Climate Change, December 2015.

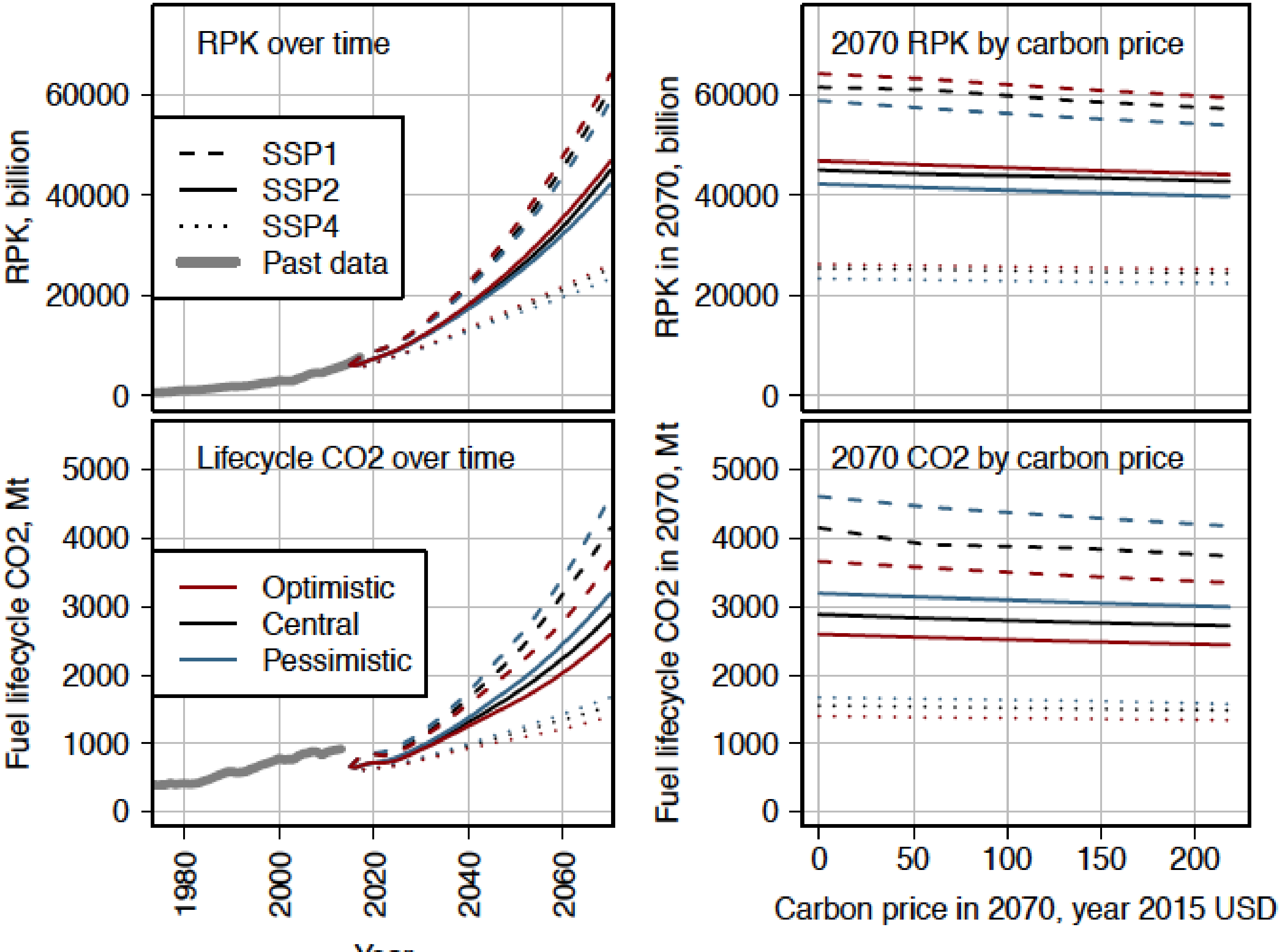
CO_2 reductions per RPK (fleet)	2%/yr
Level of finance required	
Timeframe	2050
Main challenges	

Aviation Integrated Model AIM2015 (www.ATSLab.org)

(Flights between 1,169 airports [878 cities] ≈ around 95% of global RPK, open-source code)



AIM2015: Improved mainstream technology (Global Perspective)



Dray L., Schafer A.W., Al Zayat K., 2018. "The Global Potential for CO_2 Emissions Reduction from Jet Engine Passenger Aircraft", Transp. Res. Rec., 2672(23), 40-51.

Modelling Airline Behavior

To simulate electric aircraft adoption, deployment, and economics

- Objective function: each airline sequentially maximizes profits within its network – iteration until equilibrium
- Three decision variables: airfare, flight frequency, type of aircraft → aircraft adoption, deployment, and economics
- Set of around 10 linearized constraints
- Validation: reproduce base-year itinerary passenger flows, schedules, airfares on route and airline level ($R^2 \approx 80\%$)
- IBM CPLEX linear programming solver
- Runtime on HPC: 5 min (Australia) – 24 h (North America, parallelized code)

Doyme K., Dray L., O'Sullivan A., Schäfer A.W., 2019. "Simulating Airline Behavior: Application for the Australian Domestic Market", Transp. Res. Rec., 2673(2), 104-112.

Modelling Airline Behavior, *continued*

To simulate electric aircraft adoption, deployment, and economics

- Preliminary results for Australian test case:
  - Depending on the projected techno-economic characteristics*, all airlines adopt electric aircraft for operation on suitable routes
  - Low-cost carriers (LCC) benefit most in terms of increased profits
  - Adoption of lower-DOC electric aircraft leads to strong increase in frequency competition – one LCC increases flight frequency by 90%
  - Change in airfares comparatively small
  - Today's market could employ around 60 electric narrowbody aircraft (180 PAX).

*Gnadt et al., 2019. Technical and Environmental Assessment of All-Electric 180-Passenger All-Electric Aircraft. Progress in Aerospace Sciences 105:1-30.
Schafer et al., 2019. Technological, Economic, and Environmental Prospects of All-Electric Aircraft. Nature Energy 4:160-166)

Thank You

ICAO