



Aircraft Cost Index and Carbon Emissions Reductions

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Introduction



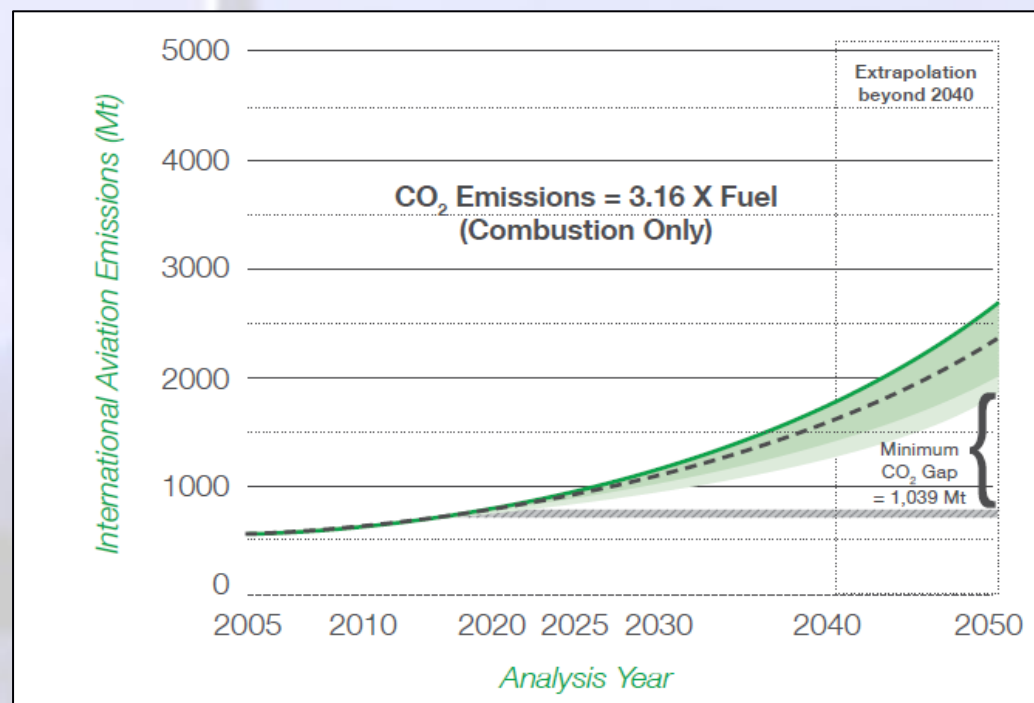
Aviation responsible for around **2-3%** of global greenhouse gas emissions

This proportion set to rise as carbon reduction solutions cannot keep up with demand growth

Likely scenario annual average growth rate:

- average growth rate 2010 to 2030 – 4.9% per annum
- 2030 to 2050 - 4% per annum

56,000 new aircraft required by 2040 (65% for growth)



$$CI = \text{Time Cost (\$/min)} / \text{Fuel Cost (\$/kg)}$$

- CI value determines the speed of the aircraft
- The higher the CI the higher the speed. This leads to higher fuel use and carbon emissions.
- Time costs are the most complicated to calculate and include
 - Flight and cabin crew costs
 - Maintenance costs
 - Depreciation costs
 - Delay costs

Cost Index



Emissions Savings:

B767-300ER – 3.4%

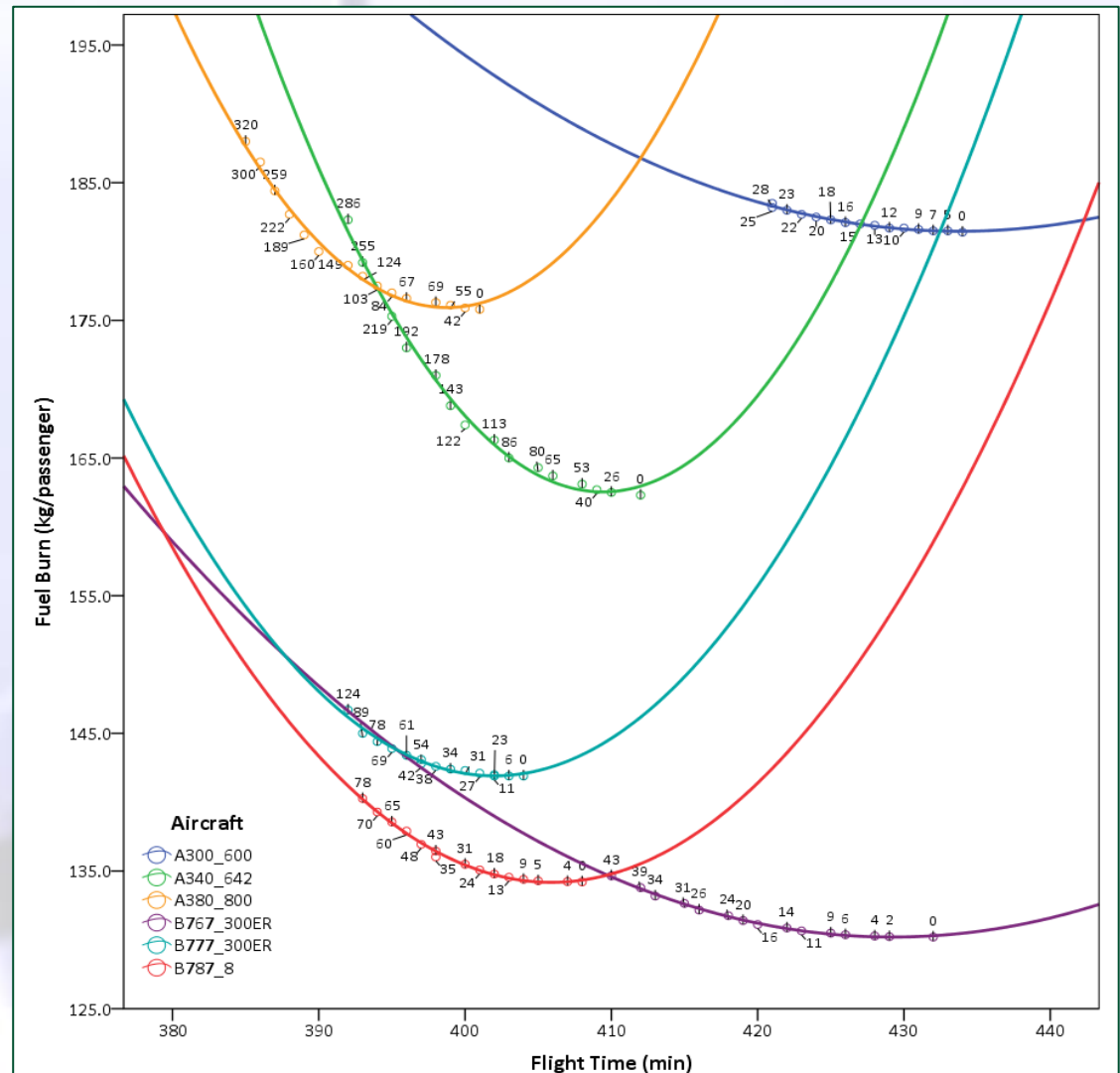
B777-300ER – 3.4%

B787-8 – 4.5%

A300-600R – 1.1%

A340-600 – 12.3%

A380-800 – 6.9%



Future Impacts



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Impacts can be divided into three main areas:

- Technology
- Policy
- Environment

Technology



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Aircraft and Airframe

- Thermodynamic propulsion efficiency
- Propulsion efficiency
- Drag
- Structural weight
- Radical designs



Operational Technology

- ADS-B
- Datalink
- Other ground systems

Maintenance – design of aircraft

Expected Improvements in fuel efficiency: aircraft technology

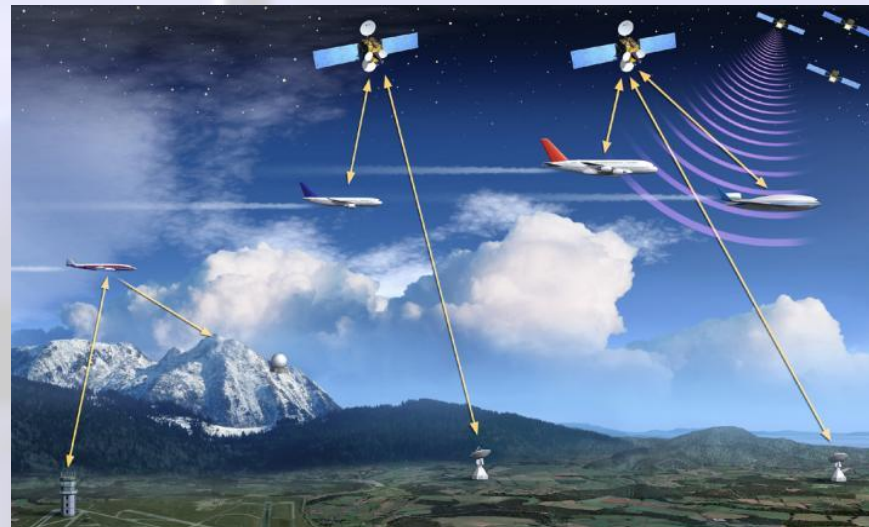
Scenario	Single Aisle		Twin Aisle	
	2020	2030	2020	2030
TS1: Continuation	23%	29%	19%	26%
TS2: Increased Pressure	29%	34%	25%	35%
TS3: Further Increased Pressure		41%		41%
TS3 with open rotor		48%		

Relative to year 2000 technology baseline

Expected Improvements in fuel efficiency: Operations

	2020	2030	2040
Goal	3.25%	6.75%	9.00%
Lower Confidence Interval	2.25%	4.50%	5.75%

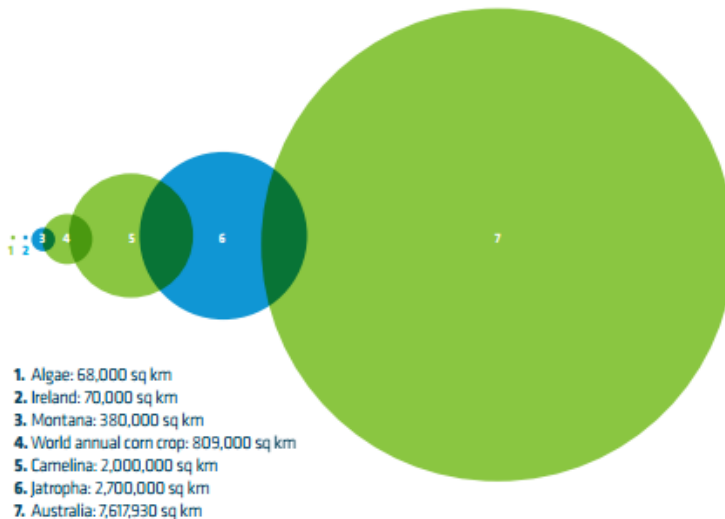
Relative to 2010 levels



Biofuels

- Started to gain attention in late 2000s with high profile test flights
- Need to be at least second generation biofuels
- Still environmental and social issues attached to production of biofuels

Land area equivalents required to produce enough fuel to completely supply the aviation industry



These diagrams represent a conservative estimate of the amount of land that would be needed to completely replace the amount of traditional jet fuel currently used with just one of these sources (as well as a comparison with different land areas).

It is unlikely that aviation will rely on just one type of biofuel, so a combination of these and other sources will be used.

Possible drop in fuel proportions:

- 2020 – 15%
- 2030 – 30%
- 2050 – 50%

Policy



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- Operations
 - Airspace charging and restricted airspace
- Emissions Trading
 - Global agreement – carbon pricing
- Regulation on crew work times
- Airport Construction

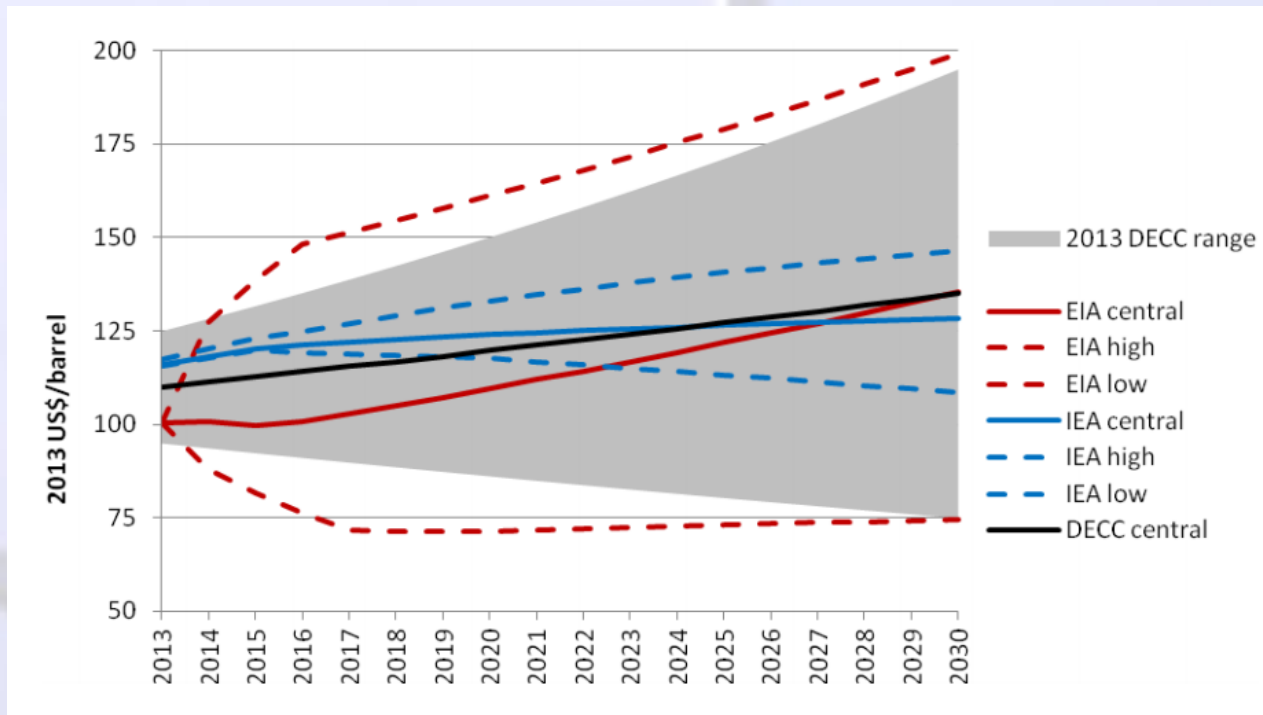
Zone	Unit Rate (EUR)
Portugal	10.60
Belg.- Luxembourg	72.19
Germany	77.47
Finland	52.21
Netherlands	66.62
Ireland	30.77
Denmark	71.53
Norway	52.66
Poland	35.36
Malta	27.76
United Kingdom	89.26
Switzerland	100.72
Austria	73.54

Climate Change Impacts on Aviation

Climate Impact	Aviation Impact
Temperature Increase	Changes in demand; changes in climb performance; redistribution on noise impact; heat damage to tarmac surfaces.
Changes in Precipitation	Operational impacts: loss of capacity and efficiency; increased delay; increased de-icing requirements; structural issues due to changes in ground frost depth and duration.
Increase in intensity and frequency of convective weather	Operational impacts: loss of capacity and efficiency, increased delay.
Changes in wind patterns	Increased crosswinds and loss of runway capacity; redistribution of noise impact due to procedural change
Sea Level Rise	Loss of network capacity; increased delays, network disruption; temporary or permanent airport closure

Jet Fuel

- In general there is an expectation that oil prices will rise
- Have to be careful that CI represents the price at origin airport
- To convert crude oil price to jet fuel price a 25% crack spread is used



Calculating CI and Costs



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- Piano-X used to model flights for B767-300ER
- Mach numbers from MRC (CI=0) and the maximum
- Fuel burn and flight time used to calculate CI for each Mach number
- Costs allocated for each CI – time costs from University of Westminster, fuel and carbon costs from DECC.

The screenshot displays the Piano-X software interface. The left panel shows input fields for aircraft load (B767-300ERW (412)), basic design weights (186880, 93032, 133810, 145149), and a Mach number (90774). Below these are buttons for 'Save Adjustments...' and 'Load Adjustments'. A 'Block Range Summary' section includes a 'GO' button and a 'with Payload (kg)' field containing 1000 and 22671.

The right panel displays the 'Piano-X Copyright © 2008 Lissys Ltd / D.Simos (www.piano.aero)' and a 'RANGE REPORT (design range & standard payload)'. The report includes the following data:

Loading plane: B767-300ERW (412)...Done.
{TOW 186880.kg./ OEW 93032.kg./ Fuel 71178.kg./ Payload 22671.kg.}
Range mode: fixed mach, step-up cruise
Climb schedule: 250./ 314.kcas/ mach 0.752 above 25276.feet
Cruise at Mach = 0.800 {FL 320 340 360 380}
ICA 32000.feet, 467.ktas, 291.kcas, CL=0.52, 46116.newtons/eng=MCR-21%
FCA 38000.feet, 459.ktas, 254.kcas, CL=0.46, 31694.newtons/eng=MCR-30%

	Distance (n.miles)	Time (min.)	Fuelburn (kg.)	
Climb	112.	17.	3310.	{S.L to ICA}
Cruise	5859.	761.	59699.	{ICA to ICA}
Descent	104.	18.	311.	{ICA to S.L}
Trip total	6070.	797.	63321.	
Block total	=====	811.	64057.	

Emissions: taxi,t/o climb cruise descent app,taxi total
(kg.NOx) 9.3 77.1 689.7 1.0 1.4 778.5
(kg.HC) 1.10 0.34 16.13 3.61 1.79 22.97
(kg.CO) 5.0 2.3 151.9 16.3 8.2 183.7
(kg.CO2) 1505. 10459. 188650. 984. 822. 202420.

Manoeuvre allowances:
taxi-out 103. kg. {extra to t/o mass} 5.0 min.
takeoff 373. kg. 1.5 min.
approach 157. kg. 3.0 min.
taxi-in 103. kg. {taken from reserves} 5.0 min.

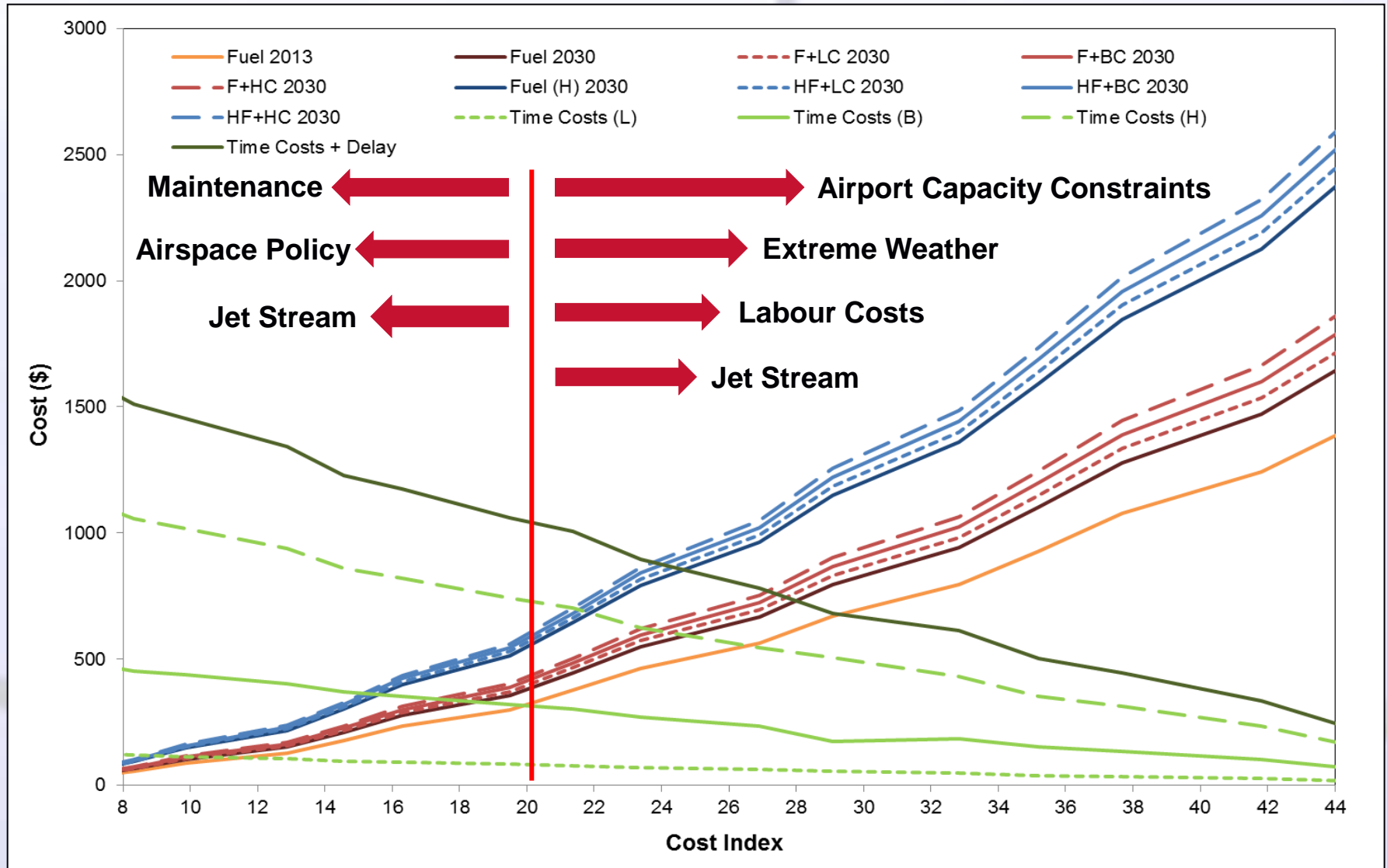
Reserves {at landing mass 123029.kg.):
Diversion distance 200. n.miles
Diversion mach 0.597
Diversion altitude 22523. feet
Diversion fuel 2503. kg.
Holding time 30. minutes
Holding mach 0.279
Holding altitude 1500. feet
Holding fuel 1632. kg.
Contingency fuel 3193. kg. {5.% of mission fuel}
Total Reserve fuel 7827. kg.

Buttons at the bottom: 'Save Output...' and 'Clear Output'.

Overall Effect on Cost Index



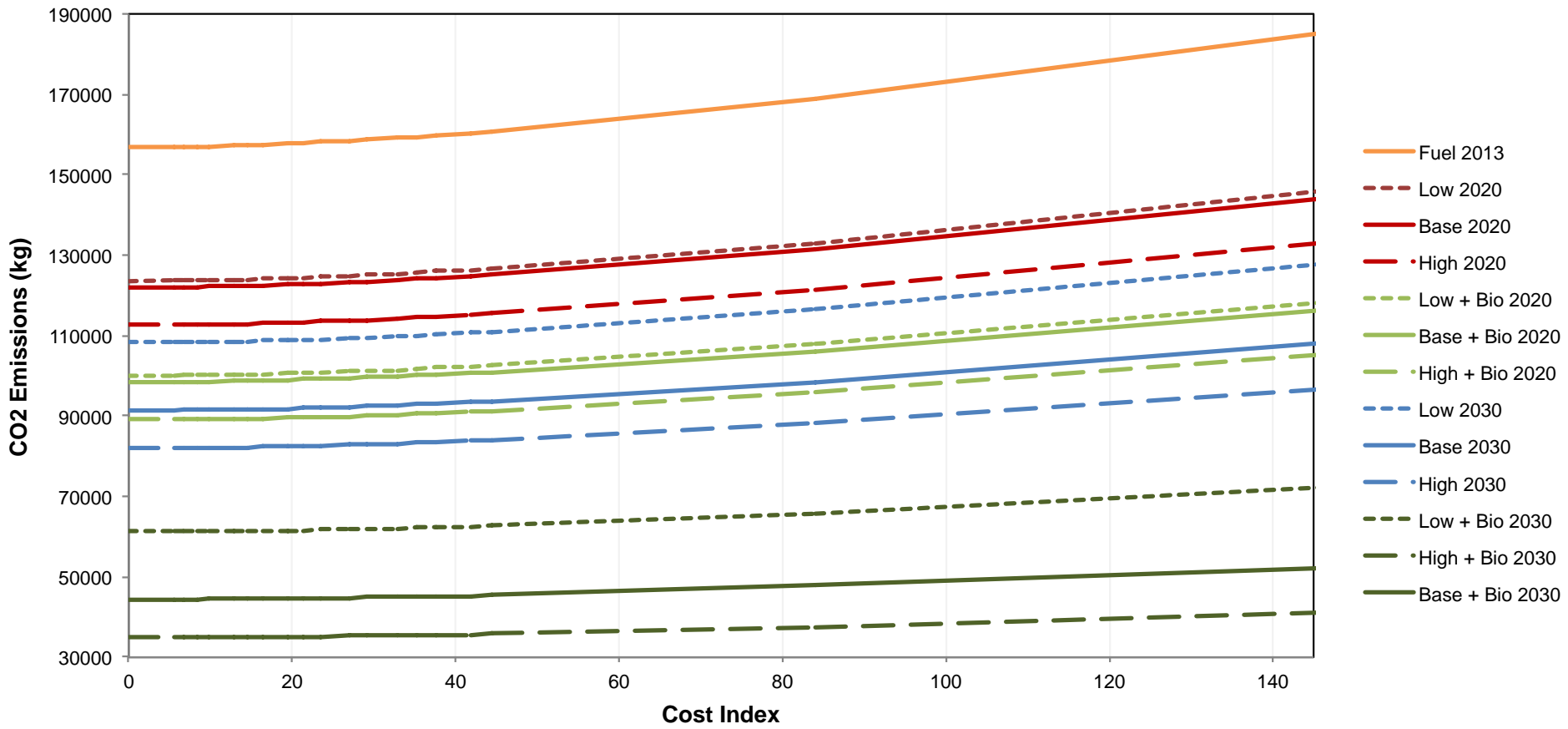
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Impact on CO₂ Emissions



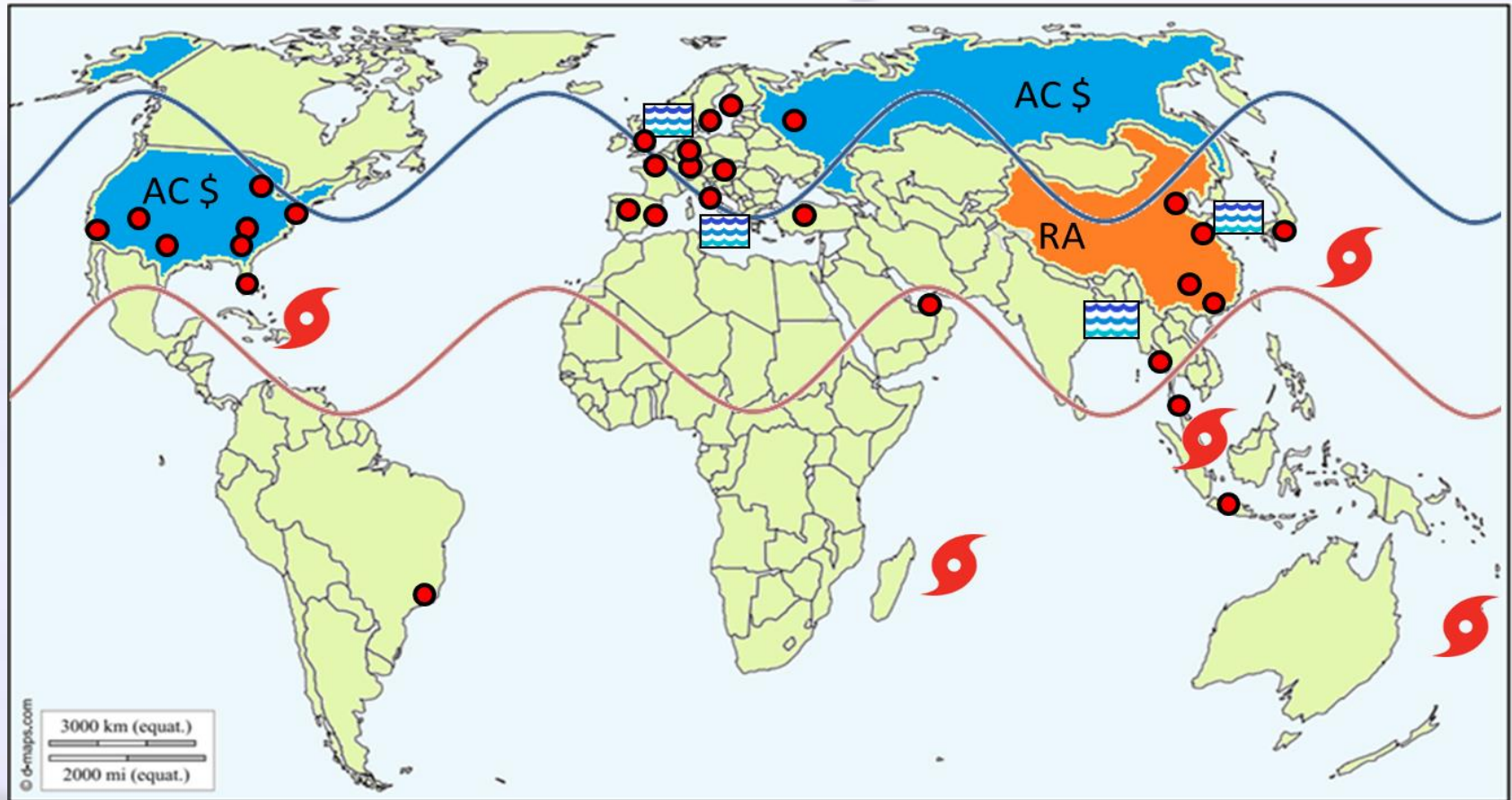
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Global Impact



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AC \$/RA: Airspace charging/restricted airspace



Severe Extreme Weather



Polar Jet Stream



Busy/Congested/
Airports



Sea Level Rise



Subtropical Jet Stream

Conclusions



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- Cost Index can provide a tool for assessing future impacts on aviation on a flight by flight basis
- Cost Index is also a tool for reducing emissions in itself
- Three main areas which will have an effect – policy and environment are still very uncertain.
- Questions over the impact of implementing a carbon price.
- Need policy that:
 - A. Addresses both direct and indirect impacts on Cost Index
 - B. Provides real incentives and solutions to reducing emissions
- Whole aviation system needs to be considered.