Aircraft Emissions

This article explains the method by which TGWS have obtained the figures we use for the effective emissions of greenhouse gases and equivalent fuel consumptions for aircraft flights. We are indebted to the Oxford University Centre for the Environment (contact Dr Christian Brand) for all the difficult research into aircraft emissions. But have then made a number of modifications which we explain, and for which we give reasons below.

The Oxford Model.

The Oxford Method makes the following assumptions:-

1. Fuel used is based on tables using standard data for a particular set of aircraft. For short haul these are Boeing 737-400, Airbus 320 & McDonald Douglas MD/82/80. For long haul they are Boeing 747, 767 & 777, also Airbus 340.
2. Seating capacities have been averaged across these models and are taken as:-

   Short Haul 149

   Long Haul 339

   N.B. Aircraft are arranged with very different numbers of seats while the above are average figures, maximum capacities are of the order of:-

   Short haul 180 Long Haul 450
3. Aircraft occupancy - uses industry figures of:-

   Short haul 62%. Long Haul 75%
4. Manoeuvring and Detours add an average amount of 50 kms to every flight irrespective of flight length.
5. Holding delays are also averaged at 1 kg of fuel per passenger.
6. 98% of the fuel used is assumed to be applicable to passengers – the other 2% is allowed for cargo.

From these assumptions the following model is constructed:-

1. Further tables are derived of the fuel used per occupied seat for a particular journey length. From which the CO_2^{dir} is derived.
2. The CO_2^{dir} per seat per km is calculated for journeys of different lengths.
3. Curves are drawn using these data points. From these curves CO_2^{dir} per seat per km can be obtained for any flight distance.

TGWS Modifications.

We have taken the data of the Oxford model but we have made the following modifications and for the following reasons:-

1. We have added 10% to the aircraft raw fuel consumptions (omitting the 2% cargo allowance and adding 8%) because a lot of the aircraft flying are older and/or less efficient models than those used for the Oxford fuel consumption figures.
2. We take off the 50kms manoeuvring distance from the flight length. This gives us raw data of fuel consumption and journey length.
3. Aircraft emissions at altitude have a considerably greater global warming effect than those emitted at ground level. We are taking the multiplying factor of 3 (the mid point of the range of values currently variously estimated as 2-4).
4. For short haul aircraft we have assumed that 1600 kgs of fuel are used in climbing and descending from altitude. That is the 865kgs {the LTO (landing and take-off) figure}

plus a further 735kgs of the CCD (climb, cruise, descent) phase. Fuel in excess of this 1600 kgs is assumed to be at altitude and to have 3 times as serious a global warming effect.

5. The same method is used for long haul flights, but here the allowance for take-off climb and descent is 6000 kgs – for the much larger aircraft.
6. This enables us to obtain an estimate for the fuel used at altitude.
7. We then calculate an average multiplying factor to be applied to the fuel used for the whole flight (3 x fuel at altitude + standard/total fuel) . This is not strictly necessary but does at least reveal the scale of the factors that are being applied.
8. From the flight length and fuel consumption, the fuel consumption and the CO_2^{dir} per seat are obtained. The multiplying factor is then applied obtaining the quantity of CO_2 which would have the same global warming effect CO_2^{eff} .
9. Finally we increase by a further 10% to allow for embodied energy in the aircraft construction and maintenance given as $CO_2^{e.e}$. We suspect that this is far too low a figure.
10. We then convert this figure into an equivalent mpg figure for a petrol car.

TGWS Calculations.

The raw data for flights is as follows:-

For Short Haul (LTO and climb = 1600 kgs)

Distance Kms	Total fuel kgs	CCD fuel at altitude kgs	Averaged Mult Factor
182	1882	282	1.30
413	2751	1151	1.84
876	4180	2580	2.23
1339	5547	3947	2.42
1802	7050	5450	2.55
2728	10042	8442	2.68
3654	13193	11593	2.76

For Long Haul (LTO and climb = 6000kgs)

Distance Kms	Total fuel kgs	CCD fuel at altitude kgs	Averaged Mult Factor
3654	35664	29664	2.66
4580	43968	37968	2.72
5506	52848	46848	2.77
6432	61977	55977	2.81
7358	71566	65566	2.83
8284	81431	75431	2.85
9210	91681	85681	2.87
10136	102182	96182	2.88
11162	113238	107238	2.89

These assumptions give the following results:-

For Short Haul (medium sized aircraft):-

Flight leng Kms	Fuel /pas-km g	CO_2 ^{dir}/ km g/pass	Factor	CO_2 ^{eff} g/pass	CO_2^{e-e} g/pass	Equiv car mpg
182	117.4	381	1.30	495	544	13
413	74.5	239	1.84	440	484	14.5

876	52.8	169	2.23	377	415	17
1339	45.6	145	2.42	351	386	18
1802	42.9	135	2.55	344	378	18.5
2728	40.2	127	2.68	340	374	18.5
3654	39.3	124	2.76	342	376	18.5

For Long Haul (Jumbo sized aircraft):-

3654	38.7	122	2.66	325	356	19.5
4580	38.0	120	2.72	326	359	19.5
5506	37.9	119	2.77	330	363	19
6432	38.1	120	2.81	337	370	19
7358	38.4	121	2.83	342	376	18.5
8284	38.8	122	2.85	351	386	18
9210	39.3	124	2.87	359.	395	17.5
10136	39.7	125	2.88	360	396	17.5
11062	40.4	127	2.89	367	404	17.5

N.B. A completely full short haul flight with high density seating can approach 35 mpg per passenger for flights over 1100 miles and a completely full Jumbo with high density seating can approach 34 mpg.

For comparison a full coach will approach 600 mpg per passenger.

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