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International marine and aviation bunker fuel: trends, ranking of countries and comparison with national CO_2 emissions

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Abstract

This report summarises and characterises fuel consumption and associated CO_2 emissions from international transport based on energy statistics compiled by the *International Energy Agency* (IEA). Shares in 1990 and 1970-1995 trends in national and global bunker fuel consumption and associated CO_2 emissions are analysed for marine and air transport. Also, the global total of international transport emissions are compared with national emissions and domestic transport emissions. During the last 25 years the average global annual increase was for marine bunkers about 0.8% and for aviation emissions about 3.3%. Annual variations per country of marine bunker fuel use are larger than of aviation fuel use, sometimes more than 50%. However, the distinction between fuel use for domestic and for international aviation is more difficult to monitor. The dominant fuel in marine bunker fuel consumption is residual fuel oil ('heavy fuel oil'). The share of diesel oil has slowly increased from 11% in 1970 to 20% in 1990. Aviation fuels sold are predominantly jet fuel ('jet kerosene'). The small share of aviation gasoline is slowly decreasing: from about 4% in 1970 to 1.3% in 1990. Carbon dioxide emissions from combustion of international marine bunker fuels and aviation contributed in 1990 globally about 1.8% and 2.4% expressed as percentage of global total anthropogenic emissions (excluding deforestation). However, aviation emissions include an unknown part of domestic aviation. When comparing with total transport emissions, then international transport has a share of 20%. For both marine and aviation bunker fuel, the Top-10 of largest consuming countries account for about 2/3 of the global total; the Top-25 countries cover already 85% or more of global total CO_2 emissions.

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Summary

This report summarises and characterises fuel consumption and associated CO_2 emissions from international transport. It was produced at the request of the Dutch Ministry of Housing, Spatial Planning and the Environment as a background document to support discussions currently being held within the framework of the UN Framework Convention on Climate Change (UNFCCC). International bunker fuel data are known to be a weak part of international energy statistics, not always monitored accurately and not always defined in a consistent way. Therefore, all conclusions we draw from the datasets used are surrounded with rather large uncertainties and should be treated with care. The analyses were based on best available data of energy statistics for most countries of the world compiled by the *International Energy Agency* (IEA). Using the IEA data as they are, shares in 1990 and 1970-1995 trends in national and global bunker fuel consumption and associated CO_2 emissions are analysed, separately for marine and air transport. Also, the global total of international transport emissions are compared with national emissions and domestic transport emissions.

The dominant fuel in marine bunker fuel consumption is residual fuel oil ('heavy fuel oil'). The share of diesel oil has slowly increased from 11% in 1970 to 20% in 1990. Aviation fuels sold are predominantly jet fuel ('jet kerosene'). The small share of aviation gasoline is slowly decreasing: from about 4% in 1970 to 1.3% in 1990. Diesel oil and aviation gasoline have small shares and their emission factor of CO_2 differs only a few percent from those of heavy fuel oil and of jet fuel, respectively. Therefore, the change in fuel mix in these source sectors does not have a substantial effect on CO_2 emissions. Carbon dioxide emissions from combustion of international marine bunker fuels and aviation contributed in 1990 globally about 1.8% and 2.4% expressed as percentage of global total anthropogenic emissions (excluding deforestation). However, aviation emissions include a unknown part of domestic aviation, so both sources currently contribute about 2% to total man-made CO_2 emissions. When comparing with total transport emissions, then international transport has a share of 20%.

According to the dataset used, there is a distinct difference in annual variation and growth trends of marine and aviation fuel use, both at national and the global level:
- Average global annual increase: for marine bunkers about 0.8%, for aviation emissions about 3.3% in the period 1970-1995;
- In the 5-year periods 85-90 or 90-95 aviation fuel use increased in 19 countries by more than 50% and marine bunker fuel consumption in 22 countries by more than 20%;
- Annual variations around 1990 per country of marine bunker fuel use larger than of aviation fuel use, sometimes more than 50%;
- Annual variations of global marine bunker fuel use (between -9% and +15%) are faster and larger than of aviation fuels (-5% and +7%).

Another difference is that aviation emissions and its effects on global warming are more complicated to estimate:
- The distinction into domestic and international fuel use is more difficult to monitor;
- The part of fuel which is actually used for domestic flights is unclear and difficult to assess;
- Besides CO_2 emissions, contrail formation adds probably substantially to enhanced radiative forcing caused by aircraft emissions.

The Top-10 of largest consuming countries account for about 2/3 of the global total; the Top-25 countries cover already 85% or more of global total CO_2 emissions of both marine and aviation bunker fuel. When ranking all countries according to their marine bunker fuel consumption in 1990, three countries have by far the largest share: USA with 24%, the Netherlands with 9% and Singapore with almost 9%; the shares of subsequent countries decrease rapidly. If we do the same for aviation fuel consumption, one country has by far the largest share: USA with 43%. Next, we have Russia with 8%, Japan with 4%, the United Kingdom with almost 4%, Germany and Canada each with 3% and France with 2%. However, in particular the figures for USA, Russia and Canada are likely to include a substantial part of domestic aviation.

Samenvatting

In dit rapport worden het brandstofgebruik en de CO_2-emissies van internationaal transport samengevat en geanalyseerd. Het is geschreven op verzoek van de Directie Lucht en Energie van het Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer als achtergronddocument in het kader van lopende discussies over het Klimaatverdrag van de Verenigde Naties. Het is bekend dat gegevens over internationale bunkerbrandstoffen een zwak onderdeel vormen van internationale energiestatistieken. Ze worden niet altijd nauwkeurig verzameld en zijn ook niet altijd op een consistente wijze gedefinieerd. Daarom worden alle conclusies, die op grond van de gebruikte datasets getrokken worden, gekenmerkt door een vrij grote onzekerheid. Ze dienen daarom met de nodige voorzichtigheid gebruikt te worden. De analyses zijn gebaseerd op de best-beschikbare gegevens uit internationale energiestatistieken, die verzameld zijn door het *International Energy Agency* (IEA). Met deze gegevens van de IEA worden voor internationale zeescheepvaart en luchtvaart apart de aandelen in 1990 en de trends in de periode 1970-1995 van nationaal en mondiaal energiegebruik van bunkers en hun CO_2-emissies geanalyseerd. Ook worden de mondiale totale internationale transportemissies vergeleken met de 'nationale' emissies en de totale transportemissies.

De belangrijkste brandstof voor internationale scheepvaart is zware stookolie. Het aandeel van dieselolie is langzaam gestegen van 11% in 1970 tot 20% in 1990. De belangrijkste vliegtuigbrandstof is jetfuel (kerosine). Het kleine aandeel vliegtuigbenzine (avgas) daalt langzaam van ca. 4% in 1970 tot 1,3% in 1990. Dieselolie en avgas hebben een klein aandeel en hun emissiefactor voor CO_2 verschilt maar en paar procent van die van zware stookolie en kerosine. Daarom heeft de verschuiving in de brandstofmix maar een gering effect op de CO_2-emissies van deze bronnen. De mondiale CO2-emissie van internationale scheepvaart en luchtvaart droegen in 1990 respectievelijk ca. 1,8% en 2,4% bij, uitgedrukt als percentage van de totale 'nationale' anthropogene emissies (excl. ontbossing). Bij de luchtvaartemissies zit een onbekend deel van binnenlands vliegverkeer; beide bronnen dragen nu dus ongeveer 2% bij aan de totale door de mens veroorzaakte CO_2-emissies; vergeleken met die van de totale transportsector, is het aandeel van internationale transport ca. 20%.

Uit de gebruikte dataset kan worden afgeleid, dat er kenmerkende verschillen zijn tussen de jaarlijkse variatie en de groeitrend van marine- en luchtvaartbunkers, zowel op nationaal als mondiaal niveau:

- de gemiddelde jaarlijkse mondiale groei bedraagt in de periode 1970-1995 ca. 0,8% voor scheepvaartbunkers en ca. 3.3% voor luchtvaartbrandstof;
- in de 5-jaar-periodes 85-90 of 90-95 nam in 19 landen het verbruik van luchtvaartbrandstof toe met meer dan 50% en in 22 landen het brandstofgebruik van scheepvaartbunkers met meer dan 20%;
- de jaarlijkse variaties per land van verbruik door scheepvaartbunkers zijn groter dan bij verbruik van luchtvaartbrandstof, soms meer dan 50%;
- de jaarlijkse variaties van mondiaal brandstofgebruik van scheepvaartbunkers (tussen -9% en +15%) zijn sneller en groter dan van vliegtuigbrandstof (tussen -5% en +7%).

Een ander verschil is dat luchtvaartemissies en hun effect op het broeikaseffect lastiger te schatten zijn:

- het verschil tussen binnenlands en internationaal energiegebruik is moeilijker vast te stellen;
- het aandeel brandstof voor binnenlandse vluchten is onduidelijk en lastig vast te stellen;
- naast CO_2 dragen ook de condensstrepen waarschijnlijk aanzienlijk bij aan de toename van de *radiative forcing* door vliegtuigen.

De 10 grootste verbruikende landen dragen ca. 2/3 bij aan het mondiaal totaal; de Top-25 draagt zelfs meer dan 85% bij aan de mondiale CO_2-emissies van zowel internationaal water- en lucht-transport. De landen met het grootste scheepvaartbunkergebruik zijn: Verenigde Staten (24%), Nederland (9%) en Singapore (bijna 9%); het aandeel van de overige landen daalt snel. Voor luchtverkeer heeft één land verreweg het grootste aandeel: de Verenigde Staten met 43%. Daarna volgens de Russische Federatie met 8%, Japan (4%), Verenigd Koninkrijk (bijna 4%), Duitsland en Canada (beide 3%) en Frankrijk (bijna 2%). Daarbij moet worden bedacht dat met name bij de cijfers voor de Verenigde Staten, Rusland en Canada waarschijnlijk een aanmerkelijk deel binnenlandse luchtvaart zit.

1. Introduction

National and global use of bunker fuel use for international shipping and for international aviation is an activity which is rather difficult to monitor and which is often neglected in national and global considerations of emissions. Nevertheless, although international bunker fuel data are known to be a weak part of international energy statistics, we will try to analyse the available data to see which robust conclusions can be still drawn.

This report is an information paper aiming at summarising and characterising this source of emissions based on best available data. For this purpose we used energy statistics for most countries of the world compiled by the *International Energy Agency* (IEA, 1997) and emission factors for CO_2 as proposed by the *Intergovernmental Panel on Climate Change* (IPCC, 1997) as default for calculation domestic and bunker fuel emissions. These data have been used in the *Emission Database for Global Atmospheric Research (EDGAR)* V3.0, which has been compiled by TNO and RIVM in the Netherlands as global database providing trends in emissions of direct and indirect greenhouse gases (Olivier *et al*., 1999a,b). Both UN and IEA share information on energy statistics submitted by countries. In addition, the IEA performs cross-checks with data obtained from major oil companies.

Uncertainty in separating international and domestic consumption by ships and aircraft
As a rule, one may expect that the domestic part of total ship and air transport will be larger for larger countries and relatively small for small countries. However, there is quite some uncertainty in proper and consistent division of marine and aviation fuels for domestic (internal) and international transport. Although there are international definitions for distinguishing transport fuels used for domestic purposes and for international transport, in practice countries may apply different ones. In particular for aviation, often bunker data exclude outbound international air traffic by domestically owned carriers. Often too, national statistics are compiled using the registered amounts of fuel sold ‘taxfree’ at marine ports, assuming only these amounts are used for international travel. However, it is known that in some cases domestic freight ships are also allowed to buy diesel fuel from marine bunkers.

Structure of the report
Using the IEA data as they are, shares and trends in national and global bunker fuel consumption and associated CO_2 emissions are analysed, separately for marine and air transport. We will focus on 1990 and years surrounding years, because this is the reference year for many countries which are party to the Kyoto Protocol to the UN Framework Convention on Climate Change (UNFCCC) (UNFCCC, 1997a). Also, we will compare the global total of international transport emissions with national emissions and domestic transport emissions. Subsequently, conclusions will be drawn on the characterisation of the two sources discussed in this report. It will show, that according to the dataset used, there is a distinct difference in annual variation and growth trends of marine and aviation fuel use, both at national and the global level.

2. Marine bunker fuels

2.1. Introduction

According to the *International Energy Agency* (IEA), 'international marine bunkers' comprise all fuels "delivered to sea-going ships of all flags, including warships and fishing vessels. Consumption by ships engaged in transport in inland and coastal waters is not included", whereas national shipping is referred to as 'internal and coastal navigation', "including small craft and all vessels not purchasing their bunker requirements under international marine bunker contracts" (IEA, 1992).

The *Revised 1996 IPCC Guidelines* (IPCC, 1997), used by the UNFCCC as guidelines for parties for reporting their national annual greenhouse gas emissions and their international bunker emissions, use slightly different definitions: "international marine (bunkers) (..) comprise sea-going ships of all flags that are engaged in international transport", whereas 'national navigation' refers to "fuel used for navigation of all vessels not engaged in international transport (..). They note that "this may include journeys of considerable length between two ports of a country (e.g. San Francisco to Honolulu)". Often national ('domestic consumption') statistics are compiled using the registered amounts of fuel sold 'taxfree' at marine ports, assuming only these amounts are used for international travel. However, it is known that in some cases domestic freight ships are also allowed to buy taxfree diesel fuel from marine bunkers.

If we look at global total annual marine bunker fuel consumption in the period 1970-1995 as presented in Fig. 2.1, it shows that the annual changes can vary rapidly between -9% and +15% in 1990. On average, in this 25 year period the annual increase was about 0.8%. The two periods of negative growth may be related to the first and second so-called 'oil crisis', which had a negative effect on economic growth in many countries. We stress, however, that time series for individual countries may contain discontinuities, such as for the USA where consumption increased 52% from 1989 to 1990; without this increase in the USA, global consumption would have increased a mere 7%. The large increase of 15% in 1990 is largely due to a discontinuity in the time series for the USA, which shows an increase of 52% from 1989 to 1990.

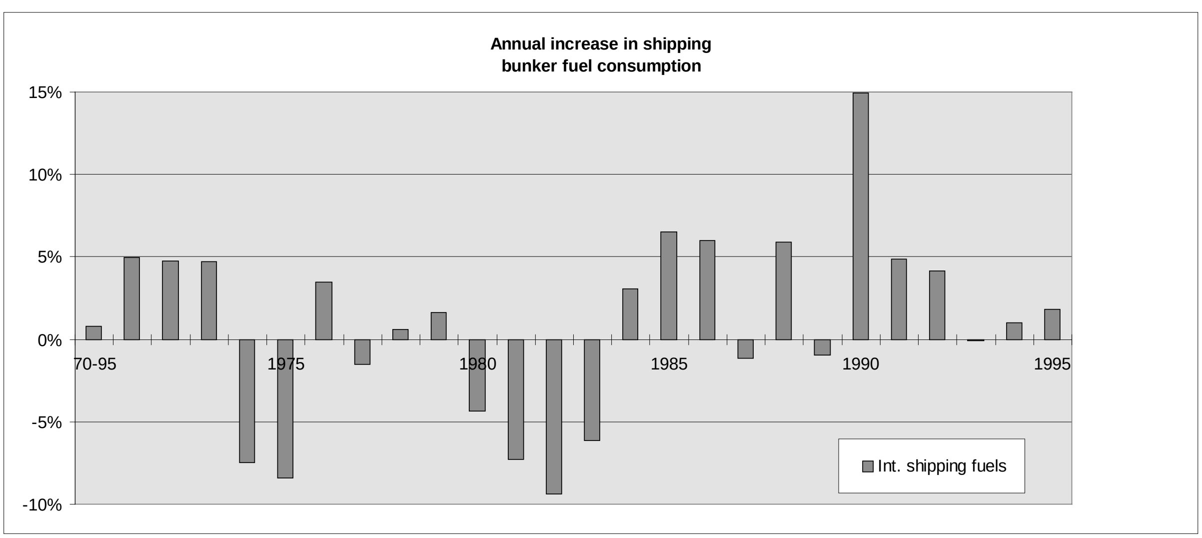

Fig. 2.1 Annual increase in international marine bunker fuel consumption 1970-1995

Marine bunker fuels sold are residual fuel oil - also known as ‘heavy fuel oil’ (HFO) - and diesel oil. Although HFO is the major marine bunker fuel, the share of diesel fuel in marine bunkers is slowly increasing: from 11% in 1970 to 20% in 1990. In 1995 its share was 21%. The change of fuel mix does not substantially affect CO_2 emissions, since the default emission factor of diesel fuel is only 4% less than the value for HFO (IPCC, 1997). This is, however, not the case for SO_2 where the default sulphur content of HFO and marine diesel oil differs between 3% (weight) for HFO and 0.3-1.0% (weight) for diesel oil (IPCC, 1997).

2.2. Top-25 countries of international shipping emissions

When we rank all countries according to their marine bunker fuel consumption in 1990, three countries have by far the largest share: USA with 24%, the Netherlands with 9% and Singapore with almost 9%; the shares of subsequent countries decrease rapidly. Table 2.1 shows that the Top-10 comprise 2/3 of the global total and the Top-25 include 87% of the global total. The table also shows how sensitive this ranking is with respect to the selected year. In four cases the 1989 or 1991 consumption data differ more than 50% from the 1990 level and in five cases the difference with the consumption level in 1985 or 1995 is more than 20%.

Table 2.1 Top-25 countries of international marine bunker fuel consumption in 1990

	Country	Sales '90	Share	Cumulative	Variation	
	[ISO A3]	**[PJ]**	**[%]**	**[%]**	**Annual >50%**	**5-Y growth >20%**
Global total:		5039				
	Top-25					
1	USA	1202	23.8%	24%	HIGH	-
2	NLD	453	9.0%	33%	-	-
3	SGP	443	8.8%	42%	-	HIGH
4	ARE	248	4.9%	47%	HIGH	-
5	JPN	213	4.2%	51%	-	-
6	RUS	201	4.0%	55%	HIGH	-
7	BEL	171	3.4%	58%	-	-
8	ESP	153	3.0%	61%	-	-
9	ITA	110	2.2%	63%	-	-
10	IRN	109	2.2%	66%	-	-
11	GBR	106	2.1%	68%	-	-
12	GRC	105	2.1%	70%	-	HIGH
13	FRA	104	2.1%	72%	-	-
14	DEU	103	2.0%	74%	-	-
15	ZAF	78	1.5%	75%	HIGH	-
16	SAU	75	1.5%	77%	-	-
17	BRA	73	1.4%	78%	-	-
18	EGY	69	1.4%	80%	-	-
19	ANT	68	1.3%	81%	-	-
20	TWN	67	1.3%	82%	-	HIGH
21	KOR	66	1.3%	84%	-	HIGH
22	HKG	59	1.2%	85%	-	-
23	PAN	42	0.8%	86%	-	-
24	DNK	40	0.8%	86%	-	HIGH
25	VEN	32	0.6%	87%	-	-
	Subtotal:	**4389**	**87%**			

Sources: EDGAR V3.0; Second National Communications as reported by UNFCCC (UNFCCC, 1997b).

Since CO_2 is closely related to fuel consumption in this sector, the Top-25 countries of CO_2 emissions from marine bunkers in 1990 follow the same pattern (Table 2.2). For comparison, we have also included the national total CO_2 emissions officially reported to the UNFCCC in their Second National Communications. This has only been done by so-called Annex-I countries: OECD countries and countries with economies in transition (i.e. in Eastern Europe and the former SU).

While the amount of marine bunker emissions expressed as percentage of global total anthropogenic emissions (excluding deforestation) is about 1.6%, for some countries this appears to be much higher: 20% in the case of the Netherlands, 12% for Belgium, 9% for Greece. For these countries major refinery activities are located near important international marine shipping routes and ports. From this subset it can be concluded that the relative amount of marine bunker emissions of CO_2 compared to national total CO_2 emissions in 1990 varies substantially from 20% to almost zero.

Table 2.2 Top-25 of CO_2 emissions from international shipping in 1990

		CO_2 Int. ship	National CO_2 em.	% of nat. emissions
	Top-25	**(Gg)**	**(Gg)**	**(%)**
1	USA	87244	4960432	1.8%
2	NLD	33164	167550	**19.8%**
3	SGP	32179		
4	ARE	18017		
5	JPN	15580	1124532	1.4%
6	RUS	14576	2372300	0.6%
7	BEL	12523	108248	**11.6%**
8	ESP	11119	226423	4.9%
9	ITA	8134	432150	1.9%
10	IRN	7879		
11	GBR	7663	583747	1.3%
12	GRC	7739	84575	**9.2%**
13	FRA	7699	378379	2.0%
14	DEU	7590	1014155	0.7%
15	ZAF	5666		
16	SAU	5435		
17	BRA	5292		
18	TWN	5094		
19	EGY	5007		
20	ANT	4934		
21	KOR	4809		
22	HKG	4243		
23	PAN	3043		
24	DNK	2928	52277	5.6%
25	VEN	2328		
	Global	**(Tg)**	**(Tg)**	**(%)**
	total	366	23018	1.7%

Note: Percentages printed in bold are larger than 4x the global average of 1.7%.
Sources: EDGAR V3.0; Second National Communications as reported by UNFCCC (UNFCCC, 1997b).

2.3. Other countries

For completeness, we also compiled a similar table for the remaining Annex-I countries. , Other OECD countries add up to an other 3.5% of the global total in 1990, while other Annex-I countries (‘Annex B’ or ‘Economies-In-Transition’) add about 2%. In this group of countries there are only three countries where annual or 5-year variations are high (using the same definition as for the Top-25 countries).

Table 2.3 International marine bunker fuel consumption in 1990 in other Annex-I countries

Country	Sales '90	Share	Variation	
[ISO A3]	**[PJ]**	**[%]**	**Annual >50%**	**5-Y Growth >20%**
Other OECD'90:				
AUS	27	0.5%	-	-
CAN	26	0.5%	-	-
CHE	1	0.0%	-	-
FIN	24	0.5%	-	-
IRL	1	0.0%	-	-
ISL	1	0.0%	-	HIGH
ISR	5	0.1%	-	-
NOR	19	0.4%	-	-
NZL	13	0.3%	HIGH	-
PRT	26	0.5%	-	-
SWE	28	0.6%	-	-
TUR	5	0.1%	-	-
Subtotal:	**175**	**3.5%**		
Other Annex B:				
ARM	2	0.0%	-	-
AZE	2	0.0%	-	-
BGR	14	0.3%	-	-
BLR	7	0.1%	-	-
EST	2	0.0%	HIGH	HIGH
GEO	2	0.0%	-	-
HRV	0	0.0%	-	-
KAZ	7	0.1%	-	-
KGZ	1	0.0%	-	-
LTU	3	0.0%	-	-
LVA	2	0.0%	-	-
MDA	2	0.0%	-	-
POL	18	0.4%	-	-
TJK	1	0.0%	-	-
TKM	2	0.0%	-	-
UKR	27	0.5%	-	-
UZB	4	0.1%	-	-
YUG	0	0.0%	-	-
Subtotal:	**95**	**1.9%**		
Global total	**5039**	**100%**		

Sources: EDGAR V3.0; Second National Communications as reported by UNFCCC (UNFCCC, 1997b).

In Table 2.4 all 33 countries are summarised where either the 1989 or 1991 consumption data differ more than 50% from the 1990 level or the difference with the consumption level in 1985 or 1995 is more than 20%. In 18 cases the 1989 or 1991 consumption data differ more than 50% from the 1990 level and in most of these countries the average growth in the period 1985-1990 or 1990-1995 was more than 4% per year.

Table 2.4 Summary of all countries with large changes around 1990 of international marine bunker fuel consumption

Country		Variation*	
[ISO A3]	**[PJ]**	**Annual >50%**	**5-Y Growth >20%**
ABW	1	HIGH	HIGH
ARE	248	HIGH	-
BFA	2	-	HIGH
BGD	1	HIGH	-
CHL	7	HIGH	HIGH
COL	5	HIGH	-
DNK	40	-	HIGH
ECU	8	-	HIGH
EST	2	HIGH	HIGH
ETH	1	HIGH	-
GIB	18	HIGH	-
GRC	105	-	HIGH
IDN	22	HIGH	HIGH
IND	17	HIGH	HIGH
IRL	1	HIGH	HIGH
ISL	1	-	HIGH
JAM	2	-	HIGH
KOR	66	-	HIGH
LBY	3	-	HIGH
MDV	0	-	HIGH
MRT	5	-	HIGH
NGA	8	HIGH	-
NZL	13	HIGH	-
OMN	15	HIGH	HIGH
PAK	1	HIGH	-
RUS	201	HIGH	-
SGP	443	-	HIGH
THA	22	-	HIGH
TUN	1	-	HIGH
TWN	67	-	HIGH
URY	5	-	HIGH
USA	1202	HIGH	-
ZAF	78	HIGH	-

* Annual variation: 89-90 and 90-91; 5-year variation: 85-90 and 90-95.

3. Aviation bunker fuels

3.1. Introduction

According to the *International Energy Agency* (IEA), ‘air transport’ comprise “deliveries of aviation fuels to international civil aviation, and to all domestic air transport, commercial, private, agricultural, military, etc. It also includes use for purposes other than flying, e.g. bench testing of engines, but not airline use of fuel for road transport” (IEA, 1992). IEA makes the observation that often fuel use for both domestic and international departures of domestically owned carriers appears to be allocated to domestic air transport (IEA, 1998). Thus, often when correcting total aviation data for the amount allocated to domestic aviation, one may unintentionally also exclude outbound international air traffic by domestically owned carriers, thereby then underestimating the real international part. Obviously, this will be of more concern to large countries like Russia, Canada, USA, China, where the domestic part of total aviation will be much larger than for smaller countries. For this reason in this chapter we will assume that all aviation fuel consumption refers to international aviation bunkers, which is acknowledged not to be correct for the largest countries.

The *Revised 1996 IPCC Guidelines* (IPCC, 1997), used by the UNFCCC as guidelines for parties for reporting their national annual greenhouse gas emissions and their international bunker emissions, use slightly different definitions: ‘international aviation (international bunkers)’ comprise “international civil aviation. Note that these emissions are to be excluded as far as possible from national totals but should be reported separately”. It adds: “In other inventory methodologies; landing and take-off (LTO) cycle emissions are often considered as domestic emissions. For the purpose of greenhouse gas inventories, fuel used during landing and take-off for an international flight stage is considered to be part of international bunker fuel use”. Subsequently, ‘domestic civil aviation’ has been defined as “all civil domestic passenger and freight (air) traffic inside a country (not used as international bunkers) and including take-offs and landings for these flight stages”. Intentionally or not, according to the IPCC Guidelines, all fuel use by ‘military aviation’ should be included in the national inventory (under the ‘Energy/Other’ category).

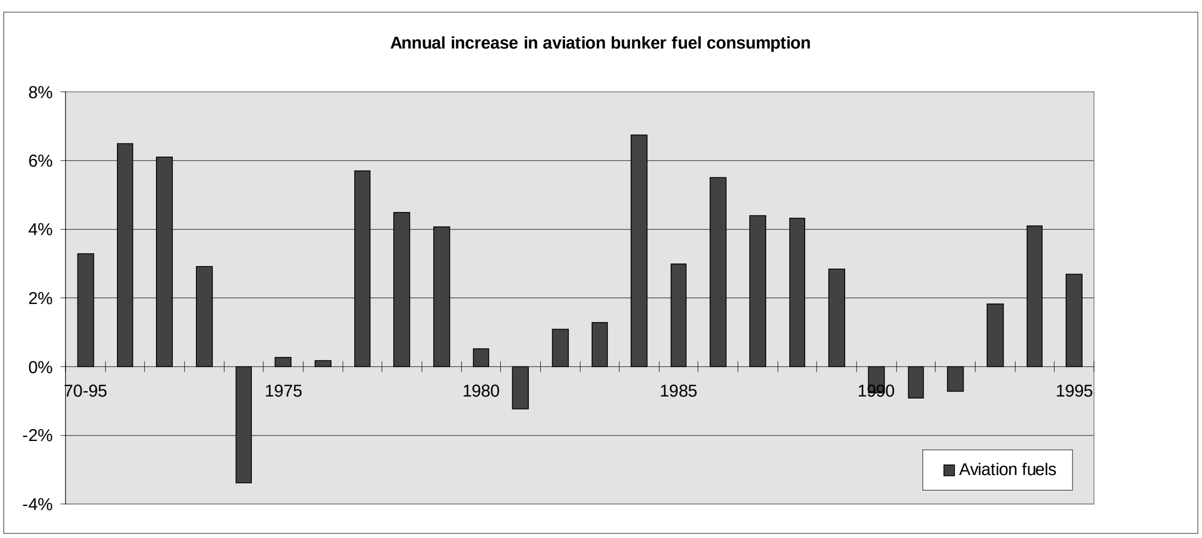

Fig. 3.1 Annual increase in international aviation fuel consumption 1970-1995

If we look at global total annual aviation fuel consumption in the period 1970-1995 as presented in Fig. 3.1, it shows that the annual changes can vary rapidly between -5% and +7%. The two years of negative growth in the 70's and 80's may be related to the first and second so-called 'oil crisis', which had a negative effect on economic growth in many countries. The negative growth in the early 90's may be partially attributed to 'Gulf war'(Kuwait crisis), when quite a lot of business travellers should reluctance to international air travelling. However, on average in this 25 year period the annual increase of aviation fuel consumption was about 3.3%. This development in terms of fuel consumption is much less than in terms of revenue passenger-km (p-km), which was historically on average about 9% per year (IPCC, 1999). These growth rates for p-km are also used in scenario studies (Olivier, 1995; IPCC, 1999). Apparently, economy of scale, improvement of energy efficiency and load factors, play an important role in civil aviation.

Aviation fuels sold are predominantly jet fuel and some aviation gasoline. The small share of aviation gasoline is slowly decreasing: from about 4% in 1970 to 1.3% in 1990. In 1995 its share as 1.1%. Jet fuel - also often referred to as 'jet kerosene' - is indeed predominantly of the kerosene type jet fuel, but also gasoline type jet fuel is used. However, the share of the gasoline type jet fuel is decreasing fast: from about 10% in the 70's to 5% in 1990 and to 1.1% in 1995. The change of fuel mix to a smaller share of aviation gasoline does not substantially affect CO_2 emissions, since the share was already small anyway and the default emission factor of aviation gasoline is only 2.5% higher than for jet fuel (IPCC, 1997).

Table 3.1 Top-25 countries of (international) aviation fuel consumption in 1990

		1990	**Share**	**Cumul.**	**Perc. domestic***
		[PJ]	**[%]**	**[%]**	**[%]**
Top-25:					
1	USA	3209	43%	43%	**100%**
2	RUS	581	7.8%	51%	
3	JPN	316	4.2%	55%	40%
4	GBR	295	3.9%	59%	38%
5	DEU	243	3.2%	62%	17%
6	CAN	184	2.5%	65%	**79%**
7	FRA	168	2.2%	67%	19%
8	SAU	116	1.5%	68%	
9	ESP	107	1.4%	70%	55%
10	AUS	104	1.4%	71%	42%
11	ITA	88	1.2%	72%	1%
12	THA	85	1.1%	74%	
13	UKR	83	1.1%	75%	
14	BRA	80	1.1%	76%	
15	SGP	80	1.1%	77%	
16	HKG	79	1.1%	78%	
17	IND	76	1.0%	79%	
18	MEX	76	1.0%	80%	
19	KOR	72	1.0%	81%	
20	NLD	70	0.9%	82%	10%
21	GRC	55	0.7%	82%	38%
22	KAZ	55	0.7%	83%	
23	CHE	50	0.7%	84%	12%
24	CHN	45	0.6%	84%	
25	BEL	41	0.6%	85%	1%
Global total:		**7475**			

* Definition of domestic air traffic varies between countries.
Sources: EDGAR V3.0; Second National Communications as reported by UNFCCC (UNFCCC, 1997b).

3.2. Top-25 countries in international aviation emissions

When we rank all countries according to their total aviation fuel consumption in 1990 (see Table 3.1), one country has by far the largest share: USA with 43%. Next, we have Russia with 8%, Japan with 4%, the United Kingdom with almost 4%, Germany and France each with 3% and France with 2%. We recall, that of these countries, USA, Russia and Canada may include a substantial part of domestic aviation, as indicated by the last column of Table 3.1 (for OECD countries only). Table 3.1 also shows that the Top-10 comprise 70% of the global total and the Top-25 include 85% of the global total aviation fuel consumption in 1990. The table also shows how sensitive this ranking is with respect to the selected year. In four cases the 1989 or 1991 consumption data differ more than 50% from the 1990 level and in five cases the difference with the consumption level in 1985 or 1995 is more than 20%.

Since CO_2 is closely related to fuel consumption in this sector, the Top-25 countries of CO_2 emissions from aviation in 1990 follows the same pattern (Table 3.2). For comparison, we have also included the national tot CO_2 emissions officially reported to the UNFCCC in their Second National Communications. This has only been done by so-called Annex-I countries.

Table 3.2 Top-25 of CO_2 emissions from aviation in 1990 and expressed as % of national emissions

		Total air CO_2 em.	**Perc. domestic***	**Nat. CO_2 em.**	**% of national emissions**
	Top-25:	**(Gg)**	**[%]**	**(Gg)**	**(%)**
1	USA	232960	**100%**	4960432	**4.7%**
2	RUS	42165		2372300	1.8%
3	JPN	22910	40%	1124532	2.0%
4	GBR	21415	38%	583747	3.7%
5	DEU	17635	17%	1014155	1.7%
6	CAN	13348	**79%**	464000	2.9%
7	FRA	12196	19%	378379	3.2%
8	SAU	8399			
9	ESP	7780	55%	226423	3.4%
10	AUS	7580	42%	273123	2.8%
11	ITA	6404	1%	432150	1.5%
12	THA	6159			
13	UKR	6055		700107	0.9%
14	BRA	5818			
15	SGP	5773			
16	HKG	5763			
17	MEX	5621			
18	IND	5535			
19	KOR	5374			
20	NLD	5086	10%	167550	3.0%
21	GRC	4011	38%	84575	**4.7%**
22	KAZ	3982			
23	CHE	3626	12%	45070	**8.0%**
24	CHN	3271			
25	BEL	3011	1%	108248	2.8%
	Global	**(Tg)**		**(Tg)**	**(%)**
	total	**544**		**23018**	**2.3%**

* Definition of domestic air traffic varies between countries.
Note: Percentages printed in bold are twice the global average or higher.
Please note that figures for USA, CAN, ESP, GBR, FRA, AUS and JPN probably include a sizeable fraction of national air traffic.
Sources: EDGAR V3.0; Second National Communications as reported by UNFCCC (UNFCCC, 1997b).

While the amount of aviation emissions expressed as percentage of global total anthropogenic emissions (excluding deforestation) is about 2.3%, for some countries this appears to be somewhat higher: about 8% in the case of the Switzerland and about 5% for the USA and Greece. Other countries with percentages in the range of 3-4% are the United Kingdom, Spain, France and the Netherlands. However, with the exception of Switzerland and the Netherlands, these are all quite large countries, so a substantial amount of domestic emissions may be included in these figures. For this subset it can be concluded that the relative amount of international aviation emissions of CO_2 compared to national total CO_2 emissions in 1990 for most countries do not vary much from the global average (from 8% to 1%), in particular, when taking a likely domestic part into consideration; that is, not so much as the international marine bunker emissions did. The only marked exceptions are Switzerland and Greece.

3.3. Other countries

For completeness, we also compiled a similar table for all Annex-I countries, split into OECD countries and Annex B countries (see Table 3.3). OECD countries add up to 69% of the global total in 1990, while other Annex-I countries ('Annex B' or 'Economies-In-Transition') add another 12%. The table also shows how sensitive this ranking is with respect to the selected year. In six cases the 1989 or 1991 consumption data differ more than 20% from the 1990 level and in nine cases the difference with the consumption level in 1985 or 1995 is more than 50%. We note that the discrimination levels for annual 'HIGH' and 5-Year growth 'HIGH' are reversed compared to the marine bunker case. This may indicate that development of aviation fuel consumption is more steadily increase and shows less large annual variation than does the marine bunker fuel consumption. Within the group of OECD countries there are only two countries where annual variations are more than 20%.

From the group of non-Annex I countries, which contribute 19% to the global total aviation fuel consumption in 1990, we listed the Top-20 countries in Table 3.4. These 20 countries comprise 2/4 of the fuel consumption of this group. In six cases the 1989 or 1991 consumption data differ more than 20% from the 1990 level and in nine cases the difference with the consumption level in 1985 or 1995 is more than 50%.

For a more detailed listing of all countries with actual figures of annual and 5-year differences and the percentage of domestic air traffic as reported by all OECD countries we refer to Appendix A.

Table 3.3. International aviation fuel consumption in 1990 in Annex-I countries

	Country	Sales '90	Variation	
	[ISO-A3]	**[PJ]**	**Annual >20%**	**5 Year growth>50%**
	OECD'90:			
1	USA	3209	-	-
2	JPN	316	-	-
3	GBR	295	-	HIGH
4	DEU	243	-	-
5	CAN	184	-	-
6	FRA	168	-	-
7	ESP	107	-	-
8	AUS	104	-	-
9	ITA	88	-	HIGH
10	NLD	70	-	-
11	GRC	55	HIGH	-
12	CHE	50	-	-
13	BEL	41	HIGH	HIGH
14	SWE	33	-	-
15	DNK	31	-	-
16	NZL	30	-	-
17	PRT	25	-	HIGH
18	NOR	22	-	HIGH
19	TUR	21	-	-
20	FIN	20	-	HIGH
21	IRL	16	-	-
22	AUT	14	-	-
23	LUX	6	-	HIGH
24	ISL	4	-	-
	OECD'90	**5153**		
	o.w. EU-15	1403		
	Annex B:			
1	RUS	581	-	-
2	UKR	83	-	-
3	KAZ	55	-	-
4	BLR	40	-	-
5	AZE	25	-	-
6	LTU	17	HIGH	-
7	BGR	13	-	-
8	CZE	11	-	-
9	YUG	10	-	-
10	POL	10	-	HIGH
11	ARM	9	HIGH	-
12	HUN	7	-	-
13	LVA	4	-	-
14	KGZ	3	-	-
15	MDA	3	-	-
16	HRV	3	-	-
17	BIH	3	-	-
18	EST	2	-	-
19	SLV	2	HIGH	-
20	SVN	1	-	-
21	TJK	1	-	-
22	MKD	0.2	HIGH	HIGH
23	ALB	0	-	-
24	ROM	0	-	-
25	SVK	0	-	-
26	TKM	0	-	-
27	UZB	0	-	-
	Total Annex B	**883**		
	o.w. former USSR	826		

Sources: EDGAR V3.0; Second National Communications as reported by UNFCCC (UNFCCC, 1997b).

Table 3.4. International aviation fuel consumption in 1990 in non-Annex-I countries

	Country	Sales '90	Variation	
	[ISO-A3]	**[PJ]**	**Annual >20%**	**5 Year growth >50%**
	Non-Annex-I:			
	Total	1440		
	o.w. **Top-20:**			
1	SAU	116	HIGH	-
2	THA	85	-	HIGH
3	BRA	80	-	-
4	SGP	80	HIGH	HIGH
5	HKG	79	-	HIGH
6	IND	76	-	-
7	MEX	76	-	-
8	KOR	72	-	HIGH
9	CHN	45	HIGH	HIGH
10	IRQ	41	HIGH	HIGH
11	IDN	40	-	HIGH
12	TWN	40	-	HIGH
13	ZAF	31	-	-
14	VEN	30	-	HIGH
15	ARG	29	-	-
16	MYS	27	HIGH	HIGH
17	IRN	25	HIGH	-
18	COL	23	-	-
19	PHL	23	-	-
20	EGY	21	-	-
	Subtotal:	**1039**		

Sources: EDGAR V3.0; Second National Communications as reported by UNFCCC (UNFCCC, 1997b).

4. Conclusions

International bunker fuel data are known to be a weak part of international energy statistics, not always monitored accurately and not always defined in a consistent way. Also, time series for some individual countries may contain discontinuities. Therefore, all conclusions we draw from the dataset are surrounded with rather large uncertainties and should be treated with care.

The dominant fuel in marine bunker fuel consumption is residual fuel oil (‘heavy fuel oil’). The share of diesel oil has slowly increased from 11% in 1970 to 20% in 1990. Aviation fuels sold are predominantly jet fuel (‘jet kerosene’). The small share of aviation gasoline is slowly decreasing: from about 4% in 1970 to 1.3% in 1990. Within the jet fuels the kerosene type jet fuel is used predominantly; the share of the gasoline type jet fuel has decreased fast from about 10% in the 70’s to 5% in 1990 and to 1% in 1995. Diesel oil and aviation gasoline have small shares and their emission factor of CO_2 differs only a few percent from those of heavy fuel oil and of jet fuel, respectively. Therefore, the change in fuel mix in these sectors does not have a substantial effect on CO_2 emissions.

Carbon dioxide emissions from combustion of international marine bunker fuels and aviation contributed in 1990 globally about 1.8% and 2.4% expressed as percentage of global total anthropogenic emissions (excluding deforestation). However, aviation emissions include a unknown part of domestic aviation, so both sources currently contribute about 2% to total man-made CO_2 emissions. When comparing with total transport emissions, then international transport has a share of 20% (see Fig. 4.1), effectively both about 8% (when excluding domestic air transport).

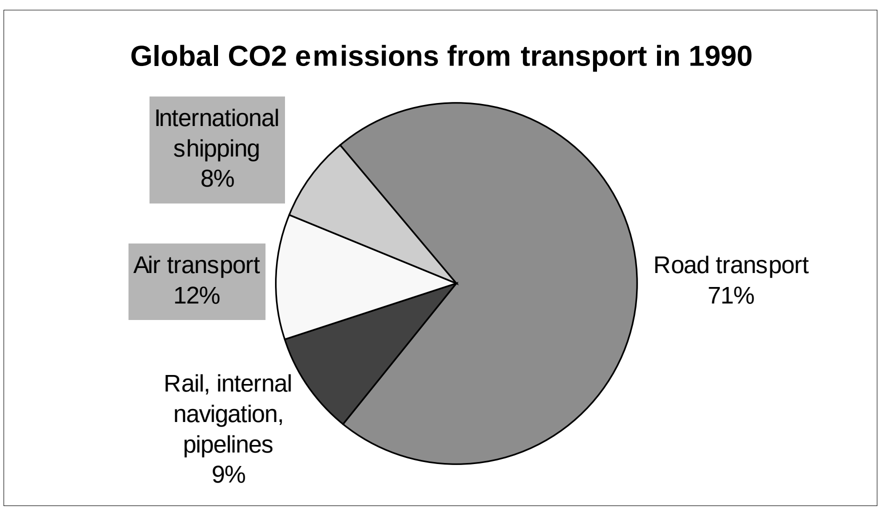

Fig. 4.1 Shares in global CO_2 emissions from transport in 1990 (source: EDGAR V3.0)

However, there are a number of marked differences between the two modes of international transport:

- Average annual increase: for marine bunkers about 0.8%, for aviation emissions about 3.3% in the period 1970-1995;
- Annual variation per country of aviation fuel use are faster and larger than of marine bunker fuel use, sometimes more than 50% (for years 1989-1991);

- Annual variation (1989-1991) of global marine bunker fuel use (between -9% and +15%) are faster and larger than of aviation fuels (-5% and +7%). However, the large +15% values is due to a discontinuity in the time series for the USA.

Another difference is that aviation emissions and its effects are more complicated to estimate:

- The distinction into domestic and international fuel use is more difficult to monitor;
- The part of fuel which is actually used for domestic flights is unclear and difficult to assess;
- Besides CO_2 emissions, contrail formation adds probably substantially to enhanced radiative forcing caused by aircraft emissions.

The Top-10 of largest consuming countries account in 1990 for about 2/3 of the global total; the Top-25 countries cover already 85% or more of global total CO_2 emissions of both marine and aviation bunker fuel. When ranking all countries according to their marine bunker fuel consumption in 1990, three countries have by far the largest share: USA with 24%, the Netherlands with 9% and Singapore with almost 9%; the shares of subsequent countries decrease rapidly. The high shares of relatively small countries as the Netherlands and Singapore are probably due to their favourable location for marine transport and low bunker fuel prices. If we do the same for aviation fuel consumption, one country has by far the largest share: USA with 43%. Next, we have Russia with 8%, Japan with 4%, the United Kingdom with almost 4%, Germany and Canada each with 3% and France with 2%. However, in particular the figures for USA, Russia and Canada are likely to include a substantial part of domestic aviation. So, a special feature of marine bunkers is the relative high share of bunker emissions relative to their national CO_2 emissions of a few countries compared to the global average. This is probably not the case or less pronounced for aviation emissions, if we could correct for the actual amounts to be allocated as domestic consumption.

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Appendix A: Changes of aviation fuel use around 1990

Detailed listing of aviation fuel consumption of all countries with actual figures for 1990 and annual and 5-year differences and the percentage of domestic air traffic as reported by all OECD countries. We stress, however, that time-series sometimes appear to contain discontinuities and domestic fraction (available for OECD countries only) may be defined differently between countries (IEA, 1997).

Table A.1: Variation in aviation bunker fuels: OECD countries

	Country	1990	Diff 89-90	Diff 90-91	Diff 85-90	Diff 90-95	Domestic part ('90)*
	[ISO-A3]	[PJ]	[%]	[%]	[%]	[%]	[%]
1	AUS	104	-4%	12%	24%	49%	42%
2	AUT	14	-8%	17%	49%	41%	50%
3	BEL	42	28%	-3%	71%	-1%	1%
4	CAN	184	-4%	-11%	16%	0%	79%
5	CHE	50	5%	-5%	27%	14%	12%
6	DEU	243	2%	-8%	34%	7%	17%
7	DNK	31	-4%	-7%	10%	7%	12%
8	ESP	107	4%	0%	25%	26%	55%
9	FIN	20	14%	-4%	81%	-11%	29%
10	FRA	168	5%	-1%	44%	22%	19%
11	GBR	295	0%	-6%	31%	16%	38%
12	GRC	55	24%	-9%	7%	-2%	38%
13	IRL	16	0%	-3%	76%	55%	5%
14	ISL	4	-11%	-12%	19%	-10%	13%
15	ITA	88	1%	16%	3%	36%	1%
16	JPN	316	8%	3%	49%	30%	40%
17	LUX	6	19%	4%	79%	43%	1%
18	NLD	70	4%	6%	30%	61%	10%
19	NOR	22	-6%	-4%	6%	11%	84%
20	NZL	30	2%	-9%	96%	14%	36%
21	PRT	25	4%	2%	25%	7%	14%
22	SWE	33	-11%	1%	38%	12%	64%
23	TUR	21	14%	3%	136%	140%	63%
24	USA	3209	3%	-3%	21%	0%	100%
	OECD'90	**5153**					**75%**
	o.w. EU-15	1213					

* Definition of domestic air traffic varies between countries.
Source: EDGAR V3.0

Table A.2: Variation in aviation bunker fuels: Annex-B countries

	Country	1990	Diff 89-90	Diff 90-91	Diff 85-90	Diff 90-95	Domestic part ('90)*
	[ISO-A3]	**[PJ]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
1	ALB	0					
2	ARM	9	30%	13%	33%	-83%	0%
3	AZE	25	-32%	-3%	-30%	-9%	0%
4	BGR	13	-34%	-36%	-20%	-16%	0%
5	BIH	3	-8%	-55%	13%	-20%	0%
6	BLR	40		0%		49%	0%
7	CZE	11	-11%	-13%	-16%	-28%	3%
8	EST	2		3%		-49%	0%
9	HRV	3	-7%	-55%	12%	19%	0%
10	HUN	7	7%	-22%	8%	10%	0%
11	KAZ	55	-32%	-3%	-30%	-66%	0%
12	KGZ	3	-32%	-4%	-29%	9%	0%
13	LTU	17	-51%	32%	12%	-90%	0%
14	LVA	4	-34%	-3%	-30%	-73%	0%
15	MDA	3	-1%	4%	1%	-86%	0%
16	MKD	0	0%	40%	0%	540%	0%
17	POL	10	-56%	11%		135%	0%
18	ROM	0					
19	RUS	581	-32%	17%	-30%	-32%	0%
20	SLV	2	29%	-28%	3%	39%	0%
21	SVK	0					
22	SVN	1	-4%	-63%	4%	-22%	0%
23	TJK	1	-32%	-5%	-27%	-74%	0%
24	TKM	0					
25	UKR	83	-32%	-3%	-30%	-52%	0%
26	UZB	0					
27	YUG	10	-7%	-32%	13%	-40%	0%
	Total Annex B	**883**					
	o.w. former USSR	826					

Table A.3: Variation in aviation bunker fuels: Non-Annex-I countries

	Country	1990	Diff 89-90	Diff 90-91	Diff 85-90	Diff 90-95	Domestic part ('90)*
	[ISO-A3]	**[PJ]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
	Non-Annex-I	**1440**					
	o.w. Top-20:						
1	ARG	29	-2%	-7%	1%	45%	0%
2	BRA	80	-5%	5%	4%	24%	0%
3	CHN	45	27%	39%	60%	172%	8%
4	COL	23	7%	-1%	17%	36%	4%
5	EGY	21	2%	-8%	8%	25%	0%
6	HKG	79	15%	-11%	120%	64%	0%
7	IDN	40	17%	-1%	82%	54%	0%
8	IND	76	-3%	-9%	19%	21%	0%
9	IRN	25	37%	5%	-6%	9%	0%
10	IRQ	41	28%	-73%	159%	-54%	0%
11	KOR	72	15%	0%	67%	28%	0%
12	MEX	76	12%	4%	18%	27%	0%
13	MYS	27	36%	12%	59%	82%	0%
14	PHL	23	-9%	-4%	49%	13%	0%
15	SAU	116	54%	30%	35%	-7%	0%
16	SGP	80	34%	-16%	76%	39%	0%
17	THA	85	14%	6%	92%	33%	0%
18	TWN	40	16%	3%	63%	89%	0%
19	VEN	30	5%	-1%	51%	7%	0%
20	ZAF	31	2%	0%	16%	47%	3%
	Global total	**7475**	**-1%**	**-1%**	**17%**	**7%**	**52%**

* Definition of domestic air traffic varies between countries.
Source: EDGAR V3.0

Appendix B: List of countries and country codes

Table B.1: List of countries and ISO-A3 country codes

ISO-A3	Country name	ISO-A3	Country name
ABW	Aruba	CXR	Christmas Island
AFG	Islamic State of Afghanistan	CYM	Cayman Islands
AGO	Republic of Angola	CYP	Republic of Cyprus
AIA	Anguilla	CZE	Czech Republic
ALB	Republic of Albania	DEU	Federal Republic of Germany (united)
AND	Principality of Andorra	DJI	Republic of Djibouti
ANT	Netherlands Antilles	DMA	Commonwealth of Dominica
ARE	United Arab Emirates	DNK	Kingdom of Denmark
ARG	Argentine Republic	DOM	Dominican Republic
ARM	Republic of Armenia	DZA	People's Democratic Republic of Algeria
ASM	American Samoa	ECU	Republic of Ecuador
ATA	Antarctica	EGY	Arab Republic of Egypt
ATF	French Southern Territories	ERI	Eritrea
ATG	Antigua and Barbuda	ESH	Western Sahara
AUS	Australia	ESP	Kingdom of Spain
AUT	Republic of Austria	EST	Republic of Estonia
AZE	Azerbaijani Republic	ETH	Federal Democratic Republic of Ethiopia
BDI	Republic of Burundi	FIN	Republic of Finland
BEL	Kingdom of Belgium	FJI	Republic of Fiji
BEN	Republic of Benin	FLK	Falklands Islands (Malvinas)
BFA	Burkina Faso	FRA	French Republic
BGD	People's Republic of Bangladesh	FRO	Faroe Islands
BGR	Republic of Bulgaria	FSM	Federated States of Micronesia
BHR	State of Bahrain	GAB	Gabonese Republic
BHS	Bahamas	GBR	United Kingdom
BIH	Republic of Bosnia and Herzegovina	GEO	Georgia
BLR	Republic of Belarus	GHA	Republic of Ghana
BLZ	Belize	GIB	Gibraltar
BMU	Bermuda	GIN	Republic of Guinea
BOL	Republic of Bolivia	GLP	Guadeloupe
BRA	Federative Republic of Brazil	GMB	Republic of the Gambia
BRB	Barbados	GNB	Republic of Guinea-Bissau
BRN	Brunei Darussalam	GNQ	Republic of Equatorial Guinea
BTN	Kingdom of Bhutan	GRC	Hellenic Republic
BVT	Bouvet Island	GRD	Grenada
BWA	Republic of Botswana	GRL	Greenland
CAF	Central African Republic	GTM	Republic of Guatemala
CAN	Canada	GUF	French Guiana
CCK	Cocos (Keeling) Islands	GUM	Guam
CHE	Swiss Confederation	GUY	Republic of Guyana
CHL	Republic of Chile	HKG	Hong Kong
CHN	People's Republic of China	HMD	Heard Island and McDonald Islands
CIV	Republic of Côte d'Ivoire	HND	Republic of Honduras
CMR	Republic of Cameroon	HRV	Republic of Croatia
COD	The Democratic Republic of the Congo	HTI	Republic of Haiti
COG	Republic of the Congo	HUN	Republic of Hungary
COK	Cook Islands	IDN	Republic of Indonesia
COL	Republic of Colombia	IND	Republic of India
COM	Islamic Federal Republic of the Comoros	IOT	British Indian Ocean Territory
CPV	Republic of Cape Verde	IRL	Ireland
CRI	Republic of Costa Rica	IRN	Islamic Republic of Iran
CUB	Republic of Cuba	IRQ	Republic of Iraq

Table B.1: List of countries and ISO-A3 country codes (c'ted)

ISO-A3	Country name	ISO-A3	Country name
ISL	Republic of Iceland	NIU	Niue
ISR	State of Israel	NLD	Kingdom of the Netherlands
ITA	Italian Republic	NOR	Kingdom of Norway
JAM	Jamaica	NPL	Kingdom of Nepal
JOR	Hashemite Kingdom of Jordan	NRU	Republic of Nauru
JPN	Japan	NZL	New Zealand
KAZ	Republic of Kazakstan	OMN	Sultanate of Oman
KEN	Republic of Kenya	PAK	Islamic Republic of Pakistan
KGZ	Kyrgyz Republic	PAN	Republic of Panama
KHM	Kingdom of Cambodia	PCN	Pitcairn
KIR	Kiribati	PER	Republic of Peru
KNA	Saint Kitts and Nevis	PHL	Republic of the Philippines
KOR	Republic of Korea	PLW	Republic of Palau
KWT	State of Kuwait	PNG	Papua New Guinea
LAO	Lao People's Democratic Republic	POL	Republic of Poland
LBN	Lebanese Republic	PRI	Puerto Rico
LBR	Republic of Liberia	PRK	Democratic People's Republic of Korea
LBY	Socialist People's Libyan Arab Jamahiriya	PRT	Portuguese Republic
LCA	Saint Lucia	PRY	Republic of Paraguay
LIE	Principality of Liechtenstein	PYF	French Polynesia
LKA	Democratic Socialist Republic of Sri Lanka	QAT	State of Qatar
LSO	Kingdom of Lesotho	REU	Réunion
LTU	Republic of Lithuania	ROM	Romania
LUX	Grand Duchy of Luxembourg	RUS	Russian Federation
LVA	Republic of Latvia	RWA	Rwandese Republic
MAC	Macau	SAU	Kingdom of Saudi Arabia
MAR	Kingdom of Morocco	SDN	Republic of the Sudan
MCO	Principality of Monaco	SEN	Republic of Senegal
MDA	Republic of Moldova	SGP	Republic of Singapore
MDG	Republic of Madagascar	SGS	South Georgia and South Sandwich Islands
MDV	Republic of Maldives	SHN	Saint Helena
MEX	United Mexican States	SJM	Svalbard and Jan Mayen
MHL	Republic of the Marshall Islands	SLB	Solomon Islands
MKD	The former Yugoslav Republic of Macedonia	SLE	Republic of Sierra Leone
MLI	Republic of Mali	SLV	Republic of El Salvador
MLT	Republic of Malta	SMR	Republic of San Marino
MMR	Union of Myanmar	SOM	Somali Democratic Republic
MNG	Mongolia	SPM	Saint Pierre and Miquelon
MNP	Northern Mariana Islands	STP	Sao Tome and Principe
MOZ	Republic of Mozambique	SUR	Republic of Suriname
MRT	Islamic Republic of Mauritania	SVK	Slovak Republic
MSR	Montserrat	SVN	Republic of Slovenia
MTQ	Martinique	SWE	Kingdom of Sweden
MUS	Republic of Mauritius	SWZ	Kingdom of Swaziland
MWI	Republic of Malawi	SYC	Republic of Seychelles
MYS	Malaysia	SYR	Syrian Arab Republic
MYT	Mayotte	TCA	Turks and Caicos Islands
NAM	Republic of Namibia	TCD	Republic of Chad
NCL	New Caledonia	TGO	Togolese Republic
NER	Republic of the Niger	THA	Kingdom of Thailand
NFK	Norfolk Island	TJK	Republic of Tajikistan
NGA	Federal Republic of Nigeria	TKL	Tokelau
NIC	Republic of Nicaragua	TKM	Turkmenistan

Table B.1: List of countries and ISO-A3 country codes (c'ted)

ISO-A3	Country name
TMP	East Timor
TON	Kingdom of Tonga
TTO	Republic of Trinidad and Tobago
TUN	Republic of Tunisia
TUR	Republic of Turkey
TUV	Tuvalu
TWN	Taiwan, Province of China
TZA	United Republic of Tanzania
UGA	Republic of Uganda
UKR	Ukraine
UMI	United States Minor Outlying Islands
URY	Eastern Republic of Uruguay
USA	United States of America
UZB	Republic of Uzbekistan
VAT	Holy See (Vatican City State)
VCT	Saint Vincent and the Grenadines
VEN	Republic of Venezuela
VGB	British Virgin Islands
VIR	Virgin Islands of the United States
VNM	Socialist Republic of Viet Nam
VUT	Republic of Vanuatu
WLF	Wallis and Futuna
WSM	Independent State of Western Samoa
YEM	Republic of Yemen
YUG	Federal Republic of Yugoslavia
ZAF	Republic of South Africa
ZMB	Republic of Zambia
ZWE	Republic of Zimbabwe

Appendix C: Mailing list

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