Aviation and Environment

A Working Paper

Arushi

Stefan Drews
Table of Contents

LIST OF FIGURES ................................................................................................................................................. 3
LIST OF TABLES ........................................................................................................................................................ 3
LIST OF ABBREVIATIONS ................................................................................................................................... 4

1. INTRODUCTION .................................................................................................................................................. 5

2. AVIATION AND ENVIRONMENT ........................................................................................................................ 6
   2.1. GROWTH OF THE INDUSTRY ........................................................................................................................... 6
   2.2. INDUSTRY STRUCTURE IN INDIA .................................................................................................................... 9
         2.2.1. Airlines .................................................................................................................................................... 9
         2.2.2. Airports and Routes ................................................................................................................................. 11
         2.2.3. Aircraft Manufacturers .......................................................................................................................... 12
         2.2.4. Aviation Fuel ........................................................................................................................................... 13
   2.3. IMPACT ASSESSMENT .................................................................................................................................... 13
         2.3.1. Climate Change ....................................................................................................................................... 13
         2.3.2. Air Quality and Health .......................................................................................................................... 17

3. CURRENT REGULATORY FRAMEWORK ............................................................................................................. 19
   3.1. INTERNATIONAL GOVERNANCE ................................................................................................................... 19
   3.2. INDIAN REGULATIONS .................................................................................................................................. 21

4. EMISSION REDUCTION POTENTIAL ...................................................................................................................... 25
   4.1. TECHNOLOGICAL IMPROVEMENTS ............................................................................................................... 25
         4.1.1. Engines ..................................................................................................................................................... 26
         4.1.2 Aircraft Design ......................................................................................................................................... 28
         4.1.2. Alternative Fuels ..................................................................................................................................... 30
   4.2 OPERATIONAL .................................................................................................................................................. 31
         4.2.1. Airlines ....................................................................................................................................................... 32
         4.2.2. Air Traffic Management .......................................................................................................................... 34
         4.2.3. Airports ....................................................................................................................................................... 36
   4.3. EXISTING ROADMAPS .................................................................................................................................. 37

5. POLICY OPTIONS .................................................................................................................................................. 41
   5.1. LEVIES ......................................................................................................................................................... 41
   5.2. EMISSION TRADING & CARBON OFFSETTING ......................................................................................... 45

6. CONCLUSIONS AND POLICY RECOMMENDATIONS FOR INDIA ...................................................................... 48

REFERENCES ............................................................................................................................................................. 50

ANNEXURE ................................................................................................................................................................. 55
   ANNEXURE I ............................................................................................................................................................. 55
   ANNEXURE II ............................................................................................................................................................ 56
   ANNEXURE III .......................................................................................................................................................... 57
   ANNEXURE IV .......................................................................................................................................................... 58
   ANNEXURE V ............................................................................................................................................................ 59
   ANNEXURE V ............................................................................................................................................................ 61
   ANNEXURE VI .......................................................................................................................................................... 62
List of Figures

FIGURE 1: INDIAN DOMESTIC & INTERNATIONAL PASSENGER TRAFFIC ................................................................. 6
FIGURE 2: PROPENSITY TO TRAVEL ..................................................................................................................... 7
FIGURE 3: ATF CONSUMPTION IN INDIA .................................................................................................................. 8
FIGURE 4: PASSENGER PERCEPTION ON DOMESTIC INDIAN AIRLINES ............................................................. 10
FIGURE 5: TRAFFIC NETWORK IN INDIA ................................................................................................................ 12
FIGURE 6: HISTORICAL AND PRESENT-DAY INVENTORIES AND FUTURE PROJECTIONS FOR CO₂ EMISSIONS FROM CIVIL AVIATION COMPILED FROM A VARIETY OF SOURCES ................................................................................................. 14
FIGURE 7: CO₂ EMISSION TRENDS IN INDIAN TRANSPORTATION FROM 1990-2007 ......................................................... 15
FIGURE 8: AVIATION RADIATIVE FORCING COMPONENTS IN 2005 ........................................................................... 16
FIGURE 9: ICAO WORK STRUCTURE ..................................................................................................................... 20
FIGURE 10: COMPOSITION OF ATF PRICE ............................................................................................................. 23
FIGURE 11: AIR TRAFFIC FUEL EFFICIENCY AND TODAY’S AIRCRAFT ........................................................................... 25
FIGURE 12: HISTORY AND FUTURE OF ENGINE FUEL CONSUMPTION TRENDS ......................................................... 27
FIGURE 13: EMISSIONS FROM JET FUEL COMBUSTION .......................................................................................... 28
FIGURE 14: EVOLUTION OF AIRCRAFT DESIGN AND TECHNOLOGY .......................................................................... 30
FIGURE 15: EFFICIENCY OPTIMIZATION: WHAT HAS THE GREATEST EFFECT? ............................................................ 33
FIGURE 16: FUEL CONSUMPTION TRENDS IN INDIAN OPERATORS IN THE INTERNATIONAL SECTOR ......................... 34
FIGURE 17: CYCLES OF AIRCRAFT MOVEMENT ...................................................................................................... 35
FIGURE 18: FUEL CONSUMPTION AS A FUNCTION OF FLIGHT DISTANCE ...................................................................... 35
FIGURE 19: CARBON EFFICIENCY PER SEAT AS A FUNCTION OF DISTANCE TRAVELED .................................................... 36
FIGURE 20: CO₂ EMISSION REDUCTION MEASURES OVER TIME ................................................................................ 38
FIGURE 21: EXAMPLES OF CURRENT OR PLANNED ETS SCHEMES ............................................................................. 46

List of Tables

TABLE 1: MARKET SHARE OF SCHEDULED DOMESTIC AIRLINES IN 2011 ..................................................................... 10
TABLE 2: REPRESENTATIVE HEALTH EFFECTS FROM LOCAL AIR QUALITY POLLUTANTS ........................................... 17
TABLE 3: EXAMPLES OF SALES TAX RATES ON ATF IN 2010 ..................................................................................... 23
TABLE 4: ANNUAL IMPROVEMENT ......................................................................................................................... 25
TABLE 5: TAX RATES ON DOMESTIC AVIATION FUEL IN SELECTED COUNTRIES AND YEARS .................................. 42
TABLE 6: UK AIR PASSENGER DUTY BANDS AND RATES ...................................................................................... 43
**List of Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AAI</td>
<td>Airport Authority of India</td>
</tr>
<tr>
<td>AEU</td>
<td>Aviation Environmental Unit</td>
</tr>
<tr>
<td>ANS</td>
<td>Air Navigation Service</td>
</tr>
<tr>
<td>APU</td>
<td>Auxiliary Power Unit</td>
</tr>
<tr>
<td>ASPIRE</td>
<td>ASia Pacific Initiative to Reduce Emissions</td>
</tr>
<tr>
<td>ATF</td>
<td>Aviation Turbine Fuel</td>
</tr>
<tr>
<td>ATM</td>
<td>Air Traffic Management</td>
</tr>
<tr>
<td>BP</td>
<td>Bharat Petroleum</td>
</tr>
<tr>
<td>BRIC</td>
<td>Brazil, Russia, India and China</td>
</tr>
<tr>
<td>CAPA</td>
<td>Centre for Asia Pacific Aviation</td>
</tr>
<tr>
<td>CAEP</td>
<td>Committee on Aviation Environmental Protection</td>
</tr>
<tr>
<td>CBRD</td>
<td>Common but Differentiated Responsibility</td>
</tr>
<tr>
<td>CCD</td>
<td>Climb, cruise and descent</td>
</tr>
<tr>
<td>CDO</td>
<td>Continuous Descent Operations</td>
</tr>
<tr>
<td>CNS</td>
<td>Communications, Navigation &amp; Surveillance</td>
</tr>
<tr>
<td>CTA</td>
<td>Controlled Time Arrival</td>
</tr>
<tr>
<td>DGCA</td>
<td>Directorate General of Civil Aviation</td>
</tr>
<tr>
<td>DLI</td>
<td>Direct Lean Injection</td>
</tr>
<tr>
<td>EU ETS</td>
<td>European Union Emission Trading Scheme</td>
</tr>
<tr>
<td>FAB</td>
<td>Functional Airspace Blocks</td>
</tr>
<tr>
<td>FIANS</td>
<td>Future Indian Air Navigation System</td>
</tr>
<tr>
<td>GHG</td>
<td>Green House Gas</td>
</tr>
<tr>
<td>GIACC</td>
<td>Group on International Aviation and Climate Change</td>
</tr>
<tr>
<td>GNSS</td>
<td>Global Navigation Satellite Systems</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>HAP</td>
<td>Hydroxyapatite</td>
</tr>
<tr>
<td>HPCL</td>
<td>Hindustan Petroleum Corporation Limited</td>
</tr>
<tr>
<td>IATA</td>
<td>International Air Transport Association</td>
</tr>
<tr>
<td>ICCT</td>
<td>International Council for Clean Transportation</td>
</tr>
<tr>
<td>ICAO</td>
<td>International Civil Aviation Organization</td>
</tr>
<tr>
<td>IEA</td>
<td>International Energy Agency</td>
</tr>
<tr>
<td>IOCL</td>
<td>Indian Oil Corporation Limited</td>
</tr>
<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
</tr>
<tr>
<td>LTO</td>
<td>Landing and Take Off cycle</td>
</tr>
<tr>
<td>Mt</td>
<td>Million tones</td>
</tr>
<tr>
<td>OPR</td>
<td>Operating Pressure Ratios</td>
</tr>
<tr>
<td>PBN</td>
<td>Performance Based Navigation</td>
</tr>
<tr>
<td>PM</td>
<td>Particulate Matter</td>
</tr>
<tr>
<td>PPP</td>
<td>Public Private Partnership</td>
</tr>
<tr>
<td>RF</td>
<td>Radiative Frocing</td>
</tr>
<tr>
<td>RQL</td>
<td>Rich Burn, Quick-Mix, Lean Burn</td>
</tr>
<tr>
<td>SWIM</td>
<td>System Wide Information Management</td>
</tr>
<tr>
<td>UK APD</td>
<td>UK Air Passenger Duty</td>
</tr>
<tr>
<td>UNFCCC</td>
<td>United Nations Framework Convention on Climate Change</td>
</tr>
<tr>
<td>VAT</td>
<td>Value Added Tax</td>
</tr>
<tr>
<td>VOC</td>
<td>Volatile Organic Compound</td>
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</table>
1. Introduction

Aviation is one of the fastest growing industries worldwide and the fastest growing transportation mode in India. In 2006-2007 the Indian civil aviation sector experienced a phenomenal growth rate of about 40%. Considering that less than 1% of the population in India boards a plane during the year, the future growth potential seems massive. Leading aircraft manufacturer Airbus expects the Indian domestic aviation to be the strongest growing market for the next two decades worldwide. While aviation undoubtedly plays a vital role in supporting the economy and creates societal benefits, it also contributes significantly to climate change and to a lesser degree to air pollution. It was the IPCC (Intergovernmental Panel on Climate Change) in 1999 that shed light on this issue for the first time by attributing 3.5% of man-made climate impact to the aviation sector.

This paper aims to broadly explore the current and the future trends in the aviation industry, the scientific consensus on its environmental impacts, and promising emission mitigation measures. This literature review aims to describe major regulatory and technological issues in the global aviation sector as well as specifically in the Indian context to lay down the foundation for future research and informed policy intervention in India.

Firstly, the paper details the passenger growth figures and its propellants along with a description of major stakeholders. Then, the role of aviation as a contributor to climate change and air pollution is examined. This is not an easy task since aviation is the only sector that emits bulk of the gases at higher altitudes between 9 and 12 km, which lead to stronger climate effects than that from emissions on the ground. Furthermore, the paper identifies key institutions that regulate the aviation sector across the globe and in India. This is followed by a review of technological and operational measures and opportunities available to improve the fuel efficiency and reduce harmful emissions. Existing environmental policies and taxation measures related to aviation for both the international and domestic markets have been discussed in the next section. Based on the literature findings of this paper we suggest a number of policy recommendations that can be implemented and indicate issues that require further research.
2. Aviation and Environment

2.1. Growth of the industry

In the two decades between 1989 and 2009, the global aviation industry has grown annually by 4.4%, measured as total scheduled traffic in tonne kilometers performed. About 2.3 billion passengers were transported by aircrafts in 2009. Future projections for air traffic expect an increase of 4.8% per year till 2036 with the Asia/Pacific region as the main contributor for this trend.¹

Civil aviation in India has experienced massive growth since the middle of the past decade. Figure 1 shows that domestic traffic tripled from approximately 15 to 45 million passengers in the period between 2004 and 2010. While domestic traffic decreased slightly during the economic downturn in 2008-2009, international passenger growth went up steadily even at that time, rising to almost 35 million in 2010. In comparison, about 20 million Indians use railways as a transportation mode per day.²

![Figure 1: Indian Domestic & International Passenger Traffic](source)

Air travel per capita in India is still significantly lower compared to other BRIC countries and to the world average, as is depicted in figure 2. It is reported that China’s domestic traffic volume is currently five times that of India and also that Australia with a population of only 22 million generates more domestic traffic³. This illustrates that only a tiny proportion of the

¹ ICAO 2010, Environmental Report 2010
² Government of India 2010b, Indian Railways Year Book (2009-2010), Ministry of Railways.
³ CAPA 2010, Preparing for Long Term Growth of Indian Aviation, New Delhi
population uses air travel as a means of transportation till now and gives a sense of the future growth potential of the Indian aviation sector highly correlated to rising disposable income.

In fact, forecasts see India to be the third largest aviation market in the next 12 to 15 years, up from her 12th position in 2007. Passenger traffic is projected to rise to 450 million passengers per year by 2020, which equates to a fourfold increase in only 10 years and an annual growth rate of more than 10%. An Airbus market outlook is in line with the aforementioned numbers and estimates that, with a rate of 9.2% per annum, the Indian domestic market will observe the fastest growth worldwide between 2009 and 2029.

Figure 2: Propensity to travel

Centre for Asia Pacific Aviation (CAPA) expects Indian commercial fleet to grow from currently 380 aircrafts to about 1000 by 2020. This year’s firm order by Indigo (an Indian airline operator) of 180 Airbus A320 aircrafts, the largest order in commercial aviation history, only exemplifies the tremendous market potential in the Indian aviation sector. Noteworthy, though it is not within the scope of this paper, the Indian business jet fleet has increased almost fivefold between 2005 and 2010 and the ratio of confirmed orders relative to the current fleet size is by far the largest number worldwide.

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4 Airbus 2010, Global Market Forecast 2009-2029, Toulouse
5 CAPA 2010, Preparing for Long Term Growth of Indian Aviation, New Delhi
7 CAPA 2010, Preparing for Long Term Growth of Indian Aviation, New Delhi.
**Liberalization**

For almost 40 years since 1953, the Indian aviation was a public sector monopoly, with Air India and Indian Airlines as the two only operators serving the domestic and international market respectively. Liberalization began in the early nineties, when air taxi operators were allowed to serve the domestic market. Many private airlines entered and subsequently exited the market quickly, with Jet Airways and Sahara as the only survivors of the initial turbulence. While Indian aviation showed limited growth between 1995 and 2003, several reforms and a new phase of development began thereafter. New entrants such as Air Deccan, Spicejet, IndiGo or GoAir adopted the low cost business model and offered air travel services at lower fares. Moreover, the government deregulated international air traffic in 2004, which allowed private Indian carriers to extend their services to international routes and gave foreign carriers more access to the Indian market.8,9

**Fuel Consumption**

Global aircraft fuel burn for scheduled flights was at 187 million tonnes (Mt) in 2006 excluding certain aviation-related operations on the ground and non-scheduled flights, which combined could increase the figure by 10% to 12%. Fuel consumption is expected to rise by 3% to 3.5% and reach between 461Mt and 541 Mt in 2036. Domestic and international operations account for 38% and 62% of global fuel consumption, respectively10.

![Figure 3: ATF consumption in India](image)

Source: Based on data from MoPNG; * provisional

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In line with the tremendous growth of air transportation in India, consumption of ATF (Aviation Turbine Fuel) in India went up by about 40% from 3.3 Mt to 4.6 Mt between 2005 and 2010. This is depicted in figure 3. India currently produces approximately twice as much ATF as it consumes and thus was a net exporter of about 4.6 Mt ATF in 2009-2010.\textsuperscript{11}

2.2. Industry Structure in India

The aviation industry comprises of airplane manufacturing companies and service providing airlines. Other important players relevant for environmental discussions are engine manufacturers, fuel suppliers and airport operators.

The civil aviation market is divided into scheduled and non-scheduled transportation. The \textit{Scheduled Transportation} services provide regular fly activities using predetermined airports and routes for passenger and freight. These can also be classified as domestic (intra-country services) and international (inter-country services). The \textit{Non-Scheduled Transportation} gathers all the remaining flying activities of the civil aviation and general aviation constitutes a major chunk of these flights. Business aviation is a further division of general aviation.

2.2.1. Airlines

The Indian airlines sector was revolutionized by the repeal of the Air Corporations act in 1994 permitting private parties to provide scheduled domestic services. This liberalization facilitated the entry of private players like Jet Airways, Sahara Airlines, Modiluft, Damania Airways, NEPC Airlines and East West Airlines to compete with the state run Indian Airlines but only Jet and Sahara sustained. The industry later saw an influx of a number of low cost airline services but many of them were closed down or merged into bigger airlines. Today, a total of 7 companies operate airlines on domestic routes (refer Annexure I).

Table 1: Market share of scheduled domestic airlines in 2011

<table>
<thead>
<tr>
<th>Airline</th>
<th>Market</th>
<th>Fleet</th>
<th>Average</th>
<th>Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingfisher</td>
<td>19%</td>
<td>66</td>
<td>2.3</td>
<td>130</td>
</tr>
<tr>
<td>IndiGo</td>
<td>18.70%</td>
<td>39</td>
<td>2.5</td>
<td>241</td>
</tr>
<tr>
<td>JetAirways</td>
<td>18%</td>
<td>96</td>
<td>4.82</td>
<td>29</td>
</tr>
<tr>
<td>Air India</td>
<td>15.80%</td>
<td>119</td>
<td>9.7</td>
<td>30</td>
</tr>
<tr>
<td>SpiceJet</td>
<td>13.80%</td>
<td>26</td>
<td>4.4</td>
<td>66</td>
</tr>
<tr>
<td>JetLite</td>
<td>8.10%</td>
<td>19</td>
<td>8.1</td>
<td>8</td>
</tr>
<tr>
<td>Go Air</td>
<td>6.60%</td>
<td>10</td>
<td>1.7</td>
<td>10</td>
</tr>
<tr>
<td><strong>100.00%</strong></td>
<td><strong>375</strong></td>
<td></td>
<td><strong>5.737653333</strong></td>
<td><strong>514</strong></td>
</tr>
</tbody>
</table>

Sources: Based on data from [www.airfleets.net](http://www.airfleets.net); company websites and DGCA (Last accessed 28/4/2011)

Kingfisher and Jet Airways are considered the undisputed leaders as far as in flight experience is concerned along with better check in and booking facilities as described in figure 3. SpiceJet and Indigo perform well when it comes to value for money.\(^{12}\) Availability is found as the most problematic area in public airlines followed by luggage handling, staff assistance, responsiveness, assurance and cleanliness.\(^{13}\) These consumer behavior studies explain the respective market shares of different airlines noted in table 1.

In 2004, the Indian carriers with scheduled services were allowed to operate international flights, if they had completed five years of continuous operations and had a minimum of 20 aircrafts. Jet Airways began operations to and from Singapore, Malaysia, Thailand, Hong Kong, UK, USA and Canada.\(^{14}\) At present, 70 foreign carriers operate flights to or from

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\(^{12}\) Agarwal S undated, Perception Mapping of Travellers: Case of Six Indian Domestic Airlines, Birla Institute of Management Technology, Noida


India. Indian carriers flying in international skies are the public Air India and private Jet Airways and Kingfisher. IndiGo is going to launch its international services by October 2011 as a part of its rapid expansion plan.

2.2.2. Airports and Routes

Altogether, there are 86 operational and 41 non-operational airports under the jurisdiction of Airport Authority of India (AAI). AAI is responsible for airport operations and management, except for the New Delhi and Mumbai airports held by a PPP model and the two Greenfield airports in Bangalore and Hyderabad. AAI also provides CNS/ATM services to all civil airports, air navigation services, and the entire civil airspace in India. The airports in India are inadequate for handling the increase in traffic. The Naresh Chandra Committee Report identifies a number of loopholes in the current system and suggests improvements. The government has decided to privatize airports in order to induce efficiency and avoid the burden of investing in the same.

Almost 70% of air traffic in India in 2005, as illustrated in figure 5, was concentrated on six major cities: Delhi, Mumbai, Chennai (Madras), Bangalore, Kolkata (Calcutta) and Hyderabad. The latest numbers for March 2011 show only a slight decline of this concentration as 63% of all domestic and international aircraft movements in India occurred at the aforementioned airports.

To regulate air transport services and fulfill the need for air transport services of different regions in the country, the Government has laid down Route Dispersal Guidelines which mandate deployment of services on Category II routes i.e. the north-eastern region, Jammu & Kashmir, Andaman & Nicobar Islands and Lakshadweep by at least 10% of their deployed capacity on the most profitable 12 trunk or Category-I routes. Moreover, 50% of the capacity deployed on Category-I routes is to be deployed on routes other than Category-I and Category-II routes i.e. Category-III routes (refer Annexure II).

15 DGCA website, http://dgca.nic.in/reports/otp.pdf
16 *India’s Aviation Industry: An Overview* by The MITRE Corporation/CAASD, 2009
17 Ohri M *Undated*, Airport Privatization in India – A Study of Different Modes of Infrastructure Provision, Delhi University
18 Ohri M *Undated*, Airport Privatization in India – A Study of Different Modes of Infrastructure Provision, Delhi University
2.2.3. Aircraft Manufacturers

The major aircraft manufacturers, such as Boeing, Airbus and Bombardier are based out of India. Home grown aircraft manufacturers, such as Hindustan Aeronautics Limited (HAL) and Pawan Hans Helicopters Ltd. mostly manufacture aircrafts for military purposes and helicopters. Hence, Indian carriers are fully dependent on imported airliners.

There are five major manufacturers of civil transport aircraft in the world. These are Europe based Airbus, USA based Boeing, Canada based Bombardier, Brazil based Embraer and Russia based Tupolev. Airbus fulfills about half or more of the orders for airliners with more than 100 seats. Most of the remaining demand of large civil aircrafts is catered by Boeing which supplies 75 % of the world’s commercial airliner fleet and including mostly Boeing Business Jets.

Indian carriers show a similar preference for Airbus aircrafts with 50 % of the current fleet and 77.8 % of the ordered aircrafts from Airbus. Airbus model A320-200 which is the most popular airliner in the world, alone accounts for 70 % of the new orders. 36.5 % of the current fleet is Boeing aircrafts but this share will decline with the inflow of newer aircrafts of which it is supplying only 14 %. Bombardier and ATR are the other two manufactures that have sold their aircrafts to Indian airlines. (Refer Annexure III)
2.2.4. Aviation Fuel

Two major types of aviation fuels are Avgas (Aviation gasoline) and Aviation Turbine Fuel (ATF, also called Jet Fuel) and are used to power piston-engine and gas-turbine engine aircrafts respectively. The most commonly used fuels for commercial aviation are kerosene based Jet A and Jet A-1 which are produced to a standardized international specification. Naphtha based Jet B also finds some application in colder climates. Most Indian carriers use Jet A-1.

The fuel demands of domestic as well as international carriers are met by a combination of public as well as private sector oil companies. IOCL has a 63% market share in aviation fuels including the supplies to defense services. Other suppliers are HP Aviation, HPCL, BP and Shell.

2.3. Impact Assessment

2.3.1. Climate Change

Global aviation contributes to climate change by changing the composition of atmospheric gases in both the lower stratosphere and higher troposphere. The principal emissions from aviation combustion processes comprise CO$_2$ and water vapour with a share of approximately 70% and a little less than 30% respectively. The remainder consists of NO$_x$, CO, SO$_x$, VOC, particulates and other trace components including HAPs. Ozone is not emitted directly into the air but is formed by the reaction of NO$_x$ and VOC in the presence of heat and sunlight. The vast majority of emissions (90%) occur during the cruise cycle, with the exception of CO and VOC, for which the share is 30% on the ground and 70% on higher altitudes.

In a landmark study the IPCC investigated the impact of global aviation on climate change using data from 1992 and found that 0.51 Gt CO$_2$ originated from aircrafts. This equaled 13% of all CO$_2$ emissions from the transportation sector and 2% of all anthropogenic CO$_2$ emissions. Different future projections from the IPCC foresee an increase of CO$_2$ emissions within a range of 0.84 and 5.32 Gt CO$_2$ by 2050 in best and worst case scenario, respectively.

20 IOCL website as accessed on 25th May 2011 www.iocl.com/AboutUs/Profile.aspx
A recent update on the IPCC report employs five different future emission scenarios and finds a range of outcomes between 1.03 and 2.41 Gt increase in CO₂ emissions by 2050. This means that CO₂ emissions will grow annually by 2.8% in the worst case and by 0.8% in the best case scenario between 2000 and 2050 and are projected to make up between 10% and 16% of total transportation carbon emission. The same simulations for NOₓ emissions vary from a 2% increment to a 0.1% decline per year by 2050. A number of CO₂ emission estimations with different assumptions and outcomes are shown in figure 7. Drawing from this picture, it is clear that CO₂ emissions will continue to rise in the future.

Figure 6: Historical and present-day inventories and future projections for CO₂ emissions from civil aviation compiled from a variety of sources


A government greenhouse gas emission inventory for India shows that the transportation sector contributed 8.2% (138.85 Mt) to the total national CO₂ emissions in 2007. Transportation emissions were composed of 87.3% (121.21 Mt) from road activities, 7.3% (10.12 Mt) from aviation, 4.3% (6.1 Mt) from railways and 1.1% (1.4 Mt) from marine navigation. Emissions from aviation have more than trebled since 1994, while the increase from road transportation is less than double and almost negligible from marine navigation and railways. However, this emission inventory only includes domestic emissions, and international bunker emissions have been estimated only for information purposes. The estimated CO₂ emissions from international aviation of domestic carriers are 3.3 Mt. In order to get the full picture of CO₂ emissions from aviation emissions in India, one has to consider

23 Owen, B. et al. 2010, Flying into the future – aviation emissions scenarios to 2050, Env. Sci. & Technology
international bunker emissions also from international airlines. The IEA\textsuperscript{26} has calculated 14.34 Mt CO\textsubscript{2} emissions from international aviation to/from India for the year 2007 and an exceptional increment of 165.7\% between 1990 and 2008, compared to the world average of 76.1\%. Figure 8 summarizes the growth trends of CO\textsubscript{2} emissions in the Indian transportation sector and displays the rising share of aviation industry emissions in the past decade.

**Figure 7: CO\textsubscript{2} emission trends in Indian transportation from 1990-2007**


A comparison of CO\textsubscript{2} intensity between different modes of transport in terms of emissions per passenger-km is very difficult to achieve, since it critically depends on factors such as the type of technology, source of primary energy and particularly load factor. Nonetheless, the IPCC\textsuperscript{27} assumes a range of 30 to 110 g CO\textsubscript{2} per passenger-km for air transport, which is comparable to cars and light trucks. Buses are assigned a value of below 20 CO\textsubscript{2} g per passenger-km, while railways varies between <5 and 50 g CO\textsubscript{2} per passenger-km.

**Non- CO\textsubscript{2} climate impact**

It is critical to distinguish between CO\textsubscript{2} and non- CO\textsubscript{2} effects of aviation activities on the atmosphere and assess the overall impact of aviation on climate change. For this, the IPCC\textsuperscript{28} used the concept of radiative forcing (RF), which is a metric to measure the capacity of a greenhouse gas to alter the energy balance of the atmosphere. Positive RF results lead to a warming of the Earth’ surface temperature, negative results reflect a cooling effect. In 1992 the RF for global aviation was estimated to be 3.5\% (0.05 Wm\textsuperscript{-2}) of the total anthropogenic climate impact. This is predicted to increase to 5\% by 2050. A recent study\textsuperscript{29} estimated the total aviation RF as 3.5\% in 2005 and 4.9\%, if the effects of aviation induced cirrus clouds are

\textsuperscript{27} http://www.ipcc.ch/ipccreports/sres/aviation/126.htm#img85 (Last accessed 25/05/2011)
\textsuperscript{28} IPCC 1999, IPCC Special Report Aviation and the Global Atmosphere.
included. Thus, the total climate impact of aviation is 1.96 times of the CO₂ impact alone and 2.7 times including cirrus clouds. The different RF components and the total aviation RF are depicted in figure 9. The bars indicate median estimates and whiskers represent 90% likelihood ranges.

Figure 8: Aviation Radiative Forcing Components in 2005


Future projections representing the A1 and B1 IPCC scenario families show that the aviation RF in 2050 will increase by a factor between 4 and 3 over the 2000 levels. Note that the scientific understanding of each RF component varies between high (CO₂), medium-low (NOₓ), low (Water vapour, Sulphae aerosol, Soot aerosol, Linear contrails) and very low (Induced cirrus cloudiness). Aviation induced cirrus clouds have been the most poorly understood RF component so far and thus excluded from the RF calculations. Recent findings³⁰ indicate that induced cirrus clouds may be the largest single RF component associated with aviation and allow to include their effects in future impact studies and policy frameworks.

RF is not the only metric used to measure the overall climate impact of aviation. Other metrics include the Radiative Forcing Index (RFI), Integrated Radiative Forcing (IRF), Global Warming Potential (GWP), Global Temperature Warming Potential (GTWP) or Economic Cost Calculations. All of these instruments have different assumptions and features, as for instance a metric might be backward-looking (e.g. RF) or forward-looking (e.g. GWP), and

thus they should be applied to different purposes and goals. However, based on the evidence it is suggested that total climate impact from aviation is likely to be at least twice of the CO₂ impact.³¹

2.3.2. Air Quality and Health

In addition to its contribution to climate change, aviation has a number of other impacts, most notably on ambient air quality and subsequently on public health. The major air pollutant from aircraft operations is NOₓ and to a considerably minor degree CO, SOₓ, VOC and PM, while Ozone is formed indirectly by the reaction between NOₓ and VOC. Most air quality assessments and emission inventories focus on aircraft emissions released during the landing and takeoff cycle (LTO) of an aircraft below 3000 feet, although 90% of emissions occur at the cruise cycle.³² Emissions also arise from various activities concerning ground transportation and power generation at the airport. Table 2 gives an overview of public health risks for people that are affected by exposure to aviation-related pollutants.

Table 2: Representative Health Effects from Local Air Quality Pollutants

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Health Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO – Carbon Monoxide</td>
<td>● Cardiovascular effects, especially in those persons with heart conditions</td>
</tr>
<tr>
<td>HC – Unburned Hydrocarbons (a primary component of Volatile Organic Compounds, or VOC)</td>
<td>● Eye and respiratory tract infection</td>
</tr>
<tr>
<td></td>
<td>● Headaches</td>
</tr>
<tr>
<td></td>
<td>● Dizziness</td>
</tr>
<tr>
<td></td>
<td>● Visual disorders</td>
</tr>
<tr>
<td></td>
<td>● Memory impairment</td>
</tr>
<tr>
<td>NOₓ – Nitrogen Oxides</td>
<td>● Lung irritation</td>
</tr>
<tr>
<td></td>
<td>● Lower resistance to respiratory infections</td>
</tr>
<tr>
<td>O₃ – Ozone (HC is a precursor for ground-level O₃ formation)</td>
<td>● Lung function impairment</td>
</tr>
<tr>
<td></td>
<td>● Effects on exercise performance</td>
</tr>
<tr>
<td></td>
<td>● Increased airway responsiveness</td>
</tr>
<tr>
<td></td>
<td>● Increased susceptibility to respiratory infection</td>
</tr>
<tr>
<td></td>
<td>● Increased hospital admissions and emergency room visits</td>
</tr>
<tr>
<td></td>
<td>● Pulmonary inflammation, lung structure damage</td>
</tr>
<tr>
<td>PM – Particulate Matter</td>
<td>● Premature mortality</td>
</tr>
<tr>
<td></td>
<td>● Aggravation of respiratory and cardiovascular disease</td>
</tr>
<tr>
<td></td>
<td>● Changes in lung function</td>
</tr>
<tr>
<td></td>
<td>● Increased respiratory symptoms</td>
</tr>
<tr>
<td></td>
<td>● Changes to lung tissues and structure</td>
</tr>
<tr>
<td></td>
<td>● Altered respiratory defense mechanisms</td>
</tr>
</tbody>
</table>

Source: ICAO 2010, Environmental Report 2010

³² Tarrason, L. et al. 2004, Study on air quality impacts of non-LTO emissions from aviation, NMI
A comprehensive study\textsuperscript{33} examined aircraft LTO impacts on local and regional air quality from 325 airports in the United States. It was found that almost all adverse health impacts result from fine PM. Further, between 64 and 270 incidences of premature mortality were attributable to the PM emissions in the analyzed year. However, the contribution of LTO aircraft emissions to the total adverse health impacts in the US due to poor local air quality from anthropogenic emission sources is reported to be very likely less than 0.6%. Annual premature deaths in the US due to poor air quality are very likely greater than 25000.

While the scientific understanding of the environmental impact of aviation during the LTO is relatively robust, there is a need to better understand the cruise cycle, in which the bulk of fuel burn occurs. A recent study\textsuperscript{34} finds that health impacts from cruise emissions might be five times higher than those at the ground level. Their estimate attributes approximately 8000 premature mortalities to aircraft cruise emissions per year. More than one third of these deaths are incurred by India and China, while the combined share of fuel burn of these two countries is only 10\% of the global figure. These transboundary impacts are due to prevailing easterly winds at high altitude and a large population exposed to these risks. The results of this paper suggest considering cruise emissions in the design of policies that seek to mitigate the environmental impact of the aviation sector.

\textsuperscript{33} Ratliff, G. et al. (2009), Aircraft Impacts on Local and Regional Air Quality in the United States. Partnership for Air Transportation Noise and Emissions Reduction Project 15 Final Report.

3. Current Regulatory Framework

3.1. International Governance

The Kyoto Protocol from 1997 linked to the United Nations Framework Convention on Climate Change (UNFCCC) aims to stabilize greenhouse gases in the atmosphere and distinguishes in its legal bindings between developed and developing nations. While domestic aviation emissions are included into national emission inventories and reduction targets, article 2.2 of the Kyoto Protocol states that emission limitations from international aviation shall be pursued through the International Civil Aviation Organization (ICAO). The ICAO is a specialized United Nations agency, which was founded in 1944 at the Chicago Convention and currently has 190 contracting states. Its mission pursues to “set standards and recommended practices for the safe and orderly development of international civil aviation”, which includes strategic objectives that seek to enhance safety, security, environmental protection and sustainable development of air transport. The ICAO Assembly composed of representatives from every contracting State, holds triennial meetings and sets the policy for coming years. The ICAO council is elected by the Assembly for three years and is composed of 36 member States. The council then adopts standards and recommended practices.35

Within the ICAO council, the Committee on Aviation Environmental Protection (CAEP) was established in 1983 to work on technical issues concerning the environmental impact of international aviation. The delivered recommendations shall meet the criteria of 1) technical feasibility, 2) economic reasonableness, 3) environmental benefit and 4) consideration of the potential interdependencies (trade-offs) with other mitigations measures (ICAO 2010). In response to the recognition of a growing climate impact from aviation activities, a Group on International Aviation and Climate Change (GIACC) was formed in January 2008. It is composed of 15 senior government officials representative of all ICAO regions and is mandated to develop an ICAO Program of Action on International Aviation and Climate Change. Since its inception the GIACC has convened four times and presented proposals to the ICAO, which subsequently held a high level meeting on international aviation and climate in October 2009.36

35 ICAO Website: http://www.icao.int/icao/en/m_about.html
The non-governmental organization Transport & Environment\textsuperscript{37} looks at the ICAO’s history regarding actions and decisions taken on climate change since the Kyoto protocol. Instead of fulfilling its responsibilities to reduce greenhouse gas emissions, the multilateral organization has shown a “devastating record” and “attempted to close doors” on various binding policy measures, including market-based options, emission standards and operational measures.

As outlined in article 44 of the Chicago Convention, the ICAO requires a non-discriminatory treatment between all contracting states in the development of its policies. This is in marked contrast to the common but differentiated responsibility (CBRD) principle under the UNFCCC’s Kyoto protocol and is often quoted as one the main reasons for the deadlock in international negotiation process and the failure to agree on binding commitments.\textsuperscript{38}

\textsuperscript{37} Transport & Environment 2010, Grounded. How ICAO failed to tackle aviation and climate change and what should happen now. Brussels.

Another crucial obstacle in international policy-making is article 24 of the Chicago Convention\(^39\). It states:

"Aircraft on a flight to, from, or across the territory of another Contracting State shall be admitted temporarily free of duty, subject to the customs regulation of the State. Fuel, lubricating oil, spare parts, regular equipment and aircraft stores on board an aircraft of a Contracting State, on arrival in the territory of another Contracting State and retained on board on leaving the territory of that State shall be exempt from customs duty, inspection fees or similar national or local duties and charges.”

This is the reason why international aviation is exempted from fuel taxation as well as almost always from sales taxation on tickets, which poses a unique disadvantage for emission control over other forms of transportation.

**Existing Emission Norms for Aircraft Operations**

Internationally binding environmental standards for aircrafts are delineated in Annex 16 to the Convention on International Aviation. Annex 16 consists of Volume I and II, dealing with aircraft noise and aircraft engine emissions, respectively. In order to control local air quality in the vicinity of airports, in 1981 the ICAO adopted international emissions standards for HC (unburned hydrocarbons), CO (carbon monoxide), NO\(_x\) (oxides of nitrogen), and smoke from newly manufactured commercial jet engines. These standards are based on the LTO cycle of an aircraft below 915 m of altitude. The emission standard for NO\(_x\) has been made 50% more stringent relative to the adoption level in 1981 and will be tightened further by 15% for newly produced large engines effective on December 31, 2013\(^40\). A key outcome of the eight meeting of CAEP was the decision to begin working on a CO\(_2\) standard that can be adopted by 2013.

**3.2. Indian Regulations**

The Ministry of Civil Aviation is responsible for the formulation of national policies and programmes for development and regulation of civil aviation. The Directorate General of

\(^39\) ICAO Website: [http://www.icao.int/icaonet/dcs/7300.html](http://www.icao.int/icaonet/dcs/7300.html) (Last accessed 29/5/2011)

\(^40\) ICAO 2010, Environmental Report 2010.
Civil Aviation (DGCA) is an attached organization of the ministry and deals with all aspects
of regulation and enforcement for civil aviation in India. Regarding environmental issues, the
DGCA sees its responsibility in “keeping a check on aircraft noise and engine emissions in
accordance with ICAO Annex 16 and collaborating with the environmental authorities in this
matter, if required”.\textsuperscript{41} In 2009, the DGCA has set up an Aviation Environmental Unit that
seeks to address environmental issues from Indian aviation and provide solutions and
guidance regarding questions of fuel efficiency improvement, CO\textsubscript{2} reduction or noise
abatement. Moreover, it has proposed that other aviation stakeholders such as airport
authorities, airlines or air navigation service providers should create environmental units
within their organizations likewise. In its environmental circular from April 2011, the DGCA
mandated airlines to submit fuel consumption data on a monthly basis, which will serve to
build up a CO\textsubscript{2} emission inventory. It is to be noted that, information on the environment units
set up by different airlines and airports is not yet available in the public domain.

Another important regulatory institution in Indian aviation is the Airports Authority of India.
It is responsible for the management of 125 airports, including 11 international airports, 8
customs airports, 81 domestic airports and 27 civil enclaves at defense airfields. Besides
operations on the ground, the AAI also provides air navigation services over 2.8 million
square nautical miles of air space. Therefore, the AAI is able to influence a wide range of
aircraft activities and thus needs to be considered carefully for potential policy interventions.

\textbf{Taxes in India}

Figure 11 demonstrates the composition of the price for ATF in India. The Indian central
government levies an 8\% excise tax on the refinery transfer price of ATF. Along with this, a
local sales tax is added that varies among states between 4\% and 30\%, as is shown in table 3.
Besides these taxes, oil companies also charge a 20\% import duty and on average a 21\%
marketing margin on top of the ATF price. This is the reason why Indian ATF is reported to
be 60\% more expensive than international benchmarks.\textsuperscript{42}

\textsuperscript{41} Government of India 2010, Office of the Director General of Civil Aviation. Duties, Functions &
Responsibilities. New Delhi.
\textsuperscript{42} Front & Sullivan (2008). Aviation Turbine (Jet) Fuels Market in India. Internet source:
\url{http://www.frost.com/prod/servlet/market-insight-top.pag?docid=134828880} (last accessed: 9/5/2011);
Delhi. p.278.
For instance, the average international jet fuel price on April 29, 2011 according to the International Air Transport Association (IATA)\(^\text{43}\) was 337.5 cts/gal = 891.57 USD/Kl compared to 1247 USD/Kl in New Delhi for International ATF\(^\text{44}\). Fuel costs make up around between 40% and 50% of total operating expenses of Indian Airlines. In comparison, this cost factor accounted for 33% on average for the global airline industry in 2008 and 26% in 2009 and 2010, respectively, according to the IATA.\(^\text{45}\)

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**Table 3: Examples of Sales Tax Rates on ATF in 2010**

<table>
<thead>
<tr>
<th>State</th>
<th>Sales Tax on Aviation Turbine Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
<td>16% (recently increased from 4%)</td>
</tr>
<tr>
<td>Kerala</td>
<td>4% (reduced from 39%)</td>
</tr>
<tr>
<td>Maharashtra (except Mumbai, Pune)</td>
<td>4%</td>
</tr>
<tr>
<td>Delhi NCR</td>
<td>20%</td>
</tr>
<tr>
<td>Maharashtra (Mumbai and Pune only)</td>
<td>25%</td>
</tr>
<tr>
<td>West Bengal</td>
<td>25%</td>
</tr>
<tr>
<td>Karnataka</td>
<td>28%</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>29%</td>
</tr>
<tr>
<td>Gujarat</td>
<td>30%</td>
</tr>
</tbody>
</table>

Source: Centre for Asia Pacific Aviation (2010), Preparing for Long Term Growth of Indian Aviation, India

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\(^\text{44}\) [http://www.iocl.com/Products/ATFInternationalPrices.aspx](http://www.iocl.com/Products/ATFInternationalPrices.aspx)

In addition to the taxes on fuel, India also levies a 10% service tax on tickets for domestic and international air travel.\textsuperscript{46} Particularly in response to the international scope of the service tax, the IATA\textsuperscript{47} has strongly opposed this and urges the Indian Government to revoke her decision.

4. Emission Reduction Potential

Aircraft entering today’s fleet are around 80% more fuel efficient than they were in the 1960s. These efficiency levels have been achieved with step by step changes in aircraft design, engine design, fleet upgradation and operation management. Each ton of fuel saved in aircraft operations translates to an approximate reduction of 3.15 tons of CO₂ emissions.48

4.1. Technological Improvements

Improvement in performance is achieved by moving from a component-based design to a fully integrated design by including wing, tail, belly fairing, pylon, engine, high lift devices etc. into the solution. A 20% improvement in fuel efficiency is projected by 2015 and a 40 to 50% improvement by 2050 relative to the aircraft currently produced. Figure 11 shows that fuel efficiency is projected to improve to 3 litres per pax/100 km by 2025.49

![Figure 11: Air traffic fuel efficiency and today’s aircraft](Image)

Table 4: Annual Improvement

<table>
<thead>
<tr>
<th>Period</th>
<th>Seat-km</th>
<th>Ton-km</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960s</td>
<td>2.3%</td>
<td>3.6%</td>
</tr>
<tr>
<td>1970s</td>
<td>0.6%</td>
<td>-0.1%</td>
</tr>
<tr>
<td>1980s</td>
<td>3.5%</td>
<td>2.5%</td>
</tr>
<tr>
<td>1990s</td>
<td>0.7%</td>
<td>0.9%</td>
</tr>
<tr>
<td>post-2000</td>
<td>0.0%</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

However, a study50 by the International Council for Clean Transportation (ICCT) shows that while average aircraft efficiency has improved annually by 1.5% between 1960 and 2008, this improvement has not occurred continuously over time. In fact, efficiency in terms of seat-km and ton-km only increased significantly in two decades, as is illustrated in table 4. In the past two decades efficiency improvements have been much lower than the often cited 1.5% per annum.

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4.1.1. Engines

Aircraft engines play the most important role in determining an aircraft’s fuel efficiency. The efficiency of a jet engine can be characterized by two main factors. Firstly, the engine’s thermal efficiency describes the effectiveness with which the available chemical energy in the fuel is turned into mechanical energy. Secondly, the propulsive efficiency indicates how well the mechanical energy is turned into thrust. Higher values for both of these factors are desirable in the drive to reduce fuel-burn and CO$_2$ emissions.\textsuperscript{51}

There have been a number of significant advances in engine design that have led to huge improvements in efficiency. Engines have come a long way from piston engines through the turboprop engine of 1940s to the turbofans in 1960s. Though turbofans are cheaper and quieter, a modern turboprop can consume 25-40\% less fuel than an equivalent turbofan engine on short-haul routes. Advanced high-bypass turbofans, geared turbofans and open-rotor engines have received specific attention to improve engine technology.\textsuperscript{52}

Multiple engine upgrade programs have already reduced the fuel burn per unit of delivered thrust by up to 2\% fuel burn in the last decade. Scheduled maintenance activities also help to keep engines operating at peak efficiency levels. According to ICAO, the following developments are expected to provide a minimum of 15\% fuel savings.\textsuperscript{53}

- Higher operating pressure ratios (OPR) to improve combustion but it needs to be balanced with the potential risks of increased maintenance costs, and weight and/or drag due to engine complexity in an overall context of maximum reliability.
- Transmissive efficiency through new components and advanced engine architecture.
- Propulsive efficiency: e.g. advanced turbofan, advanced geared turbo-fans, open-rotors, hybrids, etc.

Unfortunately, the issue of balancing propulsive efficiency and weight is complicated by the requirement of higher bypass ratios in the engines which typically requires a larger fan, low-pressure turbine system and a larger nacelle for a given thrust rating. The open-rotor architecture provides a solution for this along with offering benefits for lower NO$_x$ emissions. However, the open-rotor configuration raises some challenges for the designer with respect to noise.\textsuperscript{54}

\textsuperscript{51} Sustainable Aviation 2010, \textit{Inter-dependencies between emissions of CO2, NOx & Noise from aviation}, UK
\textsuperscript{54} Sustainable Aviation 2010, \textit{Inter-dependencies between emissions of CO2, NOx & Noise from aviation}, UK
Inter-dependencies between noise, NO\textsubscript{x} and CO\textsubscript{2} emissions are complex. While lower weight and reduced drag are advantageous for fuel-burn, they have different impacts on NO\textsubscript{x} emissions and noise. Higher OPR and a higher turbine entry temperature drive greater thermal efficiency but with the current combustor technology, they enhance NO\textsubscript{x} formation processes due to higher rates of reaction in these conditions. The use of intercooling - in which air is cooled before entering the final compressor stages, gives slightly lower efficiency and slightly higher weight, leading to slightly increased CO\textsubscript{2} emissions but has a trade off with lower NO\textsubscript{x} emissions.\textsuperscript{55}

NO\textsubscript{x} emissions from aircrafts can be reduced by using advanced combustors which are under development. Examples of such devices are: RQL combustors which control NO\textsubscript{x} production through a series of changes to the air to fuel ratio as the combustion air progresses through the combustor; Staged-DLI combustors which control NO\textsubscript{x} by switching (staging) between pilot and main burner zones arranged in concentric circles.\textsuperscript{56}

Aviation kerosene is a multi component fuel with a carbon chain length of C8–C16 developed from lamp oil. 70\%- 85\% of the fuel is made up of paraffins, with normal straight chain, branched chain isoparaffins and cycloparaffins or naphthenes being present. The high hydrogen to carbon ratio for n- and iso-paraffins gives a high heat to weight ratio and a clean burn while the cycloparaffins reduce the hydrogen to carbon ratio producing an inverse effect on heat produced per unit weight. But, cycloparaffins’ advantage is in that they help reduce

\textsuperscript{55} Sustainable Aviation 2010, Inter-dependencies between emissions of CO2, NOx & Noise from aviation, Policy Discussion Paper, UK

the fuel freeze point a vital parameter for high altitude flight. The aromatics are present at less than 25% and also have lower heat content per unit mass compared to paraffins with the same carbon number. Jet fuel also contains trace amounts of sulphur, nitrogen and oxygen containing hydrocarbon compounds, which arise from the raw crude oil, known as hetero atoms. These are found in parts per million and have an impact on the fuel’s anti-oxidation properties and lubricity.  

Hence, Jet fuel combustion produces not only CO₂ and particulate matter, but also water vapour, SO₂ and NOₓ. These have both public health and climate impacts and need to be regulated. NOₓ in particular impacts ground-level air quality.

**Figure 13: Emissions from Jet fuel combustion**

The specifications for aviation kerosene have developed over the years. The sulphur in jet fuel is present as mercaptans, sulphides, disulphides, thiophenes and other sulphur containing compounds. The mean fuel sulphur concentration within the United Kingdom and the United States is significantly lower than the stipulated maximum value of 3000 ppm and is about 600-800 ppm. IOCL, the major provider of Jet fuel in India supplies jet fuel with a maximum sulfur content of 2500 ppm.

### 4.1.2 Aircraft Design

The amount of fuel that is used in the course of a flight is approximately proportional to the drag of the aircraft or aerodynamic force that opposes an aircraft’s motion through the air.

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58 Swiss international airlines
60 QinetiQ 2009, *Reduction of sulphur limits in aviation fuel standards (SULPHUR)* for European Aviation Safety Agency (EASA)
Weight and shape of an aircraft determine the drag induced. Aircrafts overcome this resistance using the force of thrust, provided by the engines. Aircraft designers constantly strive to improve the aerodynamics and reduce aircraft weight to achieve higher fuel efficiencies.

Use of advanced alloys and composite materials, and improved and new manufacturing processes has helped in drastic reductions in aircraft weights. Metallic structure based aircraft of the 1990’s have now evolved to aircrafts such as A380 which use about 25 % advanced lightweight composite materials as opposed to 12 % in the 90’s. Aircraft with as much as 70 % of advanced materials composition are expected to enter future fleets increasing the weight savings as much as 15 % from current levels.

These composite materials are mainly carbon- and glass-fibre reinforced plastic and have much better strength-to-weight ratio than metals sometimes by as much as 20%. They are also more malleable. Innovative manufacturing techniques using advanced welding technologies such as laser beam, electron beam and friction stir welding remove the need for traditional rivets, thereby reducing aerodynamic drag as well as decreasing aircraft weight. Some other interesting and promising improvements include new aircraft paints weighing 10-20 % lesser and more resistant to chipping and cracking. A saving of 136 Kg of paint was calculated for an airline that used a paint process which eliminated the typical need for a third coat of paint.

Friction drag is the area which currently promises to be one of the largest areas of potential improvement in aircraft aerodynamic efficiency over the next 10 to 20 years. The improvements will be achieved by reducing turbulent skin friction, minimizing wetted areas and optimizing exhaust devices.

Friction drag and weight reduction are two competing issues at most times. For instance, friction drag can be reduced by increasing the wind span but this increases the weight of the wing structure. But, improvement in the cross-sectional shapes of wings (airfoils) and introduction of wingtips has made it possible to find more favorable balances between the two. Adding winglets tilted upward at the tips, either to new aircraft or as retrofits to existing

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4.1.2. Alternative Fuels

Sustainable alternative fuels are considered a promising and significant option to mitigate the sector’s environmental impact and thus receive an increasing attention by the aviation industry. Alternative fuels are mainly derived from the production of biomass (e.g. Camelina, Algea, Jatropha and Halophytes), natural gas, coal or hydrogen. The ICAO held a Conference on Aviation and Alternative Fuels in 2009 and established a Global Framework for Aviation Efficiency.67

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Alternative Fuels, which facilitates the formation of numerous research initiatives and consortia around the world.68

The deployment of sustainable aviation fuel faces serious environmental, social, economic and technical challenges. The ICAO names safety as the most critical challenge for alternative aviation fuels. Obstacles of economic nature are the supply reliability and cost competitiveness. Environmental aspects pertaining to these challenges include, among others, a comparison of life cycle GHG emissions, land use change, ecosystem interaction, soil and water use. For instance, the ICAO reports that life cycle analysis of different alternative fuels show a significant variability; emissions can be between ten times lower or eight times higher compared to those from conventional jet fuel. Variability in life cycle analysis of GHG emissions is due to land use change, co-product usage and other assumptions about specific production details.69

Life cycle GHG emissions are only one consideration and the range of results demonstrates the difficulty to make comprehensive comparisons and assessments of the sustainability of alternative aviation fuels. Another issue often raised in relation to bio fuels is food security. A recent policy report70 with contributions from international institutions such as FAO, OECD, World Bank and others addresses risks associated with the price volatility of food and other agricultural commodities. Biofuel production is one factor for upward pressure on prices and it is recommended that G20 governments remove subsidies and mandatory use of biofuels. As a second best option it is suggested to increase scientific research efforts for second generation feedstocks and biofuels that are environmentally, socially and economically sustainable.

4.2 Operational

The most direct way for an airline to improve its fuel efficiency is to modernize its fleet with new aircraft incorporating the latest available technology. In the mid-1970s, fuel conservation was further enhanced with the development of flight management systems which automatically set the most efficient cruise speed and engine power settings based on fuel and

70 FAO and OECD, 2011, Price Volatility in Food and Agricultural Markets: Policy Responses
Other operational costs involved\textsuperscript{71}. Other improvements in operational efficiency include increasing load factors; eliminating non-essential weight; Continuous Descent Approach; limiting use of auxiliary power and reducing taxiing. It has been estimated that improvements in ATM could lead to increases in energy efficiency, estimated to be in the order of 6 - 12\%\textsuperscript{72}.

\subsection*{4.2.1. Airlines}

Recently, airlines have undertaken a range of operational, maintenance and planning procedures to ensure that their current technology aircraft are flying at their optimal levels of efficiency. These range from cutting the weight of crockery to washing the aircraft’s engine. An airline introduced a new beverage cart that was 9 Kg lighter than the previous model and it estimated a saving of $500,000 in annual fuel costs across the fleet.

In March 2009, a new lightweight (6 Kg) economy seat was launched which is at least 4 Kg lighter than the average economy seat. Other ways are replacing aluminium alloy seats with carbon-fibre seats, eliminating ovens to provide hot meals on selected flights, removing magazine racks and replacing hard cabin dividers with curtains. A successful airline initiative to save weight has been to match the quantity of drinking water with the number of passengers on board more closely, rather than completely filling the water tanks for each flight. It was able to cut annual fuel consumption by 0.09\% through this measure alone.\textsuperscript{73}

Routinely inspection of aircraft exterior surfaces during regular maintenance checks to identify and correct defects – including chipped paint, scratches and damaged seals – can also reduce the annual fuel consumption of an aircraft by 0.5\%.\textsuperscript{74}

In order to increase CO\textsubscript{2} efficiency, airlines can optimize various factors. ‘Atmosfair’, a German nonprofit organization for combating climate change has identified the measures having greatest effect on reducing CO\textsubscript{2} emissions (figure 15). They have also published atmosfair Airline Index\textsuperscript{75} which has ranked global airlines based on their climate efficiency when transporting payload (passengers and co-loaded freight) using 2009 data. Separate

\textsuperscript{71} Air Transport Action Group (ATAG) 2010, \textit{Beginner’s Guide to Aviation Efficiency} \url{www.enviro.aero}.

\textsuperscript{72} Yenneti K and Joshi G 2010, Chapter 18: Carbon Dioxide Emission Reduction Potential from Civil Aviation Sector -- A Case Study of Delhi–Mumbai Air Route in the \textit{India Infrastructure Report 2010}

\textsuperscript{73} Air Transport Action Group (ATAG) 2010, \textit{Beginner’s Guide to Aviation Efficiency} \url{www.enviro.aero}.

\textsuperscript{74} Air Transport Action Group (ATAG) 2010, \textit{Beginner’s Guide to Aviation Efficiency} \url{www.enviro.aero}.

\textsuperscript{75} atmosfair 2011, \textit{atmosfair Airline Index 2011}, Berlin \url{http://cdn.atmosfair.de/atmosfair_Airline_Index_2011_en.pdf}
rankings for short-medium-long haul flights reveal that none of the airlines can be categorized in the best two classes with efficiency points more than 79 (Class A and B). Low cost airlines have been excluded from the analysis due to the subsidies, demand elasticity and infrastructural constraints associated with their operations.

**Figure 15: Efficiency optimization: What has the greatest effect?**

![Efficiency Optimization Diagram]

Source: atmosfair 2011, *atmosfair Airline Index 2011*, Berlin

Indian airline operators are amongst the most efficient airlines as per the atmosfair Airline index, especially for the short haul (<800 Km) flights where Kingfisher Airlines and Jet Airways make it to class C at second and fourth position respectively. While Kingfisher has been overall categorized in class C, Jet falls to class D due to its poor performance in long haul (>3800 Km) flights. The publicly held Air India has been classified in the E class for all the three haul segments.  

76 High passenger occupancy and relatively younger fleets of the private airlines seem as reasonable explanation for their more efficient operations.

In India, the operators are being advised on improvement in fuel efficiency in their respective fleet. The operators have already started to reduce fuel consumption by adopting better operational procedures such as minimum usage of APU, reduced flap takeoff and landings, idle reverse on landing, proper flight planning system, adhering to proper maintenance of aircraft, weight reductions in the form of reducing the weight of cabin equipment, catering services, avoiding carrying extra fuel on board, etc.  


Fuel Tankering by Commercial Operators in India

Fuel tankering is the practice of carrying excess fuel for availability or cost concerns. It results in increased fuel burned of the order of 1 % of trip fuel for every ton of fuel tankered. This malpractice has gained popularity among Indian airline operators due to the varying tax rates on ATF in different Indian states. Operators fill the fuel tanks at fuel stations with lower priced ATF and carry this fuel for a series of flights. If a sufficient price difference exits between departure and arrival airports, the operator saves on total cost of fuel even after accounting for increased fuel burnt. 79

Estimates show that airlines tanker fuel on almost 33 % of the flights and that fuel tankering results in excess fuel burn of about 40 tons per day in India which is equivalent to additional 126 tons of CO₂ and 40 Kg of SO₂ emissions per day. This is also equivalent to a loss of US$ 40,000 per day. 80

4.2.2. Air Traffic Management

In Continuous descent operations (CDO) an aircraft descends towards the airport from its cruising height in a continuous approach with minimum thrust – rather than via the conventional series of stepped descents which require the pilot to increase engine thrust to maintain level flight. Hence, up to 40 % less fuel is consumed during approach phases if CDO is adopted. The noise footprints of CDOs are substantially smaller than the footprints of  

79 Dr. Kota Harinarayana, 2010, Green Aviation presented in February at New Delhi.
80 Dr. Kota Harinarayana, 2010, Green Aviation presented in February at New Delhi
conventional approach procedures and fuel consumption is about 25-40 % lower during the last 45km of the flight.\textsuperscript{81}

**Figure 17: Cycles of aircraft movement**

Aircraft movement is typically divided into two cycles, (1) Landing and take-off cycle -- LTO and (2) Climb, cruise and descent cycle -- CCD. If the fuel burned in each section is considered separately, proportions of fuel burned in LTO to CCD will vary between flights, with short-haul flights having a much larger contribution from LTO than a transatlantic flight.\textsuperscript{82} Estimates of Airbus A340 and Boeing 747 average emissions show that the percentage of fuel consumed for LTO operations drastically reduces as we move to long haul flights. Since LTO fuel consumption is fixed, it is safe to say that long haul flights are more efficient than short haul ones.

**Figure 18: Fuel consumption as a function of flight distance**

Emission modeling is generally performed on per passenger km basis. A plot of carbon dioxide emissions per seat per kilometer shows that for very short flights, carbon efficiency is


\textsuperscript{82} Dr Christian N. Jardine 2005, *Calculating the Environmental Impact of Aviation emissions*, Environmental Change Institute, Oxford University Centre for the Environment
low, as the fuel burn required for the landing and take-off cycle is the major component of emissions. For larger aircraft on medium and long-haul flights, the landing and take-off cycle is not so critical, and the climb, cruise and descent cycle forms the major part of the fuel burn. There is a slight decrease in flight efficiency with increased distance, due to the greater fuel load that must be carried for those distances.\textsuperscript{83}

**Figure 19: Carbon efficiency per seat as a function of distance traveled**

To minimize the impacts of non-\,\textsubscript{CO}\,2 emissions from aviation, one of the key strategies prevalent internationally involves ATM aimed at reducing inefficiencies in flight patterns and encouraging flight patterns that take into account prevailing atmospheric conditions.\textsuperscript{84} Next generation ATM measures like CDO, Controlled Time Arrival (CTA) and System wide information management system (SWIM) have also been proposed for Indian airlines.\textsuperscript{85}

### 4.2.3. Airports

At the back of an aircraft is a small generator called the auxiliary power unit, or APU. This unit provides power to the aircraft when the main engines are turned off, particularly for lighting, air conditioning and other systems when parked at the airport gate. Instead of continuing to use these fuel-powered units, many airports are installing electrical supplies directly to aircraft to reduce fuel use and carbon emissions. Now, APUs are being better

\textsuperscript{83} Dr Christian N. Jardine 2005, *Calculating the Environmental Impact of Aviation emissions*, Environmental Change Institute, Oxford University Centre for the Environment

\textsuperscript{84} Yenneti K and Joshi G 2010, Chapter 18: Carbon Dioxide Emission Reduction Potential from Civil Aviation Sector -- A Case Study of Delhi–Mumbai Air Route in the *India Infrastructure Report 2010*

\textsuperscript{85} Dr. Kota Harinarayana, 2010, *Green Aviation* presented in February at New Delhi
integrated within other aircraft systems – such as more electric architectures – to provide further improvements in system weight. Fuel cells are also being considered to replace separate power generation/ storage systems. These cells could reduce carbon emissions by over 6,000 tonnes per aircraft over its operational life.\(^{86}\)

In India, the new airports are being designed on Green Building Codes to reduce their carbon footprint. They are also encouraged to use solar panels, waste management plants, waste water treatment and rain water harvesting systems. The airports are also exploring the possibilities of switching over to Compressed Natural Gas (CNG) operated vehicles inside the airport in order to reduce the carbon emissions. Some are also planning to install aircraft noise monitoring systems. (Refer Annexure V) \(^{87}\)

The air navigation service providers (ANS) are also implementing Performance Based Navigation (PBN) procedures to optimize airspace utilization and enhance airport capacity by taking advantage of airborne capabilities and Global Navigation Satellite Systems (GNSS). For sustained effort in implementing PBN procedures at all airports and airspace in India, PBN Implementation Roadmap of India has been established with the objective to accrue quantifiable benefits to the stakeholders in terms of fuel savings, reduction in emissions, capacity enhancement and improved access to the airport. PBN RNAV-1 SIDs and STARs have been made operational at Mumbai, Delhi, Ahmedabad, Chennai and Hyderabad which has reduced the flight distance (Great Circle Distance) leading to reduction in annual fuel consumption and emissions.\(^{88}\)

### 4.3. Existing roadmaps

From now until 2020, the industry is planning a 1.5 % efficiency improvement per year by using a four-pillar strategy to further increase its fuel efficiency. The biggest impact is expected to come through replacement of older aircraft in the fleet with newer, more efficient ones with an estimated total cost of $1.3 trillion. The aviation sector has further agreed to cap its net emissions at the 2020 level even when it will be growing at a fast pace after 2020. The


\(^{87}\) ICAO, 2009, Measures Adopted by Civil Aviation Sector in India presented at High-Level Meeting on International Aviation and Climate Change, Montreal

\(^{88}\) ICAO, 2009, Measures Adopted by Civil Aviation Sector in India presented at High-Level Meeting on International Aviation and Climate Change, Montreal
industry also plans to half its net emissions based on 2005 levels by 2050 despite the growth in passenger numbers.

The high-level meeting on International Aviation and Climate Change, 2009 agreed on the following to reduce carbon emissions (CO₂) from the aviation sector⁸⁹:

a. a global goal of 2% annual improvement in fuel efficiency until the year 2050, and further exploration of the feasibility of more ambitious medium and long-term goals, including carbon-neutral growth and emissions reductions;

b. development of a global CO₂ Standard for aircraft and facilitation of further operational changes to reduce aviation emissions;

c. development of a framework for market-based measures in international aviation;

d. further elaboration on measures to assist developing States and to facilitate access to financial resources, technology transfer and capacity building; and

e. submission of States’ action plans, outlining their policies and actions, and annual reporting of data to ICAO on their aviation fuel consumption.

![Figure 20: CO₂ emission reduction measures over time](source: ICAO, 2010, Environmental Report 2010, Chapter 2)

To regulate NOₓ emissions from aircrafts, certification requirements for NOₓ emissions have been upgraded periodically and mid and long term targets for NOₓ reduction have been set by CAEP, ICAO. Reducing sulfur content of kerosene to reduce SOₓO emissions and sulfate particle formation has been found to be difficult. While technology exists to remove virtually all sulfur from fuel, its removal results in a reduction in lubricity.⁹⁰

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⁸⁹ ICAO, 2010, Environmental Report 2010, Chapter 2

Many research projects have been undertaken to improve the fuel efficiency of the aviation sector. Clean Sky Joint Technology Initiative (JTI), Single European Sky ATM Research (SESAR), US Federal Aviation Administration (FAA) CLEEN programme, NASA Environmentally Responsible Aviation Program, Atlantic Interoperability Initiative to Reduce Emissions (AIRE) are the most promising initiatives.

Along with technology and aircraft design, air space optimization is also a major area of improvement to reduce emissions by optimizing routes and operations. Three major international ATM initiatives have been identified—A Single Sky for Europe; an efficient Pearl River Delta in China; and a Next Generation Air Traffic System in the US.

For instance, today, the airspace over Europe is split into around 40 different flight control zones. This maze of flight paths is planned to be reduced under the single European sky framework. Air space in Europe will become more manageable and a lot more efficient. The plan will move in stages and in the coming years, the current 36 zones will be amalgamated into 15 larger zones called ‘functional airspace blocks’, or FABs. These will eventually also merge to become a single European sky. EU is also working towards reducing the zig-zag caused due to military zones which prohibit the operation of commercial flights in certain stretches of the European sky.\footnote{IATA 2007, \textit{State of the Air Transport Industry—64th Annual General Meeting, Montreal}}

In 2008, a multilateral partnership of air navigation service providers called the ASia Pacific Initiative to Reduce Emissions (ASPIRE) was established. Currently the partnership is composed of the air navigation service providers from Australia, New Zealand, USA, Japan and Singapore, although also airlines and other industry stakeholders are associated to specific initiatives. ASPIRE aims to exchange ideas and collaborate on environmentally-friendly operational procedures, standards and best practices.\footnote{Air Transport Action Group (ATAG) 2010, \textit{Beginner’s Guide to Aviation Efficiency} \url{www.enviro.aero}.}

At present, the Indian airspace consists of almost three million square meters and is divided into five flight information regions (FIRs): Mumbai, Kolkata, Delhi, Chennai, and Guwahati (a sub-FIR). Currently, 14 monopulse secondary surveillance radars (MSSRs) providing en route coverage, 8 Terminal Area Radars (TARs) and 11 Area Control Centers (ACCs). There are 12 neighboring FIRs that share common Indian FIRs: Pakistan, Oman, Yemen, Mogadishu, Seychelles, Mauritius, Male, Sri Lanka, Malaysia, Myanmar, Bangladesh, and Nepal. Vertical segmentation of air space into lower, middle, upper, and super-high sectors in

\footnote{\url{www.aspire-green.com}}
the airspace for efficient management and safe operations practiced in other countries have not been implemented in India yet\textsuperscript{94}. 

To improve air traffic management services in the Indian sky, Future Indian Air Navigation System (FIANS) Master Plan has been developed based on the forecasted growth in traffic. In order to achieve seamless use of airspace for worldwide operations, the Plan supports meeting the interoperability requirements and standards, as well as performance based operations. Major areas of improvement listed under this initiative are digital communication; satellite-based navigation supplemented by GPS Aided Geo Augmented Navigation (GAGAN); secondary surveillance radars (SSR), ATM Automation and consolidation of 11 Area Control Centers (ACCs) into four Centers initially and two Centers in the long term; and implementing integrated weather information system. Beyond GAGAN, the ISRO is implementing an Indian Navigation Regional Satellite System (INRSS), an independent, even satellite constellation built and operated by India which will maintain interoperability between other regional augmentations to GPS for global navigation.\textsuperscript{95}

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{94} India’s Aviation Industry: An Overview by The MITRE Corporation/CAASD, 2009
\item \textsuperscript{95} India’s Aviation Industry: An Overview by The MITRE Corporation/CAASD, 2009
\end{itemize}
\end{footnotesize}
5. Policy Options

5.1. Levies

One form of policy intervention is to make aviation subject to charges or taxes. The ICAO\textsuperscript{96} distinguishes between a charge and a tax, whereby the former serves to recover the costs of providing facilities and services for civil aviation. A tax on the other hand raises national or local government revenues that are not used specifically for aviation purposes. The Chicago Convention from 1944 and bilateral air service agreements prohibit the taxation of fuel for international flights. Nevertheless, there are some policy initiatives that seek to circumvent this legal framework and levy taxes on cross-border air transportation. Furthermore, a number of differently designed policy initiatives exist on domestic grounds in many countries.

A study examines three main possible types of taxation on aviation\textsuperscript{97}:

- An excise tax on aviation fuel
- An ad valorem ticket tax
- Departure and other trip charges

Table 5 presents a selection of countries with a wide range of domestic jet fuel taxes between 0.7\% and 96\% of the average fuel price in the respective year. Jet fuel on international aviation is generally zero-rated, meaning no tax is levied on international flights either as an excise duty or VAT on fuel used. International tickets are typically exempt from VAT. Some developing countries in the sample, notably from South America, also impose VAT on international flights. The last type of taxation comprises several airport charges as well as departure and arrival taxes. Ad valorem ticket taxes, mostly in the form of VAT, are charged on domestic flights in the majority of developed countries, although often at a rate lower than their standard tax rates. A study on indirect taxes concludes that optimal aviation taxation combines a fuel or emission tax together with a departure tax, albeit the introduction of only either of these two options will result in similar outcomes.\textsuperscript{98}

\begin{itemize}
  \item ICAO 2010, Environmental Report.
\end{itemize}
Table 5: Tax rates on domestic aviation fuel in selected countries and years

<table>
<thead>
<tr>
<th>Country</th>
<th>Aviation gasoline</th>
<th>Jet fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>USD per gallon</td>
<td>Per cent</td>
</tr>
<tr>
<td>Australia (2004)</td>
<td>0.09</td>
<td>8.0</td>
</tr>
<tr>
<td>Bolivia (2000)</td>
<td>0.21</td>
<td>9.3</td>
</tr>
<tr>
<td>Brazil (2002)</td>
<td>1.57</td>
<td>40.4</td>
</tr>
<tr>
<td>Canada (2004)</td>
<td>0.06</td>
<td>6.0</td>
</tr>
<tr>
<td>Costa Rica (2003)</td>
<td>0.96</td>
<td>38.7</td>
</tr>
<tr>
<td>Ecuador (2000)</td>
<td>0.36</td>
<td>15.8</td>
</tr>
<tr>
<td>Indonesia (2001)</td>
<td>0.02</td>
<td>7.7</td>
</tr>
<tr>
<td>Japan (2004)</td>
<td>1.10</td>
<td>96.0</td>
</tr>
<tr>
<td>Netherlands (2004)</td>
<td>0.92</td>
<td>81.0</td>
</tr>
<tr>
<td>Nicaragua (2003)</td>
<td>0.91</td>
<td>21.7</td>
</tr>
<tr>
<td>Norway (2004)</td>
<td>0.16</td>
<td>14.0</td>
</tr>
<tr>
<td>Paraguay (2000)</td>
<td>0.32</td>
<td>9.2</td>
</tr>
<tr>
<td>Peru (2003)</td>
<td>0.58</td>
<td>15.9</td>
</tr>
<tr>
<td>Philippines (2004)</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Taiwan (2000)</td>
<td>0.89</td>
<td>39.4</td>
</tr>
<tr>
<td>Uruguay (2004)</td>
<td>0.09</td>
<td>5.0</td>
</tr>
<tr>
<td>US (2004)</td>
<td>0.19</td>
<td>18.1</td>
</tr>
<tr>
<td>Venezuela (2001)</td>
<td>0.05</td>
<td>4.4</td>
</tr>
</tbody>
</table>

*Percentage of average fuel prices in the respective year (USD1 per gallon worldwide for 2000–03, USD1.50 per gallon for 2004).

*Also international flights.


The findings on airport and trip charges suggest that in most countries, international travel is taxed higher than domestic travel. An exemplary and controversial departure tax that falls into this category is the UK Air Passenger Duty which is a tax levied on airlines, which usually choose to pass on the cost to the passenger at the time of the ticket sale. The current rate of the duty depends on the distance between London and the capital of the destination country and is divided into a system of four geographic regions. Table 6 shows the different distance bands and rates that are currently in place.

A different study investigated the impact of a doubling of the air passenger duty in 2007 compared to 2001 on carbon dioxide emissions in UK. Higher tax rates surprisingly increased rather than decreased CO₂ emission, albeit to a small degree. This is due to the change in relative prices, making farther destinations more attractive than nearer ones. A crucial assumption in this simulation is that domestic and foreign holidays are not treated as substitutes. When this assumption is reversed, the air passenger duty may reduce emissions. The authors conclude that the air passenger duty is mostly effective as a revenue-raising

instrument and that a simple carbon tax could achieve better environmental results and yet collect the same revenues.

**Table 6: UK Air Passenger Duty bands and rates**

<table>
<thead>
<tr>
<th>Band, and approximate distance in miles from</th>
<th>In the lowest class of travel (Reduced rate)</th>
<th>In other than the lowest class of travel* (Standard rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band A (0 - 2000)</td>
<td>£11 2009-10</td>
<td>£22 2009-10</td>
</tr>
<tr>
<td>Band B (2001 – 4000)</td>
<td>£45 2009-10</td>
<td>£90 2009-10</td>
</tr>
<tr>
<td>Band C (4001 – 6000)</td>
<td>£50 2009-10</td>
<td>£100 2009-10</td>
</tr>
<tr>
<td>Band D (over 6000)</td>
<td>£55 2009-10</td>
<td>£110 2009-10</td>
</tr>
<tr>
<td></td>
<td>£60 2010-11</td>
<td>£120 2010-11</td>
</tr>
<tr>
<td></td>
<td>£75 2010-11</td>
<td>£150 2010-11</td>
</tr>
<tr>
<td></td>
<td>£85 2010-11</td>
<td>£170 2010-11</td>
</tr>
</tbody>
</table>

*(However if only one class of travel is available and that class provides for seating in excess of 40” then the standard (rather than the reduced) rate of APD applies.)*


The 2010 coalition agreement of the Conservative-Liberal UK government aimed to explore the option of changing the tax basis from per passenger duty to per plane duty. This would establish a clearer correlation to the environmental impact of planes and give the airlines stronger incentives to increase efficiency, e.g. by flying planes fully loaded. It would also include freight and transfer passengers into the scheme, which are currently exempted.\(^{100}\)

Recently the government announced that it will not pursue to change the tax system to per plane basis. This decision mainly stems from concerns about a possible contradiction of international rules laid out in the 1944 ICAO Chicago Convention.\(^{101}\)

It is clear that a tax such as the APD has the simple objective to lower demand for air travel and subsequently reduce carbon emissions by increasing air fares. The decrease of demand depends crucially on the price elasticity of demand for air travel. A further important factor in the analysis is that some passengers, who are discouraged from flying, will shift their travel to other transportation modes. A study\(^{102}\) for the US domestic aviation markets examines these effects after a tax resembling the UK APD is introduced. A conservative assumption about the tax raises air fares by 2% while the price elasticity of demand for all domestic air travel is set at -1.15. The estimations show a 2.3% reduction in domestic air travel, which results in a decrease of 2310 million kg CO\(_2\). By using a cross-elasticity of 0.041 for the air-automobile substitution effect, vehicle traffic is responsible for a 748 million additional CO\(_2\) emissions. This means that about one third of the reduction in aviation emissions is offset by an increase


in road emissions. For that reason, it is critical to consider the effects of modal substitution when designing environmental policies aimed at only one sector and should instead take a more holistic approach.

The CE Delft Institute has undertaken a comprehensive analysis of policy options to reduce NOx emissions from aviation. Out of a list of 15 policy options, six have been selected, further described and evaluated:

1. An LTO NOx charge.
2. An LTO NOx charge with a distance factor.
3. A cruise NOx charge.
4. Including aviation NOx allowances in the EU ETS.
5. Increased stringency of ICAO LTO NOx emission standards.
6. A precautionary emissions multiplier on CO2 allowances in the EU ETS.

A LTO NOx charge is currently in place at 24 airports in Europe and one airport the US\textsuperscript{103}. Furthermore, 124 airports across the world levy noise charges. The Indian airport tariff schedule comprises of the usual charges for route navigation & facility, landing, parking & housing, baggage, passenger and user development. There do not exist any charges for emissions or noise at Indian airports\textsuperscript{104}. A LTO emission charge is legally and technically feasible to implement, but has the lowest environmental effectiveness among the instruments. It can be regarded as an instrument to improve local air quality, although a correlation between LTO NOx and cruise emissions exists and thus a policy aimed at reducing LTO emissions will also positively affect cruise emissions.

The second as well as the third option are considered to have a much stronger environmental impact. However, both of these instruments aim to relate the level of the charge to the climate damage cost of NOx, for which there is not yet an agreed scientific estimate and thus needs to be further researched. Moreover, an accurate co-efficient of the correlation between LTO and cruise emissions has to be established. Another challenge for the design of a cruise NOx

\textsuperscript{103} For more information on the specific design of worldwide airport charges, see \url{http://www.boeing.com/commercial/noise/updates.html} (last accessed 6/5/2011)
\textsuperscript{104} \url{http://www.aai.aero/misc/Updated_Airport_Charges_as_on_11_01_2011.pdf}
charge is that cruise emissions cannot be monitored directly. Therefore, emissions have to be modeled and calculated, for which further scientific research is needed.

Besides the complex relationship between NO\textsubscript{x} LTO and cruise emissions, and interdependencies in engine design between NO\textsubscript{x} and CO\textsubscript{2}, the environmental impact of standards obviously depends also on the stringency and therefore on the outcomes of international negotiation processes. The authors acknowledge the potential of every instrument to reduce NO\textsubscript{x} emissions and demand to establish a scientifically robust value for a policy-relevant metric for aviation NO\textsubscript{x} climate impact, as well as a way to model NO\textsubscript{x} cruise emissions.

Additionally, other fiscal measures appear possible to incentivize supply (manufacturers) and demand (airlines) side of the aviation industry to shift from old to new and clean technology. These include tax breaks, depreciation incentives, lump sums or grants and subsidies. For instance, depreciation incentives could help to accelerate fleet turnover.\textsuperscript{105}

5.2. Emission Trading & Carbon Offsetting

Emission trading is a market based policy instrument that aims to achieve cost-efficient emission reduction. The regulatory institutions set a bindings emission limit and allocates tradable emission permits to market participants. At the end of a period companies have to surrender permits according to their emissions. A company will decide to buy or sell emission permits depending on the cost of emission abatement and the market price of permits. Figure 22 shows examples of emission trading schemes in different parts of the world. The most prominent scheme which is also relevant for aviation is the EU ETS.

The EU announced to include aviation activities in its emission trading scheme (ETS) by January 2012 in Directive 801/2008/EC\textsuperscript{106}. The scheme envisages to cover domestic as well as international commercial flights landing and departing from EU airports in order to avoid distortions of competition and increase environmental effectiveness. The cap for 2012 is set at 97% historic aviation emissions and 95% for 2013 until 2020. Altogether 4000 EU-based and foreign-based aircraft operators will have to surrender emission allowances.\textsuperscript{107}

\textsuperscript{105} World Economic Forum 2011, Policies and collaborative Partnership for Sustainable Aviation, Geneva.
This bold move by the EU stems from its disappointment about the ICAO’s record and inaction on aircraft emissions. Nonetheless, the EU seeks to agree on a global emission framework, take into account measures taken by third countries and link them to the EU ETS. The unilateral nature of the EU’s proposal has caused mounting opposition. On its 36th session the ICAO Assembly threatened to block the possibility for EU countries to include foreign carriers in their emission trading schemes, as any measures to contain emissions should be based only on mutual agreement. Besides, the American Air Transport Association (ATA) and three American airlines, supported by the IATA, have filed a lawsuit against the EU ETS, alleging that it would violate international law under the Chicago Convention. According to the IATA, more than 120 countries object the entry into the EU ETS.  

A possible way to reconcile the CBDR principle is the establishment of a ‘Green Climate Fund’ that was decided at the UNFCCC meeting at Cancun in 2010. Key conclusions of an EU council meeting in May 2011 were to facilitate the establishment of the Green Climate Fund and that carbon pricing has potential to generate revenues for climate-related investments in developing countries. Half of the auction revenues of the EU ETS are

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earmarked for projects in the EU and third countries that seek to tackle climate change. Moreover, the EU requested the ICAO again to develop a global policy framework “without delay”.

A theoretical analysis\textsuperscript{110} compares the impacts of the inclusion of Indian carriers in the EU ETS with the imposition of a hypothetical tax in the form of the UK APD in a period between 2012 and 2018. The results of the simulation show that both market-based policy schemes would achieve approximately the same environmental goals in terms of emission reductions. However, the economic efficiency of the EU ETS is much higher, since emission reduction would be realized mostly through technological and operational improvements, whereas a decreased demand would be the main driver in the tax regime.

A complementary mechanism to an emissions trading scheme would be a link to a carbon offsetting program. This allows the regulated entity (e.g. the airline) to obtain “certified emission reduction credits” by offsetting emissions in a different activity or location, independent of its normal operations. The UN Clean Development Mechanism is an example for an offsetting program. Besides linking it to systems with binding commitments, emission offsetting can also occur in the context of voluntary agreements. There are a variety of offsetting schemes, mostly in developed countries, that offer passengers to purchase certified offset credits for their flight emissions. One example for a voluntary scheme is the IATA Carbon Offset Program, which was initiated in 2009 and has attracted more than 30 airlines to sign up for this initiative. While it has to be noted that participation rates in these voluntary schemes is still low and thus the environmental effectiveness limited, emission offsets could also be used in conjunction with emission charges. Generated revenues from charges or emissions trading schemes can fund the purchase of offset projects\textsuperscript{111}.

\textsuperscript{110} 2011, An Analysis of impacts of the existing Market based schemes aiming GHG emission reduction on the Indian aviation sector (Flight Operators).
\textsuperscript{111} ICAO 2010, Environmental Report 2010.
6. Conclusions and Policy Recommendations for India

- There is significant potential to improve efficiency of operational practices in India. This pertains to air traffic management, airport congestion, route optimization etc. Furthermore, a fragmented airspace is inefficient and automated technologies and procedures, based on satellite data-links as also proposed under Future Indian Air Navigation System (FIANS) Master Plan implementation needs to be expedited.

- No real framework to address the environmental impact of aviation in India exists, except for the “Aviation Environmental Unit” (AEU) Initiative of the DGCA. The AEU in its limited capacity has proposed measures to control noise, create emission inventory and encourage fixed power usage at airports. The body needs to be strengthened to implement and enforce further measures.

- The ICAO has failed to meet its responsibility to establish a global framework for emissions reduction. India should push for a global aviation ETS framework or an international aviation tax along with a transfer of collected revenues to developing countries, which acknowledges the CBDR principle.

- A carbon tax/emission charge on cruise emissions of domestic flights with a proportionally higher rate on short-haul flights can encourage a modal shift to railways and buses. However, it needs to be examined whether travelers divert to automobile or bus/railway and what the overall environmental impact would be like.

- A harmonization of VAT on domestic fuel among different states can discourage fuel tankering. Further, an introduction of a permissible maximum fuel load on board can limit fuel tankering. However, it needs to be studied whether this is legally and technically feasible.

- Knowledge accumulation and information diffusion in India has to be fostered among aviation stakeholders through collaborations and partnerships, such as for instance the Asia and South Pacific Partnership to Reduction Emissions (ASPIRE).

- Integrated approach: supply side comprising technology and operational practices; additional aspects of business strategies and models, demand management, customer behaviour, air transport management, airport management, research management, and regional and industrial planning.
- There is a need to analyze and discuss the “Route Dispersion Guidelines” as many planes on these routes operate with a low load factor.

- End user awareness should be raised to contain the growing demand. Voluntary emission reduction schemes by offsetting mechanisms should be introduced by the airlines.
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Annexure

Annexure I

Milestones in History of the Indian aviation industry

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Happenings in Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1933</td>
<td>Aviation Department of Tata Sons Ltd established; Tata Airlines flew 160,000 miles and transported 155 passengers in the first year</td>
</tr>
<tr>
<td>1953</td>
<td>Air Corporations Act enacted; Nationalization of Air India and Indian Airlines</td>
</tr>
<tr>
<td>1991</td>
<td>Sahara Group launches Sahara Airlines for Air Taxi services</td>
</tr>
<tr>
<td>1993</td>
<td>Jet Airways launched; NEPC-Damania and East-West Airlines launch operations for Air Taxi services</td>
</tr>
<tr>
<td>1994</td>
<td>Air Corporations Act repealed, enabling private operators to provide air transport services; Jet, Sahara, East West, Damania given scheduled operator status</td>
</tr>
<tr>
<td>1996</td>
<td>East-West Airlines grounded</td>
</tr>
<tr>
<td>2000</td>
<td>Sahara Airlines re-branded as Air Sahara</td>
</tr>
<tr>
<td>Aug-03</td>
<td>Air Deccan launched as India’s first low cost airline, connecting secondary routes (i.e. non-trunk route destinations)</td>
</tr>
<tr>
<td>May-05</td>
<td>Kingfisher Airlines and SpiceJet were launched</td>
</tr>
<tr>
<td>Oct-05</td>
<td>GoAir is launched as a cheap-ticket air travel service</td>
</tr>
<tr>
<td>2006</td>
<td>Jet buys Air Sahara</td>
</tr>
</tbody>
</table>

Annexure II

Route Dispersal Guidelines

All routes in India have been divided into three categories as described below:

**CATEGORY-I**

Routes connecting directly

<table>
<thead>
<tr>
<th>MUMBAI-BANGALORE</th>
<th>CALCUTTA-DELHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>MUMBAI-CALCUTTA</td>
<td>CALCUTTA-BANGALORE</td>
</tr>
<tr>
<td>MUMBAI-DELHI</td>
<td>CALCUTTA-CHENNAI</td>
</tr>
<tr>
<td>MUMBAI-HYDERABAD</td>
<td>DELHI-BANGALORE</td>
</tr>
<tr>
<td>MUMBAI-MADRAS</td>
<td>DELHI-HYDERABAD</td>
</tr>
<tr>
<td>MUMBAI-TRIVANDRUM</td>
<td>DELHI-CHENNAI</td>
</tr>
</tbody>
</table>

**CATEGORY-II**

Routes connecting stations in North Eastern region, Jammu & Kashmir, Andaman & Nicobar and Lakshadweep.

**CATEGORY-III**

Routes other than those in Category-I and Category-II

Any one who operates schedule air transport service on one or more of the routes under Category-I, shall be required to provide such service in Categories-II & III as indicated below:

- The operator will deploy on routes in Category-II at least 10% of the capacity he deploys on routes in Category-I
- Of the capacity thus required to be deployed on Category-II routes, at least 10% would be deployed on service or segments thereof operated exclusively within the North-Eastern region, Jammu & Kashmir, Andaman & Nicobar and Lakshadweep.
- The operator will deploy on routes in Category-III, at least 50% of the capacity he deploys on routes in Category-I.

**Note 1:** A service operated on a Category-I route as a part of international air service will not be reckoned for the above purpose.

**Note 2:** Capacity deployed will be reckoned in Available Seat Kilometres (ASKM).

**Note 3:** On multiple sector routes like Delhi-Calcutta-Guwahati-Imphal, the capacity provided on Delhi-Calcutta sector will count towards Category-I that provided on Calcutta-Guwahati sector will count towards Category-II and the capacity on Guwahati-Imphal sector will count towards service exclusively within Category-II.
Note 4: In addition to the routes identified as Category IIA in the aforesaid Ministry of Civil Aviation Order, the operations on Cochin-Agatti-Cochin route shall also be counted within the classification of Category IIA routes.

Annexure III

Table: Indian Domestic fleet by model type

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model No.</th>
<th>In use fleet</th>
<th>Ordered fleet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airbus</td>
<td>A 320-200</td>
<td>110</td>
<td>318</td>
</tr>
<tr>
<td>Boeing</td>
<td>Bo 737-800</td>
<td>94</td>
<td>43</td>
</tr>
<tr>
<td>ATR</td>
<td>ATR 72-500</td>
<td>45</td>
<td>38</td>
</tr>
<tr>
<td>Airbus</td>
<td>A 330-200</td>
<td>24</td>
<td>20</td>
</tr>
<tr>
<td>Airbus</td>
<td>A 321-200</td>
<td>28</td>
<td>--</td>
</tr>
<tr>
<td>Airbus</td>
<td>A 319-100</td>
<td>27</td>
<td>--</td>
</tr>
<tr>
<td>Boeing</td>
<td>Bo 777-300ER</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>Bombardier</td>
<td>Bombardier Dash 8 Q400</td>
<td>--</td>
<td>15</td>
</tr>
<tr>
<td>Boeing</td>
<td>Bo 787-8</td>
<td>--</td>
<td>10</td>
</tr>
<tr>
<td>Boeing</td>
<td>Bo 737-700</td>
<td>9</td>
<td>--</td>
</tr>
<tr>
<td>Boeing</td>
<td>Bo 777-200LR</td>
<td>8</td>
<td>--</td>
</tr>
<tr>
<td>ATR</td>
<td>ATR 42</td>
<td>7</td>
<td>--</td>
</tr>
<tr>
<td>Boeing</td>
<td>Bo 737-900</td>
<td>7</td>
<td>--</td>
</tr>
<tr>
<td>Boeing</td>
<td>Bo 747-400</td>
<td>5</td>
<td>--</td>
</tr>
<tr>
<td>Airbus</td>
<td>A 350-800</td>
<td>--</td>
<td>5</td>
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<tr>
<td>Airbus</td>
<td>A 380-800</td>
<td>--</td>
<td>5</td>
</tr>
<tr>
<td>Airbus</td>
<td>A 330-300</td>
<td>--</td>
<td>5</td>
</tr>
<tr>
<td>Bombardier</td>
<td>CRJ 700</td>
<td>4</td>
<td>--</td>
</tr>
<tr>
<td>Airbus</td>
<td>A 310-300</td>
<td>4</td>
<td>--</td>
</tr>
<tr>
<td>ATR</td>
<td>ATR 42-500</td>
<td>2</td>
<td>--</td>
</tr>
<tr>
<td>Bombardier</td>
<td>Bombardier CRJ200</td>
<td>1</td>
<td>--</td>
</tr>
</tbody>
</table>
Annexure IV

Table: Default fuel use and emission factors for some aircraft types for LTO cycle (Kg/LTO)

<table>
<thead>
<tr>
<th>Aircraft type</th>
<th>CO₂</th>
<th>CH₄</th>
<th>N₂O</th>
<th>NO₂</th>
<th>CO</th>
<th>NMVOCs</th>
<th>SO₂</th>
<th>Fuel</th>
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<tbody>
<tr>
<td>A300</td>
<td>5470</td>
<td>1.0</td>
<td>0.2</td>
<td>27.21</td>
<td>34.4</td>
<td>9.3</td>
<td>1.7</td>
<td>1730</td>
</tr>
<tr>
<td>A310</td>
<td>4900</td>
<td>0.4</td>
<td>0.2</td>
<td>22.7</td>
<td>19.6</td>
<td>3.4</td>
<td>1.5</td>
<td>1550</td>
</tr>
<tr>
<td>A320</td>
<td>2560</td>
<td>0.04</td>
<td>0.1</td>
<td>11.0</td>
<td>5.3</td>
<td>0.4</td>
<td>0.8</td>
<td>810</td>
</tr>
<tr>
<td>BAe 146</td>
<td>2150</td>
<td>5.8</td>
<td>0.1</td>
<td>4.9</td>
<td>67.8</td>
<td>61.6</td>
<td>0.7</td>
<td>680</td>
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<tr>
<td>B707</td>
<td>5880</td>
<td>9.8</td>
<td>0.2</td>
<td>10.8</td>
<td>92.4</td>
<td>87.8</td>
<td>1.9</td>
<td>1880</td>
</tr>
<tr>
<td>B727</td>
<td>4455</td>
<td>0.3</td>
<td>0.1</td>
<td>12.6</td>
<td>9.1</td>
<td>3.0</td>
<td>1.4</td>
<td>1410</td>
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<tr>
<td>B727</td>
<td>3980</td>
<td>0.7</td>
<td>0.1</td>
<td>9.2</td>
<td>24.5</td>
<td>6.3</td>
<td>1.3</td>
<td>1260</td>
</tr>
<tr>
<td>B737-300</td>
<td>2905</td>
<td>0.2</td>
<td>0.1</td>
<td>8.0</td>
<td>6.2</td>
<td>2.0</td>
<td>0.9</td>
<td>920</td>
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<tr>
<td>B737</td>
<td>2750</td>
<td>0.5</td>
<td>0.1</td>
<td>6.7</td>
<td>16.0</td>
<td>4.0</td>
<td>0.9</td>
<td>870</td>
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<tr>
<td>B737-400</td>
<td>2625</td>
<td>0.08</td>
<td>0.1</td>
<td>8.2</td>
<td>12.2</td>
<td>0.6</td>
<td>0.8</td>
<td>830</td>
</tr>
<tr>
<td>B747-200</td>
<td>10680</td>
<td>3.6</td>
<td>0.3</td>
<td>53.2</td>
<td>91.0</td>
<td>32.0</td>
<td>3.4</td>
<td>3380</td>
</tr>
<tr>
<td>B747</td>
<td>10145</td>
<td>4.8</td>
<td>0.3</td>
<td>49.2</td>
<td>115</td>
<td>43.6</td>
<td>3.2</td>
<td>3220</td>
</tr>
<tr>
<td>B747-400</td>
<td>10710</td>
<td>1.2</td>
<td>0.3</td>
<td>56.5</td>
<td>45.0</td>
<td>10.8</td>
<td>3.4</td>
<td>3390</td>
</tr>
<tr>
<td>B757</td>
<td>4110</td>
<td>0.1</td>
<td>0.1</td>
<td>21.6</td>
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<td>1.3</td>
<td>1300</td>
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<tr>
<td>B757</td>
<td>5405</td>
<td>0.4</td>
<td>0.2</td>
<td>26.7</td>
<td>20.3</td>
<td>3.2</td>
<td>1.7</td>
<td>1710</td>
</tr>
<tr>
<td>Caravelle*</td>
<td>2655</td>
<td>0.5</td>
<td>0.1</td>
<td>3.2</td>
<td>16.3</td>
<td>4.1</td>
<td>0.8</td>
<td>840</td>
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<tr>
<td>DC8</td>
<td>5890</td>
<td>5.8</td>
<td>0.2</td>
<td>14.8</td>
<td>65.2</td>
<td>52.2</td>
<td>1.9</td>
<td>1860</td>
</tr>
<tr>
<td>DC9</td>
<td>2780</td>
<td>0.8</td>
<td>0.1</td>
<td>7.2</td>
<td>7.3</td>
<td>7.4</td>
<td>0.9</td>
<td>880</td>
</tr>
<tr>
<td>DC10</td>
<td>7460</td>
<td>2.1</td>
<td>0.2</td>
<td>41.0</td>
<td>59.3</td>
<td>19.2</td>
<td>2.4</td>
<td>2360</td>
</tr>
<tr>
<td>F28</td>
<td>2115</td>
<td>5.5</td>
<td>0.1</td>
<td>5.3</td>
<td>54.8</td>
<td>49.3</td>
<td>0.7</td>
<td>670</td>
</tr>
<tr>
<td>F100</td>
<td>2340</td>
<td>0.2</td>
<td>0.1</td>
<td>5.7</td>
<td>13.0</td>
<td>1.2</td>
<td>0.7</td>
<td>740</td>
</tr>
<tr>
<td>L1011*</td>
<td>8025</td>
<td>7.3</td>
<td>0.3</td>
<td>29.7</td>
<td>112</td>
<td>65.4</td>
<td>2.5</td>
<td>2540</td>
</tr>
<tr>
<td>SAAB 340</td>
<td>945</td>
<td>1.4(E)</td>
<td>0.03(E)</td>
<td>0.3(E)</td>
<td>22.1(E)</td>
<td>12.7(E)</td>
<td>0.3(E)</td>
<td>300 (E)</td>
</tr>
<tr>
<td>Tupolev 154</td>
<td>6920</td>
<td>8.3</td>
<td>0.2</td>
<td>14.0</td>
<td>116.81</td>
<td>75.9</td>
<td>2.2</td>
<td>2190</td>
</tr>
<tr>
<td>Concorde</td>
<td>20290</td>
<td>10.7</td>
<td>0.6</td>
<td>35.2</td>
<td>385</td>
<td>96</td>
<td>6.4</td>
<td>6420</td>
</tr>
<tr>
<td>G4Jet</td>
<td>2150</td>
<td>0.1</td>
<td>0.1</td>
<td>5.6</td>
<td>8.5</td>
<td>1.2</td>
<td>0.7</td>
<td>680</td>
</tr>
</tbody>
</table>

Annexure V

Environmental Initiatives at Major Indian Airports

Delhi Indira Gandhi International Airport managed by DIAL and GMR Group\textsuperscript{112}

Noise:

- \textbf{Ambient Noise monitoring} is being conducted regularly at different locations in and around the airport including the areas under the takeoff and landing funnels.
- Noise reduction initiatives in the premises.
- DIAL is an integral part of the \textbf{“working group on airport noise”} formed by DGCA, exploring various possibilities and developing feasible measures to reduce excessive noise in the vicinity of IGI airport.
- DIAL is also in the process of establishing an \textbf{‘aircraft noise monitoring systems’}(ANMS) in order to develop a database of aircraft noise.

Air quality:

- \textbf{DIAL monitors air quality} at five locations inside the airport and two outside on regular basis for Suspended Particulate Matter (SPM), Sulphur dioxide (SO2), Oxides of Nitrogen(NO\textsubscript{x}), Hydrocarbon Carbon (HC) and Carbon Monoxide (CO).
- Establishment of a \textbf{CNG filling station} inside the airport.
- Usage of \textbf{battery operated vehicles} for transferring passengers from one terminal to another.
- Use of \textbf{dust screens} and \textbf{water sprinklers} at construction area to prevent gusting dust.

Climate change:

- \textbf{Green House Gas inventory program} to establish the emission data for mobile and ground vehicle. It also facilitates employees to reduce their carbon foot print by \textbf{Carpool network initiative}.
- DIAL have initiated various activities on emission reduction which include \textbf{Aircraft emission}, Vehicle, \textbf{Auxiliary Power Unit (APU)} and \textbf{Ground Power Unit (GPU)}. To reduce the APU and GPU utilisation DIAL have installed \textbf{Fixed Ground Power Unit (FGPU)} facility in its New Terminal.

Bengaluru International Airport managed by BIAL and GVK industries limited\textsuperscript{113}

No specific initiatives have been taken.

\textsuperscript{112} Source: \url{http://www.newdelhiairport.in} accessed March, 2011
\textsuperscript{113} Source: \url{http://www.bengaluruairport.com/} accessed March, 2011
Mumbai Chattarpati Shivaji International Airport managed by MIAL, GVK Industries Limited (GVK) and Airports Company South Africa (ACSA)\textsuperscript{114}

The environmental policy of the airport states that it is engaged in regularly monitoring, measuring and reviewing MIAL’s environment management system and continually improve the environmental performance. But no specific information is available.

Hyderabad Rajiv Gandhi International Airport managed by GHIAL and GMR Group\textsuperscript{115}

Air:

- All Diesel generator sets chimney height is maintained about 100 feet.
- Battery driven ground supporting equipment (GSE) are introduced and being used.
- Pollution under check is being conducted for all airport owned vehicles and ground handlers vehicles on six monthly bases.
- **Ambient air quality is being monitored** for 10 locations at airport and neighbouring areas and the results are well within the Pollution Control Board norms

Noise:

- All aircrafts using single engine taxing procedure.
- All Diesel generators sets are provided with acoustic barriers.
- **Noise levels monitoring is being conducted** for 10 locations at airport and neighbouring areas and results are well within the Pollution Control Board norms.

Chennai International Airport managed by AAI\textsuperscript{116}

No information on environmental initiatives is available in the public domain.

\textsuperscript{114} Source: Environmental Policy, CSIA: http://www.csia.in/knowyourairport/policy/Environment_Policy.pdf
\textsuperscript{115} Website-- http://www.hyderabad.aero accessed March 2011
\textsuperscript{116} Website -- http://www.aai.aero/chennai/index.jsp accessed March 2011
Annexure V

The relevant articles of the Chicago Convention (ICAO 1944) related to policy-making concerning environmental issues in international and domestic aviation are listed below.

*Article 1:* “The contracting States recognize that every State has complete and exclusive sovereignty over the airspace above territory.”

*Article 11:* “Subject to the provisions of this Convention, the laws and regulations of a contracting State relating to the admission to or departure from its territory of aircraft engaged in national air navigation, or to the operation and navigation such aircraft while within its territory, shall be applied to the aircraft of all contracting States without distinction as to nationality, and shall be complied with by such aircraft upon entering or departing from or while within the territory of that State.”

*Article 15:* “No fees, dues or other charges shall be imposed by any Contracting State in respect solely of the right of transit over or entry into or exit from its territory of any aircraft of a Contracting State or persons or property thereon.”

*Article 24:* "Aircraft on a flight to, from, or across the territory of another Contracting State shall be admitted temporarily free of duty, subject to the customs regulation of the State. Fuel, lubricating oil, spare parts, regular equipment and aircraft stores on board an aircraft of a Contracting State, on arrival in the territory of another Contracting State and retained on board on leaving the territory of that State shall be exempt from customs duty, inspection fees or similar national or local duties and charges.”

*Article 44 (g):* “Avoid discrimination between contracting states;”

For further information on compatibility with international legal provisions regarding international aviation, please look into a comprehensive analysis from Pache (2008).117

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117 Pache 2008, On the compatibility with international legal provisions of including greenhouse gas emissions from international aviation in the EU emission allowance trading scheme as a result of the proposed changes to the EU emission allowance trading directive. Würzburg
Annexure VI

The controversial ETS

The EU announced to include domestic as well as international aviation activities in its emission trading scheme (ETS) by January 2012. Altogether 4000 EU-based and foreign-based aircraft operators will have to surrender emission allowances. The unilateral nature of the EU’s proposal has caused mounting opposition. The American Air Transport Association (ATA) and three American airlines, supported by the IATA, have filed a lawsuit against the EU ETS, alleging that it would violate international law under the Chicago Convention. According to the IATA, more than 120 countries object the entry into the EU ETS.

Indian authorities when contacted admitted under the conditions of anonymity that India is opposed to the EU-ETS. All three of the Indian airlines operating in international skies have been asked to refrain from submitting any fuel or emission data to the authorities in EU. Since, India is not legally bound by the Kyoto protocol to cut its CO2 emissions, these airlines cannot be forced to comply by EU-ETS. It was further hinted that ICAO should take a global approach and such unilateral trading arrangements need to be discouraged.

Taxed airlines sought respite

High prices of ATF have been the bane of the Indian Aviation sector. One of the key contributors towards the high prices of ATF in India has been the high local taxes. States impose varying rates of VAT on ATF and the rates are mostly on the higher side. Industry demands a ‘Declared goods’ status for ATF which would ensure that VAT would be levied on ATF at a uniform rate of 4% across all Indian states.

From the year 2006, service tax is also being levied on international travel via air, in all classes other than the economy class. Since such services of international air travel cannot be claimed as ‘export of services’ (owing to specific exclusions), this levy results in an unnecessary addition to the cost of travel. Removal of levy of service tax on this category or grant of export status is certainly an industry demand. India as a member state of the ICAO is also violating ICAO’s policy on taxation as evidenced in the Resolution Document 8632.

120 Meeting with related officials on 21/04/11
121 Sujit Ghosh 2010, Declared goods status for ATF will ensure VAT at a uniform rate across states published in Financial Express, New Delhi