DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

AN APPRAISAL OF SETTING ENVIRONMENTAL STRATEGY FOR AIRPORTS AND A CASE STUDY OF THEIR CONTRIBUTION TO GLOBAL WARMING FROM TURKEY

by
Gülsan ÖZDEMİR

April, 2013
İZMİR

AN APPRAISAL OF SETTING ENVIRONMENTAL STRATEGY FOR AIRPORTS AND A CASE STUDY OF THEIR CONTRIBUTION TO GLOBAL WARMING FROM TURKEY

A Thesis Submitted to the
Graduate School of Natural And Applied Sciences of Dokuz Eylül University
In Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Environmental Engineering, Environmental Technology Program

by
Gülsan ÖZDEMİR

April, 2013
İZMİR

Ph.D. THESIS EXAMINATION RESULT FORM

We have read the thesis entitled **"AN APPRAISAL OF SETTING ENVIRONMENTAL STRATEGY FOR AIRPORTS AND A CASE STUDY OF THEIR CONTRIBUTION TO GLOBAL WARMING FROM TURKEY"** completed by **GÜLSAN ÖZDEMİR** under supervision of **PROF.DR. AYŞE FİLİBELİ** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Doctor of Philosophy.

Prof.Dr.Ayşe FİLİBELİ

Supervisor

Prof.Dr. Nurdan BÜYÜKKAMACI

Thesis Committee Member

Assoc.Prof.Dr. Serhan TANYEL

Thesis Committee Member

Prof. Dr. Bilsen BELER BAYKAL

Examining Committee Member

Prof.Dr.Tolga ELBİR

Examining Committee Member

Prof.Dr. Ayşe OKUR
Director
Graduate School of Natural and Applied Sciences

ACKNOWLEGDEMENTS

I would like to express the deepest appreciation to my supervisor Prof.Dr.Ayşe FİLİBELİ for her help, guidance and encouragement during this thesis.

I would like to thank to my thesis committee members Prof. Dr. Nurdan BÜYÜKKAMACI and Assoc. Prof. Dr. Serhan TANYEL for their valuable comments and recommendations.

I would also thank to General Directorate of State Airport Authority Izmir Adnan Menderes Airport Management for their support related to air traffic data and general airport operational statistics.

Special thanks to my managers and colleagues for their friendships and support.

I would like to my husband and children who have always stood by me and dealt with all of my absence from many family occasions with a smile.

This thesis is dedicated to my family, especially to my father who had given me the opportunity of an education from the best institutions and support throughout my life.

AN APPRAISAL OF SETTING ENVIRONMENTAL STRATEGY FOR AIRPORTS AND A CASE STUDY OF THEIR CONTRIBUTION TO GLOBAL WARMING FROM TURKEY

ABSTRACT

Aviation is a rapidly growing sector as the world economy has grown. Transportation of passenger and freight is increasing continuously, making air travel the fastest growing sector amongst all transportation types. The global air transportation system has economic and social benefits, while simultaneously environmental impacts are created. Mitigation of environmental affect to the environment is becoming a major challenge in this century. In addition, progress on noise reduction is also an important environmental issue.

Carbon footprint of airports has been managed by Airport Council International (ACI) with the Airport Carbon Accreditation (ACA) program. The program assesses and recognizes the efforts of airports to manage and reduce their carbon emissions with four levels of certification: 'Mapping', 'Reduction', 'Optimization' & 'Neutrality'.

Carbon footprint has to be calculated, reported and independently verified in accordance with ISO14064 Green House Gas Accounting Standard. The definitions of emissions footprints used by Airport Carbon Accreditation follow the principles of the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI) “Greenhouse Gas Protocol” Corporate Accounting and Reporting Standard. The carbon footprint calculations were made by the Greenhouse Gas Protocol (GHG Protocol) worksheets.

In this thesis international aviation organizations and international aviation standards were evaluated as a review. International aviation standards were evaluated related to environmental issues of airports.

The basic principles of the carbon footprint calculation of Izmir Adnan Menderes Airport International Terminal were studied. Direct and indirect emission sources related data were collected and were entered to the GHG Protocol worksheets. The verification was made according to the ISO 14064 standard for level 1- mapping level.

The carbon footprint calculations were made for aircrafts B738, A319 and A320 with several assumptions. These types of aircrafts were the first 3 types that are obtained from the statistical air traffic data for 2007 to 2010.

Keywords: Aviation standards, sustainability, airport, carbon footprint

HAVALİMANLARI İÇİN ÇEVRESEL STRATEJİLERİN DEĞERLENDİRİLMESİ VE HAVALİMANLARININ GLOBAL ISINMAYA KATKILARI ÜZERİNE TÜRKİYE'DEN BİR ÖRNEK ÇALIŞMA

ÖZ

Dünya ekonomisi büyüdükçe havacılık da hızlı bir şekilde büyüyen bir sektör olmuştur. Yolcu ve yük taşımacılığının sürekli artması, hava yolu taşımacılığını tüm ulaştırma türleri içerisinde en hızlı büyüyen sektör haline getirmiştir. Global hava taşımacılığının ekonomik ve sosyal faydalarının olmasının yanı sıra bazı çevresel etkiler de oluşturmaktadır. Günümüzde çevresel etkilerin azaltılması ana çalışmalar olmuştur. Buna ek olarak, gürültü azaltma konusunda ilerleme de önemli bir çevre konusudur.

Karbon ayak izi Uluslararası Havalimanları Konseyinin yürüttüğü Havalimanı karbon akreditasyonu program ile yönetilmektedir. Program, 'Haritalandırma', 'Azaltma', 'Optimizasyon' ve Nötralizasyon sertifikasyonları ile havalimanlarında karbon emisyonlarının yönetilmesini ve azaltılmasını sağlar.

Karbon ayak izi hesabı ve raporunun, ISO 14064 Sera Gazı Hesaplama Standardı hükümleri çerçevesinde bağımsız olarak doğrulanması gerekmektedir. Havalimanı Karbon Akreditasyonu tarafından kullanılan emisyonların ayak izleri tanımları Sürdürülebilir Kalkınma için Dünya İş Konseyi (WBCSD) ve Dünya Kaynaklar Enstitüsü (WRI) "Sera Gazı Protokolü" Kurumsal Hesaplama ve Raporlama Standardı ilkeleri doğrultusunda belirlenmektedir. Karbon ayak izi hesaplamaları Sera Gazı Protokolü (GHG Protokolü) çalışma sayfaları ile yapılmıştır.

Bu tez çalışmasında uluslararası havacılık organizasyonları ve uluslararası havacılık standartları irdelenmiştir. Uluslararası havacılık standartları özellikle çevre konuları ile bağlantılı olarak ele alınmıştır.

İzmir Adnan Menderes Havalimanı Dış Hatlar Terminali için yapılan karbon ayak izi hesabının temel prensipleri üzerine çalışılmıştır. Doğrudan ve dolaylı emisyon kaynaklarının tanımı yapıldıktan sonra, ilgili veri toplanmış ve GHG Protokol çalışma sayfalarına veri girişi yapılmıştır. Verifikasyon, ISO 14064 standardına göre seviye 1 – haritalandırma seviyesi için yapılmıştır.

Karbon ayak izi hesaplamaları bazı varsayımlar ve kabuller ile B738, A319 ve A320 tipi uçaklar için de yapılmıştır. Bu uçak tipleri 2007-2010 yılları istatistiksel hava trafiği verilerine göre ilk 3 sırada bulunan uçak tipleri olarak belirlenmiştir.

Anahtar Sözcükler: Havacılık standartları, sürdürülebilirlik, havalimanı, karbon ayak izi.

CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE
INTRODUCTION

Aviation has experienced rapid expansion as the world economy has grown. Passenger and freight movements by air continue to increase, making air travel the fastest growing sector amongst all transportation modes. Additionally travelling by airlines is believed that it has been getting safer over the years and is the safest in the world beside the other transportation types.

Managing the global air transportation system to ensure continued economic and social benefits, while simultaneously mitigating environmental impacts, is becoming a major challenge. The system is large, complex, and multi-disciplinary and involves numerous stakeholders with different agendas. Therefore, sustainable development of the system depends crucially on the delivery to policymakers and stakeholders of robust results incorporating improved understanding of the processes and interactions between the key system elements that determine environmental, social and economic impacts. There is an urgent need to model the contributions of aviation at local and global levels in order to assess aviation policies to be pursued in the future that strike appropriate balances between these impacts (Reynolds et al., 2007). Because of international aviation standards, the airports in Turkey are related to some environmental issues. These are generally wastewater treatment, drinking water treatment and solid waste management. This is a distinct difference for environmental pollution prevention related to other sectors in Turkey.

Despite the processes to reduce the environmental effects of aviation, and despite the relatively small contribution that aviation currently effects the environment, environmental concerns are strong and growing. As a result of growth in air transportation, emissions of many pollutants from aviation activity are increasing against a background of reductions from many other sources. In addition, progress on noise reduction is also an important environmental issue. Estimates suggest that millions of people are adversely affected by these side effects of aviation. Because of these factors and the rising value placed on environmental quality, there are increasing constraints on the mobility, economic vitality and security especially in U.S.A. This means that environmental constraints may impose the fundamental limit on the growth of air transportation system in the 21st century (ICAO, 2007).

Noise at points on the ground of an airport from aircraft operations into and out of an airport depends on some factors. Main factors among these are the types of aero plane and their power plant, the power, flap and airspeed management procedures used on the aeroplanes, the distances from the points concerned to the various flight paths, local topography and weather that affects sound propagation. Airport operations generally include different types of aeroplanes, various flight procedures and a range of operational weights. Because of the large quantity of aeroplane-specific data and airport operational information that would be required to compute the noise of each individual operation, it is customary in airport noise studies to make certain simplifications, leading to estimates of noise index values which are averages over long periods of time - typically several months.

There are many noise-generating activities at an airport operation which are excluded from the procedures coordinated and determined by European Civil Aviation Conference (ECAC). These are taxiing, engine testing and use of auxiliary power-units. In practice, the effects of these activities can affect the noise contours in regions near the airport boundary (ECAC.CEAC Doc.29, 1997).

International Civil Aviation Organization (ICAO) is a special agency of United Nations that was created in 1944. Their purpose is to promote the safe and orderly development of international civil aviation all over the world. ICAO is working for standards and regulations necessary for aviation safety, security, efficiency and regularity, as well as for aviation environmental protection. The Organization has 191 Member States (http://icao.int/Pages/icao-in-brief.aspx).

In this study ICAO Annex 14 and 16 are summarized. Annex 14 is a standard with the subject of “Aerodrome Design and Operations” in which physical characteristics of an aerodrome is given Annex 16 is the standard of environmental protection which is detailed in two volumes; 1. Aircraft Noise and 2. Aircraft Engine Emissions (Appendix 1).

At a global level, the major environmental challenge is related to aviation's contribution to climate change, through fuel consumption and related emissions. In recent years everyone is familiar with the issue climate change. According to the United Nations Intergovernmental Panel on Climate Change (IPCC), air transport represents 3.5% of man's contribution to global warming from fossil fuel use (http://airport-int.com/article/air-transport-a-global-approach-to-sustainability.html).

Carbon footprint of airports is another important issue in terms of global warming. Carbon footprint of an airport is the calculation of CO_2 emission released during an airport operation. Airport Council International (ACI) is the owner of the "Airport Carbon Accreditation" program. This program enables airports to implement carbon management processes. It consists of four different scheme levels. The entry point to the scheme recognizes that an airport is quantifying its carbon footprint. The overall aim of the scheme is to manage carbon emissions by managing energy during the airport operation.

Carbon footprint of airports is the main subject of "Environmental Sustainability". Sustainability is a concept which consists of environmental, social and economic pillars. Sustainable development is especially relevant to the air transport industry, which is recognized as an essential link to the global economy. Air transport makes a valuable and unique contribution to the society and the efficient and affordable access it provides to markets helps to improve living standards and foster economic growth. In "environmental" terms, air transport has been able to reduce or contain its environmental impact by continually improving its fuel consumption, reducing noise and introducing new, more sustainable technologies (http://faa.gov/airports/environmental/sustainability).

The environmental effect of air transport is a subject for local and global levels. In the near receptors of airports, the main focus is on the potential health and environmental effects of noise and air pollution from emissions. Therefore airport growth and capacity increase is a major obstacle for the aviation industry.

In this research the purpose is to define the effect of aviation on environment locally and globally. In this point of view, firstly a review of the international aviation organizations that are managing and guiding the aviation industry was made. To determine the related effects of aviation, international standards of ICAO Annex 14 and Annex 16 (Volume 1/2) were evaluated. Additionally ECAC.CEAC Doc.29 is reviewed as an international aviation standard related with noise. The standards are also a guide to manage environmental issues. The environmental issues were evaluated for two different stages; construction and operation, according to international and national environmental management strategies for airports. In chapter five, sustainability studies at airports are reviewed. Beside the sustainability concept, carbon footprint at airports is evaluated as environmental sustainability study. The main aim of this study was to show the effect of a terminal operation, international terminal of Adnan Menderes Airport, in the perspective of carbon footprint. The sixth chapter is a statistical study about the air traffic at Izmir Adnan Menderes Airport to obtain a statistic of the aircraft types that are using the airport. According to this statistical air traffic data, the aircrafts of highest flight number are determined and used to calculate the carbon footprint of an assumed flight path.

CHAPTER TWO
INTERNATIONAL AVIATION ORGANIZATIONS

2.1. IATA (International Air Transport Association)

The International Air Transport Association (IATA) is the global trade organization of air transport industries. Over 60 years, IATA has developed the commercial standards that built a global industry. IATA's mission is to represent, lead and serve the airline industry**.** Its members comprise over 240 airlines - the world's leading passenger and cargo airlines among them - representing 94 percent of scheduled international air traffic.

IATA was founded in Havana, Cuba, in April 1945. It is the prime vehicle for inter-airline cooperation in promoting safe, reliable, secure and economical air services - for the benefit of the world's consumers. The international scheduled air transport industry is now more than 100 times larger than it was in 1945. Few industries can match the dynamism of that growth, which would have been much less spectacular without the standards, practices and procedure developed within IATA.

IATA seeks to improve understanding of the industry among decision makers and increase awareness of the benefits that aviation brings to national and global economies. It fights for the interests of airlines across the globe, challenging unreasonable rules and charges, holding regulators and governments to account, and striving for sensible regulation.

IATA's aim is to help airlines help themselves by simplifying processes and increasing passenger convenience while reducing costs and improving efficiency. The groundbreaking "Simplifying the Business" initiative is crucial in this area. Moreover, safety is IATA's number one priority, and IATA's goal is to continually improve safety standards, notably through "IATA's Operational Safety Audit (IOSA)". Another main concern is to minimize the impact of air transport on "environment".

The environment is one of IATA's top priorities. Airlines are working constantly to limit their "climate change impact", "emissions" and "noise". IATA is committed to helping airlines about these environmental issues. IATA's vision is to become carbon free in the future. Complete solutions are not available today, but building blocks, such as alternative fuels, already exist. Beyond efforts on aircraft/engine technologies, the development of alternative jet fuels must be accelerated. There are however a number of major technological challenges that must be met, including energy density, thermal stability, use at very low or high temperatures, lubricating effect with materials used, and the availability of mass production facilities worldwide. If biomass were used as feedstock, the CO_2 from fuel combustion would be virtually equal to the atmospheric CO_2 absorbed when growing the feedstock. In the case of so-called "first generation" biofuels (from soy-beans, palm oil, corn etc.) valid concerns exist about land-use and competition with food crops. Second generation biofuels, while more complex and costly to produce, use non-food crops such as straw or waste lumber (wood chips), and require less land.

Of particular interest is the cultivation of oil-rich, CO_2-absorbing algae, which can be grown in large ponds and eventually in the sea. This technology may be available within 5 to 10 years. Another alternative is the use of fuel cells, which are emission-free and quieter than hydrocarbon fuel-powered engines. They save fuel and are cleaner for the environment. While it appears unlikely that fuel cells will provide primary power for future commercial passenger airplanes, they may be applied to secondary power systems, such as auxiliary power units (APUs). IATA has set a target for 10% of jet fuel to be obtained from synthetic or biofuel sources within 10 years. It has established a task force of experts, including airlines, manufacturers, the military and fuel suppliers, to consider the feasibility and environmental benefits of alternative fuels and evaluate progress towards the IATA goal.

Airlines have improved fuel efficiency and CO_2 by 20% over the past 10 years. According to IATA's data aviation is responsible for:

- 2% of global carbon dioxide (CO_2) emissions

− 12% of CO_2 emissions from all transport sources, compared to 74% from road transport

− 3 % of the total man-made contribution to climate change

By 2020, airlines are aiming for at least an additional 25% improvement in fuel efficiency and CO_2 emissions, through technology and operational enhancements.

IATA's night time operational restrictions are increasing, especially in Europe to prevent aircraft noise effect. At some airports, night flights are completely banned. These restrictions can have a serious impact on the economy, next-day delivery services, home-based charters, freight services and intercontinental flights. They can also increase daytime congestion. But today's aircraft are 50% quieter than 10 years ago.

IATA has 6 Industry Committees which are;

− Cargo Committee
− Environment Committee
− Financial Committee
− Industry Affairs Committee
− Legal Committee
− Operations Committee

The Environment Committee (ENCOM) is one of six IATA Industry Committees. ENCOM replaced the former Environment Task Force (ENTAF) on 1 June 2005. The purpose of ENCOM is to advise the Board of Governors, the Director General and other relevant IATA bodies on environmental matters, and act as the focal point in IATA on environmental issues. ENCOM is responsible for:

− monitoring, assessing and responding to environmental developments, policies and regulations of concern to IATA Member Airlines,

− developing and recommending common industry positions on environmental issues,

– advising and implementing strategies to promote IATA positions, amongst regulatory bodies and stakeholders.

Membership is made up of representatives of IATA Member Airlines, who are appointed by IATA's Director General, with the approval of the Board of Governors (http://iata.org/pages/default.aspx).

2.2. ICAO (International Civil Aviation Association)

ICAO is a specialized agency of the United Nations (UN) created in 1944, with the signing of the Convention on International Civil Aviation, to promote the safe and orderly development of global air transport. ICAO has been in the forefront of aviation environmental issues since the late 1960's. The Organization's work on the environment focuses primarily on those problems that benefit most from a common and coordinated approach on a worldwide basis, namely aircraft noise and engine emissions. Standards and Recommended Practices (SARPs) for the certification of aircraft noise and aircraft engine emissions are covered by Annex 16 of the Convention. ICAO has a membership of 191 Contracting States and works closely with other UN bodies and international organizations with an interest in aviation. ICAO has established three environmental goals:

- to limit or reduce the number of people affected by significant aircraft noise;
- to limit or reduce the adverse impact of aviation emissions on local air quality;
- to limit or reduce the impact of aviation greenhouse gas emissions on the global climate change (http://icao.int/environmental-protection/Pages/default.aspx).

ICAO's Committee on Aviation Environmental Protection (CAEP) is a technical committee of the ICAO Council and undertakes most of the Organization's work in this area. It is the international forum of expertise for the study and development of proposals to minimize the impact of aviation on the environment. Every proposal in CAEP is analyzed according to four criteria: technical feasibility; environmental benefit; economic reasonableness and in terms of the interrelationship between measures. The ICAO Council reviews and adopts the CAEP recommendations. It then reports to the ICAO Assembly, the highest body of the Organization, where the main policies on aviation environmental protection are defined and translated into Assembly Resolutions. The Organization also produces studies, reports, manuals and circulars on the subject of aviation and environment (Environmental Report, 2007).

Annexes of International Civil Aviation Standards are given in Table 2.1. They consist of 18 parts from which the 16th is the standard of environmental protection for civil aviation.

Table 2.1 Annexes of International Civil Aviation (ICAO, 2001)

Annex 1	Personnel licensing	Annex 10	Aeronautical telecommunications
Annex 2	Rules of the air	Annex 11	Air traffic service
Annex 3	Meteorological service for international air navigation	Annex 12	Search and rescue
Annex 4	Aeronautical charts	Annex 13	Aircraft accident and incident investigation
Annex 5	Units of measurements to be used in air and ground operations	Annex 14	Aerodromes
Annex 6	Operation of aircraft	Annex 15	Aeronautical information services
Annex 7	Aircraft nationality and registration marks	Annex 16	Environmental protection
Annex 8	Airworthiness of aircraft	Annex 17	Security: Safeguarding international civil aviation against acts of unlawful Interference
Annex 9	Facilitation	Annex 18	The safe transport of dangerous goods by air

ICAO like IATA has researches on alternative jet fuels. Jet fuels that are currently used by both civil and military aviation are a blend of complex hydrocarbons, and the specific composition varies within broad performance specification limits. However, typically they comprise 60 percent paraffin's, 20 percent naphthenic, and 20 percent aromatics. Also present may be sulphur; usually at less than 500 ppm. The naphthenes and aromatics have a higher carbon to hydrogen ratio than the paraffins, which gives them greater volumetric efficiency, but they include compounds which are more likely to result in the release of particulate matter in the engine exhaust – which is becoming an area of increasing environmental concern. Figure 2.1 shows the typical composition of aviation jet fuel (Environmental Report, 2007).

Alternative jet fuel studies would be of great interest to the aviation industry. Any fuel which could be used by aircraft which would produce lower emissions, such as particulate matter and carbon dioxide, would be a great subject. Recent studies show a significant advantage for biomass-derived fuels. There is clearly a need for more studies of this type before a commitment is made to any alternative fuel for aviation. Figure 2.1 offers some insight into the relative CO_2 emissions for various alternative fuels. Standard Jet Fuel is considered the baseline. Clearly the Bio Jet Fuel is worth investigating further (Dagget et al., 2007).

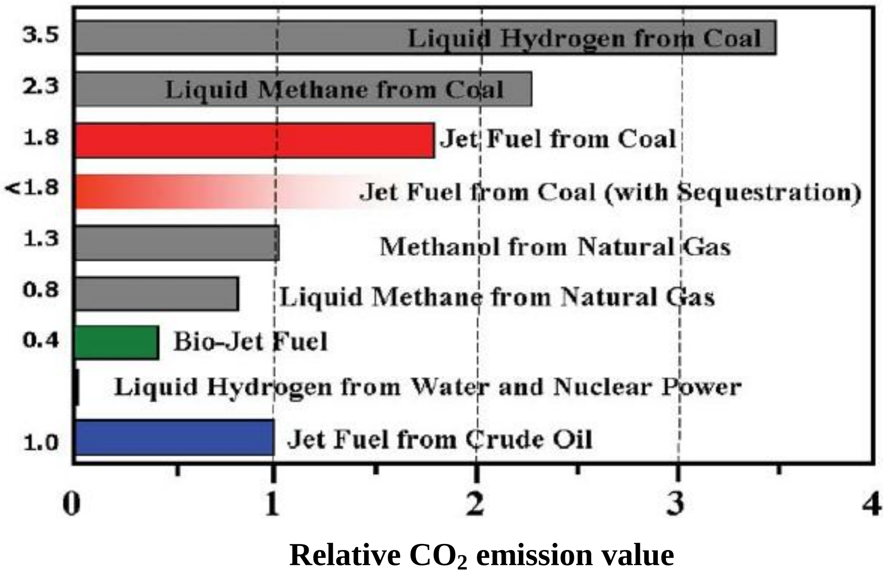

Figure 2.1 Relative CO_2 emissions from various fuels compared with Jet Fuel

2.3 European Civil Aviation Conference (ECAC)

ECAC is founded in 1955 as an intergovernmental organization. Their objective is to promote the continued development of a safe, efficient and sustainable European air transport system. With this purpose, ECAC seeks to:

− harmonize civil aviation policies and practices amongst its Member States

− promote understanding on policy matters between its Member States and other parts of the world.

Its long-established expertise in aviation matters, its membership across Europe, its close liaison with the International Civil Aviation Organization (ICAO) and the Council of Europe, its active co-operation with the institutions of the European Union, its special relationship with EUROCONTROL and the Joint Aviation Authorities (JAA), and its working relations with a wide circle of organizations representing all parts of the air transport industry, including consumer interests, allow ECAC to be a forum for discussion of every major civil aviation topic.

ECAC actively seeks and promotes arrangements, understandings and contacts with other regional organizations and States on a range of civil aviation issues of common interest (http://ecac-ceac.org/index.php/about_ecac/mission).

ECAC has established environment as one of its key priorities and continues to work on relevant issues through its “Group of Experts on the Abatement of Nuisances caused by Air Transport (ANCAT)”, which comprises representatives from Member States, aircraft operators, manufacturers, airports, EUROCONTROL and non-governmental organizations. ANCAT provides advice and recommendations to Directors General on environmental matters and also seeks to co-ordinate the development of European positions on relevant issues in preparation for discussions in the ICAO Committee on Aviation and Environmental Protection (CAEP).

The ANCAT has presented proposals on a series of indicators to demonstrate the environmental impact of aviation. The Group has recommended a primary set of ‘statutory’ indicators relating to fuel burn and global emissions, local emissions and noise. These are considered to take account of national and EU legislation on such issues as greenhouse gas emissions, pollutant ceilings, local air quality, and health and noise impacts (http://ecac-ceac.org/index.php/activities/environment).

2.4 EUROCONTROL (European Organization for the Safety of Air Navigation)

EUROCONTROL is created in 1963 by six founding members. This civil and military intergovernmental organization now counts 39 Member States from across Europe. It is based in Belgium with specialized offices in six other European countries. Their objective is the development of a uniform pan-European Air Traffic Management (ATM) system, perfectly embodied in the concept of a Single European Sky.

EUROCONTROL’s action is driven by five strategic priorities: safety, capacity, efficiency, environment and security. These priorities are a response to the tremendous changes which the European air traffic management system is undergoing:

- An increasing demand for air navigation services;
- Continued downward pressure on costs across the aviation industry;
- The implementation of the Single European Sky with its conceptual,

operational and regulatory impact.
(http://eurocontrol.int/content/about-us)

Society expects sustainable air transport with minimal impact on the environment. Air traffic management professionals reduce this impact by designing fuel-efficient routes, better distributing traffic flows within the available airspace, and optimizing the calculation of departure times. Environmental measures in air traffic management have already reduced CO_2 emissions by 2 million tons per year (equivalent to 1% of the total aviation’s emissions in Europe). This is the result of the first steps taken by EUROCONTROL:

− More direct flights. Experts have estimated that as many as 4.7 million tons of CO_2 are released unnecessarily into the atmosphere each year because of extra mileage.

− Making it possible for more airplanes to fly at an altitude where jet engine performance is optimal. This improved vertical distribution of air traffic reduces CO_2 emissions by almost 1 million tons a year.

− Trials have proven that adopting a steady trajectory during descent before landing greatly reduces aircraft emissions, fuel consumption, and noise impact. This has proven more efficient than a level-by-level descent.

− Keeping airplanes on the ground with their engines switched off until a departure slot becomes available. This initiative has helped reduce CO_2 emissions by 1 million tons in 2006.

− More flexibility of civil and military users in their use of airspace through strengthened coordination.
(http://eurocontrol.int/corporate/public/standard_page/biz_environment.html).

Management of ATM operations is seen as one of the means by which aviation's climate change and airport-related impacts could be reduced in the future. More efficient flight profiles, a fully optimized route network and more advanced noise abatement arrival and departure procedures should help to reduce noise, fuel burn, greenhouse gas emissions and flight times.
(http://eurocontrol.int/environment/public/subsite_homepage/homepage.html).

2.5 International Air Carrier Association (IACA)

IACA is the recognized voice of leisure carriers. IACA actively cooperates with international institutions, national authorities and airport authorities in order to ensure that the specific needs of leisure airlines are taken into consideration. The activities of IACA are managed by the Director General. IACA has four standing committees which bring together experts in aeropolitical issues, flight operations, ground operations and technical issues. Working groups are also convened to provide expertise on specific issues such as flight time limitations. The standing committees and working groups provide a platform to exchange information, transfer know-how and develop joint initiatives. Their mission is:

- To promote the common interests of its member airlines and development of air transport and tourism
- To cooperate with all stakeholders in aviation in the promotion of a safe and efficient air transport system to benefit the consumer
- To facilitate communication and cooperation amongst member airlines and between such members and the international aviation community
- To represent IACA members' interests in consultation with international authorities and organizations involved in air transport, such as institutions of the EU, the European Civil Aviation Conference (ECAC)**,** the International Civil Aviation Organization (ICAO)**,** the Joint Aviation Authorities (JAA) and EUROCONTROL (http://iaca.be/).

2.6 EADS (European Aeronautic Defence And Space Company)

The European Aeronautic Defence and Space Company EADS is a large European aerospace corporation of Germany, France, and Spain. The company develops and markets civil and military aircraft, as well as missiles, space rockets, satellites, and related systems. The company is headquartered in the Netherlands. (http://en.wikipedia.org/wiki/EADS).

2.7 Joint Aviation Authority (JAA)

The Joint Aviation Authorities (JAA) is an associated body of the European Civil Aviation Conference (ECAC) representing the civil aviation regulatory authorities of a number of European States who have agreed to co-operate in developing and implementing common safety regulatory standards and procedures. This co-operation is intended to provide high and consistent standards of safety and a "level playing field" for competition in Europe. Much emphasis is also placed on harmonizing the JAA regulations with those of the USA (http://jaa.nl).

2.8 SITA

SITA is the world's leading service provider of Information Technologies (IT) business solutions and communication services to the air transport industry. With over 55 years' experience:

− SITA manages complex communication solutions for its air transport, government and GDS customers over the world's most extensive communication network, complemented by consultancy in the design, deployment and integration of communication services.

− They provide market-leading common-use services to airports and air-to-ground communications to airlines.

− They deliver a comprehensive portfolio of e-commerce solutions for airlines and are pioneering new technologies in areas such as in-flight passenger communications and transportation security.

− Motivated by industry concern for lower costs, asset optimization and an improved passenger experience, we aim to simplify travel and transportation removing complexity and improving our customers' operational performance.

− SITA has two main subsidiaries: OnAir, which is leading the race to bring in-flight mobile telephony to the market, and CHAMP Cargosystems, the world's only IT company solely dedicated to air cargo. SITA also operates two joint ventures providing services to the air transport community: Aviareto for aircraft asset management and CertiPath for secure electronic identity management (http://sita.aero).

2.9 Federal Aviation Administration (FAA)

The Federal Aviation Administration (FAA) is an agency of the United States Department of Transportation with authority to regulate and oversee all aspects of civil aviation in the U.S. The Federal Aviation Act of 1958 created the group under the name "Federal Aviation Agency", and adopted its current name in 1967 when it became a part of the United States Department of Transportation. The Federal Aviation Administration's major roles include:

− Regulating U.S. commercial space transportation

− Encouraging and developing civil aeronautics, including new aviation technology

− Regulating civil aviation to promote safety

− Developing and operating a system of air traffic control and navigation for both civil and military aircraft

− Researching and developing the National Airspace System and civil aeronautics

− Developing and carrying out programs to control aircraft noise and other environmental effects of civil aviation (http://en.wikipedia.org/wiki/Federal_Aviation_ Administration).

FAA works on the same environmental issues like other aviation organizations. These are air quality, climate change, noise and differently wildlife (http://faa.gov/airports_airtraffic/environmental_issues/). Wildlife is an important issue in aviation because of birds. Bird at airports causes a big risk for aircrafts. Therefore there is always a need of wildlife mitigation.

2.10 European Aviation Safety Agency (EASA)

The European Aviation Safety Agency is the centerpiece of the European Union's strategy for aviation safety. Their mission is to promote the highest common standards of safety and environmental protection in civil aviation. While national authorities continue to carry out the majority of operational tasks - such as certification of individual aircraft or licensing of pilots - the Agency develops common safety and environmental rules at the European level. It monitors the implementation of standards through inspections in the Member States and provides the necessary technical expertise, training and research. The main tasks of the Agency currently include:

− Rulemaking: drafting safety legislation and providing technical advice to the European Commission and to the Member States;

- Inspections, training and standardization programs to ensure uniform implementation of European aviation safety legislation in all Member States;
- Safety and environmental type-certification of aircraft, engines and parts;
- Approval and oversight of aircraft design organizations world-wide as and of production and maintenance organizations outside the EU;
- Data collection, analysis and research to improve aviation safety.
- Manage the European Community SAFA program on behalf of the European Commission.

The two main environmental issues for EASA are aircraft noise and emissions. 'Emissions' in refers to gaseous emission such as CO_2 (carbon dioxide) and H_20 (steam/water/ice) which are the primary products of combustion of fuel, and more specifically the undesired side products of combustion, i.e. NO and NO_2 (nitrous oxides, commonly referred to as NO_X), CO (carbon monoxide), smoke (pure Carbon, soot) and unburned hydrocarbons (unburned fuel). EASA has the focus on regulations which aim to reduce the environmental impact of aviation at source**,** i.e. at the aircraft level in terms of products, maintenance and design. The environmental protection department of EASA has three main task areas which are**:**

- to develop and maintain the environmental essential requirements, implementing rules, certification specifications and guidance material,
- to establish international cooperation with respect to environmental certification, and
- to give technical support to the European Commission.

The Department communicates/interfaces on its activities with the European Commission other Agency and National Aviation Authorities' staff, ICAO and with all relevant stakeholders (http://http://easa.eu.int/home/r_environ_main.html).

The international aviation organizations are summarized in Table 2.2 with respect to their activities and environmental goals.

Table 2.2 Summary of international aviation organizations

Organization	Activity Site	Environmental Goals
IATA	• Global organization of Air Transport	• An active Environment Committee • Monitoring, assessing and responding to environmental developments, policies and regulations • Advising the Board of Governors, the Director General and other relevant IATA bodies on environmental matters
ICAO	• A convention on International Civil Aviation • Works closely with other UN bodies	• An active Committee on Aviation Environmental Protection (CAEP) • Focuses primarily on aircraft noise and the effect of GHG on global environment.
ECAC	• Strongly related to International Civil Aviation Organization (ICAO), Council of Europe, European Union, EUROCONTROL and the Joint Aviation Authorities (JAA)	• An active environment group ANCAT • Focuses primarily on noise, local and global emissions.
EUROCONTROL	• A civil and military intergovernmental organization from across Europe	• Efficient flight profiles • Reduction of noise, fuel burn, greenhouse gas emissions and flight times.
FAA	• Regulating U.S. commercial space transportation	• Focuses on air quality, climate change, noise, wildlife management
EASA	• Promoting standards of safety and environmental protection in civil aviation in Europe	• Environmental issues are aircraft noise and emissions.

Table 2.2 cont.

Organization	**Activity Site**	**Environmental Goals**
IACA	• Relations with the European Civil Aviation Conference (ECAC), the International Civil Aviation Organization (ICAO), the Joint Aviation Authorities (JAA) and EUROCONTROL	-
EADS	• Develops and markets civil and military aircraft, space rockets, satellites, and related systems.	-
JAA	• Civil aviation regulatory authorities of European States to implement common safety regulatory standards and procedures.	-
SITA	• Service provider of Information Technologies (IT) business solutions and communication services to the air transport industry	-

CHAPTER THREE
INTERNATIONAL AVIATION STANDARDS

In this section, ICAO international aviation standards are evaluated. To have general knowledge about the issues related to new airport projects or expansion projects of an existing airport, there is a summary of aerodrome design and operation principles.

Beside ICAO, ECAC (European Civil Aviation Conference) has published a standard related to noise in two volumes named as “Report on Standard Method of Computing Noise Contours around civil airports”. The second volume is a technical guide about airport noise modeling (ECAC.CAEC Doc.29).

3.1 Annex 14 - Aerodrome Design and Operations – Airport Planning Manual Part 1- Doc 9184

The provision of a new airport or the development of an existing airport involves capital investment and large-scale construction work. It is necessary to realize maximum benefits from the investment to ensure the safety of aircraft operations to avoid discomfort to the surrounding community without limiting the efficiency of an airport.

The starting point is assessment of the suitability and purpose of the airport that is required. The major steps of site selection for a new airport or for an existing airport are determined in the sections below.

3.1.1 Broad Determination of the Required Land Area

The required land area can be achieved by considering the space necessary for runway development that generally forms the major proportion of land required for an airport. The following factors are required:

- Runway length

- Runway orientation
- Number of runways
- Combination of length, number and orientation of runways to form an outline runway scheme for rough assessment of land required.

Detailed information about runways is given in Annex 14- Aerodrome Design and Operations (Appendix 1).

3.1.2 Evaluation of Factors Affecting Airport Location

For a general assessment collection of background information can be useful in evaluating an existing airport or a potential site for a new airport. Needed information for the evaluation is;

- Aviation activity
- Development of surrounding area
- Atmospheric conditions
- Accessibility to ground transport
- Availability of land for expansion of an airport or for a new airport
- Topography
- Environment
- Presence of other airports
- Availability of utilities.

Environmental evaluation consists of defining the locations of wildlife reserves and migratory areas. Additionally sensitive areas such as schools and hospitals should be considered.

3.1.3 Preliminary Office Study of Possible Sites

After the determinations and information collection given in 3.1.1 and 3.1.2, the next step is to analyze the possible new airport sites or additional land requirements for an existing airport. This study should eliminate undesirable sites or determine the adequacy of an existing site before costly site inspections are undertaken.

3.1.3.1 Site Inspection

Airports should be sited so that aircraft operations can be made efficiently and safely. By this way they are compatible from a social point of view and the cost is kept at the optimum level in taking all factors to account. The major factors are given below in three groups:

a) Operational Considerations:

- Airspace
- Obstacles
- Hazards
- Weather
- Approaching and landing aids

Local factors are important for the location of an airport. For example, a near industry can produce smoke that can be decrease the visibility for an airport operation. Sites near to the wildlife reserves, lakes, rivers, coastal areas, refuse dumps and sewage outfalls, etc should not be chosen because of the danger of aircraft collision with birds. The locations relative to the migratory pattern and routes of large birds such as swans and gees also requires special consideration.

b) Social Considerations:

Airports need to be sited relative to populated areas. Runways should be aligned so that flight paths do not pass over concentrations of population. Beside these properties airports also needs to be located near the towns and commercial areas. The subjects given below are the main social considerations:

- Proximity to demand centers
- Ground access
- Noise
- Land use

Aircraft noise is a serious problem in the vicinity of airports. The measurement and description of aircraft noise, land use control, ground run-up, flight noise abatement operating procedures, aircraft noise certification, human tolerant to aircraft noise, effect of increased traffic and introduction of future aircraft types on noise are main factors that should be included in airport planning. It is important to control sufficient land to overcome or reduce the noise problem for both airport and the population. The degree of noise disturbance needs to be assessed in the relation between the level and duration of the noise exposure and human reaction.

Long – term assessment of noise disturbance is expected to be speculative and less reliable than those for short - term assessment. Detailed information about noise evaluation is given in Annex 16 Vol.1- Aircraft Noise (Appendix 1).

The noise level produced by aircraft operations at and around the airport is generally considered as a primary environmental cost. The most noise exposure lays in the land area near to the aircraft approach and departure paths. Noise levels are measured as decibel level by using the duration and number of occurrence. Proper site selection and land-use planning can reduce the noise problem for the airport.

Airports should be located so that the existing forms of land-use are not affected by aircraft operations. More details are given in part 3.2 about land use.

c) Cost Considerations

Suitable returns should be obtained from a construction of an airport. The location of an airport should be optimized so that the development work cost is minimized.
Cost is strictly related with;

- Topography
- Soil and construction materials
- Services
- Land values

3.1.3.2 Environmental Study

Studies of the impact of the construction and operation of a new terminal or an expansion of an existing airport should be at acceptable levels of air quality, water quality, noise levels, ecological processes and demographic development of the area must be defined.

Aircraft noise is the most important environmental problem that should be considered for airport projects. Several studies are continuing about quieter engines and flight procedures. For a new airport project planning of land use will reduce the noise problem. But for existing airports the development of the area is continuing.

An airport can have major water pollution problems when an effective treatment system for airport wastewater is not provided.

The impact on natural environment is another major subject for airports. For large developments streams and major drainage courses can be changed, disruption of wildlife habitats and reshaping of some areas can take place.

3.1.3.3 Review of Potential Sites

At this step the planner should review the results of the research and field investigation. Unsuitable sites should be omitted at this stage.

3.1.3.4 Preparation of Outline Plans and Estimates of Costs and Revenues

The remaining sites after omitting the unsuitable sites require;

- Detailed site surveys including obstacle surveys;
- Outline preparation of airport layouts for each site
- Preparation of broad cost estimates including the total capital and operating expenditure required consisting of all associated airport items such as access roads, communications to population centers, planning control of surrounding areas and

estimates of annual percentage changes in land values for the probable life of the airport, and the anticipated phasing of the expenditure.

- When the expansion of the existing airport is in case, the determination of the depreciated and current values of the installations together with the value of all other airport associated assets should be made.

3.1.3.5 Final Evaluation and Selection

When a number of sites are considered, cost plays an important role for the final choice. Cost effectiveness requires special attention to measure and weight the benefits and costs. By analyzing the benefits and costs over the anticipated useful life of the airport, it is possible to calculate cost-benefit ratios that can serve a guide for the value of the project and the choice of the best site.

Operational and social cost benefit analyses are necessary. At the final step an assessment based on the comparison of operational, social and cost efficiencies are valuable:

a) Operational:
- Land availability
- Airspace availability
- Effect of any restrictions on operational efficiency
- Potential capacity

b) Social:
- Proximity to demand centers
- Adequacy to ground access
- Potential noise problems
- Current land use and need for control measures

c) Cost:
- Cost-benefit analysis

3.1.3.6 Report and Recommendations

A detailed report should be prepared containing drawings. The results of site inspections and evaluation, ranking of sites in order of merit and the reasons of selection and recommendations should be included in the report.

3.2 Land Use and Environmental Control / Annex 14 –Doc.9184

3.2.1 The Airport and its Environs

The compatibility of an airport with its environs can be achieved by proper planning of the airport, control of pollution creating sources, and land use planning of the area surrounding the airport. The purpose is to provide the best possible conditions for the needs of the airport, the community in the surrounding area and the ecology of the environment.

Airport planning must be recognized as an integral part of an area-wide comprehensive planning programme. The location, size and configuration of the airport need to be coordinated with patterns of residential, industrial, commercial, agricultural and other land uses of the area, taking into account the effects of the airport on people, flora, fauna, the atmosphere, water sources, air quality, soil pollution and other facts of the environment.

Within the comprehensive planning framework, airport development and operations should be coordinated with the planning, policies and programmes for the area where the airport is located. In this way, the social and economic impact, along with the environmental effects of the airport, can be evaluated to ensure to the greatest extent possible that the airport environs are compatible with the airport and, conversely, that the physical development and use of the airport is compatible with the existing and proposed patterns of land use. To the extent that technical considerations permit a choice, decisions on runway alignment and other airport development should take into account their potential effects on the environment in order to prevent or minimize environmental conflicts. In effect, “land-use control” is a term which describes only a portion of the total planning process, and even highly innovative controls can have little impact unless they are imposed within the context of sound policies and careful planning. “Land-use planning” or “planning for compatible land uses which takes into account the needs of airport development” more adequately describes the process of achieving an optimum relationship between an airport and its environs.

3.2.2 The need for Environmental Control

In recent years there has been increased public concern regarding the protection of the environment from the impact of transportation, and consequently, a growing emphasis on the need to employ effective measures to minimize the impacts. Since pollution may be generated within an airport as well as within the area surrounding it, environmental controls should be applied at the airport and its environs.

The environment has been defined as including:

a) Air, land and water;

b) All layers of the atmosphere;

c) All organic and inorganic matter and living organisms and

d) The interacting natural systems referred to in a) to c).

Because of all the interaction of the components, disruption to one may have a profound effect on the entire system. Therefore, to lessen local and global impacts, it is important that the entire civil aviation industry endeavors to control harmful emissions.

Pollution occurring in and around the airport has the potential to affect not only the immediate area, but also the surrounding areas. Because it can have an effect on human health and the ecology of the surrounding area, efforts should therefore be made towards pollution prevention. Environmental controls thus provide a means of either decreasing pollution at the source or reducing the potential for negative environmental impacts. Controls such as air and water quality guidelines, aircraft engine noise limits, waste management plans, environmental emergency plans, and environmental management plans are necessary.

Airports can operate with limited environmental impact by incorporating environmental management plans and procedures with land-use planning. In the past, environmental management has concentrated on pollution abatement by finding ways to dispose waste. More recently, organizations have been shifting toward pollution prevention, which focuses on reducing or eliminating the need for pollution control. Pollution prevention can be defined as “the use of materials, processes or practices that reduce or eliminate the creation of pollutants and wastes at the source.” It includes practices that reduce the use of hazardous and nonhazardous materials, energy, water or other resources. Anticipatory action is used to preempt the need for control or remedy.

3.2.3 The need for Land Use Planning

The need for some public control of land in the vicinity of an airport was recognized in the early history of civil aviation. In general, these early measures were usually concerned with height control of possible hazards obstacles to flight into or out of airports. Also recognized was the need to control potentially conflicting activities, such as:

a) Activities that could cause electrical interference with radio communications and navigation aids;

b) Lights that might confuse pilots in the clear interpretation of aeronautical lights; and

c) Production of smoke that reduces visibility

After the widespread introduction of commercial turbo-jet aircraft that the compatibility of land uses with noise exposure in the vicinity of airports became a major consideration. Aircraft noise is the most significant form of pollution caused by aircraft operation and is therefore a major factor influencing land-use planning in the vicinity of airports.

The requirement for land-use planning in the vicinity of an airport is twofold, namely:

a) to provide for airport needs, e.g. obstacle limitation areas and future airport development

b) to ensure minimal interference to the environment and the public, e.g. by locating residential areas away from zones subject to excessive noise or other pollution and by preserving parklands.

3.2.4 Environmental Impacts Associated with Aviation Activities

3.2.4.1 Aircraft Noise

After the production of jet aircraft, noise has been considered to be the most important environmental problem associated with civil aviation. Noise levels in the vicinity of airports are affected by two opposing trends: the replacement of noisy aircraft by quieter ones and the increasing number of aircraft movements. As a result, the problem of noise may decline at some airports but increase at some others. The noise problem has prevented the expansion of airport capacity in some cases, thereby contributing to airport congestion. Because of this and other environmental problems, some States are considering limiting aircraft operations at airports based on environmental considerations, rather than on airport capacity. In other words, the standard “operational airport capacity” is replaced by measures of capacity based on environmental parameters.

Engine testing and auxiliary power units (APUs) used during ground operation, as well as ground power units (GPUs) and vehicles that are used at the apron, are additional noise sources at airports.

Sonic boom, caused by supersonic aircraft, is not a major problem at the present time but could become an issue if manufacturers proceed with plans for a new generation of supersonic aircraft. This problem was considered in detail by ICAO during the 1970s when supersonic aircraft operations were first introduced. At present, most States do not permit civil supersonic flights over their territories. For most aircraft types, the noise caused by aircraft en route (other than sonic boom) is not a significant problem because the aircraft are flying too high to cause a disturbance at ground level. However, this can be a problem in the case of helicopters and, if ever they materialize, aircraft driven by prop fan engines (Doc 9184 AN/902, ICAO, 2002).

Annex 16 (Appendix 1), Environmental Protection, Volume 1 Aircraft Noise sets the Standards for noise certification of large subsonic jet and propeller-driven aircraft, small propeller-driven aircraft and helicopters. At present, there are no specific Standards for supersonic aircraft. Annex 16 also includes guidelines for noise certification of APUs.

3.2.4.2 Air Quality in the Vicinity Of Airports

Air quality in the vicinity of airports is affected by aircraft engine emissions, emissions from airport motor vehicle and access traffic, and emissions from other sources (e.g. heating/power plants and incinerators).

Air pollution refers to a condition of the air marked by the presence therein of one or more air contaminants that can:

- endanger the health, safety;
- interfere with normal enjoyment of life or property;
- endanger the health of animal life;
- cause damage to plant life or to property.

Air pollution is a major environmental problem in most countries, especially in urban areas, and is generally recognized to contain CO_2, CO, NO_X, VOCs, HCs and O_3.

CO_2 is produced by the oxidation of carbon in fuel, while CO is a product originating from the incomplete combustion of hydrocarbon fuels. Nitrogen oxides result from high temperature combination of nitrogen and oxygen (primarily NO and

NO_2) in aircraft engines and internal combustion sources. VOCs which are directly emitted from the combustion process are considered carcinogenic, and chronic exposure to VOCs could cause health problems. Hydrocarbons (HC) cover a wide range of pure and impure hydrocarbons (methane, olefins, aldehydes, ketones and terpenes) whose sources include fuelling activities and incomplete combustion processes. O_3 is primarily a by-product of photochemical reactions and is known to play an important role in the chemistry of NO_X and HC. It is an irritant gas which can cause health problems, such as irritation to the nose, eyes and throat, as well as respiratory problems, and has damaging effects on plant and animal life.

Although the air quality in the vicinity of airports is generally no worse, and in fact is often better than that found in most urban areas, it is nevertheless a cause for concern.

Sources of pollution at airports include:

a) aircraft engine emissions; principal pollutant is NOX, while other pollutants are CO, unburned hydrocarbons and smoke.

b) emissions from heating/power plants and incinerators, such as fires set for the purpose of training rescue and firefighting crews;

c) emissions from motor vehicles, notably from airport motor vehicles used by airport operators, air carriers and other businesses based at an airport;

d) emissions from access traffic comprising of passengers' and visitors' motor vehicles, cargo and delivery trucks, and service and public transport vehicles (Doc 9184 AN/902, ICAO, 2002).

Annex 16, Environmental Protection, Volume II Aircraft Engine Emissions contains the Standards for the control of gaseous emissions through engine certification scheme. It establishes the limits for the emission of NO_X, CO, unburned hydrocarbons, and smoke from new engines. The need to reduce air pollution emanating from emissions of airport motor vehicles, access traffic and other sources has attracted the attention of most governments and some intergovernmental organizations. The extent of the air pollution problem may vary from one airport to another, depending in particular on the location of an airport and the availability of public transport facilities serving the airport. As more solutions emerge, the scope for reducing air pollution from the different sources should also increase (Annex 16, ICAO, 1993).

Airlines and airports use chlorofluorocarbons (CFCs) and other ozone depleting substances (such as chlorinated solvents and oxides of nitrogen) in air-conditioning and chilling systems, degreasers in heavy maintenance operations, cleaning of avionics circuit boards, fumigation operations, and fire extinguishers on aircraft and in computer rooms.

The principal cause of the ozone-depletion problem is considered to be chlorofluorocarbons (CFCs) which are primarily employed as aerosol propellants or as refrigerants. Although civil aviation uses CFCs, it only uses small quantities.

3.2.4.3 Water and Soil Pollution in the Vicinity at Airports

Water pollution can result from direct or indirect discharge of substances into the aquatic environment, leading to alterations in the properties of the natural ecosystems and water chemistry and having subsequent effects on human health. Surface water is most often affected, as pollutants run off the airport pavements and enter into the streams, rivers, lakes, etc. However, sub-surface water may also become contaminated when leaks or spills of fluids seep through the soil into the ground water.

Airports use a variety of chemicals in their day to day operations. If not controlled, these contaminants may have harmful effects on nearby surface and/or subsurface (ground) water. Water contaminants at airports and their sources include:

- glycol, from de-icing/anti-icing of aircraft;
- urea, from de-icing/anti-icing of runways, aprons, and taxiways;
- fuel, from spills during refueling and leaks from pipes or tanks;
- fire suppressant chemicals and foams dispersed in firefighting exercises;

- dust, dirt and hydrocarbons from paved surfaces;
- herbicides and pesticides

can result in the discharge of industrial effluents, e.g. paint stripping, metal coating, detergents from aircraft, and vehicle and pavement washing.

The discharge of chemical pollutants can disturb aquatic life and diminish water quality in three primary ways:

a) Toxic effect: Even a small amount of contaminant is toxic to plants and animals as it can cause either short- or long-term (acute or chronic toxicity) consequences;

b) Eutrophication: Excessive levels of nutrients result in prolific alga and plant growth which, in turn, chokes up the water body, causing long-term degradation in water quality and community structure;

c) Oxygen depletion: The degradation of certain chemicals in the water leads to the consumption of large quantities of oxygen, causing the water to become oxygen-deficient which is detrimental to aquatic life.

3.2.4.4 Waste at Airports

The disposal of environmentally harmful materials used in aircraft servicing and maintenance (e.g. oils, cleaning fluids and paints) and of waste from the airport and incoming aircraft should be managed effectively.

Although airports are not usually considered as industrial complexes, daily activities, such as movement of aircraft and ground vehicles, fuelling operations, aircraft maintenance and repair work (including painting and metalwork), engine test cell operations, and ground vehicle maintenance, are all sources of airport industrial waste.

Waste management at an airport may require permits and registration due to State and local requirements.

3.2.4.5 Environmental Problems Arising from Aircraft Accident/Incident Involving Dangerous Goods and Emergency Procedures

It is important to establish an environmental emergency plan in order to responses to environmental emergencies quickly. The types of environmental emergencies at airports include fuel and chemical spills and incidents involving dangerous goods or hazardous materials that may affect the environment. The objective of the environmental emergency plan is to provide a complete and immediate response to an environmental incident.

Many aircraft are not structurally able to withstand a landing at maximum take-off mass. In the event of an emergency requiring an overweight landing, it is sometimes necessary to dump fuel into the atmosphere, although this is a rare occurrence. Air Traffic Control (ATC) establishes specific areas where fuel can be dumped in case of an emergency.

3.2.5 Environmental Consequences and Control Measures

3.2.5.1 Noise Abatement

Before an aircraft is permitted to operate, it must receive noise certification granted by the State of Registry. Aircraft noise certification provisions are detailed in Annex 16 (ICAO, 1993). In addition to the noise limitations imposed by aircraft certification, States and local authorities frequently implement local restrictions applicable to specific airports, aircraft types and/or operations. Such local restrictions have been responsible for the introduction of night curfews and even the banning of certain aircraft types due to noise considerations.

To meet the demand for quieter aircraft engines, manufacturers have undertaken research which has led to a considerable reduction of aircraft engine noise output. As a result, modern transport aircraft now being manufactured are much quieter than earlier generation aircraft, such as the B-707, B-727, B-737/200, DC-8 and DC-9.

Noise restrictions have necessitated the introduction of operational procedures to reduce the noise level in nearby areas. For example, the selection of specified approach and take-off paths and the modification of engine thrust settings for certain operational phases are commonly employed aircraft noise abatement procedures. Controls may also be imposed on the noise generated by aircraft engine and auxiliary power units (APU) ground running, ground movement of aircraft and certain airport construction activities.

In addition to the measures that attack noise at its source through certification, operational means, and scheduling, it is possible to reduce the effects of noise by land-use planning and acoustical barriers.

Acoustical barriers can include such wide-ranging measures as the use of protective ear coverings for people subjected to high-intensity noise, soundproofing of buildings, and methods for screening sound.

Trees may be planted to screen certain areas from some airport noise. A study in Japan of the sound insulating characteristics of wooded areas indicated that judiciously planted trees can offer good protection against ground run-up noise. Various configurations of insulating forest were considered but a study recommended the configuration shown in Figure 3.1. The sloped embankment makes planting easier and a considerable sound-insulating effect can be expected, even during the early stage when the trees are not fully grown, because the embankment itself has a significant sound-insulating effect. Figure 3.2 shows the sound absorption effect of different tree species. The sound attenuation through 100 m of evergreen trees will be 25 to 30 dB (Doc 9184 AN/902, ICAO, 2002).

When selecting trees to be used in the development of a sound-insulating forest, consideration should be given to selecting species which:

a) are suitable to the climatic conditions of the airport site;

b) have effective sound-insulation properties (e.g. do not shed their leaves or needles in winter and grow rapidly and densely);

c) do not generate a bird hazard;

d) are easy to care for (e.g. healthy and not easily affected by blight or noxious insects).

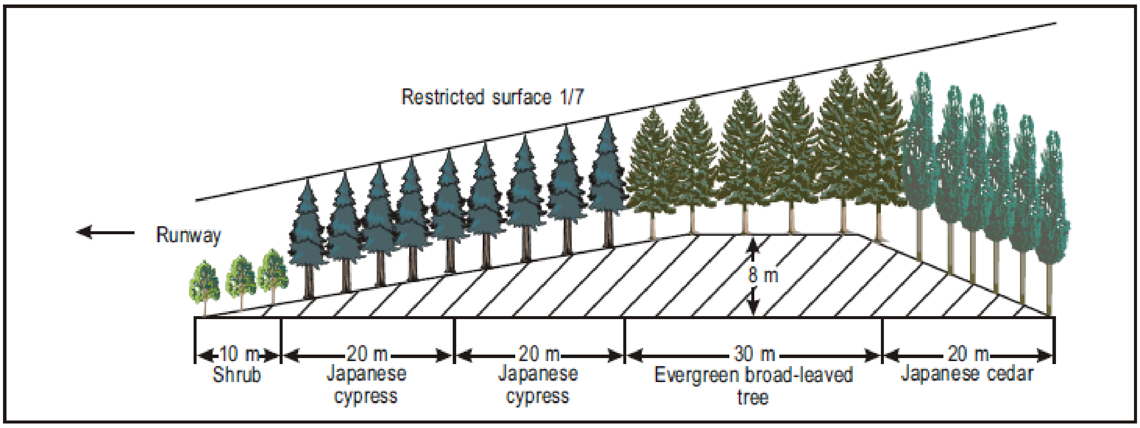

Figure 3.1 Cross-section of sound insulating forest

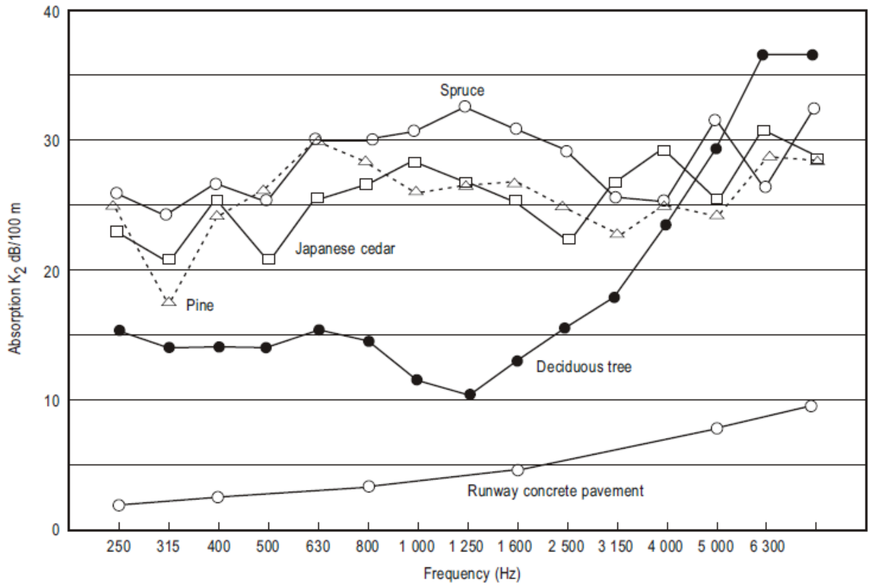

Figure 3.2 Sound absorption by tree species

Buildings may be soundproofed to protect the occupants against excessive noise levels.

3.2.5.2 Air Pollution Control

Some degree of air pollution associated with an airport is unavoidable, but this can be substantially reduced with proper pre-development planning and mitigation measures. Air pollution associated with airports is generated by aircraft, vehicles and facility operations (defined as terminal buildings, cargo, and maintenance facilities).

Air pollution control technology is continuously advancing, and measures to reduce the emission of pollutants by aircraft are being developed. Jet engine combustors which eliminate smoke emissions are now available, and on many aircraft, the venting of fuel directly to the atmosphere during normal operations is avoided. Designers now devote much effort toward the reduction of gaseous emissions. Operational procedures that reduce emissions are also possible, such as:

a) reducing time spent with engines idling by delaying start-up of engines until it is known that a direct taxi to take-off is possible;

b) encouraging early shutdown of one or more engines after landing, although it must be remembered that such techniques can increase noise by requiring higher power or thrust from the remaining engines;

c) using operational towing to delay the start-up of the aircraft engines, provided this does not create delays which could contribute to congestion.

Air pollution originating from aircraft engine testing and maintenance facilities may be controlled through the use of test cells equipped with afterburners and catalytic converters. Measures should also be taken to reduce emissions from incinerators, heating and air-conditioning plants, fire training, and from certain construction or maintenance works (e.g. smoke from asphalt paving plant and refuse burning). A number of steps can be taken to decrease emissions from ground support vehicles and increase the fuel efficiency of these vehicles. These include:

a) maintaining the vehicles;

b) avoiding unnecessary idling by shutting off engines when operation is stopped for periods of more than one minute;

c) reducing driving distances by planning routes;

d) accelerating smoothly;

e) driving at optimum speeds;

f) using alternative bio-diesel and low-sulphur diesel fuels;

g) using catalyst technologies to convert vehicles so that they operate on natural gas or propane;

h) using oxidation catalysts and particulate traps which can reduce hydrocarbon and particulate mass emissions up to 95 per cent;

i) encouraging purchase of fuel-efficient vehicles and the use of alternative energy sources, such as ethanol and propane;

j) replacing the power/air conditioning requirements on the ground with more energy/fuel-efficient equipment in order to cut the amount of operation time of APUs;

k) improving public transport access to airports so as to reduce emissions from private vehicles.

Where internal combustion-engine vehicles are used, environmental impacts should be considered in the selection of the vehicles. It may be possible to ease the environmental impacts by using alternative fuels including electric power (depending on the ultimate source of electricity). This option can be of particular significance in the case of airport ground vehicles and equipment. Similarly, airports should consider the use of hybrid-fuelled vehicles which utilize dual types of fuel.

While work is underway to manufacture alternatives, the majority of existing refrigeration systems (for both food storage and air conditioning) uses CFCs. The long-term aim must be the replacement of CFC-based equipment. However, in the interim, it is vital to ensure that leaks of CFCs are minimized and that unwanted CFCs are disposed of responsibly.

Another environmental consideration is related to respiratory conditions that can arise as a result of bacteria in water-cooled air conditioning systems. Water cooling towers, often part of an airport air conditioning system, can present a great risk in this area if they are not properly maintained. Where such towers are used, regular laboratory monitoring of the system is recommended.

Studies on aircraft emissions have led to the publication of Annex 16 — Environmental Protection, Volume II — Aircraft Engine Emissions. This publication provides the Standards and Recommended Practices on instruments and methods used for measuring aircraft emissions from a range of engine types (ICAO,1993; Appendix 1).

The transport of people, baggage, cargo, etc. to and from and within an airport area presents another source of air pollution. However, rail transport, "people movers" and, above all, careful initial layout design can all contribute significantly to the minimization of the environmental impacts and operating costs arising from such transport needs. The provision of an excellent public transport system may be outside the scope of the airport authority, but there is the possibility of encouraging staff to travel by this means. Provision can be made for inter-modal interchange facilities in the layout planning and design of new airports and in the extensions of existing infrastructure, particularly terminals. Passengers may be provided linkage to light, conventional or high-speed rail systems as well as regional and local bus facilities, the latter being particularly appropriate for employee access. The provision of such facilities should go hand in hand with the development of an airport public transport strategy appropriate to local conditions and consistent with a policy of cooperation with surface transport providers.

3.2.5.3 Water Pollution Control

Airports are subject to both national and international environmental regulations which may include both quantity and quality discharge limits. Airport waste water must be treated before being discharged so as not to pollute ground water or nearby streams. Waste water may be treated on site or at a nearby municipal treatment system. It should be noted that local water quality regulations may require pretreatment before discharge to a municipal system. In order for airport operators to control waste water at their facilities, pollution prevention planning can identify areas and activities to be managed. The type and nature of airport operations will influence the type and extent of waste water treatment. The primary products which can be found in untreated waste water discharges include fuel, oil and greases, and heavy metals.

In order to determine the type of practices to be incorporated in a water pollution control programme, airport operators should conduct a review of the site conditions. This review should include the following:

a) topography;

b) presence of bodies of water;

c) storm water discharge points, including infrastructure and natural bodies of water;

d) drains, culverts and catch basins;

e) paved areas and buildings;

f) aircraft and vehicle service areas; and

g) operational areas and activities, i.e. fuelling, de-icing.

Petroleum and chemicals are largely used at airports. Airports store and handle large quantities of petroleum and chemical products, which are potential sources of water pollution. The following paragraphs outline management practices that may be employed in maintenance areas, aprons, fuel farms, and de-icing areas.

Aircraft maintenance areas, as well as automotive and equipment service areas, should be provided with oil-water separators which are, in turn, connected to sanitary sewers leading to the municipal waste treatment plant serving the airport. All existing oil-water separators should be checked and upgraded when necessary by airport personnel to meet the requirements of the municipal sewerage treatment plants. All oil-water separators must be inspected by airport personnel on a monthly basis and deficiencies promptly corrected.

The primary pollutant originating from aprons is oil from spills and accumulations. Grease and suspended solids from various sources such as aircraft, service vehicles and minor aircraft maintenance may also occur. The airport pollution control programme must therefore focus on:

a) strict enforcement of good housekeeping regulations to control pollution at its source and to minimize accidental spills;

b) removal of accidentally spilled oil and fuel through containment and spill recovery;

c) completion of all regular maintenance activities in hangars protected by oil-water separators in order to limit aircraft maintenance on the aprons;

d) ban on washing of equipment in apron areas; and

e) immediate cleaning of all spills of fuel or oil by using environmentally sound absorbents which are subsequently removed from the airport by licensed disposers.

Airport personnel must respond to spill reports, heck all relevant access pits and sumps, monitor the removal of any fuel or oil found therein, and analyze spill reports for common causes in order to prevent future spills. Trucks used for fuelling operations should be inspected every six months and hydrant pits used for transferring fuel from the underground piping systems should be checked on a routine basis for any accumulation of fuel.

Another water pollution problem is the presence of underground oil-saturated soils at fuel farms. Aside from above ground leakage from storage tanks, there are several potential sources of oil contributing to the oil-saturated soil beneath a fuel farm:

a) leakage in underground fuel distribution lines;

b) leakage from mechanical equipment which penetrates cracks and joints in the slabs beneath the equipment;

c) leakage through the joints in the storm water drainage pipe used to transport condensate from the fuel storage tanks to the oil-water separator system.

A number of steps can be taken to solve the problem of underground oil-saturated soils. When necessary, well points are installed at pre-selected locations to determine the presence and depth of oil. Pipes are inserted into the ground to a depth that ensures a penetration below the ground water elevation. A continuous slotted pipe assures that any oil floating on the surface of the underground water is free to enter the pipe at its natural elevation and also assures that any fluctuations in the underground liquid surface are accurately reflected inside the pipe.

A probe — an instrument developed to measure the depth of water that collects beneath fuel oil in storage tanks — is utilized to measure the pressure and depth of oil. An alarm sounds when the probe makes contact with the water. The probe is then withdrawn and its dry length and total length are measured. The elevation of the oil or water surface is calculated by subtracting the measured length from the preestablished elevation at the top of the well-point. Once underground oil is detected at any well point, supplementary well points are installed around the first well point to define the horizontal limits and thickness of the oil-saturated soils. If oil is found in the supplementary well point, additional well points are installed, in stages. This procedure may be repeated through several stages until the outer perimeter of well points indicates the absence of oil.

De-icing is an operation in which glycol is used as the de-icing fluid. This chemical has a high Biochemical Oxygen Demand (BOD). Aircraft deicing fluids, if released into receiving waters, can be a potential pollution problem as well as a potential hazard to aquatic life. Excess de/anti-icing fluid running off an aeroplane, if allowed to mix with other surface run-off, poses the risk of contaminating the ground water. Furthermore, the fluids also have an adverse effect on the pavement surface friction characteristics. Therefore, it is imperative that only an optimum quantity of the fluids be used. Nevertheless, all excess fluids must be properly collected to prevent ground water contamination. All surface run-offs from de-icing areas must be adequately treated before being discharged into storm water drains. For further information on aircraft de-icing, including environmental considerations, refer to the

Aerodrome Design Manual (Doc 9157), Part 2 — Taxiways, Aprons and Holding Bays (Appendix 1).

To minimize the effects of the spent fluids, the following precautions should be exercised:

a) reduce chemical usage by:

— centralizing spray operations,

— using designated de-icing pads,

— recapturing, filtering, and/or recycling glycol in leak-free tanks, and

— minimizing pavement de-icing on aprons by using pavement heating systems;

b) create spill response plans and ensure that all users are properly trained on chemicals and procedures;

c) maintaining the facility in good order, including:

— pavement conditions,

— storage area, and

— runoff control.

Glycol management plans should be filed at the beginning of the de-icing season and should outline the following areas:

a) site responsibilities,

b) site specifications,

c) glycol storage and handling,

d) glycol application,

e) containment,

f) collection and storage of effluent,

g) means of disposal, and

h) reporting plan.

Further information on de-icing is available in the Manual of Aircraft Ground De/Anti-icing Operations (Doc 9640) (Appendix 1).

3.2.5.4 Waste Management

Waste management is concerned with the reduction of both hazardous and non-hazardous wastes. The 4Rs — reduce, reuse, recycle and recover — are good practices for any workplace. A waste management programme should include the three practices: Planning, Procedures and Special Provisions.

Planning: Airports should establish a dedicated programme for the management of waste. This plan should consist of the following:

a) A description of design intent, construction details, overall land fill development plan, and site closure plan;

b) A clear description of the chain of authority, organizational structure, job descriptions and job responsibilities for all personnel;

c) An itemized list of mandatory regulatory reporting requirements;

d)An itemized list of internal, written reporting requirements and record keeping;

e) A description of health and environmental monitoring programmes and related reporting requirements;

f) A description of routine landfill operational procedures;

g) Emergency procedure plan; and

h) Training of all employees in landfill concepts and day-to-day landfill operating procedures, equipment operating instructions, safe practices and emergency procedures.

Procedures: It is important that the waste management plan incorporate the following procedural elements:

a) Describe waste reduction, reuse and recycling plans (i.e. reduce or eliminate operations/processes that generate solid waste, redesign processes to reduce waste, and substitute products for waste reduction);

b) Choose green products and services;

c) Compost organic wastes;

d) Provide training for proper material handling to reduce waste and spills, and equip waste transport vehicles with anti-spill equipment;

e) Centralize responsibility for waste management and establish written procedures for loading/unloading and transfer operations;

f) Track waste generated and disposed by the following means:

— identify waste streams,

— evaluate the process generating the waste,

— prioritize waste streams,

— prepare inventory reports, and

— maintain records on waste production and disposal costs;

g) Isolate hazardous wastes by containment and prevent mixing of hazardous and non-hazardous wastes;

h) Isolate liquid waste from solid waste;

i) Separate biomedical wastes with infection potential for special treatment and disposal; and

j) Segregate incompatible materials/wastes to avoid dangerous reactions in the event of a spill.

Special Provisions: It should be noted that in the management of hazardous wastes, special provisions will be required by airport operators. These provisions consist of the following:

a) Perimeter security fence;

b) Security alarms on the gate and security fence;

c) Designated vehicle wash-off area;

d) Provision of a dedicated building or storage sheds for materials storage;

e) Safety control devices such as fire and gas alarms;

f) Installation of ventilation systems, non-spark electrical controls and fire extinguishers; and

g) Implementation of a bird and mammal control programme.

An effective waste management programme can be enhanced by employee awareness of the three waste management practices. An awareness programme can include training, participation in special events, information sessions and informative newsletters. Employees should stay current on changes and new information to ensure adherence to policies and procedures.

3.2.5.5 Energy Management

The majority of energy used at an airport is associated with the provision of heating, ventilation, air conditioning and lighting. The essential services such as airfield lighting and instrumentation actually use a relatively small amount of energy. It is estimated that energy costs account for about 5 per cent of the operating costs of a modern airport and that use of the best available conservation techniques can reduce this cost by 5 to 20 per cent. To assess energy and environmental performance, suitable indicators are required. The actual choice of the indicators will depend on the size of the airport but suitable indicators may include:

a) Energy consumption per:

— 1 000 passengers

— air transport movement

— tonne of cargo movement

— traffic unit (TU)1

b) Pollutants released:

— directly per 1 000 passengers/TU, and

— indirectly per 1000 passenger/TU

Reporting should be done annually so that performance improvements can be demonstrated and compared to other indicators, such as traffic, finance and employment. To use such performance indicators in a report, it is necessary to record actual energy consumption and to have information on the effects produced by using various energy sources. While indicators based on measures of consumption are essential for reports on environmental effects, indicators based on cost are essential from a management viewpoint.

In order to heighten awareness of energy efficiency within the airport and interested communities, some airports adopt an energy policy guidance statement.

Turning these statements into effective action requires a clear definition of responsibility for energy efficiency. Ideally each operational manager will have energy responsibility, with expert knowledge being provided by engineering and energy specialists. Examples of policy statements are as follows:

a) This airport aims to use energy as effectively as possible in the pursuit of its corporate objectives.

b) This airport will always consider the environmental impact of its direct and indirect energy consumption.

c) This airport is committed to the efficient use of energy in all its activities.

An effective energy strategy will include a statement of objectives to make all personnel aware of what the organization is committed to achieve, but the pursuit of environmental performance without regard for cost is not a plan for success. The two main elements of an energy strategy should be the following:

a) Choice of energy source: Without environmental consideration, the preferred energy sources, as selected from available sources, would be those with the lowest overall cost. Currently, the market costs of energy sources may not necessarily reflect their corresponding environmental impact. It is important to consider both the direct and indirect environmental effects. For example, using electricity may have a negligible environmental effect locally, but its effect may be significant elsewhere if the power is generated by the combustion of coal.

b) Effective utilization and management of energy: The key aim must be to conserve energy and still meet the operational objectives of the airport. To do this, it is necessary to understand where, how and why energy is used. This may be accomplished by means of an energy audit, which, for the sake of convenience, may be combined with an environment audit. To be effective, energy audits should be carried out at regular three-year intervals.

All control points related to heating and air conditioning systems should be checked, including the heating and cooling temperatures, control of humidity, and boiler adjustments. While such actions are simple, the combined effect of incorrect settings could mean the use of 10 per cent more energy than is necessary. Other simple procedures include checking the insulation of pipe work, duct work and buildings themselves. All these measures can optimize the performance of the system. Where a comprehensive building management system is installed, many checks and adjustments can be carried out from a central control room. Once the existing plant is operating efficiently and as much waste is eliminated as possible, further capital investment may be considered, including investments in additional sophisticated control systems, variable speed drives for fans and pumps, heat recovery systems, and new boiler plant.

The lighting of buildings accounts for a major part of the energy consumption at an airport. Sometimes it is possible to reduce the requirement for artificial lighting by the introduction of more natural lighting — providing this does not add significantly to heat or cooling loads. Where artificial lighting is installed, it should be appropriately controlled and should use the most efficient, suitable light source. Paying close attention to the location of lighting and operating on the basis of time, ambient light levels, occupancy, etc. can lead to very worthwhile savings and can be self-financing. Since most light fittings produce heat, recovering this heat and/or ensuring that it does not add to the air conditioning loads of the building should also be taken into consideration.

3.2.5.6 Environmental Emergencies

In order to respond effectively to environmental emergencies, the airport emergency plan should include specific plans and procedures to deal with such emergencies.

These plans and procedures must clearly identify a predetermined sequence of communication and action plans to be implemented quickly to deal with various types of environmental emergencies at airports. Such emergencies include fuel and chemical spills, and incidents involving dangerous goods or hazardous materials that may affect the environment. The plans and procedures must incorporate the elements of command, communication and coordination.

Environmental emergency planning should include the following:

a) General

— Table of contents

— Record of agreements

— Purpose of the plan

— Geographic location of airport

— Environmentally sensitive area

— Emergency telephone list, and

— Grid/reference maps.

b) Actions

— Persons of authority — Site roles

— Major types of airport environmental emergencies

— Site management/spill clean-up and restoration

— Site hazardous materials inventory

— Emergency equipment on site

— Spill clean-up contractors, agencies and specialists

— Monitoring, reporting and follow-up procedures

— Media relation guidelines, and

— Training protocol.

Environmental emergency planning should incorporate the following steps to emergency response:

a) Secure: Establish a hazard zone that will keep nonemergency response personnel out of danger.

b) Approach: Approach from upwind to avoid coming in contact with vapors.

c) Identify: Utilize placards and/or labels on containers to provide information on the product involved. The United Nations Product Identification Number (PIN) will provide information for personnel protection and spill response information. The exact identity of the products involved can also be found by examining the shipping documents.

d) Assess: The following points should be considered:

— Is there a fire?

— Is there a spill or a leak?

— What are the weather conditions?

— What is the terrain like?

— What is at risk: people, property or the environment?

e) Respond:

— Respond in an appropriate manner.

— Establish lines of communication.

— Establish line of command.

— Ensure coordination.

It is important that the airport emergency plan be tested on a regular basis and that corrective measures are taken immediately after an exercise or real incident where deficiencies in procedures are identified.

3.2.5.7 Environmental Impact Assessment of Airport Development Projects

An environmental impact assessment provides a systematic approach for identifying the environmental effects of prop seed projects in order to allow for, where necessary, the modification of plans and incorporation of measures to minimize or eliminate any potential adverse effects on the environment.

The environmental impact assessment report should contain the details that are needed to make informed decisions with respect to the environment. This is achieved by:

a) Identifying all project components for the purpose of refining the scope of the project and the scope of the environmental assessment;

b) Carrying out a detailed and organized environmental screening of the project based on specific terms of reference and any approved modification/additions;

c) Presenting the process and results in a screening report suitable for public scrutiny and decision making.

The environmental assessment process should include project description, environmental description, project/environment interaction analysis and its impact, and mitigation measures. A final report should be prepared which details all the phases and results of the environmental assessment. The environmental impact assessment report must be clear, concise and suitable for public scrutiny, if required.

It is necessary to develop a description of both the physical and social environment, which includes:

a) Context, study area, and site plan;

b) Definition of the items in c) and d) which are to be addressed in the assessment;

c) Physical environment:

- physiography and local topography
- soil
- landscaping
- surface water/drainage basins
- groundwater/aquifer
- air quality
- atmosphere/weather
- vegetation/crops
- terrestrial species/habitat
- aquatic species/habitat
- avifauna migration routes, and
- ecological systems

d) Social environment:

- land use
- light emissions
- impact on the community
- recreational uses
- aesthetics
- employment
- economic
- municipal services

- noise
- archeological factors/heritage, and
- planning framework

Project-environment interaction analysis requires identification of the environmental components which may be affected by each of the project construction and/or operational activities. A level one matrix should be used to identify the interaction between activities and general categories of environmental components involved.

The identification of possible impact points is followed by an impact analysis. This will require a general description of each potential impact, the determination of valued ecosystem components, and the prediction and evaluation of impacts.

Specifically, the potential effects of the proposed activities on the environmental components should be described. Any particular concerns of the public should be noted. Through further detailed analysis and consideration of mitigation measures, impact predictions regarding specific project-environment interactions should be developed.

Ultimately, the environmental assessment should provide clear projections regarding the nature and type of impact. The assessment should conclude by summarizing decisions regarding the environmental impacts of the project, the specific mitigating measures and monitoring requirements. A recommended environmental assessment decision should be provided, reflecting the options selected among those presented.

The environmental assessment report should be organized in such a manner that information (procedures, findings, etc.) for each of the key stages of the assessment is presented. A table of contents with major headings similar to the following would be appropriate:

- Name of the proposal
- Description of project activities
- Description of the environment
- Environmental effects (including any cumulative environmental effects)
- Proposed mitigation measures
- Determination of significance
- Expert government agencies consulted (expert help, if required)
- Public consultation (including methods and results, if required)
- Approximate date of implementation
- Decision and rationale
- Consultant/expert contact (name, title, and address)

A follow-up programme should detail the monitoring programmes required to evaluate the effectiveness of the mitigation measures as well as to determine the accuracy of the environmental assessment. This programme is not always required for every project. The decision maker should identify and implement a follow-up programme if one of the following situations occurs:

- the project involves new or unproven technology;
- the project involves new or unproven mitigation measures;
- the assessment was based on a new assessment technique or model, or there is some uncertainty about the assessment's conclusion.

3.2.5.8 Environmental Management

The environmental management activities of an airport can be divided into three basic categories:

- Environmental awareness,
- Planning and monitoring, and
- Remedial measures.

The objective of the environmental awareness programme is to promote increased environmental consciousness and to make individuals aware of their own environmental protection responsibilities, both in decision making and in the day-to-day work of the airport. This is accomplished primarily through employee education, training and incentives.

Most of the environmental activities at airports involve planning and monitoring, including:

- environmental assessments;
- monitoring and compliance;
- environmental audits, where necessary; and
- environmental emergency contingency plans.

The environmental assessment process has proven to be an important part of the project design procedures. Potential environmental impacts can be identified before they occur and before irrevocable decisions on the design of a project are made. Mitigation of environmental impacts can and should be made an integral part of the planning process.

Monitoring and compliance programmes assess air quality, water quality, soil and ground water quality, noise levels, etc. These programmes are designed to detect developing problems in the early stage before environmental impacts become significant and to identify the source of the problem.

Periodic inspections should be undertaken in order to provide a thorough assessment of the environmental implications of operations and management practices at a given point in time and to determine the degree of compliance with applicable regulations, guidelines and codes of practice. The inspections are used to assess whether or not the monitoring and compliance programmes are functioning properly and to identify any problems not previously detected. They provide the basis for action plans. In addition, such inspections are valuable tools for identifying opportunities for enhancing environmental management practices as a whole.

Although the ultimate goal of a proactive environmental strategy is to minimize the creation of environmental problems, in the interim, there is a need for remedial measures to correct situations resulting from material handling and management practices of the past. Airports in general have an obligation to protect the physical environment by evaluating the impacts of their policies and regulatory decisions on the environment and by promoting and meeting environmental standards while serving the public to optimal satisfaction and safety. By adopting ISO 14000 Standards and implementing an EMS, it is expected that airports will make a major push towards achieving environmental standards and objectives.

3.2.6 Land-use Planning

The problem of noise in the vicinity of airports can only be solved by pursuing all possible means to alleviate it. Proper land-use planning can contribute materially to the solution. There are substantial benefits to be gained from the correct application of land-use planning techniques in the development of new airports. While these benefits should not be overstated, more attention should be given to proper land use planning as a tool. In many instances, though, the benefits may be realized only in the long term, and any solution to the noise problem is also likely to be long range. Efforts to correct situations detrimental to proper land use around airports should however not be ignored simply because of the time required for such measures to be effective. This is particularly true in the application of land use planning to existing airports where it is recognized that the ability to make immediate land-use changes is limited, but where it is also important to prevent further expansion of incompatible land uses.

3.2.6.1 Assessing Noise for Land-Use Planning

The intrusiveness of aircraft noise into airport communities is dependent upon many factors including the following:

- Sound pressure level
- Broadband frequency distribution

– Special irregularities
– Noise duration
– Flight path including take-off and landing profiles
– Number of operations
– operating procedures (such as engine power settings)
– mix of aircraft
– runway utilization
– time of day and year including meteorological conditions

All these factors contribute to the total aircraft noise exposure of the communities.

The response of communities to aircraft noise exposure is dependent upon such factors as:

- Land use
- Building use
- Type of building construction
- Distance from airport
- Ambient noise in the absence of aircraft
- Diffraction, refraction, and reflection of sound due to buildings and topographical and meteorological conditions
- Factors of sociological nature

All these factors contribute to the sensitivity of communities to the airport environment.

Methods for forecasting aircraft noise exposure and predicting community response have been developed:

a) to determine the relative merits of different aircraft operating procedures and runway utilization in reducing aircraft noise exposure;

b) to serve as a guide for airport and community planners in planning land use and building construction in the vicinity of airports.

Noise exposure forecasts are necessary in the development of programmes to limit the total exposure of communities to aircraft noise and to make airport operations and community life mutually compatible. These programmes must coordinate various measures such as the monitoring of noise caused by aircraft movements and the planning and control of land use. Effective programmes can be established only if the basic principle is applied, namely that aircraft noise around an airport should be described, measured and, if necessary, monitored by methods that make due allowance for the effect such noise has upon people.

3.2.6.2 Noise Zones and Associated Maximum Noise

A review of current practices used by States shows that there are two basic approaches to the establishment of noise zones around the airport.

a) The first approach is a broad approach typified by designation of at least two zones. The preference for this approach is due to the accuracy of the techniques used to measure and forecast noise exposure (current accuracy level is believed to be at least 5 dB) and the greater flexibility in application.

b) With the second approach, States favor more than two noise zones because the finer gradation allows for more optimized utilization of the land area around the airports. When applying the zones to existing airports, this approach enables planners to identify the most effective remedial treatments. While the basic accuracy of the noise exposure indices is perhaps coarse, planning authorities compensate for this shortcoming with the finer distinction between zones. There is unanimous agreement that the structure of noise zones must be inherently related to the particular environment where they are applied.

A minimum of two zones should be established for the purpose of land-use planning with regard to aircraft noise in the vicinity of airports: These zones may be subdivided into various noise exposure levels for appropriate land-use planning and other measures by the national or local authorities. Outside these noise zones, restrictions are generally not required. The values of the noise exposure indices, corresponding to the noise zones adopted for land-use planning, should form a logical progression. States use different noise descriptors and noise-exposure calculation methods to determine the noise levels for different land uses. An approximate comparison can be made between the values of the different methods used by States1. However, the materials submitted by the United States (DNL method), the United Kingdom (16H-Leq), France (IP method), Germany (Q method), and the Netherlands (Ke method) indicate that the correlation between the ICAO unit and the units used by States is:

a) strictly limited to a particular situation, e.g. the standard reference situation;

b) only an approximation and is affected by the accuracy of the method used to convert one unit of perceived noise level to another, e.g. the dB(A) and the PNdB when considering the IP method;

c) impossible to establish when the physical properties of sound being measured are basically different (e.g. when comparing the dB(A) and PNdB methods).

3.2.6.3 Risk of Aircraft Accidents around Airports

Airports are centers for air traffic in the air transportation system. Consequently, their presence causes a convergence of air traffic over the area surrounding the airport. For those people living in the vicinity of an airport, this implies involuntary exposure to the risk of aircraft accidents.

Although the public is generally aware of the fact that flying is a very safe mode of transportation and that the probability of an accident is very small, the frequent noise associated with aircraft passing overhead nevertheless acts as a strong reminder of that possibility.

Irrational as they may seem, actual local risk levels around airports are perhaps higher than might be expected. Although the probability of an accident per flight is very low (typically in the order of 1 in 1 000 000), accidents tend to happen mostly during the take-off and landing phases of a flight and hence, close to an airport. The low probability of an accident per movement combined with the large number of movements (typically several hundreds of thousands) may suggest the probability of one accident per year near a large airport. This probability is of course much higher than the better known and smaller probability of being involved in an aircraft accident as a passenger.

Local risk levels around large airports are, in effect, of the same order of magnitude as those associated with participation in road traffic. Because an increase in airport capacity usually involves changes to runway layouts, route structures and traffic distributions which in turn affect the risk levels around the airport, third party risk is an important issue in decision making on airport development.

Major airport development plans, such as building additional runways, almost invariably involve government decision making and public inquiries. Therefore, the public's perception of the local consequences of developments is of paramount importance.

3.2.6.4 Land Uses within Noise Zones and High Risk Zones

Examples of the types of development allowed in the zones may be used as a guide for States contemplating or operating land-use planning schemes. It should however be emphasized that the examples of different development and land uses should be taken only as a broad indication of the relative sensitivity of the activities mentioned to aircraft noise exposure. Other planning considerations, such as the need to provide community services (e.g. schools or hospitals) to communities already established in noise-exposed areas, may allow developments with adequate sound-proofing, etc. in order to maintain the viability of the community. Wherever possible, and particularly when planning the construction of new airports, the location of the airport should be considered as a part of the total planning environment, so that long-term community needs and the consequences of the airport's operation in terms of noise exposure are not in conflict.

3.2.7 Land-Use Control Systems

Various measures are available for controlling the use of land around airports. The effectiveness of these measures for both existing and new airports should be considered on a case-by-case basis. Based on a survey of land-use measures and policies in the countries reviewed, it can be stated that no single strategy prevails over other strategies in dealing with this issue. While land-use control and noise insulation measures are generally transferable from one place to another, the selection of a particular measure or measures over others and the precise manner in which any measure is formulated, applied and financed depend to a great extent on specific national and local circumstances. Overall, land-use control measures can be categorized as:

a) planning instruments, including comprehensive planning, noise zoning, subdivision regulations, transfer of development rights, and easement acquisition;

b) mitigating instruments, including building codes, noise insulation programmes, land acquisition and relocation, transaction assistance, real estate disclosure, and noise barriers;

c) financial instruments, including capital improvements, tax incentives and noise-related airport charges.

3.2.7.1 Planning Instruments

Comprehensive Planning

Comprehensive planning takes into account existing development and ensures that future development is compatible with various community goals. In most countries, the land-use planning and control authority rests with local governmental bodies, which may be obliged or advised to take into account aviation noise measures.

A well worked-out comprehensive plan that is used effectively to guide local land-use decisions and development controls (e.g. zoning, capital improvements planning, subdivision regulations, and environmental review) is among the most powerful and affordable of all compatibility strategies. This is particularly true in still developing areas, but it can also be highly effective in guiding urban renewal or redevelopment. The success of such comprehensive planning depends upon its appropriate implementation through various developmental decisions and controls.

As a land-use control system in relation to airports, comprehensive planning is applied in varying degrees in all the countries surveyed. This strategy appears to be a valuable instrument that is transferable to other countries.

Noise Zoning

Noise zoning for land use serves a two-fold purpose: the protection of the airport and the protection of the residents. It can be applied to existing airports as well as to future airport development. Zoning should take into account anticipated future airport development so that when airport development takes place, interference to the vicinity will be minimal.

Noise zoning enables a national or local government to define the uses for each parcel of land, depending on the level of noise exposure. It generally consists of a zoning ordinance which specifies land development and use constraints, based on certain noise exposure levels. The noise contours extending outward from the airport delineate areas affected by different ranges of noise exposure. No uses other than those specified for a particular area should be permitted.

A single authority should have overall responsibility for developing land-use criteria for use and development of an airport development area. Local zoning and land use should be consistent with these criteria, and the authority should be empowered to make amendments to ensure consistency.

Such a single-authority approach may overcome the problem of multi-jurisdictional interests in the airport environs which has sometimes prevented effective zoning. This of course involves the transfer of zoning powers to some higher governmental level, such as an area wide planning agency or the State, with the designated public agency exercising the authority to ensure compatibility between airports and their neighbors. Local jurisdictions with zoning power (cities, towns or larger administrative units) have rarely taken effective zoning action needed to alleviate the problem of multijurisdictional interests, because a given airport often affects several jurisdictions and the coordination of zoning is difficult. Moreover, zoning has proven extremely vulnerable to development pressures and local politics. Another problem is that the interests of the affected communities are not always consistent with the needs and interests of the airport operator or with those of each other. Within each community, there is usually a desire for a larger tax base, population growth, and rising land values, and these goals are often in conflict with the need to preserve the airport environs for “non-sensitive” activities.

Noise zoning can and should be used constructively to increase the value and productivity of the affected land. One of the primary advantages of zoning is that it may be used to promote land-use compatibility, while still leaving land in private ownership, on the tax rolls, and as economically productive as possible.

Zoning is not necessarily permanent and may be changed, although this may be difficult in some countries because of the local legal system. Zoning is usually not retroactive. Changing zoning primarily for the purpose of prohibiting a use which is already in effect is generally not possible. Where such zoning is allowed, an existing use may be allowed to remain as “nonconforming” until a later date when it is changed voluntarily to a conforming use. For this reason, zoning is most effective at airports that have not yet felt the impact of buildings. Furthermore, the proposed use of vacant land must be related to the market demand for the proposed activities, such as commerce or industry.

Noise zoning around airports is applied in nearly all the surveyed countries as a physical planning measure to prevent new noise-sensitive developments near the airport. However, it is sometimes only applied to the larger or national airport(s). Ideally, noise zoning should be established for all airports.

Subdivision Regulation

Noise zoning ordinances may include subdivision regulations. These regulations may serve as a guide to development in noise-impacted areas by reducing building exposure through orientation and density transfer and by providing open-space requirements.

Subdivision regulations on their own can be useful in minimizing noise impacts on new development. They would not affect existing development. By means of restrictive covenants, the owner is legally notified that the property is subject to noise from aircraft operations. Additionally, a covenant could require buildings to be designed and constructed in such a way as to minimize interior sound derived from exterior noise sources to the acceptable level. This strategy is applied in Canada, Lithuania, the Netherlands, New Zealand, Poland, and some parts of the United States.

Transfer of Development Rights

Under this concept, some of the development rights of a property are transferred to another property that is far from the airport where the rights may be used to intensify the level of allowable development. Landowners could be compensated for the transferred rights by the sale of these rights at new locations or the purchase of the rights by the airport. Depending upon the market conditions and/or legal requirements, the airport could either hold or resell the rights.

The transfer of development rights must be fully coordinated with a community's planning and zoning. It may be necessary for zoning ordinances to be amended in order to permit the transfer of development rights. Such transfers are usually affected within a single jurisdiction. In the United States, some experience has been gained in working with airport operators on the use of this instrument. Lithuania also mentioned this as a useful instrument. However, its transferability to other countries depends upon the prevailing legal systems.

Easement Acquisition

An easement confers the right to use a landowner's property for a limited purpose. In the context of airport noise-compatibility planning, two general types of easements are available:

a) those which permit noise over land; and

b) those which prevent the establishment or continuation of noise-sensitive uses on the subject property.

For maximum effectiveness, easements should restrict the use of land to that which is compatible with aircraft noise levels. Easements should also ensure the right of flight over the property, the right to create noise and the right to prohibit future height obstructions into airspace. Restrictions that may be addressed by such easements include types of buildings, types of agricultural activity that may attract birds, electromagnetic interference, and light emissions.

The first type of easement simply buys the right to make noise over the land, has fewer advantages. It does nothing to change the noise-sensitive character of the land or to reduce noise for people on the property. However, it does legally protect the airport operator from noise litigation, financially compensates property owners for noise, and warns potential buyers that a property is subject to aircraft noise.

The second type of easement can be a highly effective strategy for ensuring compatible development around airports in situations where land is being developed for the first time or is being redeveloped in connection with a land acquisition and relocation strategy or general urban redevelopment programme.

The easement has the advantage of being permanent. It is less costly than outright purchase of land (if the land has not otherwise been purchased) and it allows the land to remain in private ownership, in productive use, and on local tax rolls. This latter type of easement is used most frequently in the United States in combination with noise insulation. Such easements are often required by airport owners in exchange for noise insulation. Easements are possibly amenable to transfer to other countries, depending on the legal system.

3.2.7.2 Mitigating Instruments

Building Codes

Minimum structural construction techniques and material standards often determine whether changes in current standards or the adoption of new standards can increase the interior noise-reduction levels of residential or commercial structures in noise-impacted areas. Building codes are essentially a legal means of requiring the incorporation of adequate sound insulation in new construction. Any noise-insulation strategy depends upon a closed-in structure for maximum effectiveness, and this in turn usually raises the issues of adequate ventilation and air conditioning in warm weather. Building codes are usually applied in most countries.

Noise Insulation Programmes

Noise insulation can lower interior noise levels for structures that cannot reasonably be removed from noise exposed areas (e.g. residential buildings). Noise insulation is particularly effective for commercial buildings, including offices and hotels. However, it is much more desirable to control insulation requirements for such buildings from the outset, if they must indeed be constructed in noise-exposed areas. While there may be difficulties in getting sound insulation requirements incorporated in building codes for new construction, these are slight compared with the problems of effective sound-proofing for existing buildings, particularly housing. Even if houses in high-noise areas were made of stonework, insulation and air conditioning may cost more than the value of the additional rent or sales' prices. The degree of insulation requirements varies from country to country. In some countries the acceptable level of interior noise is prescribed by legislation.

A noise-insulation programme should be preceded by a structural and acoustical survey of all homes and other buildings earmarked for noise insulation. The cost of noise insulation can range from the equivalent in U.S. dollars of $2 000 to $50 000 per dwelling, depending upon several variables, such as the degree of insulation required (from insulating the attic only to insulating all exterior walls and ceilings and upgrading doors and windows), size and condition of the building, and location within the noise-exposure area.

For effective noise insulation, it is necessary to have a closed-window condition, which may not be desirable to home owners in all seasons and which imposes additional ongoing costs to home owners for climate-control systems. The major drawback to noise insulation is that it does nothing to mitigate noise outdoors. This drawback however does not apply as much to schools, hotels, commercial structures, or even large apartment buildings; because they are frequently constructed with a closed-window condition and their activities usually take place indoors.

Insulation programmes for noise-affected dwellings around airports (mostly in coordination with noise zoning) are applied in: Australia, Denmark, France, Germany, Ireland, Japan, the Netherlands, Latvia, New Zealand, Norway, Poland, Republic of Korea, Spain, Switzerland, the United Kingdom, and the United States.

Noise insulation appears to be transferable to other countries. However, in Greece and Italy, for example, noise insulation is not considered to be an adequate measure due to the warm climate which leads people to leave their windows opens (Doc 9184 AN/902 ICAO, 2002).

Land Acquisition and Relocation

This strategy involves the acquisition of land through purchase by the airport operator (or planning authority in case of new developments) and the relocation from the acquired land of residences and businesses that are not compatible with airport-generated noise levels. This strategy is within the direct control of the airport operator (or planning authority) and does not require additional action by another political entity.

Land acquisition and relocation assure an airport of long-term land-use compatibility. Acquired land can be cleared, sold with easements (to control future development), and redeveloped for compatible land uses. However, this strategy is not a practical solution to the total noise problem because it is costly and socially disruptive to buy all significantly noise-impacted land.

Land acquisition and relocation have been widely used in the United States by airport operators as the ultimate solution to land-use compatibility in certain areas with significant noise exposure.

Transaction Assistance

Transaction assistance involves some level of financial and technical assistance to a home owner who is trying to sell a noise-impacted property. It may involve paying realtors' fees. In extreme cases, an airport actually buys properties which have been on the market for an extended period of time and then resells them. In order to become compatible with noise levels, the properties are noise-insulated prior to resale and usually resold with an easement. This strategy can be useful in areas where it has been decided that existing residential neighborhoods will e maintained. It can also be less expensive than other acquisition strategies. Home owners are sometimes given a choice of noise insulation/easement or transaction assistance. These choices enable those people most annoyed by noise to leave the area and prevent the airport authorities or developers from having to buy out everyone.

Transaction assistance is a comparatively new programme in the United States. It has not yet been comprehensively evaluated as a strategy in comparison to noise insulation/easement alone. It does appear, however, to offer more flexibility to property owners. Transaction assistance is also applied in Australia and in some

European countries, e.g. Germany (around Düsseldorf Airport) and the Netherlands (Doc 9184 AN/902 ICAO, 2002).

Real Estate Disclosure

The preparation of real estate disclosure notices is a common practice in cases where environmental regulations and issues affect development. Identification of the aviation noise impact on real estate may foster an awareness of airport/community relationships and serve notice to prospective buyers of potential disturbances caused by aircraft noise.

Incumbent property owners and realtors are often opposed to real estate disclosure because it makes it more difficult to sell noise-impacted property. It does not reduce the noise impact or the non-compatible land use. Instead, it may deter buyers who are the most sensitive to noise. Still, real estate disclosure ensures that a buyer who purchases a noise-impacted property is fully aware of the property’s noise condition so that the buyer does not become a noise complainant or noise litigant in the future.

The strategy is used in the United States, sometimes in combination with an easement or an appropriate release with respect to noise from the buyer. The advantages of this strategy are its relatively low cost and its retention of otherwise viable residential areas. Real estate disclosure with respect to noise impact appears to be transferable to other countries.

Noise Barriers

Noise barriers consist of earthen berms or man-made barriers on the ground which are located between sources of loud ground-level noise at the airport and very close-in, noise-sensitive receptors. Noise barriers must be both structured and positioned accurately to provide any meaningful relief. They are of limited use at airports except for ground-running operations, etc. and do not mitigate in-flight noise. However, they do appear to have a psychological benefit — people tend to hear less noise if they don’t see the aircraft on the ground or the maintenance facility that is the source of the noise. It is also particularly beneficial to install earthen berms for visual appeal. A proper positioning of airport buildings can also function as a noise screen for adjacent communities.

Noise barriers are used in Denmark, France, Germany, Japan, the Netherlands, Norway, Poland, Republic of Korea, Switzerland, the United Kingdom and the United States, as well as in many other countries in specific cases (Doc 9184 AN/902 ICAO, 2002).

3.2.7.3 Financial Instruments

Capital Improvements Planning

Development can be stimulated or discouraged by the presence or absence of an infrastructure network, which typically includes roads and utilities (power, gas, water and sewer). Other community facilities and services, such as schools, police, and fire service, also tend to promote development. Capital improvements can be planned in order to locate infrastructure in areas where industrial and commercial growth would be compatible. This strategy can also discourage certain types of growth, such as residential development, from areas that are deemed incompatible for such use. Similarly, the capital improvements programme can be developed to encourage noise-tolerant land uses with appropriate types, size, and locations of infrastructure in the noise-impacted areas.

This strategy may be appropriate for directing new development or extensive urban redevelopment. It is however not useful when the impacted areas are fairly well developed and already have adequate infrastructure. There may also be legal impediments to using this strategy when infrastructure improvements are required as part of the development plan. The strategy is applied in Latvia, Poland, Republic of Korea, Spain, and in some parts of the United States (Doc 9184 AN/902 ICAO, 2002).

Capital improvements planning, to the extent that it is useful, may be amenable to transfer to other countries, particularly developing countries.

Tax Incentives

Tax incentive programmes are often used to promote noise-insulation improvements. The strategy is to provide tax incentives to existing incompatible uses in order to encourage structural improvements which would reduce interior noise levels.

Additional tax incentive programmes may be instituted by governmental bodies as a means of redeveloping specific areas. For instance, a designated blighted zone or foreign trade zone can be a catalyst for redevelopment.

Various tax incentives, such as reduction or elimination of property taxes, may also be introduced (usually to private industry) to encourage relocation or expansion of industry as a means to increase the local ad valorem tax base or to diversify the local economy.

Tax reduction or differential tax assessment can be offered as incentives for development in specific areas. For example, development of noise-tolerant uses in areas subject to higher noise levels can be encouraged, which may consequently discourage other noise-sensitive uses. Industrial development is particularly sensitive to taxation systems and is more affected by taxation than residential or commercial development. This type of strategy typically requires input and support from the local economic development agency in terms of designation of areas, and planning and zoning coordination with regard to compatibility and appropriate zoning issues.

In Canada and the United States, this strategy is applied in some cases, but the value of tax incentives for compatible land-use purposes has not been evaluated. There is also little information regarding its use and effectiveness. In some other countries (e.g. the Netherlands), the housing tax depends on the location of the house and the quality of its environs. Noise and less attractive surroundings would thus imply a lower level of the housing tax (Doc 9184 AN/902 ICAO, 2002).

Noise-related Airport Charges

Noise-related airport charges may be levied by airports with noise problems in order to recover the costs incurred for the alleviation or prevention of noise. The costs recovered should not exceed the costs incurred. The application of noise-related charges should follow the principles for such charges developed by ICAO and contained in the ICAO's "Policies on Charges for Airports and Air Navigation Services". There are various systems of noise-related airport charges. One system divides all aircraft into several categories according to the noise production and determines the airport charge. Another system returns part of the landing fee if the aircraft meets certain noise criteria. A third system levies extra noise charges on top of the normal landing fee based on the noise production of the aircraft. In some countries, extra charges are levied on night operations because of the additional disruption during night hours.

There may be competitive implications for is charges, either between airports or States. Noise-related charges are applied at some airports; in Australia, Belgium, France, Germany, Japan, the Netherlands, Latvia, Norway, Republic of Korea, Sweden, Switzerland, the United Kingdom and the United States (Doc 9184 AN/902 ICAO, 2002).

3.3 ECAC.CAEC Doc.29

This document describes the major aspects of the calculation of noise contours for air traffic at an airport. It is primarily intended to be applied to civil, commercial airports, where the aeroplanes in operation are mostly either jet-engine powered or propeller driven heavy types. If appropriate noise and performance data are available for propeller-driven light aeroplanes, these may also be included in the evaluation.

3.3.1 Aircraft Noise Modeling

The second volume of ECAC document is a technical guide for modelers who can develop and maintain the computer models and their databases. It fully describes a specific noise contour modeling system which is considered by ECAC. It does not prescribe a computer programme but rather the equations and logic that need to be programmed to construct a physical 'working model'. Any physical model that complies fully with the methodology described can be expected to generate contours of aircraft noise exposure around civil airports with reasonable accuracy. The methodology can be described as given in Figure 3.3.

This guidance represents a major advance in three important respects. Firstly, it comprises entirely new detailed guidance on the practical implementation of aircraft noise contour modeling, especially regarding the extreme importance of correctly representing aircraft types and their operating configurations and procedures. Secondly it describes up-to-date algorithms that incorporate the latest internationally agreed advances in segmentation modeling.

There are a number of noise-generating activities on operational airports which are excluded from the 'air noise' calculation procedures given here. These include taxiing, engine testing and use of auxiliary power-units, and their noise generally comes under the heading of ground noise. In practice, the effects of these activities are unlikely to affect the noise contours in regions beyond the airport boundary. This does not necessarily mean that their impact is insignificant; however assessments of ground noise are usually undertaken independently of air noise analyses.

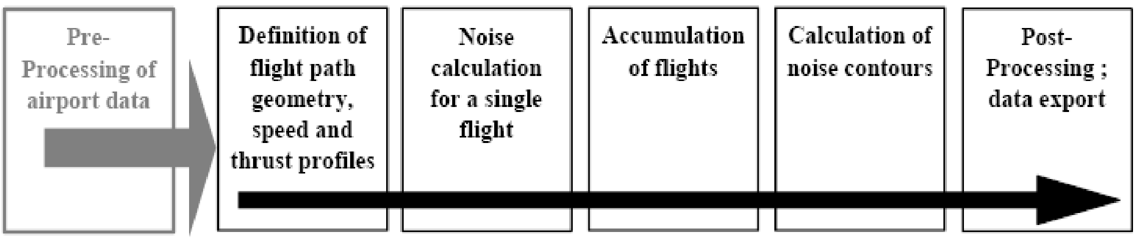

Figure 3.3 The noise contour generation process

3.3.1.1 The Concept of Segmentation

For any specific aircraft, the database contains baseline Noise-Power-Distance (NPD) relationships. These define, for steady straight flight at a reference speed in specified reference atmospheric conditions and in a specified flight configuration, the received sound event levels, both maximum and time integrated, directly beneath the aircraft as a function of distance. For noise modelling purposes, the all-important propulsive power is represented by a noise-related power parameter; the parameter generally used is corrected net thrust. Baseline event levels determined from the database are adjusted to account for, firstly, differences between actual (i.e. modelled) and reference atmospheric conditions and (in the case of sound exposure levels) aircraft speed and, secondly, for receiver points that are not directly beneath the aircraft, differences between downwards and laterally radiated noise. This latter difference is due to lateral directivity (engine installation effects) and lateral attenuation. But the event levels so adjusted still apply only to the total noise from the aircraft in steady level flight.

Segmentation is the process by which the recommended noise contour model adapts the infinite path NPD and lateral data to calculate the noise reaching a receiver from a non-uniform flight path, i.e. one along which the aircraft flight configuration varies. For the purposes of calculating the event sound level of an aircraft movement, the flight path is represented by a set of contiguous straight-line segments, each of which can be regarded as a finite part of an infinite path for which an NPD and the lateral adjustments are known. The maximum level of the event is simply the greatest of the individual segment values. The time integrated level of the whole noise event is calculated by summing the noise received from a sufficient number of segments, i.e. those which make a significant contribution to the total event noise.

The method for estimating how much noise one finite segment contributes to the integrated event level is a purely empirical one. The energy fraction F – the segment noise expressed as a proportion of the total infinite path noise – is described by a relatively simple expression which allows for the longitudinal directivity of aircraft noise and the receiver's 'view' of the segment. One reason why a simple empirical method is generally adequate is that, as a rule, most of the noise comes from the nearest, usually, adjacent segment – for which the closest point of approach (CPA) to the receiver lies within the segment (not at one of its ends). This means that estimates of the noise from non-adjacent segments can be increasingly approximate as they get further away from the receiver without compromising the accuracy significantly.

3.3.1.2 Flight Paths: Tracks and Profiles

In the modeling context, a flight path (or trajectory) is a full description of the motion of the aircraft in space and time. Together with the propulsive thrust (or other noise related power parameter) this is the information required to calculate the noise generated. The ground track is the vertical projection of the flight path on level ground. This is combined with the vertical flight profile to construct the 3-D flight path. Segmentation modeling requires that the flight path of every different aircraft movement is described by a series of contiguous straight segments. Each segment has to be defined by the geometrical coordinates of its end points and the associated speed and engine power parameters of the aircraft (on which sound emission depends). Flight paths and engine power may be determined in various ways, the main ones involving (a) synthesis from a series of procedural steps and (b) analysis of measured flight profile data.

Synthesis of the flight path (a) requires knowledge of (or assumptions for) ground tracks and their lateral dispersions, aircraft weight, speed, flap and thrust-management procedures, airport elevation, and wind and air temperature.

In an ultimate noise modeling application, each individual flight could, theoretically, be represented independently; this would guarantee accurate accounting for the spatial dispersion of flight paths - which can be very significant. (ECAC.CEAC Doc29, 1997).

3.3.1.3 Airport and Aircraft Operations

3.3.1.3.1 General Airport Data. The aerodrome reference point (simply to locate the aerodrome in appropriate geographic co-ordinates). The reference point is set as the origin of the local Cartesian co-ordinate system used by the calculation procedure.

− The aerodrome reference altitude (= altitude of aerodrome reference point). This is the altitude of the nominal ground plane on which, in the absence of topography corrections, the noise contours are defined.

− Average meteorological parameters at or close to the aerodrome reference point (temperature, relative humidity, average wind speed and wind direction).

3.3.1.3.2 Runway Data. For each runway:

- Runway designation
- Runway reference point (centre of runway expressed in local co-ordinates)
- Runway length, direction and mean gradient
- Location of start-of-roll and landing threshold3. Datasheets for runway data representation

3.3.1.3.3 Ground Track Data. Aircraft ground tracks have to be described by a series of coordinates in the (horizontal) ground-plane. The source of ground track data depends on whether relevant radar data are available or not. If they are, a reliable backbone track and suitable associated (dispersed) sub-tracks can be established by statistical analysis of the data. If not, backbone tracks are usually constructed from appropriate procedural information, e.g. using standard instrument departure procedures from Aeronautical Information Publications. This conventional description includes the following information:

- Designation of the runway the track originates from
- Description of the track origin (start of roll, landing threshold)
- Length of segments (for turns, radius and change of direction)

This information is the minimum necessary to define the core (backbone) track. But average noise levels calculated on the assumption that aircraft follow the nominal routes exactly can be liable to localized errors of several decibels. Thus lateral dispersion should be represented, and the following information of the width of the swathe (or other dispersion statistic) at each segment end is necessary.

3.3.1.3.4 Air Traffic Data. Air traffic data are

− The time period covered by the data and

− The number of movements (arrivals or departures) of each aircraft type on each flight track, subdivided by (1) time of day as appropriate for specified noise descriptors, (2) for departures, operating weights or stage lengths, and (3), if necessary, operating procedures.

Most noise descriptors require that events (i.e. aircraft movements) are defined as average daily values during specified periods of the day (e.g. day, evening and night).

3.3.1.3.5 Topographical Data. The terrain around most airports is relatively flat. However this is not always the case and there may sometimes be a need to account for variations in terrain elevation relative to the airport reference elevation. The effect of terrain elevation can be especially important in the vicinity of approach tracks, where the aircraft is operating at relatively low altitudes.

Terrain elevation data are usually provided as a set of (x,y,z) co-ordinates for a rectangular grid of certain mesh-size. But the parameters of the elevation grid are likely to be different from those of the grid used for the noise computation. If so linear interpolation may be used to estimate the appropriate z-co-ordinates in the latter.

Comprehensive analysis of the effects of markedly non-level ground on sound propagation is complex and beyond the scope of this guidance. Moderate unevenness can be accounted for by assuming ‘pseudo-level’ ground; i.e. simply raising or lowering the level ground plane to the local ground elevation (relative to the reference ground plane) at each receiver point.

3.3.1.3.6 Reference Conditions. The international aircraft noise and performance (ANP) data are normalized to standard reference conditions that are widely used for airport noise studies.

<u>Reference conditions for NPD (Noise-Power-Distance data)</u>

❖ Atmospheric pressure:	101.325 kPa (1013.25 mb)
❖ Atmospheric absorption:	Attenuation rates
❖ Precipitation:	None
❖ Wind Speed:	Less than 8 m/s (15 knots)
❖ Groundspeed:	160 knots
❖ Local terrain:	Flat, soft ground free of large structures or other reflecting objects within several kilometers of aircraft ground tracks.

Standardized aircraft sound measurements are made 1.2 m above the ground surface.

Comparisons of estimated and measured airport noise levels indicate that the NPD data can be assumed applicable when the near surface average conditions lie within the following envelope:

a) Air temperature less than 30 °C

b) Product of air temperature (°C), and relative humidity, (percent) greater than 500

c) Wind speed less than 8 meters per second (15 knots)

This envelope is believed to encompass conditions encountered at most of the world's major airports.

Reference conditions for aeroplane aerodynamic and engine data:

- ❖ Runway Elevation: Mean sea level
- ❖ Air temperature: 15 °C
- ❖ Takeoff gross weight: As defined as a function of stage length in the ANP (Aircraft Noise and performance Database)database (http://aircraftnoisemodel.org)
- ❖ Landing gross weight: 90 percent of maximum landing gross weight
- ❖ Engines supplying thrust: All

3.3.1.4 Description of the Flight Path

A noise model requires that each different aircraft movement is described by its three-dimensional flight path and the varying engine power and speed along it. As a rule, one modeled movement represents a subset of the total airport traffic, e.g. a number of (assumed) identical movements, with the same aircraft type, weight and operating procedure, on a single ground track.

3.3.1.4.1 Relationships Between Flight Path and Flight Configuration. The three-dimensional flight path of an aircraft movement determines the geometrical aspects of sound radiation and propagation between aircraft and observer. At a particular aircraft weight and in particular atmospheric conditions, the flight path is governed entirely by the sequence of power, flap and attitude changes that are applied by the pilot (or automatic flight management system) in order to follow routes and maintain heights and speeds specified by ATC - in accordance with the aircraft operator's standard operating procedures. These instructions and actions divide the flight path into distinct phases which form natural segments. In the horizontal plane they involve straight legs, specified as a distance to the next turn, and turns, defined by radius and change of heading. In the vertical plane, segments are defined by the time and/or distance taken to achieve required changes of forward speed and/or height at specified power and flap settings. The corresponding vertical coordinates are often referred to as profile points.

For noise modeling, flight path information is generated either by synthesis from a set of procedural steps (i.e. those followed by the pilot) or by analysis of radar data - physical measurements of actual flight paths flown. Whatever method is used, both horizontal and vertical shapes of the flight path are reduced to segmented forms. Its horizontal shape (i.e. its 2-dimensional projection on the ground) is the ground track defined by the inbound or outbound routing. Its vertical shape, given by the profile points, and the associated flight parameters speed, bank angle and power setting, together define the flight profile which depends on the flight procedure that is normally prescribed by the aircraft manufacturer and/or the operator. The flight path is constructed by merging the 2-D flight profile with the 2-D ground track to form a sequence of 3-D flight path segments.

3.3.1.4.2 Source of Flight Path Data

3.3.1.4.2.1 Radar Data. Although aircraft flight data recorders can yield very high quality data, this is difficult to obtain for noise modeling purposes and radar data must be regarded as the most readily accessible source of information on actual flight paths flown at airports. As it is usually available from airport noise and flight path monitoring systems, it is now used increasingly for noise modeling purposes. However the analysis of radar data is a complex task for which methods are still under development.

3.3.1.4.2.2 Procedural Steps. In many cases is not possible to model flight paths on the basis of radar data - because the necessary resources are not available or because the scenario is a future one for which there are no relevant radar data.

In the absence of radar data, or when its use is inappropriate, it is necessary to estimate the flight paths on the basis of operational guidance material, for example instructions given to flight crews and aircraft operating manuals - referred to here as procedural steps. Advice on interpreting this material should be sought from air traffic control authorities and the aircraft operators where necessary (ECAC.CEAC Doc29, 1997).

In Table 3.1 there is a summary of the reviewed standards with their main contents.

Table 3.1 Summary of international aviation standards

ICAO **ANNEX 14**	
Aerodrome Design and Operations– Airport Planning	
	1. Determination of the Required Land Area
	2. Factors Affecting Airport Location
	3. Office Study of Possible Sites
	- Site Inspection
	- Environmental Study
	- Review of Potential Sites
	- Preparation of Outline Plans and Estimates of Costs and Revenues
	- Final Evaluation and Selection
	- Report and Recommendations
Land Use and Environmental Control	
	1. Airport and its Environs
	2.Need for Environmental Control
	3.Need for Land use Planning
	4.Environmental Impacts Associated with Aviation Activities
	- Aircraft Noise
	- Air Quality
	- Water and Soil Pollution
	- Waste
	- Environmental Problems Arising from Aircraft Accident/Incident
	5. Environmental Consequences and Control Measures
	- Noise Abatement
	- Air Pollution Control
	- Water Pollution Control
	- Waste Management
	- Energy Management
	- Environmental Emergencies
	- Environmental Impact Assessment of Airport Development
	- Environmental Management
	6. Land-Use Planning
	- Assessing Noise for Land-Use Planning
	- Noise Zones and Associated Maximum Noise
	- Risk of Aircraft Accidents around Airports
	- Land Uses within Noise Zones and High Risk Zones
	7. Land-Use Control Systems
	- Planning Instruments
	- Mitigating Instruments
	- Financial Instruments
ECAC.CAEC Doc.29	
Aircraft Noise Modeling	**1. Concept of Segmentation**
	2. Flight Paths: Tracks and Profiles
	3. Airport and Aircraft Operations
	- General Airport Data
	- Runway Data
	- Ground Track Data
	- Air Traffic Data
	- Topographical Data
	- Reference Conditions
	4. Description of the Flight Path
	- Relationships between Flight Path and Flight Configuration
	- Source of Flight Path Data (Radar Data,Procedural Steps)

CHAPTER FOUR
ENVIRONMENTAL MANAGEMENT AT CONSTRUCTION AND OPERATION PHASES FOR AN AIRPORT

This chapter is a review of the environmental management at an airport for construction and operation phases. The environmental issues in this part are mainly about land use, soil erosion, impacts on surface and subsurface water drainage, and the impact on flora and fauna. Environmental problems do not exist when a new airport is being developed. These problems also exist when airport operations are continuing or when an airport is being expanded. Each airport may have different problems related to the area at which the airport exists.

Soil erosion problems can generally be prevented by replanting; however, in arid areas it can be necessary to take artificial erosion protection measures, such as facing of escarpments, paving of taxiway shoulders and lining of drains.

During construction phases of airports special consideration should be given to possible water pollution. Construction activities likely to cause stream pollution include clearing, grubbing and pest control. For instance, the clearing of vegetation generally results in greater soil erosion into streams. Pest control, particularly the use of sprays, can introduce long-life toxic chemicals into the water. Fuel spillages from equipment and chemicals used in building and pavement construction work can disrupt the hydrological balance of waterways in the area. Changes to the natural drainage patterns of an area due to the construction of an airport can overload certain streams and give rise to flooding. Diversion of flow may cause streams to dry up.

The sitting of some airports may interfere with the shorelines of rivers, lakes and the sea. In planning such airports, careful consideration should be given to possible environmental problems associated with water currents, silt deposits, impacts on marine or fresh water life and marine or stream erosion.

The utilization of land for airport purposes can also cause disturbances to flora and fauna. Airport development work frequently entails clearing and cutting back of trees and other vegetation, changes to the topography of the area, and interference with watershed patterns. Thus airports may destroy the natural habitat and feeding grounds of wildlife and may deplete certain flora that is vital to the ecological balance of the area.

There are also potential impacts on human beings. For example, airport construction may destroy sources of food or firewood, or may cause agricultural land loss that is a major concern in certain areas of the world.

An important consideration related to airport operational safety is the prevalence and habits of birds in the area and the associated risk of aircraft bird strikes. Bird hazards at proposed new airports can be minimized by careful selection of the site to avoid established bird migration routes and areas naturally attractive to birds and by using the land surrounding the airport for purposes which will not attract concentrations of birds to the area. At existing airports, the bird problem may be controlled by scaring techniques and by making the airport and its environment unattractive to birds. The subject of bird strike reduction is also covered in detail in the Airport Services Manual Part 3, Bird Control and Reduction (ICAO Doc. 9137, 1999).

As far as these environmental problems are concerned, airport construction is not significantly different from any large construction site. In many countries, the issue is governed by general legislation on planning and development of construction sites.

4.1 Environmental Management System

Airports like other organizations are becoming more concerned about achieving an environmental performance by controlling the impact of their activities, products or services on the environment. The regulations are very stringent nowadays. The economic policies are more carefully developed to foster environmental protection.

Public and stakeholders are aware about the environmental matters related to airport construction and operation stages.

The environmental management activities of an airport can be divided into three basic categories:

a) Environmental awareness
b) Planning and monitoring
c) Remedial measures

Environmental awareness programme is to promote increased environmental consciousness and to make individuals aware of their own environmental protection responsibilities. This is very important in decision making and in the day-to-day work of the airport. The programme is generally accomplished through employee education, training and incentives.

Most of the environmental activities at airports involve planning and monitoring, including:

a) Environmental assessments
b) Monitoring and compliance
c) Environmental audits
d) Environmental emergency contingency plans

The environmental assessment process is an important part of the project design. Mitigation of environmental impacts should be made an integral part of the planning process.

Monitoring and compliance programmes assess air quality, water quality, soil and ground water quality, noise levels, etc. These programmes are used to detect problems in the early stage before environmental impacts become significant and to identify the source of the problem.

Periodic audits should be undertaken in order to provide an assessment of the environmental issues of construction and operation stages. These audits will help to determine the degree of compliance with applicable regulations, guidelines. The audits also are useful to assess whether or not the monitoring and compliance programmes are functioning properly and to identify any problems not previously detected. They provide the basis for action plans. In addition, such audits are valuable tools for identifying opportunities for enhancing environmental management practices as a whole.

These changing conditions have led several organizations to carry out environmental reviews or audits to assess their environmental performance. For an effective way, these reviews have to be conducted within a structured management system. The ISO 14001 Standard provides organizations an effective environmental management system, which can be integrated with other management systems, to assist them in achieving their environmental and economic goals.

The Environmental Management System known as EMS (ISO 14001, 1996) is part of the overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy. EMS is seen as the best method to incorporate environmental management into all levels of corporate operations and decision making processes.

Some of the benefits of implementing an EMS programme include:

a) the long-term economic benefit of balancing and integrating economic and environmental interests
b) reduced costs associated with third party audits
c) enhanced compliance with environmental legislation
d) competitive advantage with customers who prefer or require ISO 14001 certification
e) consolidation of all environmental programmes into one coherent system
f) increased flexibility to changing circumstances

Airports in general have an obligation to protect the environment by evaluating the impacts of their policies and regulatory decisions on the environment and by promoting and meeting environmental standards while serving the public to optimal satisfaction and safety. By adopting ISO 14001 Standards and implementing an EMS, it is expected that airports will make a major push towards achieving environmental standards and objectives (ICAO Doc 9184 AN/902, 2002).

In the paragraphs below there are some examples of airports environmental management systems.

4.1.1 Darwin International Airport (DIA)

At DIA, the environmental strategy is designed to provide a leading edge environmental management approach for Darwin International Airport. Specific objectives of the environmental strategy are:

- Establish and maintain an Environmental Management System that is consistent with the ISO 14001 series
- Establish clear environmental objectives and targets for all Airport operations
- Establish environmental management committees and workgroups
- Define clear responsibilities and conduct training for staff and contractors in upholding the objectives of the Environmental Management System and to ensure that appropriate authority and resources are provided to effectively meet environmental targets
- Inform all new and existing staff and contractors working within the Airport environs of their environmental responsibilities;
- Maintain systems that will identify legal and other requirements that apply to environmental management
- Establish procedures for the control, reduction or prevention of pollution caused by Airport activities
- Provide programs for monitoring and reporting of pollution within the Airport

- Establish and maintain systems to ensure compliance with all requirements of the Act, Regulations and the Environmental Management System
- Establish clearly defined contingency plans for dealing with accidents and emergencies and to ensure adequate training of staff;
- Ensure non-conformances are detected, investigated and documented and that corrective and preventative action procedures are adopted;
- Establish a system of ongoing auditing of the Environmental Management System to as certain compliance with the objectives
- Ensure periodic review of the Environmental Management System to ensure its continuing suitability, adequacy and effectiveness
- Involve the local community and Airport users in the development of future strategies
- Ensure sub-lessees, licensees and other Airport users commit to environment strategies
- To encourage the local community to support the strategy

The main issues that are managed at DIA are storm water and erosion control, soil and groundwater pollution control, effects on flora and fauna, air quality and noise control, waste management, energy efficiency, airport bird hazard and vector control. (Darwin International Airport Final Environment Strategy, 1999).

4.1.2 Melbourne Airport

At 2003 a five-year Environment Strategy was developed and implemented by Melbourne Airport which was approved by the Minister for Transport and Regional Services in late August 2003. Melbourne was the first airport in Australia who has the ISO 14001 management system at 2004. Waste minimization, water and energy efficiency, flora, fauna and cultural heritage protection (especially during construction), noise, environmental incident control and waste management are the main issues controlled and managed at Melbourne Airport (Public Environment Report2003/2004, Australia, 2005).

In 2012, Melbourne Airport has participated in the State Government's Electric Vehicle trial to assess different technology. From December 2010 to March 2011, Melbourne Airport staff has successfully trialed the electric vehicle to assess the viability of electricity as an alternative fuel source. Melbourne has also upgraded its waste management systems with all bins within Melbourne's car parks now meeting the new Australian Standards through improved lid color, signage and public awareness on recycling. This has resulted in a significant increase in the amount of waste diverted from landfill to recycling with a current level of 27 % waste diversion from landfill across Melbourne Airport.

Melbourne Airport is continuing to work collaboratively with key environmental stakeholders including the Federal Government's Airport Environment Officer, business partners, local councils and the community (Australia Pacific Airports Corporation Annual Report 2011, Australia, 2012).

4.1.3 Vancouver International Airport

Vancouver International Airport (Canada) has an Environmental Management Plan approved in 2004. The Airport Authority's policy provides definition to be excellence in environmental performance to keep excellence in safety, security, and environmental performance as their first priority. The Authority's Environmental Policy provides full support to the environmental aspects of sustainability through actions of continual improvement, including:

- Minimizing risk and contributing to improved economic performance through the implementation of environmental plans and programs
- Exceeding or complying with all applicable environmental laws and regulations
- Promoting open discussions among all stakeholders about the environmental aspects of operations and developments
- Making informed choices that consider environmental, social and economic implications
- Training, supporting and motivating employees and business partners to be aware of and meet their environmental responsibilities

- Setting specific measurable environmental objectives and targets

The Environmental, Health and Safety Management System identify key areas of risk or opportunities which become the basis for the development of environmental programs. They believe that good environmental performance contributes to good economic performance. The programs are managed by the Environment Department in conjunction with other Airport Authority departments and cover a number of areas, including:

- Aeronautical Noise
- Air Quality
- Contaminated Sites
- Environmental Impact Assessment
- Hazardous Materials
- Natural Habitat
- Resource Efficiency
- Recycling
- Water Quality.

  (Vancouver International Airport Environmental Management Plan, 2005).

4.1.4 Oakland International Airport

Oakland International Airport takes a leadership role in promoting a sustainable operating environment. That means at current day-to-day operations or forecasting future needs and requirements.

The Port of Oakland is an independent department of the city of Oakland and is required to do its part to be a good neighbor, an environmental steward, and a responsible business operator in its efforts to support the city’s sustainability goals. Through its efforts, the Port of Oakland contributed to the recent recognition of the city of Oakland as one of the best examples of urban sustainability at the 2005 United Nations World Environment Day conference in San Francisco.

Oakland International Airport supports this policy through a variety of environmental programs:

- Air Quality and Alternative Fuels
- Construction Mitigation
- Noise Abatement
- Recycling/Waste Reduction
- Water Quality/Storm water Program
- Water and Wetlands
- Wildlife Management (http://oaklandairport.com).

4.1.5 Auckland International Airport

Auckland International Airport is one of New Zealand's largest businesses. It has developed Environmental Policy Goals to meet specific environmental objectives. These goals are:

- Storm water
- Groundwater
- Aircraft noise
- Air quality
- Conserve and promote recycling
- Wildlife management
- Community interests
- Greening the airport

(http://aucklandairport.co.nz/Corporate/Social-Responsibility/Sustainability-policy/Environmental-management.aspx).

4.1.6 Athens International Airport

Athens International Airport is an airport with an Environmental Department certified according to EN ISO 14001 since December 2000. The Environmental Management System sets up the framework, for the achievement of the department's annual environmental targets and ensures a high level of environmental services of the Airport. Overall, the Environmental Services Department is committed to comply with the current environmental legislation and other requirements in order to ensure continual improvement of the department's environmental activities. The Environmental Services Department performs an extensive environmental audit program that aims to ensure:

- Compliance with environmental legislation
- Consistency with the implementation of each company's Environmental Management Plan
- Compliance with the department's guidelines. Airport's daily inspections take place in order to identify any areas of non-compliance **(**http://athensairport.com).

4.1.7 Munich Airport

Munich Airport is working constantly to sustain levels of environmental performance beyond statutory requirements and to actively avoid and reduce environmental impact and risks. They focus their processes on sustainability. The staff is motivated for forward-thinking and being an innovative company in terms of environmental stewardship and they provide a platform for trials of new environmental technologies. Environmental awareness for their employees is an important issue. They are in constant contact with the airport's neighbors to ensure active and effective communication with local communities on environmental issues and concerns. Through close collaboration with customers and contractual partners, the aim is to achieve higher environmental standards throughout the airport. Munich Airport also plays an active part in national and international working groups and organizations in order to promote greater awareness of new and advanced environmental thinking. They are working constantly to reduce aviation emissions and noise. The main issues are given below:

- Air traffic noise monitoring
- Engine testing hangar
- Air quality monitoring
- Water management
- Waste management

- Fuel supply
- Landscape planning (http://munich-airport.de).

The State of Bavaria assisted the ARGEMUC Munich Airport Hydrogen Project with 11 partners in the Project organization. The purpose was to test the feasibility of hydrogen as an energy source for road traffic under operating conditions. The airport has hosted this project since 1999. Besides providing the site for a hydrogen filling station, FMG has been operating three hydrogen powered passenger buses, and supplies the power used in the electrolytic hydrogen production process (Munich International Airport Annual Report 2002, 2003).

The environmental management system of Munich Airport was certified in 2005. The system was declared to be in compliance with DIN ISO 14001:2004 and the European EMAS Ordinance 761/2001. In the course of the system launch, a legal audit was carried out and all environmental regulations were assembled and subjected to a structured review. For this purpose, all direct and indirect environmental impacts of the airport's operations were identified and evaluated. This includes the utilization of energy, fuel and water, as well as the effects of aircraft noise and pollution emissions of aircraft and road traffic. All internal processes were described and documented in an environmental management handbook. The environmental declaration required by EMAS includes the public disclosure of the company's environmental policy. To reduce environmental pollution, a catalog of measures for Munich Airport has been developed. For example, the airport plans to reduce harm to groundwater through de-icing agents and reduce the fuel consumption of ground service vehicles. Another environmental objective is to persuade airlines to use quieter aircraft by offering staggered discounts on landing fees for modern jets (http://munich-airport.de).

4.1.8 Stockholm Arlanda Airport

The environmental impact of air travel is of critical importance to the aviation industry and thus to Swedavia Group. Swedavia Group gives high priority to reducing emissions of greenhouse gases, minimizing energy use, working to achieve resource-efficient operations and reducing emissions to the ground and water. Arlanda Airport handles chemicals responsibly and strives to replace chemicals that are hazardous to the environment with less harmful ones. Waste is minimized in three ways – first by preventing waste production, second by reusing products and third by recycling materials and energy (Swedavia Annual Report 2010, 2011).

Several Airports can be given in this section as an example for environmental management throughout the world. In a global view, the most important issue for aviation is climate change as it is for each industry. More details are given in Chapter 5 related to carbon dioxide emissions at airports.

4.2.Environmental Management System in Turkey

Environmental management becomes important with the beginning of the Built-Operate-Transfer project of airports in Turkey. These projects are tendered by Ministry of Transport Maritime Affairs and Communications and General Directorate of State Airports Authority. The environmental management plan (EMP) consists of two stages; construction and operation. The issues are nearly the same but some issues are strictly related with the stages. This plan considers public complaints especially at construction stage. For the two stages different check lists are recommended for audits.

The overall objective of the EMP is to eliminate potential environmental and social impacts, or to reduce them to acceptable levels, comply with regulatory requirements, and continuously improve the environmental management at airports in Turkey. The management system was modeled on Turkish Legislation and Standards. This EMP sets out the basic principles for environmental management of the airport over 5 years. It provides a responsible and structured management approach to monitor, to report and to prevent or to minimize adverse environmental impacts.

Topics for environmental inspection and monitoring during construction phase include the following:

- Cultural Heritage
- Ecology
- Solid Waste Management Procedures
- Hazardous Waste Management Procedures
- Liquid Discharges
- Water Quality
- Air Emissions
- Noise Levels at Sensitive Receptors
- Natural Resources And Energy
- Landscape and Visual Impacts

Topics for environmental inspection and monitoring during operation will include the following:

- Aircraft Operations: Fueling, Aircraft Exterior Cleaning & Aircraft Deicing
- Airport Operations: Runway Deicing
- The storage and handling of hazardous chemical substances and additives
- Ecology
- Solid Waste Management Procedures
- Hazardous Waste Management Procedures
- Liquid Discharges
- Water Quality
- Soil Quality
- Air Emissions
- Noise Levels At Sensitive Receptors
- Natural Resources And Energy
- Landscape and Visual Impacts (Adnan Menderes Airport EMP, 2005).

The management of the airports in Turkey and provision of the air traffic service and its control in Turkish Airspace is performed by General Directorate of State Airports Authority (DHMI). Therefore aviation standards are determined by DHMI. In Table 4.1 there is a summary of the standards related to environmental issues (General Management of DHMI, 2006).

Table 4.1 National Aviation Directives of DHMI

SUBJECT	Definition of Standard
Management and operation of Airports Instruction 9	All technique services are defined according to ICAO, ECAC and EUROCONTROL
Terminal operations Instruction 12 Instruction 23.5	Health and disinfection Pest control actions must be taken according to ICAO, WHO and Turkish Ministry of Health for airports and aircrafts. Housekeeping and waste collection activities in terminals are under the responsibility of DHMI. DHMI has generally a contract with a general housekeeping company.
Runway, taxiway, apron Services Instruction 19 Instruction 22.8	 B Section: Apron security management Precautions must be taken during aircraft fuelling Hazardous material storage and delivery; A person or company licensed by the Ministry of Transportation, Maritime Affairs and Communications can take the responsibility of Hazardous material management. ICAO standards must be considered.

Table 4.1 cont.

SUBJECT	Definition of Standard
Airport Control and Maintenance Instruction 7 Instruction 8 Instruction 9 Instruction 13	Runway, taxiway, apron areas -Runway, taxiway, apron areas must be controlled every six months for rubber waste. - Material used for fuel and oil absorber must be collected. - Kerosene leakages from fuel tank of aircraft must be controlled, because it affects the surface of the runway, taxiway, and apron areas. - Rubber washing basins should be installed, waste rubber collection is important. Rubber cleaning ways on runway, taxiway, apron areas. - Chemical cleaning: Chemical is sprayed on the rubbery surface to decompose it. Then the surface is cleaned with water. The water is vacuumed from the surface. - High pressurized water is sprayed to surface. Waste water is collected with special vehicles from the surface. - Hot compressed vapor is given to the surface. The vapor decomposes the rubber to take them easy from the surface. Fuel and oil removal Fuel and oil removal ways, - Oil solving sprays - Fuel and oil absorbing materials - From concrete and asphalt surfaces fuel and oil removing is not easy. The only way is to renew the surface. Drainage system b) suitable drainages for aircraft maintenance areas, chemical and fuel storage areas are needed g) the drainage system needs an oil-fuel separator before the sewage system for the given areas in (b).

Table 4.1 cont.

SUBJECT	Definition of Standard
Airport management at snowy weather Instruction 10 Instruction 16 Instruction 19	Stock control of anti-icing, deicing chemicals Anti-icing, deicing chemicals; - Solid chemicals - Liquid chemicals Sodium chloride and calcium chloride usage is not allowed to use at airports. Environmental pollution prevention is important during the usage of anti-icing, deicing chemicals
Ecology Instruction 6 Instruction 8 Instruction 11	It is not allowed to create any adverse effect on ecology. Chemicals which are hazardous to environment cannot be used. Bird and animal attracting sources (waste storage, etc.) must be prevented. <u>Bird attracting sources;</u> - Food sources - Water sources - Solid waste storage areas - Plants - Agricultural areas i) Catering service preparation areas must be continuously checked for bird attracting sources. j) Solid waste containers must be continuously washed and disinfected. Containers must be rapidly emptied. DHMI makes generally a contract for waste collection.

Table 4.1 cont.

SUBJECT	Definition of Standard
Cleaning of runway, taxiway, apron areas and herbal fight Instruction 10 Instruction 13	- Absorbents used for fuel and oil removal must be rapidly collected from runway, taxiway, and apron areas. - Construction waste inside or outside the runway, taxiway, apron areas must be rapidly collected the areas. - After the construction works near the runway, taxiway, apron areas, all waste and rubbish material must be collected by the contactor. - At rainy weather the baggages are covered with plastic sheets. These sheets can be dangerous for the air traffic in case of wind. This situation must be controlled. - Waste storage area must be tidy Rubber Waste Removal - Chemical cleaning: Chemical is sprayed on the rubbery surface to decompose it. Then the surface is cleaned with water. The water is vacuumed from the surface. - High pressurized water is sprayed to surface. Waste water is collected with special vehicles from the surface. - Hot compressed vapor is given to the surface. The vapor decomposes the rubber to take them easy from the surface. Fuel and Oil Removal Kerosene leakages from fuel tank of aircraft effects the surface of the runway, taxiway, and apron areas. This case must be controlled. If needed the surface of the runway, taxiway, and apron areas must be renewed rapidly.

Table 4.1 cont.

SUBJECT	Definition of Standard
Ground Handling	a) Services that are continuously on the runway, taxiway, and apron areas must be aware of environmental pollution prevention (fuel, oil, chemical leakages…). b) Precautions must be taken during aircraft fuelling c) Environmental pollution prevention is important during the usage of anti-icing, deicing chemicals on runway, taxiway, and apron areas. d) All precautions must be taken during taking the wastewater from the aircraft. Incineration is not allowed for herbal removal. Ground Handling companies must have; - Vehicle for wastewater collection - Vehicle for Clean water transportation to the aircraft. - Vehicle for anti- icing deicing. - Air conditioning service - Waste containers Efficient aircraft cleaning devices.
Audit for Catering Services The questions given on the right are in the check lists prepared for audits.	- Have the company continuous water during food production? - Is there an efficient chlorine dosage to water? - Are the drainage systems working? - Are the production area and the environment clean? - Have they a suitable waste storage area?

These directives are mainly related to ICAO, ECAC and EUROCONTROL standards. Additionally DHMI is managing their activities according to ISO 9001, ISO 14001 and OHSAS 18001 standards.

CHAPTER FIVE
SUSTAINABILITY AT AIRPORTS

Sustainability is a term which can be defined in many ways. The main and general definition is the" Development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (http://sustainabilitydictionary.com). According to Epstein (2008), sustainability has a broad definition which includes ethics, governance, transparency, business relationship, financial return, community involvement (economic development), values of products and services, employment practices and protection of the environment. Another definition for sustainability consist of sustainable actions which reduce environmental impacts, help maintain high, stable levels of economic growth and help achieve "social progress", a broad set of actions that ensure organizational goals are achieved in a way that's consistent with the needs and values of the local community (http://faa.gov/airports/environmental/sustainability).

The sustainability concept is a balance between three basic pillars;

- **Economic:** The economy must be strong enough to allow business to thrive, which means that spending, saving, and consuming must be in accord with one another to allow an economy to survive.
- **Social:** A number of people working and living in a certain area must be maintained within the means of those individuals or people should be included in discussions and decisions that impact on their communities.
- **Environmental:** Production and consumption should advance in a way that does not diminish the world's natural resources, now and for the generations to come. Environmental sustainability takes into account the people living within an environment and their capacity to survive as a species within that environment (http://airport-int.com; http://, answers.yourdictionary.com).

The current position of the increase of the human population, sustaining resources is impossible in perpetuity. The world basically cannot continue consuming at a rising rate while resources are decreasing. At some point, there will be no resources left to consume. Our existence on earth cannot continue with causing a negative impact on the environment. That negative impact would leave populations without resources. Actually sustainability seeks to use less resource or restore those that have been used. (http://answers.yourdictionary.com/science).

Between 1980 – 2000 air transport is one of the world's fastest growing industry. The demand for air travel has increased and is estimated to double by 2020. This situation shows how essential the industry is to modern life. Only few people could imagine or would want a world without air travel. On the other hand the benefits of being linked to all regions worldwide via a network of air routes are increasingly significant in terms of access, time savings, economic benefits and safety.

Sustainable development for the air transport industry is especially recognized as an essential link to the global economy. Air transport makes a valuable and unique contribution to the society. The efficient and affordable access helps to markets to improve living standards and foster economic growth. Beside this there are results of reduced environmental degradation.

Air transport is an innovative, environmentally responsible industry that considers economic and social progresses. From an "economic" point of view, air transport is important for world business and tourism. There exist new jobs and facilitates the expansion of world trade by opening up new market opportunities. It also attracts businesses to locations in the developed and developing world thereby satisfying the mobility requirements of a growing portion of the world's population. By this way, moves of products and services are quickly over long distances enabling economic and social participation by outlying communities. As the "social" progress, air transport forms a unique global transport network linking people, countries and cultures safely and efficiently. It is increasingly accessible to a wide number of people who can now travel by air for leisure and business purposes. In "environmental" terms, air transport has the ability to reduce its environmental impact by continually improving its fuel consumption, reducing noise and introducing new, more sustainable technologies.

The environmental issues related to air transport are being addressed at the local and global levels. Airports focus on the potential health and environmental effects of noise and air pollution from emissions such as nitrogen oxides. These are major issues presenting an obstacle to an airport in case of growth of airport capacity.

As a global view, the major environmental issue is related to the effect of aviation's contribution to climate change, through fuel consumption and related emissions. In the recent years there is a special attention for the issue "climate change". According to the United Nations Intergovernmental Panel on Climate Change (IPCC), air transport represents 3.5% of man's contribution to global warming from fossil fuel use, taking into account the fact that most aviation emissions take place at cruising altitudes.

Nowadays, three types of market-based options have been identified for CO_2 emission. They include taxes and charges (which the industry, unsurprisingly, is opposed to), voluntary measures (which are recognized as the most cost-effective way to reduce emissions in the short term), and emissions trading that is based on the selling and purchasing of CO_2 permits between industries on the understanding that CO_2 reductions should take place where they are the most cost-effective (http://airport-int.com).

Table 5.1 Topics of airport sustainability practices (Berry F et.al, 2008)

LIST OF TOPICS ADDRESSED IN THE AIRPORT SUSTAINABILITY PRACTICES SURVEY

Introduction and Organizational Governance	Existing Sustainability Practices			Barriers and Future Priorities
	Environmental	Economic	Social	
Respondent Profile	Management of Environmental Practices	Management of Economic Practices	Management of Social Practices	Other Sustainability Practices
Expenditure and Employment	Measuring and Monitoring	Hiring and Purchasing	Public Awareness and Education	Barriers to Sustainability Practices
Responsibility for Sustainability Practices	Water Conservation	Community Contributions	Stakeholder Relationships	Future Priorities and Drivers for Sustainability
Reporting and Policies	Water Quality	Quantifying Sustainability	Employee Practices And Procedures	
Existing Drivers of Sustainability	Climate Change	Contribution to Research and Development	Sustainable Transportation	
	Air Quality	Incentivizing Sustainable Behavior	Alleviating Road Congestion	
	Land Use		Accessibility	
	Biodiversity		Local Identity Culture and Heritage	
	Materials		Indoor Environmental Quality	
	Waste		Employee Well-being	
	Noise and Aesthetics		Passenger Well-being	
	Energy			
	Green Buildings			

Airports in USA have determined environmental practices as key issue for the future, following with social and economic practices. Energy, green buildings, and climate change are the main environmental sustainability studies for large and medium type airports. These studies are;

- Energy conservation, efficiency, energy management, and baseline audit
- Emission (CO_2) reductions
- Clean energy production and clean fuel vehicles
- Use of green building principles, sustainable design, and high-performance buildings.
- Green building certification using Leadership in Energy and Environmental Design (LEED), a green building rating system developed by the U.S. Green Building Council.

Europe and the United Kingdom (UK) mentioned their issues as noise, aesthetics, and sustainable transportation issues including noise insulation scheme, minimizing operations noise and improvement of railway infrastructure to the airport. Additionally they mentioned energy, climate change, water, waste, and stakeholder relationships. Airports of Europe, Asia, and Canada have a special interest improve governance of sustainability at their airport, such as corporate social responsibility and implementing the United Nations Global Compact. The United Nations Global Compact is a structure that is committed to aligning operations and strategies with 10 universally accepted principles in the areas of human rights, labor, the environment, and anticorruption (Berry and Gillhespy, 2008).

An urgent need is to define the environmental effects of air transportation, beside the rapid grow of economy and the demand for air transportation. When these effects could not be addressed, they could constrain air transportation growth in the 21st century (Wait z et al. 2004). In the future airports have to deal with the environmental concerns of the communities that are surrounding the airport. (Committee on Aviation and Environmental Protection, 2007).

5.1 Review of Sustainability Reports – Environmental Sustainability

5.1.1 Fraport (Frankfurt International Airport)

Frankfurt International Airport has the aim to achieve sustainable reductions in the environmental impact of their business activities. Their strategy focuses on efficient environmental management. The main subject in their environmental strategy is climate protection adopted in 2008. They consider significant reduction in carbon dioxide emissions per traffic unit by 2020. In order to improve energy efficiency, the new Terminal 3 is planned as an “Eco Terminal” and will serve as an important mission in achieving this target. Fraports target is to reduce CO_2 emissions at Frankfurt Airport per traffic unit (1 passenger or 100 kg freight) by 30 % and avoid additional CO_2 emissions caused by their expansion projects. In the Eco-Terminal, Terminal 3, geothermal energy will be used.

Specific points for carbon footprint calculations for scope 1 and scope 2 emissions (direct area of influence) are given as;

- Energy optimization of approximately 60 office and service buildings (15 percent reduction of energy consumption by 2020)
- Energy optimization of terminal systems (in particular technical control centers)
- Deployment of innovative IT tools for optimization of apron traffic
- Expansion of the stationary 400 Hz ground power supplies
- Training sessions on the issue of energy saving in the workplace
- Purchase of certified green electricity from hydropower for the years 2008 – 2013
- Fraport sources district heating from highly efficient cogeneration (i.e., 60 percent CO_2 saving compared with conventional heat generation).

The second specific point for carbon footprint calculations for scope 3 emissions (indirect area of influence) is given as;

- Fraport offers third-party companies at Frankfurt Airport the possibility of purchasing certified green electricity from renewable sources for the years 2010 – 2013.
- Further development of the intermodal product for passengers in high-speed trains and in the public transport system.
- Launch of the rail connection and development of freight transport by train as alternatives to truck.

Frankfurt Airport is also searching about the feasibility of further climate protection measures like;

Energy optimization of infrastructure and processes;

- Advanced planning for Terminal 3 with particular focus on energy efficiency and profitability
- Reviewing APU replacement by Preconditioned Air for positions on Terminal 3
- Reviewing the introduction of the Departure Management System

Generating/sourcing of renewable energy;

- Reviewing the feasibility of a geothermal power plant
- Reviewing the deployment of photovoltaics for power generation
- Reviewing the sourcing of certified green electricity from renewable sources beyond 2013.

Fraports main target is to heat the new terminal using a highly efficient, environmentally benign gas and steam turbine which is called co-generation.

Investigations of the availability of technical options for optimizing energy distribution in Terminal 3 are continuing. The aim is to use the waste heat and excess cooling capacity generated in certain sections of a building complex – for example in order to provide heating and cooling capacity for purposes of heating and cooling in other parts of the complex.

Fraport is also considering how to apply energy storage effects associated with certain times of the day. This can be obtained by using thermal component activation in which the heat storage capacity of walls, ceilings or floors is used to regulate the room temperature. Floor temperature regulation (attemperation) using geothermal energy is a possibility for the check-in hall, at the gates, and in the office areas. Geothermal energy is planned to be used for the new Terminal 3. The feasibility studies showed that the use of geothermal energy will avoid emissions of up to 22.000 metric tons of CO_2 / year.

Frankfurt Airport and its subsidiaries are using certified green electricity from hydropower since 2008. By this way, more than 135.000 metric tons of CO_2 in 2008 and 2009 is avoided. They are also serving Green electricity to third party companies since 2010. This could avoid the emission of up to 70.000 metric tons of CO_2 / year (Fraport Fairplay Sustainability Report, 2008). CO_2 emission change at Frankfurt Airport is given in Figure 5.1.

In Table 5.2, there is a list of the environmental performance indicators for 2007 and 2008 of Frankfurt Airport. Performance indicators are defined according to the Global Reporting Index (GRI). The number of GRI performance indicators of a report gives the type of the sustainability report which has been prepared.

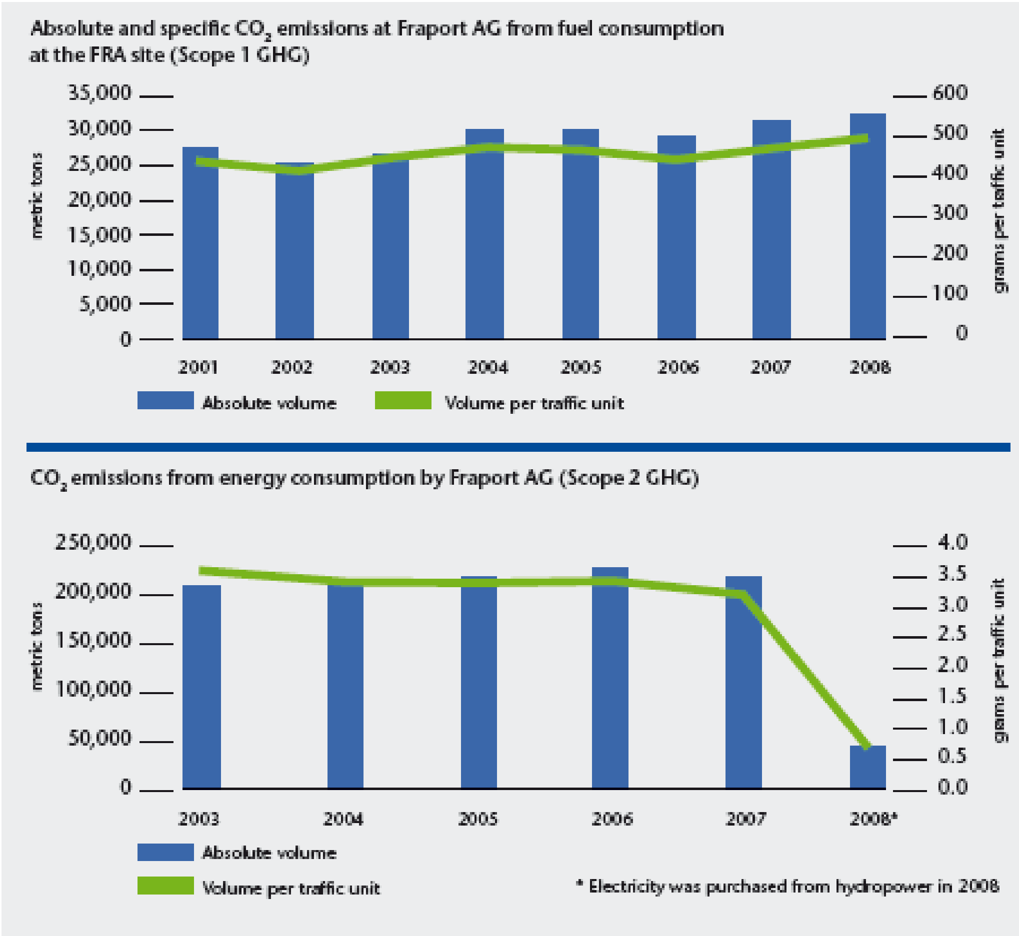

Figure 5.1 CO_2 emission change at Frankfurt Airport

Table 5.2 Sustainability performance indicators according to GRI Index

Examples of Environmental Indicators for Frankfurt Airport	2007	2008
Energy		
Average age of the mobile work machines and vehicles deployed (not including 1-year leased cars) [years]	6,50	6,00
Fuel consumption of mobile work machines and cars on the apron and site roads [liters]	11.949.807	12.453.635
Total energy consumption (electricity, heating energy, cooling energy) [kWh millions]	566,9	569,1
Power		
Electricity consumption [KWh millions]	285,62	296,04
Percentage of renewable energy (hydropower, wind energy, solar energy) [%]	21,5	100
Percentage of nuclear energy [%] EN	19,5	0
Percentage of fossil fuels and other energy sources (coal, lignite, natural gas) [%]	59	0
Air - Greenhouse gases (CO_2)		
Direct CO2 emissions (Scope 1 GHG Protocol Standards: fuels, fuels for fossil-fired facilities, here heating oil, natural gas, propane gas) [metric tons]	33.300	34.100
Indirect CO2 emissions (Scope 2 GHG Prot ocol Standards: Sourcing of power, district heating and district cooling,incl. technical losses in the grid at the Fraport site) [metric tons]	216.000	48.700
Traffic		
Percentage of employees of Fraport AG using public transport [%]	33,2	42,9
Percentage of employees of Fraport AG traveling to work in a car pool [%]	12,5	11
Waste (including all third parties)		
Total waste without soil and building debris [metric tons]	24.703	24.112
Recycling rate [%]	83	83
Non-hazardous waste [metric tons]	23.186	22.145
Hazardous waste [metric tons]	1.516	1.967

5.1.2 Dublin Airport

The Intergovernmental Panel on Climate Change estimates that the global aviation is responsible of approximately 3.5% of the total human contribution to greenhouse gas emissions, and expects that this will rise to between 3% and 15% by 2050.

Aircraft emissions are generally not under the control of an airport. However energy consumption of the airport is one of the largest effects to greenhouse gas emissions. The increase of passenger numbers and airport staff gives a natural in energy consumption in the recent years.

Nowadays increases in cost of energy have brought a greater awareness of the impact of energy use on the environment. Energy reduction studies have increased relatively. For Dublin Airport in 2009 have installed an energy monitoring and targeting system and networked it to their existing systems. “Energy Strategy Group” Dublin Airport has monthly meetings and discusses all energy related issues. Records of the meetings are maintained to show areas targeted and reductions achieved.

Dublin Airport has operated two Combined Heat and Power units (CHP) with a combined electrical output of 3.7 mega watts. The CHP’s electrical output is used on site reducing their purchased type of electricity. The generated heat is a by-product of the CHP system and is used for heating purposes of the terminal buildings and domestic water. The high efficiency of the use of CHP’s at airports gives a global reduction in green house gas emissions.

The energy management strategies at Dublin Airport include activities that are;

- Small changes in ambient temperatures in specific parts of the campus;
- Close control and ongoing analysis of building management systems to achieve further reductions in energy use;
- Reducing lighting and temperature demand in areas of low or infrequent usage;

- Extending the use of PIR (Passive Infra-Red controls) across the campus for areas such as toilets, escalators and bridges;
- Reducing the lighting load in specific areas;
- Regular survey of all areas to identify scope for additional energy reductions;
- Detailed analysis of recently expanded energy management system to set further targets for energy reduction;
- Active participation and cooperation with external agencies (Dublin Airport Sustainability Report, 2009).

5.1.3 Auckland Airport

Auckland Airport has the target to decrease the CO_2 emission 10% CO_2 emissions per passenger and 5% CO_2 emissions footprint with energy and fuel efficiency.

Auckland Airport has an energy conservation group (ECOG). This group is responsible for the company's emissions reduction plan and provides focus and action on the reduction of fuel and energy use.

A comprehensive energy audit had been made in 2009 for the international terminal building. The results showed that some significant cost and carbon savings could be achieved with a small payback of less than two years. An energy efficiency programme had been installed which are summarized below;

- UV C cleaning of coils improving the efficiency of the whole heating, ventilation and air conditioning system,
- Low flow shower fittings to reduce both water and energy usage,
- Variable speed drives to reduce energy costs,
- Building management system software upgrades and extensive metering (this will allow monitoring and verification of energy savings)
- The combined impact is a reduction of energy costs of over 20% and a reduction in Auckland Airport's total carbon footprint of over 10%.

Auckland Airport has reported its first company emission profile for year 2006 defined as FY06 (financial year 2006). Auckland Airport emissions profile between 2006-2010 financial years can be seen in Table 5.3 given below (Auckland Airport Sustainability Report, 2009).

Table 5.3 Auckland Airports CO_2 change for the financial years (FY)

	FY06 (CO_2e) Tonnes	**FY07** (CO_2e) Tonnes	**FY08** (CO_2e) Tonnes	**FY09** (CO_2e) Tonnes	**FY10** (CO_2e) Tonnes
Natural Gas	1.025	1.752	1.846	2.307	2.059
Petrol 91	218	207	192	138	122
Petrol 96	44	42	29	13	0.5
Diesel	320	314	294	272	303
Avgas	2	2	0	0	0
Jet A1	77	48	77	105	77
Electricity	6.555	6.585	6.833	6.179	6.137
Air travel short haul <500km	41	24	24	11	13
Air travel medium haul 501-1,600km	1	8	12	3	7
Air travel long haul >1,600km	130	73	78	59	32
Construction	2.240	1.903	1.922	2.641	627
Total	**10.654**	**10.958**	**11.306**	**11.727**	**9.377**

5.1.4 BAA Stansted Airport

UK's total CO_2 emissions from aviation were estimated as 6% in 2007 (around ten million tonnes of carbon). The projected growth in air travel shows an increase in emissions for aviation. The Government's predictions are that aviation could account for around 25% of the UK's total carbon emissions by 2030.

The principal way for managing aviation climate change by the Government is emission trading. Under current EU proposals, all flights arriving in, and departing from, destinations in Member States will be covered by the European Union's Emission Trading Scheme from 1 January 2012.

Sustainability objectives for Climate change and energy are,

• Avoid emissions contributing to climate change;

• Exercise leadership and encourage innovation to control and reduce emissions contributing to climate change over which BAA does not have direct control (e.g. from aircraft in flight);

• Use of sustainable sources, materials and energy supplies

• Reduce demand for energy through good design of airport and surface access infrastructure.

BAA's main target is to approach to carbon dioxide emissions associated with the buildings and infrastructure of the expanded airport that will not exceed 2006 levels by 2030. Carbon dioxide emissions in 2006 were around 43.000 tones. In 2030 it is estimated that CO_2 emissions per passenger will be one third of the CO_2 emissions per passenger in 2006.

Emission reductions will be obtained through energy efficiency measures, use of renewable energy sources for heating, cooling and providing electricity to the airport.

Energy efficient measures will be considered throughout the airport campus design in order to reduce energy values. Examples are outlined as;

• insulation and shading of buildings will minimize the use of artificial heating or cooling;

• maximizing the use of natural light to avoid using artificial light;

• internal and external lighting systems will incorporate low energy technologies and will be zoned to maximize control;

• efficient displacement air conditioning will be used which only heats or cools the occupied part of a building;

• providing opportunities for businesses on the airport to limit the energy that is used and use energy from a renewable source.

Most heating and cooling demands for the Airport Development buildings and facilities could be met through the use of ground sourced chiller heat pumps. Utilizing the natural ground temperature, the ground sourced chiller heat pumps will pipe water below ground to dissipate heat in the summer and draw heat from below ground in the winter for use in heating installations. The overall objective is for the summer/winter warming/cooling cycle to remain in balance so that over each year there will be no net heating or cooling of the chalk layer. The heat exchange into the chalk will be indirect; no water will be drawn from or introduced into the chalk. This system contributes to over 50% of energy demand being met by on-site renewable sources.

If appropriate, micro-renewable technology will be implemented at Stansted Airport. This is mainly the use of photo-voltaic (solar panels) panels. The power will be used for the car parking areas that are remote from the central terminal area.

Business travels of BAA Stansted employees will be carbon neutral. Travels of business flights, rail and car journeys will be calculated yearly and offset by using a regulated scheme that meets published standards.

BAA is searching to develop a more sustainable aviation industry, with specific attention paid to the inclusion of aviation into international emissions trading schemes. In order to increase the awareness, passengers will be informed and educated about sustainability practices at the airport. By this way, individuals can reduce their own environmental impact of their activities.

BAA has also some projects to obtain further carbon dioxide emission reductions through a combination of infrastructure and non-infrastructure solutions. To ensure progress to achieving the sustainability target for carbon dioxide emissions reductions is transparent, BAA will publish an annual report to manage emissions. The annual report will be verified by an accredited external organization (Stansted Generation 2 Sustainability Report, 2008.)

5.1.5 Los Angeles World Airport

Los Angeles World Airport (LAWA) has the target to reduce its greenhouse emissions to 35% by 2030 below its level obtained in 1990. LAWA has prepared a greenhouse gas inventory to determine its baseline greenhouse gas emissions. The baseline calculations have been made for the year 1990 by using available data for 1990. The baseline carbon dioxide equivalents (CO_2e) emissions have been obtained as 18 million metric tons. According to their target, LAWA will decrease its CO_2e to 11 million metric tons (Los Angeles World Airports Sustainability Report, 2008).

5.1.6 Schipol Group Airport

A Climate Plan has been set up in 2007 at Schipol Airport to define their policy, strategy, programme and targets in order to improve air quality and reduce CO_2 emissions. A Climate Plan was prepared to develop the “Sustainable Mobility Concept” and the “Energy Blueprint” in 2008.

- **Sustainable Mobility Concept**

This concept is defined to guarantee and improve the accessibility of the airport and decrease emissions from road traffic. By this way overall emission reduction and local air quality improvement has been obtained. The investigations were divided into four groups: influencing mobility behavior, improving (public transport) infrastructure and timetables, developing spatial and transport concepts and measures to reduce emissions at the source.

- **Energy Blueprint**

The Energy Blueprint is an integrated energy plan (Figure 5.2.) which looks at limiting the demand for energy. Beside this Schipol Airport is generating its own sustainable energy on the Schipol site. The Blueprint provides to reach the target of being CO_2 neutral by 2012. Additionally at least 20% of their own energy demand by 2020 will be generated by sustainable energy.

For the both concepts, their aim is to reduce their consumption of energy and fossil fuels. A certain reduction will lead to an immediate decrease in CO_2 and NO_x emissions. A strict reduction can be achieved by cutting back on car use. When energy and fuels demand has been reduced, it will be possible to obtain efficient energy and fossil fuel uses. Schipol Airport additionally wants to increase the use of sustainable energy and environmental friendly fuel. By this way they have the aim to decrease CO_2 emissions and in some cases also NO_x emissions.

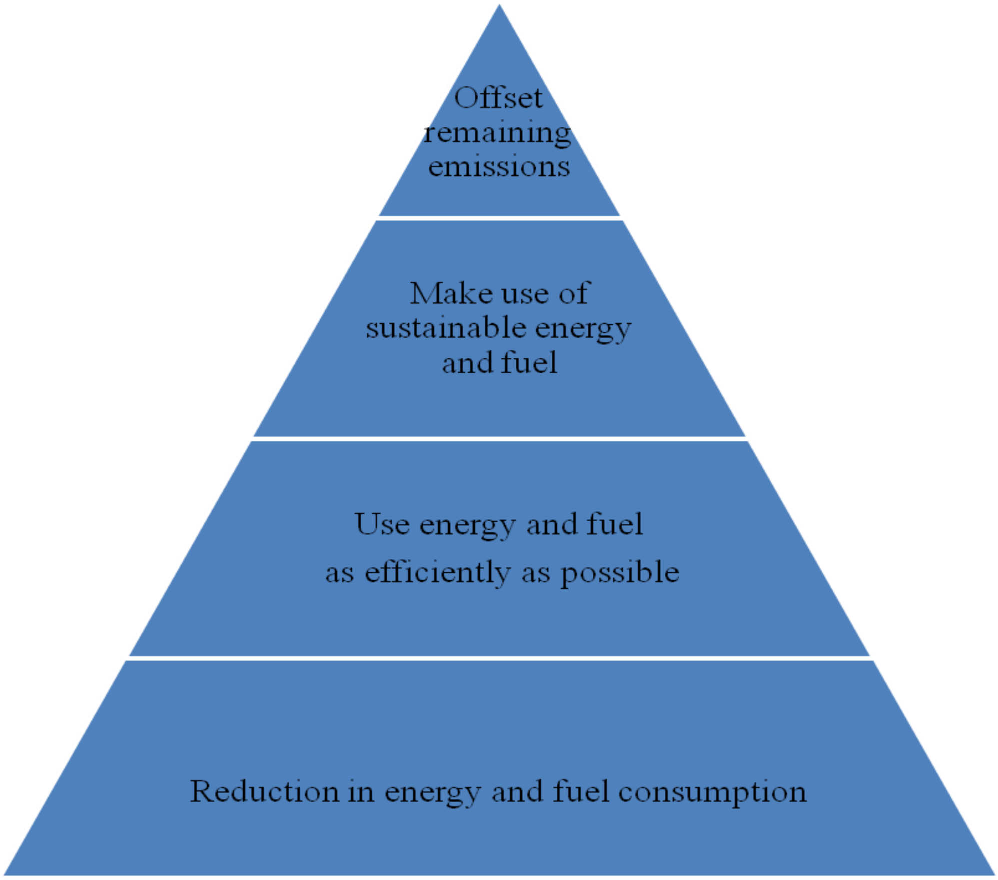

Figure 5.2 Climate plan of Schipol Group Airport

The main source of CO_2 emissions is energy consumption during an operation of an airport. Schipol Airport had reduced 40% CO_2 emission (nearly 50.000 tones) in 2007 compared to 2006. This reduction was obtained by purchasing green electricity, a small part by generating energy by means of heat/cold storage and by the use of biodiesel and by reducing the fuel consumption of their vehicle fleet (Amsterdam Schipol Airport Corporate Responsibility, 2008).

In the study by Kesgin U. (2006), the landing and take-off (LTO) emissions for 40 Turkish airports were evaluated. The calculation model includes the emission factors obtained from the ICAO Engine emission data bank. The results for air side emissions of the airports showed that a decrease of 2 min. in taxiing time results a decrease of approximately 6 % of LTO emissions. Another observation was that an increase of 25 % in LTO cycles might cause 31 to 33% more emissions.

An estimation of aircraft operations had been made by Elbir T. (2008). The results showed that an increase of 1 min. in taxiing time causes an increase of 4.2%, 4.6%, and 0.4% in the amount of HC, CO, and NO_X emissions, respectively. Another approach for air side emissions was that taxiing aircrafts are a significant source of hydrocarbon and carbon monoxide emissions, when engines operate at low power.

As a view of global level, climate change is the most important issue to drive important changes in the aviation industry over the next 20 years. It has been forecasted that global air transport aviation carbon dioxide emissions tripled between 1990 and 2050. Therefore the total global warming effects are forecasted to increase fourfold over the same period (Aviation and the Global Atmosphere, 1999). Airport operators are realizing how construction, operation, maintenance, and other activities at airport facilities can contribute to the industry's overall climate change impacts. Airports can play a role in reducing their impact on climate change by addressing emissions in ground transportation, energy use in buildings, and associated indirect emissions (Berry and Gillhespy, 2008).

Sustainability reports are generally prepared according to Global Reporting Initiative (GRI) G3 Guidelines (Snapshot of Sustainability Reporting in the Airports Sector, 2009). GRI is a multistakeholder non-profit organization that develops and publishes guidelines for reporting on economic, environmental, and social performance (sustainability performance). The Global Reporting Initiative (GRI) is a network-based organization that has pioneered the development of the world's most widely used sustainability reporting framework. The Reporting Framework sets out the principles and Performance Indicators that organizations can use to measure and report their economic, environmental and social performance (http://globalreporting.org/AboutGRI).

5.2 Carbon Footprint

Carbon footprint which is also defined as carbon profile is the overall amount of CO_2 and other greenhouse gas (GHG) emissions (e.g. methane, laughing gas, etc.)

associated with a product along its supply-chain and sometimes including from use and end-of-life recovery and disposal. Causes of these emissions are, for example, electricity production in power plants, heating with fossil fuels, transport operations and other industrial and agricultural processes.

Indicators are used to calculate the carbon footprint such as the Global Warming Potential (GWP). According to the Intergovernmental Panel on Climate Change (IPCC), a GWP is an indicator that reflects the relative effect of a greenhouse gas in terms of climate change considering a fixed time period, such as 100 years (GWP100).

European Commission defines carbon footprint as a life cycle assessment with the analysis limited to emissions that have an effect on climate change (European Commission, 2007).

In other words, “the carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product." This includes activities of individuals, populations, governments, companies, organizations, processes, industry sectors etc. Products include goods and services. For the calculation of carbon footprint, all direct (on-site, internal) and indirect emissions (off-site, external, embodied, upstream, and downstream) need to be taken into account. In the literature there are many definitions for carbon footprint. These definitions are given in Table 5.4 (Wiedmann and Minx, 2008).

Table 5.4 Different definitions of "carbon footprint" from literature

SOURCE	DEFINITION
BP	"The carbon footprint is the amount of carbon dioxide emitted due to your daily activities – from washing a load of laundry to driving a carload of kids to school."
British Sky Broadcasting	The carbon footprint was calculated by "measuring the CO_2 equivalent emissions from its premises, company-owned vehicles, business travel and waste to landfill."
Carbon Trust	"… a methodology to estimate the total emission of greenhouse gases (GHG) in carbon equivalents from a product across its life cycle from the production of raw material used in its manufacture, to disposal of the finished product (excluding in-use emissions). "… a technique for identifying and measuring the individual greenhouse gas emissions from each activity within a supply chain process step and the framework for attributing these to each output product (The Carbon Trust will refer to this as the product's 'carbon footprint')."
Energetic	"… the full extent of direct and indirect CO_2 emissions caused by your business activities.

ETAP	"…the 'Carbon Footprint' is a measure of the impact human activities have on the environment in terms of the amount of greenhouse gases produced, measured in tonnes of carbon dioxide."
Global Footprint Network	"The demand on biocapacity required to sequester (through photosynthesis) the carbon dioxide (CO_2) emissions from fossil fuel combustion."
Grub & Ellis	"A carbon footprint is a measure of the amount of carbon dioxide emitted through the combustion of fossil fuels. In the case of a business organization, it is the amount of CO_2 emitted either directly or indirectly as a result of its everyday operations. It also might reflect the fossil energy represented in a product or commodity reaching market."
Parliamentary Office of Science and Technology	"A 'carbon footprint' is the total amount of CO_2 and other greenhouse gases, emitted over the full life cycle of a process or product. It is expressed as grams of CO_2 equivalent per kilowatt hour of generation (gCO_2eq/kWh), which accounts for the different global warming effects of other greenhouse gases."

CO_2 is the gas that has the most important effect to the planetary, with a percentage of 76 of the greenhouse gases in our atmosphere. CO_2 is released to the atmosphere in huge amounts by human activities and has a lifecycle of approximately 100 Years (Bouley, 2011).

The increasing public awareness of global warming increased the interest in carbon footprint. Nowadays public knows the need to reduce greenhouse gas emissions to mitigate climate change. Countries, organizations and individuals are starting to take responsibility.

Businesses and services can find marketing advantages by defining their carbon management. Carbon footprint is the first step towards making quantifiable emissions reductions. On the other hand, that can lead to long term financial savings as well as reducing emission impact.

The most widely known system for businesses and organizations is the WBCSD/WRI Greenhouse Gas Reporting Protocol. The GHG protocol divides emissions sources into three 'scopes' according to level of responsibility where some indirect sources (eg. emissions from waste and subcontracted activities) are optional for reporting. The California Climate Action Registry General Reporting Protocol largely follows the GHG protocol. ISO 14064 provides an international standard for organizations based on the GHG protocol. Other company-specific protocols, for example the Carbon Neutral protocol, also refer to the GHG protocol. The GHG protocol works well for internal benchmarking but is not so well suited for comparisons of carbon footprints between organizations due to optional reporting of 'Scope 3' activities (ECCM, 2008.)

In order to decrease the effect of climate change a global solution is needed. The solution includes all countries and regions, every business, irrespective of size, sector or location that can play a positive role. At the beginning measuring emissions and then reducing their emissions, both economic and environmental benefits can be obtained.

Energy consumption is strictly related with emission increase. All reduction projects are improving the efficiency and thereby the firm is more competitive of a firm. After a company has quantified its carbon footprint, the company should:

- Use the data collected to identify all areas where emissions can either be reduced or efficiencies improved.
- Prioritize the options based on feasibility, environmental or financial benefits.
- Set targets for improvements internally, with contractors and with upstream suppliers.
- Implement the actions.
- Monitor the performance on an ongoing basis.
- Communicate success (Small Firms Association, 2007).

5.3 Carbon Footprint of Airports

Carbon footprint of Airports is accredited by ACI (Airport Council International) EUROPE. It is a program that is defined as “Airport Carbon Accreditation (ACA)” which is the European carbon standard for airports. The programme assesses and recognizes the efforts of airports to manage and reduce their carbon emissions with four levels of award: 'Mapping', 'Reduction', 'Optimization' & 'Neutrality'. (http://airportcarbonaccreditation.org).

ACA is a program that is managed and controlled by an independent party which is WSP Environment & Energy. WSP is an international consultancy appointed by ACI EUROPE to enforce the accreditation criteria for airports on an annual basis. The administration of the scheme is overseen by an Advisory Board.

Carbon footprint calculations of an airport must have been verified independently according to ISO14064 Greenhouse Gas Accounting. The main definitions of carbon footprint calculations used by Airport Carbon Accreditation are the principles of the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI) “Greenhouse Gas Protocol” Corporate Accounting and Reporting Standard. In case of considering the emission from aircraft within the airport perimeter, on final approach and initial departure, Airport Carbon Accreditation uses the International Civil Aviation Organization’s (ICAO) definition of the Landing-Take Off cycle and requires airports to comply with these definitions.

The airport is a uniquely complicated space, typically bringing together hundreds of companies, thousands of vehicles and millions of passengers. Airlines, air traffic control, ground handlers, baggage handlers, catering companies, refueling trucks, passenger shuttle transport, airport maintenance services, emergency services, police, border control, retailers have a an active role at each airport (Figure 5.3). Airports have set environmental management programmes related with monitoring air quality, water management, noise mitigation and biodiversity management for forty years. Nowadays, environmental management is mainly the climate change concept. Each part of an airport operation has a portion to help to decrease CO_2 emissions at the airport.

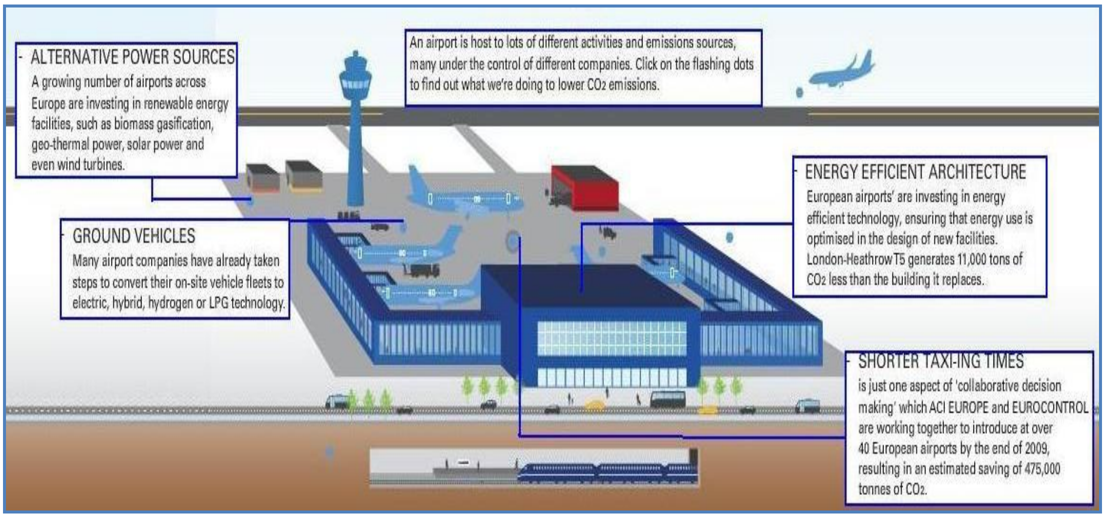

Figure 5.3 Airport complex

Greenhouse Gas Protocol (GHG Protocol) defines emissions as direct or indirect for the accreditation process. Direct emissions are defined as the sources that are owned or controlled by the reporting entity. Indirect emissions are activities of the reporting entity, but the source is owned or controlled by another entity. The GHG Protocol categorizes direct and indirect emissions into three scopes as seen in Table 5.5.

Scope1: All direct greenhouse gas emissions (electricity and natural gas consumption, fuel consumption, etc.)

Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam

Scope 3: Other indirect emissions, such as:

- The extraction, production and transport of purchased materials and fuels
- Transport-related activities in vehicles not owned or controlled by the reporting entity
- Outsourced activities
- Waste disposal etc. (http://airportcarbonaccreditation.org).

Any airport that will join to the Airport Carbon Accreditation program of ACI must verify their Inventory Report by an independent accredited verification body in accordance with ISO 14064. The Scope of ISO 14064 for GHG accounting and verification standard has three parts:

Part 1 - Greenhouse gases: specification for the quantification, monitoring and reporting of organization emissions and removals:

Part 1 of ISO 14064 will specify verifiable requirements for organizations to design, develop, maintain and report the greenhouse gas inventory on organizational level. The Part 1 standard will be of interest to organizations participating in voluntary GHG registries or regulatory allowance-based schemes or GHG scheme administrators designing such programs or schemes.

Part 2 - Greenhouse gases: specification for the quantification, monitoring and reporting of project emissions and removals:

Part 2 of ISO 14064 will specify verifiable requirements for GHG project to plan, monitor, quantify and report on projects, including resultant GHG emission reductions or removal enhancement units. The Part 2 standard will be of interest to project proponents participating in voluntary programs or regulatory credit-based schemes or GHG scheme administrators designing such programs or schemes.

Part 3 - Greenhouse gases: specification and guidance for validation, verification and certification:

Part 3 of ISO 14064 will specify verifiable requirements for validation/verification bodies and validators/verifiers in providing assurance against GHG claims from organizations (eg, Part 1) or projects (eg, Part 2). The Part 3 standard aims to be applicable to any GHG scheme and will be of interest to validation/verification bodies, validators/verifiers and GHG scheme administrators.

The Greenhouse Gas Protocol (GHG Protocol) is the most widely used international accounting tool for government and business leaders to understand, quantify, and manage greenhouse gas emissions. The GHG Protocol is working with businesses, governments, and environmental groups around the world to build a new generation of credible and effective programs for tackling climate change.

It serves as the foundation for nearly every GHG standard and program in the world, from the International Standards Organization to The Climate Registry, as well as hundreds of GHG inventories prepared by individual companies. The GHG Protocol also offers developing countries an internationally accepted management tool to help their businesses to compete in the global marketplace and their governments to make informed decisions about regulations to manage the effect of climate change.

The scope of greenhouse gases shows only CO_2 in carbon accreditation scheme. As given before carbon emissions are defined and awarded with four levels: Level 1 - Mapping, Level 2 - Reduction, Level 3 – Optimization, Level (3+) - Neutrality. The requirements for the application of the different levels are given in the following paragraphs.

Table 5.5 Scope definitions for an Airport according to ACA

	CONTROL Facilities, services, activities and equipment for which the airport company has ownership/control	**GUIDE** Facilities, services, activities and equipment owned/controlled by subcontractors, close partners and suppliers for which the airport company can provide guidance	**INFLUENCE** Facilities, services, activities and equipment owned/controlled by loose partners, tenants, customers, goverment agencies, etc. for which the airport company can only influence
Scope 1-Direct Emissions			
Stationary Sources	Boilers, furnaces, burners, turbines, heaters, incinerators, engines, fire fighting exercises, flares, etc.		
Mobile Sources	Automobiles (airside/landside), trucks, employee buses, ground power units, business travel		
Process Emissions	Onsite waste management, waste water management		
Other	Leaks from plants particularly refrigerants, fire supression CO2, methane, fuel tanks (optional)		
Scope 2-Energy Indirect Emissions			
Indirect Emissions	Emissions from purchased electricity, heating, cooling, etc.		
Scope 3- Other Indirect Emissions			
Aircraft		Aircraft ground movements, engine start up to idle (run ups), engine reverse thrust, taxiing, APU, PCA	Take off, landing, approach, climb, cruise
Stationary Sources		Boilers, furnaces, burners, turbines, heaters, incinerators, engines, fire fighting exercises, flares operated by contractors or close partners	3rd party boilers, furnaces, burners, turbines, heaters, incinerators, engines
Mobile Sources	Business travel of airport company staff	Vehicles, GSE equipments and ground power units operated by third parties, staff travel in own vehicle/commute, haulage	Business travel (3rd parties), surface access (passengers), staff travel/commute (3rd parties), 3rd partie owned vehicles
Process Emissions		Offsite management/disposal of airport waste	Management of waste where disposal arrangements are made by 3rd parties
Infrastructure		Grid power and fuel consumed by close partners	Grid power and fuel purcahsed by other 3rd parties.

<u>Level 1 – Mapping</u>

The requirements of Level 1 of Airport Carbon Accreditation are;

☑ Definition of the scope of the airport's carbon footprint which should include;
   – A detailed list of activities and facilities which are under the direct control of the airport (identified as scope 1 and scope 2 emissions)
   – For each emission source, the department or function that has responsibility for the activity or facility
   – A summary list of airport activities and facilities that fall within guide and influence (Scope 3 emission sources defining the body or bodies that have primary responsibility for these activities or facilities.)

☑ Submission of a verified carbon footprint report of those emissions within the airport's direct control (all the identified scope 1 and 2 activities and facilities).

☑ The scope of greenhouse gases included only CO_2. Airports can include emissions of other greenhouse gases on a voluntary basis.

☑ Leased or rented equipment that is under the control of the airport or is under the control of a leasing company but is operated for the sole benefit of the airport should be included in scope 1 or scope 2 irrespective of the financial or legal arrangements.

<u>Level 2 – Reduction</u>

The requirements of Level 2 of Airport Carbon Accreditation are;

☑ Submission of a verified carbon footprint report as required for Level 1 for entering the Level 2.

☑ Development and submission of a "Carbon Management Plan" covering activities over which the airport has direct control. These activities will have been defined during the preparation of the airport's Carbon Footprint in Level 1 of the Airport Carbon Accreditation Scheme that include:
   – On-site combustion – boilers, generators, fire exercises
   – Airport owned vehicles – airside transit, company cars
   – Purchased electricity for airport consumption
   – On site waste treatment.

☑ Detailed identification of the emission reduction improvements

☑ Demonstration of improvement in the "emission reduction (metric tonnes)" vs. the "average of the past three years". It is also possible to join or upgrade to Level 2 without having 3 years of historical data.

Level 3 – Optimization

The requirements of Level 3 participation are;

☑ Expansion of the scope of the carbon footprint is required to include specific Scope 3 emissions sources to the inventory report. These will comprise emissions from activities that are central to the airports operation and that an airport can be expected to guide or have a significant influence over.

Emission sources that are required to be included in Level 3 of the scheme are;

- The Landing Take Off (LTO) cycle as defined by the ICAO Airport Air Quality Guidance Manual (Doc No. 9889) and all running ground operations including auxiliary power units (APU), fixed ground power and ground service equipment.
- Surface (passenger and airport company staff) access
- Airport company staff business travel.

☑ Submission of a verified carbon footprint report including Scope 3 emission sources.

☑ Ongoing implementation and maintenance of the "Carbon Management Plan".

☑ Demonstration of improvement in the emissions improvement metric tonnes vs. the average of the past three years. It is possible to join or upgrade to Level 3 without having 3 years of historical data as for Level 2.

☑ Evidence of activities (e.g., committees, training, incentives, projects, etc.) to engage stakeholders (covering major activities over which the airport does not have direct control), such as airlines, ground handlers, staff, passengers, transport.

Level (3+) – Neutrality

The requirements of Level (3+) participation are the same as those for Level 3 with the following additional requirement:

- ☑ Purchase of offsets to cover residual emissions in scope 1 and 2 only. Evidence of purchase should be provided (Airport Carbon Accreditation Documentation and Guidance, 2011).

As an example Swedavia Group Arlanda Airport has zero net emissions of carbon dioxide from heating and energy consumption and is certified by ACI as Level (3+) – Neutrality. Buildings at the airport are heated with district heating based on biofuel, and the electricity used comes from renewable energy sources. Stockholm Arlanda is served by their own biogas-fuelled buses that have placed Arlanda Airport to the first airport in the world with these types of vehicles. While Swedavia's cars, buses and other vehicles are gradually being replaced by vehicles with biogas or hybrid vehicles, they also reduce their business fleets.(http://swedavia.com/arlanda).

The most important project of Arlanda Airport is the construction of an Aquifer Thermal Energy Storage (ATES) plant. This project is supplying the airport natural, renewable heat and cold. As a result they have replaced conventional chillers and have reduced the dependence of electricity and district heating. In Figure 5.4 there is a view of the carbon neutral project which is a large energy storage unit.

The system is designed to cover a cooling and heating load of approximately 8 MW at a maximum ground water flow of 720 m^3/h. The aquifer is situated locally a couple of kilometers away from the terminals. The flow is obtained from five cold wells in the northern part of the aquifer and six warm wells in the southern part. The system is a closed circuit where the groundwater is used for the transmission of energy through a large heat exchanger. The water is pumped up from one side delivering heat or cold passing the heat exchanger, and then continuously injected back at the other side to the aquifer. The heat or cold is distributed by a local district pipe system to connected buildings.

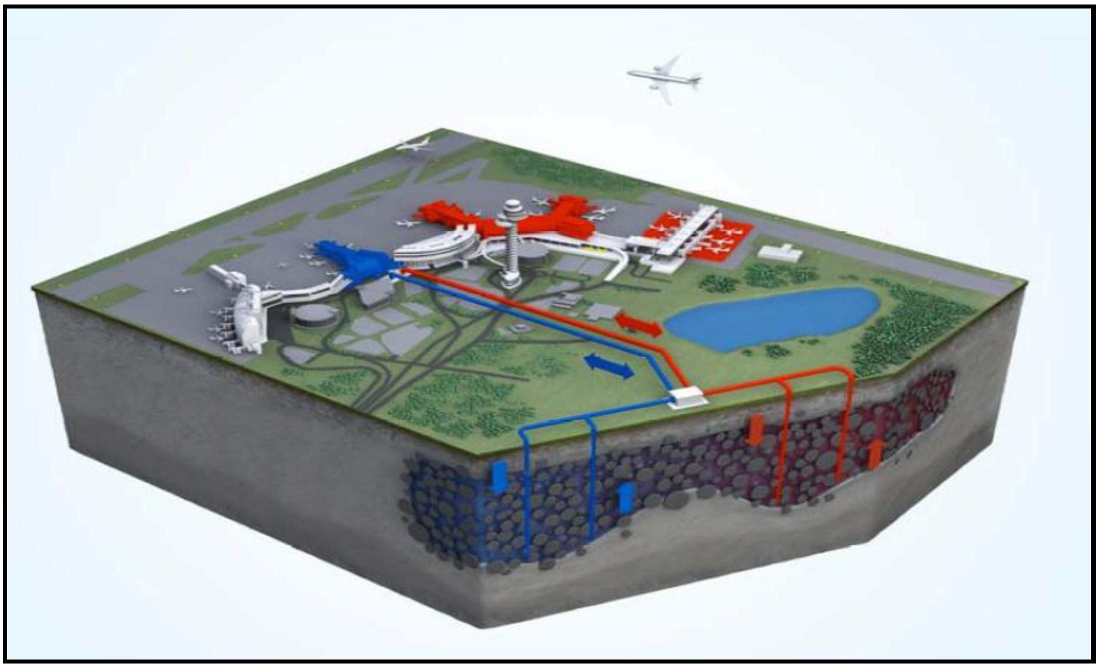

Figure 5.4 General view of the ATES Project

During winter season the heat from the plant is used to preheat ventilation air to the terminals and to the system of ground heating coils at the gates. The waste cold from heating is distributed back and stored at the cold side of the aquifer. The cold storage temperature is estimated to vary between +3 and +5°C under normal conditions. The heating is district heating and the plant is reducing dependence of district heating with 10-15 GWh per year.

In summertime the flow of aquifer system is reversed. The ATES plant then delivers cooling to the terminals where the need of cooling is large. The warm water in return holds a temperature of about +15 °C. However, this temperature can be increased to approximately +25 °C by using the ground heating coils at the gates as solar collectors during sunny days. The conventional chillers are the main cooling producing units that are 4-5 GWh electricity per year (Wigstrand I., 2010).

On the way back to ACA program, "GHG Protocol Worksheets" are used to calculate CO_2 emission. These worksheets are a number of excel worksheets that are available on the web site of GHG Protocol. Applicants have to submit their carbon foot printing data by using the worksheets provided by the GHG protocol.

In Chapter 7, carbon footprint calculation for Izmir Adnan Menderes Airport International Terminal has been made. All details of the procedure to calculate the terminal's carbon footprint are given in that chapter. In Chapter 6 there is a statistical study of the air traffic at Adnan Menderes Airport. According to these data the aircraft type that is mostly landing and taking off Izmir is determined and a basic carbon footprint calculation has been made for that aircraft with certain assumptions.

CHAPTER SIX
GENERAL INFORMATION AND STATISTICAL DATA OF IZMIR ADNAN MENDERES AIRPORT

6.1 General Information

Adnan Menderes Airport was opened in 1987 because of the need according to the development of aviation and tourism in the 80's in Turkey. Therefore, DHMİ Adnan Menderes Airport was put on service on 17 November 1987. The increase in flights of airline operators, there was a need to have an efficient apron capacity. In 2006 a new International Terminal and additional apron was constructed. A general view is given in Figure 6.1. DHMI has the role to overcome with the problems related to airport capacity that is parallel with increasing passenger and aircraft traffic numbers. General information about Adnan Menderes Airport is given in Table 6.1.

Figure 6.1 General view of Adnan Menderes Airport

General Directorate of State Airports Authority (DHMI) is responsible of management of airports and control of Turkish airspace in Turkey. DHMI is a state economic enterprise (SEE) that is general management organization of Ministry of Transportation. The Authority`s activities are defined as civil aviation activities, management of airports, performing ground services at airports and air traffic control services, establishment and operation of air navigation systems, facilities and other related facilities and systems, and to maintain them at the level of modern aeronautics. DHMI has to perform their activities according to international civil aviation rules and standards. Additionally DHMI is a member of International Civil Aviation Organization (ICAO). On the other hand it is a member of relevant international organizations, especially EUROCONTROL and Airports Council International (ACI) (www.dhmi.gov.tr).

Table 6.1 General information about Adnan Menderes Airport

City	Izmir
Distance to City	18 km
Starting Date of Operation	1987
Aerodrome Status	Civil
ICAO Code	LTBJ
IATA	ADB
Traffic Type	Domestic / International
Illumination Category	CAT II
Firefighting Category	CAT IX
Height (AMSL)	125.5
Geographical Coordinates	38°17`21"N, 27°09`18"E

As an environmental point of view, each airport has environmental issues to track. At Adnan Menderes Airport, waste management, water quality, wastewater quality, landscaping and visual effect, ecology is managed according to their Environmental Management System. Domestic waste, recyclable waste and hazardous waste is defined as the airport waste types. Water quality is analyzed (physical, chemical, bacteriological analyzes) every month for samples taken from the drinking water treatment system that is operated by the terminal operator. Wastewater quality is also analyzed continoulsy for the treated effluent water obtained from the wastewater treatment plant. Additionally indoor air quality and stack gas is regularly analyzed.

Energy management studies are carried out by the energy committee. These studies are very important cases to manage carbon for the international terminal.

According to the statistical data of DHMI, traffic of airplanes and passengers has increased significantly in recent years. In Table 6.2, the change in air traffic is given for the years 2010, 2011.

Table 6.2 Change of air traffic for 2010-2011

	2010	2011	Growth
Overflight	293.714	292.816	-0.3
International	421.549	462.881	9.8
Domestic	497.862	579.488	16.4
TOTAL	1.213.125	1.335.185	10.06

Figure 6.2 shows the change in traffic between 2003-2011. A continuous increase is seen in the graph. This shows that aviation is an important area for economic growth in Turkey. The breakdown value of the air traffic in 2011 is 43% for domestic flights, 35% for international flights and 22% for overflights (2011 Annual Report, 2011).

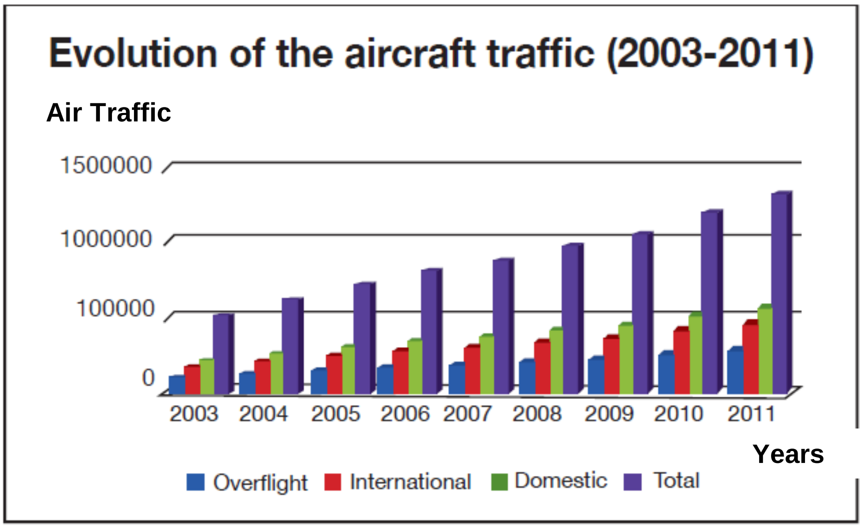

Figure 6.2 Air traffic change for 2003-2011

DHMI has built the new international terminal building by a build-operate-transfer model in 2006. The international terminal has an area of 107.699 m^2. The capacity of the terminal is 5 million passenger/year. Additionally because of the continuous and rapid increase in air traffic the new domestic terminal construction has began in 2012. It will be opened at the beginning of 2014. The new domestic terminal will have a capacity of 25 million passenger/year.

In this chapter the air traffic data is evaluated for Izmir Adnan Menderes Airport.

6.2 Statistical Air Traffic Data

The air traffic data has been obtained by the Research-Planning Committee of DHMI (Appendix 2). This department is collecting the air traffic data from the related departments and tracks them by certain quality forms.

The statistical study has been carried out by the data between 2007 and 2010. Data has been evaluated for type of aircraft and seasonal changes in air traffic. The statistic covers only aircraft traffic. Number of passenger has not been considered.

Table 6.3 Air traffic at Adnan Menderes Airport for 2007

	CIVIL AIRCRAFTS		PRIVATE-MILITARY AIRCRAFTS	
	Domestic Lines	International Lines	Domestic Lines	International Lines
January	2639	645	240	45
February	2452	453	288	32
March	2871	574	282	60
April	2949	912	325	46
May	3070	1161	445	120
June	2980	1343	310	251
July	3031	1639	298	341
August	3030	1739	352	315
September	2723	1487	250	192
October	2833	1184	295	123
November	2646	654	312	87
December	2743	654	262	84
TOTAL	33967	12445	3659	1696
G.TOTAL	46412		5355	

In the Table 6.3, data is given for the year 2007. In 2007, the number of flights for civil aircrafts is obtained as 46412 and 5355 for private/military aircraft as the sum of domestic and international lines. This means that 88.46 % of the total air traffic is obtained from civil aircraft flights (Figure 6.3). In this chapter only civil air traffic data is used for the statistic purposes. The total value for private and military aircrafts is given as an additional statistic data.

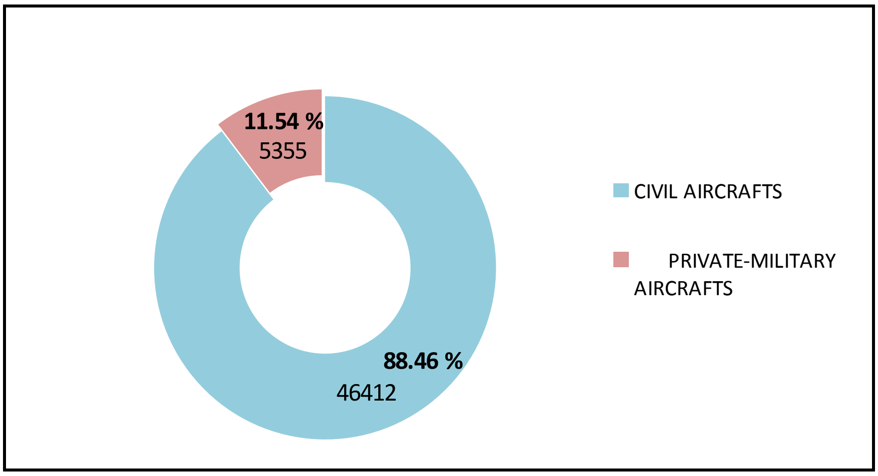

Figure 6.3 Air traffic at Adnan Menderes Airport -2007

Data for civil aircraft is divided into four quarters to see the seasonal change for 2007. The divided data is given as a graph in Figure 6.4. As seen from the graph, there is a peak for the third quarter which is obtained for July –August-September. For the first three quarters an increase is obtained. However, for the fourth quarter (autumn), a decrease is seen in flight number.

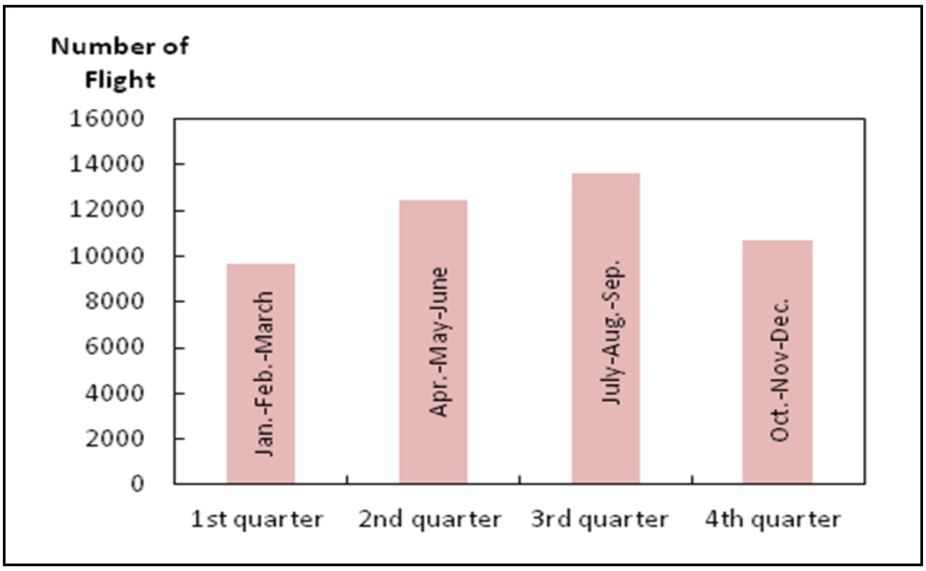

Figure 6.4 Seasonal changes in air traffic-2007

Beside the number of flights, air traffic data is also evaluated as aircraft type data to see which type of aircraft are using Adnan Menderes Airport for domestic and international flights. As seen in the Figure 6.5, the highest number of flight is obtained for the aircraft Boeing 737-800 (B738).

According to Figure 6.5, mainly Airbus and Boeing type aircrafts are landing and taking off for domestic and international flights at Adnan Menderes Airport which is also a result in the data for the whole years evaluated in this study. The highest number of flight is 3606 for B 738. The second aircraft type is Airbus 319 (A319) with the total number of flight as 2068.

In the second quarter of 2007 the highest number of flight is obtained as 4671 for B 738. The second aircraft type is again Airbus 319 (A319) with the total number of flight as 2336.

Aircraft types for the third quarter of 2007showed the highest number of flight that is obtained as 4436 for B 738. The second aircraft type is Airbus 319 (A319) with the total number of flight as 2348.

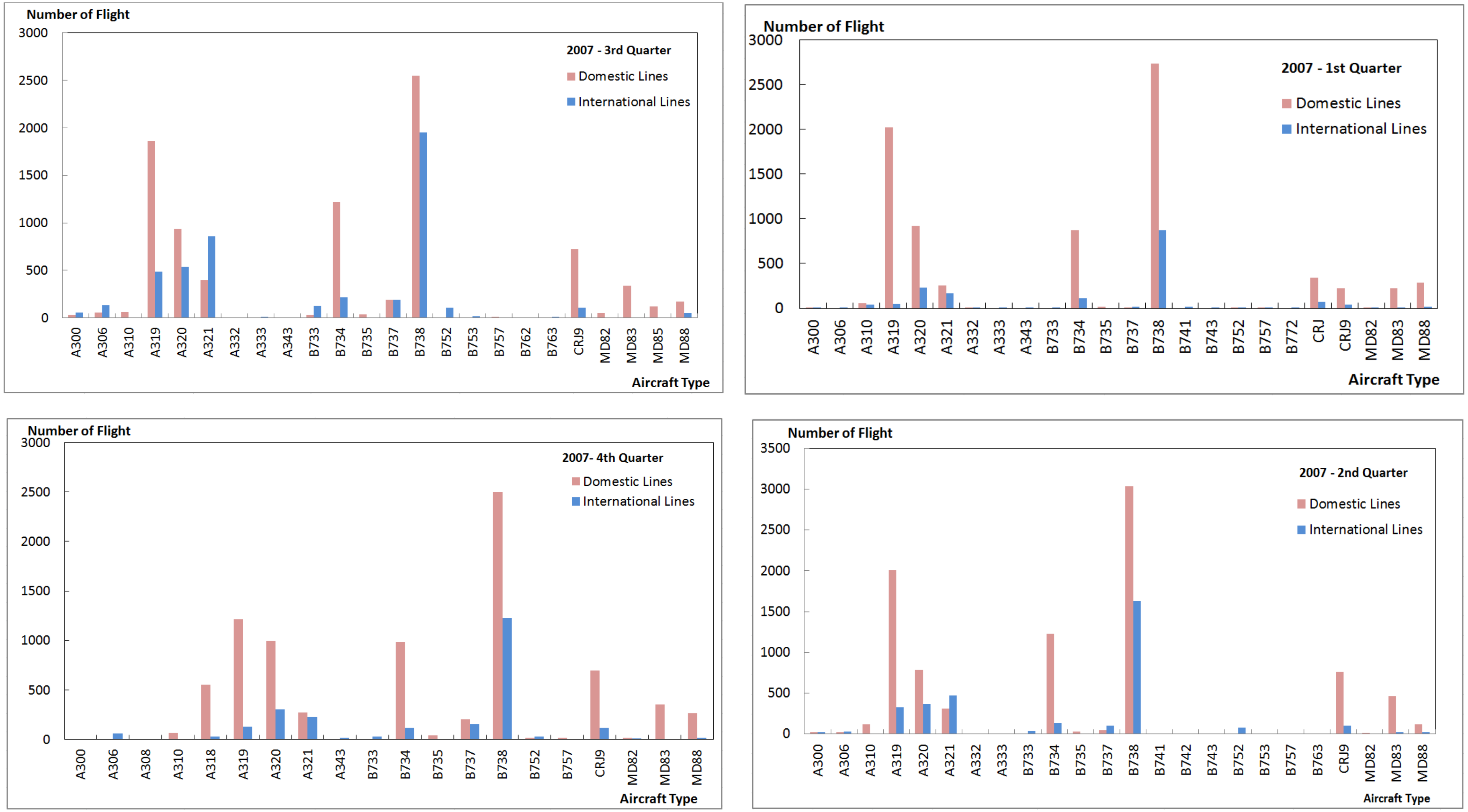

Figure 6.5 Number of flights for different aircraft types of 2007

The last quarter of 2007 has given the highest number of flight as 3725 for B 738 (Figure 6.5). The second aircraft type is Airbus 319 (A319) with the total number of flight as 1346 like the other quarters of 2007.

Table 6.4 Air traffic at Adnan Menderes Airport -2008

	CIVIL AIRCRAFTS		PRIVATE-MILITARY AIRCRAFTS	
	Domestic Lines	International Lines	Domestic Lines	International Lines
January	2778	580	264	47
February	2641	496	340	33
March	2795	685	277	58
April	2759	858	378	62
May	2931	1219	492	97
June	2830	1423	516	210
July	2991	1726	510	231
August	3089	1543	311	164
September	2666	1469	359	163
October	2799	1157	296	49
November	2861	730	315	36
December	2672	660	244	37
TOTAL	33812	12546	4302	1187
G.TOTAL	46358		5489	

In Table 6.4, the air traffic data is given for year 2008. The number of flights for civil aircrafts is obtained as 46358 and 5489 for private/military aircraft as the sum of domestic and international lines. This is a result of 88.16 % of the total air traffic for civil aircraft flights (Figure 6.6). In this chapter only civil air traffic data is used for the statistical purposes.

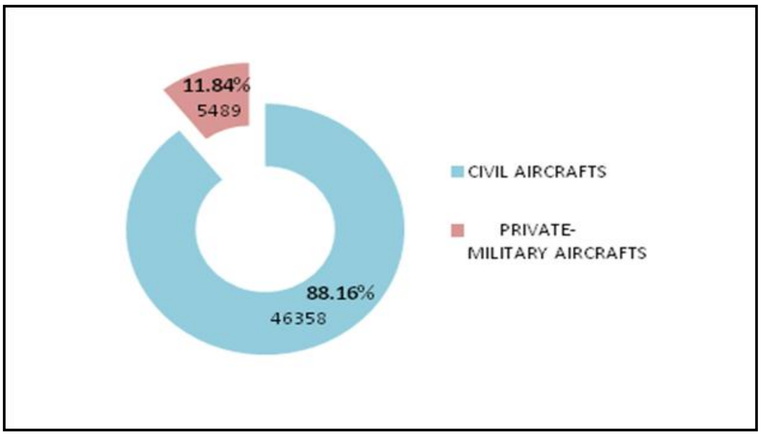

Figure 6.6 Air traffic at Adnan Menderes Airport -2008

In the same manner data is divided into four quarters related to the seasonal change for 2008 as in Figure 6.6. There is a peak for the third quarter which is obtained for July –August-September and an increase for the three quarters, January to September 2008, can easily be seen from Figure 6.8. A decrease is seen for the last quarter of 2008 in flight number for Adnan Menderes Airport as it was obtained for the data of 2007.

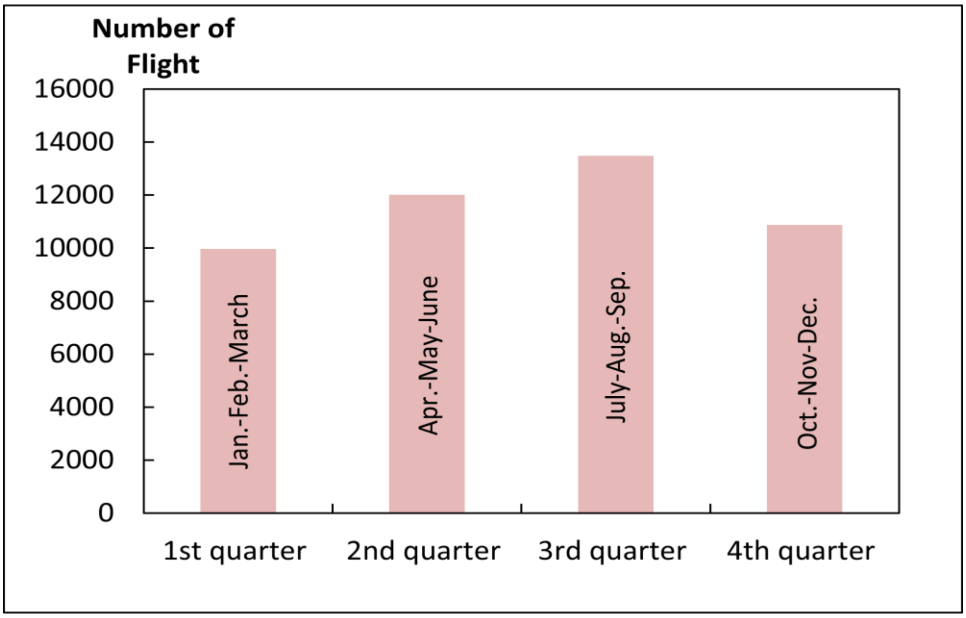

Figure 6.7 Seasonal changes in air traffic-2008

Aircraft type data is given in Figure 6.7 for the 4 quarters of 2008 as domestic and international flights. As seen in the following figures, the highest number of flight is obtained for the aircraft Boeing 737-800 (B738) as for the data of 2007.

Data of the first quarter of 2008 (Figure 6.8) shows that Airbus and Boeing type aircrafts are creating the air traffic for Adnan Menderes Airport. The highest number of flight is 4412 for B 738. The second aircraft type is Airbus 319 (A319) with the total number of flight as 1558 in the first quarter of 2008.

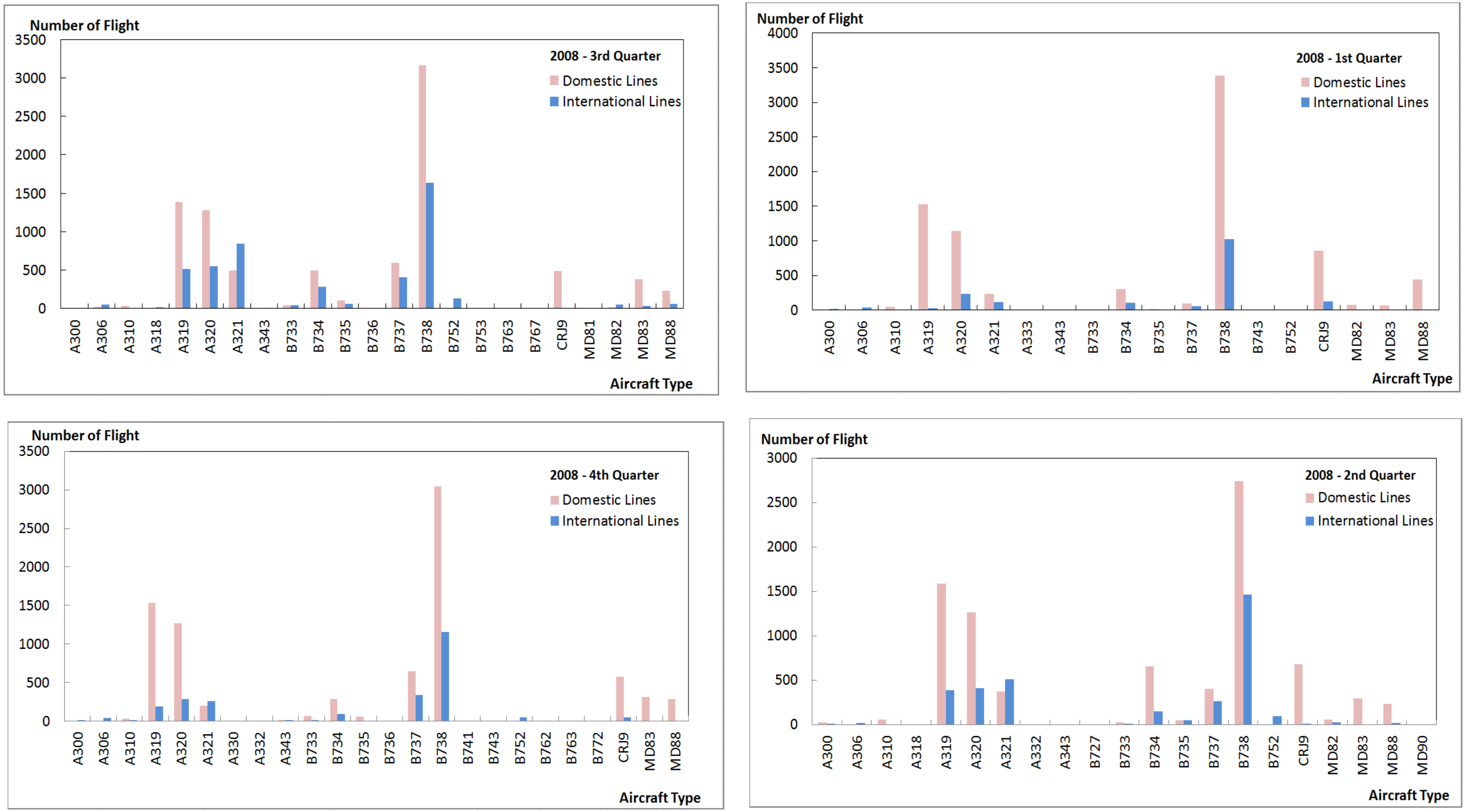

Figure 6.8 Number of flights for different aircraft types of 2008

In the second quarter of 2008, B 738 has the highest number of flight as 4212. The second aircraft type is again Airbus 319 (A319) with the total number of flight as 1984 (Figure 6.8).

In the third quarter, the highest flight number is obtained as 4802 for B 738. Airbus 319 (A319) with the total number of flight as 1904 has the second place of aircraft types.

In the last quarter of 2008, B 738 has the highest number of flight as 4208. The second aircraft type is Airbus 319 (A319) like the other quarters of 2008 with the total number of flight as 1727.

Table 6.5 Air traffic at Adnan Menderes Airport -2009

	CIVIL AIRCRAFTS		PRIVATE-MILITARY AIRCRAFTS	
	Domestic Lines	International Lines	Domestic Lines	International Lines
January	2583	571	244	58
February	2365	468	244	8
March	2679	595	389	24
April	2870	846	264	56
May	3100	1150	472	65
June	3120	1345	373	131
July	3314	1678	424	159
August	3108	1532	314	100
September	3111	1529	339	75
October	3336	1262	315	53
November	3268	867	286	62
December	3350	776	281	80
TOTAL	36204	12619	3945	871
G.TOTAL	48823		4816	

The air traffic data for 2009 is given in the Table 6.5. The number of flights for civil aircrafts is obtained as 48823 and 4816 for private/military aircraft as the sum of domestic and international lines. According to this data 90.14 % of the total air traffic is obtained for civil aircraft flights (Figure 6.9).

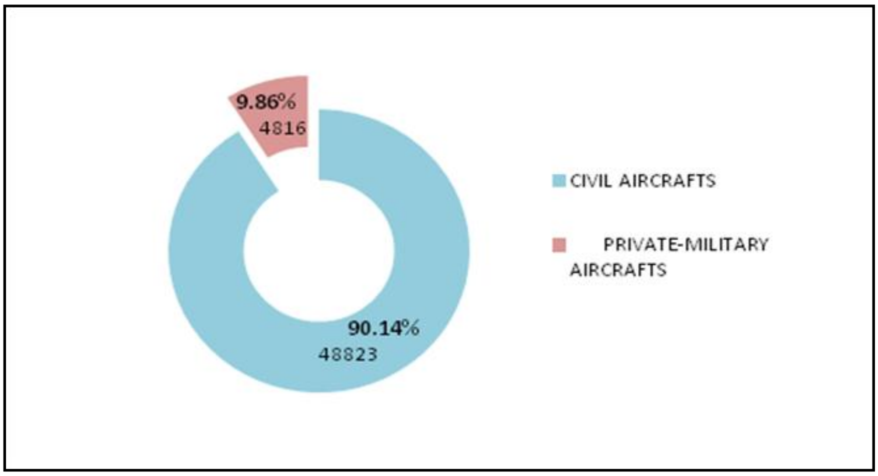

Figure 6.9 Air traffic at Adnan Menderes Airport -2009

Data of 2009 is analyzed in four quarters related to the seasonal change for 2009 as seen in Figure 6.10. As it has been obtained for the data of 2007 and 2008, there is a peak for the third quarter which is obtained for July –August-September. For the three quarters January to September 2009 there is an increase and at the last quarter of 2009, the flight number is decreasing for Adnan Menderes Airport.

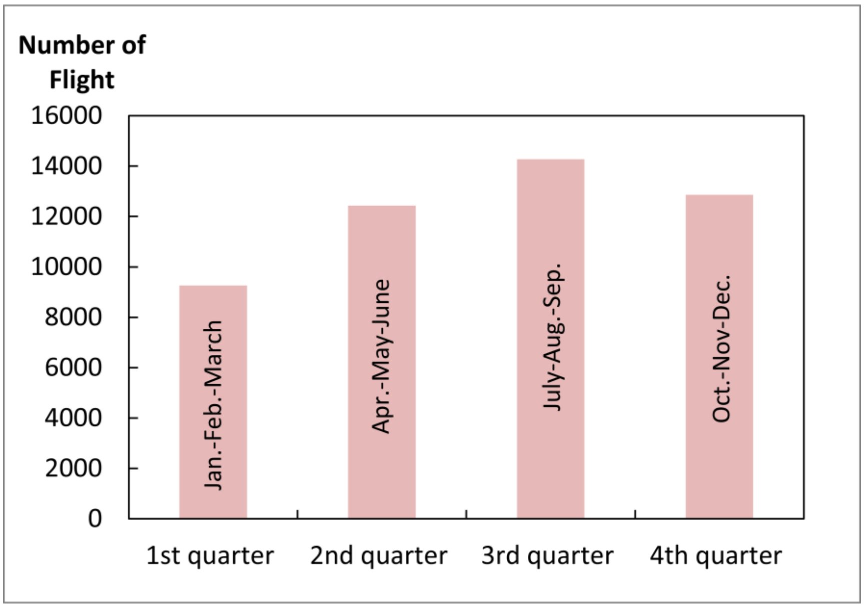

Figure 6.10 Seasonal changes in air traffic-2009

Seasonal data for the four quarters of 2009 is analyzed as aircraft type data which is given in the Figure 6.11 as domestic and international flights.

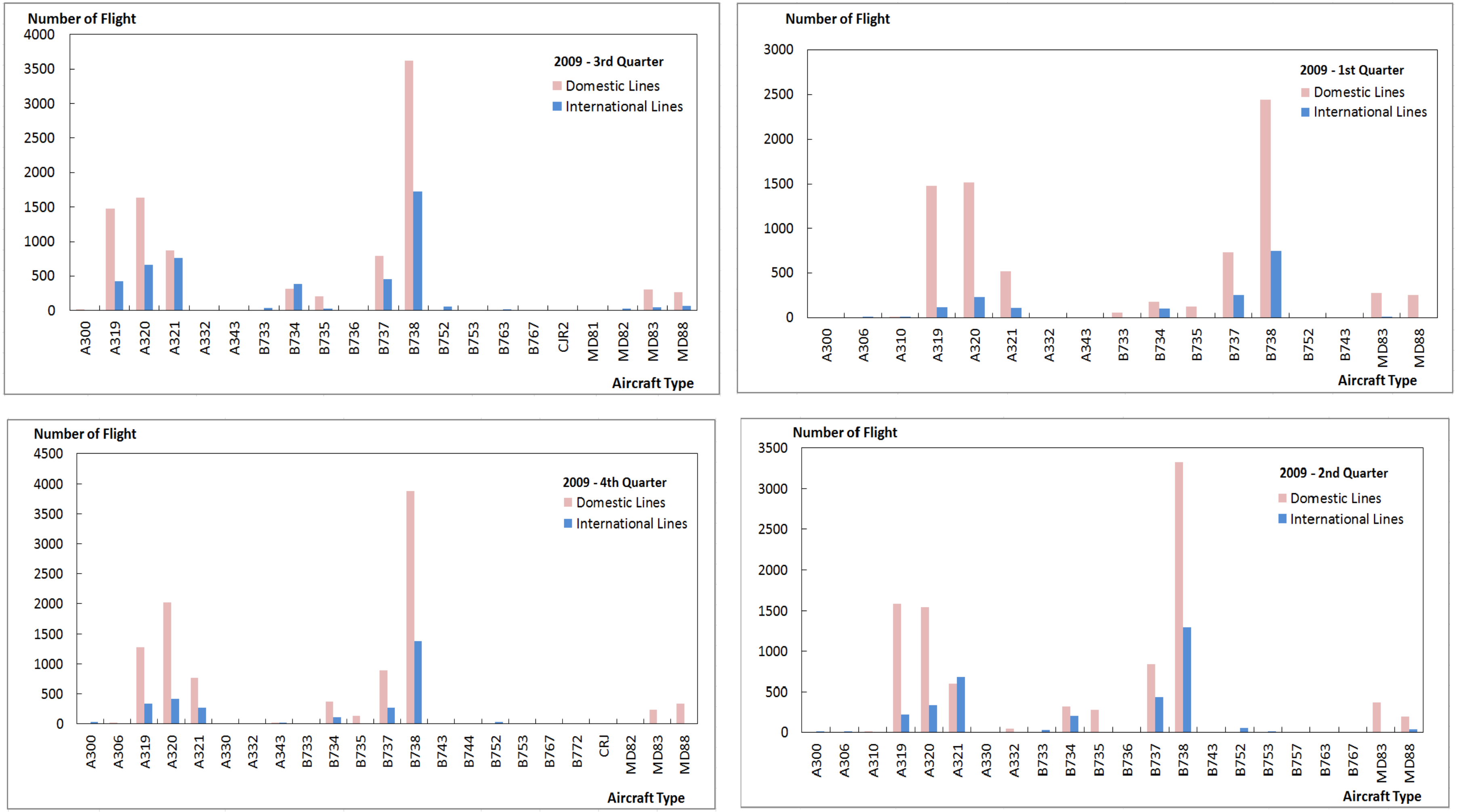

Figure 6.11 Number of flights for different aircraft types of 2009

For the first quarter of 2009, B738 has the highest flight number as 3187. In the first quarter of 2009 different from 2007 and 2008 Airbus 320 (A320) has taken the second place with the number of flight as 1751.

In the second quarter the highest number of flight is obtained as 4614 for B738. As it has been for the first quarter the second aircraft type is A320 with the flight number of 1875.

Figure 6.11 shows the third quarter of 2009. The highest number of flight is obtained as 5346 for B738. For 2009, the second aircraft type is A320 with the flight number 2303.

B 738 has the highest number of flight as 5255 for the fourth quarter. The second aircraft type is A320 with the total number of flight as 2432.

Table 6.6 Air traffic at Adnan Menderes Airport -2010

	CIVIL AIRCRAFTS		PRIVATE-MILITARY AIRCRAFTS	
	Domestic Lines	International Lines	Domestic Lines	International Lines
January	3312	729	269	27
February	2920	599	373	15
March	3362	777	426	30
April	3245	977	372	55
May	3471	1531	428	118
June	3373	1717	457	159
July	3683	2129	408	249
August	3557	2100	432	245
September	3594	1811	344	185
October	3636	1602	322	130
November	3553	966	449	54
December	3664	726	543	38
TOTAL	41370	15664	4823	1305
G.TOTAL	57034		6128	

The air traffic data for 2010 is given in the Table 6.6. The number of flights for civil aircrafts is obtained as 57034 and 6128 for private/military aircraft as the sum of domestic and international lines. The percentage values are 89.26 % and 10.74% for civil aircraft flights and private/military aircraft flights respectively (Figure 6.12).

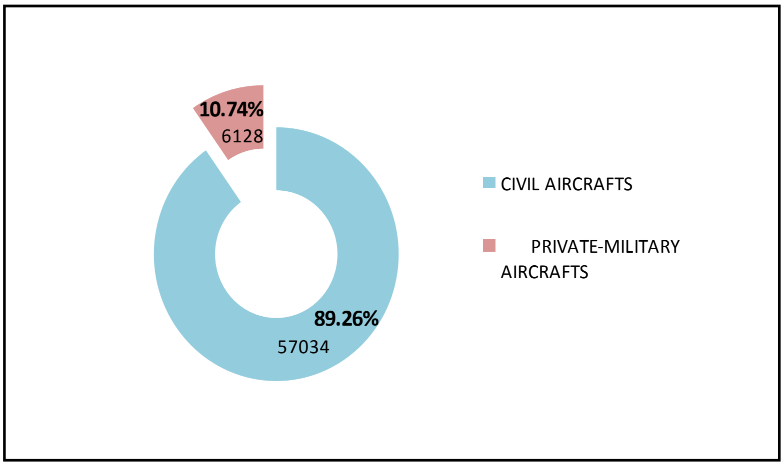

Figure 6.12 Air traffic at Adnan Menderes Airport -2010

The analyses of the quarters for the data of 2010 are given in Figure 6.13. The third quarter July –August-September 2010 has the highest flight number value. For the three quarters, January to September 2010, there is an increase that has been obtained for 2007, 2008, and 2009. At the last quarter of 2010, there is a decrease for Adnan Menderes Airport.

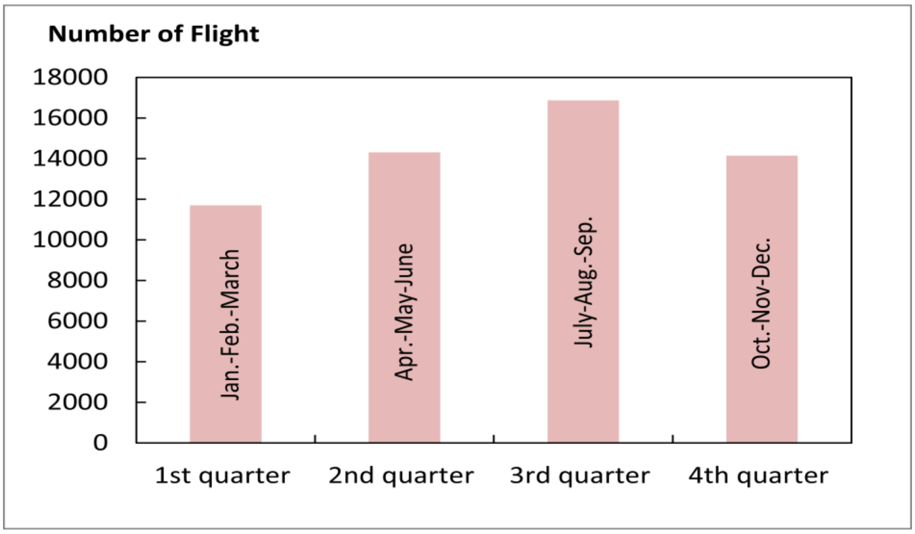

Figure 6.13 Seasonal changes in air traffic-2010

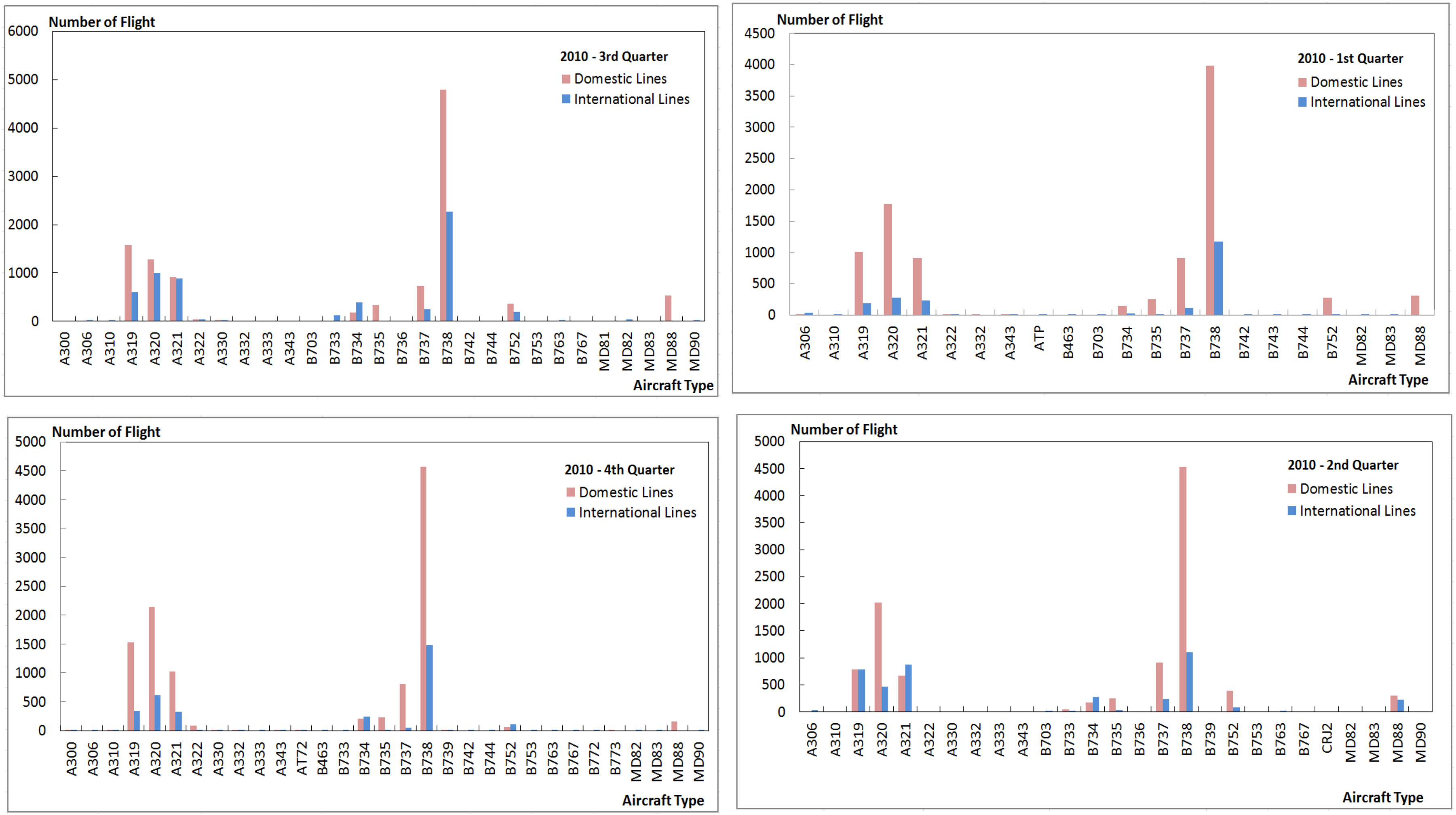

Figure 6.14 Number of flights for different aircraft types of 2010

Figure 6.14 shows the analyses of aircraft type data which is given as domestic and international flights. B738 has the highest flight number as 5156 at the first quarter of 2010. As for 2009, in the first quarter of 2010 A320 has taken the second place with the number of flight as 2055.

The highest number of flight is obtained as 5633 for B738. The second aircraft type is A320 with the flight number of 2481.

The highest number of flight is obtained as 7074 for B738 for the third quarter of 2010 (Figure 6.14). The second aircraft type is A320 with the flight number 2288.

In the last quarter of 2010, B 738 has the highest number of flight as 6052. The second aircraft type is A320 for the fourth quarter with the total number of flight as 2749.

As a general result the total number of flight for the 4 year analyzed data has been obtained as 220.413 (Table 6.7). In Table 6.8 total flight number is given between 2007 and 2010 in numbers of domestic and international flights.

Table 6.7 Total flight number between 2007 and 2010

Year	**Total Number of Flight**
2007	51767
2008	51847
2009	53639
2010	63160
TOTAL	220413

Table 6.8 Total flight number between 2007 and 2010 as domestic and international flights

		CIVIL AIRCRAFTS		PRIVATE-MILITARY AIRCRAFTS	
		Domestic Lines	International Lines	Domestic Lines	International Lines
2007	TOTAL	33967	12445	3659	1696
	G.TOTAL	46412		5355	
2008	TOTAL	33812	12546	4302	1187
	G.TOTAL	46358		5489	
2009	TOTAL	36204	12619	3945	871
	G.TOTAL	48823		4816	
2010	TOTAL	41369	15663	4823	1305
	G.TOTAL	57032		6128	

In Figure 6.15, the change in air traffic according to the years 2007, 2008, 2009, and 2010 is given. In 2008 there was a slight decrease in flight number for civil aircrafts. However in 2009 an increase was obtained compared to the values of 2007 and 2008. In 2010 there was an increase of 14.4 % compared to 2009. When the flight number of 2007 is compared to the flight number of 2010, 18.6% increase was obtained.

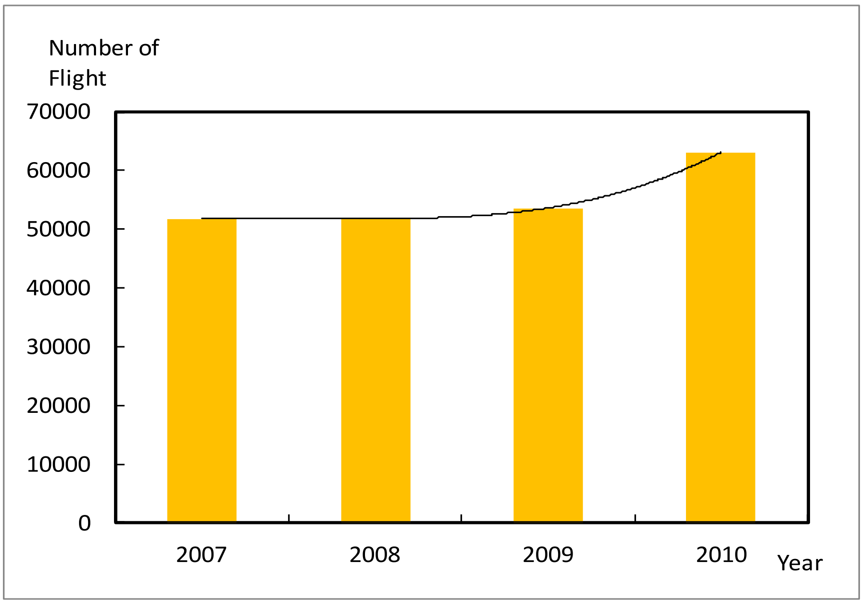

Figure 6.15 Change in air traffic between 2007 and 2010

In additon to the flight number data for the years between 2007 and 2010, the aircraft types are also determined in number of flight. In Table 6.9, among the different aircraft types seen in the Figures during this chapter, the most popular three aircraft types are given.

Table 6.9 Total flight number for the most popular aircraft types

Aircraft Type	**Total Number of Flight**
B738	76452
A319	15271
A320	17934

CHAPTER SEVEN
CARBON FOOTPRINT AT AIRPORTS

7.1 General Definitions of Carbon Footprint

Carbon footprint calculation of an airport has some steps to define. The first step is the definition of the organizational and operational boundaries of the airport. Organizational boundary is a cooperation of government, terminal operator, security, ground handling and catering companies, airlines, fuel companies, duty free, car rentals and car park operators. This boundary is showing the control, guide and influence affect of the airport operation. The second step is the definition of the operational boundary. The operational boundary is the detail of the terminal management activities. Terminal management activities are divided in two main departments, operation and technical. Technical department involves mechanical systems and installations, constructional maintenance, electrical & electronical systems, logistics and contracts department, Health and Safety, architectural and environmental departments. Operational departments especially deal with services for planes and passengers. All technical and operational activity details must be determined to obtain the safe data for the calculation of carbon footprint. According to the organizational and operational boundaries the decision has to be determined to obtain the scopes which will be used for carbon footprint calculation. The methodology to calculate the carbon footprint is given in Figure 7.1.

Scope 1 is defined as direct GHG emissions which are created by generation of electricity, steam or heat in equipment that is owned by the reporting organization, natural gas consumption, fuel consumption, travels by vehicles that are owned by the organization, employee transportation. These activities are directly controlled by the organization.

Scope 2 is defined as indirect GHG emissions that are created by electricity production that is purchased by the organization. Electricity production related emission is created by another facility. That's the meaning of indirect emission. On the other hand the electricity purchasing activity is the controlled issue by the organization. Therefore Scope 1 and 2 are the main controlled activities of the organization. The GHG Protocol recommends that an organization, at a minimum, reports scope 1 emissions and scope 2 emissions. However it is recommended to include scope 3 emission where possible.

Scope 3 is defined as other indirect GHG emissions from business travel, leased assets, outsourced activates. In Figure 6.2 there is an image defining the scopes (Guide for NSW Government Agencies, 2009).

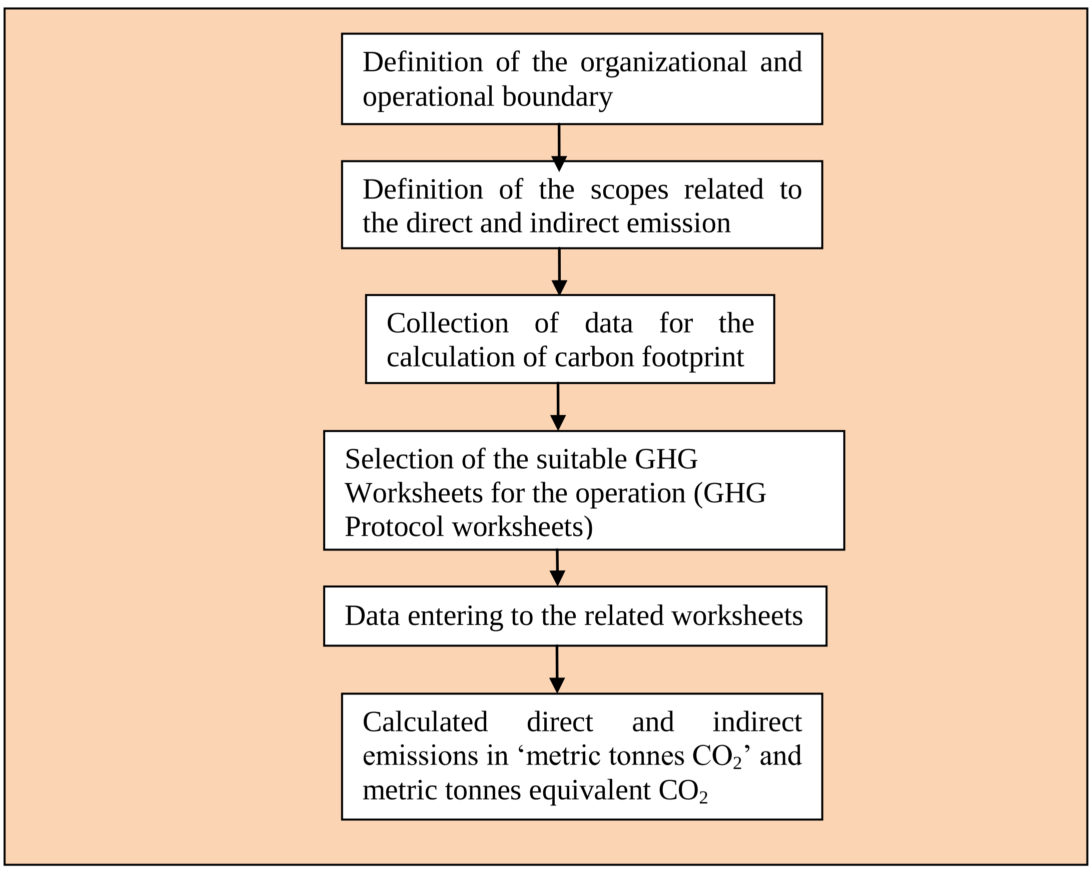

Figure 7.1 Method of carbon footprint calculation

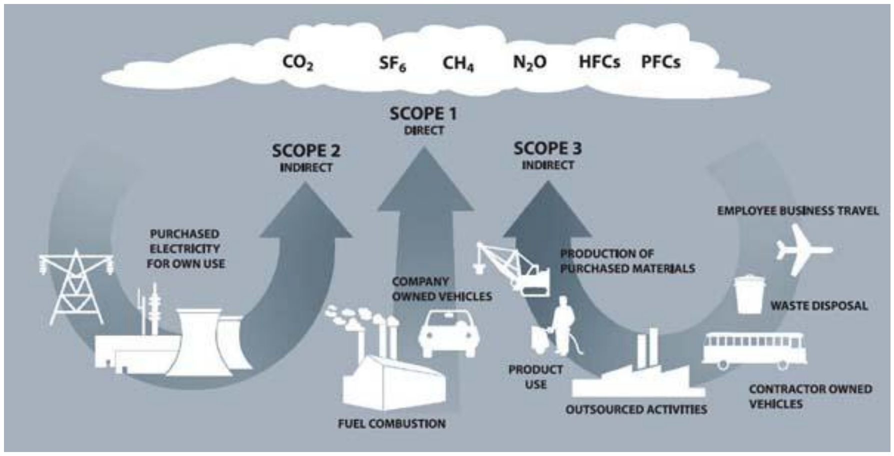

Figure 7.2 Emission reporting scopes

In the Figure 7.3, the scopes can be defined for an airport according to the Table 5.5 given in Chapter 5. As seen from the figure, control, guide and influence affect of an airport operation is colored in different tones of blue.

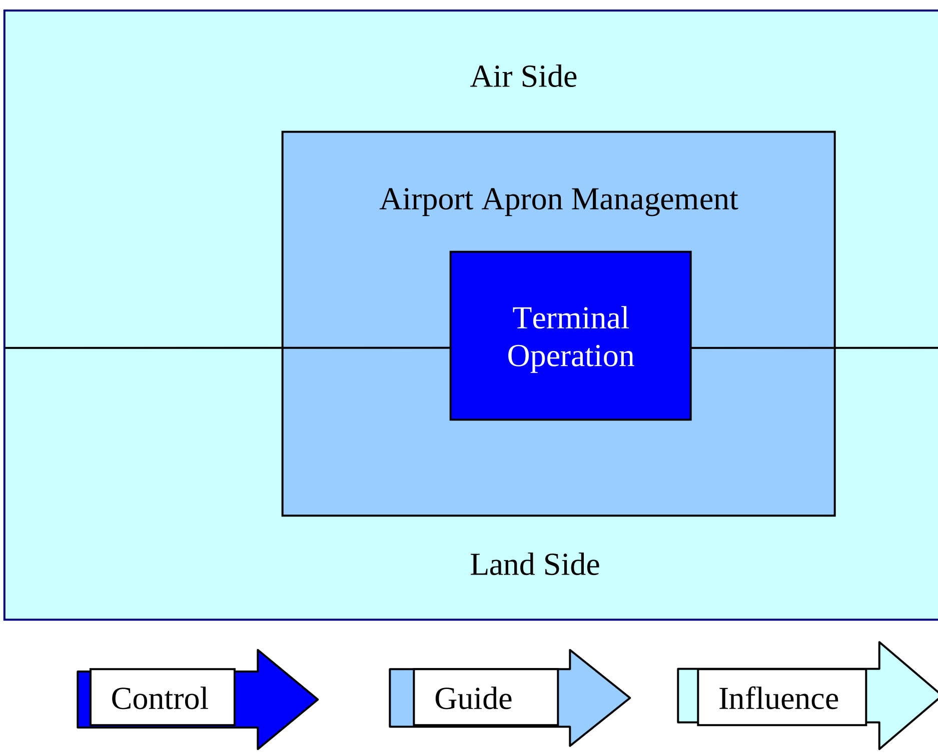

Figure 7.3 Operational boundary of an airport

Table 7.1 shows the operational boundary and the scope definitions for Adnan Menderes Airport International Terminal.

Table 7.1 Operational boundary for the international terminal

Item	Activity	Responsible Department	Control	Guide	Influence
Leased vehicles	Fuel consumption - Scope 1	Administration Department	+	+	+
Passenger Boarding Bridges (PCA, 400Hz)	Electricity sold for aircrafts - Scope 2	Terminal Operation Center (TOC)	+	+	+
Boilers & burners	Heating - Scope 1	Mechanical Installation Department	+	+	+
Water Supply		Mechanical Installation Department	+	+	+
Rental Shops	Scope2	Financial Department	+	+	+
Waste water treatment	Treatment process - Scope 1	Environmental Department	+	+	+
Generators / Energy Supply	Fuel consumption - Scope 1	Electrical & Electronical Department	+	+	+
Landscaping		Environmental Department- Subcontracted	N/A	+	+
Employee Transportation	Fuel consumption - Scope 1	Administration Department - Subcontracted	N/A	+	+
Leased vehicles for constructional & operational work	Fuel consumption - Scope 3	Maintenance & Repair Dep. & TOC / Subcontract	N/A	+	+
Car park	Electricity consumption - Scope 2	TOC	+	+	+
Baggage Handling	Electricity consumption - Scope 2	TOC	+	+	+
Ramp Tower Service	Electricity consumption - Scope 2	TOC / DHMI	N/A	+	+
Check-in Desks Rental	Electricity consumption - Scope 2	TOC	+	+	+
Housekeeping	Fuel Consumption - Scope 1 Electricity Consumption - Scope 2	TOC / Subcontracted	N/A	+	+
Luggage Rack		TOC / Subcontracted	N/A	+	+
Left Luggage	Electricity consumption - Scope 2	TOC / Subcontracted	N/A	+	+
Lost Luggage	Electricity consumption - Scope 2	TOC	+	+	+
Apron Menagement		DHMI	N/A	N/A	+
Ramp Tower Service & DGS (Docking Guidance Systen	Electricity consumption - Scope 2	DHMI / TOC	N/A	+	+
Check-in Desks & Information Desks	Electricity consumption - Scope 2	TOC	+	+	+
Flight Information Display System (FIDS)	Electricity consumption - Scope 2	TOC	+	+	+
Medical Service	Electricity consumption - Scope 2	Subcontracted	N/A	+	+
VIP Service	Electricity consumption - Scope 2	DHMI	N/A	+	+
CIP Service	Electricity consumption - Scope 2	Subcontracted	N/A	+	+
Transportation of solid waste	Fuel consumption - Scope 3	TOC / Subcontracted	N/A	+	+

7.2 Calculation of Carbon Footprint

The definition of operational boundary is the most important step for the determination of the scopes. In this study Adnan Menderes Airport International Terminal Izmir, Turkey is chosen to calculate the carbon footprint of the operational activity. The operational boundary is selected as international terminal as a case study. General information of Adnan Menderes Airport related to aviation has been given in chapter six.

Activities that are under “direct control” with “direct emission” are defined as Scope 1 which is summarized in Table 7.2. Leased vehicles for operational needs and employee transportation are the main fuel consumption ways. Fuel consumption of generators is related with the electricity generation in case of power outage for the terminal operation at the airport. Mobile lift is generally used for housekeeping and maintenance purposes and is working with fuel. On the other hand the fuel consumption of boilers is not a big amount because heating with fuel consumption is a backup system for the terminal operation. The heating system is actually consuming natural gas.

The wastewater treatment plant of international terminal has a design capacity of 2000 m^3/day. The treatment plant is a typical domestic wastewater treatment plant. It consists of eleven units. These are coarse screen, aerated grit chamber, equalization tank, aeration tank (aerobic biological treatment), sedimentation tank, disinfection, foam collection tank, sludge collection tank, sludge thickener, belt press unit and sludge drying beds.

The wastewater treatment system is determined as Scope 1 activity but its CO_2 emission is not considered according to the Intergovernmental Panel on Climate Change (IPCC) Guidelines. That is because of the biogenic origin of the process and should not be included in national total emissions (2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 5, 2006). On the other hand electricity consumption of the wastewater treatment plant is a CO_2 emission source. Electricity is used from the main line of the terminal. Therefore the electricity consumed from the process of the wastewater treatment plant is included in the general electricity consumption of the terminal.

Table 7.2 Scope 1&2 emissions of Adnan Menderes Airport International Terminal

SCOPE 1 EMISSION	**ACTIVITY**	**DATA SOURCE**
Heating system	• Natural Gas Consumption for the heating system of the terminal building. • Hot water production in winter • Catering activities	Natural gas invoices controlled by mechanical installations department.
Fuel consumption	• Generators • Mobile Lift usage • Boilers and diesel pumps • Leased vehicles for operational needs	Fuel purchasing invoices controlled by electrical & electronic systems, mechanical installations, administrative departments.
Employee Transportation	• Employee transportation to and from the airport	Distance covered controlled by administrative department.
Wastewater treatment system	• Treatment of wastewater created during terminal operation	Not included to the carbon footprint calculation.
SCOPE 2 EMISSION	**ACTIVITY**	**DATA SOURCE**
Purchased electricity	• Electricity consumption during terminal operation • Electricity sold for leased area (stakeholders) in the terminal • Electricity sold for planes (Ground Power Unit-GPU)	Electricity invoices controlled by electrical & electronic systems department.

Activities that are under “direct control” with “indirect emission” are defined as Scope 2, which is given in Table 7.2.

Purchased electricity is under direct control and is used in every activity in the terminal. Electricity which is sold to stakeholders (commercial area consumption) and airlines (as GPU usage) are included to the general electricity consumption values for the carbon footprint calculation. By GPU , an aircraft can obtain electrical energy as 400 Hz for electricity needs without running the motors using fuel.

All calculation tools for carbon footprint are selected from Green House Gas Protocol web site calculation tools part (http://ghgprotocol.org/calculation-tools).

7.2.1 Calculation of Scope 1 Activities

7.2.1.1 Heating System

The heating system of the terminal has a natural gas consumption for heating purposes. Monthly invoices of natural gas are used to obtain a statistical approach related to the consumption. The consumption data is used as m^3/year. However natural gas consumption is used as kwh/year (energy unit) for CO_2 emission calculation. The annual natural gas consumption data is given in Table 7.3.

The CO_2 emission calculation has been made by using the "Stationary Combustion Tool (Version 4.0)" of GHG protocol. The calculation tool has a common and set emission factor for natural gas according to 2006 IPCC Guidelines. The stationary combustion tool is using the emission factor as 0,20196 $kgCO_2$/kwh for natural gas.

Table 7.3 Natural gas consumption data for the international terminal

Time Interval	**Natural Gas Consumption (m^3)**	**Natural Gas Consumption (Kwh)**
June 2008-May 2009	451.658,456	4.805.645,989
June 2009-May 2010	404.991,593	4.309.110,550
June 2010-May 2011	403.807,89	4.296.515,91

7.2.1.2 Fuel Consumption

7.2.1.2.1 Generators. Five generators are in the operation to generate electrical energy during any power outage. Generators are important equipments to have continuous electrical energy in case of a power outage. Each generator has the capacity of 2000 kWh. The fuel type is diesel oil for the generators.

Fuel consumption of boilers and diesel pumps is another source of CO_2 emission. These two systems are using diesel oil as the fuel type. The boilers with diesel oil as the fuel are a reserve for the case of any trouble in natural gas delivery for the heating system. In this study, there has not been any fuel consumption data for the boilers.

Furthermore, for firefighting system there are 2 pumps with diesel motors. Approximately 1.89 liters diesel fuel is used for periodical efficiency tests (30 minutes test time). Tests are made 2 times per month. This means 45.36 liters diesel fuel consumption per year.

In Table 7.4, the fuel consumption data for generators and diesel pumps are given. As for the heating system natural gas consumption data, CO_2 emission for diesel fuel consumption data of generators and diesel pumps is calculated by using the same tool,” Stationary Combustion Tool (Version 4.0)”. The emission factor is automatically set by the tool which is 2,672588 kgCO_2/ liter.

Table 7.4 Diesel fuel consumption data for generators and pumps

Time Interval	**Generators (liter)**	**Diesel Pumps (liter)**
June 2008-May 2009	5.203	45,36
June 2009-May 2010	11.470	45,36
June 2010-May 2011	3.420	45,36

7.2.1.2.2 Fuel Consumption of Leased Vehicles and Mobile Lift. The terminal operation has control on vehicles that are a need for operational activities. Fuel type is diesel oil and unleaded gasoline for the vehicles that are generally leased by the terminal operation. The fuel consumption data taken from the invoices are used for

CO_2 emission calculation. This tool is related to mobile transport vehicles CO_2 emission calculations. The emission factor 2,68kg/L is used for diesel fuel, 2,323 kg/L is used for unleaded fuel (gasoline/petrol) for the calculations which are given in GHG Protocol CO2-Mobile.xls excel sheet.

Mobile lift usage is another transport type that is added to the calculation. The mobile lift is generally used for housekeeping and maintenance works at high levels inside and outside the terminal. Its fuel type is diesel fuel. On the other hand this type of lift can be charged by electricity. The emission factor 2.68 kg/L is used for diesel fuel (GHG Protocol CO2-Mobile.xls excel sheet) for the CO_2 emission calculation related with mobile lift usage.

The fuel consumption values are given in Table 7.5 for fuel consumption of leased vehicles and mobile lift. The calculation has been made by using the "WRI Transport Tool" of GHG protocol.

Table 7.5 Fuel consumption data of leased vehicles and mobile lift

Time Interval	Leased Vehicles		Mobile Lift
	Diesel fuel (liter)	**Unleaded gasoline (liter)**	**Diesel fuel (liter)**
June 2008-May 2009	6.004	3.569	220
June 2009-May 2010	5.989,44	2.879,43	122
June 2010-May 2011	6.142,37	2.385,83	51,13

7.2.1.2.3 Employee Transportation. Employee transportation is subcontracted to a third party company. The fuel type of the buses which are used for employee transportation is diesel fuel. For this data the terminal operator has no control on fuel consumption data, but has a guidance and influence by setting the routes of the vehicles. Therefore calculation of CO_2 emission could be made for vehicle distance based data. CO_2 emission of employee transportation is calculated by using the "WRI Transport tool". Distance based data is given in Table 7.6.

Table 7.6 Distance data of employee transportation

Time Interval	Distance (km)
June 2008-May 2009	404.321,80
June 2009-May 2010	389.448
June 2010-May 2011	390.855

7.2.2 Calculation of Scope 2 Activities

7.2.2.1 Purchasing Electricity From Producer

The international terminal operator has full control on electricity consumption by collecting invoices as data. Electricity is purchased by a government party or by special electricity generating companies. For the CO_2 emission calculation the "Electricity, Heat and Steam Purchase Tool" has been used. For the calculations standard method has been chosen. The standard method is defined as the emission factor based methodology.

The emission factor has been chosen as 432,842 grams CO2 / kWh which is the factor given for Turkey (ACA Documentation and Guidance, 2011). This high value of the emission factor is related with the electricity production installations using coal as fuel in Turkey. The electricity consumption data is given in Table 7.7.

Table 7.7 Purchased electricity consumption data

Time Interval	Electricity consumption (kWh)
June 2008-May 2009	14.175.049,5
June 2009-May 2010	14.104.143,5
June 2010-May 2011	14.352.562,6

7.2.2.2 Selling Electricity for Terminal Services

Electricity is sold by the terminal operator to different shops, to food and beverage companies (named as leased area). Consumed electricity by these business activities is controlled by power meters (gauges). The power meters are controlled each year by an analyzer for calibration purposes. The consumption data of sold electricity is read from the power meters and added to the calculation for net off purpose. In Table 7.8 the electricity consumption for sold area is given.

Table 7.8 Electricity consumption data of leased area in the terminal

Time Interval	Electricity consumption (kWh)
June 2008-May 2009	2.081.784
June 2009-May 2010	2.038.954
June 2010-May 2011	2.149.804

After landing of an aircraft, the airline can use its "Aircraft Power Unit (APU)" system to run its inside systems or can purchase electricity from the terminal operator from the frequency converter equipment mounted on passenger boarding bridges which is also named as 400 Hz. This system is defined as "Ground Power Unit (GPU)". The frequency converter uses mainline electricity which is 50 Hz and converts it to 400 Hz frequency for the use of aircrafts. The electricity consumption data of the GPU system is given in Table 7.9.

The calculation for the CO_2 emission of sold electricity (leased area, GPU) is carried out by "Electricity, Heat and Steam Purchase Tool" with standard method. The sold electricity data is used to net off the total value from the main electricity consumption data. Therefore the net off procedure has decreased the total CO_2 emission value because of the emission transfer to another activity.

Table 7.9 Electricity consumption data of GPU

Time Interval	Electricity consumption (kWh)
June 2008-May 2009	12.691
June 2009-May 2010	18.556
June 2010-May 2011	38.374

These Scope 2 activities are fully controlled by the terminal operator. The emission factor has been chosen as 432.842 grams CO_2 / kWh which is the value given for Turkey (ACA Documentation and Guidance, 2011). A summary about the emission factors used during the calculations are given in Table 7.10.

Table 7.10 Emission factors for fuels and electricity (ACA Documentation and Guidance, 2011)

	Emission Factor	**Unit**
Natural Gas	0,20196	kgCO_2/kwh
Diesel oil	2,6753	kgCO_2/liter
Diesel Fuel	2,6813	kgCO_2/liter
Unleaded gasoline	2,3273	kgCO_2/liter
Electricity	432,842	grams CO_2 / kWh

7.3 Results of Carbon Footprint Calculation For The Terminal Operation

The CO_2 emission calculation results are given in Table 7.11 for the defined time intervals June 2008-May 2009, June 2009-May 2010, June 2010-May 2011. As a general view, the emission has decreased in the second year (June 2009-May 2010) and in the third year (June 2010-May 2011) compared to the first year (2008-May 2009). However it has increased slightly in the third year compared to the second year.

As seen from the Table 7.10, results showed that there has been obtained a slight (1, 7%) decrease in CO_2 emission for the interval June 2009-May 2010 compared to the data calculated for June 2008-May 2009. This decrease is obtained by managing energy in the terminal building. The Building Management System (BMS) is modified to prevent any losses in energy. Additionally it is seen that there is a decrease for June 2010-May 2011 (1.28%) compared to June 2008-May 2009. On the other hand, there is an increase (0.4%) for June 2010-May 2011 compared to June 2009-May 2010. This situation is mainly related to the hard conditions with high temperatures at summer 2010. It is known that electricity consumption of the cooling system is the main CO_2 emission creating system. That's because of the highest percentage of electricity consumption of the HVAC (heating, ventilation, air conditioning) system for terminal buildings. During the terminal operation the highest electricity is obtained by the HVAC system with 60% of total electricity consumption.

Direct emissions showed a decrease for the three time intervals. Scope 1 emissions decreased 7.7 % for the time intervals June 2008-May 2009 to June 2010-May 2011.

Indirect emissions showed not an increase like direct emissions. There is a slight increase as 0.69 % for the time intervals June 2008-May 2009 to June 2010-May 2011.

As a general result, CO_2 emission reduction has been calculated as 86,932 metric tonnes CO_2 for the time intervals June 2008-May 2009 to June 2010-May 2011. In the same manner the CO_2 reduction has been calculated as 115,374 metric tonnes CO_2 for the time intervals June 2008-May 2009 and June 2009-May 2010.

Energy management is an important point to reduce CO_2 emission release. The main purpose of an operation should be awareness of employee. Energy management is a key issue for the employee. Without awareness no operation can contend with CO_2 reduction. Especially technical department have to analyze data and develop projects to obtain efficient energy management.

Table 7.11 GHG emissions for international terminal (direct and indirect emissions)

Emission Source Group	CO_2 (Tonnes)		
	June 2008-May 2009	June 2009-May 2010	June 2010-May 2011
Direct GHG Emissions Scope 1 (Heating)	873,424	783,179	780,889
Direct GHG Emissions Scope 1 (Fuel Consumption of Generators)	13,926	30,699	9,154
Direct GHG Emissions Scope 1 (Fuel consumption of Fire System Pumps)	0,121	0,121	0,121
Direct GHG Emissions Scope 1 (Fuel Consumption of Mobile Lift)	0,59	0,327	0,137
Direct GHG Emissions Scope 1 (Leased Vehicles / Unleaded Gasoline consumption)	8,306	6,702	5,553
Direct GHG Emissions Scope 1 (Leased vehicles / Diesel Fuel consumption)	16,099	16,060	16,470
Direct GHG Emissions Scope 1 (Employee Transportation/distance based)	687,906	662,600	664,993
Direct GHG Emissions Scope 1	**1.600,372**	**1.499,688**	**1.477,18**
Energy Indirect GHG Emissions Scope 2 (Electricity Consumption)	6.135,56	6.104,87	6.212,39
Energy Indirect GHG Emissions Scope 2 (Electricity Sold / leased area)	-901,08	-882,54	-930,53
Energy Indirect GHG Emissions Scope 2 (Electricity Sold / Aircraft -GPU)	-5,49	-8,03	-16,61
Energy Indirect GHG Emissions Scope 2	**5.228,99**	**5.214,3**	**5.265,25**
TOTAL	**6.829,362**	**6.713,988**	**6.742,43**

7.4 Carbon Footprint Of Aircrafts

The carbon footprint calculation for an aircraft is in nature a complex situation. Generally there can be differences between the emissions of a calculated flight and any single flight. The reasons are;

- Climatic conditions can vary like headwinds or tailwinds

- Flight distance can vary, due to detours to avoid inclement weather
- Aircraft can be kept in holding patterns
- The mass of aircraft load can vary between flights

Generally passengers don't know that their flight has many factors influencing the CO_2 emissions. These factors are;

- The plane type
- The engine type on the plane
- The seating configuration
- The freight load

In order to calculate the carbon footprint of aviation there have to make some assumptions about each of the above given factors.

A standard calculation methodology should make assumptions related to the type of planes that fly short-haul and long-haul routes, and the amount of seats of the aircraft.

The distance between point of origin and destination can be calculated using a circle method. In different methods the distance is adjusted by using a factor. The type of plane is important for any flying distance related to the fuel burn. Emissions are changing for different plane models. In Figure 7.4, there is a graph about CO_2 emissions for different types of planes as a function of distance. As seen from Figure 7.4, it can be said that there is nearly a factor of 2 between the most and least efficient plane models flying the same distance. Additionally the graph show that the relationship between emissions and distance travelled for the plane types are not linear. The reason is the take-off emissions of a flight (Jardine C.N, 2009).

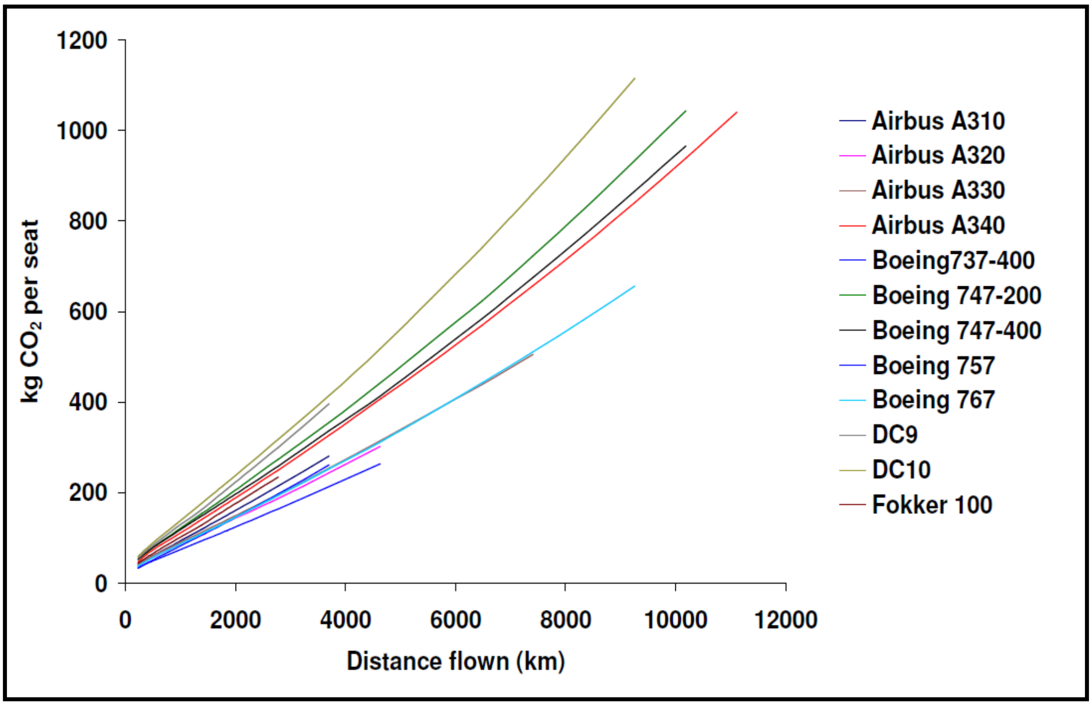

Figure 7.4. CO_2 emission as a function of distance for different aircraft models

A carbon footprint calculation has been made for the aircraft types that are the first three using the Adnan Menderes Airport. These are B738, A319 and A320 types according to the statistical data for Adnan Menderes Airport in Chapter 6. The calculation is only a sample for a İzmir-İstanbul flight. This calculation is independent of the carbon footprint for the international terminal.

Carbon footprint can be calculated by "GHG protocol WRI Transport tool" for the aircraft types which has also been used for the carbon footprint calculation of Scope 1 Transport activities of the international terminal. For the calculation selections are as follows:

☑ The scope is defined as "Scope 3".

For the international terminal, CO_2 emission of aircraft cannot be controlled. Therefore it is an indirect emission without control of the operational boundary.

☑ Type of activity data is chosen as "Passenger Distance".

The flight distance data can easily be found but the fuel consumption data of an aircraft cannot be found easily. The GHG Protocol WRI Transport tool gives the opportunity to calculate CO_2 emission by using distance data.

The activity data used for the calculation are;

☑ **Vehicle Type:** Air - Short Haul - Economy Class.

This data is assumed. Short haul is chosen for Izmir - Istanbul flight. Additionally the flight is chosen as economy class flight. This is optional. For example the flight can be changed as long haul-business class flight.

☑ **Distance Travelled:** Izmir-Istanbul flight is chosen for the calculation.

B738, A319 and A320 type aircrafts are generally used for domestic flights. The travelled distance is used as 419 km (information taken from an airline company). Unit of distance is defined as passenger kilometer.

☑ **Number of Passenger:** Economy class has been chosen as seating number. B738, A319 and A320 have 150, 230, 150 economy class seating respectively (http://airliners.net/aircraftdata).

After entering the needed data and information, CO_2 emission is calculated automatically by the system. The results of the carbon footprint calculations for B738, A319 and A320 type aircrafts are given in Table 7.12.

Table 7.12 Carbon footprint of Boeing and Airbus type aircrafts

Aircraft Type	**Total GHG Emission (metric tones CO_2)**
B738	6,419
A319	9,843
A320	6,419

A 319 is medium to long range wide body aircraft, A320 and B738 are short to medium range aircrafts. Therefore the emission value for A319 is higher than the other emission values because of higher seat number. That is related with the weight of the aircraft. Weight increase needs more efficiency and energy for flight. For this reason more fuel is consumed to increase the efficiency.

CHAPTER EIGHT
CONCLUSION AND RECOMMENDATION

This study is a general view of carbon footprint calculation principles for terminal operation activities at airports. The given study is a result of mapping level carbon accreditation according to Airport Council International (ACI) – Airport Carbon Accreditation (ACA) Program. The main aim is to give an idea about CO_2 emission created at airports during terminal operation activities.

Carbon footprint calculation of the international terminal was defined firstly as organizational and operational boundaries. Organizational boundary is a cooperation of government, terminal operator, security, ground handling and catering companies, airlines, fuel companies, duty free, car rentals and car park operators. This boundary is showing the control, guide and influence affect of the airport operation. The second step is the definition of the operational boundary. The operational boundary is the detail of the terminal management activities. Terminal management activities are divided in two main departments, operation and technical. Technical department involves mechanical systems and installations, constructional maintenance, electrical & electronical systems, logistics and contracts department, health and safety, architectural and environmental departments. Operational departments especially deal with services for planes and passengers. All technical and operational activity details were determined to obtain the safe data for the calculation of carbon footprint. According to the organizational and operational boundaries Scope 1 (direct emissions) and Scope 2 (indirect emissions) activities were determined.

Scope 1 is defined as direct GHG emissions which are created by generation of electricity, steam or heat in equipment that is owned by the reporting organization, natural gas consumption, fuel consumption, travels by vehicles that are owned by the organization, employee transportation. These activities are directly controlled by the organization.

The CO_2 emission calculations were made for three time intervals; June 2008-May 2009, June 2009-May 2010 and June 2010-May 2011. The emission had decreased in the second year (June 2009-May 2010) and in the third year (June 2010-May 2011) compared to the first year (2008-May 2009). However it had increased slightly in the third year compared to the second year. The calculated results showed that there had been obtained a slight (1.7%) decrease in CO_2 emission for the interval June 2009-May 2010 compared to the data calculated for June 2008-May 2009. This decrease was obtained by energy management studies in the terminal building. The Building Management System (BMS) was modified to prevent any losses in energy. Additionally it was seen that there was a decrease for June 2010-May 2011 (1.28%) compared to June 2008-May 2009. On the other hand, there was an increase (0.4%) for June 2010-May 2011 compared to June 2009-May 2010. This situation was mainly related to the hard weather conditions at summer 2010. It was obtained that electricity consumption of the cooling system was the main CO_2 emission creating system. That was because of the highest percentage of electricity consumption of the HVAC (heating, ventilation, air conditioning) system for terminal buildings. During the terminal operation the highest electricity consumption was obtained by the HVAC system with 60% of total electricity consumption.

Direct emissions showed a decrease for the three time intervals. Scope 1 emissions decreased 7.7 % for the time intervals June 2008-May 2009 to June 2010-May 2011.

Indirect emissions showed not a decrease like direct emissions. There is a slight increase as 0.69 % for the time intervals June 2008-May 2009 to June 2010-May 2011.

As a general result, CO_2 emission reduction has been calculated as 86,932 metric tonnes CO_2 for the time intervals June 2008-May 2009 to June 2010-May 2011. In the same manner the CO_2 reduction has been calculated as 115,374 metric tonnes CO_2 for the time intervals June 2008-May 2009 and June 2009-May 2010.

The carbon footprint calculation for aircrafts is in nature a very complex case. A CO_2 emission calculation was made by making some assumptions that cannot be set. Carbon footprint calculations had been made for B738, A319 and A320 type aircrafts that have the highest flight number according to the statistical air traffic data. Related to passenger number and flight km 6,419; 9,843; 6,419 tones CO_2 had been obtained for B738, A319 and A320 type aircrafts respectively.

Level 1 – Mapping is a way to define the CO_2 emission created during terminal operation activity. Level 1 is the basic level and does not contain the effect of airlines (aircraft movements) at the air side. By increasing the levels, the process is going more complex. During the level increasing process other parties that are not under the control of the terminal operator must be included. However it is a team work that will show the real effect to climate change of an airport at land side and air side together.

REFERENCES

Airliners. (n.d.). *Aircraft technical data & specifications*. Retrieved January 01, 2013 from http://airliners.net/aircraftdata

Airport Council International Europe. (2012). *Commited to carbon reduction*. Retrieved May 28, 2012 from http://airportcarbonaccreditation.org

Airport Council International. (2011). *Airport carbon accreditation documentation and guidance*. WSP Environment and Energy. Manchester.

Athens International Airport. (2011). *The environmental management system of the environmental services department of Athens international airport*. Retrieved October 12, 2011 from http://athensairport.com

Auckland Airport Management Co. (2009). *Auckland airport sustainability report*, New Zealand.

Auckland Airport. (n.d.) *Environmental management*. Retrieved October 12, 2011 from http://aucklandairport.co.nz/Corporate/Social-Responsibility/Sustainability-policy/Environmental-management.aspx

Australia Pacific Airports Corporation. (2012). *Australia pacific airports corporation annual report*. Australia.

Australia Pasific Airports. (2005). *Melbourne airport public environment report (2003/2004)*. Australia.

Baron, S. T., Tuchschmid, M., Martinetti, G., Pépion, D. (2011). *High speed rail and sustainability. Background report: Methodology and results of carbon footprint analysis. International Union of Railways (UIC)*. Paris.

Berry, F., Gillhespy, Rogers, J. (2008). *Airport cooperative research program. airport sustainability practices. A Synthesis of Airport Practice.* Washington DC.

Bouley, D. (2011). *Estimating a data center's electrical carbon footprint.* Schneider Electric. UK.

Dagget, D., Hadaller, O., Maurice, L., Rumizen, M., Brown, N., Altman, R., Aylesworth, H. (2007). *The commercial alternative aviation fuel initiative*. SAE-07ATC-15.

Darwin International Airport Management Co. (1999). *Darwin international airport final environment strategy*. Austria.

Department of Environment, Climate Change and Water NSW. (2009). *Guide for NSW government agencies: How to prepare a greenhouse gas emissions inventory*. DECCW 2009/669. ISBN 978 1 74232 449 4. Australia.

Dictionary of Sustainable Management. (n.d.).*What is sustainability*. Retrieved April 06, 2012 from http://sustainabilitydictionary.com

Dictionary. (n.d). *Why is sustainability important*. Retrieved April 06, 2012, from http://answers.yourdictionary.com/science/why-is-sustainabilityimportant.html

Dublin Airport Management Co. (2009). *Sustainability report*. Dublin.

Elbir, T. (2008). Estimation of engine emissions from commercial aircraft at a midsized turkish airport. *J. Environ. Eng. 134* (3), 210-215.

Epstein, M.J. (2008). *Making sustainable work*, ISBN-13:9781906093051. USA.

Eurocontrol. (n.d). *About us, what is Eurocontrol.* Retrieved January 01, 2013 from http://eurocontrol.int/content/about-us

Eurocontrol. (2007). *Air traffic management*. Retrieved November 23, 2007 from http://eurocontrol.int/environment/public/subsite_homepage/homepage.html

Eurocontrol. (2007). *Sustainable air transport*. Retrieved November 23, 2007 from http://eurocontrol.int/corporate/public/standard_page/biz_environment.html.

European Aviation Safety Agency. (n.d.). *Rulemaking environmental activities.* Retrieved November 23, 2007 from http://easa.eu.int/home/r_environ_main.html

European Civil Aviation Conference (ECAC). (1997). *Report on standard method of computing noise contours around civil airports.* 21. Plenary Session of ECAC. France.

European Civil Aviation Conference. (1997). *ECAC.CEAC Doc29, Report on standard method of computing noise contours around civil airports*. France.

European Civil Aviation Conference. (n.d.). *About ECAC*. Retrieved December 23, 2012, from https://http://ecac-ceac.org/index.php/about_ecac/mission

European Civil Aviation Conference. (2008). *Environmental Activities*. Retrieved January 02, 2008 from http://ecac-ceac.org//index.php/activities/environment

European Platform on Life Cycle Assessment. (2007). *Carbon footprint*. European Commission. Italy.

Federal Aviation Administration. (n.d.). *Airport sustainability*. Retrieved April 6, 2012 from http://.faa.gov/airports/environmental/sustainability

Federal Aviation Administration. (n.d.). *Environmental Review*. Retrieved November 23, 2010 from http://faa.gov/airports_airtraffic/environmental_issues

Flughafen München GmbH. (2003). *Munich international airport annual report 2002,* Germany.

Flughafen München GmbH. (n.d.). *Environmental and climate protection.* Retrieved October 14, 2011 from http://munich-airport.de

Frankfurt Airport , Fraport. (2008). *Fraport fairplay sustainability report*, Germany.

General Directorate of State Airport Authority. (2005). *Adnan Menderes Airport environmental management Plan*. Istanbul, Turkey.

General Directorate of State Airport Authority.(n.d.). *İzmir Adnan Menderes Airport General Information.* Retrieved April 06, 2012 from http://dhmi.gov.tr/aerodromes.aspx

General Directorate of State Airports Authority.(2011). *2011 Annual report*. Ankara, Turkey.

General Directorate of State Airports Authority. (2006). *DHMI instructions*. Ankara, Turkey.

Global Reporting Initiative. (2009). *Snapshot of sustainability reporting in the airports sector.* ISBN number: 978-90-8866-028-3.Amsterdam.

Green House Gas Protocol. (n.d.). *Cross sector tools.* Retrieved May 23, 2012 from http://ghgprotocol.org/calculation-tools

Intergovernmental Panel on Climate Change. (1999). *Aviation and the global atmosphere*. Geneva, Switzerland.

Intergovernmental Panel on Climate Change. (2006). *IPCC guidelines for national greenhouse gas inventories*. Volume 5 Waste. ISBN 4-88788-032-4. Japan.

International Air Carrier Association. (n.d.). *Main activities*. Retrieved November 27, 2007 from http://iaca.be

International Air Transport Association. (n.d.) *About us*. Retrieved November 23, 2007 from http://iata.org/pages/default.aspx

International Civil Aviation Organization. (1987). *Airport planning manual- Doc 9184 AN/902 Master planning*. Part 1. Canada.

International Civil Aviation Organization. (1999). *Airport service manual Doc 9137*. Part 3.Canada.

International Civil Aviation Organization. (2002). *Airport planning manual - land use and environmental control Doc 9184 AN/902.* Part 2. (3rd ed.).Canada.

International Civil Aviation Organization. (2007). *Airport Air Quality Guidance Material*. (1st ed.). Committee on Aviation and Environmental Protection. Seventh Meeting. Canada.

International Civil Aviation Organization. (2007). *Information Paper*, Joint Planning and Development Office. U.S.A..

International Civil Aviation Organization. (1993). *Annex 16 to the convention on international civil aviation environmental protection. Volume I Aircraft Noise*. Canada.

International Civil Aviation Organization. (1993). *Annex 16 to the convention on international civil aviation environmental protection. Volume II Aircraft Engine Emissions.* Canada.

International Civil Aviation Organization. (2007). *Environmental Report*. Canada.

International Civil Aviation Organization. (n.d.). *About ICAO, ICAO in Brief*. Retrieved May 05, 2012, from http://icao.int/Pages/ icao-in-brief.aspx

International Civil Aviation Organization. (n.d.). *Environmental protection*. Retrieved February 15, 2013, from http://icao.int/environmental protection/Pages/default.aspx

International Council of Civil Aviation. (2001). *Annex Documentation*. Canada.

Jardine, C.N. (2009). *Calculating the carbon dioxide emissions of flights. Final Report.* Environmental Change Institute, Oxford University Centre for the Environment.U.K.

Joint Aviation Authority. (n.d.). *About Joint Aviation Authority.* Retrieved November 23, 2007 from http://jaa.nl

Kesgin, U. (2006). *Aircraft emissions at turkish airports*. *Energy, 31,* 372-384.

LAWA Group Airports. (2008). *Los Angeles World Airports sustainability report*. Los Angeles.

London Stansted Airport. (2008). *Stansted Generation 2 sustainability report.* UK.

Oakland Airport.(n.d.). *Environmental management*. Retrieved October 12, 2011 from http://oaklandairport.com

Reynolds, T.G., Barrett, S., Dray, L.M., Evans, A.D., Köhler, M.O., Morales, M.V., Schäfer, A., Wadud, Z., Britter, R., Halam, H., Hunsley, R. (2007). Modelling Environmental & Economic Impacts of Aviation: Introducing the Aviation Integrated Modelling Project, Revised paper for *7th AIAA Aviation Technology*, Integration and Operations Conference, Belfast, Paper No. AIAA–7751, 18–20.

Schipol Group. (2008). *Amsterdam Schipol Airport corporate responsibility report.* Amsterdam.

SITA.(n.d.). *About SITA*. Retrieved November 23, 2007 from http://sita.aero

Small Firms Association. (2007). *Environmental management guidelines for small businesses*. Dublin.

Swedia Swedish Airports Group. (2011). *Swedavia Annual Report 2010*. Sweden.

Swedia Swedish Airports Stockholm Arlanda Airport. (2013). *Stockholm Arlanda, a zero vision for carbon dioxide emissions.* Retrieved January 12, 2013 from http://swedavia.com/arlanda/about-stockholm-arlanda-airport-/about-stockholm-arlanda-airport/environment/carbon-dioxide-emissions

The Air Transport Action Group (ATAG). (2010). *Air Transport – A global approach to sustainability*. Retrieved November 23, 2010 from http://airport-int.com/article/air-transport-a-global-approach-to-sustainability.html

The Edinburgh Centre for Carbon Management. (2008). *What is a carbon footprint*. Reference ECCM-EM-483-2007. Sweden.

The free encyclopedia wikipedia. (n.d.). *European Aeronautic Defence and Space Company (EADS).* Retrieved November 23, 2007, form http://en.wikipedia.org/wiki/EADS

Vancouver Airport Authority. (2005). *Vancouver international airport environmental management plan*. Canada.

Waitz, T., Townsend, J., Cutcher-Gershenfeld, J., Greitzer, E., Kerrebrock, A. (2004). National Vision Statement, Framework for Goals and Recommended

Actions, Partnership for Air Transportation Noise and Emissions Reduction. *J. Aviation and the Environment.* Washington, D.C.

Wiedmann, T., Minx, J., Pertsova, C. C. (2008). *A definition of carbon footprint., ecological economics research trends.* Chapter 1. pp. 1-11. USA.

Wigstrand, I. (2012). *The ATES project, a sustainable solution for Stockholm-Arlanda Airport.* Department of Arlanda Energi, Stockholm, Arlanda, Sweden.

APPENDIX

1. LIST OF ABBREVIATIONS

ACA: Airport Carbon Accreditation

ACI: Airport Council International

APU: Aircraft Power Unit

BMS: Building Management System

CHP: Combined Heat and Power Unit

DHMI: General Directorate of State Airports Authority

EADS: European Aeronautic Defence and Space Company

ECAC: European Civil Aviation Conference

EASA: European Aviation Safety Agency

EMP: Environmental Management Plan

EMS: Environmental Management System

EUROCONTROL: European Organization for the Safety of Air Navigation

FAA: Federal Aviation Administration

GHG: Green House Gas

GPU: Ground Power Unit

GRI: Global Reporting Index

HVAC: Heating, ventilation, air conditioning

IACA: International Air Carrier Association

IATA: International Air Transport Association

ICAO: International Civil Aviation Association

IPCC: International Panel on Climate Change

JAA: Joint Aviation Authority

LEED: Leadership in Energy and Environmental Design

WBCSD: World Business Council for Sustainable Development

WRI: World Resource Institute

2. International Civil Aviation Organization. (1999). *Annex 14 to the convention on international civil aviation, aerodrome design and operations.* Volume I, 3rd edition. Montreal.

3. International Civil Aviation Organization. (1993). *Annex 16 to the convention on international civil aviation environmental protection, aircraft noise*. Volume I. Montreal.

4. International Civil Aviation Organization. (1993). *Annex 16 to the convention on international civil aviation environmental protection, aircraft engine emissions.* Volume II. Montreal.

5. European Civil Aviation Conference.(1997). *ECAC.CEAC Doc.29, report on standart method of computing noise counters around civil airports*. France.

6. General Directorate of State Airports Authority – DHMI, air traffic data.

7. Roadmap of carbon footprint calculation.