GREEN INITIATIVE TO REDUCE CARBON EMISSION FOR AEROPLANES USING MALAYSIA AIRLINES BERHAD AS A CASE STUDY

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ABSTRACT

A case study was carried out in Malaysia Airlines Berhad (MAB) to evaluate the green initiatives carried out to reduce CO_2 emission. The reduction in fuel consumption relatively reduces the CO_2 emission thus having mutual benefits both financially and environmentally. The four-pillar strategies comprising of technological improvement, operational efficiencies, infrastructure development and market-based measures developed by the International Association of Air Travel (IATA) are used as a basis for the evaluation on the initiatives carried out by MAB in reducing their CO_2 emission and fuel consumption. Many initiatives carried out by the organization has resulted in positive results. The Boeing 737 fleet which operates 80% of Malaysia Airlines routes are evaluated individually. Additional strategies that could be implemented further concluded that a further 55,626 tonnes of fuel consumption and 175,221 tonnes of CO_2 reduction could be further achieved. These strategies adopted by the aviation industry in mitigating climate change could also be extended to other industry in Malaysia such as the ground transportation. Some of the strategies are worth exploring and the role of the stakeholders in taking the necessary steps by adopting similar measure like in the aviation industry is of prime importance. Malaysia being the home of three growing international airlines and with one of the highest number of private vehicle owners in this region needs to fast track its vision of becoming a developed country by 2020.

Key word: Carbon emission, fuel consumption, aviation

ABSTRAK

Sebuah kajian dalam Syarikat Penerbangan Malaysia (MAB) telah dibuat untuk menilai inisiatif hijau yang dijalankan bagi mengurangkan pelepasan CO_2 dan pengunaan minyak. Inisiatif pengurangan penggunaan minyak dan pelepasan CO_2 akan membawa faedah kepada sektor ekonomi dan alam sekitar sekaligus. Strategi yang digunakan oleh industri penerbangan adalah merangkumi peningkatan teknologi, kecekapan operasi, peningkatan kemudahan infrastruktur dan kaedah pasaran berdasarkan ekonomi. Strategi yang di syorkan oleh Pertubuhan Penerbangan Udara Antarabangsa (IATA) ini telah digunakan sebagai asas bagi membuat analisis dan menilai inisiatif yang diambil oleh Syarikat Penerbangan Malaysia bagi mengurangkan pelepasan CO_2 dan penggunaan minyak. Sebahagian besar daripada inisiatif ini telah mendatangkan faedah setakat ini. Kapalterbang Boeing 737 yang merangkumi 80% daripada operasi MAB pula dipilih untuk kajian yang lebih terperinci. Saranan strategi tambahan yang disyorkan mendapati bahawa sejumlah 52,563 tan pengurangan minyak dan 165,573 tan pelepasan carbon dioksida mampu dikurangkan. Strategi yang diguna pakai oleh industri penerbangan bagi menangani masalah ancaman perubahan iklim ini juga mampu dilanjutkan kepada industri lain di Malaysia seperti industri pengangkutan darat. Peranan kesemua pemegang saham dan pihak yang berkepentingan dalam menjayakan inisiatif ini adalah amat penting sekali. Malaysia mempunyai tiga buah syarikat penerbangan antarabangsa yang masih berkembang dan dengan kadar pengunaan kenderaan swasta yang tinggi dirantau ini harus mempercepatkan usahanya untuk mencapai visi taraf negara maju pada tahun 2020.

Kata kunci: Pelepasan karbon disoksida, penggunaan minyak, penerbangan

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

List of Abbreviation and Symbol

ATF	Aviation Turbine Fuel
ATJ	Alcohol to Jet
APU	Auxiliary Power Unit
APM	Aircraft Performance Monitoring System
A330	Airbus 330-300
A380	Airbus 380-800
A350XWB	Airbus 350 Extra Wide Body
B737	Boeing 737-800
CO_2	Carbon Dioxide
CORSIA	Carbon Offset and Reduction Scheme for International Aviation
CAEP	Committee on Aviation Environmental Protection
COG	Centre of Gravity
EO	Engine Out
EPA	Environmental Protection Agency
ETS	Emission Trading System
FAA	Federal Aviation Administration
FTK	Freight-Tonne-Kilometre
FRIM	Forest Research Institute of Malaysia
GDP	Gross Domestic Product
GHG	Global Greenhouse Gases
GPU	Ground Power Unit
GFI	Green Fleet Index
H2O	Water Vapour
HEFA	Hydrotreated vegetable oils
HC	Hydrocarbons

ICAO	International Civil Aviation Organisation
IATA	International Air Transport Association
IPCC	Intergovernmental Panel on Climate Change
ITAG	International Transport Action Group
ITF	International Transport Forum
KLIA	Kuala Lumpur International Airport
KPI	Key Performance Indicator
LOI	Letter of Intent
LRT	Light Rail Transit
MAB	Malaysia Airlines Berhad
MAG	Malaysia Airlines Group
MBMs	Market Based Measures
MRP	Malaysia Airlines Recovery Plan
MRT	Mass Rail Transit
NRE	Natural Resources and Environment
NOx	Nitrogen Oxide
O_3	Ozone
OTP	On-Time Performance
PSI	Pound Square Inch
RTM	Resin Transfer Moulding
RPKs	Revenue-Passenger-Kilometre
RTD	Road Transport Department
SOx	Sulphur Oxides
SIA	Singapore International Airlines
SAFUG	Sustainable Aviation Fuel Users Group
SEP	South East Pahang Peat Swamp Forest

SPAD	Land Public Transport Commission
USD	United States Dollar
ULDs	Unit Loading Devices
3R	Reduce, Reuse and Recycle

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

Aviation has been a large carbon footprint producing industry. Commercial aviation produced 781 million tonnes of CO_2 worldwide in 2015, while humans produced over 36 billion tonnes of CO_2, where the former translates to about 2% of all human induced carbon dioxide (CO_2) emissions. Aviation is responsible for 12% of CO_2 emissions from all transport sources, compared to 74% from road transport. This is according to statistical studies carried out by the Air Transport Action Group in 2016 (ATAG, 2016a). Besides that, studies also indicates that the emission from aircrafts has bigger impact than emission from the ground due to the chemical and physical processes when the emission is at an altitude from the ground (Masiol & Harrison, 2014).

The aviation industry has grown exponentially ever since the Chicago Convention in 1944 where 52 nations signed the Convention on International Civil Aviation Organisation (ICAO). In 1947, ICAO was established to become the agency under the United Nations(UN) that sets regulations and standard for international aviation. The strategic goal of ICAO on environmental protection is to minimize the adverse effect of global aviation on the environment and the goal is to limit or reduce the impact of aviation greenhouse gases (GHG) emissions on the global climate.

Figure 1.1 (top) shows the growth of the industry from 1940 onwards, taking into account the consumption of fuel and the passenger growth from 1970 in terms of revenue-passenger-kilometre (RPKs). According to the International Transport Forum (ITF), the RPKs and air freight which is measured in per-tonne kilometre (FTK) has grown and will continue to grow at the rate of 4 to 5% annually.

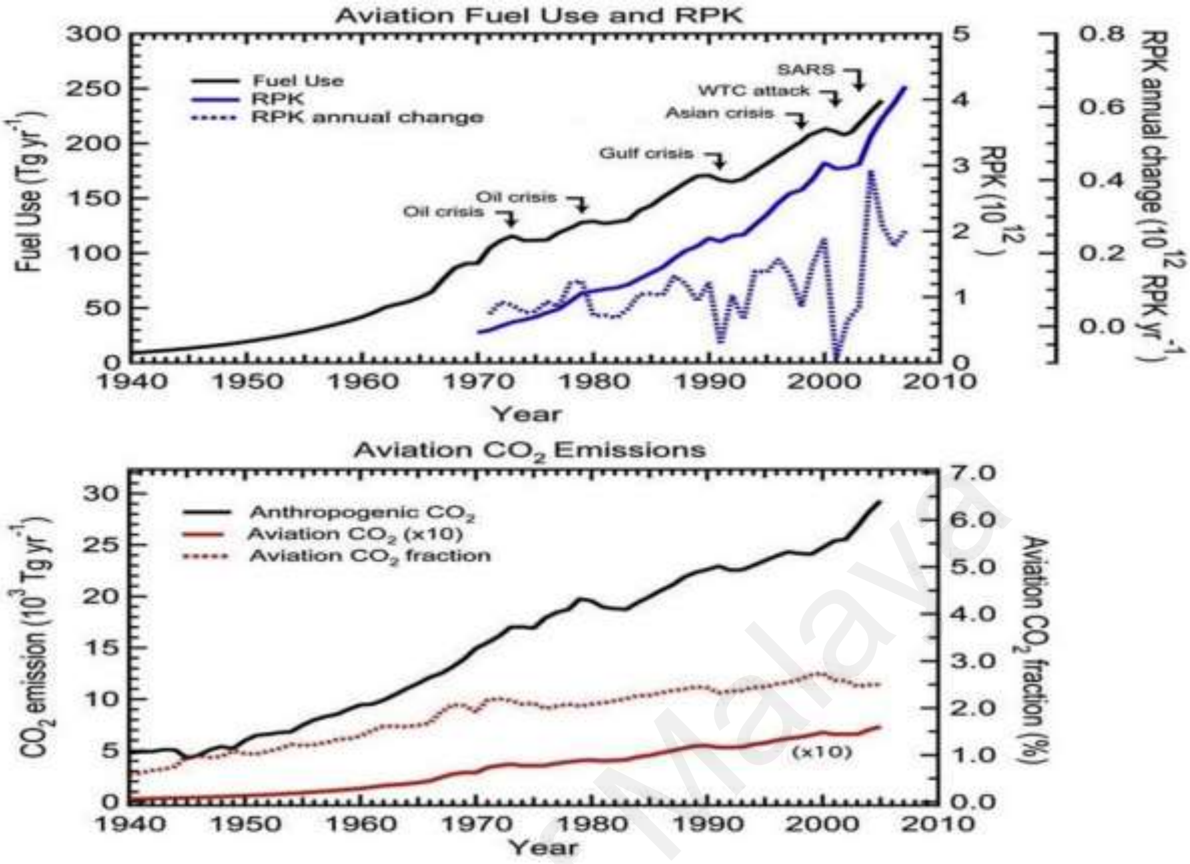


Figure 1.1: Aviation fuel use and CO2 emission since 1940

Source: (D. S. Lee et al., 2009)

Figure 1.1 (top) illustrates the passenger growth from 1970 (RPKs), with the yearly change of RPKs (far right-hand axis, with offset zero). The arrows signify the impact of significant events worldwide that posed a challenge to the industry, like the oil crisis in the 70's, Gulf war and the financial crisis in Asia in the 90's, the September 11 attacks in 2001 and the effect of health crisis from Severe Acute Respiratory Syndrome (SARS).

Figure 1.1. (bottom) shows CO_2 emission rate growth scaled (x10) along the same time of growth for aviation fuel consumption. The anthropogenic CO_2 emission rate in total is shown as a fraction of aviation's total.

Aircraft manufacturer, Boeing Industries meanwhile forecasts the number of aircraft will increase from 19,890 in 2011 to 39,780 in 2031. This will only add to the already increasing environmental concerns from the aviation industry. Therefore, it is crucial for the industry to tackle these environmental issues.

The aviation industry operates in a highly regulated environment and must meet various regulatory obligations both domestically and internationally. The International Civil Aviation Organisation (ICAO) and International Air Travel Association (IATA) impose strict compliance and requirement to adhere to international environmental laws. In 2008, the global stakeholder associations of the aviation industry (Airports Council International, Civil Air Navigation Services Organization, International Air Transport Association and International Coordinating Council of Aerospace Industries Association), under the umbrella of the Air Transport Action Group, committed to a global challenge in addressing the global challenge of climate change and adopted a set of ambitious targets to mitigate CO_2 emissions from air transport (EASA, 2016). They are:

1.1 An average fuel efficiency of 1.5% per year from 2009 to 2020

In the past few decades fuel efficiency has become a primary concern for the aviation industry. High volatility of the oil market and rising oil price has driven the innovation for new and efficient aircraft technologies. The challenge faced by this industry has benefited the environment in a way as the aim for fuel consumption reduction will also result in less emission of harmful gases to the environment, primarily CO_2. The target of 1.5% fuel efficiency per year can be achieved by many ways which will be subjected to further discussions.

1.2 A cap on net aviation CO_2 emission from 2020 (carbon neutral growth)

Achieving a carbon neutral growth is a stepping stone for the aviation industry in moving towards zero carbon scenario. This means that the net CO_2 emissions will be halted despite continuing demand and growth for air travel. This will ensure countries like

Malaysia which has a growing aviation industry being able to enjoy its economic benefit and at the same time balancing it with climate action. A cap on emission will be a way to go in order to achieve this.

1.3 Reduction in net aviation CO_2 emission of 50% by 2050, relative to 2005 level

A net reduction of 50% of CO_2 emission will have to be achieved by 2050 which would have to be the range equivalent of what the industry emitted in 2005. Among all three targets, this has the longest time span and it is the most ambitious target. Nevertheless, it is not impossible and measures are already being put in place by the aviation partners to achieve it. IATA has developed a four-pillar strategy as a guideline to achieve this target. They comprise of technological improvement, operational efficiencies, infrastructure development and a single global market-based measure to fill the remaining gap.

1.4 Technological Improvement

Among the four-pillars, technological improvements are probably the most effective way to reduce carbon emission in the industry. Aircrafts today consumes 15% less fuel and 40% less emission than their predecessors 10 years ago. They are more fuel efficient, less noisy, and much cleaner. The A380 and A350XWB from Airbus Industries and the Boeing 787 Dreamliner are among the most advanced airplanes around. Sustainable aviation fuel that is made of renewable sources is another area of technological advancement that can leap frog the aviation industry forward in tackling climate change. Bio-fuel are capable of reducing the CO_2 emission by 80% per tonne fuel. Having said that the cost benefit analysis is a prime factor in pursuing the initiatives above. Investment in the region of USD 1.5 trillion is needed to purchase about 5,500 new aircraft by 2020 which is about 27% of the whole fleet worldwide. This no doubt will be able to reduce the CO_2 emission by 21% compared to not renewing the fleets at all. However not many airlines are able to do so due the large amount of investment involved (IATA, 2009a).

1.5 Operational Efficiency

Even though technology is a preferred choice for the reduction of CO_2 emission, it may not be a one size fit all measure. This is due to the fact that, airlines need large investment to do this. With the current economic uncertainty, not all airline operators have the financial means to adopt it. Therefore, operational efficiency will contribute significantly to the reduction of CO_2 emissions with proper planning and processes in place. Airlines consider their On-Time Performance (OTP), as one of the important Key Performance Indicator (KPI) in terms of profitability. OTP basically means ensuring the aircraft departs on time without any delay and this are achieved by improving operational efficiency and work processes. Other practices include the reduction of auxiliary power unit (APU) on ground, efficient flight procedures and reduction of aircraft weight to mention a few. According to IATA operational efficiency will contribute to an overall 3% reduction in emission (IATA, 2009b).

1.6 Infrastructure Improvement

According to the Intergovernmental Panel on Climate Change (IPCC) the aviation industry experiences about 8% inefficiency in airport infrastructure. Having a modernised and efficient Air Traffic Management (ATM) system will add about 4% reduction of CO_2 emission. A sophisticated ATM will enable the optimum use of airspace and networking. Improving airspace by using Performance Based Navigation (PBN) and Continuous Descent Arrival/Operation (CDA/O) is another CO_2 emission reduction method (IATA, 2009b).

1.7 Market Based Measures (MBMs)

The three pillars discussed above might not be able to compensate the climate change factor in the beginning stage. It will take substantial amount of coordinated effort to convince an entire global network to work in tandem to achieve the objective. It is here that, market-based measure plays a role. This fourth pillar will fill in any remaining gap. An offset system is an example of this measure that would be able to reduce 90 million tonnes of CO_2.

In the 39th ICAO Assembly in Montreal, Canada and as one of ICAO's 191-member states, Malaysia agreed to implement a Carbon Offset and Reduction Scheme for International Aviation (CORSIA).

CORSIA is the first global market-based measure for the aviation industry. The agreement ensures that the aviation industry's economic and social contributions are matched with cutting-edge efforts on sustainability thus bringing aviation to the forefront of industries combatting climate change. CORSIA is set to commence with a voluntary period (2021-2026) after which it will become mandatory. CORSIA will apply to international passenger and cargo flights as well as business jets that generate more than 10,000 tons of emissions annually. Airlines operating such planes will have to buy carbon credits to offset growth in emissions**.** CORSIA with other global market-based measures, will continue to drive its four-pillar strategy on climate change. This can be expected to be achieved by 2025, where the emissions are expected to be at 2020 levels. However, this will cost another 7 billion USD of investment (IATA, 2009b).

All these strategies are just a recommended measure and it does not necessarily mean that airlines are compelled to use them. Each airline will have their own strategies as they all have different economic models for doing business. As such, each will have their own challenges to deal with and Malaysia Airlines has its own.

1.8 Malaysia Airlines Berhad's Challenges

Malaysia Airlines being a member of IATA, has taken responsibility and initiated many measures to reduce its carbon footprint. It has been actively involved in identifying and implementing green initiative towards achieving a more sustainable practice in its daily operations. Recently, these initiatives have been extended to other areas, like inflight operations, servicing of the aircraft, catering, and maintenance to mention a few

In this study, the green initiatives implemented in a typical airplane from the design stage up to operation stage (flying) will be identified and evaluated by way of a case study. The initiative will be based on the four-pillar approach. From the experience of the airline industry, this work will explore if some of the approaches can be used in other industries.

The information gathered will consist of past practices, current and future plans of the airline towards achieving a greener mode of travel and how it intends to achieve it. As the aviation industry is a unique area, the strategies implemented may not be generally adopted to suit every other sector. The intention is to make practical improvements to applicable areas. Some feedback on improvement to the various processes is recommended to possibly be implemented. Malaysia Airlines are a household name in the aviation industry in terms of its service. It is therefore, important for it to state its commitment as an environmentally responsible airline by managing its carbon foot print.

1.9 Aim

The purpose of the case study is to evaluate the current green practices that leads to the reduction of carbon emission which can be possibly extended to other areas or similar industries, like the ground transportation sector. The achievement of the aviation industry in reducing the carbon foot print may contribute to the development of knowledge which can be shared in other areas.

1.10 Objectives

1. To identify and evaluate initiatives implemented based on the four-pillar strategy recommended by IATA to reduce carbon emission and fuel consumption.
2. To ascertain the possibilities of expanding the existing strategy to another industry

1.11 Research Problem

The aviation sector is poised to overtake other contributors of GHG and move in to higher percentage among the GHG contributors, if efforts are not taken to reduce its carbon emission. It is therefore of utmost importance that a comprehensive and sustained measure be taken to mitigate this problem by all the relevant stakeholders.

With the regulatory framework in place to tackle the issue and guidance from IATA, it is imperative that airlines do an evaluation of its current green performance and look for possibilities to compensate for the carbon emission it is expected to contribute.

There are however, limited research done as of to date on airlines in Malaysia where an exponential growth in aviation is expected to take place, primarily due to emerging economies like China and India where Malaysia Airlines have set their eyes to capitalise on. This case study will make an evaluation on some of the 'green' practices in Malaysia Airlines and in order to substantiate the aim above, will endeavour to answer the following research questions:

a) What is the current state of carbon emission reduction strategy in the operation of Malaysia Airline's aircrafts, based on the four-pillars recommended by IATA?
b) How can some of the initiatives be implemented in other industry where carbon emission is of a concern?

1.12 Scope of Study

The study has been carried out from the time the aircraft is on ground, which includes during transits, inflight and after landing till it reaches its parking gate. The total employee of Malaysia Airlines is 14,000. The research will not however focus on the entire operation, but with those concerning the aircraft and its directly related operations.

1.13 Report Layout

The first chapter introduces the aviation industry and its role in environmental impact. The introduction of the core principles of the study are discussed briefly. The aim and objective are stated highlighting the purpose and respective objectives. Research problem includes the research questions that need to be answered are highlighted. Overall, the chapter covers the basic layout of the entire research.

Chapter 2 discusses and compares case study data from various literatures including from open sources, and organizations environmental report among others. All relevant citations are included.

Chapter 3 describes the basic method of carbon emission calculation practiced industry wide and as per information from the relevant sources. Other information pertaining to how the study was conducted is also explained like the site visits, interviews and personal observations conducted.

Chapter 4 then discusses the measures taken by Malaysia Airlines in general to mitigate carbon emission and further information is simplified in a table format. The Boeing 737-800NG and its carbon emission reduction strategy is then evaluated. Recommendation are then given and a projection of savings in terms of fuel and carbon emissions is given. The strategies used in the aviation industry is then evaluated if it can be used of other sectors like the ground transportation.

The conclusion highlights the major findings of this study and identifying the current green initiatives carried out in MAB, the challenges, suggestions for improvement and recommendations for future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Brief History of Malaysia Airlines Berhad

Malaysian Airline System Berhad, also known as Malaysia Airlines (MAS) is fully owned by Khazanah Malaysia, an investment arm of the Malaysian government. It operates from its home base, Kuala Lumpur International Airport. A joint initiative of the Ocean Steamship Company of Liverpool, the Straits Steamship of Singapore and Imperial Airways proposed to the Colonial Straits Settlement to run an air service between Penang and Singapore. The result was the incorporation of Malayan Airways Limited (MAL) on 12 October 1937. On 2 April 1947, MAL took to the skies with its first commercial flight as the national airline. Fuelled by a young and dynamic team of visionaries, the domestic carrier turned into an international airline in less than a decade.

With the formation of Malaysia in 1963, the airline changed its name to Malaysian Airlines Limited and soon after, Borneo Airways was incorporated into MAL. Within 20 years, MAB grew from a single aircraft operator into a company with 2,400 employees and a fleet operator using the then latest Comet IV jet aircraft, 6 F27s, 8 DCs and 2 Pioneers. In 1965, with the separation of Singapore from Malaysia, MAL became a bi-national airline and was renamed Malaysia-Singapore Airlines (MSA). A new logo was introduced and the airline grew exponentially with new services to Perth, Taipei, Rome and London. However, in 1973, the partners went separate ways; Malaysia introduced Malaysian Airline Limited, which was subsequently renamed Malaysian Airline System, or simply known as Malaysia Airlines. The airline holds a lengthy record of service and best practices excellence, having received more than 100 awards in the last 10 years.

Malaysia Airlines fleet strategy with an ongoing five-year 12-point MAS Recovery Plan (MRP) unveiled on 29 August 2014, involved the resetting of the airline's operating business model towards a competitive cost position, with a focus on the network and revenue management.

On the 21st September 2017, Malaysia Airlines made a firm order of 25 Boeing 737 aircraft and options on other types of aircraft, including both new and used aircraft from Boeing and Airbus. Malaysia Airlines also signed a Letter of Intent (LOI) for the lease of six (6) second hand Airbus A330-200, as replacement for six narrow body Boeing 737 that are being returned to lessors. Malaysia Airlines and Boeing also signed a memorandum of understanding to acquire 16 airplanes - eight 787 Dreamliner and eight 737 MAXs.The A330-200 aircraft, will allow the airline to bridge the next generation wide-body aircraft orders. Malaysia Airlines currently operates six A380s, 15 A330-300s and 54 B737-800s.

2.2 Malaysian Aviation Industry

The Malaysian aviation industry has three major players, Malaysia Airlines Berhad (MAB), Air Asia and Malindo Air. The economic contribution from these 3 airlines has been immense as it is a major contributor to the economic wellbeing of the country. Airlines and its support system has created about 460,000 jobs collectively in Malaysia in 2014. The air transport industry is estimated to have supported a $4.9 billion gross value-added contribution to Gross Domestic Product (GDP) in Malaysia in 2014 and supported by foreign tourists with a further $ 6.3 billion gross value-added contribution to the country's GDP. As shown in Figure 2.1, this means that 3.3 percent of the country's GDP is supported by the air transport sector and foreign tourists arriving by air.(IATA, 2017)

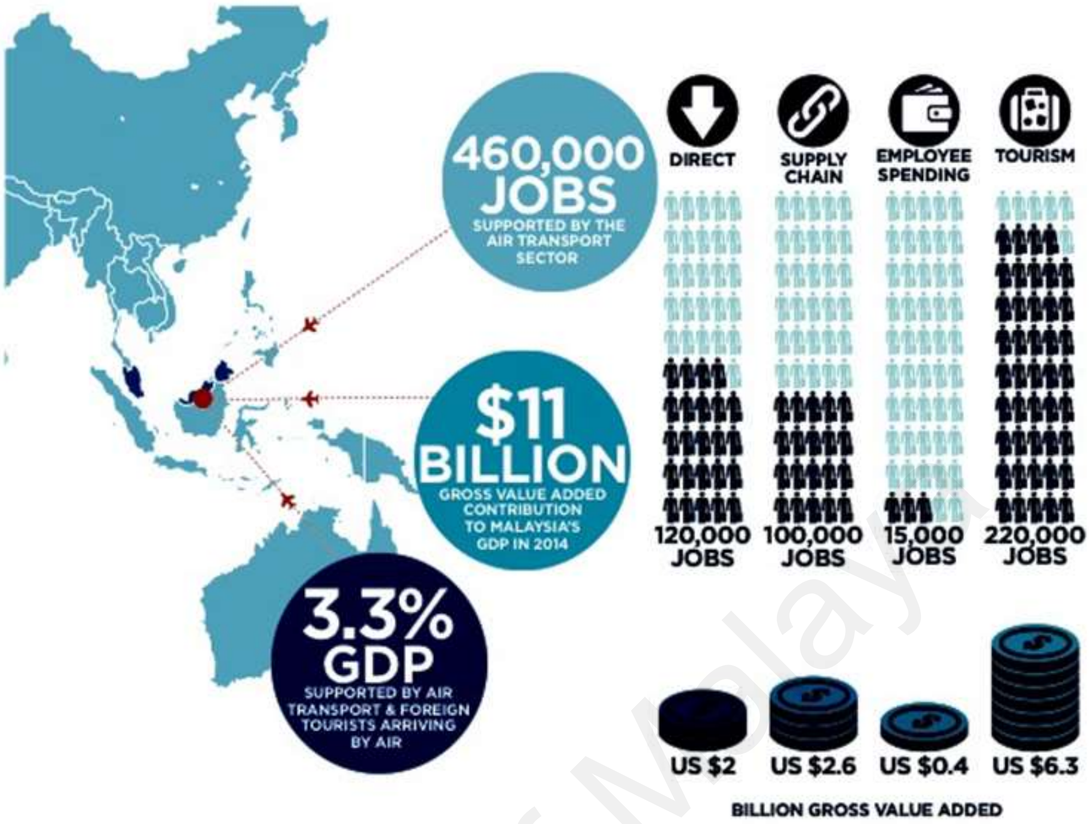


Figure 2.1: Economic contribution of Aviation and its related industry in Malaysia

Source: IATA, Oxford Economics, International Monetary Fund, and national statistics

With the massive amount of economic prosperity brought about by the aviation, it is also seen as a major culprit to carbon emission by some. The challenges are formidable and it needs to strategize itself and in order to come out victorious both economically and environmentally.

2.3 Aviation and climate change

Greenhouse gases (GHG) produced by aviation industry are CO_2 and water vapour (H_2O). The IPCC Fourth Assessment Report in 2004, says aviation is responsible for around 2% of anthropometric (CO_2) emissions and about 12% of CO_2 emission from all transport source.

Aviation also emits nitrogen oxides (NOx) that impact the concentrations of other GHGs, mainly ozone (O_3) and methane (CH_4). Nitrogen oxides (NOx) leads to the formation of other air pollutants which harm health such as particulates and ground-level ozone and cause acidification and eutrophication of water and soil. Black carbon (soot) is a directly emitted aerosol, together with sulphur oxides (SOx), NOx, and hydrocarbons (HC) that leads to aerosol production after emission. Water vapour emissions in combination with emitted or background aerosol lead to contrail formation, and persistent contrails increase cloudiness. Aviation aerosols also modify natural clouds or trigger cloud formation.

The specific climate impacts of these gases and particles when emitted and formed are difficult to quantify at present. As Figure 2.2 illustrates, GHGs trap heat in the Earth's atmosphere, leading to the overall rise of global temperatures, which could disrupt natural climate patterns. On the other hand, non- CO_2 climate impacts of aviation emissions are quite variable in space and time. The primary factor for non- CO_2 emissions from aircraft is that the largest portion of these emissions are emitted in the flight corridors throughout the upper troposphere and lower stratosphere at altitudes of 8 km to 13 km (26,000-40,000 ft.). The lifetime of the associated atmospheric changes ranges from minutes for contrails, to years for changes in methane (ICAO, 2017a).

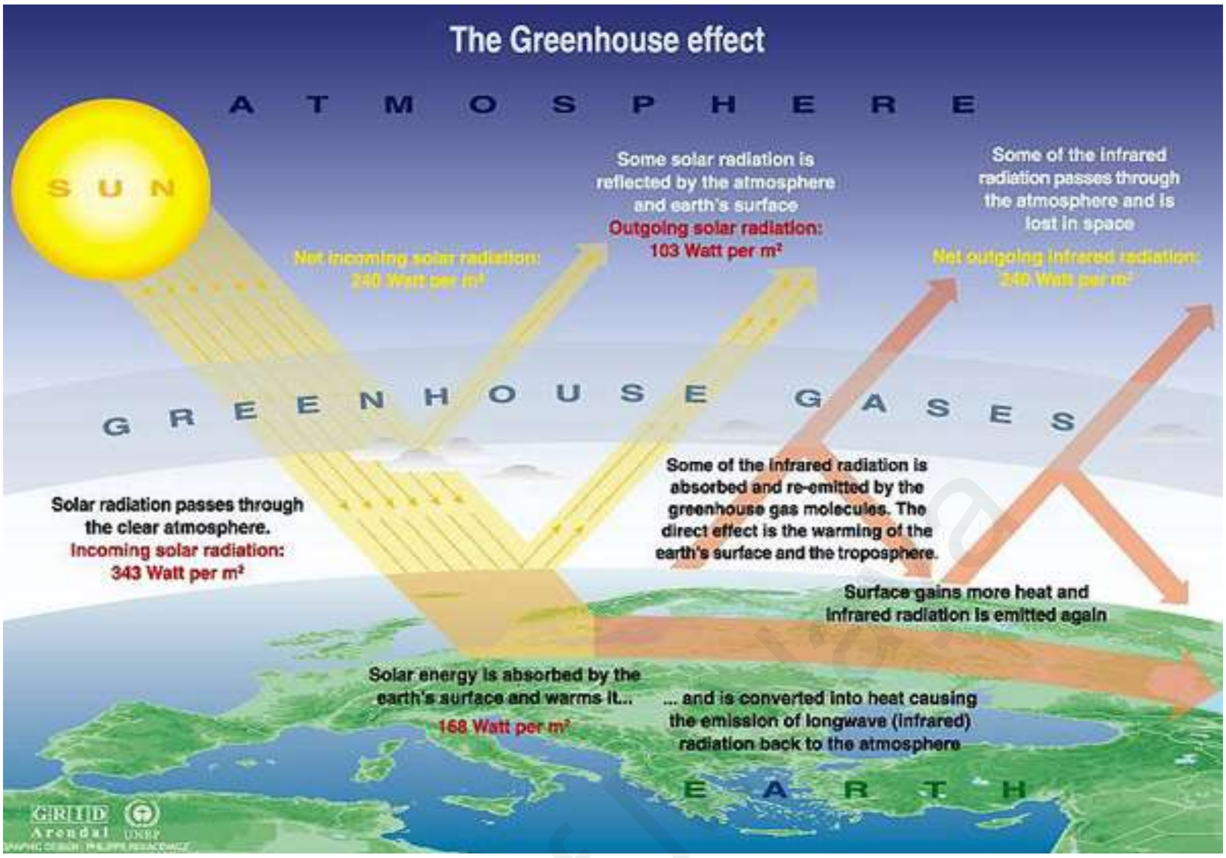


Figure 2.2: The greenhouse effect on the atmosphere (IPCC Fourth Assessment Report)

Source: IPCC

Figure 2.3 displays a schematic of aircraft emissions and their resulting potential impacts on climate change and social welfare. Aviation CO_2, H_2O and soot emissions contribute directly to climate change with positive radiative forcing (net warming). Whereas, emissions of NOx, SOx, H_2O and black carbon aerosols contribute indirectly to climate change.

Generally, there is a better understanding of the impact of GHG emissions that have direct impact on the climate than emissions that have indirect impact. Scientific studies conducted so far has made some great advances in better characterizing aviation climate change impacts. However, the level of scientific understanding for quantification of the climate impacts remains unchanged and ranges between low and very low, respectively.

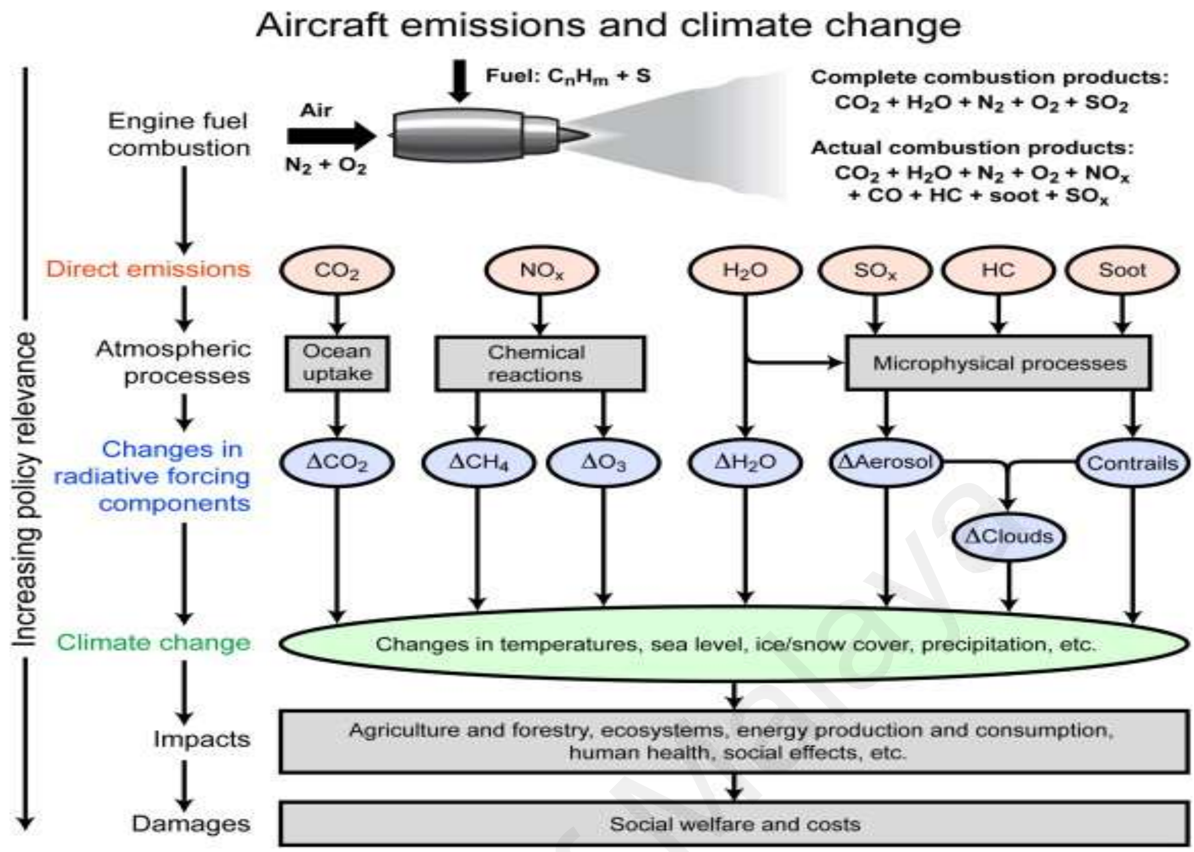


Figure 2.3: Aircraft emissions, their usual linkages with potential climate and social welfare impacts (Wuebbles, 2007)

Source: Transactions American Geophysical Union

The above challenges however can be mitigated with a concrete effort from all stakeholders and not just the airline operators. As the aviation industry is a cross border business, it is an industry that is regulated by the United Nations specialized agency for international aviation. This is where the role of ICAO, IATA and other regulatory body comes in.

2.4 Role of ICAO and IATA

International Civil Aviation Authority and The International Civil Aviation Organization (ICAO) comes under the umbrella of the United Nations, which adopts standards and recommended practices concerning all aspects of international civil aviation including air navigation, prevention of unlawful interference, facilitation of border-crossing procedures, air accident investigation and transport safety. ICAO has a dedicated environmental unit, the council's Committee on Aviation Environmental Protection (CAEP), which focuses on problems that benefit most from a common co-ordinated worldwide approach, such as aircraft noise and the impact of aircraft engine emissions. ICAO has investigated the potential of market-based measures such as trading and charging as a means of reducing emissions. It has endorsed the development of an open emissions trading system for international civil aviation, and is developing guidance for states who wish to include aviation in an emissions trading scheme. Based on the environmental trend assessment by the ICAO Council's Committee on Aviation Environmental Protection (CAEP), international aviation fuel consumption is estimated to grow somewhere between 2.8 to 3.9 times by 2040 compared to the 2010 levels. In October 2013, the 38th Session of the ICAO Assembly adopted Resolution A38-18, which resolved that ICAO and its Member States, with relevant organizations, would have to work together to strive and achieve a collective medium term global aspirational goal of keeping the global net CO_2 emissions from international aviation from 2020 at the same level (so-called "carbon neutral growth from 2020"). The collective industry targets are a 1.5% per annum fuel efficiency improvement until 2020, carbon neutral growth from 2020 onwards and an absolute reduction in CO_2 emissions of 50% by 2050, compared with 2005 levels.

The International Air Transport Association (IATA) as a trade organisation sets goal to ensure proportionate and coherent environmental policies are implemented by governments around the world. IATA supports the aviation industry’s sustainability path while at the same time allowing environmental improvements to be achieved in a cost-effective manner (K.-C. Lee, Tsai, Yang, & Lin, 2017). IATA under the leadership of ICAO in 2016 achieved a historic agreement to implement a market-based measure that will support airlines’ efforts to stabilize emissions with carbon neutral growth.

The Intergovernmental Panel on Climate Change (IPCC) has forecasted that aviation emissions will make an important contribution to the build-up of greenhouse gases (GHGs) in the atmosphere, heavily contributing to global warming in the next few decades.

IATA together with ICAO are committed to the four-pillar strategy to meet these targets, which is by improving technology (advanced engines, airframes and sustainable biofuels), effective operations (more direct flight paths, continuous descent approaches and flexible routings that take advantage of weather), efficient infrastructure (improved air traffic management) and positive economic measures or market-based measures (MBMs). MBM is a policy tool that is designed to achieve environmental goals at a lower cost and in a more flexible manner than traditional regulatory measures. Examples of MBMs include levies, emissions trading systems, and carbon offsetting (IATA, 2016). At the moment a voluntary phase from 2021 to 2026 has been agreed upon and thereafter it will become mandatory in 2027.

The role of ICAO and IATA in mitigating climate change is of paramount importance. Only a binding agreement will ensure that a commitment to this cause is achievable. Most of the world's major airlines have committed to a treaty aimed at reducing aviation's carbon footprint, making it the first commercial sector on its own to tackle the effects of climate change. Globally airlines are making great strides by taking many measures to achieve the intended target.

2.5 Measures taken by the Aviation Industry

After spending of billions of dollars on investment and collaborative action already taken by the industry, a passenger today produces half the CO_2 per kilometre flown compared to 1990 which is quite significant (CAEP/8, 2009).

Achieving an under 2 degrees Celsius average temperature needs to look at a huge cut in emission from every sector. The aviation industry is always seen as a major culprit to the growing issue of emission. However, the robustly expanding global aviation industry has made many commitments to tackle this issue. One of it is the carbon offsetting strategy. Voluntary offsetting of carbon is an option already made available by many airlines to its customers.(Becken & Mackey, 2017)

Aircraft manufacturers and airlines has been working hard to reduce emissions by themselves, by cutting fuel consumption. They are obsessed with fuel efficiency, because fuel is their biggest single expense contributing to about 33 percent of total operating cost. Many airlines are trying out new initiatives. Pilots are carrying tablets instead of piles of paper manuals. Ryanair puts less ice in passengers' drinks than it used to, and made its magazines physically smaller. Samoa Air, even charges passengers by weight.

Besides reducing weight where possible, airlines are also trying to make the planes they already have more efficient. Typically, aircrafts lifespan is about 20 or 30 years. It is therefore, crucial for the operators to adopt the latest technology and cut fuel to sustain its profitability in the long run. This often means adding aerodynamic devices to wingtips (Boeing calls them winglets, Airbus calls them "sharklets"), which can cut fuel use by up to 5 percent on single-aisle jets. Another area that has huge possibilities is the possibility of an alternative sustainable fuel that has great potential in the reduction of carbon emission. As the technological improvement including alternative sustainable fuel is seen as the best bet to achieve carbon emission targets, a brief look at these two strategies is worth discussing before taking a look at a few other airlines strategies in terms of emission reduction.

2.6 Alternative Sustainable Fuel

The use of fossil fuel in the aviation industry has been extensively researched and explored as the expected growth in air transport will see a further increase in greenhouse gas emission (GHG) and further deterioration of environmental condition. Together with the volatile situation in most of the oil producing countries which affects the stability of fuel price, it is about time the aviation industry looks into renewable energy seriously. Biofuels are the future saviour of the world in moving towards a sustainable planet. It would be even better if the biofuels developed with further research and development, can be used for both the aviation and ground transportation sector (Yilmaz & Atmanli, 2017).

Biofuels from renewable sources like wood, algae, agricultural waste and some plants are going to play a big role in saving the environment. According to the Air Transport Action Group, the use of sustainable alternative fuel will reduce 80% of the carbon foot print of an airplane and produce much lower sulphur oxides and particulate matter.

At the moment the Federal Aviation Administration (FAA) U.S, are making effort to develop cleaner, sustainable renewable jet fuels that are economically and technically viable. It is projected that by 2018, one billion gallons of renewable jet fuel can be ready to be utilized for the aviation sector. Example of renewable jet fuel are those developed through Fisher-Tropsch process, (chemical reaction that changes a mixture of carbon monoxide gas and hydrogen gas into liquid hydrocarbons like gasoline or kerosene. Meanwhile, hydrotreated vegetable oils (HEFA) have already been approved for use in jet fuel blends of up to 50%. A synthetic iso-parafinn fuel made from the conversion of sugars are used with a blending ratio limited to 10%. The research on the use of alcohol to jet (ATJ) fuel are ongoing at the moment.

Only a 6% use of this fuel will reduce the carbon foot print by 5%. At this moment the use of biofuel has not reached a satisfactory level and there is still a long way to go. The 'buy in' to use sustainable alternative fuels are very low in the aviation industry, even though this initiative will substantially reduce the GHG in future. The use of sustainable alternative fuel is still very much dependant on the fluctuating price of the petroleum as the cost benefit analysis of the business in general are often a deciding factor. Only a binding agreement together with an aggressive approach from the relevant authorities, international regulatory bodies and private sectors, will help develop a sustainable process to reduce carbon emissions. Incentives are a good way to encourage the development of sustainable fuel. Another option is to implement carbon taxes which will eventually push up the affordability of fossil fuel and at the same time giving incentives for renewable energy usage (Brooks et al., 2016). The production of sustainable alternative fuel is also anticipated to be quite limited in the next few years and it is quite unlikely that the target to achieve it by 2020 will be met (EASA, 2016). Therefore, the next huge option available to greatly reduce the carbon emission besides alternative fuel is investment in technology.

2.7 Technological Advancement in Aviation

Airplanes today comes with advanced technological capabilities and are highly efficient. The latest Boeing 787 Dreamliner and the Airbus A350 for example, are much more efficient than its predecessors. It is made of almost entirely from composite material instead of metal, making it so much lighter. Engines have gone through breakthrough technological changes, across the line. The new LEAP engines on the new Boeing 737 Max delivers 15% improvement fuel consumption compared to CFM56 from the 737 New Generation aircrafts and maintains same level of dispatch reliability and life cycle maintenance cost which gives more time in the air and less maintenance time. The LEAP engine fan is made from 3D woven RTM (Resin Transfer Moulding) carbon fibre composite that makes it so much more lightweight and durable that are able to support the weight of a wide-bodied airplane like A350. It is also the first engine to use additive manufacturing to "grow" complex, fully dense yet lighter engines. Its fuel nozzles are 25% lighter than previous models and five times more durable than parts manufactured conventionally. They also reduce NOx emission by 50% and produces 40% lesser noise.(CFM, 2016)

According to IATA (2009), technological approach has the best chance among the four-pillars strategy. Due to great achievement in technology such as state of the art plane designs like high-lift wing designs, latest lightweight airframes made of composite materials, advanced engines, breakthrough in fuel technology such as bio-fuels, and many others, airline industry will be able to compensate emission issue with expected business growth. New aircrafts will cost aviation up to $1.5 trillion by 2020 with about 5500 being replaced by that year worldwide. That is about 27% of total fleet. It is expected to reduce CO_2 emission by 21% compared to assuming no action taken (K.-C. Lee et al., 2017).

In February 2016, after a 6-year technical study, ICAO made an agreement with governments to adopt a standard on CO_2 efficiency for all commercial aircrafts. The standard that applies from 2020 will require emission of CO_2 from all new aircraft types does not exceed a limit defined as a maximum fuel burn per flight kilometre based on weight and size of aircraft. By 2023 the standard will be applicable to designs of aircraft that are in production. Despite these measures and it being a game changer in the reduction of carbon emission, various other measures are also taken by major airlines globally that are worth considering as a strategy to reduce carbon emission. A case study of airlines and their green initiatives to reduce fuel consumption, thus reducing carbon emission in the past 10 years are discussed in the following paragraphs.

2.8 Case Study 1 in Air Asia

An investigative study was conducted to determine the green practices carried out in low cost carrier Air Asia. Listed below are the findings in the case study pertaining to Air Asia's contribution to environmental sustainability and the items are not an exhaustive list.

Air Asia invested in the latest Pratt & Whitney Pure Power Geared Turbofan (GTF) engine to power it's A320 aircrafts and the technological advantage of this engine has saved 16% litre fuel per flight or about 600 kg CO_2 as well as reduced particulate and microorganisms in the atmosphere by 50%.

The aircraft has been painted with the latest Base Coat Clear Coat (BC/CC) with only a few layers required and with lesser cycle time and are able to reduce 136 kg of weight per aircraft. It is fast drying and has a low dirt pick up attributes. It also has low volatile organic compound (VOC) emission.

The maintenance division also played an important part by having its aircraft tyres consistently checked and serviced to prevent delay and thus disrupting operation in terms of delay which requires more energy to be used. The auxiliary power unit (APU) which provides power to the aircraft on ground runs on fossil fuel.

As for the cleaning services, the cleaning agents used are basically Hydrogen Peroxide which is a "greener" chemical and therefore is much safer to the environment.

Air Asia uses an advanced Aircraft Monitoring System (APM) that provides technical information about aircraft performances that helps in improving efficiency. Through the APM, it was found that a landing gear needed to changed, and this saved 2% or 336kg of fuel on a 4-hour flight.

The engineering team has a strict maintenance schedule and one important task is to wash the compressor and engine blades to get rid of dust and other residue which will reduce the drag on each engine by 0.2% and saves about 171,000 litres of fuel a month.

The draining of waste fuel of about 1000 litres and waste oil of about 600 litres at every night stop is carried out in order to prevent water contamination. This initiative reduces pollutants, microorganisms and also ensures accurate reading of fuel, thus ensures the planes reliability.

The 'sharklets' are one aspect of the aircraft frame that reduces drag over the wing and this saves 147 litres of fuel per flight or 464 kg CO_2.

Operational manoeuvres like the single engine operation after landing is implemented and this saves 8 litres of fuel per minute or 28 kg of CO_2 per 100 flights. This is due to the reduction of fuel burn when only one engine is used instead of the normal two on an Airbus 320. Flight procedure that uses shorter route also has been regularly practiced and saves fuel burn.

Another weight reduction initiative that comes due to the courtesy of advancement in technology is the capability of storing all that important and huge number of manuals and documents in digital format. Electronic manuals have resulted in a savings of 2 litres fuel or 6 kg of CO_2 per flight. This is due to reduction of about 23 kg per flight.

The airline has also outsourced its Unit Loading Device (ULDs) management to CHEP Aerospace Solutions and the company has switched from the aluminium containers which weighs about 79 kg to a lighter one which weighs 17 kg lighter at 62 kg each. This is expected to reduce aircraft weight and CO_2 emissions as well.

Managing Portable Water of 200 litres capacity tank in an A320 is managed according to flight sector requirement. For instance, if the plane is flying from Kuala Lumpur to Penang, it doesn't need to carry a full capacity tank of water. This economisation of water has reduced weight and resulted in saving of 12 kg CO_2 per flight.

The in-flight initiative carried out by its cabin crew member is the Reduce, Reuse and Recycle strategy. All used plastic cups, bottle and others recyclable items are collected and sorted at source to be recycled. This initiative is also an adaption from Air Asia India which uses this as an offset mechanism to negotiate for certain privileges with the airport authorities. They are currently looking at trying out the same in Malaysia.

The A320 aircraft that runs on the CFM engine burns 15 to 20% lesser fuel compared to the older models. This is about 660 kg of CO_2 savings. The free flap landing measures saves about 25 kg of CO_2.

Air Asia utilises the Required Navigation Performance (RNP) which is actually a type of performance based (PBN) system that allows an aircraft to fly a specific pat between two 3D-defiend points in space. This saves about 182 litres of fuel per flight and about 575 kg of CO_2.

Currently Air Asia in partnership with Petronas are looking at the possibility of bio-fuel usage in its fleet of aircraft. All these green initiatives carried out by Air Asia has managed to save about 22,602 tonnes of CO_2 which is equivalent to planting about 113,012 trees (Abdullah, 2017).

2.9 Case Study 2 in Emirates Airlines

A case study in Emirates Airline’s is done through information available in open source. During the reporting period 2012-2013, Emirates increased its fleet size by 24 passenger aircraft and four freighters, as well as opening 10 new destinations and increasing frequencies on many existing routes. Fuel consumption and emissions grew in relation to each other and thus explains the airlines environmental results in 2012-13. Overall, total jet fuel consumption rose by 15.9% from 6,145,434 tonnes in the 2011-12 financial year to 7,125,216. The increases were the result of the arrival of its 10 new Airbus A380s and 24 new Boeing 777s (20 B777-300ERs and four B777 freighters) into service and it did little to offset the retirement of its older fleet of Airbus A330-200s and Airbus 340-300s.

Emirates managed to increase its fuel efficiency in 2011-2012 by 1% compared to previous years due to its new fuel-efficient aircrafts. Its cargo operations improved by 7.6% compared to previous years. Emirates has an average fleet size of 6 years compared to IATA fleet average of 11.7 years.

The airline refurbished its interior on its 33 Boeing 777 aircrafts and managed to recover and recycle the used materials from the aircrafts. The old seats, used carpets, galleys, toilets, entertainment systems and wiring, and even the overhead luggage bins were stripped and changed to new. The seat frames made of aviation-grade A aluminium alloy, steel items, polycarbonate plastics (from seat mouldings), wiring, textile and leather seat coverings and electric motors which move the seats into various positions in our premium cabins are all weighed, checked and were sent off for recycling.

A total of 432,904 kilograms of materials were separated and sent for recycling, thus diverting it from filling up the landfills. This includes 103,396 kg aviation grade A aluminium, 183,202 kg of polycarbonate plastic, 81,109 kg of textiles, leather and carpet, 702 kg of cables and 495 kg of electric motors/actuators. A further 3,553,793 kilograms of recyclable materials from its general waste stream, including 86,904 kg of scrap metal and tin cans, 164,582 kg of plastic containers and 3,302,307 kg of cardboard and paper. All these generated about USD150,000 which were channelled to a fund to support non-profit organisations that are involved in worthwhile environmental projects.

Leftover food, used cans, bottles, used cooking oil, aluminium cans, cardboard, paper, plastic and foil are all recycled by a firm specially set up with full time staff. All revenues collected from recycling contracts are used to pay the staffing costs.

The airline also replaced lights used for aircraft cabin maintenance with light emitting diode (LED) lights, which uses 50% less energy. This will produce less heat and which eventually reduces the load on pre-conditioned air meant for aircraft cooling.

The airline has 4,688 ground handling vehicles that runs on fossil fuel and diesel equipment which consumed 47,199,900 litres. The airline initiated a few programmes to reduce fuel usage by purchasing replacement vehicles with smaller engine sizes, using luxury vans to chauffeur families travelling on Emirates instead of several sedans and increased monitoring of driver productivity to encourage efficiency. This managed to reduced emissions by 884 tonnes of CO_2, or 3% of the total for ground services. It generated 23,560,782 tonnes of carbon dioxide equivalent (CO_2e) emissions in 2012-2013.

Emirates also replaced all its Unit Loading Devices (ULDs) which is used to accommodate freighter load and baggage with the Kevlar AKE unit which weighs about 56 kg per unit. The previous model which is made of aluminium weighed 79 kg and are less durable than the Kevlar units. The airline is expected to save about 14,475 tonnes of fuel or 45,595 tonnes of CO_2 emissions annually.

In future the use of electrically powered vehicles will be used. At the moment a trial period is in process and once approved, about 50 of electric vehicle tractors will be purchased. Even though the cost of these vehicles is twice as much higher, it does not require much maintenance. Overall the total carbon emission for the airline is 31, 884,260 tonnes CO_2 as reported by the airline in its environmental report (Emirates, 2016).

2.10 Case Study 3 in Cathay Pacific Airlines

The airline purchased 10 Airbus A350-900XWB aircraft in 2016 which uses the Rolls-Royce Trent XWB engines and this resulted in a 25% less fuel consumption due to the technological advances in the aircraft which includes lighter plane, advanced aerodynamics and efficient engines.

In-flight waste management on 2 long-haul (Europe and North America), 2 medium-haul (Australia and New Zealand) and 4 short haul flights (Asian) were carried out in Cathay Pacific Airlines which is based in Hong Kong. The waste consists of 2 streams, which is galley and cabin waste. Galley waste are rubbish from the bins and trash compactors. Cabin waste are collected from passenger's compartment after the aircraft has landed. All food waste went back to the caterer.

In this study, it is noted that the economy class passengers had the least amount of waste generated of about 0.38 kg and the highest is by first class passengers by up to 2.84 kg. The total waste per-aircraft can range from between 152 kg to about 244 kg depending on the duration, destination, profile and other factors. The initiative showed that many waste that could be reduced or recycled. The biggest waste was from newspapers which is about 32 to 71% of the total of all waste collected. Next were plastic items which is about 13% and aluminium cans of about 4%. Food waste made up the remaining waste.

In 2009, the airline managed to recycle 92,607 kg of a combination of aluminium cans, plastic bottles and plastic cups. The study concluded that about 45 to 58% of the total aircraft waste from in-flight service could be reduced and recycled. The use of light weight items on board like light weight cargo cart, service trolley cart, baggage cart and cutleries has saved 78,460 tonnes CO_2 since 2004.

Cathay Pacific has also indicated that it will be using bio-fuel made from landfill rubbish on its selected long-range flights beginning in 2019. The bio-fuel would be in combination with conventional fuel and are expected to cut emission by 80%.

The engine out (EO) procedure has resulted in saving of 12,000 tonnes CO_2 per year. The modification of its A330 engines has resulted in savings of 11,000 tonnes CO_2. The reduction of weight from reducing in-flight magazines, newspapers has brought in savings of 880 tonnes CO_2 per year. The flight optimization initiative like using manual fine-tuning of the flexi-track approach and using real time weather data and other measures has saved 607 tonnes CO_2 per flight monitored.

Cathay also maintains its aircraft engines by washing it regularly and this initiative has resulted in savings of 5,500 tonnes of fuel resulting ins 17,200 tonnes of CO_2 reduction in 2015. Starting from 2016, the airline increased its frequency of engine wash from 11 to 16 weeks to 6 to 11 weeks. This is expected to further reduce fuel burn and CO_2 emissions. It has also saved about 134 tonnes of CO_2 emission by using the base coat paint in its A340 aircrafts in 2008. The airline has incorporated an environmental message in its inflight magazines to create more awareness.

The airline's carbon offset system launched in 2009, managed to offset 14,000 tonnes CO_2 including the offsetting of its customers and staff travel (Cathay, 2016).

2.11 Case Study 4 in KLM Royal Dutch Airlines

KLM in 2016, reduced their emissions by 3% compared to 2015, in part because of the delivery of more fuel-efficient aircraft. The Dreamliner's that joined their fleet generated 35% less CO_2 than the aircraft they replaced, while the new Embraer 175 has 35% lower emissions compared to the old Fokker 70. KLM compensated 632,000 tonnes of CO_2 in 2016 through the European Trading System, while passengers offset 19,000 tonnes through customer-offset program.

KLM initiated a bio fuel initiative in 2010. A private company supplied the biofuel and the KLM Corporate Biofuel program was launched. Its objective was to encourage the market demand for sustainable biofuels that meet a strict technological and ecological requirement. These cooperation among members and their leadership may contribute to the development of a market for sustainable aviation biofuels. Biofuel facilitates a circular process. The energy is obtained from decayed plant waste and biomass, as well as from used frying oil. In 2011, the first commercial flight operated by KLM used biofuel made from used cooking oil. Thereafter many flights were operated using bi-fuel including medium and long-haul destinations like Paris, Rio de Janeiro, New York, Aruba and Bonaire. KLM aims to supply 1% of KLM's entire fleet with sustainable jet fuel in 2015-2016.

KLM also created the KLM Environmental Centre, which processed waste water and hazardous waste originating from maintenance from its engineering and maintenance division. The engineering division also does an engine wash for all its aircrafts by using a system called 'semi-dry wash'. This measure uses 80 times lesser water per wash or just 150 litres than the conventional method which uses 12,000 litres of water per wash. The used water is also collected for recycling and results in saving 8 million litres of water per year.

KLM also revised its sustainability policy by including the principles of minimizing waste in its supply chain and by using renewable energy. It also engaged Michael Braungart, one of the founders of the cradle-to-grave philosophy to assist in its application of life cycle analysis cradle to grave concept. Wherever possible, the cradle-to-cradle principle is applied, returning discarded materials to the production cycle through external waste treatment facilities Aircraft carpets are recycled in cooperation with the Dutch carpet manufacturer Desso. In 2014, KLM provided 39 tons of carpet with a second life. Some 90,000 kilograms of fabric that were left over after the uniforms were changed in 2010 was converted into a resource, and was made a part of the new carpets aboard the aircraft.

The company also defined specific product specification to their suppliers to develop sustainable products. They relocated their laundry services nearer to the airport, so that the laundry company need not travel far to collect the pillow, blankets and other laundry items from arriving flights. They also acquired UTZ certified coffee and sustainable palm oil and soy products in their catering on board.

In 2014, KLM produced almost 18,000 tons of waste at Amsterdam Airport Schiphol, and approximately 26 percent of which was recycled. There are fourteen waste flows; residual waste, paper, wood and glass being the main ones. A few other flows may be smaller but represent greater financial value, such as aircraft components and the company look into reuse, upcycling, recycling and recovery in order of priority.

In 2009, it set up a Scrap Plaza, an isolated area near the Engineering and Maintenance division, where all the flows of technical waste from aircraft and engines are collected.

The waste generated from cabin, like catering waste which is of a sizeable amount of 12 million kilograms of packaging and residual waste are recycled. The glass wine bottles were replaced by PET plastic bottles in order to save weight and thus reduce fuel (KLM, 2012).

2.12 Case Study 5 in Singapore Airlines

Singapore Airlines owns a combined total of 284 comprising of both the Airbus and Boeing fleets. A part of SIA's fuel saving initiatives are keeping a modern and fuel-efficient fleet. It has one of the most modern and fuel-efficient fleet in the world with an average age of 6 years old. It has also ordered five A380-800s, 30 787-10s and 56 A350-900s. and in February 2017, it signed letter of intent with Boeing for 20 777-9s and 19 additional 787-10s.

Alternative sustainable fuel is one of the top priority for SIA. SIA is a member of Sustainable Aviation Fuel Users Group (SAFUG) which was established in 2008. The body overlooks the development and commercialisation of sustainable aviation fuels. SIA is currently collaborating with government agencies and stakeholders to overcome supply and infrastructure challenges that may hinder the commercial use of sustainable aviation fuels.

In flight operations, SIA it has implemented the installation of lighter in-flight entertainment system which expected to save about 2,440 tonnes of fuel.

It has also implemented tailored water uplift initiative based on flight sector requirements through a tailored potable water programme saving 2,325 tonnes of fuel and the removal of unutilised overhead storage compartments located in between the galleys of their 777-300ERs which saved about 2,400 tonnes of fuel per year. Fleet wide engine washing initiative has resulted in a savings of 10,400 tonnes of fuel per year. Engine modification of the A380 Trent engine has resulted in 10,010 tonnes of fuel being saved a year.

SIA also uses procedural initiative such as ‘continuous descent’ operations, to minimise fuel use without compromising safety. It also applies Data Analytics which accurately measure performance in addition to identifying and prioritising opportunities for further fuel productivity improvement. SIA uses mobile ground power units that runs on diesel fuel and preconditioned air units during night stops on long transits to reduce using aircraft auxiliary power units (APU) which runs on jet fuel which is far more expensive. This initiative saves about 2,400 tonnes of fuel per year.

It has also engaged route planning procedures ascertain most fuel-efficient routes possible and implemented Centre of Gravity Optimisation initiative into their Load Planning System. This will automatically derive a preferred centre of gravity position for loading of cargo pallets and containers, leading to improved fuel efficiency in aircraft operations.

On the 3R (REDUCE, REUSE, RECYCYLE) initiative, a campaign was launched to create awareness among the cabin crew on waste reduction on flights. Crew are told to use reference materials digitally on screens instead of printing them on paper for pre-flight briefings, printing double-sided documents, storing documents, files and archives electronically. Using electronic methods of communication whenever possible.

Crew are told to reuse materials like using envelopes designed for multiple use for internal correspondence and using printed paper that is no longer needed for drafting and note-taking purposes.

Recycling bins were conveniently placed around offices and canteens for recycling waste such as paper, magazines, newspapers and aluminium cans. Recycling used carton boxes, magazines, newspapers and glass bottles collected from during flights were done (Singapore Airlines, 2016).

2.13 Case Study 6 in Virgin International Airways Limited

Virgin Atlantic Airway's carbon reduction initiatives saw an eight percent decrease of its carbon foot print from year 2015 which was 4,433,713 tonnes of CO2e to 4,082,195 tonnes of CO2e in year 2016. It is also twenty two percent reduction from the baseline of year 2007.

This is achieved mainly due to the fleet and operational changes. The new Boeing 787 are more fuel efficient and the airline has also recently invested in a further twelve A350 aircraft to be delivered in 2019. The fleet renewal programme has already exceeded IATA target of 2020.

The onboard weight reduction, optimisation of aircraft cleaning and maintenance together with efficiency of the pilots in flying the plane, saved a total of 21,507 tonnes of CO_2, which is about 6,828 tonnes of fuel.

Virgin Atlantic has been working with a clean technology company called Lanza Tech since 2011 to develop low carbon fuels from waste carbon gases. The process involves converting waste carbon monoxide (CO) gas from heavy industries like steel mills into ethanol which can be used in the production of aviation fuel via an alcohol-to-jet conversion process. This is expected to reduce the CO_2 emission by 75% compared to conventional kerosene. This initiative is still in its preliminary stage.

Food waste is a highly regulated in its disposal process in the United Kingdom. As such, all food waste is required to be taken away by the respective catering companies and deep landfilled or incinerated. As for cabin waste, they are sent to offsite 'energy from waste' facilities where the energy generated are used within the airport itself. The airline also managed to recycle about 453 tonnes of aircraft food waste in the year 2016. This is about 43% more than in 2008 when the project was launched.

Virgin Atlantic Airways is one of the first airline to introduce a carbon offset program for its passengers. Passengers carbon offset will be channelled to beneficial projects in India like the power plant project that runs on farm waste (sugar cane husks) and Indonesia where hydropower project is undertaken. It only supports renewable energy or energy efficiency technologies rather than tree planting or gas flaring. Virgin Atlantic calculated the amount of carbon generated by each passenger according to the class of travel taking into account all other variables such as weight of equipment used, seat, cargo carried and others. Generally, the upper-class passengers pay more than economy class passengers.

Virgin Atlantic Airways target is to reduce aircraft CO_2 emissions by 30% per Revenue Tonne Kilometre between 2007 and 2020. CO_2 per Revenue Tonne Kilometre (RTK) is an efficiency measure that accounts for the amount of CO_2 emitted in relation to the people, luggage and cargo carried (Virgin, 2017).

2.14 Case Study 7 in Lufthansa Airlines

Lufthansa achieved fuel efficiency of its aircrafts by 12.18 percent since 2006. It aims to have a reduction of 25 percent of its CO_2 emission by 2020. Its nitrogen oxide per tonne kilometre has been cut by 26 percent since 1991 and aims to reduce it further to 80 percent by 2020. Its 'green fleet' planning by modernizing its fleet of aircrafts has resulted in adding 180 new aircrafts by 2025.

In its pursuit of sourcing of alternative sustainable fuel, it experimented with its Airbus A321 on a route from Hamburg to Frankfurt. It used a blend of 50/50 regular fuel with biosynthetic kerosene. It aims to conduct further research in this area and gain more experience in the process of developing this project as a long-term solution to carbon emission.

It also has made many efforts to optimize its operations. Flight routing, flight speed, efficient airplane configurations, long term weight reduction initiatives and optimum aircraft loading is some of its initiatives. It currently became the launch partner for a technology company (PACE) to use its Flight Profile Optimizer on its regional operations. It has managed to save about 4% fuel per flight using this technology to improve it operations. It is currently working on an effective policy to upgrade its infrastructure in the air and ground together with the airport authorities and regulatory bodies.

Lufthansa is still working towards a market based and competition neutral system for implementation of a global climate protection fees. Its carbon offset system is already in place where customers are given an option to voluntarily contribute funds to compensate the CO_2 emission. This fund will help support climate protection projects.

Green incentive systems in Frankfurt, Munich, Dusseldorf, Cologne, Hamburg and Hanover airports has made the group to take innovative measures to manage its nitrogen oxide emission as this determines who pays less airport charges which is now dependant on the nitrogen oxide emission by airlines operating into these airports (Lufthansa, 2017).

2.15 Case Study 8 in Green Fleet Strategy (Investing in Newer Fleet)

A comparative study involving an analysis of aircraft fleets owned by Malaysia Airline and Air Asia to determine the profitability and green performance of the airline was done. Five types of aircraft, i.e. B737–400, B737–800, B777–200, A330–300 and A380 were used that operates about 38 routes for a span of 8 years. Having a green fleet is considered the basic steps in tackling the pollution caused by the aviation industry. A Green Fleet Index (GFI) was used to indicate and quantify the green performance of airline's fleet, which determines the degree of compliance against standard requirement with regards to emission, noise, and fuel consumption.

The study suggests that a dynamic decision-making model whether to lease or purchase an aircraft must be considered. Even though the airline's profit is affected, it could be compensated from environmental cost savings. Aircrafts with state of the art technology saves fuel burn by 70% compared to its predecessors 40 years ago. Newer aircraft are greener than aging aircraft due to the incorporation of advanced technology and fuel-efficient with less pollutant produced. The case study concludes that fleet planning and operational profit are interrelated and dependant on the green initiatives of an airline. With some trade-offs in terms cost against environmental problem, which can be mitigated with operational strategies like increasing load factor, and reducing frequency of service, the airlines green performance will improve together with its profit. The GFI findings suggested that the green performance of both the airline's fleet is improving at 2% per annum for the planning period of 8 years. Its gradual improvement is due to the usage of newer aircraft (Khoo & Teoh, 2014).

With more emphasis placed on the production of more fuel-efficient 'next generation' aircraft, the room to increase profit from lesser fuel burn and CO_2 emissions is immense which will help any airline to be in compliance with future environmental legislation and market-based incentive schemes. Airlines in Europe, such as low-cost carriers Ryanair, EasyJet, and Norwegian Air Shuttle have always kept a younger fleet of aircraft. Some analysis done however feels that even though a younger fleet and increased capacity will only have marginal increase in fuel burn and CO_2 emission, it may not lead to a substantial overall reduction in total fuel burn and emissions, at least in the short term (Budd & Suau-Sanchez, 2016).

2.16 Summary of green initiatives in Aviation Industry

The green initiatives carried out by the airlines for the past 10 years along IATA's four-pillar strategy and are further summarized in Table2.1

Table 2.1 Summary of green initiatives to reduce fuel and CO_2 emissions

No	Green Initiatives	Air Asia	Emirates Airlines	Cathay Pacific	KLM Royal Dutch
1.	Bio-Fuel	In progress with Petronas	None	Expected to be used in 2019	Using bio-fuel from cooking oil (1% used)
2.	Fleet Renewal	6.1 years	5.7 years	7.8 years	11.1 year
3.	BC/CC Paint	136 kg weight reduction per aircraft	NONE	134 tonnes CO_2 saved in its A340 aircrafts	YES
4.	Latest Engines	P&W(GTF)1 6%/ 660kg CO_2 emission per flight	GP7200(A38 0) 14%	CFM (LEAP1-A) 15% & Rolls Royce Trent (25%)	General Electric (35% less CO_2 emission
5.	Engine wash	(0.2% or 171,000 litres fuel saved	YES	Eco-power wash saved 17,200 CO_2 emissions in 2015	'semi-dry wash' saves 8 million litres of water per year

Table 2.1 Summary of green initiatives to reduce fuel and CO_2 emissions

No	Green Initiatives	Air Asia	Emirates Airlines	Cathay Pacific	KLM Royal Dutch
6.	APU use reduction	Uses fixed electrical supply system	YES	YES	Mandated
7.	Tyre Maintenance	YES	YES	YES	YES
8.	Light weight tyres	YES	YES	YES	YES
9.	Light weight containers (Unit Load Devices)	Current ULD weighs 17 kg lighter at 62kg	Saved 14,475tn fuel/45,495 CO_2 emission	ULDs weighs 58 kg each	YES
10.	Winglets or Sharklets	147 litres fuel/464 kg CO_2 saved	YES	YES	YES
11.	Aircraft performance Monitoring System	YES	YES	YES	YES
12.	Single engine operation (Engine out)	8 litres fuel per minute	NONE	12,000 tonnes CO_2 emissions per year	YES
13.	E- manuals	23 kg fuel perf light	YES	51 kg weight reduced per aircraft	YES

Table 2.1: Summary of green initiatives to reduce fuel and CO_2 emissions

No	Green Initiatives	Air Asia	Emirates Airlines	Cathay Pacific	KLM Royal Dutch
14.	Portable Water Optimization	12 kg CO_2 emission per flight	YES	YES	YES
15.	3 R initiative	YES	432,000 kg weight reduced by recycling	92,607 kg waste recycled in 2009	12 million kg waste recycled till 2012
16.	Other weight reduction initiatives	YES	YES	880 tonnes CO_2 emission per year	YES
17.	Engine Modification	NONE	NONE	11,000 tonnes CO_2 emissions saved	YES
18.	Optimized Flight Profile	RNP saved 82 litres fuel/575 kg CO_2 emissions per flight		607 tonnes CO_2 emissions savings per flight	
19.	Emission trading system	NONE	NONE	YES	Compensated 65,000 tonnes of CO_2 in 2016
20.	Carbo Offset System	YES	YES	14,000 tonnes CO_2 since 2009	632,000 tonnes and 19,000 from passengers

Table 2.1: Summary of green initiatives to reduce fuel and CO_2 emissions

No	Green Initiatives	Singapore Airlines	Virgin Atlantics	Lufthansa
1.	Bio-Fuel	Using bio-fuel combination from 2017	Preliminary stage (Alcohol to Jet process/ATJ)	Currently being tested
2.	Fleet Renewal	8.2 years	7.9 years	11.4 years
3.	BC/CC Paint	YES	YES	YES
4.	Latest Engine	YES	YES	YES
5.	Engine wash	YES	YES	YES
6.	APU use reduction	2,400 tonnes fuel saved per year	YES	Mandated
7.	Tyre Maintenance	YES	YES	YES
8.	Light weight tyres	YES	YES	YES
9.	Light weight containers (Unit Load Devices	YES	YES	YES
10.	Winglets or Sharklets	YES	YES	YES

Table 2.1: Summary of green initiatives to reduce fuel and CO_2 emissions

No	Green Initiatives	Singapore Airlines	Virgin Atlantics	Lufthansa
11.	Aircraft Performance Monitoring (APM)	YES	YES	Using Flight Profile Optimizer managed to save 4% fuel per flight on
12.	Single engine operation (Engine out)	YES	YES	YES
13.	E- manuals	YES	YES	YES
14.	Portable Water Optimization	2,325 tonnes fuel saved per year	YES	YES
15.	3 R initiative	YES	453 tonnes of cabin waste recycled	YES
16.	Other weight reduction initiatives	4,725 tonnes fuel per year	2,276 tonnes of fuel/7,169 tonnes of CO_2 per year	YES
17.	Engine Modification	10,010 tonnes fuel saved per year	YES	YES
18.	Emission trading system	YES	NONE	YES

2.17 Summary of Literature Review

The reviewed literature has somewhat revealed that most airlines worked along the four pillars strategy recommended by ICAO and IATA. It shows the management of environmental carbon foot print in the aviation industry has to be dealt with combined and sustained effort from all the airlines and its stakeholders globally.

There are very few studies done on the benefits of these measure especially among the airlines in Malaysia. There are very limited information and practically no in-depth study on the green practices in Malaysia, especially a national carrier like Malaysian Airline. Even though most airlines tend to work along the four-pillars recommended by IATA, it would be interesting to find out how Malaysia Airlines performed compared to their counterparts in the region. There are some differences in measures undertaken by theses airlines. Most airlines in the European region are very much inclined and involved in undertaking effort in the development of alternative fuel compared to their counterparts in the Asian region. Furthermore, the compliance level to the environmental regulations and carbon emission restrictions by the western airline operators are higher compared to their counterparts in the Asian region.

One important observation here is the use of technological improvement as a preferred measure among most airlines. The effort to develop bio-fuel as a sustainable alternative fuel is more prominent among the Western carriers, with only a handful of Asian carries involved and that too only happened recently.

Another finding is the significant increase in the effort to use alternative sustainable fuel as a catalyst to fast track the reduction in CO_2 emission. Even though biofuel is an excellent source of alternative fuel and an environmental friendly source of energy for the aviation industry, there are still remains some concerns. The biggest is the cost of bio-jet fuel, which is nearly double the price of jet kerosene. Investing in bio-fuels could turn out to be a risky move for many airlines, as they struggle to balance their economic priorities in order to remain afloat in a challenging environment where managing cost priority will determine survival (Hari, Yaakob, & Binitha, 2015).

Many of the initiatives could be explored in order to be used for other transportation sector, especially the ground transportation sectors. The possibility of using the same approach as the aviation industry is worth exploring given the ambitious target set.

CHAPTER 3

METHODOLOGY

A case study is an investigation of a small sample and sometimes it can also be a single case study. It can also be from a particular point of view or perspective (Tight, 2010). A case study is an approach-based study of quantitative or qualitative methods or a combination of both. It is therefore less of a methodological choice per se. It is an in-depth research work where data are gathered in relation to a single individual, program or event in order to understand or learn about an unknown or not so well understood scenario.(Baboucarr Njie & Soaib Asimir, 2014).

This report investigates and evaluates the green initiatives practiced in Malaysia Airlines which is based along the recommended four-pillar strategy mooted by IATA to reduce CO_2 emissions. As the reduction in carbon emission has direct relation to fuel consumption, any effort to reduce fuel consumption will relatively reduce CO_2 emission as well. The areas that are investigated is kept within the boundaries of a typical aircraft operation.

Case study was chosen for this research as it contributes to an in-depth and a real scenario context. There is limited research done using case study method among airlines in the Asian region, especially in Malaysia where the aviation industry is rather crowded with three international airlines. Malaysia Airline is selected based on its role as a 'national carrier' which envision the country's aspiration towards pursuing green growth for sustainability and resilience.

Information from documented evidence is considered a formal evaluation of a case study, which may consist of press release, company websites, published journals, news clippings and environmental reports. These sources serve as a primary source in the development of a case study (David E Gray, 2013).

Multiple sources of information are relied upon when developing this case study. Documents pertaining to environmental regulations are reviewed, direct and indirect observations made, interviews with senior management were conducted, historical records are taken into consideration and site visits are conducted. Majority of the data are sourced from direct interview and documentary evidence. It is analysed according to the four-pillar strategy to have a structured framework that is applicable to all airlines globally. The Boeing 737 fleet operations is further chosen as a stand-alone fleet to be evaluated due to the reason below.

Malaysia Airlines long term business strategy is the expansion of its networks in the Asian region, and the operation of its flight would involve the utilisation of the Boeing 737 aircraft to a large extent. As such an evaluation on the green initiative carried out in the operation of the Boeing 737-800 fleet is carried out. Recommendations are given to yield positive results on investment.

3.1 Location of Study

Malaysia airlines employs about 10,000 workers currently. The study however, focuses on the green practices involving the operation of the aircraft, from the time the aircraft is on ground prior to push back from its parking bay, take off, cruise and landing and back to its parking bay. The research only consists of areas that the organization has operational control over. This includes aircraft fuel usage, and all other services that are directly related to the aircraft operation.

3.2 Site Visit

Access to the aircraft were granted to the researcher by MAB as the researcher is part of the workforce in the organization. However, some section within the airport vicinity remained restricted area due to safety and security reason. The visit to the Boeing 737-800 aircraft was done on October 25th 2017. The visit was conducted prior to an evening departure of the flight to a local destination as it was the most suitable time where there is limited traffic movement, especially in the domestic arrival area where the aircraft is parked. This facilitated a walkaround inside the aircraft and observing all the operational activity like the loading of inflight meals by the catering to cargo loading by their personnel's. Engineering activities like the tyre checks, refuelling procedures and aircraft portable water uplift procedures were observed. The activities carried out by the flight crew and cabin crew and other personnel were observed. Access to airside operation however were not granted due safety reasons. Nevertheless, the information on airside operations were sourced by other means such as document review and interviews.

3.3 Interview

Interviews conducted involved personnel from five business units or division which is the Corporate Safety Oversight Department (Environmental Unit), In-flight Services, In-flight product development, Fuel Management Team and Airport Operations Department. The interview was carried out informally and the sample questions are shown in Appendix 1. One personnel from each of the department above was interviewed who are the subject matter experts. Due to the request of privacy and to comply with the Personal Data Protection Act 2010 (PDPA), some sensitive information including names are not disclosed. All the processes involving the operation of the aircraft are discussed and reviewed over the interview period. Question were asked on the current fuel saving initiatives adopted, future strategies and challenges. The information obtained is documented without revealing any sensitive information pertaining to safety and security of the airline.

3.4 Methodology of CO_2 emission calculation

Aircraft CO_2 emission are an exact multiplication of fuel consumption. However, fuel consumption being typically expressed in volume, needs to be converted into mass as shown below:

Equation 1:

Mass of fuel consumed = Volume of fuel consumed × Fuel density

Some of the possible sources of fuel density is by having an on-board measurement system, fuel supplier information or density -temperature table. In this study, whenever there is a need to covert volume to mass, a standard figure of 0.8 kg/litre is used which is the density of aviation turbine fuel (ATF) or Jet Fuel obtained from information from the supplier. An example of a simple calculation method is shown below:

Example: 1000 litres of (ATF) fuel × 0.8 kg = 800 kg

The CO_2 emission is then calculated by multiplying the mass of the fuel by an emission factor as shown below:

Equation 2:

Emission =Mass of fuel consumed × emission factor

Example: 800kg fuel × 3.15 = 2,520 kg/CO_2

The industry standard emission factor to calculate CO_2 emission is 3.15 per kg fuel consumed.(IATA, 2015)

3.5 Weight to fuel consumption ratio

Another factor to consider is the effect of weight on the amount of fuel consumption. Each amount of weight reduced will have a relative reduction in fuel consumed. As it is difficult to quantify the exact amount, a general 'rule of thumb' figure is widely adopted in the aviation industry whereby it is assumed a 1% weight reduction will have a reduction of 0.75% fuel consumption (World Heritage Encycopedia, 2016).

In Malaysia Airlines, according to the Weight and Balance schedule used for the purpose of weight management of the aircraft operation, 1000 kg of weight increase will require an additional 75 kg of fuel uplift per 4 hours of flight time or 13.33 kg fuel per additional kg carried. Generally, a Boeing 737-800NG consumes about 2,400kg fuel per hour. This assumption is made considering variables such as take-off, cruise, taxi, landing, contingency fuel and other factors that affect the weight of the aircraft. An example is given below of a given a scenario of one additional passenger carried with a weight of 75 kg:

75 kg (passenger weight) ÷ 13.33 = 5.6 kg fuel consumption per 4 hours flight.

3.6 Safety and confidentiality

Airline operators are exposed to a significant amount of safety and security risks. In order to conduct this research, prior permission was obtained from the airline operator. Certain safety and security measures like the requirement to have an airport pass was needed. The airport pass is granted once the security vetting system has given the green light. Information deemed critical to the security of airport and airline operations are not disclosed in this study. A letter of non-disclosure of sensitive information is signed prior to conducting this study.

3.7 Approval for site visit

Prior to interviewing the personnel's involved, a written notification was given and a verbal approval were granted by the Director of Flight Operations for Malaysia Airlnes Berhad, Captain Hamdan Che Ismail. An assurance is given by the researcher that the study is meant for academic research purely and not intended for publication

CHAPTER 4

RESULTS AND DISCUSSION

4.1 The Four-Pillar Strategy

In this chapter, strategies implemented by Malaysia Airline is evaluated based on the four pillars and a specific fleet, the Boeing 737-800NG's carbon emission and fuel consumption reduction is evaluated and possible recommendations are given with an expected return on investment in terms of CO_2 and fuel reduction. The recommendation given would potentially have a faster trajectory to achieve the target set by the authorities to meet the emission reduction road map which is illustrated in Figure 4.1 It shows an aspirational goal of carbon neutral growth from 2020 that is to be achieved.

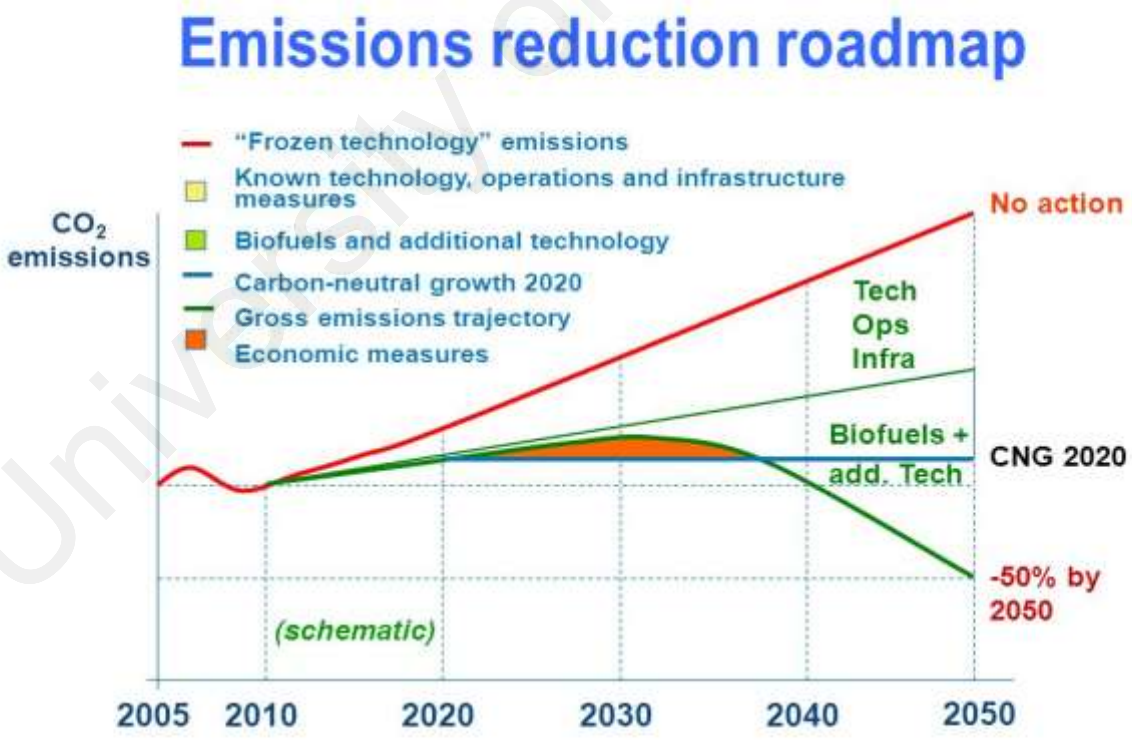


Figure 4.1: Emission reduction roadmap

Source: Environment, Air Transport Bureau of ICAO

In order to meet this ambitious target, Malaysia Airlines strategies will be discussed and evaluated in the next following paragraphs. The initiative to reduce carbon emission is evaluated and categorized along the four- pillar strategy.

4.2 Technological Improvement

As stated earlier, technology has the best possible chance to meet the roadmap earlier than all other measures. The major possible technological improvement available are discussed and Malaysia Airlines effort are evaluated. It may not however be feasible for Malaysia Airlines to initiate all possible measure to in order to meet the roadmap due to the various reasons such as cost, business model and operational viability. Malaysia Airline's strategy using this pillar is discussed below together with Table 4.1 that highlights the measures.

4.2.1 Fleet Renewal (Green Fleet Strategy)

MAB has an average fleet age of 5.3 years powered by technologically advanced engines that reduces fuel burn and CO_2 emissions. MAB's investment for the next 5 years on new aircraft purchase is about USD 10 billion. The six new A350-900 aircraft being periodically beginning December 2017 is the world's latest generation airliner featuring the latest aerodynamic design, carbon fibre fuselage and wings, plus new fuel-efficient Rolls-Royce Trent XWB engines. With the latest in technology, the aircraft provides unrivalled levels of operational efficiency, with a 25% reduction in fuel burn and emissions and lower maintenance costs. In future MAB needs to choose the aircraft that meets its current and future demand and look at how it fits into its dynamic business model. This is due to the lesson learnt from the acquisition of the A380 aircrafts which were not able suit the dynamic business model MAB has. After the selection of aircraft type, the next important consideration is the type of engine that it needs to invest.

4.2.2 Aircraft Engines

The choice of engine is an important factor to consider and the existing manufacturers of aircraft engines like Rolls Royce, Pratt & Whitney and CFM are constantly developing new technologically advanced engines. The B738 aircrafts CFM 56-7B engines has a light-weight carbon fibre fan and are able to save to 15 % more fuel efficient than the earlier models or consumes 600kg fuel lesser per hour. Lately engine development has taken into consideration the suitability of bio-fuel use and in future, MAB has to consider it, as it is one of the most effective measures in the effort to reduce carbon emission along the four-pillar strategy.

4.2.3 Alternative Sustainable Fuel

MAB has not initiated any project on alternative fuel development, citing the unfavourable cost effectiveness of bio-fuel at the moment. MAB may need to engage industry players and collaborate with other agencies with similar objectives and need to work together with suppliers and all stakeholders to develop an alternative fuel development project IATA believes that by 2020, a 3%–4% of bio-fuel made from biomass, agricultural residues or waste, would be used. That is a potential global supply of up to 13 million tonnes of sustainable aviation biofuel by 2030 which is an equivalent to saving 35 million tonnes of CO_2. All in, sustainable biofuels could bring an 18% reduction to the carbon savings mix by 2050 (IATA, 2014).

4.2.4 Aircraft Performance Monitoring System (APM)

Aircraft performance monitoring (APM) system would be able to assist in the performance of the aircraft engines and fuel consumption by accurately identifying areas that are not fully efficient. At the moment fuel consumption and other data are measured by calculating fuel consumption from cruise flight data. Currently deviation of the performance of the aircraft from the baseline measurement can only be measured as specific air range deviation using current method. A cruising flight data cannot be used for other aircraft performances such as maximum rate of climb and climb angle. The APM are able to evaluate certain physical characteristic that changes in the aircraft such as aerodynamic inefficiencies by identifying physical parameter changes like type of engine degradation. Some of the other areas that can be identified is aircraft weight from load and trim sheet and fuel consumption, engine rotation speed percentage and engine pressure ration for the purpose of power setting, exhaust gas temperature and lower heat value of fuel (K. Krajček i dr, 2015). Investing in the latest APM system may save about 2% or 336 kg of fuel on a 4-hour flight. Potential CO_2 reduction is about 1058 kg.

4.2.5 Aerodynamic Drag Reduction

The installation of 'winglets' as it is called in the Boeing aircrafts or sharklets'in Airbus, saves 116 kg of fuel burn or 365 kg of CO_2 emissions per flight. Winglets and Sharklets are small aerodynamic surfaces mounted almost vertically at the wingtips to reduce induced drag and improve the overall aircraft lift-drag ratio. MAB installed 'winglets' and 'sharklets' in all its aircraft beginning from 2005.

4.2.6 Information Technology Turnaround Program

MAB, as a technology driven company invested in an Information Technology (IT) turnaround programme with Phase 1 (technology replacement) and Phase 2 (Information Systems replacement) for 2017 successfully completed. This will minimise system disruptions and increase operational efficiency. A third Phase will be carried out next year which focuses on digital transformation. Nevertheless, training for staff to facilitate a seamless transformation and minimise disruptions must be given.

Table 4.1 Technological improvement in MAB

No	Technology	Malaysia Airlines Current Initiatives	Expected or actual Fuel/CO2 reduction
1.	New Fleet (Green fleet strategy)	MAB has a fleet age average of 5.3 years. Has one of the youngest fleet in the world.	A fuel savings of about 15 to 25% per year forecasted.
2.	Engines (Advanced engines)	A330 (PW4000) A380 (RR Trent 900) A350 (RR Trent XWB) B737 (CFM 56-7)	Expected fuel and emission saving of 16%. (A350 saves 25%)
3.	Alternate Fuel (Bio-fuel)	No initiatives yet	Expected 18% fuel savings
4.	Aerodynamic Drag Reduction	Installation of "Sharklets' in Airbus or 'Winglets" in Boeing (since 2005)	Reduction of fuel burn of 116 kg or 365 kg CO_2 per flight.
5.	IT turnaround programme (Future initiative)	Phase 1 (technology replacement) and Phase 2 (Information Systems replacement) completed.	Expected to increase operational efficiency which affects aircraft efficiency
6.	Aircraft Performance Monitoring System	Current system in place is tracked manually to monitor fuel performance.	Identifies area to improve efficiency to reduce drag. Potential saving of 2% fuel consumption per flight

4.3 Operational Improvement

Even though technological improvement is seen as major component of the four-pillars, technology without the use of efficient operations will be a waste of investment. Operationally improvement is a process that involves a lot of planning and foresight. It does not necessarily mean a huge investment like in technological advancement is needed. Some of the measures taken by the airline to improve its operational efficiency are discussed below and Table 4.2 highlights the process:

4.3.1 Optimization of Flight Profile

One effective way to improve operational efficiency among airline is the optimization of flight profile. MAB optimizes its resources by working out efficient weather report data, maps, flight procedures, variable speeds, optimum flight altitudes or climb profiles, and efficient flight path using the Required Navigation Performance (RNP). RNP provides a basis for designing and implementing automated flight paths to facilitate airspace design, traffic flow and improved access to runaways. It is the first airline in South East Asia that introduced RNP approaches on B737-800 in 2014. The RNP approach provides precise approach stability without the need for ground infrastructure and also reduces the distance flown which eventually reduces fuel burn, emission and noise. specially in remote airports.

MAB still has room to improve compared to airlines that has invested in far more superior technology like latest software systems. Flight crew are trained to closely operate to the optimum flight path as possible. This however are not entirely possible as many parameters can change along the vertical flight profile such as, wind conditions, changes in flight level due to certain restrictions, flight connection changes for passengers, Air Traffic Controller instructions such as detour or speed control. The operational flight plan and flight management system are usually a few hours old and are already calculated and filed with the authorities which may change even before take-off. After the flight takes-off the flight management system computational limitation capability only facilitates a basic trajectory recalculation whenever there are changes. Pilots often use procedural measures and experience to handle the situation. The use of a software like the one used in Lufthansa will help save fuel consumption by about 1% per flight by accurately predicting the information and in a timely manner.

4.3.2 Auxiliary Power Unit Reduction

The use of ground power unit (GPU) that operates on electrical power replaces the need to use the auxiliary power unit (APU) that runs on fuel. Aircrafts that remain on ground for long periods benefit most out of this process. An A330 aircraft for example consumes about 6 to 9 kg of fuel per-minute depending on the load factor, electrical power required, air-conditioning system usage and the type of engine used. (6 kg for General Electric and 9 kg for Rolls Royce per minute). MAB managed to save 413,043kg of fuel or 1,239,131kg CO_2 per year. This figure however is only for the year 2016 and currently this practice is not widely used as MAB is experiencing issues with ground support services like manpower and frequent maintenance related problems. Furthermore, when possible, MAB uses the electrical supply from the passenger loading bridge (PLB) to connect to the GPU which in turn provides power to the aircraft. This however are not an available option at all the departure gates due to insufficient infrastructure support system.

4.3.3 Single engine operation or engine out (EO)

Currently this initiative is carried out on the B737 and A330 aircraft and it will be extended to the A380 fleets if possible. The procedure requires strict conformance to safety parameters set by the regulators, company and aircraft's manufactures. It saves 8 litres fuel or 28 kg of CO_2 per minute taxi. The taxi period can range from 15 to 20 minutes on average in KLIA airport. This initiative however cannot be executed at all airports where minimum safe operations with engine out cannot be met.

4.3.4 Aircraft inflight weight reduction

The cabin service trolleys made of light weight composites is used in the new A350XWB. This can reduce aircraft weight, which will reduce fuel burn and CO_2 emission. The "Quantum" trolley, developed by Canadian manufacturer Norduyn is one third lighter than its predecessor and saves around 28,000 tonnes of CO_2 annually for Lufthansa

Airlines.(CAEP/8, 2017). Currently only the latest A350XWB has the light weight carts on board and this initiative can be extended to all fleets in MAB. MAB should consider the possibilities of using seats that are lighter which could save about 30% weight per seat. Besides that, the standard stowage units can also be replaced with lighter units that are available in the market. There are still about 30kg of flight deck manuals that needs to be replaced with electronic manuals, which will save another 3kg CO_2 emission per flight.

Another area for weight reduction measure is at the freight and baggage container or unit loading devices (ULDs) which is currently made of aluminium and weighs about 79kg. This model can be replaced with the much lighter Kevlar model that weighs about 56kg.

4.3.5 Light weight Tyres and Maintenance

An aircraft tyre maintenance is done regularly as part of the safety procedures. Tyre checks involves pressure checks like under inflation and other irregularities in general. The checks are carried out by engineering personnel every two weeks and pre-flight checks are carried out by the pilots before every departure to check any physical irregularities. MAB are in the process of sourcing for light weight tyres to be used in all its aircrafts in future. MAB should consider the use of the latest tyres developed by Boeing (Flight Radial) which is ultra-lightweight with strong rigid tread belts and enhanced rubber. This will contribute to reduction in weight and operating cost. In the meantime, durability of tyres can be extended with proper maintenance regularly. Nevertheless, other circumstances like the number of hard landings and runaway conditions can have an effect on the tyre performance. This, however can be mitigated by working together with airport authorities on the maintenance of proper runaway and taxiway conditions.

4.3.6 De-rated Take-off

De-rated take-off is a process where less thrust is used on the engines during take-offs. It is done by utilising less thrust than of the engines that operated under existing conditions of temperature and pressure altitude. This manoeuvre can improve engine life and reliability, reduce operating cost and may reduce fuel burn eventually but the implementation must be within safe parameter and protocols. This manoeuvre is not mandatory in MAB but are encouraged to be used. The benefits of such procedure are not easily quantifiable by fuel savings, however a study conducted by the engine manufactures CFM International highlights a potential savings of USD 82,000 when a 20% de-rated take-off operation is carried out. The savings are in terms of maintenance costs primarily (CFM International, 2009).

4.3.7 Continuous Descent Arrival (CDA) Procedure

CDA is an operating technique where the aircraft descends from an optimal position with minimum thrust and avoids level flight within the safe operations criteria. The technique reduces noise, fuel burn and emissions. CDA gives an early chance to save fuel burn of up to 150,000 tonnes per year and reducing CO_2 emissions by 500,000 tonnes per year or 630 kg of CO_2 per landing compared to a traditional stepped approach to landing (Skybrary, 2017). Adoption of this method will reduce noise, emission and fuel burn saving of up to about 40%. There is a need however to collaborate with airport authorities and regulators, as the procedure is carried out in certain airports only (Sarkar, 2012).

4.3.8 Centre of Gravity (CG) Management

This measure is done where the load of the aircraft is moved towards the aft of the plane and it saves about 0.05% fuel burn every 1% shift of load towards the aft. Most commercial aircraft have their centre of gravity(COG) forward of their centre of lift in order to remain stable in flight. Fuel and payload disposition determines the COG position and the allowable range of COG positions is defined in the Flight Manual. The COG position towards the rear of the allowable range, will allow a more aerodynamic configuration and reduce drag and fuel burn. This measure however can only be implemented in wide-bodied dual aisle aircraft and certain models as this may involve transfer of fuel manoeuvres that are not applicable on the smaller jets that has only two engines.

4.3.9 Engine and airplane wash and polish

Over the period of time accumulation of dirt, the engine's fan and compressor air foils will reduce engine efficiency. MAB carries aircraft engine wash using a special eco-power engine wash by using clear water which gives compression efficiency by removing dirt of the compressor blades. The water is deionised, heated and atomised before spraying to clean the engine components. No chemical or detergents are used and it can be performed without towing the aircraft to remote bays as it can be done at the gate. The washing of planes and polishing further reduces the drag and saves fuel burn and CO_2 emissions from 0.5% up to 1.5% per flight. Currently MAB does not use the Base Coat Clear Coat as its exterior paint. If used this will save the paint cycle by 40% with extended durability, improved colour retention, reduced application time and reduction of up to 6 hours of drying time per colour.

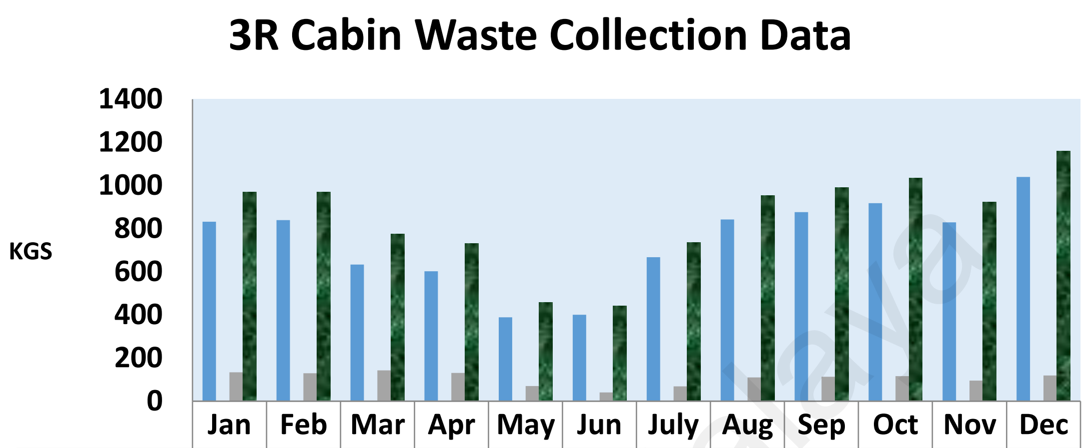
4.3.10 Aerodynamic Drag Reduction Measures

The aerodynamic drag reduction depends on the maintenance of physical surfaces of the aircraft. The airframe panels, doors, external paint and others must be free of defect and irregularities. Doors and panels must be flushed with the structure and control surface must be rigged to its intended position. The surface must be as smooth as possible to reduce the lowest amount of drag possible. Some of the engineering initiatives to reduce drag and eventual fuel burn and CO_2 emissions are like replacing worn out seal flap, missing parts, mismatched surface, door seal leakage, skin roughness, skin dents, butt joint gaps unfilled, butt joint gaps overfilled, external patches and paint peeling. If done regularly this will have a positive impact on the amount of drag an aircraft experiences. Inspection is done regularly in MAB to ensure this maximum operational efficiency of the aircraft. The use of Base Coat/ Clear Coat paint will also help reduce the aircraft drag.

4.3.11 Inflight Service cabin waste (Reduce, Reuse & Recycle) 3R Project

The implementation of the reduce, reuse and recycle project were carried out from 2011 to 2015. The waste like used cans, plastic materials, aluminium foils, bottles and other recyclable material were collected and sold to generate income. Passengers were also told to recycle the plastic cups instead of throwing them away. However, these measures have been temporarily abandoned due to operational constraint and other issues. Currently 80,000 plastic cups are used per day which weighs about 400kg and if this can be recycled it may reduce the consumption by 50%, which will save about 200 kg of weight or 6 kg or 19 kg CO_2. The management via its internal communication has also highlighted the amount of paper cups meant for use by the pilots which has been utilized by crew members inefficiently. A total of 45,000 paper cups each weighing 10 grams are used on a monthly basis resulting in high cost to the company. An efficient way to manage this is to encourage the utilization of individual personal container or mugs for the cabin crew. More importantly all these wastes can be saved from making its way to the landfills. The company can consider using its on board literature or visual aids to create awareness and education for the need to recycle items like plastic cups and others on board.

The management needs to set a 3R policy, revive the project and sort out operational issues. Figure 4.2 shows the collection of inflight waste, an initiative done by the cabin crew on board. The data is derived from a voluntary participation of the crew involved in only about 30% of the flights operated in Malaysia Airlines in the year 2014 and does not reflect the actual potential benefit if the initiative is carried out in all aircraft fleet by all of its crew members. Potential collection would be more if all flights are implemented with this initiative.



	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Plastics	832	839	633	602	388	400	667	842	877	918	829	1039
Cans	4.05	0	0	0	0	0	0	0	0	0	0	0
Foils	135	130	142	131	69.6	41.3	68.6	110	113	117	95.8	119
Total (KG)	971	969	776	732	458	441	736	952	990	1035	924	1159

Figure 4.2: Cabin Waste Collection Data

Source: Malaysia Airlines Berhad, Go Green Team

4.3.12 Optimized Portable Water

A full capacity water is not required for certain sectors like from Kuala Lumpur to Penang where the flight time is 45 minutes and there is no necessity to fill the tank to a maximum level. A Boeing 737 aircraft are able to carry a maximum 235 litres. A flight sector like the above only requires half of the amount. This would give a savings of 93 kg fuel or 292 kg CO_2 reduction per flight. At the moment MAB are in the process of implementing a system of measuring water level using the standpipe which needs to be purchased and installed.

4.3.13 Excess baggage carried into the cabin

An observation was carried out on a total of 10 flights departing out of KLIA and it was noticed that a fraction of passengers does not adhere to the baggage policy that limits the hand carried baggage brought into the cabin, which is limited to one bag for an economy class passenger and two bags each for a business class passenger. On average about 10 passengers on each of the flights observed does not adhere to this policy. This is an area where potential amount of revenue could be earned by charging for the excess weight. Furthermore, if there is strict compliance, the chances of passengers bringing in additional baggage and increasing the weight of the aircraft will be reduced. An additional 700 kg per flight is reduced per flight could be saved. Perhaps a mechanism or process can be established to assist in identifying this issue.

Table 4.2: Operational Efficiency in MAB

No	Operational Efficiency	Malaysia Airlines current initiative	Expected or actual Fuel/CO2 reduction
1.	Optimize Flight Profile	Done by optimising available resources	Able to save about 0.5% CO_2 emission per year.
2.	Ground Electrical Power(GPU)	Carried out whenever possible	Savings of 413,043 kg of fuel or 1,239,131kg CO_2 per year using GPU
3.	Single Engine or Engine Out (EO) Operations for taxiing	Done in B737 & A330 fleets.	Savings of 8 litres fuel per minute, 28 kg CO2per
4.	Weight reduction. Using light weight trolley/carts/stowage unit and lighter safety equipment's. Magazines and newspaper quantity reduced. Manuals are replaced with electrical manuals.	Lighter trolley, carts, and stowage units introduced in A350 aircrafts and are in the process of implementing it in all other aircrafts.	Savings of up to 9000 kg fuel and 28,350 kg CO_2. Electronic manuals saved 6kg fuel or 19 kg CO_2 emissions per flight. 720 tonnes weight reduced per year by weight reduction initiatives in total.

Table 4.2: Operational Efficiency in MAB

No	Operational Efficiency	Malaysia Airlines current initiative	Expected or actual Fuel/CO2 reduction
5.	Maintenance of tyres	Being carried out currently	Gives better reliability to prevent delay due to tyre issues.
6.	De-rated Take-off	Pilot initiative	Reduced engine maintenance cost. Savings of USD82k per year based on 20% use of procedure for take-off
7.	Inflight Service cabin waste 3R (Reduce, Reuse & Recycle) Project	Project abandoned due to operational constraint and lack of support	Average of 10,143kg items collected since 2012 till 2015 when it was implemented. Income of Ringgit Malaysia 3000 yearly.
8.	Continuous Descent Arrival (CDA)	Not done currently as not all airport can accommodate this measure.	Potential savings of 285 kg of fuel per landing approach or 900kg CO_2 emission.
9.	Centre of gravity (COG)load management	Carried out on all aircraft.	Savings of 0.05% fuel by a 1% shift to the aft of aircraft per flight.
10.	Engine washing and airplane washing and polishing	Done at least once a year or when needed.	Reduction of 0.2% drag on each engine.
11.	Aerodynamic Drag Reduction Measures	Various maintenance initiative done by the Engineering team	This measure reduces the drag by about 1%
12.	Optimized Portable Water	Currently ongoing, but not consistent.	Reduces the weight of aircraft and CO_2 emission of 10 to 12 kg per flight on average
13.	Excess weight of hand carried luggage into the aircraft	No mechanism to ensure compliance of maximum 7 kg per baggage per passenger.	Many passengers bring in excess of the 7 kg allowed, however it is difficult to ascertain actual weight without the weighing scale at the boarding gate or check in counters.

4.4 Infrastructure Development

The development of airport infrastructure plays a major role in harmonising the available technology and harnessing the benefit of an efficient operational system. Malaysian airports are one of the most advanced airports in the world with world class facilities. In recent years many developments have taken place in terms of infrastructure development and has benefited Malaysia Airlines tremendously. They are discussed below accompanied by Table 4.3 which highlights the infrastructure development scenario for Malaysia Airlines.

4.4.1 Air Traffic Management System

Latest air traffic management (ATM) has facilitated communication, navigation and surveillance systems(CNS) and assisted Malaysia Airlines to use the most favourable routes, altitudes and also can reduce the take-off distance and the waiting time on the runaway. An efficient Air Traffic Management (ATM) system will mitigate the necessity of unnecessary queuing in line for take-off, 'holding' in air and parking gates after arrival. The process of utilizing this system more efficiently however are not fully harnessed as there are still issues that affect the on-time performance of the airline. Issues like congested airways, and poor coordination between operators sometimes results in delays and this can only be resolved by having a concerted effort between all the airlines operating and sharing the facilities to cooperate and coordinate with all the stakeholders like the Air Traffic Controllers, airlines and other regulatory bodies. The technological capability of the existing ATM also must be harnessed fully to be able to cope with the increasing air traffic. Systems like the Controller Pilot Data Link Communication is an example of such technology where effective communication with pilots over a datalink system can contribute to flight efficiency and safety. This has a potential fuel savings of about 18% per year, according to IATA (Sarkar, 2012).

4.4.2 Airside Infrastructure

At the moment the airside infrastructure supporting the operations of Malaysia Airlines are reasonably good. However, due to financial constraint at times the airline is not able to utilize the facilities due to inadequate internal support systems. An example is where the Ground Power Units (GPU) are not sufficient for the operation of all its fleet especially during busy periods of departures.

In future the airport planning, infrastructure development and upgrading requires collaboration from the airlines, airport authorities, regulators and design consultant taking into consideration the capabilities of the airline operators. With proper consultation and planning, an efficient infrastructure and flexible facilities that supports future growth will be beneficial. When the aprons, taxiways and taxi-lanes impede free flow of aircraft movements, aircrafts will be delayed on the ground, either on stand or when manoeuvring between stand and runaway and cause severe disruption and recurring delays which will result more fuel consumption.

4.4.3 Fixed Gate Services

The benefits of using a fixed electrical ground power and pre-conditioned air at the gate are able to reduce the use of APU on ground. The fixed supplies allow the aircraft to obtain power directly from the local grid. This will enable the aircraft to use the airport's air-conditioning to control the temperature on board. The use of APU is only needed when the aircraft is about to depart in order to start its engines, thus it can be switched on only when required. At the moment the use of this services is somewhat limited and Malaysia Airlines are not fully utilizing the benefit as it has operational issues like inadequate resources in terms of staff to deal with. According to Nice airport operators in France, this measure saved 416 tonnes of CO_2 emissions in 2014. A use of 2 minutes after an aircraft arrival until 5 minutes before its departure in Barcelona airport saved 58,000 tonnes CO_2 emission per year (ATAG, 2016b).

Table 4.3 Infrastructure development

No	Infrastructure Improvement	Malaysia Airlines current initiative	Expected or actual Fuel/ CO_2 reduction
1.	Air Traffic Management System	Ongoing process of upgrading the Air Traffic Management System	Expected fuel savings of 18% per annum or 193,943 tonnes of fuel or 610,922 CO_2 emissions
2.	Airside Infrastructure	Collaboration between MAB and airport authorities ongoing	Designing, upgrade and improving airside facilities can prevent delays and save fuel consumption. (Aircraft aprons, support network of taxiways, taxi-lanes and ground service equipment)
3.	Fixed gate services	Currently only available at selected gates	Savings of APU use on ground and energy savings when using pre-conditioned air

4.5 Market Based Measures (MBMs)

A market-based measure is the use of positive economic instruments in order to achieve the reduction of carbon emission in order to fill the remaining gap from after the implementation of the other pillars to mitigate carbon emission. It is however widely used among many airlines as it is ‘deemed’ cost effective and Malaysia Airlines has in the past used this measure. The airline has also indicated its intention to use the carbon credit offset system in future.

4.5.1 Voluntary Carbon Offset System

In 2014 Malaysia Airlines participated in enhancing the carbon stocks and promoting biodiversity conservation of the degraded forests which was gazetted as a Permanent Reserved Forest within the South-East Pahang Peat Swamp Forest (SEPPSF) covering approximately 570,000 acres. MAB partnered the Ministry of Natural Resources and Environment (NRE), Forestry Department of Pahang and Forest Research Institute Malaysia (FRIM) and undertook this project. A total of 1000 Mersawa Paya (Anisoptera Marginata) and Ramin Malawis (Gonystylus Bancanus) saplings were planted with the help of local indigenous Jakun villagers in an area of 2.7 hectares. Unfortunately, the program did not yield the intended result as many of the saplings did not survive for long. This is because the area chosen is a peat swap area which is susceptible to fire and are also a flood prone area. In future, research will have to be done on the suitability of the soil and favourable geographical factors before a similar program is to be undertaken. The use of a levy system is also an option that can be considered.

4.5.2 Levy System

A levy is an effective measure to collect revenue from emission contributors. A mechanism similar to a fuel surcharge can be imposed. There is a possibility of these levy being passed on down the supply chain, however it will trigger the search for improvement in the other three pillars an eventually lead to reduction of fossil fuel, increase operational effectiveness as well as technological improvement. An international fund to manage the levies collected can be established to fund initiative to reduce emissions.

Offsetting means, reduction of emission in other sector or place and not at the emitters location. Many will argue that this is not a good measure, and reduction of emission matter still. However, in an industry where competition and cost are getting higher, it is more cost effective to have an offsetting program. Whether the emission reduction happens at the point of origin or elsewhere, it really doesn't matter from a climate point of view. What matters is the offset, balances the equation event tough it happens far away from the point of emission.

4.5.3 Emission Trading System (ETS)

The aviation industry is an industry that practically has no borders when conducting its business and its environmental impact that results from it. As airlines fly into different countries and continents, the issue of managing CO_2 emission cannot be based on individual whims and fancies of the different countries. If left to the individual airline and its local, national or regional regulatory body to implement their own way of charging CO_2 taxes, offsetting mechanisms, emission trading schemes and different carbon pricing methods, it would lead to a complex and costly exercise that would be almost impracticable to comply with. A need for a single point of accountability is therefore a practical way of mitigating this issue. A single global market based measure are the most practical way to do it (Johnson & Gonzalez, 2013).

By using a cap and trade system where a maximum limit to emissions generated by the industry players will benefit all parties. A cap (i.e. maximum limit) is placed on aggregate emission within a country, a sub-national jurisdiction or a sector. A unit of CO2e are created equal to the size of the cap and these units are then distributed to the emitters. Each emitter needs to obtain and redeem units to cover its emission on an annual basis. Emitters can trade units among themselves, for example, an emitter which manage to reduce its emission, can sell its units for a profit. This is known as carbon credit which basically is a permit that represents one tonne of carbon dioxide (CO_2) that has either been removed from the atmosphere or saved from being emitted. As long as the cap is consistent, the systems environmental objective is attained. Perhaps a system similar to these can be implemented within the context of the Malaysian aviation industry first.

As a market-based measure to reduce carbon emission, MAB has indicated the use of carbon credits to offset its emission. It is a carbon offsetting measure that funds any initiative on the ground that is taken to reduce emission. The airline will purchase carbon credits that are generated by these initiatives from the generators. Once purchased, the carbon credits are retired and cannot be sold or used anymore. Even the passengers can have a voluntary contribution to the own carbon foot print via the airlines initiatives. One such measure is the European Union's Emission Trading System (EUETS). This system is most favoured by the airline now as it is cost-effective compared to other measure as the priority of the company is to have a financially sustainable business model before embarking on other ambitious measure

4.6 Evaluation of initiatives to reduce CO_2 emissions in Boeing 737-800NG fleet

An evaluation of the green initiatives in the Boeing 737-800 New Generation fleet of aircrafts in Malaysia Airlines was carried out. The Boeing 737 is particularly chosen due to the fact that 80% of Malaysia Airlines flights are operated using this aircraft thus the impact on climate change attributed by this aircraft is greater. Figure 4.3 shows a typical composition of emission in an hour flight with a passenger load of 150. This is similar to a flight from Kuala Lumpur to Penang on a Boeing 737-800. The Boeing 737-800 fuel consumption is usually stated in average consumption per hour. With a load factor of 80%, rate of climb and other parameters typical Being 737-800NG consumes about 2,400 kg of fuel per hour (Ryerson, Hansen, & Bonn).

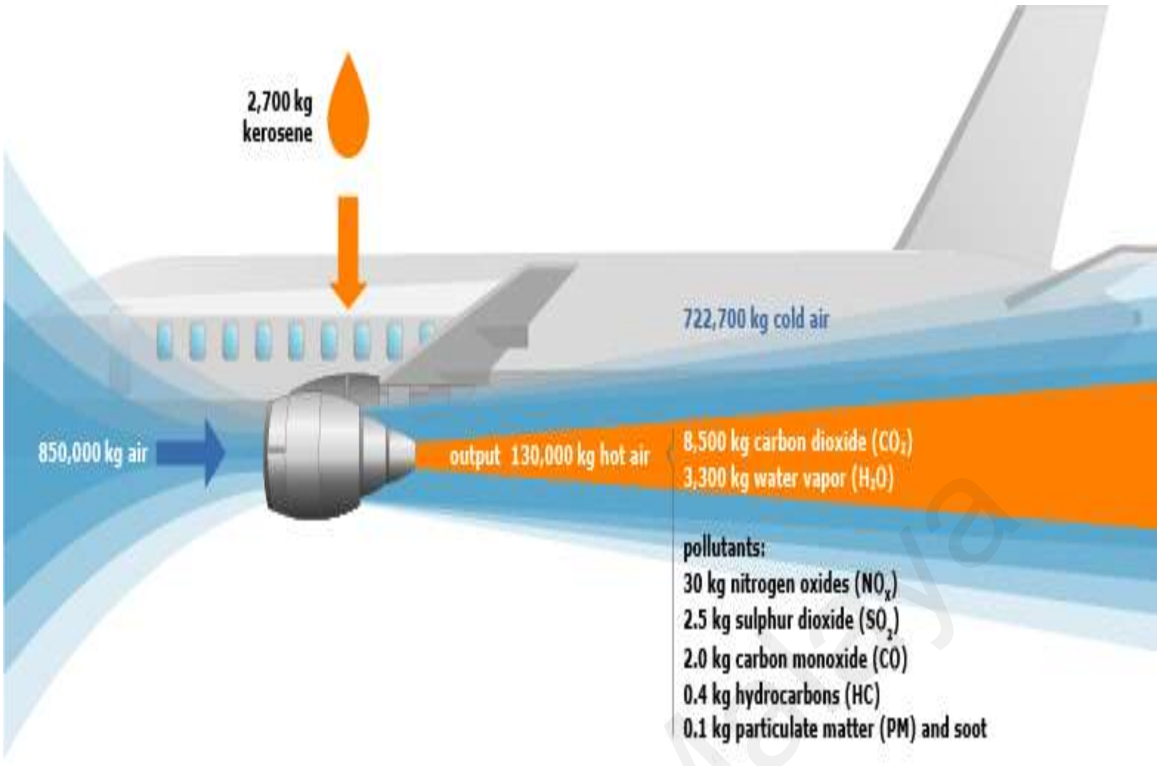


Figure 4.3: Emission from a two-engine jet aircraft during 1-hour flight with 150 passengers

Source: (FOCA)

Listed below in Table 4.4 are some of the fuel saving measures that has resulted in the reduction of fuel consumption and carbon emission. The assessment is over the past 10 years. In some instances, estimation of fuel consumption of carbon emission is given, especially when the measures are not easily quantifiable. The calculations are based on total fuel burn figure of 409,533 tonnes in the year 2016. Appendix 2 shows the total fuel consumption according to aircraft types, domestic and international sector operations in Malaysia Airlines Group(MAG).

Table 4.4: Current Initiatives carried out in Boeing 738-800 to reduce CO_2 emissions.

No	Initiatives	Fuel consumption reduction	CO_2 emission reduction/tonnes per year
1.	25 B738MAX new aircraft will be added to replace the older ones (15% less fuel per aircraft) (CFM 56-7 engines)	32,925 for 25 aircrafts	103,713
2.	Engine wash saves 100 kg per aircraft a year (5,400 kg overall) per year	4 tonnes	12.5
3.	Aircraft exterior wash and polish	Carried out 2 twice a year	9000
4.	Aerodynamic Drag reduction measures	Carried out during schedule maintenance	26,230
5.	Installation of winglets (5%) Split Scimitar Winglets	20,476	64,500
6.	Single engine out operation based on 50% average application per year	11 tonnes	35
7.	Continuous Descent Arrival(CDA) per approach	180 kg	36,741
8.	In-flight manuals to electronic manuals (23 kg per aircraft)	306 kg	0.9
9.	Reducing one crew member per-flight (100 kg saving including baggage)	1, 333 kg	4.2
10.	Centre of gravity load management	Saving of about 1% fuel per flight	9,072

Table 4.5 shows the potential savings based on practical measures that can be implemented for the Boeing 737 aircraft. The estimation is based on 180 flights out of 285 flights operated by Malaysia Airlines per day by B737, based on an 80% load factor.

Table 4.5 Potential reduction of fuel consumption and CO_2 emission reductions

No	**Recommended Initiatives based on 54 aircrafts currently in service**	**Expected Fuel savings (tonne/year)**	**CO_2 emissions savings tonnes/year**
1.	Replacing 29 remaining aircrafts with B738MAX (CFM 56-7 engines) 15% or 1,137 tonnes per aircraft per year	32,973	103,865
2.	Engine wash cycle to increase by 50% will result in 30% more fuel savings	1.2	3.7
3.	Installation of winglets (1.5% more savings from earlier models) Advanced Technology Winglets	307	968
4.	GPU use on ground savings per year	268	845
5.	Optimized Portable Water (reduction of 60 kg weight per sector or 3.8 million kg weight reduction per year	291	917
6.	The use of Flight Profile Optimizer (saves about 4% fuel)	16,381	51,601
7.	Electronic news replacing current newspapers reducing 47 kg weight per flight or 3.05 million kg per year	228	719
8.	"Going Places" magazines to be converted to electronic medium (52 kg weight per flight or 3.37million kg per year)	253	796

Table 4.5 Potential reduction of fuel consumption and CO_2 emission reductions

No	**Recommended Initiatives based on 54 aircrafts currently in service**	**Expected Fuel savings (tonne/year)**	**CO_2 emissions savings tonnes/year**
9.	All other magazines to be removed as readership on board is poor. (11.5 kg per flight, thus saving 745,200 kg per year)	56	176
10.	Use of base coat clear coat paint reduces 136 kg weight per aircraft/flight or 8.8 million kg weight per year	661	2082
11.	Replacing ULD' (88 kg current ones) with lightweight ones (56 kg) Savings of 32 kg per ULD	4147	3,063
12.	Replacing trolley carts (currently 28 kg to light weight carts of 10 kg) Weight reduction of 18 kg x 12 carts =216 kg per flight	1000	3307
13.	Reducing excess hand carried luggage into cabin (7 kg per baggage x 10 incidents observed per flight/day or 252,000 kg per year	19	59
14.	Reduction of flight deck manuals and documents (25 kg per aircraft or 1.62 million per year)	121	382
15.	Reduction of inflight plastic cups, boxes and aluminium cans (approximately 70,000 kg per year)	5.2	16.5
16.	Reduction of crew paper cups of 35,000 cups per month or 420,000 a year (420 kg)	0.03	0.1
Total Expected Reduction of fuel consumed and CO_2 emissions		52,563 tonnes of fuel savings per year	165,573 tonnes of CO_2 emission reduction per year

The result shows that a potential reduction of 55,626 tonnes fuel consumption or 175,221 tonnes of carbon emission per year can be achieved. This will ensure that Malaysia Airlines will be on track to meet the emission reduction road map as well as fulfilling its business objective. In the next few paragraphs, an evaluation on the possibilities of using some of these measures to reduce the carbon emission of ground transportation in Malaysia will be discussed.

4.7 Carbon emission reduction in ground transportation

Malaysian transport sector is seen as the biggest challenge towards climate change as it consumes 35% of energy total and emits 50 million tonnes of CO_2 in 2015.Road transport contributes about 85 percent of those emission figure where individual owners of cars are responsible for about 59 percent of it (Giz, 2016).

As the aviation sector is an industry that has international synergy in working towards climate change mitigation due to international bodies like ICAO and IATA, it does have some advantage in leading the pursuit in climate change mitigation. Some of the measures taken the by aviation industry in mitigating its carbon emission could be beneficial for s ground transportation and briefly discussed with accompanying Table 4.6 highlighting the possible application among the various ground transportation sectors in Malaysia.

4.7.1 Possible strategies for ground transportation CO_2 emission reduction

The use of bio-fuel is an area where tremendous improvement of CO_2 emission reduction. Even the aviation industry at its Conference on Aviation and Alternative fuel in October 2017 has indicated that the aspirational goal to deliver a 2% fuel-efficiency is unlikely to be met, unless alternative sustainable fuel is used.(ICAO, 2017b) Therefore, the development of bio-fuel in a country where natural resources and waste products are not efficiently used, it will be a prudent strategy to consider implementing.

The development of engines that are runs on bio-fuel needs to explored and existing older model vehicles can be replaced with this new engine that could use bio-fuel depending on the viability of costs involved. In terms of keeping a fleet of vehicles that are newer, the incentive for the owners may not seems significant enough to change to a newer model. However, if there is a regulative process in place that makes it compulsory for vehicles older than 10 years to be replaced with much more efficient models, the environment will benefit. This may not be applicable for the rail system like the mass rail transit (MRT) and the light rail transit (LRT) which runs on electrical energy.

The design of the vehicles whereby aerodynamic drag can be further reduced would be a possibility to consider. Removing unnecessary roof racks and other unwanted accessories will also reduce the drag. A large amount of aerodynamic drags is responsible to the increase in fuel consumption and it can be up to 50 percent in some instance. The use of vortex generator, spoiler, splitter and other active flow control like suction and air jet is could be used to reduce drag in vehicles (Sudin, Abdullah, Ramli, Musthafah, & Shamsudin, 2014). In some large vehicles items like full roof deflector, fairings, sloped hood, round corners, aero bumper, side skirtings, recessed door hinges and grab handles can be used to improve aerodynamic drag and reduce fuel consumption and emissions.

Maintenance of engine by regularly washing and cleaning, as the engines gets older or working in an unfavourable environment will add to the reduction in fuel consumed and CO_2 emissions. Components like injectors that are dirty is the single largest reason of fuel inefficiency. A good fuel additive that multifunction as a cleaner will get rid of impurities over time. Cleaning of oil sludge using engine flush cleaner can lengthen engine efficiency, thus the importance of engine cleaning.

Carrying excess load which is not required will increase fuel consumption. An additional 45 kg weight increase will consume up to 2% fuel, thus increasing the carbon emission.

Maintenance of vehicle tyres should be done regularly and this is not widely practiced among car owners in Malaysia. The petrol station operators could assist by promoting the use of tyre inflators as how they assist in cleaning the windshield in some petrol stations.

Under inflated tyres burn more fuel which is not uncommon. If a tyre is under inflated by a mere 8 pounds per square inch (PSI) it will have a rolling resistance of 5% increase on the tyres. In typical heavy vehicle such as truck and buses a 10 PSI under inflation will reduce fuel efficiency by 1%. The use of light weight tyres will reduce the amount of fuel consumed and the aesthetic features of sports edition rims or 'sport rims' does not necessarily increase fuel consumption but rather the weight and proportionate size does.

Speed optimization using the optimized flight profiling could also have significant savings. Aircrafts do rely on this system to optimize the best flying manoeuvres, distance travelled and favourable environmental conditions. Ground vehicles could incorporate this with the existing cruise control technology which are known to reduce fuel consumption by up to 6%, except in motorcycles where the benefits are not very significant.

In terms of infrastructure development, the government through its regulatory agencies like the Road Transport Department (RTD) can use a system similar to the aviation where there is minimum disruption to the movement of the vehicles unnecessarily. An example would be like allowing a vehicle to proceed on its journey with minimum idling and stops by creating a smooth traffic flow. This is similar to the CDA operation in the aviation sector. This can be done via monitoring of the actual traffic condition rather that a predefined time for limit for the traffic lights to operate. Even pilot's behaviour and skills contribute to the fuel consumption. Excessive speed, idling, operating the wrong gear, rapid acceleration or deceleration also impacts fuel efficiency. This poor skills can cause increase fuel economy by 30% (Cummins, 2017).

The use of market-based instrument is more viable to be used among cars as public car owners contribute about 59% of emissions in Malaysia. Carbon trading system can be used to reduce emissions in Malaysia's transport arena. A policy to regulate the carbon emission of private car owners including ride hailing companies can be developed whereby a mechanism to determine individual emission be evaluated. Each private vehicle owners can be subjected to a cap on net emissions taking into consideration the number of vehicles owned. A voluntary market-based measure like the aviation can benefit other transportation sector as well.

Table 4.6 Possible measures to reduce CO_2 emission for other sectors

No	**Reduction measures**	**Motorcycles**	**Cars**	**Heavy vehicles (Bus & Lorry)**	**Rail System**
1.	Bio-fuel	√	√	√	√
2.	Fleet Renewal	√	√	√	×
3.	Advanced Engines	√	√	√	√
4.	Aerodynamic design to reduce drag	√	√	√	×
5.	Engine wash	√	√	√	×
6.	Weight Reduction	√	√	√	√
7.	Optimized Fuel (similar to optimization of portable water)	√	√	√	×
8.	Tyre Maintenance	√	√	√	×
9.	Light weight tyres	√	√	√	×
10.	Flight Profile Optimizer	×	√	√	×
11.	Reduction of excess weight	×	√	√	√

Table 4.6 Possible measures to reduce CO_2 emission for other sectors

No	Reduction measures	Motorcycles	Cars	Heavy vehicles (Bus & Lorry)	Rail System
12.	Traffic management system	√	√	√	×
13.	Centre of gravity (Low)	×	√	√	√
14.	Carbon Offset System	×	√	×	×
15.	Levy System	×	√	×	×
16.	Emission Reduction Scheme	×	√	×	×

CHAPTER 5

CONCLUSION

The carbon emission roadmap and IATA's four-pillar strategy has helped airlines mitigating climate change by aligning their efforts to reduce carbon emission along the four-pillar principals. Most airline worldwide has adopted the recommendation made by the authorities. Technological improvement has come out as a clear winner among the four-pillars. New planes that comes with better fuel efficiency can contribute to almost 15% of fuel saving. This is a substantial sum considering fuel contributes to a about 30% of total operational costs for airlines the world over including Malaysia Airlines.

New planes that comes with the latest technology and alternative sustainable fuel is seen as the best bet to reach the emission reduction road map. The volatile oil market has accelerated the search for a suitable bio-fuel that is cost effective without decremental effects to the environment.

However, as the world is facing a dip in world oil price, bio-fuel is deemed not cost effective since fossil fuel is a cheaper option at the moment. The excitement among the airlines in developing bio-fuel as an alternative sustainable fuel just a few years ago when the oil price sky rocketed, has somewhat become lukewarm. Nevertheless, regulations and requirements like the Carbon Offset Reduction for International Airlines (CORSIA) has somewhat rescinded the demand for bio-fuel, especially when CORSIA will become mandatory after 2027.

Malaysia Airlines green initiative has been somewhat commendable. Among the four-pillars, the technological aspect is the one that has resulted in tremendous contribution towards its green initiatives. The advent of market-based measures, Carbon Offset Reduction Scheme (CORSIA) and the emission trading regulation can play a bigger role in reducing carbon emission. It is seen as a practical solution for most airlines and Malaysia Airlines in particular are more inclined towards a carbon offset scheme as a choice for its emission reduction strategy at the moment. This is due to the fact it is more practical compared to fixing operational deficiency especially when it is at a time facing a resource constraint situation

The study also managed to identify other significant areas where further improvements can be made. Malaysia Airlines needs to take an aggressive approach towards improving its operational efficiency where a serious lack of resources and other issues has somewhat dampened the effort to achieve the second pillars objective which is operational efficiency. The study realised that a possible savings in fuel consumption of 52,563 tonnes and a consequent reduction in CO_2 emissions of 165,573 tonnes per year can be achieved realistically using the four-pillar based approach. This is the equivalent to planting of about 827,856 trees.

In the meantime, the initiatives made by the aviation industry in reducing its carbon footprint can be extended to other sectors like the ground transportation and assist in the development of a dynamic model similar to the four-pillars strategy.

The ground transportation system however has a unique challenge as a big portion of polluters are private vehicle owners primarily, cars being the major culprits. A levy system or a voluntary carbon emission scheme can be introduced in the beginning before other ambitious measures can be undertaken. A control mechanism can also be put in place to possibly limit the private vehicle ownership in future. The MRT system that is being developed would also be able to mitigate these effects to a certain extent. Alternative sustainable fuel is another area where cleaner and higher performance oil can be used and reduce further carbon emission.

The older models of heavy vehicles can also experience tremendous green performance if similar strategies are adopted. However, the rail system with the exception of the “komuter’ system has already been highly energy efficient and therefore may only need minimum improvements comparing to the car segments. Many of the initiative from the aviation sector can also be a source of knowledge for future research work in finding ways to reduce carbon emission. The transportation sector in Malaysia emits about 50 million tonnes of CO_2 annually according to the ASEAN Transport & Climate Change Report. Malaysia will be able to attain its greenhouse gas (GHG) emission target of 45% reduction by 2030 following the Paris climate deal if some of these measures are taken into consideration.

As for future research work, it would be interesting to see a comparative study between the three airlines in Malaysia done on their green performances. A competitive emission standards or green performance criteria specifically for the aviation sector in Malaysian could be developed which encourage a competitive nature among them to achieve exceptional green performances.

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APPENDICES

Appendix A

Interview Questions

What are the measures that MAB did in order to reduce its fuel consumption and CO_2 emission?	The questions were further expanded to: a) What are the areas that can generate highest reduction? b) Is there a road map or target? c) How is this measure being evaluated or monitored? d) What is the level of commitment form the top management?
Does MAB use the four-pillar approach based in IATA's recommendation?	a) What is MAB's short and long-term approach to cut emission? b) Which is the pillar that is most likely to be used by MAB c) State the reason why a particular method is favoured?
What is the long-term plan in order to mitigate CO_2 emission when the voluntary period is over in 2026?	a) Does MAB have any other green initiative in the organisation? b) How far is MAB in reaching the target as per IATA''s emission reduction road map?
What is the current practice on board the aircraft among pilots and cabin crew in the reduction of carbon foot print?	a) Is there any incentives for pilots to carry out fuel savings measure? b) Does the cabin crew voluntarily participate in the 3R project? c) Does the passenger cooperate in this measure? d) Does the cabin crew get any incentives by managing waste for 3R on board?
What are the major challenges faced by the organisation in implementing measure to reduce fuel burn and CO_2 emissions?	a) How is the level of cooperation from staffs across the board? b) Does MAB have enough resources to carry out the initiatives? c) Is there a program conducted on environmental awareness in MAB?

Appendix B

MALAYSIA AIRLINES GROUP FUEL CONSUMPTION (2016)				
Row Labels	**Domestic**	**International**	**Grand Total**	
333	748,925	351,070,028	351,818,953	**Airbus A330-300**
388	65,687	215,833,171	215,898,858	**Airbus A380-800**
738	157,330,027	252,203,576	409,533,603	**Boeing 737-800**
744	51,980	32,660	84,640	**Boeing 747-400**
772	154,156	10,916,858	11,071,014	**Boeing 777-200**
33X	3,870,203	33,996,285	37,866,488	**Airbus A330-Freighter**
74Y	129,034	9,287,133	9,416,167	**Boeing 747 Freighter**
AT7	33,320,393	5,802,933	39,123,326	**ATR 72**
DHT	2,651,969		2,651,969	**Dehaviland Twin Otter**
GRAND TOTAL	**198,322,374**	**879,142,644**	**1,077,465,018**	