Sustainable development – the key for green aviation

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Abstract: *The aviation industry has always been seeking the technological progress that will optimise the economic, operational and environmental way of flying. In the first part of this study the author describes the impact of the CO2 emissions on the climate change. Also, the author emphasises the fact that once again the aviation environment is asking for new breakthroughs to face the challenge of the aviation's sustainable growth. Airbus and its approach with the least possible impact on environment are introduced in the last part of this paper. Additionally, the environmental way of greener aviation is illustrated by examples of fuel consumption and CO2 emissions measurements made for several selected airlines.*

Key words: *sustainable development, climate change, fuel efficiency, green aviation, CO2 emissions.*

1. INTRODUCTION

Although the aviation is a relatively small industry, it has a disproportionately large impact on the climate system. The environmental impact of aviation occurs because aircraft engines emit noise, and particulates gases which contribute to climate change and global dimming. And despite emission reductions from automobiles and more fuel-efficient turbofan or turboprop engines we still can see a rapid increase in total pollution attributable to aviation. Fortunately, EUROCONTROL puts its environmental expertise at the service of its Member States, the European Commission and the aviation community to help measure, monitor and mitigate the impact aviation on the environment.

Moreover, the aviation brings enormous benefits to communities and economies around the global environment. It also ensures economic growth, social and touristic connectivity and access to markets, indeed. Air transport plays important role at job market due to supporting about 56 million jobs and over $2.2 trillion of global GDP with a strong track record of fuel efficiency and CO2 emissions savings. And that's why it is a strategic contributor to a sustainable development.

2. CO2 EMISSIONS AND ITS IMPACT ON THE ENVIRONMENT

Throughout the history of aviation, the challenge of reducing the aircraft fuel consumption has been a main drive for research and technical development, bringing with it greater fuel efficiency for airlines and better environmental performance.

The aviation industry has developed many operational measures to minimize the fuel usage. Notably, the aircraft engine emissions are directly related to the fuel burn. Each

kilogram of fuel saved reduces carbon dioxide (CO2) emissions by 3.16 kg. So the key for airlines to minimize their environmental impact is to use fuel more efficiently.

Moreover, fuel-efficient technology opportunities for future aircraft, including improved engine efficiency or aerodynamics deliver the highest improvement benefits and results for CO2 reductions. New-generation aircraft planned for the next decade are expected to reduce burn and carbon emissions by 25-40% compared to the aircraft they will replace.

Environmental impact of aviation on climate change

Most forms of aviation release carbon dioxide (CO2) and other greenhouse gases into the Earth's atmosphere, contributing to the acceleration of global warming. In addition to the CO2 released by most aircraft in flight through the burning of fuels such as Jet-A or Avgas, the aviation industry also contributes to the greenhouse gas emissions from ground airport vehicles and those used by passengers and staff to access airports. [1]

Subsonic aircraft-in-flight contribute to climate change in 4 ways (as can be seen in **Figure 1**). Furthermore, it is necessary to admit that emissions of passenger aircraft per passenger kilometre vary extensively, according to variables such as the size of aircraft, the number of passengers on board, and the altitude and distance of the journey as the practical effect of emissions at high altitudes may be greater than at low attitudes.

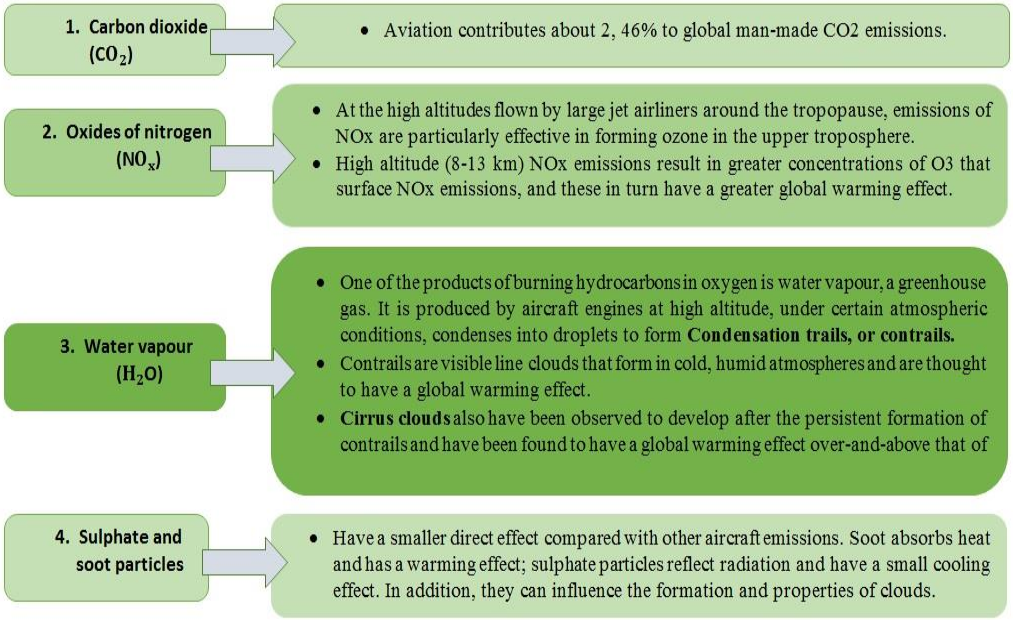

Fig. 1 Breakdown of emissions and its impact on environment [2]

The Aviation contributes about 2, 46% to the global man-made CO_2 emissions (**Figure 2**). But over the past few decades, the volume of air transport has been continuously growing with an average rate of 5% p.a. and is predicted to grow with a similar rate in the foreseeable future (**Figure 3**).

By 2050 the aviation's contribution to the global anthropogenic carbon emissions could grow to 3% and it will represent 5% of total greenhouse gas emissions. Although these figures are still relatively low, a growing carbon footprint is not acceptable for any industry. Effective emissions reduction measures are therefore needed to compensate for the effect of traffic growth.

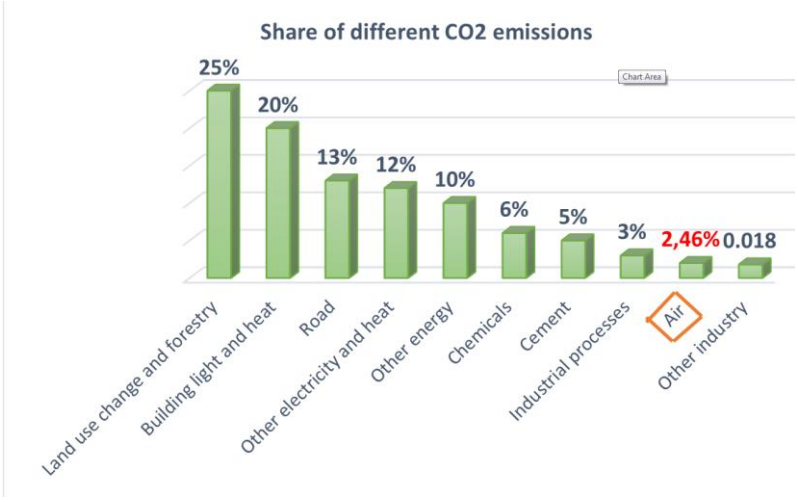

Fig. 2 Breakdown of different emissions [compiled by author]

Next **Figure 3** shows prediction of increasing amount of emissions from the global fuel burn of commercial airlines) due to rapid growth of air traffic. The continuous improvement of air transport's environmental performance, and its impact on climate change, is one of the big challenges for today's aviation industry and research. Hence, we can see support many organisations such as EUROCONTROL and its model called *The Advanced Emission Model (AEM).* This model can estimate both the mass of fuel burnt by the main engines of a specified type of aircraft with a specified type of engine flying a specified 4D trajectory as well as the corresponding masses of certain gaseous and particulate emissions that are produced by the burning of that fuel. The input to AEM is a set of flight profiles, which contains the types of aircraft and engine as well as 4D trajectory descriptions. Another important data are references for fuel burn calculation and they depend on altitude above or below 3000ft. As the **Figure 4** shows, in the case that aircraft is below 3000ft, the calculation is based on the ICAO LTO – *Landing and Take-off* cycle that covers 4 modes of engine operation (idle, approach, climb out and take off), each associated with a specific engine thrust setting and a time in mode. When the aircraft is above 3000ft, the fuel burnt calculation is based on the data stored in database which contains altitude and attitude, for the instance climb, cruise or descent, dependent performance and rate of fuel burn data for different types of aircraft.

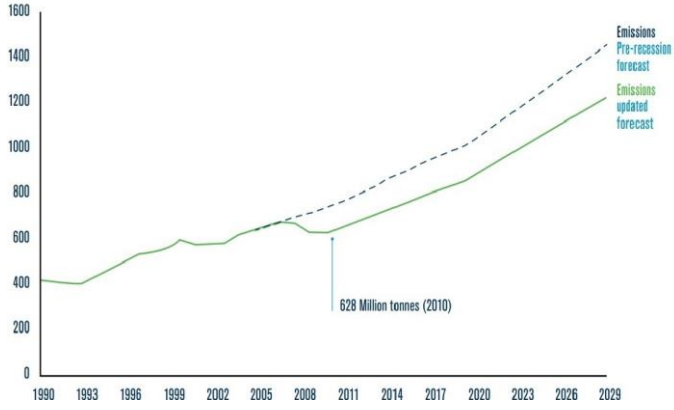

Fig. 3 Overview of past and future prediction of emissions by commercial airlines [IATA website]

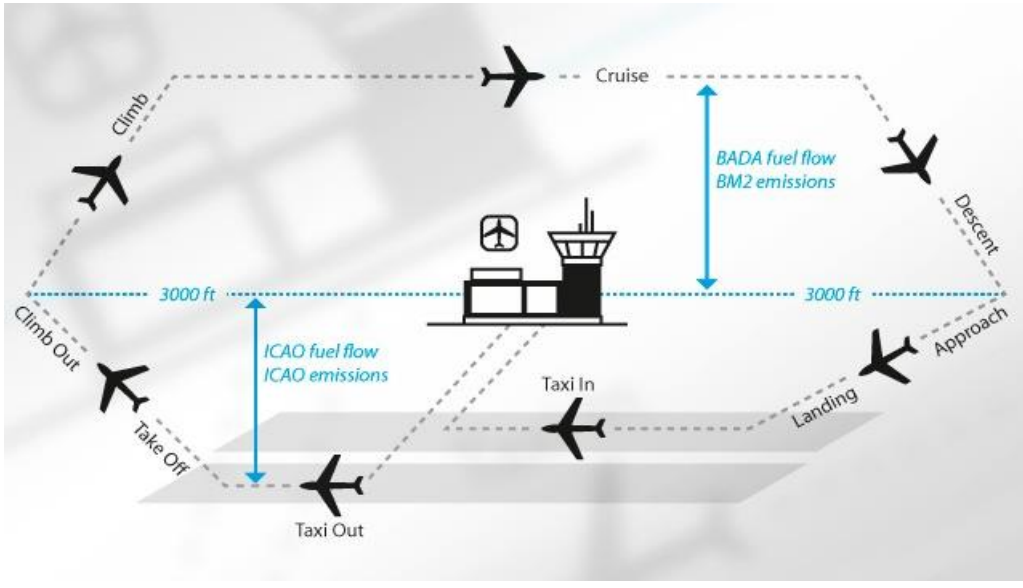

Fig. 4 Concept of emission model [3]

In addition, improved operational practices could help to achieve further reductions in CO2 emissions. Also, full implementation of more efficient air traffic management and for alternative fuels has been identified as excellent candidates for helping achieve this goal.

For instance, the next **Figure 5** shows predictions for further improvement and expected results in cooperation with new technology improvement and bio fuels usage.

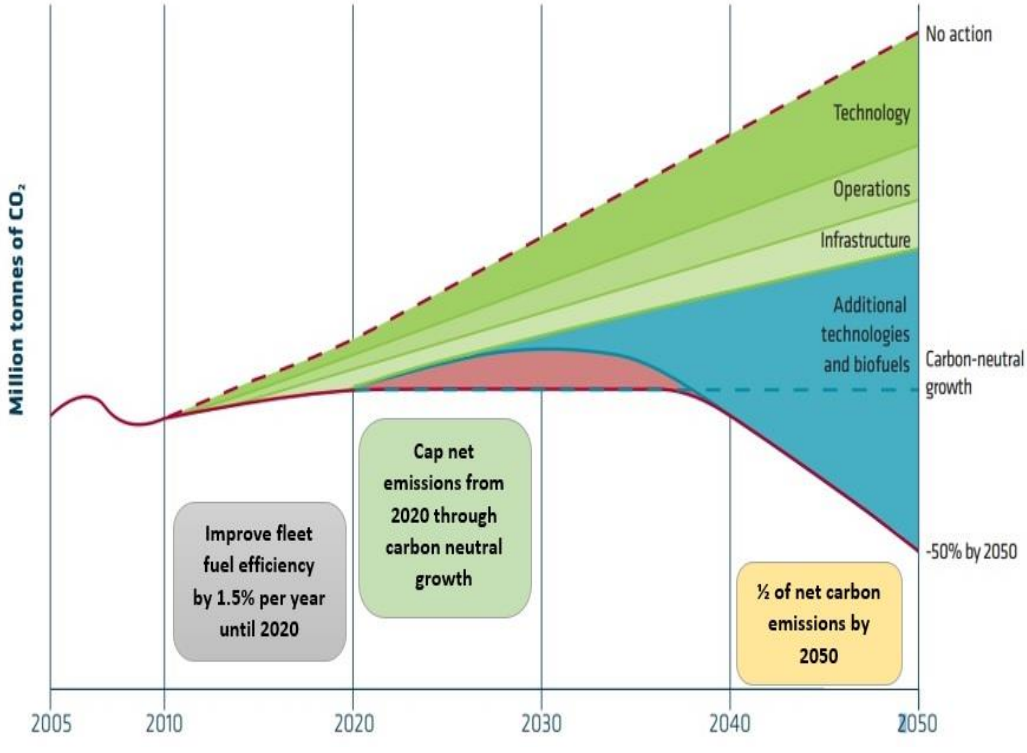

Fig. 5 Diagram of future prediction due to improve technologies [4]

As can be seen in **Figure 5**, the key CO2 abatement opportunities for the aviation sector are the implementation of new technologies, and on-going improvements in operational efficiency and ATM systems and processes. It is necessary to realize, while the aviation sector continues to explore and exploit the full range of those abatement opportunities, on the other hand it is also important to consider the interrelationships between the various mitigation measures. In brief, all measures should be technologically feasible, economically reasonable and mainly environmentally beneficial.

No doubt, emissions trading could be more cost-effective solution as part of a global package of measures including technology improvements. Another important fact is that as civil aviation continues to grow at around 5% each year, such improvements are unlikely to keep carbon emissions from global air travel from increasing. A new way to reduce emissions is presented by the introduction of biofuels that meet the demanding specifications of the aviation industry to achieve this goal.

Alternative fuels for aviation are not a new concept due to late 1970s and the early 1980s, where 'synthetic' aviation fuels were developed from a number of sources (shale oil, tar sands and coal liquids). But from the other point of view, the oil glut in the late 1980s let to abandon the programs, as production of these fuels was not cost effective.

Also, sustainable aviation fuel research is a core tenet of many aircraft manufacturers such as Airbus or Boeing, to reduce the environmental impact of air transport and also lowering its overall CO2 footprint. For instant, one of interesting Airbus prediction comes from thinking that mixing with an adequate supply of sources such as *jatropha* is possible to achieve 1/3 of aviation fuel from alternative sources by 2030.

NOTE: JATROPHA BIO FUEL (Bio-Derived Synthetic Kerosene) – is bio-fuel for aviation and its quality is even better than Jet-A kerosene and can 50/50% be blended with Jet-A kerosene. In this case Airbus is leading this supply effort through an ambitious global program connecting farmers, refiners and the airlines to form regional sustainable aviation fuel value chains. Due to this support, researchers in Brazil are working on a sustainable aviation fuel created from the jatropha plant – with 4000 hectares being grown for production. Also, Airbus teamed with Virgin Australia Airlines to support the cultivating of eucalyptus in Australia, and it is supporting the development of 2,000 hectares of camelina for aviation fuel in Spain.

On the other hand, the industry is exploring alternatives to conventional jet fuel that will be sustainable and will have a smaller carbon footprint. *Bio jet fuels* are one of the most significant solutions to meet the industry's ambitious carbon emissions reduction goals. Also, IATA is working with ASTM International and other certification institutions on new alternative fuel standards, such as ASTM D7566. And since 2011 bio jet fuel blends of up to 50% are certified for commercial passenger flights. Many countries had set targets to achieve more efficient fuels (Aireg in Germany set a target of 10% of alternative aviation fuel for 2025). Another example is Indonesia that has introduced a bio jet fuel mandate of 2% commencing in 2016, rising to 5% by 2025. [5] [6] [7]

THE AUTHOR'S SUMMARY

In my opinion, the key answer for better and greener aviation is based on need for harmonized technology developments in operational processes and it is also necessary for calling of efficiency improvements. Also, interesting point of view comes from manufacturing side of the aviation industry during the full product lifecycle. And in this case we should emphasize the need to look at the entire lifecycle of aircrafts, from efficient manufacturing processes to completed production of more efficient aircrafts. Therefore, the

green aviation focuses on improvement of the sustainability of day-to-day operations throughout the product lifespan and it is right step due to expected half amount of emissions CO2 by 2050.

3. ACQUAINTANCE WITH WORLDWIDE ECO-EFFICIENT SOLUTIONS

Technological progress, infrastructure improvements and also operational measures require efforts from all the parties involved in the aviation value chain to be sustainably successful. It is inevitable to ensure cooperation with airlines, airports, ATM authorities, aircraft and engine manufactures, fuel suppliers and governments. This effort will continue to be key factor in developing an environmentally – efficient and ultimately sustainable aviation industry with links to better and greener way to fly.

For illustrating, innovation is the driving force of Airbus, and more than ever is providing the solutions for aviation's sustainable future with the least possible impact on the environment. Investment in new, modern aircraft is the best way to be eco-efficient and Airbus with its A380, A350XWB and A320neo Family recognises that it is right step ahead. The next **Figure 6** shows selected advantages on environment due to eco-efficient technologies in aircraft designs.

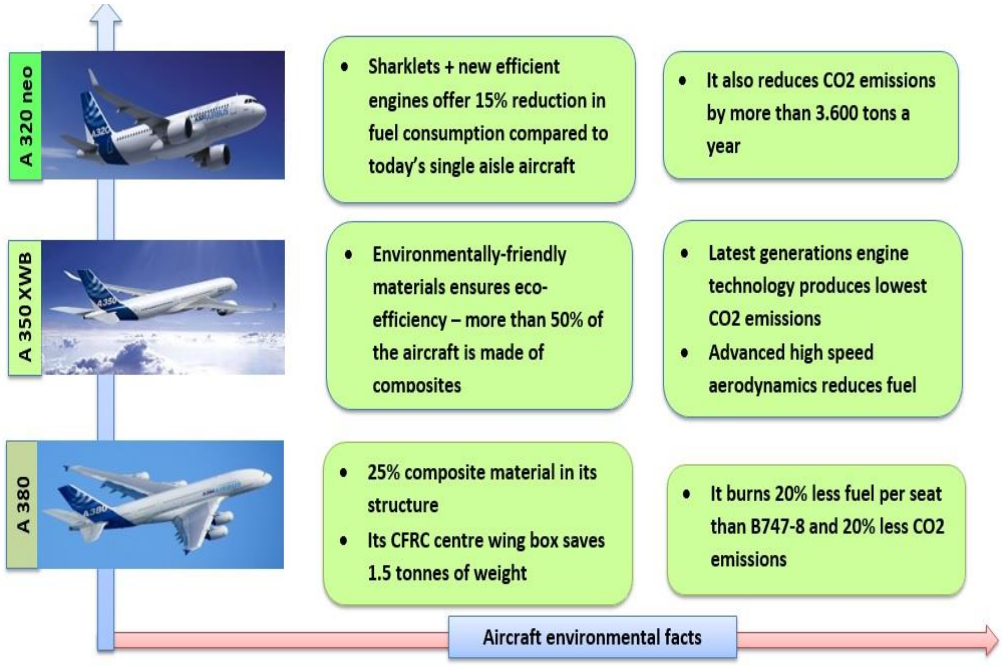

Fig. 6 Diagram of eco-efficient aircrafts of Airbus Family [compiled by author]

According to **Figure 6** which is illustrated above, we can see that Airbus has pioneered the use of composites and other advanced materials in aircraft design and manufacturing environmentally-friendly jetliners. Furthermore, composites are corrosion-free and the weight reductions from composites also result in lower fuel consumption during and aircraft's operational lifetime. Each new generation of aircraft is more fuel efficient, quieter and cleaner. Airbus works in cooperation with all of its engine manufacturers to ensure the most efficient technologies and optimised propulsion systems and offering measurable reductions in the engine emissions contributing to climate change.

On the other hand, we have to realize that each step of the manufacturing process, operations and end-of-life of each aircraft should be part of the responsible approach to the environment.

Research of fuel consumption and CO2 emissions in Emirates

Over the past 50 years, the aviation industry has cut fuel consumption and CO2 emissions by more than 70% and NOx emissions by 90%. Aircraft manufacturers and airlines have already developed products to reach these targets such as sustainable aviation fuels are also an option which is reducing CO2 emissions.

This can be seen in the largest airline based in the Middle East – EMIRATES which makes a step ahead through the development, selection and operation of their aircraft. They have the most fuel efficient aircraft and in this case, their emissions are 30% lower than the European global fleet average.

The Airbus A380 is one of the most environmentally advanced aircraft and plays a key role in greener aviation. With its efficiency as low as 3.1 litres per 100 passenger kilometres, ultra quiet engines and a host of light-weight component which is important factor to reduce emissions and maximize eco-efficiency. [8]

The *Engine Alliance* is a 50-50 joint venture of General Electric Co. and Pratt & Whitney of United Technologies Corp. With the continued investment of member companies, only the GP7200 engine has demonstrated 3 separate improvements in fuel burn since entry into service. Significant operational milestone has achieved with 2 million revenue flight hours after 5 years of service (August 2008).

In accordance to A380 technical characteristics in cooperation with advanced GA engines, we can observe many operational advantages and environmental results, as can be seen in **Figure 7.**

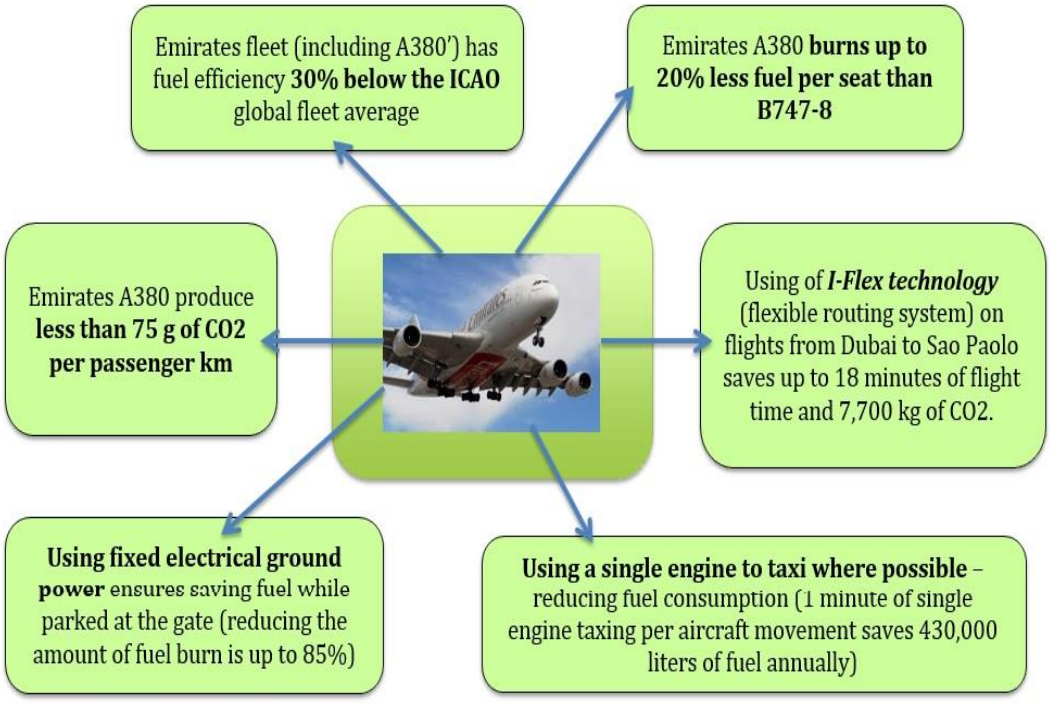

Fig. 7 Diagram of environmental processes in Emirates Group [compiled by author]

Carbon dioxide emissions are directly related to jet fuel consumption, with each kilogram of fuel consumed creating more than three kilograms of carbon dioxide. Furthermore, it is clear that fuel efficiency has a significant impact on environment. Airlines fuel efficiency is affected by a number of factors, including technology such as aircraft and engine type and so on. The next **Figure 8** shows different rate of fuel consumption in different time periods due to implementation of more efficient aircrafts and technologies.

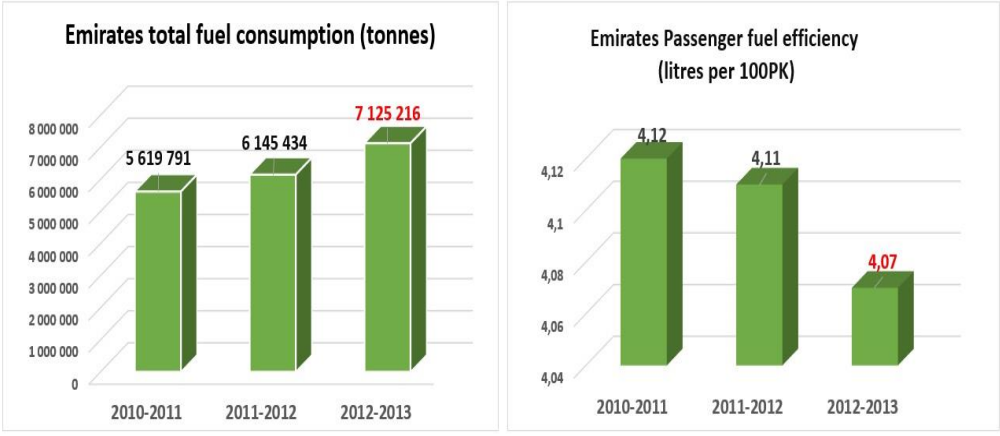

Fig. 8 Diagram of comparison fuel efficiency in Emirates Group [compiled by author]

As can be seen in **Figure 8** above, Emirates in 2010-2011 time periods consumed 5 619 791 tonnes of Jet A1 (including Cargo operations). Fuel efficiency was 4.12 litres per 100 PK. This amount was 25% better than results of other airlines (Cathay Pacific – 4.84 litres per 100 PK, Lufthansa Group – 4.20 litres per 100 PK). But on the other hand we can see improvement due to 2012-2013 time periods that shows 4.07l/100PK, what means an improvement of 1% compared against the previous period 2011-12 due to the introduction of new, more fuel efficient aircraft to help reducing fuel consumption and fuel burn.

Also Emirates' total fuel efficiency for 2012-13 is 15.7% lower than IATA's 2012 industry average of 0.368l/100PK and ahead of other airlines. (**Figure 9)**. [9] [10]

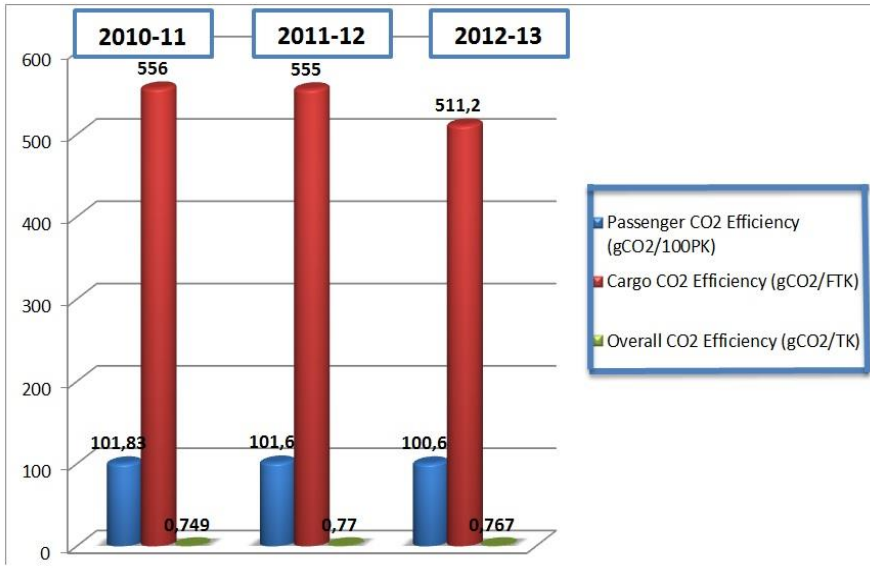

Fig. 9 Diagram of Emirates CO2 efficiency [compiled by author]

However, it is clear that there are no limits to improve environmental performance. It is necessary to develop environmentally-responsible work practices and mainly eco-efficient operations. Also, Emirates will continue to work towards introducing new practices, technologies and materials to lessen their operation's impact on the environment. In my opinion, we are committed to operate all assets in the most environmentally-responsible manner, and in compliance with all applicable environmental regulations and standards.

Research of fuel consumption and CO2 emissions in Lufthansa

Green aviation is one of many priorities that airlines focus on their activities. Lufthansa is fully aware of its responsibility for the climate and better cleaner skies. The company reduce specific CO2 emissions; also they implement environmental management systems and expand different measures further to keep emissions down.

Moreover, Lufthansa has provided 42.6% of its additional transport services in a carbon-neutral manner – an increase in efficiency that no other mode of transport can claim. Also, Lufthansa makes goals to reduce its specific CO2 emissions by 25% by 2020. Also, the reason for the recent reductions of specific kerosene consumption and emissions levers is the continuous and intensive efforts to improve fuel efficiency across the company.

In 2010 the lowest level of fuel consumption was 4.2 litres per 100 passenger kilometres, and in 2011 it sank even further – by 0.4% to 4.18 litres per 100 passenger kilometres (**Figure 10).** The next picture (**Figure 11**) shows CO2 emissions from passenger transport in all part of Lufthansa Group.

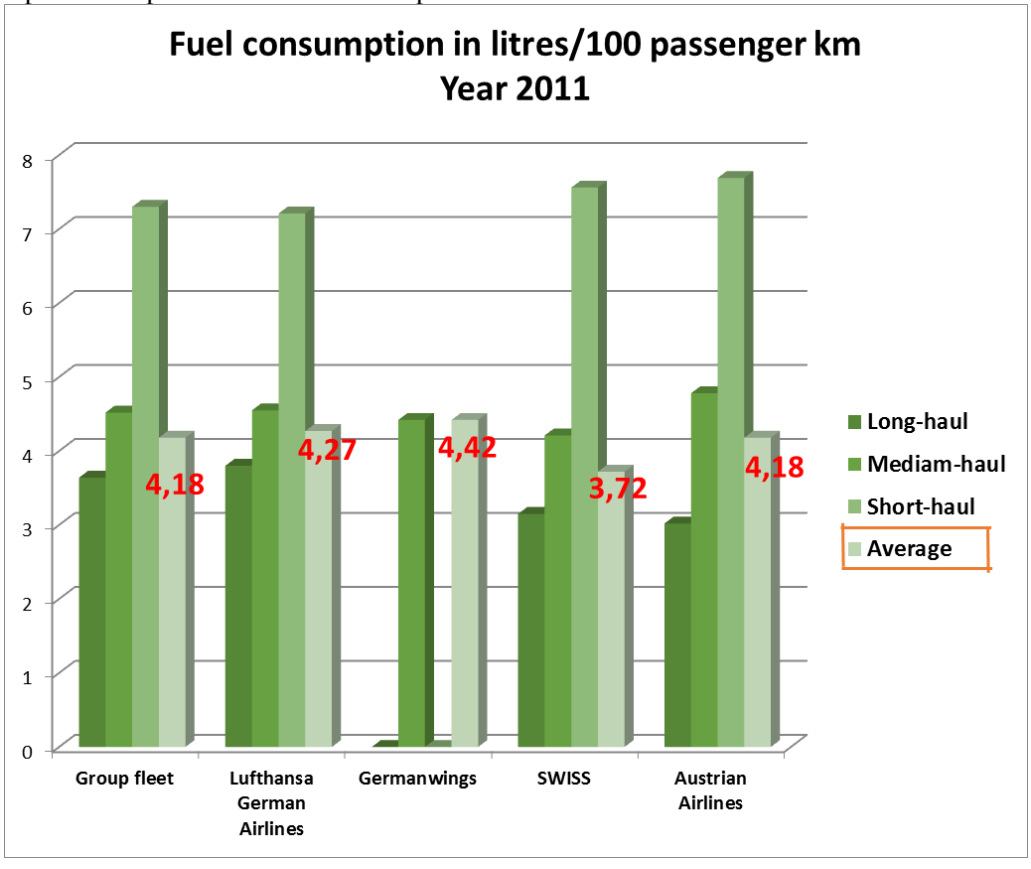

Fig. 10 Diagram of Lufthansa fuel consumption – year 2011[compiled by author]

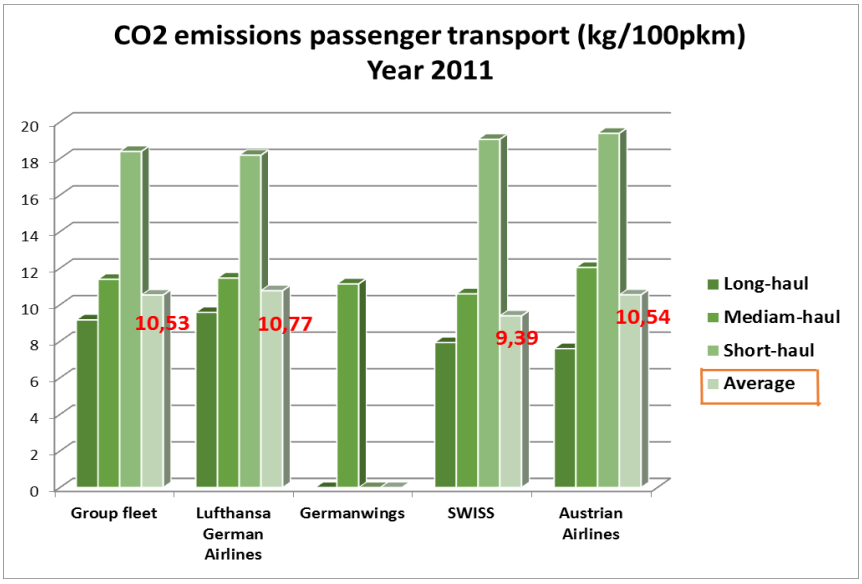

Fig. 11 Diagram of Lufthansa CO2 emissions – year 2011 [compiled by author]

Additionally, as can be seen in previous diagrams above, fuel efficiency is one of the central objectives for cutting costs and protecting the environment. The aviation industry has taken on a big job in terms of climate protection and its plans to improve fuel efficiency assume average fuel efficiency by 1.5% per year up to 2020. From the other point of view, aviation's net CO2 emissions should be reduced by half by 2050. [11]

Besides, Lufthansa flies more and more fuel efficiently, for instance in 2012 fuel consumption fell to only 4.06 litres per 100 passenger kilometres and so it reached a record company according to amount for 4.18 litres per 100 passenger from previous year 2011. The next pictures (Figure 11 and Figure 12) show closer look at Lufthansa Group and its fuel consumption / CO2 emissions during 2012 time period.

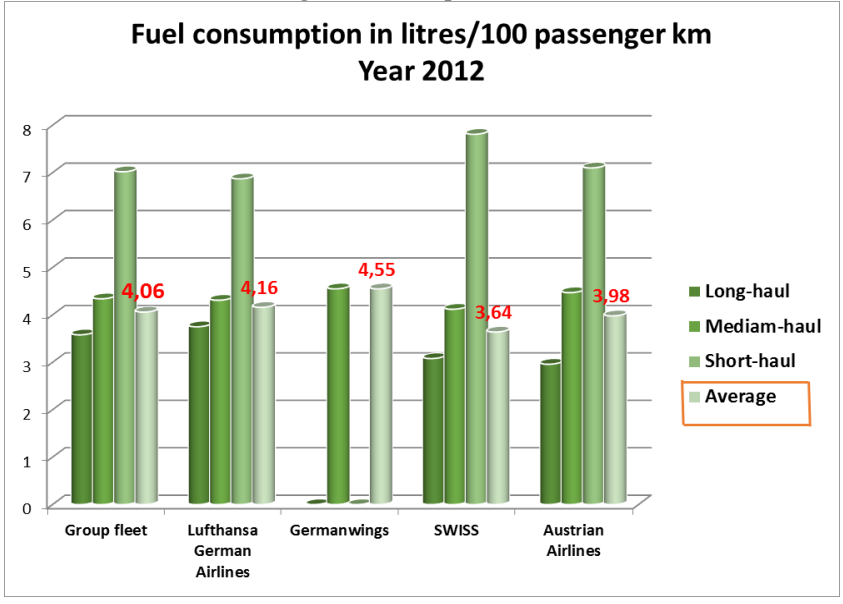

Fig. 12 Diagram of Lufthansa fuel consumption – year 2012 [compiled by author]

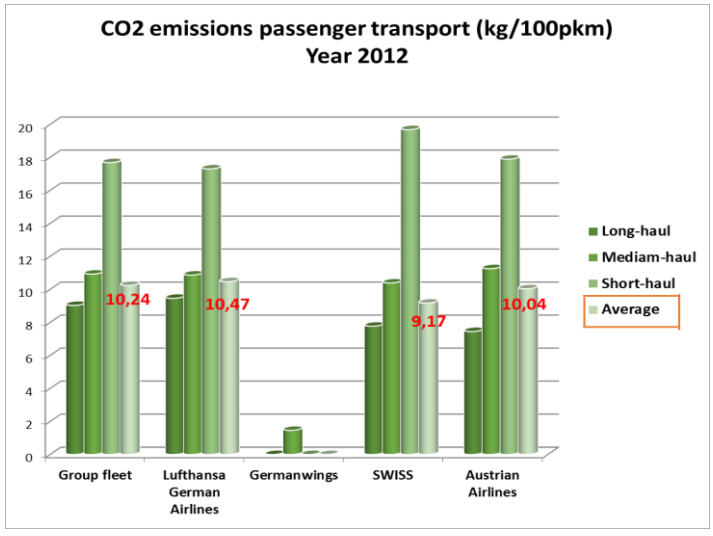

Fig. 13 Diagram of Lufthansa CO2 emissions – year 2012 [compiled by author]

As a matter of fact, fuel is the largest cost item in airlines operating costs and unfortunately it has been on the rise for years. That's why the aviation companies work flat out to use kerosene as efficiently as possible. Because interesting thing is that due to statistics cutting fuel consumption by just 1% can improve the annual result by about 74 million euros and this is valuable amount.

RESEARCH RESULTS OF COMPARED AIRLINES

Emirates and Lufthansa are airlines that have a significant position on the market. The author chooses those airlines to show the same environmental aim for both of them, but mainly to emphasise difference in results which are presented in **Figure 14** (time period 2011-12) below.

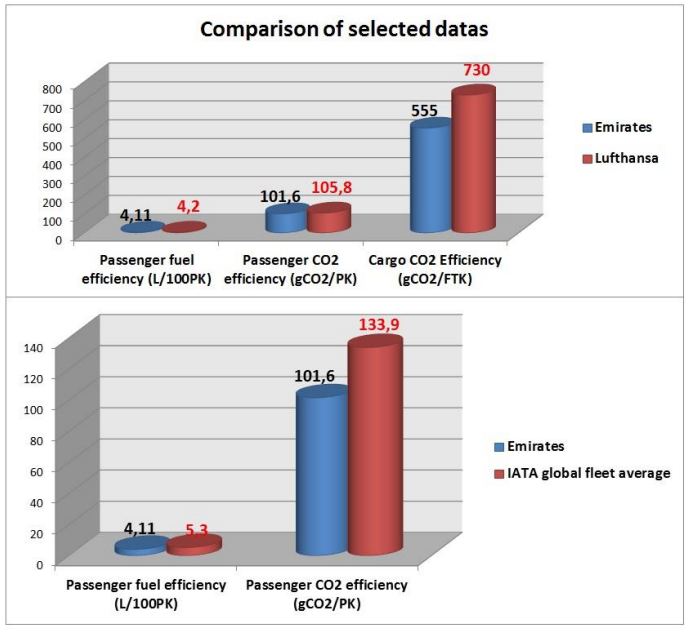

Fig. 14 Diagram of comparison Lufthansa and Emirates emissions [compiled by author]

We can not to forget that airlines fuel efficiency is affected by a number of factors, including technology (aircraft and engine type) or operational processes. Both of the selected airlines have efficient aircraft fleet with the aim of achieving fuel and emissions levels as low as possible.

As can be seen in previous diagrams, the amount of passenger fuel efficiency and passenger CO2 efficiency was changing in different time period due to effective operational processes and selected aircraft types.

Passenger fuel efficiency (litres per 100 PK)

As mentioned in **Figure 8** we can assume the following: *Emirates* and its *passenger fuel efficiency* achieved amount of 4.07l per 100 PK in 2012/2013 time period and in this case it is a big success towards environmental way of flying. If we take a look back to the time period 2010/2011, as a matter of fact, this amount was bigger – 4.12 l per 100 PK. Although this slight increasing is still less than amount of its European competitor – Lufthansa – its fuel efficiency presented 4.20 l per 100 PK.

Among the *Lufthansa Group* companies (as could be seen in **Figure 10**), SWISS and Austrian Airlines were able to decrease their kerosene consumption slightly to 3.72 litres and 4.18 litres per 100 PK. Otherwise, Lufthansa Group including all companies presented 4.18 litres per 100 PK in 2011 and we can see significant decreasing just *4.06 litres per 100 PK* in 2012. (NOTE: this amount is lowest during monitored time periods).

According to the **Figure 13** that can be seen above, the situation significantly changed due to period 2011/2012, where Lufthansa's fuel efficiency presented just 4.2 l / per 100 PK, whereas Emirates' fuel efficiency was much bigger – 4.11 l / per 100 PK. Otherwise, Emirates' amount of 4.11 l / 100 PK was markedly lowest in comparison with IATA global fleet average that was 5.3 litres / per 100 PK.

Passenger CO2 efficiency (gCO2/PK)

Emirates' passenger carbon dioxide efficiency for 2010/2011 was 101.83 grams of carbon dioxide per passenger-kilometre flown (gCO2 / per PK). Unlike this amount we can see 25% better than IATA's 2010 industry average, which was 136.5 gCO2 / per PK.

Moreover, results of 2011/2012 time period due to mentioned **Figure 14**, was slightly different; Lufthansa's CO2 efficiency was slightly worse – 105.8 gCO2 / per PK than Emirates'– it decreased to amount of 101.6 gCO2 per PK in comparison with time periods 2010/ 2011. Also, we can see a significant decreasing of CO2 efficiency in Emirates' case in comparison with IATA's industry average, which was 133.9 gCO2 / per PK.

THE AUTHOR'S SUMMARY

The way airlines operate their aircraft plays a critical role in managing and minimising the fuel consumption and emissions of their aircraft fleet. However, in the air or on the ground, it is still necessary to act sustainably in the interests of green aviation due to many disruptions to air from natural calamities or economic crisis.

In my opinion, we have to recognise that although aviation industry is only responsible for approximately 2, 46% of global greenhouse gas emissions from human activity; it must be committed to growing sustainably and reducing the growth of aviation's emissions. For instance, Emirates improved their operational flying technique to reduce carbon emissions by new modern aircrafts which are 30-40% more efficient than those of 15 years ago. Just Airbus A380 burns up to 20% less fuel per seat than Boeing 747/8. Also other measures in Emirates Group consists of using a single engine to taxi where possible and later studies

have shown that fixed electrical ground power can reduce the amount of fuel burn used on ground power by up to 85%. In other words, focusing on operational improvements can reduce the impact of aviation on the environment and this should be priority for all participants in aviation industry.

4. RESULTANT CONCLUSIONS

The aviation industry recognises the growing and urgent need for saving the environment and decreasing the fuel burning. It is clear that technology plays a vital role in promoting sustainable development and it is the best way for reducing aviation emissions. Especially, we can see the improvement in new aircraft designs and radical engine advances present major effective facilities for CO2 reductions.

For instance, Lufthansa's 59 new aircraft will consume on average only 2.9 litres of kerosene per passenger and 100 kilometres flown. This investment in the latest technology emphasises the positive effect on the carbon footprint.

In addition, one of the most exciting prospective technological developments is the development of jet fuels produced from sustainably sourced biological material – namely plant material.

Fuels produced from such biological feedstock have potentially up to 80% less carbon dioxide emissions (in their overall lifecycle) than traditional fossil-fuel derived kerosene. So it is important to ensure connectivity between new, more efficient technologies and green environmental ways of flying.

Innovation is essential to meet the environmental challenges that society is facing. For instance, the success of leading aircraft's manufacturers is built on innovation and through its own research and development and partnership with all participants across the industry. Also, important fact is that those aircraft manufacturers are ready to meet the opportunities and challenges of today demand and offer the solutions for tomorrow.

It is clear that the harmony of ecological and economic goals is especially pronounced in the area of fuel efficiency. In this case, the topic of efficiency is at the top of environmental agenda. Also, it is necessary to emphasise that operational efficiency is one of the most important pillar of any active environmental management.

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