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Aviation Industry - Mitigating Climate Change Impacts through Technology and Policy

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Abstract

About 15,000 aircraft service nearly 10,000 airports and operate over routes approximately 15 million km in total length. More the 2.2 billion passengers flew on the world's airlines for vacation and business travel, and well in excess of a third of the value of the worlds manufactured exports were transported by air. Further, aviation industry generates 32 million jobs worldwide and contributes nearly 8% to world gross domestic product. It goes without saying that air transportation has a big economic footprint. However, the aviation industry is not immune to the impact it has on climate change. As the aviation skies continue to crowd so does the impact of CO2 emissions.

This paper reviews the challenges facing the aviation industry and what is it doing about reducing its environmental footprint. The paper concludes that aviation industry needs to look past their traditional business model and move to a model that allows them to operate in a new global business environment which puts emphasis on environmental alignment of business goals. In the interim, the aviation industry continues to explore the issues related to alternative fuels, more efficient engine technology, better traffic management and policy mechanisms (such as emissions trading and carbon offsets) with some degree of success. The paper strongly recommends the involvement of governments in establishing ground rules to help global aviation industry to mitigate climate change risks.

Keywords: aviation industry; environmental footprint; alternative fuels; policy mechanisms; emissions trading.

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Aviation History - Convenience to Climate Change

The first demonstrated flight to take place was on June 4, 1783, when the Mongolfier brothers took off in a hot air balloon in Annonay France. In the 1800's, Sir George Cayley became the first person to successfully create a human carrying glider. He was also responsible and credited with being the first person to explain the aerodynamic forces of flight weight, lift, drag and thrust and their relationship.

Fast forward to the 1900's. On December 17, 1903 the first sustained and controlled "heavier then air" powered flight took place with the Wright brothers. In 1907 development work began on the Gnome rotary aero engine and in 1908 the first Gnome rotary aero engine is produced. August 1909, the United States government bought its first airplane (Wright Model A) for $30,000. In 1912 the first all metal aeroplane was flown by a French man and in 1913 the first flight to reach an altitude of 20,000 feet was flown.

In July of 1940 the first airliner with a pressurized cabin, the Boeing 307 Stratoliner, entered service with Transcontinental Airways on the New York to Burbank in California route.

After World War II (around 1947) jet propulsion, aerodynamics, radar technology catapulted the aviation industry, which made aircraft larger, faster and featured pressurized cabins.

Growth and Impact of Aviation

The aviation industry has come a long way since 1783; today more commercial flights occupy the skies than ever. GLOBE-Net (2007) reports that "Air travel is also on the rise, with GHG emissions from international air travel jumping by almost 70% between 1990 and 2002. In China, air travel is growing by around 12% per year, and worldwide passenger air travel is increasing by 5% annually, a faster rate of growth than any other travel mode. Air freight has also been growing rapidly, though it remains a small share of total air traffic."

The commercial sector of the airline industry is very competitive. About 15,000 aircraft service nearly 10,000 airports and operate over routes approximately 15 million km in total length. More the 2.2 billion passengers flew on the world's airlines for vacation and business travel, and well in excess of a third of the value of the worlds manufactured exports were transported by air (Penner *et.al.,* 2001). Further, aviation industry generates 32 million jobs worldwide and contributes nearly 8% to world gross domestic product (IATA, 2008). It goes without saying that air transportation has a big economic footprint.

However, the aviation industry is not immune to the impact it has on climate change. As the aviation skies continue to crowd so does the impact of CO2 emissions. The aviation industry is responsible but for a small but growing proportion of GHG emissions. Aircraft are responsible for around three percent of global carbon dioxide emissions. But emissions of nitrous oxides (NOx) and the formation of condensation trails (contrails) from water vapour at near stratospheric levels where commercial jets fly mean the actual impact on global warming is much higher - possibly as much as ten percent (GLOBE-Net, 2007).

Air Travel is the world's fastest growing source of greenhouse gases like carbon dioxide, which cause climate change. Globally the world's commercial jet aircraft fleet generates more than 700 million tons of carbon dioxide (CO2), the world's major greenhouse gases, per year. One person flying a return trip between Europe and New York generates between 1.5 and 2 tons of CO2. This is approximately the amount a European generates at home for heating and electricity in one year (GreenSkies, n.d). Crowded skies translate to more flights which equates to more consumption and waste. Consuming more in the aviation industry equates to more greenhouse gas emissions which negatively adds to global warming.

North America and Europe are at greatest risk as 70 to 80 % of all global flights operate within these two regions (GreenSkies, n.d.; pg.2; Kirby, 2008; pg. 32). Aviation is responsible for 2% of global CO2 emissions and by 2050 is predicated to represent 3% (IATA, 2008). Further, as more people in countries like China are able to afford airline tickets, worldwide air tourism travel is bound to increase. Most experts believe that

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air travel could double within fifteen years if current trends persist. By 2050, the Intergovernmental Panel on Climate Change (IPCC) believes that aircraft could account for up to 15% of the global warming impact from all human activities (GLOBE-Net, 2007).

Just like consumption of more goods demands a lot of energy, getting from one place to another does too. Transportation as an industry consumes about 20% of the global energy supply, 80% of which comes from fossil fuels. He states that 80% of transport-related greenhouse gas emissions come from road transport. Seven percent is related to sea transport and 0.5% is attributed to rail. Air transportation is the second largest with a 13% share of transport-related greenhouse gas emissions (Kirby, 2008; pg. 35-36).

Aviation plays a vital role in society as demonstrated above; it generates jobs and supports commercial and private travel. However one of the negative impacts of travel is its environmental impact associated with local noise and air pollution. A number of aircraft emissions can affect climate, carbon dioxide (CO_2), Nitrogen oxides (NO_x), and water (H_2O) do so directly.

Even though vehicles and aircraft are becoming more efficient, but the fact remains that people are driving and flying more than ever. This increases the miles traveled and transport-related emissions.

In short, airline carbon footprint is growing at a rapid pace and it must be addressed.

The intent of this paper is to review the challenges facing the aviation industry and what is it doing about reducing its environmental footprint. The paper, however, does not discuss the environmental management systems such as ISO 14000 being adopted by aircraft manufacturers such as Boeing and Airbus to make their production systems environment friendly.

Environmental impact of Flight

The main environmental concerns associated with aircraft are climate change, stratospheric ozone reduction (leading to increased surface UV radiation, regional pollution, and local pollution. During flight, aircraft engines emit carbon dioxide, oxides of nitrogen oxides of sulphur, water vapour, hydrocarbons and particles - the particles consist mainly of sulphate from sulphur oxides, and soot. These emissions alter the chemical composition of the atmosphere in a variety of ways, both directly and indirectly (RCEP, 2002).

While much of the CO_2 is absorbed on Earth in plants and the ocean surface, a huge amount goes into the atmosphere, where it and other gases create a kind of lid around the globe --the so-called greenhouse effect. Heat that would normally escape into space is thus reflected back to Earth, raising global temperatures (Lehrer, 2001). Nitrogen oxides (NO_x) and H_2O vapor from aircraft increase the formation of cirrus clouds and create contrails, which are visible from the ground.

The combination of “contrails and cirrus clouds warm the Earth's surface magnifying the global warming effect of aviation. Together, NO_x and water vapour account for nearly two-thirds of aviation’s impact on the atmosphere (IPCC estimated that radiative forcing from all aircraft greenhouse gas emissions is a factor of 2 to 4 times higher than that from its CO_2 emissions alone). Hence any strategy to reduce aircraft emissions will need to consider other gases and not just CO_2” (GreenSkies, n.d.; pg.1).

The environmental issues associated with flight are also correlated with the altitude at which the carbon dioxide is emitted, the higher the attitude the greater damage to the ozone layer. Research has shown that the majority of flights fly at an altitude between 29,500 ft and 39,400 ft (9-12 km). **Figure 1** (Federal Aviation Administration, 2005; pg. 32) highlights the distribution to total fuel burn and emissions by 1 km altitudes for the year 2000.

The lower spike in fuel burn and emissions in the 0-1 km range is attributed to aircraft emissions from the ground when aircraft are idling or taxiing. It was noticed after the events of 9/11 (when there was a temporary halt to all commercial flights) that the Earth’s temperature was 1 to 2 degrees Celsius colder, which coincides with the theory that aircraft emissions do impact the environment.

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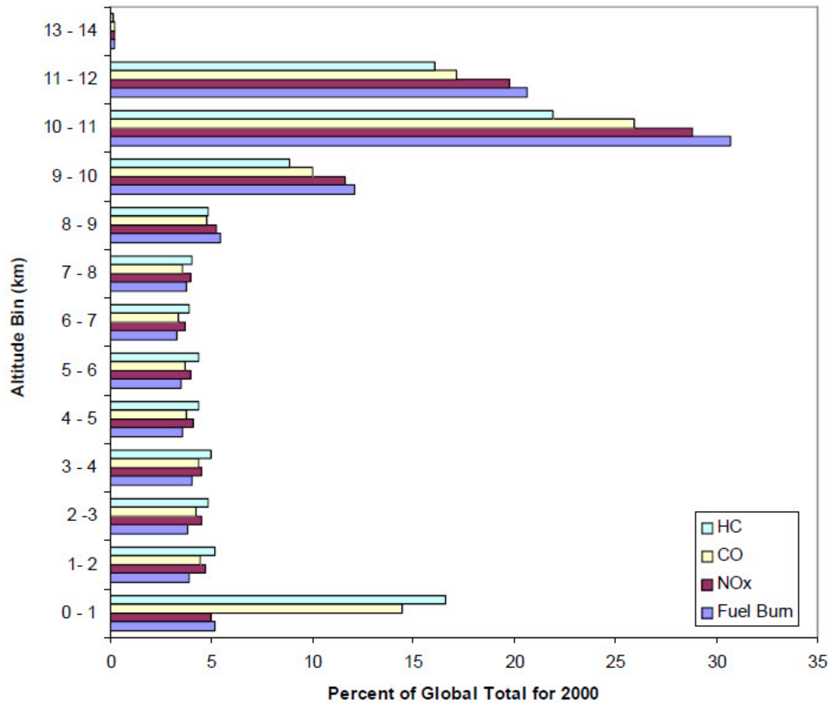

Figure 1. Altitude distribution of fuel burn and emissions

Approaches to Mitigating Environmental Impacts

The aviation sector these days is buzzing with talks about aviation emissions. There is a call for aviation emissions by the airlines to be included in climate change pacts (Fogarty, 2009). Talk is now turning to ways of mitigating air travel's future impact on climate change, and these "generally fall within two spheres: technology development, and policy mechanisms" (GLOBE-Net, 2007).

Engine Technology, Aerodynamic Body and Weight

It is estimated that the aircraft we fly today are 70% more efficient than those 10 years ago. IATA predicts that by 2020, another 25% efficiency will be added to the present day fleet (GLOBE-Net, 2007). Improvements in aerodynamics, engine design and weight reduction are the main areas of improvement to counter the dependence on fossil fuel. Though the replacement of fossil fuel is being vigorously pursued with some limited success, fossil fuels will not expect to be replaced in the near future. Apart from engine efficiency, finding an alternative fuel is part of the challenge for the aviation industry.

GLOBE-Net (2007) reports that the majority of efficiency improvements over past aircraft have been achieved through the development and improvements in engine technology. Engine improvements, as in the case of automobiles, must increase fuel efficiency (and therefore, decrease CO2 emissions) with reductions in NOx, water vapour, and other air pollutants. Some technological advancement in engine technology uses high pressure ratios to improve efficiency but this worsens the problem with NOx. If new control techniques for NOx are developed to keep within regulatory compliance limits, high pressure ratios will likely be the path pursued by aircraft manufacturers.

Further reduction in emissions can be achieved by matching the advancements in engine technology with better aerodynamic shape and use of light weight material to reduce drag. This certainly contributes to reducing the impact on environment and also can be promoted as a cost-saving measure (e.g., savings in fuel costs).

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Boeing (2007; pg. 1) indicated that "four key technologies contribute to an impressive 20% improvement in fuel use for the 787 Dreamliner as compared to today's similarly sized airplane. New engines, increased use of light weight composite materials, more-efficient systems applications and modern aerodynamics each contribute to the 787's overall performance."

Aircraft manufacturers are also exploring the benefits of other technologies such as the use of winglets, fuselage airflow control devices and weight reductions. These could "reduce fuel consumption by a further 7% says the IPCC, although some have limited practicability" (GLOBE-Net, 2007). In the long term, new aircraft configurations (such as a blended wing body) may achieve major improvements in efficiency.

Alternate Energy Solutions

The time for zero emission aircraft is still far away. The technologies that may make that possible are still in early stages of development and evaluation. Second-generation biofuels, solar power and fuel cells are all being investigated by the aviation industry as well as the automobile industry.

The more fuel aircraft burns, the more emissions emitted into the atmosphere thereby increasing its environmental footprint. The aviation industry has come a long way with fuel technology and with the help of Boeing and Airbus (the world's largest aircraft manufacturers). Today aircraft are lighter, quicker and more fuel efficient.

Boeing has an ongoing legacy of integrating environmental performance improvements through technology advancements. Over the last 40 years, airplane CO_2 emissions have been reduced by around 70% and the noise levels have been reduced by approximately 90 percent. The noise footprint of the new 787 Dreamliner is 60% lower than any similar aircraft (Boeing 1998-2007; pg. 14).

That legacy continues today with every airplane they design and build (Boeing, 1998-2008; pg. 16). One of the many initiatives supported by Boeing is its search for alternative energy solutions. This initiative will lead to reducing greenhouse gas emissions and at the same time Boeing is pioneering three key environmental advancements:

- Advanced-Generation Biofuels - Boeing, Virgin Atlantic and GE Aviation conducted the first commercial flight using a biofuel mix with traditional kerosene-based fuel in February 2008.
- Solar Cells - Converting sunlight into electricity
- Fuel Cells - Convert hydrogen into heat & electricity without combustion, reducing the need for conventional fuels and eliminating emissions.

Like Boeing, Airbus has partnered with Honeywell Aerospace, International Aero Engines and Jet Blue Airways in pursuit of developing a sustainable second-generation bio-fuel for commercial jet use, with the hope of reducing the aviation industry's environmental footprint. Alternative fuel research is a core tenet of Airbus' eco-efficiency initiatives (Airbus, 2008).

Airbus research has also lead to test flights using gas to liquid kerosene, which is similar to jet fuel but results in lower emissions and is a much cleaner fuel source. Airbus has also researched other types of alternative fuels; for example, bio-mass to liquid and coal to liquid. On February 1, 2008 an Airbus 380 (in collaboration with Shell International and Rolls Royce) conducted a test flight using gas to liquid kerosene in one of the A380 engines.

Over the last year, four airlines have flight tested on biofuel: Virgin Atlantic (in February 2008), Air New Zealand (in December 2008), Continental Airlines and Japan Airlines (in January 2009). They have "already flown on routes with one engine part-powered by a range of biofuels including algae and jatropha. Jatropha, a poisonous plant that produces seeds that can be refined into biofuels, is being touted as a good alternative fuel and a potentially powerful weapon against climate change. Experts say the perennial plant can grow on marginal land with limited rainfall, and does not compete with other food crops or encourage deforestation. Following its flight using jatropha in late December, Air New Zealand has set a goal to have 10 percent of fuel coming from biofuel sources by 2013, while Virgin is aiming for 5 percent by 2015" (Szabo *et al.*, 2009).

Pew (2009) reports that "the push in development of biofuels continues with a recent $25 million contract

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awarded by the Defense Advanced Research Projects Agency to SAIC. The company is being tasked to lead a team in development of an integrated process for producing JP-8 from algae at a cost target of $3/gal." The two-phase program aims to conclude with the design and operation of a pre-pilot scale production facility. But another project that involves Boeing, Honeywell, and CFM hopes to see biofuel production levels in the hundreds of millions of gallons per year by 2012 (Pew, 2009).

The International Air Transportation Association (IATA) feels that any alternative fuel should be tested for performance and environmental impact before introducing into the marketplace. IATA researched has shown that the conservative nature of the industry will foster alternative fuels that originally are combined with conventional jet fuel. According to IATA (2008a), alternative fuel systems derived from biomass sources have the potential to lower the carbon footprint and lower other emissions as well. New technologies and more economic integration of alternative fuels along with government subsidies will accelerate the acceptance of these fuels in the market place (IATA, 2008a).

In "Are bio-fuels really an alternative?" Jeff Gazzard (2009), a board member of the Aviation Environment Federation contends that the biofuel issue may not be as clear as it seems. The jury is still out as to whether either synthetic or biofuels are yet capable of being either entirely fail-safe for aviation use or environmentally sustainable in the longer term. According to Gazzard (2009) alternate fuels looked attractive when oil was marching towards $147 a barrel, but now that oil has fallen back to below $50 a barrel, $75-$85 a barrel for biofuel is not as attractive. He points out that another issue is that aviation consumes approximately 240 million tones of kerosene a year. Replacing the current aviation fuel with bio-fuel from productive arable land that does not compete with food production would take almost 1.4 million square kilometers, which is greater than twice the area of France.

Gazzard (2009) is not convinced that aviation would be the best end-user even if biofuels could be produced sustainably. The industry has also followed with increasing interest in algae as a potential source of aviation fuel but is unconvinced that any cost-effective algae-derived aviation fuel could be produced within a practical timeframe that would allow such fuels to make any substantial contribution to climate change policies of today. Regardless of the skepticism, more and more airlines are testing alternative fuel sources and as global warming continues to escalate in the minds of the consumers.

The assessment of GLOBE-Net (2007) is similar - "biofuels could mitigate some aircraft emissions, but the production of biofuels to meet the aviation industry's specifications and quantity demands is currently untested. Ethanol and biodiesel both have properties that make them currently unsuitable for jet fuel, but companies such as Virgin are pursuing biofuels research, investigating possibilities including the use of microorganisms."

Further, the option of solar power is still in its infancy and largely unexplored. Boeing (1998-2008; pg. 16) is working with their wholly-owned subsidiary Spectrolab in this area. Spectrolab is one of the world's leading manufacturers of solar cells, powering everything from satellites and interplanetary missions.

However, without the commercialization of these and other novel new technologies, annual air traffic growth is expected to outstrip efficiency improvements, resulting in a net rise in CO_2 emissions of around 3-4% per year, along with increases in NO_x and water vapour emissions.

Better Traffic Management

One possible contributor to greater aircraft efficiency is improved air traffic management. According to the IATA (2007), there is a 12% inefficiency in global air traffic management which could largely be addressed by three 'mega-projects': a Single Sky for Europe, an efficient air traffic system for the Pearl River Delta in China and a next generation air traffic system in the United States. However, there has not been much progress on these initiatives much to the disappointment of IATA and its leadership.

Scientists and aviation experts worldwide are investigating improved air traffic management, lower flight speeds, reducing idling and other efficiencies, searching for areas of potential emissions reductions.

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Policy Mechanisms

In February 2009, four leading airlines and an airport authority - Air France/KLM, British Airways, Cathay Pacific, Virgin Atlantic and airport operator BAA - called for aviation emissions to be included in a broader climate pact. This can be seen as a move to ward off criticism from environmental groups and to probably have a negotiated deal instead of a one that is imposed upon them. Even with only 2% of global pollution coming from airlines, the pressure of the aviation industry has been mounting to participate in emission reduction initiatives (Fogarty, 2009).

This call was a prelude to the 2009 Copenhagen Summit on Climate Change where nations are expected to find an agreement around a climate pact that replaces the Kyoto Protocol whose first phase ends in 2012. To date "international air travel is exempt from carbon caps under the Kyoto Protocol. Neither do airlines pay tax on fuel. Understandably, lawmakers are wary of disrupting aviation since air travel represents a cash cow for governments. In the US, for example, the average tax on a $200 ticket is 26%, amounting to about $15bn a year. And the air travel industry picks up the tab for its own infrastructure, an annual bill of about $42bn, according to IATA" (Balch, 2009).

In recent years, governments and international organizations have looked at policy options that could create incentives or impose requirements on aircraft operators and manufacturers to reduce emissions. At the forefront of this push is the European Union, which has proposed that aircraft be covered under the region's Emissions Trading Scheme (ETS). Under the proposal, emissions from all flights within the EU will be covered in 2011, with international flights to be included in 2012. The EU hopes to serve as a model for other countries (GLOBE-Net, 2007). An Ernst & Young (2007) study commissioned by the airline industry projects the system would cost airlines more than 40 billion Euros from 2011 to 2022.

The IATA states in its climate change strategy that it prefers emissions trading to a carbon tax or other charges, but would rather participate in a worldwide voluntary scheme instead. "The challenge is for the International Civil Aviation Organization (ICAO) and its 190 member States to deliver a global emissions trading scheme that is fair, effective and available for all governments to use on a voluntary basis" (IATA, 2007).

Short-term Measures

In recent times some airlines have started offering passengers a chance to purchase carbon offsets to neutralize / minimize their carbon emission footprint. Air Canada partners with ZeroFootprint while Westjet has partnered with Offsetters.ca. In 2009, Japan airlines joined hands with Recycle One to help its passengers offset the carbon caused by their flight. "The total emissions figure is based on factors such as distance of travel, aircraft type, baggage and passenger to cargo ratios" (Balch, 2009). Continental, SAS, Qantas, British Airways, JetStar, Virgin Atlantic and Virgin America and some other airlines offer similar programs.

Such programs are leading the way now but stronger action may be required to bring a significant reduction in GHG emissions.

Long-term Thinking

To address the problem of Climate Change, like all other industries, airlines will also have to re-think their business model. They will have to probably agree to be part of a network that moves people and goods from one place to another in an efficient and timely manner. To achieve this goal, they will have to collaborate and network with other transport operators like the railways. "In the Netherlands, airlines and rail companies have a history of cooperation. Long before its merger, KLM had already cancelled several short-haul flights on routes where fast train links existed. Many of KLM's international flights to Dutch cities also finish with a final leg by train" (Balch, 2009).

The "Flight" Ahead

As demonstrated, the aviation industry plays a vital role in the global economy and provides economic and social benefits. It is also apparent that global temperatures continue to rise while the aviation industry continues to grow. The combination of aviation growth and climate change leads us to believe that CO2 emissions from the aviation industry is one of the many other factors

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impacting global warming. It has to be addressed even though its impact today is limited to a very low percentage. But with a potential to grow, it cannot go unattended. With this in mind, the following main areas have been identified in order to help reduce aviation emissions.

- Strengthen the global leadership strategy (for example, add aviation emissions to Kyoto protocol; revisit fuel surcharge (taxation) issue; create an emissions charge; implement an emissions cap on aviation emissions; enforce Carbon offset programs for all airlines; etc.)

- Increase Alternative Fuel technology/implementation (for example, increase biomass fuel technology; etc.)

- improvements in Aircraft Technology Efficiency (for example, reduce aircraft fuel consumption and CO2 emissions by replacing older, less fuel efficient aircraft with aircraft using latest fuel efficiency technology and navigation equipment; reduce aircraft noise - mitigate inefficient noise procedures; reduce oxides of nitrogen - try to go beyond compliance limits; etc.)

- Improvements in Air Traffic Management (for example, cut inefficiency in current flight patterns - more fuel efficient approaches and overall routing; encourage flight patterns that minimize the impact of non CO2 emissions; optimize aircraft speed; etc.)

- Improvements in Operational Efficiencies (for example, increase load factors; eliminate non-essential weight - reassess the value of onboard materials; limit auxiliary power (APU) use by reducing engine idle times and by shutting down engines when taxiing to reduce APU use and fuel burn; reduce taxiing time of aircraft; etc.)

All these suggestions require stimulating technology advancements and innovation. Holliday *et al.* (2002) state that innovation is critical for any organization and industry if it wants to operate in a new global business environment which puts emphasis on environmental alignment of business goals.

The aviation industry (airlines, governments, non government organizations, suppliers, manufactures) must work together and create technology advancements that catapult the industry into the future. The innovation created must not only look at how the aviation industry can improve on their CO2 emissions but also how it can change the CO2 emissions landscape. Improving current practices is not good enough. The aviation industry must change the way they operate in order to reduce CO2 emissions. Governments must get involved and work with airlines to spur innovation and remove obstacles for airlines leading the environmental movement.

Closing Remarks

The aviation industry transports 2.2 billion passengers annually while providing trade and tourism for developed and developing regions (Penner et.al., 2001). Although airlines have improved their fuel efficiency and CO2 emissions over the past 10 years (5% from 2003 to 2005), the industries greenhouse gas emissions could reach 5% by 2050 (Balch, 2009). Airlines are determined to reduce their CO2 emissions a further 25% between 2006 and 2020 with huge investments in fleet renewal (IATA, 2007).

The challenges faced by the industry have vastly been covered in this review of CO2 emissions in the aviation industry. The option of eliminating air travel is not a feasible alternative in order to deal with aviation greenhouse gas emissions as aviation is the most efficient way of traveling; especially long distance international travel. Other modes of transportation (rail, sea and road) are not as quick, and in the case of motor transportation are much more damaging to the environment then air travel.

The issue then becomes how do we reduce greenhouse gas emissions from the aviation industry and ultimately reduce their environmental impact? The suggestions outlined in this review provide the aviation industry with a solid foundation for moving towards sustainable development. They challenge the aviation industry's operating procedures to reducing CO2 emissions and provide the foundation for eco-strategies that reduce the consumption of fossil fuels. The players involved in this crisis are vast and plentiful, which is a curse and blessing.

The number of stakeholders that are involved in the aviation industry is large which makes the task daunting because it takes more collaboration to have such a large

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and diverse group agree on strategic direction. However this can also be a blessing because the aviation industry has many leaders that can influence change. Some have already taken the lead - Airbus, Boeing, Virgin Atlantic to name a few.

Throughout time, leaders emerge as individuals or organizations that discover in us the emotional intelligence it takes to get a job done, even when that set of tasks requires sacrifices and sustained restraint (Piasecki *et al.*, 1999). One immediate name that comes to mind is Virgin Atlantics Sir Richard Branson, who has invested $3 billion dollars to flight global warming. Sir Richard Branson's is tireless in his efforts to fight CO2 emissions and its impact to global warming and is a clear leader within his industry. Although it is pivotal for individuals and firms to do their part in the battle of global warming, governments must also step up to the plate and enforce their power. Without accountable government and effective institutions, sustainable development is impossible (Holliday et.al., 2002).

Busy skies and the increasing demand on airlines services is pushing their environmental footprint to all time high's. However, collectively the aviation industry is chipping away at CO2 emissions and as time elapses reducing their carbon footprint becomes more of a priority for airlines. However, it cannot be left up to the airlines alone. All parties involved must play a role in adoption of sustainable development in the aviation industry. Heightened awareness and acceptance of such practices and changing the mindset of public are important steps in this process. The sooner environmental objectives are part of the normal practices of a firm the quicker the world will address the rapid rate of natural resource consumption.

Evidence that firms have become environmentally conscious either 'voluntary' (as a result of changes in corporate values), or because market forces have encouraged them, is in fact rather thin. The vast majority of new environmental activities have been explicitly developed as a result of the statutory regulation of markets or of political pressure from environmentalists (Jacobs, 1993).

Due to the enormity of the challenge it must be reiterated that governments' interaction in this challenge is paramount. Until someone steps up and enforces rules that govern the green practices of the entire aviation industry, the industry will (unfortunately) muddle along with short term measures for reducing its environmental footprint.

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