Airline Industry

Aviation contributes approximately 2 percent of total greenhouse gas emissions, a figure which is projected to grow through 2050. Although fuel efficiency has improved by nearly 16 percent since the 1990s, future technologies—including better flight patterns, more-efficient engines, and alternative fuels—have promise for further emissions reductions. The profitability challenges of the early twenty-first century, however, affect the industry's ability to invest in new technology.

Every day, millions of people board planes to reach points all over the world. In 2006, 744 million passengers stepped aboard planes in the United States alone, generating revenues of nearly $164 billion (Air Transport Association 2008). Air travel, once seen as a dream in the 1800s and later a luxury for the rich, is now available to all for fares as low as $40. This has occurred at the same time that incomes and wealth have increased dramatically around the world. Whether for business or pleasure, air travel is now the preferred method of getting where you want to go. But few people consider the impact of their decision to step on a plane on the global environment. A Boeing 747-400 burns approximately 5 gallons (19 liters) of fuel per mile on a 3,500 statute mile (~5,645 kilometer) flight, which totals about 17,500 gallons (66,500 liters) for a flight roughly equal to the flight distance from New York to London (Boeing 2009b). In the United States, a total of nearly 797 billion passenger miles (1,285 billion passenger kilometers) were flown in 2006 (Air Transport Association 2008). Globally, air travel was estimated to be responsible for approximately 480 million tons (~435 million metric tons) of carbon dioxide emitted into the atmosphere in the year 2000 (GAO 2009). With the rapidly increasing onset of global warming, high carbon intensive industries (such as airlines) must find sustainable strategies to maintain growth and profitability or risk further damage to the world's environment.

Historical Background

Early aviation was driven by the creative entrepreneurship of many engineers and hobbyists in the late 1800s and early 1900s. Wilbur and Orville Wright made the first validated human flight in North Carolina on 17 December 1903. After that well-known, momentous flight, airplanes became significantly more reliable and were able to travel farther distances. They were quickly adopted for military uses in World War I. Government investment in aviation rapidly helped the industry develop new planes that were capable of carrying passengers.

Despite these developments, commercial aviation did not appear economically feasible until the 1920s. In that decade, a number of airlines started and failed as expensive ticket prices and reports of crashes jeopardized demand for travel. Even with these circumstances, the number of airline passengers grew from 6,000 in 1926 to approximately 173,000 in 1929 (U.S. Centennial of Flight Commission 2009). Air travel in the 1920s and 1930s was not a pleasant experience: planes were not pressurized, which led to significant ear pain for travelers, and low-altitude turbulence often meant multiple cases of air sickness. Yet customers continued to take to the air in droves as air travel became linked to business transactions. The year 1937 witnessed airline-passenger traffic break the 1 million passenger mark. Transatlantic air travel became possible in the 1940s but was extremely limited. What used to be an unsafe, uncomfortable, and unaffordable new development swiftly became a norm for both the rich and the businessmen of the generation. Additionally, commercial aviation was preparing to take the next innovative step, which would launch air travel into the mainstream.

The introduction of the jet engine in the late 1950s revolutionized air travel. Jet engines offered more speed and comfort to passengers and were cheaper to maintain than traditional piston-driven engines. But jet engines required more fuel than the conventional engine to generate higher air speeds and altitudes. The jet engine made longer flights significantly more feasible and allowed many shorter routes due to easier maintenance requirements for the engines. With this new development, the variety of aircraft types multiplied. Smaller planes handled the new shorter routes, and large wide-body models, such as the Boeing 747, made the longer flights. Travelers could now reach hundreds of destinations whenever they wished. Shortly thereafter, another major movement would vastly expand the number of travelers pursuing those destinations.

Up until the late 1970s, air travel in the United States was highly regulated by the government with six major carriers—United, American, Delta, Eastern, TWA, and Pan Am—dominating certain travel routes. But in 1978 the U.S. Airline Deregulation Act enabled new airlines to enter the market and existing airlines to expand their routes. Europe followed the United States' example with a stream of deregulation acts that culminated in 1997. In the deregulated environment, higher competition quickly drove airfares lower, and airlines found it very difficult to sustain profitability. Eastern, TWA, and Pan Am subsequently went bankrupt. The average airfare in 1992 cost nearly 66 percent less than the average airfare in 1977 (U.S. Centennial of Flight Commission 2009). With these decreases in prices, demand for flights more than tripled from 1975 to 2005. Globally, aviation now transports more than 2.2 billion people and more than 44 million tons of freight (Bisignani 2009). Despite the global recession that began in late 2007, demand for air travel appears poised to continue growing into the distant future as global incomes rise and distances between people continue to shrink.

Challenge of Sustainable Growth

Because of the amount of fuel consumed on each flight, greenhouse gas emissions are a significant issue for the aviation industry. It is estimated that commercial aviation is responsible for 3 percent of global-warming emissions; this may grow to as much at 5 percent by 2050 as demand for air travel increases (Milmo 2008). With concentrations of carbon dioxide, methane, and nitrous oxide higher in today's atmosphere than at any time in post–Industrial Revolution history, any significant source of emissions must be evaluated closely. At the same time, this rise in pollutants corresponds to a significant increase in global warming in the last 150 years. Just since the 1970s, temperatures have risen on average by 1°F (or approximately .56°C), which correlates closely with the global boom in aviation (United States Environmental Protection Agency 2009).

It should not be thought, however, that air travel is the primary party responsible for increased greenhouse gas emissions. The transportation industry as a whole contributes approximately 20 percent of total carbon dioxide emissions globally, with road transit accounting for 74 percent of industry emissions and aviation and air freight accounting for only 13 percent (United States Environmental Protection Agency 2009). In fact, planes can typically be more fuel efficient than many cars. A Boeing 747 will burn about 5 gallons of fuel per mile over a 3,500 mile flight (or approximately 12 liters per kilometer during a 5,632 kilometer flight). The 747 can also carry more than 500 people on a flight, which means that the 747 is typically traveling about 100 miles per gallon (42 kilometers per liter) per passenger (Boeing 2009b), which translates to significantly higher fuel efficiency compared to individuals traveling in cars. Overall, U.S. airline fuel efficiency has improved from an average of 48 available seat miles (an industry measurement of an airline's capacity equal to the number of seats available multiplied by the number of miles flown) per gallon (20.4 kilometers/liter) in 1981 to an average of 58 seat miles per gallon (approximately 24.6 kilometers/liter) in 2008 (GAO 2009); nevertheless, some operating challenges have diminished the rate of improvement. Airlines face multiple challenges when it comes to operating more sustainably. In terms of financial performance, airlines have struggled to generate profits since deregulation in the 1970s. In the last fifteen years in the United States, airlines have generated nearly $2 trillion in total revenues but produced a negative $32 billion in total profits. According to the Bureau of Transportation Statistics (2009), even in the days of steady profitability during the 1990s' economic expansion, airline net-income profit margins maxed out at 4.72 percent in 1997. Since 2001, it has become an even greater struggle to remain profitable—the industry generated positive profits in only two out of eight years, and losses totaled over $55 billion (Bureau of Transportation Statistics 2009). In times of economic expansion, high fuel prices adversely affect airline profitability; during economic downturns, customer demand declines. While these results are certain to concern shareholders, they pose significant challenges to the environment as well.

Because airlines are forced to operate under such tight margins and cash-constrained positions, it is often difficult for them to invest in new technology for retrofitting existing planes as well as investing in newer fleets with better technology provided by manufacturers such as Boeing and Airbus. This leads many airlines to operate fleets that include planes thirty-five to forty years old, such as the DC-9 airplanes. These aging fleets are generally less fuel efficient than modern planes and engines. With poor financial performance, it is difficult for airlines to order lighter, more fuel-efficient planes that could carry more passengers with a lower overall fuel burn even though planes are usually leased to airlines with financing offered by manufacturers (Carey 2009).

The economic recession that began in late 2007 led to even more difficult conditions for airlines, which are forecast to lose nearly $80 billion in customer revenues in 2009 (Bisignani 2009). While airlines are rapidly reducing flights and scaling down capacity, it does not look as if they will be able to take advantage of lower oil prices and improve their operating profits. Despite these conditions, airlines are taking a number of measures to reduce their impact on the environment.

Sustainability in Aviation

Due in part to the steep rise of fuel costs before the recession and in part to efforts to decrease total carbon emissions, major airlines have taken a number of steps to reduce their carbon emissions footprint.

- Maximizing Capacity—While the main reason for maximizing capacity is to maximize revenue, full capacity flights also reduce the amount of carbon emissions per person. During the recession that began in late 2007, airlines reduced the number of flights available to ensure that airplanes were as full as possible.
- Introducing Winglets—Winglets, vertical attachments on the end of the wing, were originally invented by National Aeronautics and Space Administration (NASA) researchers in the late 1970s and early 1980s in response to the high gas-price shock of the 1970s. More recently, high fuel prices drove many airlines to invest in retrofitting their existing fleet with winglets. Winglets are estimated to improve fuel efficiency by as much as 7 percent (NASA 2008).
- Continuous Descent Approach—Utilizing a new descent approach to airport runways with their landing procedures has allowed airlines to use lower engine-power levels and burn less fuel on the aircraft's descent.
- Reducing Flight Weight—Airlines evaluated everything that goes on a flight, including carpet, seats, and fuel requirements, to see if it was possible to shed extra weight. An extra 1,100 pounds (455 kilograms), the equivalent of six passengers, can lead to an additional fuel burn of 66 to 110 pounds (30 to 50 kilograms) on a 90-minute flight. For 3,000 hours of flying, this represents an additional cost of $40,000 to $70,000 per plane.
- Ground Power—Planes once used engines on the ground to support power systems and air conditioning on the plane in between flights. Now, airline crews increasingly use "drive-up" ground-power units that provide electricity directly to the plane from a fuel-efficient generator.
- Engine Washing—Airlines found that simply washing engines with pressurized water can remove a lot of buildup.
- Emissions Offset Programs—Many large U.S. airlines, including Delta, American, United, and Continental Air Lines, have introduced voluntary carbon offset programs with partners like The Conservation Fund and Sustainable Travel International to give customers the opportunity to purchase carbon offsets for their flights. These airlines often provide incentives, such as additional frequent-flier miles or matching donations to funds contributed by customers.

These measures began to have some positive effects on fuel consumption as the International Air Transport Association (IATA) reported that fuel efficiency improved by nearly 16 percent from 2001 to 2008 (IATA 2009, 2). In 2008, airlines were carrying 20 percent more passengers and consuming 3 percent less fuel than in 2000. But anticipation of higher future demand leads many experts to believe that fuel consumption and emissions will continue to rise. Therefore, airlines and airline manufacturers are continuing to look for more potential solutions to increase fuel efficiency while governments are simultaneously considering new policies to reduce airline emissions.

Government Regulations and Aviation

Despite improvements in fuel efficiency over the past ten years, airlines must find new ways to reduce their contribution to climate change. It takes a significant amount of time to process greenhouse gas emissions out of the atmosphere, so adding more every year extends the effects of these emissions for years to come. Governments are beginning to take a much more proactive stance in managing these emissions. There are two particular mechanisms in particular that governments are considering to reduce emissions.

Carbon Tax

A carbon tax is a tax on any fuel containing carbon-based elements, such as coal, oil, and natural gas. The carbon tax would be implemented in the upstream production process where it is extracted from the ground, which would then lead to higher downstream prices for all industries that rely on these fuels. This higher price essentially acts as an excise tax, much like current taxes on alcohol and tobacco. A carbon tax theoretically would encourage individual businesses and consumers to use less and shift their spending to other goods.

While proponents of a carbon tax argue that it could be phased in gradually so the effects would not introduce a significant price shock, airlines are especially sensitive to increases in fuel costs because they represent 30 percent of the airlines' operating costs. Opponents of a carbon tax point out that fuel prices are already subject to increase, as they did in the summer of 2008, due to rising global demand. Some airlines, such as Virgin Airlines, have indicated they would be willing to pay a carbon tax as long as it was fairly applied (Environmental Leader 2008).

Cap-and-Trade Carbon Trading System

A cap-and-trade system works through a series of limits set on high emissions companies (such as electricity providers and airlines). The company would use emissions permits for each ton of carbon emissions that it releases into the atmosphere. Carbon permits would initially be auctioned off to all major producers of emissions, creating a new revenue stream for the government. The credits could be traded from more efficient producers, who generate emissions below their limit, to those producers who need to purchase more credits in order to offset their emissions. Essentially, this system creates more incentives to reduce total aggregate emissions by encouraging large emitters to become more efficient or switch to cleaner fuel sources. This type of trading system worked very well in reducing sulfur dioxide and the incidence of acid rain in the United States during the 1980s and 1990s.

As of 2009, plans are in motion to institute a cap-and-trade system in the airline industry. The European Union (EU) has set a goal of implementing an airline cap-and-trade system by 2012. It expects this program to initially reduce emissions by 3 percent from their 2004–2006 level, steadily growing to a reduction of 15 percent of all carbon emissions (EurActiv 2009).

Outlook for Sustainability in Aviation

Proposed regulations have led airlines to recognize the need to become more sustainable in their operations. Many U.S. airlines, including Delta, American, and Southwest, have published sustainability reports in the past. In these reports, they often highlight new recycling initiatives and efforts to increase fuel efficiency. However, there is still room to improve in environmental measurement practices. UPS (n.d.) is one of the few companies in the United States to report total emissions for its operations: 15.4 million tons (14 million metric tons) of carbon dioxide emissions, of which 53 percent is driven by jet-fuel consumption. American Airlines also tracks their total emissions, which consisted of 30.1 million tons (27.7 metric tons) of carbon dioxide emissions in 2007 (AMR n.d., 23). Many European airlines are very advanced in their sustainability reporting. For instance, Air France-KLM's 2009 report documents their improvements in grams of carbon dioxide per passenger per kilometer, down from 107 grams (3.7 ounces) in 2000 to 95 grams (3.3 ounces) in 2008.

In the future, more airlines will need to report their total carbon footprint as regulation of emissions becomes much more prevalent. Impending cap-and-trade regulation for airlines in the EU will force airlines to measure their emissions on flights involving a European departure or arrival. Airlines are unsure of the impact such legislation will hold. For example, Delta Air Lines, the largest airline in the world by revenue, recently stated in its 2008 annual report:

> We expect that such a system will impose significant costs on our operations in the European Union. Similar cap-and-trade restrictions are being proposed in the United States. In the event that U.S. legislation or regulation is enacted or in the event similar legislation or regulation is enacted in other jurisdictions where we operate or where we may operate in the future, it could result in significant costs for us and the airline industry. At this time, we cannot predict whether any such legislation or regulation would apportion costs between one or more jurisdictions in which we operate flights, which could result in multiple taxation or permitting requirements from multiple jurisdictions. Certain credits may be available to reduce the costs of permits in order to mitigate the impact of such regulations on consumers. At this time, we cannot predict whether we or the aviation industry in general will have access to offsets or credits. We are carefully monitoring and evaluating the potential impact of such legislative and regulatory developments. (Delta Air Lines 2009, 9)

The airline industry clearly understands the risk posed to its business by a cap-and-trade system, yet they also recognize the value that improving sustainability and fuel efficiency can have on their bottom line. Airlines that are able to innovate and reduce their emissions will be better positioned to thrive in this new environment of potentially higher costs.

A number of technological developments will also help the airline industry reduce their total emissions.

Improved Engine Efficiency

Engines in development will likely rely on geared turbofans developed by NASA and Pratt & Whitney to reduce fuel consumption by as much as 12 percent (Pratt & Whitney 2009). Other potential improvements include open rotor engines and distributed power generation systems, but these technologies are long-term improvements that are still being researched for feasibility.

Airframe Enhancements

With high fuel prices, airlines took a number of steps to make planes lighter by reducing the weight of current on-board items (e.g., catering carts, carpet, water, and blankets), replacing old seats with lighter seats, and adding baggage restrictions. For instance, American Airlines contends that reducing flight weight by 100 pounds would save them nearly 1.1 million gallons of fuel (American Airlines 2009). Aircraft manufacturers further perpetuated this idea and are developing lightweight composite materials for the body of aircrafts. Boeing's new 787 is expected to consist of nearly 50 percent carbon-composite materials, which will help the 787 become nearly 20 percent more efficient than similarly sized planes (Boeing 2009a). Additionally, new electric systems are being employed that will replace hydraulics and significantly lighten planes. Airbus is also currently researching new oscillating wings that could reduce air friction considerably.

Flight Operations Improvements

The U.S. Federal Aviation Administration (FAA) is developing a new air-traffic management system known as NextGen that will allow pilots to craft more efficient flight paths to their destination. This system will also help pilots use real-time weather information to avoid delays and use tailwinds efficiently. This system is already showing significant reductions of greenhouse gas emissions and saving millions of dollars at airports such as Atlanta, Phoenix, and Dallas-Fort Worth (Federal Aviation Administration 2009).

Additionally, Boeing has performed some work that is immediately applicable to reducing airline emissions across its fleet. Boeing developed a new Tailored Arrivals program, which gives airline crews the most efficient flight path by taking into account factors such as aircraft performance, air traffic, airspace, and weather. A one-year pilot program at San Francisco's airport reportedly decreased fuel consumption by 1.1 million pounds (nearly 500,000 kilograms) and reduced carbon emissions by 1.6 tons (1.45 metric tons) (Boeing 2008).

Alternative Fuels

Four airlines have recently completed tests of biofuels (an alternative to fossil fuels composed of or produced from biological raw materials) mixed with jet fuel in standard jet engines. Potential sources for airline biofuel include switchgrass, jatropha oils, and algae, among others. Continental Airlines (2009) recently performed a test with one engine using traditional jet fuel and another engine using a fuel of half jatropha- and algae-derived fuels mixed with jet fuel. The results showed a dramatic reduction of 60 percent to 80 percent emissions for the biofuel-based engine and 1.1 percent increase in fuel efficiency (Continental 2009). However, several steps need to be taken to determine if biofuel may be commercially viable and to understand other environmental considerations associated with second-generation sources of biofuel.

Outlook for the Twenty-First Century

Although some innovations soon may be adopted into modern aviation, advances in technology are difficult to obtain and must pass strict safety standards. Boeing has experienced numerous delays in launching the new 787 and continues to push back its delivery date over two years because of needed changes, such as reinforcement of the aircraft body near its carbon-composite wings. Even though existing orders number more than 800, it is unclear when Boeing will be able to deliver the planes. Despite the significant promise of new technologies, innovation is expensive, and aging fleets and existing processes will be difficult to replace in an industry that struggles to maintain profitability in the economic environment of the early twenty-first century.

The economic recession that started in late 2007 will make it difficult for airlines to take on new investments and generate profits. Capacity will continue to shrink in an effort to keep planes full at stable prices. This could lead to further consolidation in the industry as airlines with lower cash balances seek to be acquired or restructured. Regardless, the aviation industry is well aware of the new environmental expectations placed on them by upcoming regulations such as the EU's emissions trading program. The airline industry is often viewed as slow and bureaucratic, but in order to succeed in this new economic climate, airlines will need to innovate quickly to get ahead of their competition. Those who are best able to adopt new technologies, maximize their revenue per flight, and operate with a lower carbon footprint will be best-suited to survive.

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See also Automobile Industry; Cap-and-Trade Legislation; Design, Industrial; Energy Efficiency; Energy Industries—Oil; Investment, CleanTech; Steel Industry; Travel and Tourism Industry

Further Reading

Air France-KLM. (2009). Corporate sustainability report 2008–2009. Retrieved June 30, 2009, from http://developpement-durable.airfrance.com/FR/fr/common/pdf/af_ra_gb.pdf

Air Transport Association. (2008). 2008 economic report: Connecting/protecting our planet. Retrieved June 8, 2009, from http://www.airlines.org/NR/rdonlyres/770B5715-5C6F-44AA-AA8C-DC9AEB4E7E12/0/2008AnnualReport.pdf

American Airlines. (2009). Fuel smart. Retrieved December 18, 2009, from http://www.aa.com/i18n/amrcorp/newsroom/fuel-smart.jsp

AMR Corporation. (n.d.). 2007 environmental responsibility report prepared by AMR Corporation. Retrieved June 30, 2009, from http://www.aa.com/content/images/amrcorp/amrerr.pdf

Bisignani, Giovanni. (2009, June 8). State of the air transport industry. Retrieved June 12, 2009, from http://www.iata.org/pressroom/speeches/2009-06-08-01.htm

Boeing (2008). Boeing tailored arrivals ATM concept cuts fuel, emissions in initial deployment. Retrieved June 15, 2009, from http://www.boeing.com/commercial/news/2008/q3/080711a_nr.html

Boeing. (2009a). Boeing 787 Dreamliner will provide new solutions for airlines, passengers. Retrieved June 2, 2009,

from http://www.boeing.com/commercial/787family/background.html

Boeing. (2009b). 747 fun facts. Retrieved December 18, 2009, from http://www.boeing.com/commercial/747family/pf/pf_facts.html

Bureau of Transportation Statistics. (2009, June 15). Air carrier financial: Schedule P-11. Retrieved June 15, 2009, from http://transtats.bts.gov/Fields.asp?Table_ID=290

Carey, Susan. (2009, June 4). United plans huge jet order. *Wall Street Journal*. Retrieved September 14, 2009, from http://online.wsj.com/article/SB124408456205084093.html

Center for American Progress. (2008, January 16). Cap and trade 101: What is cap and trade, and how can we implement it successfully? Retrieved June 4, 2009, from http://www.americanprogress.org/issues/2008/01/capandtrade101.html

Continental Airlines. (2009, June 17). Continental Airlines announces results of biofuel demonstration flight. Retrieved June 20, 2009, from http://phx.corporate-ir.net/phoenix.zhtml?c=85779&p=irol-newsArticle&ID=1300025

Delta Air Lines. (2009, March 2). Annual report to the Securities and Exchange Commission for the year ending December 31, 2008. Retrieved June 1, 2009, from http://images.delta.com.edgesuite.net/delta/pdfs/annual_reports/2008_10K.pdf

Environmental Leader. (2008, June 25). Virgin's Branson says airlines, other industries should pay. Retrieved December 18, 2009, from http://www.environmentalleader.com/2008/06/25/virgins-branson-says-airlines-other-industries-should-pay/

EurActiv. (2009, February 2). Airlines prepare for EU carbon trading scheme. Retrieved November 30, 2009, from http://www.euractiv.com/en/transport/airlines-prepare-eu-carbon-trading-scheme/article-179059

Federal Aviation Administration. (2009, April 24). NextGen goal: Performance-based navigation. Retrieved December 18, 2009, from http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=8768

Government Accountability Office (GAO). (2009, June). Aviation and climate change. Retrieved June 12, 2009, from http://www.gao.gov/new.items/d09554.pdf

Grant, R. G. (2002). *Flight: 100 years of aviation*. New York: DK Publishing.

Intergovernmental Panel on Climate Change. (2001). Aviation and the global atmosphere. Retrieved June 4, 2009, from http://www.grida.no/publications/other/ipcc_sr/?src=/Climate/ipcc/aviation/094.htm

International Air Transport Association. (2009). A global approach to reducing aviation emissions. Retrieved October 21, 2009, from http://www.iata.org/NR/rdonlyres/DADB7B9A-E363-4CD2-B8B9-E6DEDA2A6964/0/Brochure_Global_Approach_to_Reducing_Aviation_Emissions_280909.pdf

Milmo, Cahal. (2008, May 6). Airline emissions "far higher than previous estimates." Retrieved October 21, 2009, from http://www.independent.co.uk/environment/climate-change/airline-emissions-far-higher-than-previous-estimates-821598.html

NASA. (2008, March 3). Dryden Flight Research Center fact sheets: Winglets. Retrieved June 1, 2009, from http://www.nasa.gov/centers/dryden/about/Organizations/Technology/Facts/TF-2004-15-DFRC.html

Pratt & Whitney. (2009). Pratt & Whitney PurePower PW1000G engine. Retrieved December 18, 2009, from http://www.pw.utc.com/Products/Commercial/PurePower+PW1000G

United States Environmental Protection Agency. (2008, December 17). Atmosphere changes. Retrieved May 29, 2009, from http://www.epa.gov/climatechange/science/recentac.html

United States Environmental Protection Agency. (2009, April 15). Trends in greenhouse gas emissions. Retrieved May 27, 2009, from http://www.epa.gov/climatechange/emissions/downloads09/TrendsGhGEmissions.pdf

UPS. (n.d.). 2008 UPS corporate sustainability report. Retrieved June 25, 2009, from http://www.community.ups.com/docs/2008_CSR_PDF_Report.pdf

U.S. Centennial of Flight Commission. (2009). History of flight. Retrieved May 30, 2009, from http://www.centennialofflight.gov/essay_cat/8.htm