

The air transport industry is the global network of commercial aircraft operators, airports, air navigation service providers and the manufacturers of aircraft and their components. It is responsible for connecting the global economy, providing millions of jobs and making modern quality of life possible. The Air Transport Action Group (ATAG), based in Geneva, Switzerland, represents the full spectrum of this global business. ATAG brings the industry together to form a strategic perspective on commercial aviation's sustainable development and the role that air transport can play in supporting the sustainability of other sectors of the economy. ATAG's Board of Directors includes: Airports Council International (ACI), Airbus, ATR, Boeing, Bombardier, Civil Air Navigation Services Organisation (CANSO), CFM International, Embraer, GE Aviation, Honeywell Aerospace, International Air Transport Association (IATA), Pratt & Whitney, Rolls-Royce and Safran.

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THROUGH PARTNERSHIPS  
AND VISIONARY  
COMMITMENTS, THE  
INTERNATIONAL  
AVIATION SECTOR  
HAS BEEN ACTIVELY  
PROGRESSING ITS OWN  
STRATEGY TO ADDRESS  
ITS CO<sub>2</sub> EMISSIONS.

FOREWORD:

## DR. OLUMUYIWA BENARD ALIU

*PRESIDENT OF THE INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO) COUNCIL.*

**AT ICAO'S 38TH ASSEMBLY IN 2013, OUR MEMBER STATES AGREED TO FINALISE A NEW CO<sub>2</sub> STANDARD AND TO DEVELOP A GLOBAL MARKET-BASED MEASURE (GMBM) TO ADDRESS INTERNATIONAL AVIATION EMISSIONS BY THE NEXT ICAO ASSEMBLY IN SEPTEMBER 2016. IT WAS ALSO AGREED THAT THE GMBM SHOULD BE IMPLEMENTED BY 2020. 2015 IS A CRITICALLY IMPORTANT YEAR IN TERMS OF ICAO'S PREPARATION FOR OUR NEXT ASSEMBLY, AND THE UNFCCC COP21 IS AN IMPORTANT MILESTONE IN THAT PROCESS. THIS LANDMARK CLIMATE EVENT WILL BE SEEKING TO REACH A UNIVERSAL AND LEGALLY BINDING AGREEMENT TO EFFECTIVELY COMBAT CLIMATE CHANGE, AND IN SO DOING BRING GREATER IMPETUS TO THE MUCH NEEDED GLOBAL TRANSITION TOWARDS RESILIENT, LOW-CARBON SOCIETY.**

ICAO, governments, civil society and the industry have been working in concerted partnership towards delivering a practical GMBM proposal next year. Aviation must remain fully unified in these efforts to achieve progress. A positive outcome at COP21 will be crucial to encouraging ICAO Member States to make further progress at ICAO's 39th Assembly on reducing emission from international aviation, including an agreement on a GMBM.

In September 2015, as part of our preparations in advance of COP21, ICAO held a Global Aviation Partnerships on Emissions Reduction Seminar. Impressively, over a thousand partnerships to address aviation emissions were presented during this event, including emerging challenges for aviation such as aircraft recycling and adaptation.

We should also take note that the 2015 United Nations Summit has now adopted the new post-2015 UN Sustainable Development Goals. Aviation substantially contributes to a number of these and as a sector we should work harder to underscore the positive impacts of safe and reliable air operations on the SDG targets relating to emissions reduction, socio-economic prosperity, infrastructure development and poverty eradication.

These goals are also related to several of the priorities ICAO is pursuing under our "No Country Left Behind" (NCLB) initiative. ICAO's capacity building and financing strategy in support of actions by our Member States to reduce aviation emissions, in particular the ICAO State Action Plans initiative and two ongoing green financing projects supported by the European Commissions and UNDP/GEF, are concrete examples of our action and resolve under NCLB.

Through partnerships and visionary commitments, the international aviation sector has been actively progressing its own strategy to address its CO<sub>2</sub> emissions, and to achieve ICAO's global aspirational goals of improving fuel efficiency by two per cent per year while stabilising our sector's CO<sub>2</sub> emissions at 2020 levels. ICAO States are seeking to realise these targets through measures including technological and operational improvements, alternative fuels and market-based measures.

Taking action in all areas is crucial for the success of next ICAO Assembly, and I am grateful to ATAG that this publication highlights a series of actions and partnerships to address aviation and climate change.

We now find ourselves on a shared journey toward achieving carbon neutral growth from 2020 – a clear and common objective for ICAO and ATAG. I strongly believe that this will be possible only by continuing to work together, in line with our historic tradition in global civil aviation, and by actively forging and refining our related partnerships.

Few goals have ever been more critical to our sector, and none are as urgently essential to our shared and future prosperity today than attaining meaningful environmental sustainability.







EVERY MEASURE  
FROM OPERATIONAL  
IMPROVEMENTS TO  
TECHNOLOGICAL  
DEVELOPMENTS  
TO MARKET-BASED  
MEASURES AND  
ALTERNATIVE FUELS  
ARE NEEDED.

FOREWORD:

# CHRISTIANA FIGUERES

*EXECUTIVE SECRETARY OF THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC).*

**SINCE THAT FIRST FLIGHT AT KITTY HAWK BY THE WRIGHT BROTHERS, THE AVIATION SECTOR HAS GROWN EXPONENTIALLY AND EMERGED AS A GLOBAL FORCE FOR GOOD, LINKING COMMUNITIES BIG AND SMALL, DRIVING ECONOMIC GROWTH, AND FACILITATING BETTER CROSS-CULTURAL UNDERSTANDING AMONG PEOPLES OF THE WORLD.**

Accompanying this growth has been an increase in the sector's carbon footprint.

While remaining a relatively small percentage of global emissions, it is nevertheless a significant contributing factor to our planet's changing climate with a potential for aviation emissions to keep rising sharply if we continue business as usual.

Nations are about to reach a new climate change agreement that puts the world on track to stay below a temperature rise of 2°C degrees and allow all countries and industries to contribute to that success by building a clean, efficient and sustainable economic future.

The goal is essential but the benefits of taking part represent a transformational opportunity for all sides.

That's why we need the aviation sector, which has always shown a remarkable ability to be one step ahead in the design and implementation of new technologies and ways of operating, literally to take flight and apply these formidable skills to the challenge.

The aspirational goal of carbon-neutral growth beyond 2020, as expressed by countries under the International Civil Aviation Organization, is a promising start and a contribution to climate science, which requires the world to reach carbon neutrality as soon as possible in the second half of this century.

To achieve this in aviation, every measure from operational improvements to technological developments to market-based measures and alternative fuels are needed.

Aviation technology innovations have transformed the way we live. They helped get us to the moon. Cutting emissions rapidly and making ourselves resilient to climate change is our generation's moon landing. Help us get there and land safely.





# THE SOLUTIONS

THIS REPORT CONTAINS 100 SOLUTIONS ACROSS A RANGE OF CATEGORIES. IT IS JUST A SAMPLE OF THE WORK TAKING PLACE TO IMPROVE FUEL EFFICIENCY AND REDUCE CO<sub>2</sub> EMISSIONS ACROSS THE INDUSTRY. THE COMPANIES MENTIONED BELOW ARE THOSE THAT SUBMITTED A CASE STUDY ON THE SUBJECT – OFTEN THEIR EFFORTS ARE BEING REPLICATED AT PARTNERS AROUND THE WORLD.

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# CLIMATE ACTION TAKES FLIGHT

**SIX YEARS AGO, THE AVIATION INDUSTRY TOOK AN UNPRECEDENTED STEP – IT AGREED A SET OF GLOBAL CLIMATE GOALS, THE FIRST FOR ANY INTERNATIONAL TRANSPORT SECTOR AND IT AGREED A STRATEGY TO ACHIEVE THEM. THE GOALS WERE AMBITIOUS BUT THEY ALSO CONVEYED THE MESSAGE THAT THE ENTIRE AIR TRANSPORT COMMUNITY WAS ENGAGED: AIRPORTS, AIRLINES, AIR TRAFFIC MANAGEMENT AND THE MAKERS OF AIRCRAFT AND ENGINES ALL WORKING TOGETHER TO ADDRESS THE URGENT CHALLENGE OF CLIMATE CHANGE.**

Since then, the world's governments have been locked in climate negotiations which have developed into a mirror image of our own pathway.

Pre-2020 ambition is evident from the aviation sector in the work that has taken place to implement the efficiency measures needed to meet our first goal. Much of that work is detailed in this report. Whilst the 101 case studies here provide only a snapshot of the many thousands of projects taking place across the industry, they do give a good flavour of the variety and scope of the industry's efforts.

Some actions are big: such as bringing a new aircraft to service; and some are smaller, but significant in their own way. This is a reflection of the aviation industry as a whole. We serve thousands of communities and over three billion passengers a year, but each journey tells its own unique story. It is also a reflection of what will be needed to tackle the climate challenge on a broader level. All parts of the economy and all parts of society have a role to play, with both small day-to-day actions and large shifts in thinking.

The companies mentioned in this report are the tip of the iceberg of a massive energy efficiency movement in aviation.

Our mid-term objective of carbon-neutral growth from 2020 now aligns very well with the UNFCCC's deadline for the start of a new climate agreement. In order to meet our goal, we will need governments to agree to the development of a global market-based measure at the 2016 International Civil Aviation Organization (ICAO) Assembly in one year's time. It is a vital step towards a sustainable future for aviation and, once agreed, it will be the first time there has ever been a global market-based measure of any sort.

In the long-term, we have said we will halve CO<sub>2</sub> emissions from air transport by 2050, based on 2005 levels. It's an ambitious goal but work is already underway to achieve it. Some good examples are provided in the alternative energy section where companies are really stepping up to the

challenge of developing our next-generation energy source. Starting from a very modest base today, these low-carbon fuels will provide a great deal of our needs in the future. The examples and case studies in this publication provide not only evidence of climate action taking place across the sector, but also a set of suggestions to those industry partners looking for inspiration on how to improve the efficiency of their operations. We urge everyone in the industry to strive to be best in class in this area, but let's also share with each other the lessons learned and scale up our ambition where possible. We hope that this publication will help those efforts.



**Michael Gill**  
*Executive Director*  
*Air Transport Action Group, Geneva*












# MAP OF GLOBAL AVIATION CLIMATE ACTION

OVER 400 ORGANISATIONS ARE INVOLVED IN AVIATION CLIMATE SOLUTIONS IN THIS REPORT. THEY ARE BASED IN 65 DIFFERENT COUNTRIES WORLDWIDE. BUT WE ARE A GLOBAL INDUSTRY AND OUR SOLUTIONS TRAVEL EVERYWHERE, EVERY DAY. THERE'S A VERY GOOD CHANCE YOU'VE FLOWN ON AN AIRLINE OR TRAVELLED THROUGH AN AIRPORT UNDERTAKING CLIMATE ACTION RECENTLY.





ALL PARTS OF THE INDUSTRY ARE INVOLVED AND THE SOLUTIONS FEATURED IN THIS PUBLICATION ARE SIMPLY A SNAPSHOT OF ACTION TAKING PLACE IN MANY OTHER PARTNERS AROUND THE WORLD.

## KEY TO ICONS USED IN REPORT






### WHICH CATEGORY OF CLIMATE ACTION?

-  COLLABORATION
-  INNOVATION
-  ALTERNATIVE ENERGY
-  EFFICIENCY IN THE AIR
-  EFFICIENCY ON THE GROUND
-  PEOPLE
-  BUILDING AND CONSTRUCTION
-  STEP-CHANGE TECHNOLOGY
-  CARBON MANAGEMENT

### UNDER WHICH OF THE INDUSTRY'S FOUR Pillars OF CLIMATE ACTION DOES THE SOLUTION SIT?


-  TECHNOLOGY AND ALTERNATIVE FUELS
-  OPERATIONS
-  INFRASTRUCTURE
-  MARKET-BASED MEASURES

### WHICH PART OF THE INDUSTRY IS LEADING ON THIS SOLUTION?

-  AIRPORT
-  AIRLINE
-  AIR TRAFFIC MANAGEMENT
-  MANUFACTURER
-  SUPPLIER







WE WANTED TO EXPLORE THE VARIETY OF CLIMATE ACTION TAKING PLACE WORLDWIDE IN THE SECTOR. IN EARLY 2015, WE ASKED INDUSTRY COLLEAGUES TO REPORT ON THEIR CLIMATE ACTION PROJECTS AND ALMOST 200 SUBMISSIONS WERE RECEIVED. WE ASSESSED EACH OF THEM BASED ON THEIR POTENTIAL FOR MITIGATION OF AVIATION'S CO<sub>2</sub> EMISSIONS AND GAVE PRIORITY TO THOSE CASE STUDIES WHICH ARE: **REPLICABLE** BY OTHER PARTNERS ACROSS THE INDUSTRY; PARTICULARLY **INNOVATIVE; COLLABORATIVE;** AND **SCALABLE** TO FURTHER INCREASE FUEL AND EMISSIONS SAVINGS.

*All prices in this publication are in United States dollars.*

*All measures are metric, aside from normal aviation terms in nautical miles (distance) and feet (referring to altitude).*

*Tonnes of CO<sub>2</sub> = metric tonnes.*



AIR TRANSPORT IS AN ESSENTIAL CONNECTOR OF THE MODERN WORLD, BRINGING TOGETHER PEOPLE AND BUSINESS. OVER 3.3 BILLION PASSENGERS A YEAR, A THIRD OF WORLD TRADE BY VALUE AND HALF OF ALL INTERNATIONAL TOURISTS TRAVEL BY AIR. WE SUPPORT AROUND 60 MILLION JOBS AND 3.5% OF GLOBAL GDP. BUT WE ALSO PRODUCE AROUND 2% OF THE WORLD'S HUMAN-INDUCED CO<sub>2</sub> EMISSIONS.

AS AIR TRAFFIC GROWS, PARTICULARLY TO POWER THE EMERGING ECONOMIES OF THE WORLD, HOW DO WE BALANCE THAT GROWTH WITH THE OBLIGATION ALL SECTORS FACE TO CONTROL THEIR CLIMATE IMPACTS?

HERE IS WHAT AVIATION IS DOING...

THE THREE GLOBAL SHORT-, MEDIUM- AND LONG-TERM GOALS:

## GOAL 1

PRE-2020 AMBITION

**1.5% AVERAGE ANNUAL FUEL EFFICIENCY IMPROVEMENT FROM 2009 TO 2020.**

PROGRESS

Currently tracking well above goal, although figure expected to normalise.

HOW IS INDUSTRY ACHIEVING THIS?

Through actions outlined in this report in the first three pillars: new technology, more efficient operations and better use of infrastructure.

T O I

## GOAL 2

IN LINE WITH THE NEXT UNFCCC COMMITMENT PERIOD

**STABILISE NET AVIATION CO<sub>2</sub> EMISSIONS AT 2020 LEVELS THROUGH CARBON-NEUTRAL GROWTH.**

PROGRESS

Industry is pushing for action at an intergovernmental level.

HOW IS INDUSTRY ACHIEVING THIS?

Through the four-pillar strategy, including a global market-based measure at the International Civil Aviation Organization (ICAO).

T O I + M

## GOAL 3

ON THE 2°C PATHWAY

**REDUCE AVIATION'S NET CO<sub>2</sub> EMISSIONS TO 50% OF WHAT THEY WERE IN 2005, BY 2050.**

PROGRESS

Significant research efforts underway.

HOW IS INDUSTRY ACHIEVING THIS?

Two main areas of action: development of sustainable alternative aviation fuels; research into future design concepts by aircraft and engine manufacturers.

T O I

UNDERPINNED BY FOUR PILLARS OF CLIMATE ACTION:

T

TECHNOLOGY AND SUSTAINABLE ALTERNATIVE FUELS

O

OPERATIONS

I

INFRASTRUCTURE

M

MARKET-BASED MEASURES

THIS IS A JOINT EFFORT, WITH COLLABORATIVE ACTION TAKING PLACE ACROSS THE AVIATION SECTOR. AIRPORTS, AIRLINES, AIR TRAFFIC MANAGEMENT ORGANISATIONS, THE MANUFACTURERS OF AIRCRAFT AND ENGINES AND PARTNERS ACROSS THE SUPPLY CHAIN ARE WORKING TOGETHER ON ACTION THAT WILL REDUCE AVIATION CO<sub>2</sub> EMISSIONS. MANY OF THEM ARE OUTLINED IN THIS PUBLICATION, BUT THIS SECTION PROVIDES AN OVERVIEW OF THE RESULTS OF THAT ACTION.

## AVIATION'S EMISSIONS PROFILE

Air transport generated 724 million tonnes of CO<sub>2</sub> in 2014. This is around 2% of the 36 billion tonnes of CO<sub>2</sub> generated by human activities every year. Of the total, 65% is from international aviation activity and 35% from domestic.

Historically, international transport emissions from aviation and shipping have not been included in the international climate regime administered by the United Nations Framework Convention on Climate Change (UNFCCC), as these emissions fall outside of the scope of nationally-determined climate action. Instead, these emissions have been dealt with by the International Civil Aviation Organization (ICAO) and shipping's equivalent, the International Maritime Organisation.

## EFFICIENT ALREADY... BUT MORE EFFICIENCY IS ON THE WAY

Our focus on efficiency has seen a halving of fuel use per tonne kilometre travelled since 1990. In other words, your flight today will generate around 50% the CO<sub>2</sub> per kilometre compared

to the same flight back in 1990. This progress has not just been through technological advances – the operational and infrastructure measures that make up our framework also play an important role.

## SERVING THE WORLD

Fuel and CO<sub>2</sub> efficiency on an individual flight basis have been making impressive progress. But overall emissions from aviation have continued to rise, as traffic (both passenger and cargo) has grown. Most growth has been taking place in emerging economies, as they recognise the benefits of the connectivity that air travel provides. Trade and tourism are important drivers of economic development around the world and as middle-classes continue to grow, their appetite to see the world also needs to be catered for.

The industry's climate action framework is designed to help balance the two goals – economic growth through connectivity and reducing climate impacts in the long run. Partners within and outside the air transport sector will need to work together to achieve the aims, but the outcome will be worth the effort.

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THIS IS A BRIEF SUMMARY OF OUR BROADER ACTION AGENDA, WHICH CAN BE DOWNLOADED AT

[WWW.ENVIRO.AERO/CLIMATEACTION](http://WWW.ENVIRO.AERO/CLIMATEACTION)

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THE STORIES IN THIS REPORT OUTLINE THE ACTION TAKING PLACE ALREADY ACROSS THE SECTOR.

# MEETING GOAL ONE: 1.5% IMPROVEMENT IN FUEL EFFICIENCY PER ANNUM

## T NEW TECHNOLOGY

**Aviation is a technology-driven business. And technology can provide the biggest improvements in fuel efficiency. Since the start of jet travel, each generation of aircraft has cut fuel use and subsequently CO<sub>2</sub> emissions. It is these step-changes that bring about large efficiency shifts across the global airliner fleet.**

Each new generation of aircraft brings around 15-20% savings in fuel and CO<sub>2</sub> from the aircraft it replaces. Once a new model of plane enters service, they can have a profound impact on the carbon footprint of the sector. For example, after years of financial difficulty, airlines in the United States have recently replaced a lot of older aircraft with brand new, fuel efficient planes. This is one of the reasons why absolute emissions from US airlines dropped by 8% between 2000 and 2014, while traffic rose by 20%.

Globally, over 9,500 new aircraft have been delivered since 2009 at a cost of \$1 trillion. This is a significant investment in a new fleet. Whilst 44% of these aircraft are to cope with growth in traffic, mainly in emerging economies, the rest will replace older less efficient aircraft being retired from the fleet.

## O MORE EFFICIENT OPERATIONS

**Once aircraft are in service, there are a range of things that can be done to reduce the emissions from their operation. A lot of it has to do with cutting the weight carried on board: more weight means more fuel used. But it can also mean flying each flight more efficiently, and even using electricity instead of jet fuel when on the ground.**

There are around 27,000 aircraft already in service worldwide. Whilst a number of them are the latest technology, many older planes can have efficiency measures undertaken on them to improve fuel use and CO<sub>2</sub> reductions, before they are replaced with new planes.

## I BETTER INFRASTRUCTURE

**Infrastructure is the third main pillar of climate action in aviation. It represents an ideal opportunity for significant fuel efficiency improvements, coupled with capacity enhancements. Air traffic management organisations are taking proactive action to cut emissions, both individually and in partnerships. However, much of the potential relies on government action on systematic changes in air traffic management and investment in new technology and procedures.**

Airports have been taking action too, much of it to reduce energy consumption and fossil fuel use in their buildings or for their operational activities, but there are also ways they can help airlines reduce jet fuel use.

The biggest gains can come through development of the air traffic system away from a strict 'control' model to a 'management' concept that gives greater autonomy to individual flights without compromising safety. There are a number concepts and techniques by which air traffic management can reduce aviation CO<sub>2</sub> emissions. Many are already being implemented and there is impressive action already taking place in many parts of the world, but there is also a more systematic need to introduce new technology and techniques, not to mention changing the institutional environment for many air traffic management organisations.



## MEETING GOAL TWO: STABILISING CO<sub>2</sub> EMISSIONS FROM 2020

### **M** CARBON-NEUTRAL GROWTH

**Once the first three pillars have been maximised, market-based measures can help bring down aviation emissions to meet the 2020 goal. The industry has taken the unprecedented step of asking for a global market-based measure to be developed through the International Civil Aviation Organization (ICAO), a process now well underway. This will be used, along with the other pillars of action, to meet the industry-wide goal of carbon-neutral growth from 2020.**

Aviation is a global sector that relies on global standards and solutions for so many issues. On environmental issues, too, we need a standard approach – air traffic management systems must be compatible with aircraft that could fly across 20 or 30 different pieces of airspace in a single day – and the same can be said for development of a market-based measure (MBM) for the sector.

#### **Avoiding the patchwork**

To avoid a potential patchwork of different measures popping up in countries and regions around the world, the aviation industry took a pragmatic decision to push for the development of one global MBM, to be designed under the direction of States meeting at ICAO. A single global scheme will help ensure environmental integrity. It will also avoid the market distortion which would be caused if some airlines need to pay for emissions and some are exempt, based on whether they are registered in developing or developed nations.

The industry has therefore called for one global scheme for international flights, to come into effect from 2020. Governments, civil society and the industry are currently working under the auspices of ICAO to design the framework of such a scheme, which will be presented to the next ICAO Assembly in September 2016.

#### **An important part of any scheme**

The industry has set out some criteria it considers important in any MBM, which should: maximise environmental integrity; be cost-efficient (both to the industry and to governments); not be used to raise general revenues or suppress the demand for air travel (which breaches the Chicago Convention and does not meet the needs of developing nations which need aviation connectivity to power economic growth); minimise competitive distortion; and be easy to implement and administer.

The aviation industry has a stated preference for carbon offsetting as the mechanism, as it would be easiest to implement, most cost-efficient and, importantly, the fastest to establish given the 2020 deadline.

#### **Political challenges**

Given the difficulty in reaching multilateral consensus at the UN climate talks, particularly over issues concerning differentiated responsibility for climate action between developed and developing countries, the industry has been very encouraged by the positive approach taken by parties around the ICAO table. There is a general understanding that, for aviation at least, a global approach is needed.

The creation of a viable global MBM for aviation is a formidable challenge, but it should be seen in the context that this is the first time such an endeavour has been attempted. ICAO is well placed and well advanced in its efforts to adopt a global MBM.

## MEETING GOAL THREE: 50% REDUCTION IN NET CO<sub>2</sub> EMISSIONS BY 2050

### **T** SUSTAINABLE ALTERNATIVE FUELS

**Until very recently, the only source of energy for aviation has been traditional jet fuel. It has served us very well since we first started flying jets. But we need to diversify our energy supply and move away from fossil sources and the transition has already begun.**

So far, over 2,000 commercial flights by more than 20 airlines have taken place using alternative aviation fuel from renewable and sustainable sources. The cost of the fuel is still high, mainly due to the small batches being produced. To bridge the gap between small-scale production and commercialisation, several airlines have taken a bold approach and signed forward purchase agreements for up to 340 million litres of fuel per year with alternative fuel suppliers, over periods as long as ten years.

The alternative fuels being investigated for aviation use are so-called 'drop-in' fuels which share almost the same properties as current jet fuel. As new supplies come on stream, they can be blended with traditional fuel in increasing quantities. It also means that alternative aviation fuel can be used in high blend percentages (whilst there is currently a technical blend limit, up to 100% will be able to be used in future).

Sustainability is at the heart of aviation's efforts on alternative fuels. Although the CO<sub>2</sub> benefits vary according to feedstock, transport and processing needs, studies have shown that some of the options being looked at for aviation have a CO<sub>2</sub> reduction of up to 80% compared with traditional jet fuel.

### **O** RADICAL NEW TECHNOLOGY

**Every year, aircraft and engine manufacturers spend upwards of \$15 billion on efficiency research and development. Some of it looks at improvements to existing models, a lot is dedicated to the next series of aircraft entering service in 5-10 years' time and some looks even further out, to future generations.**

Manufacturers of aircraft and engines spend \$15 billion a year on research to produce more efficient aircraft. It is this investment which is already supporting the wave of new-generation technology enter the fleet over the past few years and is already working on long-term technology advances.

Further out, researchers are looking into radical new designs which use the latest materials to build even more efficient aircraft, engines and fuels. Some of these new designs could enter into service from around 2035 and continue the legacy of step-changes in aircraft efficiency.



**THIS PUBLICATION SHOWS THAT THE INDUSTRY IS ALREADY TAKING IMPRESSIVE CLIMATE ACTION. ON OUR OWN INITIATIVE, WE HAVE AVOIDED 8.5 BILLION TONNES OF CO<sub>2</sub> EMISSIONS SINCE 1990 AND HALVED FUEL USE PER TONNE KILOMETRE. WE HAVE DEVELOPED AND LAUNCHED 12 NEW FUEL-EFFICIENT AIRCRAFT TYPES AND THEIR ENGINES IN THE LAST DECADE. AIRLINES HAVE SPENT A TRILLION DOLLARS BUYING THEM SINCE 2009. AIR TRAFFIC MANAGEMENT AND AIRPORT COMPANIES HAVE ENGAGED IN IMPRESSIVE COLLABORATIVE ACTION. AND WE HAVE SET AMBITIOUS TARGETS FOR CONTINUING THIS WORK IN THE LONG-TERM.**

But, as a heavily-regulated sector, there is only so much we can do ourselves. To accelerate action even further, we need a supportive environment from policymakers. Through the following key areas, we can ensure that the potential to halve aviation emissions by 2050, based on 2005 levels, can be achieved. Importantly, many of these policy responses will also reap benefits under the sustainable development agenda, ensuring that access to mobility is available to as many citizens as possible, but with as little environmental impact as possible.

Each of these suggestions should be seen as part of 'smart regulation' which: solves real, not imagined problems; takes advantage of broad consultation – including with industry; rigorously weighs costs and benefits with a keen awareness to avoid unintended consequences; and respects global standards where they exist.

#### **AIR TRAFFIC MANAGEMENT INVESTMENT AND REFORM**

Many air traffic service providers are constrained by governance arrangements from reforming the way they are structured and operate. In order to realise the great efficiencies possible in streamlining air traffic systems, a new way of thinking needs to be pursued.

#### **SUPPORT FOR RESEARCH AND DEVELOPMENT: NEW TECHNOLOGY AND OPERATIONS**

Advanced research can help bring about new technologies, materials, operational practices and infrastructure opportunities, if supported by government direction.

#### **DESIGNING AND IMPLEMENTING A GLOBAL MARKET-BASED MEASURE AT ICAO**

Governments need to support the work being undertaken at ICAO on developing and then implementing a global MBM for aviation. This work is ongoing now and needs to be delivered by the 2016 ICAO Assembly.

#### **IMPROVED INTERMODAL TRANSPORT PLANNING**

Transport is a system and whilst aviation is a unique global mode of transport, the system as a whole must be planned and designed for maximum efficiency. High-speed rail can play a positive role in some city-pair routes, although aviation will always be needed for longer journeys or to connect less dense urban centres.

#### **SUSTAINABLE ALTERNATIVE AVIATION FUELS**

A key component of future aviation sustainability will be the use of alternative aviation fuels. Whilst air transport is not looking for subsidies, there are some reasonable policy incentives that can help get the sustainable alternative aviation fuel sector going.

**THIS IS A BRIEF SUMMARY OF OUR BROADER ACTION AGENDA,  
WHICH CAN BE DOWNLOADED AT [WWW.ENVIRO.AERO/CLIMATEACTION](http://WWW.ENVIRO.AERO/CLIMATEACTION)**







# COLLABORATION

**COLLABORATION IS INHERENT IN MOST AIR TRANSPORT OPERATIONS.  
WE COLLABORATE TO GET 100,000 FLIGHTS A DAY TO THEIR DESTINATION.  
AND WE ARE COLLABORATING TO REDUCE CO<sub>2</sub> EMISSIONS.**

Whilst most of the solutions in this book are examples of collaboration, these stood out as being particularly noteworthy projects, bringing together aviation partners as well as those in academia, other business sectors and governments. The climate challenge requires co-ordinated efforts being made by all sectors of business and society acting together.

These examples should inspire you to set up your own group of experts.



# ELECTRIC GROUND MOVEMENT

## E-PORT AN (E-PORT ON) joint initiative by Lufthansa Group and Fraport

Strom Bewegt (Hessian State Government), Modellregion Elektromobilität Rhein-Main (Federal Government of Germany).



[www.e-port-on.com](http://www.e-port-on.com)



**EXPECTED TO SAVE  
AROUND 1,500 TONNES  
OF CO<sub>2</sub> PER YEAR BY  
2020, NEARLY 4% OF THE  
TOTAL CO<sub>2</sub> EMISSIONS OF  
FRANKFURT AIRPORT.**

**E-PORT AN IMPROVES  
LOCAL AIR QUALITY  
MARKEDLY.**

**E-PORT AN LOWERS  
NOISE LEVELS ON THE  
GROUND NOTICEABLY FOR  
BOTH APRON STAFF AND  
SURROUNDING AREAS.**

**FOCUSSING ON EMISSIONS IN THE AIR, IT IS EASY TO FORGET THE CO<sub>2</sub> SAVING OPPORTUNITIES ON THE GROUND. IN ITS E-PORT AN INITIATIVE, FRAPORT AND THE LUFTHANSA GROUP AIM TO POWER ALL GROUND MOVEMENT WITH ELECTRICITY.**

The E-PORT AN partnership started in 2012 with the goal of converting ground movements from fuel-burning to electric propulsion wherever feasible and sensible.

The ground handling fleet currently comprises almost 300 vehicles. Vehicles under review include those that carry passengers, personnel, baggage, cargo, catering, fuel, jet bridges and mobile stairways.

To allow engines to remain switched off until the aircraft is at the head of the runway, Lufthansa and partners are testing their developments of two electric towing vehicles for aircraft: the pilot-driven TaxiBot (see page 35 for information); and the eSchlepper, which is the world's first aircraft tug for towing wide body aircraft over distances of up to seven kilometres from maintenance hangars to apron positions. This saves significant amounts of diesel and is expected to reduce maintenance by about 50%.

Further to the electric towing vehicles, E-PORT AN is working on: an eTaxi system which is fitted onto the landing gear, replacing conventional aircraft engine taxiing with an auxiliary power unit electric drive. The eLift catering truck, which uses both electric drive and lift; Fraport is also deploying prototypes of an electric container transporter, a solar-driven passenger stairway, nine electric pallet loaders as well as two mini buses and 30 electric cars; and numerous charging points installed throughout the airport apron for the regular cars used by ground personnel.

The E-PORT AN project was honoured with the prestigious Green Tec Award in the category Aviation in 2014.



# MORE CHAT = LESS FUEL



**ENSURING THAT FLIGHTS IN AND OUT OF AIRPORTS ARE CARRIED OUT SAFELY AND EFFICIENTLY IS AN EXTREMELY COMPLICATED BUSINESS INVOLVING MANY DIFFERENT PARTIES. FOR AIRPORT TRAFFIC TO RUN SMOOTHLY, AND WITH MINIMUM FUEL WASTAGE, COMMUNICATION AND COLLABORATION BETWEEN ALL PARTNERS IS ESSENTIAL.**

Issues such as delays at the runway and unnecessarily long taxi time can impact significantly on fuel burn and CO<sub>2</sub> emissions. Lack of information sharing can also result in low levels of slot adherence, causing additional time in the air for aircraft as they await their turn to land.

To cut down on these sorts of inefficiencies, Eurocontrol, working together with airports in Europe, has developed the concept of airport collaborative decision-making (A-CDM). The process to becoming an A-CDM airport has been developed over time and follows a defined set of steps which bring together the different on-airport partners and instils information sharing protocols and channels between them. This means that all parties get all-important arrival and departure information at the same time and allows the different organisations involved in a flight to adjust their schedules and resourcing as the latest information comes to hand.

The benefits are visible at a network level, with more accurate take-off information feeding into the air traffic flow and capacity management system run by the Eurocontrol Network Manager. The network will be able to use the available capacity more efficiently. More effective use of slots results in reduced delays, improved predictability of events during a flight and optimised use of resources at airports.

Munich Airport was the pioneer of A-CDM when it began its programme in 2007. Following the success in Munich, Eurocontrol and ACI Europe jointly launched a wider deployment programme, which has been gradually rolled out across Europe. There are now 35 airports in Europe at various stages of implementing A-CDM, with 16 airports fully-integrating the concept in their procedures. The network manager's goal is to have a minimum of 42 A-CDM airports in Europe by 2019.

## Eurocontrol

Civil Air Navigation Services Organisation (CANSO), Airport Council International – Europe, International Air Transport Association and partners.



[www.eurocontrol.int](http://www.eurocontrol.int)

[www.euro-cdm.org](http://www.euro-cdm.org)

**AT BRUSSELS AIRPORT, THE ABILITY TO ABSORB DELAYS AT THE GATE HAS RESULTED IN AN ANNUAL CO<sub>2</sub> SAVING OF 17,022 TONNES AND THE AVERAGE TAXI TIME WAS REDUCED BY THREE MINUTES.**

**AT PARIS CHARLES DE GAULLE, CO<sub>2</sub> EMISSIONS HAVE BEEN REDUCED BY 44 TONNES PER DAY COMPARED TO PRE- A-CDM LEVELS.**







# AIM HIGH

## Airport Authority Hong Kong (AAHK)

Over 45 airport business partners including airlines, hotels, airline caterers, government departments, cargo handlers and ground services providers.



[www.hongkongairport.com](http://www.hongkongairport.com)



**AIRPORT-WIDE CARBON INTENSITY WAS REDUCED BY 17.9% IN 2013 COMPARED TO THE 2008 BASELINE.**

**EMISSIONS OF NITROGEN OXIDES AND PARTICULATE MATTER ON THE APRON ARE ALSO REDUCED THROUGH IMPLEMENTATION OF AN AUXILIARY POWER UNIT USE BAN.**

**THE LED REPLACEMENT PROGRAMME ALSO DELIVERED SUBSTANTIAL SAVINGS IN MAINTENANCE COSTS THAT MORE THAN COVERED THE HIGHER COST OF LEDS AND FITTINGS.**

**SOMETIMES THE BEST WAY OF ACHIEVING A GOAL, IN THIS CASE, CUTTING CO<sub>2</sub> EMISSIONS, IS BY SETTING FIRM TARGETS. WHILE THE AVIATION INDUSTRY AS A WHOLE HAS SUCH GOALS, HONG KONG INTERNATIONAL AIRPORT HAS TAKEN UP THE CARBON-REDUCTION CHALLENGE WITH GOALS OF ITS OWN.**

The HKIA Carbon Reduction Programme is a voluntary ongoing, multi-stakeholder programme involving AAHK and 46 airport business partners. The programme aims to reduce airport-wide carbon intensity by 25% between 2008 and 2015.

While AAHK accounts for approximately 40% of HKIA's carbon emissions, the remaining 60% come from business partners. In 2011, AAHK developed an online reporting platform and free audit service, and the partners are responsible for identifying and implementing their own carbon reduction measures.

AAHK also instituted a number of projects to reduce emissions and achieve the target.

In 2009, AAHK began Hong Kong's largest ever LED replacement programme to replace more than 100,000 traditional lights with LEDs in terminal buildings. Each year the project saves around 15 million kilowatt hours of electricity and reduces carbon emissions by over 9,000 tonnes. A major reconfiguration of the chillers also delivered substantial reductions.

In December 2014 the airport banned the use of aircraft auxiliary power units at frontal parking stands. To facilitate the ban, the airport invested over \$7.8 million to upgrade all its fixed ground power and pre-conditioned air systems. In addition, the airport engaged airlines and line maintenance operators in the development of the new policy through preparatory meetings and trials.

The airport authority also promotes the use of electric vehicles and electric ground support equipment at the airport, investing \$1.5 million for 158 electric vehicle chargers and 56 electric ground support equipment chargers.



# CONGESTION-BUSTING THROUGH COLLABORATION



Port Authority of New  
York and New Jersey

Saab-Sensis.



[www.panynj.gov](http://www.panynj.gov)

**SURFACE CONGESTION MANAGEMENT IS GATHERING MOMENTUM AS A RECOGNISED METHOD OF CUTTING EMISSIONS AND REDUCING DELAYS. PARTNERS AT JFK AIRPORT RAISE STANDARDS EVEN HIGHER WITH A UNIQUE COMBINATION OF SOPHISTICATED TECHNOLOGY AND COLLABORATIVE DECISION-MAKING FOR STERLING RESULTS.**

The Port Authority of New York and New Jersey, in partnership with airlines operating at JFK, deployed the Surface Congestion Management Program in 2010 and has been making continual improvements to the system ever since. The number of parties involved in making the system successful is unprecedented as it requires teamwork between air traffic control, airline ramp operators, central airline control centres and the Port Authority.

The concept behind the programme is to establish the number of aircraft allowed to taxi during a given time period, based on variables such as weather, time of day and regional air traffic. The system uses sophisticated hardware and software technology in conjunction with collaborative decision-making.

With the goal to minimise the departure queue at JFK, aircraft are held at the gate or a remote holding with engines off, rather than in a departure line with engines idling and awaiting take-off. Through the programme, flights are placed into a virtual queue, or 15 minute departure 'buckets,' based upon coordination between ramp personnel, the metering desk, and air traffic control.

The project proves that using such a system airport-wide and year-round (rather than for specific airlines and in certain weather conditions) can bring major positive benefits for all parties – and the climate.

**ESTIMATED ANNUAL SAVINGS OF 20 MILLION LITRES OF AVIATION FUEL, 48,000 TONNES OF CO<sub>2</sub>.**

**THE PROGRAMME CUTS DELAYS BY REDUCING CONGESTION ON THE AIRFIELD, REDUCING 17,000 HOURS OF TAXI-OUT TIME.**

**IT IS ESTIMATED THE PROGRAMME SAVES AIRLINES \$7.64 MILLION IN FUEL PER YEAR.**





# BRINGING US AIRSPACE INTO THE 21<sup>ST</sup> CENTURY

Federal Aviation  
Administration



[www.faa.gov/nextgen](http://www.faa.gov/nextgen)

CO<sub>2</sub> SAVINGS FROM  
NEXTGEN ARE FORECAST  
TO BE 52.6 MILLION  
TONNES BY 2030.



**TO UPDATE THE AIR TRANSPORTATION SYSTEM IN THE UNITED STATES AND INCREASE THE OVERALL EFFICIENCY OF FLIGHTS TRAVELLING THROUGH AMERICAN AIRSPACE, THE FEDERAL AVIATION ADMINISTRATION HAS INVESTED IN A MASSIVE MODERNISATION PROGRAMME CALLED NEXTGEN.**

The programme, in which the United States plans to invest roughly \$29 billion, is part of a root-and-branch revamp of the national airspace system. It is made up of many projects deployed throughout the country.

Working in close partnership, the US aviation industry and the FAA have identified four overarching priorities to focus on in the next three years through which they will achieve a higher level of efficiency and cut down on fuel burn.

The first of these, improved multiple runway operations, allows for more arrivals and departures, cutting down on wasteful time in the sky for aircraft as they wait for an opportunity to land.

The second priority is data communications. Currently, the communications system between pilots and controllers remains the same as it was in the mid-20th century, with audio channels being used to provide instructions by voice. While this has worked well for decades, far more information can be delivered quickly and accurately by messages transferred in text form and displayed in the cockpit.

The third priority is performance-based navigation, which defines more accurate and direct flight paths for pilots to follow by using satellite-based technology.

The fourth priority of the partnership is to improve surface operations by sharing more data with stakeholders and working to increase predictability and efficiency on the surface.

Each of these improvements is taking place in various forms and locations throughout the USA and continues to help reduce the level of CO<sub>2</sub> emissions created by aircraft in US airspace.



# ALL IN IT TOGETHER



International Civil  
Aviation Organization



[www.icao.int](http://www.icao.int)

**IN 2010, WORLD GOVERNMENTS AGREED TO AN AMBITIOUS SET OF CLIMATE TARGETS FOR AVIATION THROUGH THE INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO), A UNITED NATIONS SPECIALISED AGENCY. AS PART OF THIS AGREEMENT, ICAO MEMBER STATES WERE INVITED TO SUBMIT 'STATE ACTION PLANS'.**

State action plans assist governments, in partnership with the aviation industry, to identify the appropriate mitigation measures to reduce their local CO<sub>2</sub> emissions derived from air transport activity. They are additionally useful with respect to determining any support which might be needed for States to implement such measures. In turn, the aggregated information contained in a given State's action plan helps ICAO to assess its progress toward the global aspirational environmental goals agreed to at recent assemblies, and to help coordinate the assistance needed for them to do so.

Since the beginning of the ICAO action plan initiative, 79 States representing 83.12% of international traffic have developed and submitted their targets and 11 new States are expected to submit their action plans this year. The high level of participation seen has largely been due to a robust capacity-building programme, and ICAO is continuing to drive further Action Plan progress with a target of 90% of international aviation emissions being covered by 2016.

Partnerships have been essential to the State Action Plan initiative, and ICAO is presently seeking to build upon the capacity-building success which has been achieved to-date on the basis of three key agreements.

The first of these was developed with the European Commission, and aims to assist selected Member States in the African and the Caribbean regions, including three small island developing states (SIDS).

The second partnership, with the Global Environment Facility and United Nations Development Programme, has thus far led to a pilot renewable energy project to be implemented in Jamaica. A key objective here is to demonstrate the environmental and financial feasibility with respect to developing States and SIDS replicating the project.

Thirdly, the Inter-American Development Bank is funding several projects that are leading the development and deployment of alternative aviation fuels, and ICAO is currently exploring new projects with them.

**CAPACITY BUILDING HAS BEEN CARRIED OUT IN 114 ICAO STATES REPRESENTING 85.46% OF GLOBAL AIR TRAFFIC.**

**TO DATE, 79 ICAO MEMBERS HAVE SUBMITTED THEIR STATE ACTION PLANS, ACCOUNTING FOR MORE THAN 83% OF GLOBAL INTERNATIONAL AIR TRAFFIC.**



# CROSS-AIRPORT PARTNERSHIPS FOR SUSTAINABILITY

## Heathrow Airport Limited

World Duty Free Group, AOC, Apcoa, Balfour Beatty, British Airways, Dnata, Ferrovial Agroman, Gate Gourmet, Hertz, JCDcaux, NATS



[www.heathrowairport.com](http://www.heathrowairport.com)



IN 2014, HEATHROW CUT ELECTRICITY USE FROM EXISTING OPERATIONS BY 20 GIGAWATT HOURS THROUGH ENERGY DEMAND MANAGEMENT PROJECTS.

IN 2014, OVER 90,000 LITRES OF USED COOKING OIL WAS COLLECTED, WHICH PRODUCED AROUND 85,000 LITRES OF BIODIESEL.

THE ESTIMATED FINANCIAL SAVING ASSOCIATED WITH ADOPTING MORE ENERGY EFFICIENT DESIGNS WITHIN TERMINAL 2 RETAIL UNITS IS \$348,854.

**RUNNING AN AIRPORT IS LIKE RUNNING A CITY – THE AIRPORT OPERATOR IS MUCH LIKE THE CITY COUNCIL, WITH AIRLINES, GROUND HANDLERS, RETAILERS, CONSTRUCTION COMPANIES AND THE MANY OTHER BUSINESSES ON THE SITE ALL NEEDING TO WORK TOGETHER.**

The Heathrow Sustainability Partnership was established in 2010 to promote collaboration amongst partner companies, with a goal of long-term sustainability improvements at Heathrow Airport. It covers a wide variety of sustainability projects and practices, including waste and water use; safety and health; and energy efficiency.

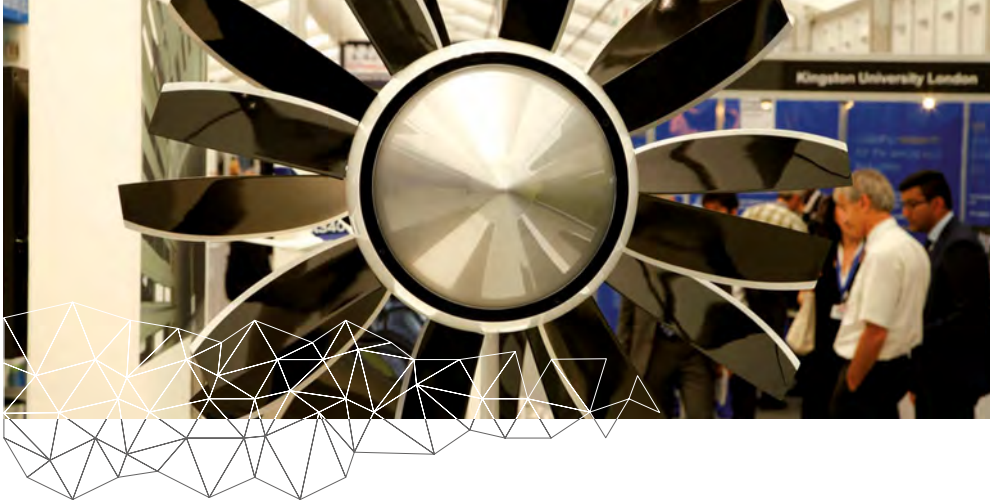
In 2014, partnership member World Duty Free Group led the development of an Energy Code of Practice, to contribute to Heathrow's carbon reduction target of 34% by 2020 (1990 baseline). The code sets out the benefits of energy efficiency and guidelines for airport-based partner companies to benefit from these cost, carbon and energy performance benefits. Partners adopting the code commit to monitoring and then reducing energy use wherever possible, developing targets and ensuring accountability, while Heathrow ensures it reduces power demand from existing assets through energy efficiency measures and exceeding design standards for new-build and refurbishment and increases the supply of low- and zero-carbon heat and power generation across the estate.

Other projects include the Clean Vehicles Partnership which works with airport partner companies to reduce their emissions by minimising the hours and mileage of their use and introducing cleaner, low emissions vehicles.

Another project of note is the Cooking Oil Recycling Club. Heathrow uses a local recycling company to turn cooking oil from the airport's restaurants into biodiesel. This is used by local private hire companies and helps them to cut CO<sub>2</sub> emissions. This is helping the airport move towards achieving its goal to recycle 70% of the waste generated at Heathrow by 2020 and reduce emissions from vehicles at the airport.



# WORKING CLEANLY TOGETHER



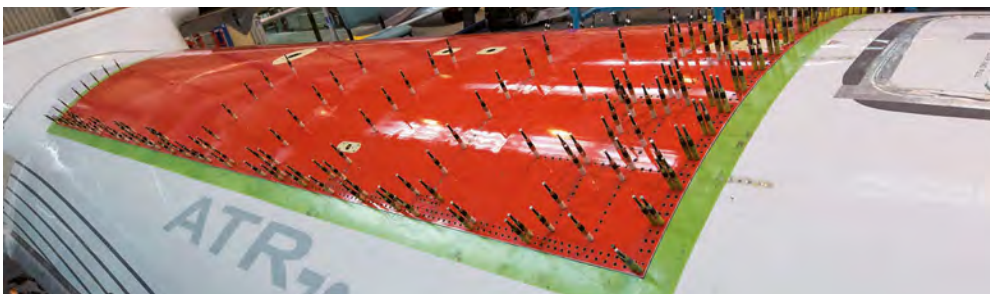
**THE CLEAN SKY JOINT UNDERTAKING BETWEEN THE EUROPEAN COMMISSION AND THE EUROPEAN AVIATION INDUSTRY IS THE LARGEST AERONAUTICS RESEARCH PROGRAMME IN EUROPE. IT IS A COLLABORATIVE INITIATIVE AIMED AT RESEARCHING AND DEVELOPING GROUND-BREAKING TECHNOLOGIES ACROSS NINE KEY FOCUS AREAS TO IMPROVE THE ENVIRONMENTAL PERFORMANCE OF AVIATION.**

Formed in 2008, the Clean Sky Joint Undertaking has been developing a range of new technologies which aim to reduce the CO<sub>2</sub> and noise emissions associated with air transport. During this time Clean Sky has come up with a number of innovative and imaginative ideas to tackle the climate challenge and improve competitiveness and mobility in Europe.

The flagship project of Clean Sky is a new type of propulsion concept called the Counter-Rotative Open Rotor. As the name suggests, the engine consists of two rotor fans that rotate in opposite directions on a turbo engine. The concept is expected to enable reductions of over 35% in fuel burn and CO<sub>2</sub> emissions per passenger-kilometre when compared to the standard reference aircraft. The wind tunnel tests carried out in 2012 showed very encouraging results and plans are already being made for a ground demonstration at the beginning of 2016.

Another example of more general Clean Sky research is their work on efficient navigation systems. The flight management systems have been designed so as to allow for optimised flight paths. These systems, which are used on all modern commercial aircraft to automatically execute the flight plan have been enhanced so as to take all considerations into account and propose the best trade-off to the crew. The system makes automatic calculations relating to speed, altitude and thrust, and then measures the impact these would have on fuel consumption and noise, allowing the crew to decide what aspects are a priority at any given time.

In addition, Clean Sky has a long list of innovative research projects across Europe. The Clean Sky project shows what can be achieved when industry and governments work together with a shared vision and commitment to cleaner aviation technology.



## Clean Sky Joint Undertaking

Airbus, Fraunhofer, Alenia Aermacchi, Agusta Westland, Safran, Thales, Saab, Dassault Aviation, Liebherr, Rolls-Royce and ATR together with SMEs, research centres and academia.



[www.cleansky.eu](http://www.cleansky.eu)

**CLEAN SKY SETS ITS SIGHTS ON REACHING THE AMBITIOUS GOALS SET BY THE ADVISORY COUNCIL FOR AERONAUTICS RESEARCH IN EUROPE (ACARE):**

**- 50% REDUCTION OF CO<sub>2</sub> EMISSIONS THROUGH DRASTIC REDUCTION OF FUEL CONSUMPTION**

**- 80% REDUCTION OF NO<sub>x</sub> (NITROGEN OXIDE) EMISSIONS**

**- 50% REDUCTION OF EXTERNAL NOISE**

**- A GREEN PRODUCT LIFE CYCLE: DESIGN, MANUFACTURING, MAINTENANCE AND DISPOSAL / RECYCLING.**

*As part of the regional aircraft manufacturer ATR's wider environmental work, the company is taking part in the Clean Sky research initiative, through its Italian shareholder Alenia Aermacchi, the coordinator of the green regional aircraft integrated technology demonstrator. In 2015, real-world testing began on several components of the research including new, lightweight, composite panels and vibro-acoustic sensors, which will benefit not only ATR, but also aviation's environmental progress as a whole. The company is also involved in research for the all-electric aircraft initiative, finding ways to replace heavy hydraulic and pneumatic systems with electrical compressors.*





# MAKING A PERFECT FLIGHT

**Air Canada**

Airbus.



[www.aircanada.com](http://www.aircanada.com)



THE PERFECT FLIGHT  
DEMONSTRATED A  
40% CO<sub>2</sub> REDUCTION  
COMPARED TO A  
REGULAR FLIGHT.

DEMONSTRATED A RANGE  
OF PROCEDURES TO CUT  
FUEL USE, MANY NOW  
BEING IMPLEMENTED IN  
DAY-TO-DAY FLIGHTS.

**MAKING REAL GAINS IN CO<sub>2</sub> REDUCTION IS, OF COURSE, ABOUT MORE THAN CARRYING OUT ONE MEASURE. IT'S WHEN YOU ADD ALL THE LITTLE THINGS TOGETHER THAT THE REAL SAVINGS CAN BE MADE. THIS IS EXACTLY WHAT AIR CANADA DID WITH ITS 'PERFECT FLIGHT' PROJECT.**

Bringing together best industry practices: latest aircraft technology; sustainable alternative fuel; optimised routings and flight altitude; and eco-efficient operational procedures, Air Canada was able to demonstrate emissions reductions of over 40% compared to a normal flight.

Making up part of ICAO's 'Flightpath to a Sustainable Future' initiative through which delegates were flown to the Rio+20 conference on sustainable development, the perfect flight took place in June 2012 and was operated on an Airbus A319 travelling from Toronto to Mexico City.

A number of CO<sub>2</sub> saving measures were taken on the flight, including a 50% mix of biojet fuel made from used cooking oil, a range of lighter-weight materials, an engine compressor wash carried out prior to the flight, and optimised routing. Through support from aircraft maker Airbus and coordination with the various air traffic control and airport authorities involved, the flight was an extraordinary example of what is possible.

Air Canada has now started to put into daily practice some of the procedures trialled on that Perfect Flight. It has assisted with setting up studies on feedstock development for Canadian-sourced alternative aviation fuel. Through its Fuel, Energy and Emissions Reduction Programme, the airline has worked with pilots and fuel suppliers to ensure optimal fuelling (rather than just 'filling the tanks' for each flight), which alone saves around 2,500 tonnes of CO<sub>2</sub> per year.

The perfect flight is a fine example of how all airlines can cut out unnecessary CO<sub>2</sub> emissions through collaboration and won Air Canada and Airbus the Eco-partnership Award 2013 from the aviation publication, *Air Transport World*.

# SKY WITHOUT LIMITS



**INTERNATIONAL AIR TRAVEL, BY DEFINITION, INCLUDES CROSSING COUNTRY BORDERS. WITH SEPARATE REGULATORY ARRANGEMENTS AND AIR TRAFFIC MANAGEMENT SYSTEMS, THIS NATURALLY POSES PROBLEMS IN EFFICIENCY. THE EUROPEAN UNION, HOWEVER, IS UNDERTAKING TO OVERHAUL EU AIRSPACE TO SOLVE THIS PROBLEM.**

Europe has some of the busiest skies in the world, with as many as 33,000 flights in the air every day. In 2004, the European Union launched the Single European Sky initiative and its technological pillar, SESAR (Single European Sky Air Traffic Management Research) to modernise and harmonise air traffic management systems through the definition, development and deployment of innovative technological and operational solutions.

Established in 2007, the SESAR Joint Undertaking is a public-private partnership which pools the knowledge and resources of the entire air traffic management community in order to define, research, develop and validate SESAR solutions. The SESAR project brings together industry members and works closely with staff associations, regulators, airport operators, and the scientific community.

One of SESAR's main environmental goals is to simplify flight paths in the EU, which are currently often longer than necessary, due to the need to follow particular corridors and circle destinations waiting for a landing slot. SESAR technology and operational improvements will enable more direct flight paths and smooth descent and climbing, which will eliminate some of these inefficiencies.

SESAR will enable airspace users, air navigation service providers and airport operators to reduce the environmental impact of their operations for each flight phase through better technology and improved communications channels. But the SESAR collaboration is not just about reaching the Single European Sky goal. Each of the projects in the programme is also bringing efficiency measures in its own right. A number of them are featured in this publication.

## SESAR Joint Undertaking

European Union, Eurocontrol and industry partners.



[www.seasrju.eu](http://www.seasrju.eu)

**TARGET: CONTRIBUTE TO THE SINGLE EUROPEAN SKY OBJECTIVE OF REDUCING FLIGHT EMISSIONS BY 10% BETWEEN 2008 AND 2020.**

**IMPROVED SAFETY IN EUROPEAN AIRSPACE.**

**FEWER DELAYS AND EASIER JOURNEYS – A VITAL PART OF EUROPEAN MOBILITY AND INTEGRATION.**







# INNOVATION

**SOMETIMES, IT'S THE SMALL THINGS THAT MATTER. BIG CHANGES ARE GREAT, BUT THE CLIMATE CHALLENGE WILL NOT ONLY BE SOLVED IN GIANT STEPS. SMALL STEPS ARE NEEDED TOO.**

They don't always make the news, but every day hundreds of engineers and experts across the sector are working to save half a percent of fuel or 1% of CO<sub>2</sub> here and there. All these little innovations add up. They can be used on the next generation of new aircraft, or they can be retro-fitted to existing equipment.

These examples should inspire the next aeronautical engineer to try their idea.



# THOSE THINGS ON THE WINGS

## UPS, United Airlines

200 airlines in 100 countries with Airbus, Boeing, Bombardier, Embraer, Aviation Partners Boeing



[www.airbus.com](http://www.airbus.com)



A range of concepts exist for wingtip devices.

MORE THAN 8,300 AIRCRAFT WITH ADD-ON WINGTIP DEVICES ARE NOW IN SERVICE WORLDWIDE. IN TOTAL, OVER 20 BILLION LITRES OF JET FUEL HAS BEEN SAVED, AVOIDING OVER 56 MILLION TONNES OF CO<sub>2</sub> EMISSIONS SINCE THE YEAR 2000.

UPS ADDED WINGLETS TO ITS 767 FREIGHTERS AND REDUCED CO<sub>2</sub> EMISSIONS BY 80,000 TONNES IN 2014 ALONE.

UNITED AIRLINES IS UPGRADING ITS WINGLET-EQUIPPED AIRCRAFT TO NEW SPLIT-SCIMITAR WINGLETS. THE COMBINED WINGTIP-EQUIPPED FLEET IS ESTIMATED TO CUT CO<sub>2</sub> BY 645,000 TONNES PER YEAR. UNITED HAS RETROFITTED OVER 160 AIRCRAFT WITH THE SPLIT-SCIMITAR WINGLETS AND CURRENTLY HAS MORE THAN 370 AIRCRAFT FITTED WITH ADVANCED BLENDED WINGLET TECHNOLOGY.

**ADDING THESE DEVICES TO AIRCRAFT WINGS CAN MAKE THE PLANES LOOK SLEEKER, BUT THEY BRING WITH THEM SOME SERIOUS SAVINGS IN FUEL AND EMISSIONS AS WELL: BETWEEN 3% AND 6% OFF A SINGLE AIRCRAFT'S CO<sub>2</sub> EMISSIONS PER YEAR.**

Aviation Partners Boeing has made its "Blended Winglets" available for several models of commercial jet. A typical winglet-equipped 737 in airline service saves 380,000-570,000 litres of fuel per year compared to a 737 without the devices. Savings climb to 1.9 million litres per year on the 767ER. Aside from fuel and CO<sub>2</sub> savings, co-benefits include a reduction in aircraft noise and as much as 8% reduction in NO<sub>x</sub> emissions. A new model launched in 2014, "Split Scimitars", brings down emissions a further 2% compared to the Blended Winglets.

Taking this technology another step, Boeing will offer its "Advanced Technology" winglet on the new 737 MAX. Aerodynamicists used advanced computational fluid dynamics to combine rake tip technology with a dual feather winglet concept to improve efficiency by up to 5.8% relative to a wing without a winglet, and by more than 1.5%, depending on range, over current designs.

Airbus has also developed the "Sharklet" product for its own A320 aircraft family. These deliver more than 4% fuel saving on longer sectors and are available on new A319, A320 and A321 aircraft, or for retrofit. In fact, an A320 equipped with Sharklets can cut between 500 and 1,000 tonnes of CO<sub>2</sub> per year in typical operations, depending on the average flight length. Around 90% of new A320s being delivered today are equipped with the devices.

Other aircraft, such as the Bombardier commercial and business jet lines, Embraer and some existing Airbus and Boeing aircraft also have wingtip devices in-built, including some that may not appear to be as obvious – like the Boeing 777's "raked wingtip".



The wingtip devices help reduce the 'wake vortex' created when air moves at different speeds over the top and bottom of the wing. This creates drag and requires the aircraft to use more power. But cutting the vortex and drag, the aircraft uses less fuel to achieve the same results.

# ELECTRIC TAXIING TAKES AIRCRAFT EFFICIENCY TO A NEW LEVEL



**TRADITIONALLY, AIRCRAFT TAXI BETWEEN THE TERMINAL AND RUNWAY USING THEIR MAIN ENGINES, REQUIRING SIGNIFICANT FUEL CONSUMPTION. WITH EGTS, USE OF THE MAIN ENGINES IS NO LONGER REQUIRED, RESULTING IN SIGNIFICANT REDUCTIONS IN EMISSIONS AND NOISE POLLUTION.**

Modern jet engines are superbly efficient in the air but are not optimised for ground use. The EGTS system works by using electric motors fitted to the main landing gears.

The system allows fully autonomous aircraft movement on ground, notably eliminating the need for tug tractors for pushback, and requiring use of the main engines only for a few minutes before take-off and after landing (necessary for main engine warm up and cool down). EGTS is particularly geared towards short-and medium-haul aircraft, which spend a relatively long time taxiing in comparison to their time in the air.

Compared with a typical dual-engine taxiing operation, it is estimated that using EGTS will cut CO<sub>2</sub> emissions by 61%, NO<sub>x</sub> emissions by 51%, unburned hydrocarbons by 62% and CO emissions by 73%.

The EGTS system was first demonstrated during the Paris Air Show in 2013, when a test aircraft flawlessly completed a number of manoeuvres without using the main engines. In December 2013, Airbus subsequently signed a memorandum of understanding with EGTS International to further develop and evaluate an autonomous electric pushback and taxiing solution for the A320 family.

In early 2014, EGTS sought the advice of pilots themselves, giving more than 30 pilots from around the world the opportunity to 'test drive' the EGTS electric taxiing system in Toulouse. The event gave pilots an early opportunity to evaluate the operational advantages of using the system, by testing the prototype in real taxiway conditions.

## EGTS International

Joint venture between Honeywell and Safran.



[www.greentaxiing.com](http://www.greentaxiing.com)

**TYPICAL USE WITH AN A320 AIRCRAFT IS PREDICTED TO BE EQUIVALENT TO PLANTING UP TO 948 TREES PER AIRCRAFT PER YEAR.**

**IT HAS BEEN ESTIMATED THAT ON AVERAGE EGTS WILL SAVE AIRLINES AROUND \$250,000 PER AIRCRAFT PER YEAR IN FUEL COSTS.**

**IN ADDITION TO REDUCED EMISSIONS LEVELS, THE EGTS SYSTEM SIGNIFICANTLY REDUCES NOISE IN THE AIRPORT ENVIRONMENT.**





# NEXT GENERATION COMPONENTS, LAYER-BY-LAYER

Airbus

[www.airbus.com](http://www.airbus.com)

LESS WEIGHT MEANS LESS FUEL BURN, WHICH REPRESENTS SIGNIFICANT REDUCTIONS IN CO<sub>2</sub> EMISSIONS.

3D PRINTING ALSO RESULTS IN SHORTER LEAD TIMES AND FEWER MATERIALS USED DURING PRODUCTION.

ONLY 5% TO 10% WASTE MATERIAL (WHICH CAN BE RECYCLED AND REUSED), INSTEAD OF THE 85-95% FROM CURRENT MACHINING.

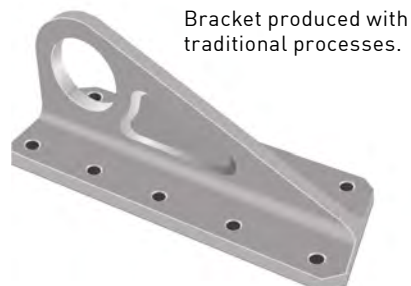
**AIRCRAFT MANUFACTURING TECHNOLOGY HAS COME A LONG WAY SINCE THE START OF THE INDUSTRY. NOT ONLY HAVE AIRCRAFT AND ENGINE MAKERS PIONEERED THE USE OF METAL ALLOYS AND COMPOSITE MATERIALS OVER THE DECADES, THEY ARE NOW AT THE FOREFRONT OF ANOTHER INDUSTRIAL REVOLUTION.**

Innovative additive layer manufacturing, or more simply '3D printing' technology, is beginning to shape the future of aircraft component manufacture. Parts produced with this method are already beginning to appear on the latest generation of aircraft, producing components that weigh 30-55% less than traditional metal parts.

Whilst there are a huge number of options across the fields of aircraft manufacturing for 3D parts, at Airbus there are two principal types of new manufacturing capabilities offering environmental benefits. The first only uses the material needed to produce the part and gives a significant reduction in waste. Airbus is already qualifying some metallic components in titanium, such as welded brackets to hold bleed air pipes in the aircraft hold, that provide an 87% saving in waste for its A350 XWB aircraft.

The second offers weight saving through 3D design of the components, without having to take into consideration the manufacturing constraints of producing a traditional metal part. Strength is provided where it is needed, with no excess in the material used. Less weight reduces fuel burn and CO<sub>2</sub> emissions. 3D Polymer components, such as ramps used to attach electrical harnesses to the aircraft structure, saving 2.4 kilograms per plane, will be equipping the A350XWB.

As the technology matures, more and more parts will be produced, bringing down weight and emissions even further. This game-changing technology could also decrease total energy used in production, by up to 90% compared with traditional methods.



Bracket produced with traditional processes.



Same bracket produced using additive-layer manufacturing.

# YOU DON'T KNOW IF YOU DON'T TRY...



**PURSuing EVEN MORE INNOVATIVE WAYS TO IMPROVE AVIATION'S FUEL EFFICIENCY, BOEING AND ITS PARTNERS ARE RESEARCHING NEW CO<sub>2</sub> AND NOISE REDUCTION TECHNOLOGIES THROUGH THE ECODEMONSTRATOR PROGRAMME, LAUNCHED IN 2011.**

Since then, it has tested more than 50 new technological innovations on a Next-Generation 737, the 787 Dreamliner and a 757. Some of the success stories with these experiments include the winglet technology used on the new 737 MAX and a lighter-weight composite component for the Dreamliner.

In 2015, Boeing teamed up with NASA and TUI Group to test more than 15 technologies on the ecoDemonstrator 757. In cooperation with NASA, the ecoDemonstrator 757 tested active flow control on the airplane's vertical tail by using small jets of air to improve airflow over the rudder, maximising aerodynamic efficiency.

An aircraft's vertical tail is primarily used to add stability and directional control during take-off and landing, especially in the event of an engine failure. But the large, heavy tail is not necessary when the aircraft is cruising at altitude. Based on ground testing, active flow control could reduce the size of the tail by an estimated 17%, which would significantly save weight as well as drag.

Two other experiments were designed to avoid an issue that you might not expect to affect a plane's efficiency: insect build-up on the wings. Drivers will be well-familiar with the issue of insect build-up after long road trips. On aircraft, something as small as insect residue interrupts laminar flow, or the smooth flow of air over the wing. On the left wing, Boeing tested a Krueger shield to block insects from hitting the wing's leading edge. And on the right wing, in collaboration with NASA, the ecoDemonstrator tested several 'bug-phobic' coatings, with NASA reporting that one coating reduced bug remnants by as much as 40%.

Aside from Boeing proprietary technology, the results of ecoDemonstrator testing conducted with NASA will be shared publicly to benefit broader industry environmental goals.

## Boeing

NASA, TUI Group.



[www.boeing.com](http://www.boeing.com)

**SAVING CO<sub>2</sub> BY TESTING A RANGE OF DIFFERENT TECHNOLOGIES.**

**USING 'ACTIVE FLOW CONTROL' COULD ALLOW DESIGNERS TO SCALE-DOWN THE VERTICAL TAIL BY AS MUCH AS 17% AND REDUCE FUEL USAGE BY AS MUCH AS HALF A PERCENT.**



# NEXT GENERATION ENGINES

## Rolls-Royce



[www.rolls-royce.com](http://www.rolls-royce.com)

**WILL SAVE AN ESTIMATED  
AVERAGE 20,000  
TONNES OF CO<sub>2</sub> PER  
AIRCRAFT, PER YEAR.**

**MORE EFFICIENT  
ENGINES WILL IMPROVE  
LOCAL AIR QUALITY  
AND REDUCE NOISE FOR  
LOCAL COMMUNITIES.**



**BECAUSE OF THE ADVANCED TECHNOLOGIES AND THE LONG DEVELOPMENT TIMES (NOT TO MENTION AN EXTREMELY RIGOROUS TESTING PROCESS), ENGINE MANUFACTURERS ARE OFTEN ALREADY WORKING ON THE NEXT GENERATION OF DESIGN WHILE SEEING THEIR BRAND NEW PRODUCTS ENTERING THE COMMERCIAL FLEET.**

Rolls-Royce is well on the way to testing its “Advance” and “Ultrafan” engines. Utilising the latest technology and manufacturing processes, the new engines improve efficiency and drive down CO<sub>2</sub> emissions by between 20-25% compared to Rolls-Royce’s first generation Trent series of engines.

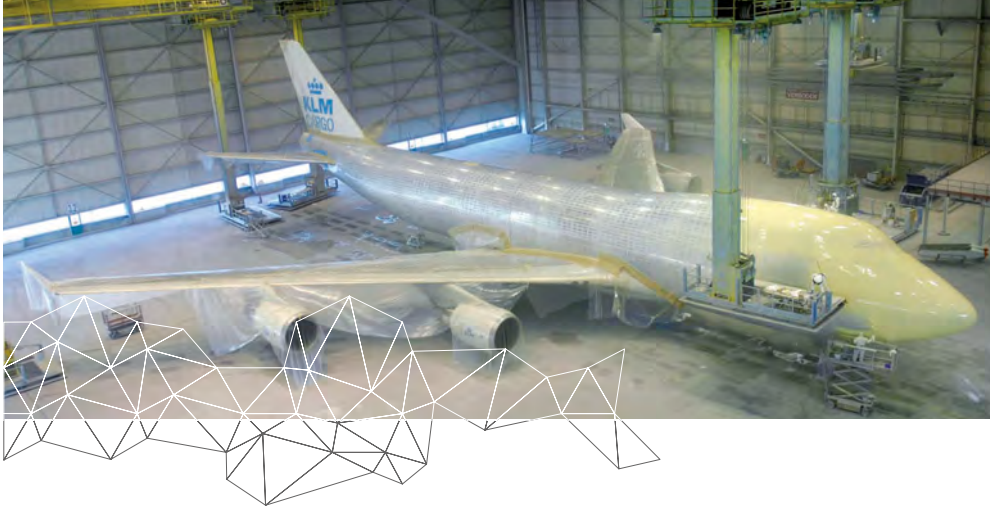
A major contributor to the efficiency improvements expected with these engines is the utilisation of lightweight carbon/titanium composite fan blade technology. After considerable research and development, this new fan system technology completed flight testing this year. Large 3D printed structures which also save weight, are being flight tested this year.

In addition to the fan technology, Rolls-Royce’s new core architecture delivers higher efficiency from an increased overall pressure ratio of more than 60:1 in the Advance engine and 70:1 in the Ultrafan, far higher than previous models. Higher temperatures in the engine also contribute to higher efficiency, enabled by ceramic matrix composites.

The first Advance demonstrator engine is on build and due to go to test in late 2016 and parts for the Ultrafan will be ready for testing in early 2016, when the new power gearbox rig will also begin testing.



# PAINT: THINNER



**WHILE SOME OF THE WEIGHT SAVING MEASURES TAKEN BY AIRLINES TO SAVE FUEL AND REDUCE CO<sub>2</sub> EMISSIONS WOULD BE FAIRLY OBVIOUS TO MOST PEOPLE, SUCH AS LIGHTER SEATS AND TROLLEYS OR USING COMPOSITE MATERIALS, OTHERS REQUIRE A LITTLE BIT OF CREATIVE THINKING.**

You wouldn't think that an aircraft's paint job would be an area where airlines can save weight, but it actually makes more of a difference than you might realise. The fuselage of a painted Boeing 747-400, for example, typically carries about 250 kilograms' worth of paint. Aside from making the aircraft look good, it performs an important role protecting the fuselage.

KLM's engineering and maintenance department took on the challenge of reducing the weight added by the livery paint and, with the help of German supplier, Mankiewicz, were able to develop a new paint system that reduces the weight of the paint by 15%, through applying more, but thinner layers.

The paint developed also has other advantages. It is also chrome-free and can be washed by soap and water alone, cutting out the need for the use of additional solvent chemicals, which can have a detrimental effect on the local environment.

Of course, paint is not the only area where KLM have managed to make weight savings. As well as the usual lighter seats and trolleys, KLM was the first airline to implement polypropylene trays, which not only reduces weight but also has less environmental impact during production. In addition, Air France-KLM-Martinair Cargo introduced a range of new lightweight cargo nets made from a fibre called ultra-high molecular-weight polyethylene which reduces the weight of the nets by 50%.

## KLM

Mankiewicz and DSM.



[www.klmtakescare.com](http://www.klmtakescare.com)

**THE NEW PAINT JOBS AND CARGO NETS CAN SAVE 60,000 TONNES OF CO<sub>2</sub>.**

**THE NEW PAINT SYSTEM ALLOWS THE GLOSS AND COLOUR TO LAST LONGER.**

**THE CARGO NETS ARE EASIER TO USE FOR THE STAFF.**



# CUTTING-EDGE AERODYNAMICS REDUCE FUEL BURN

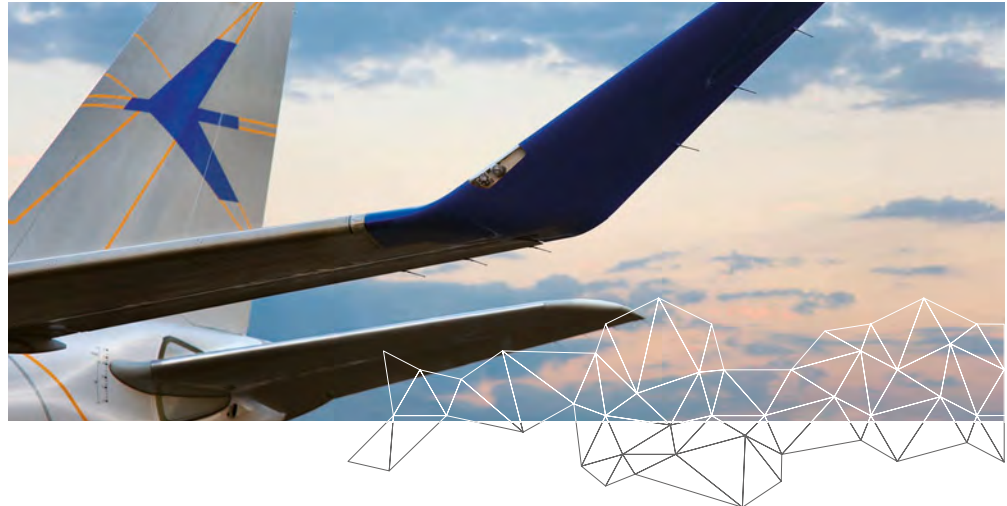
Embraer



[www.embraer.com.br](http://www.embraer.com.br)

AN E175 WITH THE FUEL BURN IMPROVEMENT PACKAGE REDUCES MORE THAN A TONNE IN CO<sub>2</sub> EMISSIONS PER YEAR.

FUEL CONSUMPTION ON A TYPICAL FLIGHT IS 6.4% LOWER THAN ON THE ORIGINAL E175.



**REDUCING FUEL CONSUMPTION IS OFTEN ACHIEVED THROUGH MAJOR CHANGES TO THE AIRCRAFT. THE ENGINEERS AT EMBRAER FOUND A COST-EFFECTIVE WAY TO RE-SCULPT AN EXISTING AIRCRAFT MODEL TO ACHIEVE ITS EFFICIENCY POTENTIAL WITHOUT COMPROMISING THE ORIGINAL HANDLING.**

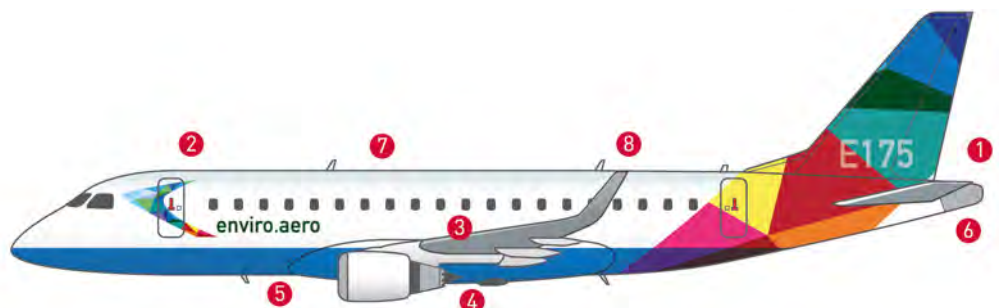
The E175 fuel burn improvements package project consisted of a combination of aerodynamic improvements within a challenging time-frame that reduced fuel consumption for the commercial aircraft model by 6.4% in a typical flight. These improvements include new wingtips, systems optimisation and streamlining of aerodynamic surfaces.

The project had the direct participation of more than 600 people, with experts at Embraer as well as major contributions from ten suppliers located in the USA, Europe and Japan. The majority of the company departments got involved, from market intelligence, engineering and flight tests up to sustainability and customer support.

The project had two phases. The first phase devised a package of modifications that resulted in: ① horizontal tail gaps and ② rain-deflector adjustments; ③ environmental control system and anti-ice optimisation; and ④ wheel fairing and ⑤ RAM air door development.

The second phase involved more aerodynamic improvements such as ⑥ tail cone inlet modification and ⑦ red beacon optimisation. A new wingtip ⑧ was also a part of this package and turned out to be the main contributor for the fuel burn gains as well as the main challenge for the engineers.

The project had an important premise to follow – the modifications incorporated had to preserve the aircraft handling. This target was accomplished, allowing the changes to be brought in by airlines without any pilot re-training or additional costs.



# SEMI-ROBOTIC TAXIING



**PASSENGERS WILL BE FAMILIAR WITH THE SIGHT OF THE 'TUG' VEHICLE ATTACHING ITSELF TO THE FRONT WHEEL OF THE AIRCRAFT, PUSHING IT BACK FROM THE GATE AND THEN DETACHING SO THE AIRCRAFT CAN MOVE TO THE RUNWAY.**

TaxiBot presents a taxiing solution which can tow an aircraft without the engines running from the terminal gate to take-off, whilst enabling the pilot to maintain control of the aircraft. It operates at regular taxiing speeds and has the added benefit of protecting the nose landing gear, which helps to maximise service life. This system has been in regular commercial use since November 2014.

The initial pushback operation is performed by the TaxiBot driver, after which the pilot takes control. While a more conventional tow tug would have to detach and move away from the aircraft after pushback, this procedure is now eliminated which helps minimise bottlenecks and delays at the departure gate area. The aircraft engines are then started before take-off. The same happens in reverse for an incoming flight.

This system is being developed to be compatible with all existing and future single-aisle and twin-aisle aircraft. It requires minimal extra training for the pilot. Because the engines are not required during taxiing for take-off and landing, considerable quantities of fuel and resulting CO<sub>2</sub> can be saved.

## Israel Aerospace Industries

TLD, Lufthansa LEOS, Lufthansa, Siemens, Airbus (technical partner), Boeing (supporter).



[www.taxibot-international.com](http://www.taxibot-international.com)

**UP TO 85% OF FUEL AND GREENHOUSE GASES ARE SAVED DURING AIRPLANE TAXIING.**

**TAXIBOT OPERATION IS 59% QUIETER THAN A BOEING 737 TAXIING UNDER ENGINE POWER AS CALCULATED IN A STUDY AT DARMSTADT UNIVERSITY.**

**FOREIGN OBJECT DEBRIS RISK REDUCTION DURING TAXIING.**





# THE AIRCRAFT DIET

**Lufthansa Group (Lufthansa, Germanwings, Eurowings, Swiss International Air Lines, Austrian Airlines, equity interests in Brussels Airlines and SunExpress)**

Jettainer, Recaro, LSG Sky Chefs, Spiriant, Norduyn.



[www.lufthansagroup.com](http://www.lufthansagroup.com)



**A 2012 WEIGHT 'AUDIT' ON A LUFTHANSA AIRBUS A340-300 IDENTIFIED POTENTIAL WEIGHT SAVINGS OF 100 KILOGRAMS. ITEMS WERE IDENTIFIED THAT COULD BE REMOVED FROM THE AIRCRAFT, OR REPLACED WITH LIGHTER ALTERNATIVES. THIS PROCESS LOWERED CO<sub>2</sub> EMISSIONS BY AROUND 3,500 TONNES PER YEAR.**

**THE GROUP-WIDE "FLY GREENER" INITIATIVE IS WORKING FOR A REDUCTION OF WASTE VOLUMES ABOARD, NOT ONLY TO CONSERVE RESOURCES, BUT ALSO TO FURTHER REDUCE WEIGHT.**

**FOR AIRLINES, ANY EXTRA WEIGHT CARRIED MEANS MORE FUEL USED AND MORE CO<sub>2</sub> RELEASED. CUTTING WEIGHT ON BOARD IS A VITAL PART OF ANY AIRLINE'S FUEL SAVING AND CLIMATE STRATEGY. IN LUFTHANSA GROUP'S CASE, THIS ALSO MEANS INVESTING IN NEW ON-BOARD EQUIPMENT.**

One of the world's largest airline families, the group has been working on a programme of cutting weight across its fleet of aircraft for a number of years.

The group has replaced the seats across its short- and medium-haul fleet with a slimline and lightweight seat. This allows more passengers to be carried (increasing the per-passenger efficiency) and greater leg room for those on board. But it also cuts the weight per seat by 30% and CO<sub>2</sub> by more than 21,000 tonnes.



Inside the cabin, almost 30,000 new light-weight catering trolleys have been pushed into service. The introduction of the "Quantum" trolley, which is one third lighter than its predecessor, saves around 28,000 tonnes of CO<sub>2</sub> annually. Canadian manufacturer Norduyn worked with LSG Sky Chefs to develop the trolley made entirely of lightweight composites and is the only aircraft cabin service trolley of its kind available on the market.

Lufthansa is equipping its long-haul fleet with the new in-flight entertainment system RAVE. Depending on the type of aircraft, this saves 30% to 40% weight when compared with previous equipment.

Lufthansa Cargo completely replaced its fleet of 5,500 standard freight containers (used for passenger and cargo shipments) with versions around 15% lighter than their aluminium predecessors. With up to half a million movements per year, the 14 kilogram difference will cut overall CO<sub>2</sub> by around 7,000 tonnes. Subsidiary Jettainer, together with partners from business and science, is already advancing development of the next generation of lightweight containers and pallets. Tomorrow's standard pallets are expected to weigh as much as 25% less than their predecessors.

# UPDATES READY TO INSTALL



**RATHER THAN DESIGNING AND BUILDING ENTIRELY NEW AIRCRAFT EVERY FEW YEARS, MANUFACTURERS OFTEN INTRODUCE PERFORMANCE IMPROVEMENT 'UPDATES' TO EXISTING AIRCRAFT. THIS IS EXACTLY WHAT BOEING HAS DONE WITH ITS BEST-SELLING PLANE, THE 737.**

In 2011 Boeing introduced a number of performance enhancements to the Next-Generation 737 that reduced fuel consumption and emissions by 2%.

The 737 Performance Improvement Package comprises technology designed to both reduce drag and improve propulsion efficiency to reduce fuel use and CO<sub>2</sub> emissions. Among other changes, the package:

- ① Replaced the upper and lower red manoeuvring light assemblies with a more aerodynamically designed shape to reduce aerodynamic drag. The upper skin was revised, and no electrical interface changes were required to accommodate the new lights;
- ② Refined wing control surfaces, such as reducing the thickness, minimising gaps and altering the shape slightly of some of the wing control surfaces;
- ③ Re-contoured the five rear wheel-well fairing assemblies to smooth the airflow near the main landing gear, reducing aircraft drag;
- ④ Included changes to the CFM International engines that contributed additional reductions in fuel use and CO<sub>2</sub> emissions.

More than 1,500 of the performance-improved aircraft have been delivered so far. And the technology isn't just restricted to new 737s straight off the production line: it can be retrofitted to existing aircraft, allowing airlines to improve the environmental performance of their existing fleet.



Boeing



[www.boeing.com](http://www.boeing.com)

REDUCES FUEL USE AND  
CO<sub>2</sub> BY AN ADDITIONAL 2%.

LOWER NOISE FOOTPRINT.

UP TO \$120,000 WORTH  
OF FUEL SAVED  
PER AIRCRAFT.









# ALTERNATIVE ENERGY

WE'VE BEEN FLYING ON THE SAME TYPE OF FUEL SINCE THE BEGINNING OF JET AIRCRAFT. JET A-1 IS PERFECT, BUT IT IS MADE FROM FOSSIL SOURCES AND THE TIME HAS COME TO MOVE ON.

We need to look for an alternative fuel that shares the same qualities as traditional jet fuel (high energy density, low high point, low freeze point), but is from renewable resources. It must drop-in to current equipment and not compete for food and water resources. Over 2,000 commercial flights have taken place using alternative fuels so far. From now on, that will become an everyday occurrence. We are also looking at alternative energy for airports.

These examples should inspire more innovation in alternative energy across the sector.



# FROM THE SEA TO THE DESERT

## Etiha Airways

Boeing, Masdar Institute  
of Science and Technology



[www.etihad.com](http://www.etihad.com)



**SUSTAINABLE  
ALTERNATIVE BIOFUEL  
REDUCES CARBON  
DIOXIDE EMISSIONS  
BY 50-80% COMPARED  
TO FOSSIL FUELS.**

**ENHANCES LOCAL  
FOOD SECURITY  
AND SUSTAINABLE  
AQUACULTURE.**

**ENSURES FUEL  
PRODUCTION IN A DESERT  
ENVIRONMENT WITH NO  
NEED FOR FRESHWATER.**

**FINDING INNOVATIVE WAYS OF PRODUCING SUSTAINABLE ALTERNATIVE AVIATION FUEL USING FEEDSTOCKS THAT DON'T IMPACT FOOD SECURITY AND FRESHWATER RESOURCES IS THE IDEAL FUTURE FOR ENERGY IN AIR TRANSPORT. IN THE UNITED ARAB EMIRATES, RESEARCH IS WELL UNDERWAY TO DO JUST THAT.**

The Masdar Institute of Science and Technology, supported by Etihad Airways, Boeing and others have come up with an original way of using the country's desert conditions and proximity to the sea to the advantage of aviation.

In 2011, they established the Sustainable Bioenergy Research Consortium, to investigate methods of producing sustainable alternative aviation fuels in the UAE. In particular, its flagship project is researching a method of producing biofuel from halophytic (saltwater-tolerant) plants by using an integrated seawater energy and agriculture system approach.

This innovative integrated system uses the saline wastewater produced as a byproduct of aquaculture farming to irrigate salt-tolerant plants grown in the coastal desert. The cultivated halophytes – salicornia and mangrove – provide the necessary biological clean-up of the wastewater from the fish and shrimp farming operations, using the nutrients as fertiliser.

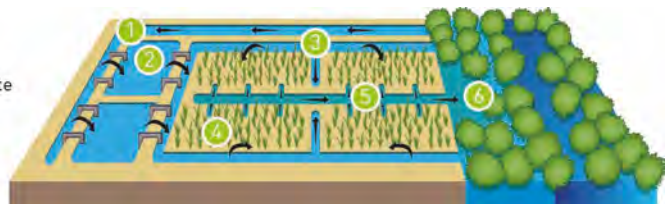
The oily seeds of the salicornia and the biomass produced by both halophytic plants will be turned into sustainable jet fuel, chemicals, and biomaterials. In addition the plants are able to sequester carbon dioxide from the atmosphere, a task which the mangroves are particularly effective at doing, given their extensive root system.

In June 2015, following several years of intensive R&D into the system operations and plant capabilities, the Masdar Institute began construction of a two hectare demonstration project within Masdar City in Abu Dhabi. In time, the partners anticipate that this approach will produce sustainable alternative fuel and reduce carbon dioxide emissions and water pollution, whilst supporting local food production.

Airline part of:



- 1 Pump seawater from the ocean to ponds.
- 2 Aquaculture for fish and shrimp.
- 3 Wastewater from the aquaculture operation, rich in nutrients, is used to irrigate salt-tolerant biomass – in this case salicornia and mangrove.
- 4 Biomass is used to produce bioenergy, including sustainable aviation fuel.
- 5 Water drains into a mangrove wetland.
- 6 Biomass from the mangroves can also be converted to bioenergy.



# A NEW BIOFUELS RESEARCH CENTRE IN BRAZIL



**Embraer and Boeing**



[www.embraer.com.br](http://www.embraer.com.br)

[www.boeing.com](http://www.boeing.com)

**EMBRAER AND BOEING DECIDED TO COMBINE WORLD-CLASS AERONAUTICAL EXPERTISE WITH BRAZIL'S NATURAL AND HISTORICAL VOCATION FOR THE LARGE SCALE PRODUCTION OF BIOFUELS. THE RESULT IS THE BOEING-EMBRAER JOINT BIOFUELS RESEARCH CENTRE.**

From 2012 to 2013, Boeing, Embraer, the São Paulo Research Foundation and the State University of Campinas held a series of workshops in Brazil. These workshops were the catalyst for a 2014 publication called *Flightpath to Aviation Biofuels in Brazil*, which identified gaps in establishing this industry. Embraer and Boeing took the further step of opening a joint sustainable aviation biofuel research centre in a collaborative effort to establish the aviation biofuel industry in Brazil.

The centre's opening was held in January 2015, at the Parque Tecnológico de São José dos Campos, with the mission to: champion and enable research, development and innovation; support the development of public policies to encourage use of alternative fuel; promote the development of sustainability criteria; and promote the establishment of technical forums in Brazil.

Alternative aviation fuels stand out today as one of the most promising solutions to help reduce aviation's carbon footprint and fulfil its commitment to cut carbon dioxide emissions in half by 2050, compared to 2005 levels.

The centre has already started by supporting regional initiatives to foster the aviation biofuel value chain; identifying partnerships in universities, research and development centres and suppliers for aviation biofuel research in Brazil; and engaging with government agencies to establish a national policy for the development and promotion of biofuel.

TO GIVE AN EXAMPLE OF THE POTENTIAL OF BIOFUEL, A 3% VOLUME BLEND OF SECOND GENERATION BIO JET FUEL WOULD SAVE OVER TEN MILLION TONNES OF CO<sub>2</sub> IN ONE YEAR IF CONSUMED WORLDWIDE.

THE BLEND BETWEEN BIOFUELS AND CONVENTIONAL JET FUELS HAS THE POTENTIAL TO REDUCE PARTICULATE MATTER EMISSIONS FROM ENGINES.

BESIDES DIVERSIFYING LOCAL ECONOMIES, A WELL-ESTABLISHED BIO JET FUEL CHAIN WOULD MAKE THE AVIATION SECTOR LESS DEPENDENT ON FOSSIL FUEL PRICES VARIATION IN THE INTERNATIONAL MARKET.





# OUT OF THE FRYING PAN AND INTO THE SKY!

## SkyNRG and KLM Royal Dutch Airlines

The Port Authority of New York  
& New Jersey, JFKIAT LLC,  
Amsterdam Schiphol Airport,  
Allied Aviation, Delta Air Lines.



[www.skynrg.com](http://www.skynrg.com)

[www.klm.com](http://www.klm.com)



IN TOTAL 232 TONNES  
OF CO<sub>2</sub> EMISSIONS  
WERE SAVED WITHIN  
THE JFK GREEN LANE  
PROGRAMME.

KLM ALSO OPERATED  
A SERIES OF 200  
FLIGHTS ON BIOFUEL  
BETWEEN AMSTERDAM  
AND PARIS AND 20  
FLIGHTS BETWEEN  
AMSTERDAM AND  
ARUBA AND BONAIRE.

THERE ARE CURRENTLY 16  
CORPORATE CUSTOMERS  
OF KLM INVOLVED IN  
THE KLM CORPORATE  
BIOFUEL PROGRAMME.

**THE SUPPLY CHAIN AND LOGISTICS FOR SUSTAINABLE ALTERNATIVE AVIATION FUEL ARE STILL IN THEIR EARLY STAGES. KLM DECIDED TO GIVE THE NEW ENERGY SOURCE A BOOST WITH A HALF YEAR FLIGHT PROGRAMME (26 FLIGHTS) BETWEEN NEW YORK AND AMSTERDAM.**

In March 2013, KLM, in collaboration with its partners undertook a project called the JFK Green Lane programme. Once a week, a flight with a Boeing 777-200 aircraft departing from New York's JFK International Airport for Amsterdam Schiphol Airport was operated with sustainable jet fuel.

The fuel for the first half of the project was made from used cooking oil. For the second part of the project, oil from the camelina plant was used. Used cooking oil and camelina are seen as sustainable feedstocks that received a positive review from SkyNRG's independent Sustainability Board, on which the WWF Netherlands sits. Camelina can be grown on marginal agricultural land and is actively good for the soil. When used as part of crop rotations, it can help enrich the soil with nutrients, increasing yields of other crops grown.

Some of KLM's corporate customers got involved, paying a premium on their flights to support the project and reduce their own carbon footprint. This partnership demonstrates how social responsibility can cascade down the supply chain. These customers include large businesses in the Netherlands such as Schiphol Group, Nike, Philips, Heineken, DSM and Accenture, that have all signed up to the KLM Corporate BioFuel Programme. Their participation helps to kick-start a sustainable alternative fuel industry and will help make everyone's flights greener once the new fuels really take off.

# BIOJET FUEL ON TAP



**THE POTENTIAL FOR SUSTAINABLE ALTERNATIVE FUELS FOR AVIATION IS WELL DOCUMENTED AND PROGRESS IN RECENT YEARS HAS BEEN IMPRESSIVE. AS WE BUILD TOWARDS REGULAR FLIGHTS POWERED BY BIOFUEL, ONE AIRPORT IS AT THE FOREFRONT OF BIOFUEL INVESTMENT.**

Oslo Airport, operated by Avinor, is set to become the first hub in the world to receive regular deliveries of biojet fuel. From 2015, the SkyNRG partnership with Air BP will provide 2.5 million litres of biofuel to the airport.

What's more, Oslo intends to be the first to integrate the biojet fuel into the airport's hydrant system, previously one of the main obstacles to increased uptake of biofuel powered flights. This will allow aircraft to refuel in the usual way, without the need for specialised fuel trucks travelling from one aircraft to another.

Lufthansa Group, KLM and SAS serving Oslo are the first to participate in the initiative, but the programme is open to all airlines.

Initially, the fuel will be made from camelina or used cooking oil, but Avinor's long-term goal is to set up a supply chain based on Norwegian forest residues, which are produced in abundance as a by-product of the forestry industry. Two producers are already lined up to develop this fuel and, when taken together, they are forecast to produce enough biojet fuel to reduce emissions from Norwegian aviation by 10-15%.

- » *Schiphol Airport in Amsterdam is also moving towards creating a 'bioport'. Having signed an agreement with SkyNRG and home carrier, KLM, Schiphol hopes to have the scheme, which will use biofuel made from used cooking oil, up and running by 2017.*
- » *Brisbane Airport has also engaged with SkyNRG and Virgin Australia to develop a bioport. Research on appropriate feedstocks is underway and hopes are high that Brisbane will have the first bioport in the Asia-Pacific region.*

## Oslo Airport, run by Avinor

Air BP, SkyNRG, Lufthansa Group, KLM and SAS.



[www.avinor.no](http://www.avinor.no)

ESTIMATED EMISSIONS  
SAVING OF SIX MILLION  
TONNES OF CO<sub>2</sub>E.

THE BIOFUEL PLANTS  
WILL ALSO PRODUCE  
BIODIESEL FOR  
ROAD VEHICLES.



# TURNING AGRICULTURAL WASTE INTO AVIATION FUEL

## Gulfstream Aerospace

Honeywell UOP, AltAir, World  
Fuel Services



[www.gulfstream.com](http://www.gulfstream.com)

THE PROJECT WILL  
SAVE 500 TONNES  
OF CO<sub>2</sub> PER YEAR.

THE PROJECT MAKES  
USE OF EXISTING  
AGRICULTURAL WASTE BY  
TURNING IT INTO A HIGH  
VALUE AVIATION FUEL.

SINCE THE RENEWABLE  
FUEL HAS LESS  
SULPHUR CONTENT, THE  
PROJECT WILL IMPROVE  
LOCAL AIR QUALITY BY  
REDUCING THE AMOUNT  
OF PARTICULATE  
MATTER RELEASED INTO  
THE ATMOSPHERE.



**IN A PIONEERING MOVE, GULFSTREAM HAS BECOME THE FIRST BUSINESS JET MANUFACTURER TO REGULARLY USE RENEWABLE FUELS, BY SIGNING A THREE-YEAR CONTRACT WITH WORLD FUEL SERVICES – USING AGRICULTURAL WASTE AS FEEDSTOCK.**

In 2011, Gulfstream collaborated with Honeywell to conduct flights using a 50/50 mix of Honeywell green jet fuel and traditional jet fuel on Gulfstream's G450 aircraft. This testing culminated in a transatlantic flight from North America to Europe, making the G450 the first aircraft to cross the Atlantic using a 50/50 blend of renewable fuel to power one of its two engines. The feedstock for the fuel was camelina, a non-food grass crop which can be grown in rotation with food crops and actually replenishes the soil for greater yields overall.

In 2012, Gulfstream flew its fleet to the National Business Aviation Association convention in Orlando on a 50/50 blend of renewable fuels. In April 2015, Gulfstream signed a three-year contract with World Fuels for the purchase of up to 1,363,828 litres of renewable fuel per year. The fuel will be a blend of 30% renewable fuel and 70% petroleum-based Jet-A. The feedstock for the neat fuel will be from agricultural waste and demonstrates a 50% reduction in CO<sub>2</sub> based on lifecycle emissions compared to traditional jet fuel.

This renewable fuel will be used to power the Gulfstream Airborne Product Support plane, which delivers aircraft parts to customers in North America, senior management transportation and customer demonstration flights and the flight testing of the newly-announced G500 and G600 aircraft.

Gulfstream's commitment to using renewable fuels will support the refineries that are breaking new ground by entering into this market. This project will also support the business aviation industry's goals of carbon neutral growth by 2020.



# ALTERNATIVE FUELS, DEPARTING LOS ANGELES



**AS SUSTAINABLE ALTERNATIVE FUELS FOR AVIATION CONTINUE THE JOURNEY FROM FRINGE TO MAINSTREAM, UNITED AIRLINES JOINS FORCES WITH PARTNER ORGANISATIONS TO CONVERT AN IDLE FUEL REFINERY INTO A THRIVING BIOFUEL PLANT.**

Since 2009, United Airlines has been working in collaboration with AltAir Fuels to bring competitively-priced sustainable aviation biofuel to its Los Angeles Airport hub. United Airlines will purchase 57 million litres of lower-carbon, renewable jet fuel over a three-year period, starting in 2015, with an option to buy more. This is the first purchase of alternative jet fuel by a US airline to be used in regularly scheduled operations. Environmental responsibility is further promoted by retrofitting part of an existing, idle, refinery near Los Angeles to become an advanced biofuel refinery, creating 150 new jobs in the area. The plant will use Honeywell UOP technology to convert non-edible natural oils and agricultural wastes into sustainable aviation biofuel.

In addition, United has committed to a \$30 million equity investment in US-based alternative fuels developer Fulcrum BioEnergy. The airline will have the opportunity to purchase at least 340 million litres of sustainable aviation biofuel a year for a minimum of ten years at a cost competitive with conventional jet fuel. This alternative jet fuel, produced from household waste, is a 'drop-in' fuel that meets all of the airline's technical requirements and specifications. Fulcrum expects its first alternative fuels plant to begin commercial operation in 2017.

In addition to the equity investment, United and Fulcrum have entered into an agreement that contemplates the joint development of up to five projects located near United's hubs and expected to have the potential to produce up to 680 million litres of fuel per year.

## HOW THE FULCRUM PROCESS WILL WORK



## United Airlines

AltAir, Fulcrum BioEnergy,  
Honeywell UOP, World Fuel  
Services, Los Angeles  
World Airports



[www.embraer.com.br](http://www.embraer.com.br)

[www.boeing.com](http://www.boeing.com)

THE ALTAIR JET FUEL IS EXPECTED TO PROVIDE MORE THAN 60% REDUCTION IN GREENHOUSE GAS EMISSIONS ON A LIFECYCLE BASIS, COMPARED TO TRADITIONAL JET FUEL.

FULCRUM'S RENEWABLE JET FUEL IS EXPECTED TO PROVIDE A GREATER THAN 80% REDUCTION IN LIFECYCLE CARBON EMISSIONS, COMPARED TO CONVENTIONAL JET FUEL.

THE PROJECTS WILL DECREASE UNITED'S CARBON FOOTPRINT, DIVERT WASTE FROM LANDFILLS AND CREATE NEW JOBS IN COMMUNITIES WHERE REFINERIES ARE LOCATED.



# MAKING A PLEDGE ON ALTERNATIVE FUELS

## Sustainable Aviation Fuel Users Group

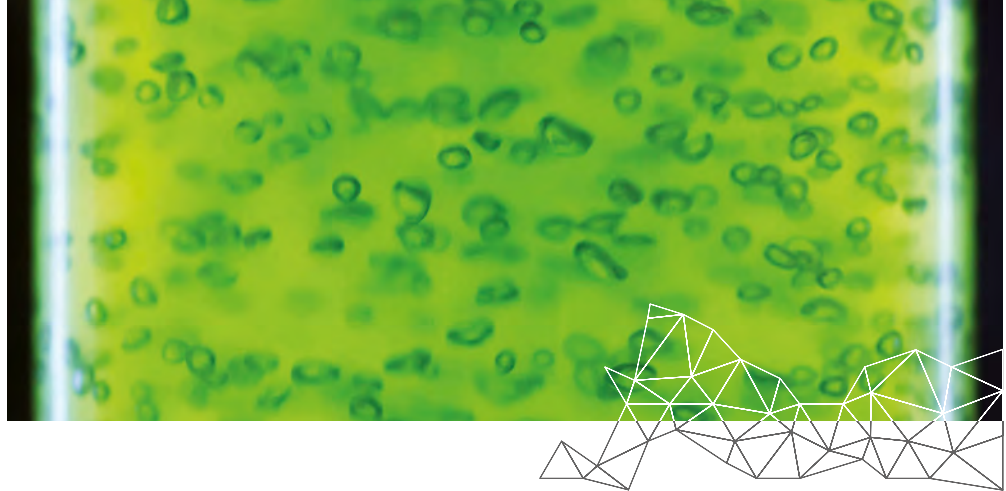
Air China, Aero Mexico,  
Air France, Air New Zealand,  
Alaska Airlines, ANA,  
Avianca Taca, British Airways,  
Cargolux, Cathay Pacific,  
Etihad, GOL Linhas Aéreas  
Inteligentes, Gulf Air,  
Japan Air Lines, jetBlue,  
KLM, Lufthansa, Qantas,  
Qatar Airways, SAS,  
Singapore Airlines, South  
Africa Airways, TAM, TUI  
Group, United Airlines, Virgin  
America, Virgin Atlantic,  
Virgin Australia, Boeing,  
Honeywell UOP, Airbus,  
Embraer, Aeropuertos  
y Servicios Auxiliares



[www.safug.org](http://www.safug.org)

**COLLECTIVELY, SAFUG  
MEMBERS REPRESENT  
APPROXIMATELY 33% OF  
COMMERCIAL AVIATION  
FUEL DEMAND.**

**SAFUG ARE COMMITTED  
TO SOURCING FUELS  
IN A SOCIALLY AND  
ENVIRONMENTALLY  
SUSTAINABLE WAY.**



**FOR SUSTAINABLE ALTERNATIVE FUELS TO MAKE AN IMPACT ON CO<sub>2</sub> EMISSIONS FROM AVIATION, AIRLINES ARE WORKING TOGETHER AND WITH OTHER SUSTAINABILITY-FOCUSED ORGANISATIONS TO ENSURE THAT NOT ONLY CAN THESE FUELS BE ADOPTED ON A LARGE SCALE, BUT ALSO THAT THEY ARE SUSTAINABLY PRODUCED.**

As a means of getting this balance right, a group of airlines from all over the world, with support and advice from environmental organisations, joined together in 2008 to found the Sustainable Aviation Fuel Users Group (SAFUG). Together, the members make up 33% of global commercial aviation fuel demand.

Each of the members of SAFUG signed a sustainability pledge, which is designed to ensure development of alternative fuels that enable aviation to meet its CO<sub>2</sub>-emissions reduction commitments and can also be incorporated into the global aviation system.

To meet those goals, SAFUG members agree that the fuels must meet key sustainability criteria: exhibit minimal impact on biodiversity; meet a sustainability standard with respect to land, water, and energy use; do not harm food security and provide a positive socioeconomic impact. Fuels that meet these criteria include those which come from a wide range of feedstocks, such as algae, used cooking oil and municipal waste. At the same time, SAFUG is focused on biofuel types that also do not require any changes to aircraft, engines or the airport fuelling infrastructure.

SAFUG members are committed to working in partnership with governments, other industries and representatives of civil society on this issue, and hope to have other members of the aviation industry join them to further develop the use of sustainable alternative fuels and lessen aviation's climate impact.

# A FUTURISTIC, ECONOMICAL AND ETHICAL RENEWABLES VALUE CHAIN



**GOL AND PARTNERS CREATED A PLATFORM TO MERGE THE EXPERTISE OF EVERY SECTOR OF THE SUSTAINABLE ALTERNATIVE AVIATION FUEL VALUE CHAIN. THE RESULT IS A "FROM RESEARCH TO FLY" INTEGRATED VALUE CHAIN THAT WILL REFOREST THE SÃO FRANCISCO RIVER BASIN, CREATE LOCAL EMPLOYMENT, AND MAKE COMMERCIAL BIOFUELS.**

The Plataforma Mineira de Bioquerosene e Renováveis was launched in 2013 with the support of airlines, major aircraft manufacturers, prestigious regional research institutions and industrial and agricultural federations.

The goal of this platform was to bring together key stakeholders from every part of the value chain, to take renewable fuel from research through to commercial production. Stages to be evaluated included production, processing, location and transport. The outcome of this forum was a streamlined, ethical and ingenious value chain, comprising:

- » Processing: Thermal catalytic conversion to be used for cracking (the process of breaking down hydrocarbons). This process does not require high pressure vessels, since it uses patented thermal cracking with an activated carbon catalyst derived from the macaúba coconut, avoiding costly hydrogen which is more commonly used for cracking carbon chains.
- » Location and transport: The biorefinery site was selected to be close to Belo Horizonte Airport, reducing logistics costs to the airport. Neat and blend certification facilities at a fuel laboratory close to the airport will further enhance the competitiveness of the process.
- » Production: Choosing the native macaúba palm in the reforestation of the São Francisco River Basin will improve water production capacity of this hydrobasin, absorb CO<sub>2</sub>, offer employment to local family farmers, produce sustainable biomass for the biorefinery and boost the local economy.

## GOL Linhas Aéreas Inteligentes

Associação Brasileira das Empresas Aéreas, Acrotech, Avianca, Boeing, Curcas, Embraer, GE, KLM, Solea, UFV and other partners



[www.voegol.com.br](http://www.voegol.com.br)

CO<sub>2</sub> WILL BE CUT BY THE USE OF BIOJET FUEL AT BELO HORIZONTE AIRPORT, AND REFORESTATION WILL FURTHER IMPROVE THE CARBON FOOTPRINT.

THE PROJECT WILL PLANT 200 MACAÚBA TREES PER HECTARE TOGETHER WITH OTHER SPECIES TO PROMOTE BIODIVERSITY IN THE PERMANENT ENVIRONMENTAL PROTECTION AREAS. MACAÚBA WILL ALSO SUPPORT THE RECUPERATION OF DEGRADED PASTURELAND.

THE AGRICULTURAL PROCESSING AND REFORESTATION WILL POTENTIALLY ENGAGE 400,000 FAMILY FARMERS AND INCLUDE THE STATE IN THE GREEN ECONOMY.





# TAKING THE SMOKE OUT OF TOBACCO

## South African Airways

Boeing, Sunchem, SkyNRG.



[www.projectsolaris.co.za](http://www.projectsolaris.co.za)



CO<sub>2</sub> EMISSIONS ARE ESTIMATED TO BE SIGNIFICANTLY LOWERED COMPARED WITH NORMAL JET FUEL, BASED ON A LIFECYCLE ASSESSMENT.

SOURCING ITS OWN JET FUEL, RATHER THAN IMPORTING FOSSIL FUELS FROM ABROAD, WILL BRING BENEFITS TO THE SOUTH AFRICAN ECONOMY.

SKILLS IN SUSTAINABLE AGRICULTURE WILL ALSO BE DEVELOPED WITHIN COMMUNITIES, WITH A KNOCK-ON EFFECT FOR OTHER FARMING ACTIVITIES.

**TOBACCO MIGHT NOT BE TOO BAD AFTER ALL... AS LONG AS YOU DON'T SMOKE IT. SOUTH AFRICAN AIRWAYS AND PARTNERS HAVE DEVELOPED AN INGENIOUS WAY OF MANUFACTURING SUSTAINABLE ALTERNATIVE AVIATION FUEL FROM A NICOTINE-FREE STRAIN OF THE TOBACCO PLANT.**

Increasing the use of alternative fuels is vital to the sustainable development of the aviation industry. The challenge, however, is to identify feedstocks that are commercially viable and do not compete with food sources. SAA has committed to an ambitious goal of sourcing half its fuel by sustainable means and feedstocks by 2023. To help achieve this goal, a partnership between SAA, Boeing, Sunchem and SkyNRG has pioneered an innovative approach to feedstock for aviation fuel.

Solaris is a strain of tobacco which contains no nicotine, making it unfit for use as a smoking tobacco. However, the strain has larger than normal seeds and flowers and has smaller leaves which make the plant optimal for oil extraction. It also grows exceptionally well on both irrigated and non-irrigated land. What's more, by using land and resources that were previously reserved for growing traditional tobacco, the project is able to take advantage of existing skills and workers. SAA predicts that almost 100,000 direct jobs will be created in an area suffering from extreme poverty.

SAA plans on conducting at least four alternative fuel demonstration flights in 2016 and is aiming to gradually increase the frequency of these flights in the build up to its 2023 target. Currently, Solaris tobacco is planted on 50 hectares of land and will be upscaled to meet SAA's target of 20 million litres of sustainable bio jet fuel by 2017. The crop has been audited by the RSB and certified as sustainable. SAA is an RSB member.

Airline part of:



# FLYING ON SUGAR



**AMYRIS, A CALIFORNIA-BASED INTEGRATED RENEWABLE PRODUCTS COMPANY, IN A JET FUEL JOINT VENTURE WITH TOTAL ENERGIES NOUVELLES ACTIVITÉS USA, HAS COME UP WITH A WAY OF PRODUCING SUSTAINABLE BIOJET FUEL CALLED FARNESANE. THIS BIOFUEL IS NOW FULLY CERTIFIED AND IS BEING USED BY BRAZILIAN AIRLINE, GOL.**

Farnesane is a sustainable biofuel made using sugarcane, making it a perfect fit for production in Brazil, which has the world's largest sugarcane industry. As sugarcane is not classed as an essential crop, it can be used as a biofuel feedstock and the farnesane-based fuel received full approval from the global standards agency, ASTM International, in 2014 and Brazilian authorities in the same year.

Farnesane is made through fermentation, where yeast is used to convert sugar cane syrup into a hydrocarbon. By adding hydrogen atoms to the farnesene through a process called hydrogenation, Amyris are able to produce the molecule, which in turn produces the renewable jet fuel.

In July 2014, GOL began flying its first commercial route between Brazil and the USA with a 10% farnesane biofuel mix on its fleet of Boeing 737 Next Generation aircraft.

The potential for farnesane is huge as Amyris' production facility near São Paulo, with a ready supply of sugarcane, has the capacity to produce around 50 million litres per year. Other airlines have now taken notice of the fuel's potential and it is likely that we will be seeing more flights running on farnesane in the near future.

**GOL Linhas Aéreas  
Inteligentes**

Amyris, Boeing, Total



[www.voegol.com](http://www.voegol.com)

**UP TO 80% LESS CARBON  
INTENSIVE OVER ITS  
LIFECYCLE THAN  
TRADITIONAL JET FUEL.**

**SUPPORTS THE  
SUGARCANE INDUSTRY  
IN BRAZIL, PROVIDING  
JOBS AND ECONOMIC  
OPPORTUNITIES.**

**ALSO HAS LOWER  
PARTICULATE MATTER  
EMISSIONS, FURTHER  
REDUCING AIR POLLUTION  
AROUND AIRPORTS.**



# MAKING JET FUEL FROM... STEEL?

## LanzaTech

Virgin Atlantic Airlines, HSBC,  
Pacific Northwest National  
Laboratory, United States  
Department of Energy



[www.lanzatech.com](http://www.lanzatech.com)



A LIFECYCLE  
ASSESSMENT HAS  
SHOWN THE NEW FUEL  
WILL HAVE A 60% LOWER  
CO<sub>2</sub> FOOTPRINT THAN  
TRADITIONAL JET FUEL.

IN 2013, LANZATECH'S  
PROCESS AT ITS ETHANOL  
PLANT IN BEIJING, CHINA  
SECURED A WORLD  
FIRST SUSTAINABILITY  
CERTIFICATION FROM  
THE ROUNDTABLE  
ON SUSTAINABLE  
BIOMATERIALS.

**WHAT TO DO WITH WASTE GAS PRODUCED FROM INDUSTRIAL PROCESSES IS AN ENVIRONMENTAL CHALLENGE IN ITSELF. ONE COMPANY HAS COME UP WITH AN INGENUOUS WAY OF USING THIS GAS FOR THE BENEFIT OF AVIATION.**

The US-based company, LanzaTech, originally founded in New Zealand, uses a technique called 'carbon capture and reuse' to recycle the carbon monoxide produced as a waste product in these industrial processes (particularly steel production) and convert it into certified jet fuel.

Proprietary microbes consume waste gases to make alcohol, much like yeast consuming sugars to make beer in a brewery. The alcohol is converted into jet fuel through dehydration, oligomerisation and hydrogenation (a process developed by Pacific Northwest National Laboratory). This is beneficial as it reuses the carbon in gases that would otherwise be emitted straight into the atmosphere.

In addition, by using waste gases, the LanzaTech process has no impact on land use or food production.

LanzaTech estimates that its process can apply to 65% of the world's steel mills, allowing the fuel to be scaled up for worldwide use. With support from HSBC Bank, the process has moved from the laboratory to a real-world demonstration plant. Indeed, LanzaTech is working with Virgin Atlantic towards future flights using this fuel.

Once certified, fuel made with waste industrial gases will then be able to be added to the growing list of sustainable feedstocks for alternative aviation fuel.



# A WHOLE NEW WAY TO FLY



**PUSHING INNOVATION IS ONE OF THE CORNERSTONES OF AVIATION ADVANCEMENT. WHILST THE INDUSTRY IS WORKING HARD TO MAKE BOTH MORE FUEL EFFICIENT AIRCRAFT AND LOWER-CARBON FUELS, THERE IS A NEW AIRCRAFT BEING DEVELOPED THAT WOULD SKIP OVER THOSE STEPS ENTIRELY.**

The Airbus Group has been developing an electric aircraft – the E-Fan – which is powered by a series of batteries contained in the wing's inboard section. The company is rolling out two- and four-seater versions of the E-Fan for pilot training and general aviation over the next few years. Its modern, connected cockpit will make learning how to fly more intuitive, while the digital controls automatically handle the electrical functions.

As a highly-efficient propulsion system, E-Fan's engines are electric motors that provide all of the power needed from take-off to landing. The engines are almost noise-free while its zero emissions contribute to reducing aviation's impact on the environment.

Small electric aircraft are seen as a key step towards introducing electric propulsion on larger planes – perhaps even regional-sized aircraft. As a highly innovative technology flying testbed, the E-Fan demonstrator is stimulating research in electric propulsion and is also helping to promote the certification of electrical flight concepts.

The E-Fan is aligned with the European Commission's "Flightpath 2050" goals. These call for significant reductions in aircraft CO<sub>2</sub> emissions and noise to ensure the aviation industry's sustainable development.

The aircraft made its first public flight in April 2014 and on 10 July 2015 the E-Fan technology demonstrator became the world's first all-electric two-engine aircraft taking off by its own power to successfully cross the Channel. The E-Fan's flight of 74 kilometres between Lydd, England, and Calais in France was completed in 36 minutes, proving the potential of electric flight.

## Airbus Group

Safran, Zodiac Aerospace, Aero Composites Saintonge, Evtronic, Serma Technologies, Siemens, Daher, CEA, ENAC, ENSAM, ISAE



[www.airbusgroup.com](http://www.airbusgroup.com)

**ZERO CO<sub>2</sub> EMISSIONS  
CONTRIBUTING TO  
REDUCING AVIATION'S  
IMPACT ON THE  
ENVIRONMENT.**

**E-FAN ENGINES ARE  
NEARLY NOISE-FREE,  
MAKING THE E-FAN  
A GOOD NEIGHBOUR  
AT AIRPORTS.**



# POWER FROM THE SUN

## Athens Airport, Brisbane Airport

100+ other airports worldwide



[www.lanzatech.com](http://www.lanzatech.com)



AROUND 100 AIRPORTS  
WORLDWIDE HAVE  
SOLAR INSTALLATIONS,  
GENERATING OVER 400  
MEGAWATTS OF ENERGY.

KUALA LUMPUR  
AIRPORT IN MALAYSIA  
HAS INSTALLED THE  
COUNTRY'S LARGEST  
SOLAR ARRAY. IT IS  
ESTIMATED THE 19  
MEGAWATT PLANT  
WILL HELP SAVE THE  
AIRPORT \$750,000 IN  
ELECTRICITY COSTS AND  
SOME 18,000 TONNES  
OF CO<sub>2</sub> EACH YEAR.

THE CARIBBEAN ISLAND  
OF ARUBA'S FIRST SOLAR  
PARK IS LOCATED AT  
THE INTERNATIONAL  
AIRPORT AND PRODUCES  
3.5 MEGAWATTS AS  
PART OF ARUBA'S 2020  
VISION TO BECOME  
100% INDEPENDENT  
FROM FOSSIL FUELS.

Many of these airports take part in:



**AIRPORTS ARE THE PERFECT LOCATION FOR SOLAR ELECTRICITY GENERATING INSTALLATIONS. THE LARGE, FLAT SURFACES BOTH ON THE GROUND AND ON TOP OF TERMINAL AND HANGAR BUILDINGS ALLOW FOR SIGNIFICANT SOLAR INSTALLATIONS TO BE BUILT.**

Whilst the design and siting of such solar arrays is not challenge-free – engineers must work with air traffic management and airlines to ensure that reflected sunlight does not blind controllers or pilots – it is possible to install them and benefit from the associated carbon-free energy.

Athens International's photovoltaic park produces more than 13 thousand MWh of emission-free electricity annually, corresponding to approximately 25% of the airport's own electricity needs. This results in an average annual CO<sub>2</sub> emissions reduction of 11,500 tonnes and, as a landmark project in Greece, helped spark a photovoltaic revolution in the years following. The solar panels face south and are installed on fixed structures, which are built to withstand strong winds and hail and have a very low reflectivity factor (much lower than most objects found at airports, such as parked cars).

Solar panels installed at Brisbane Airport produce an estimated 125 MWh/year of green energy. They directly save 118 tonnes of CO<sub>2</sub> per year compared to using grid electricity. Brisbane Airport also purchased Nissan Leaf electric vehicles for staff pool use. The electric charging points for the cars are located at the buildings where the solar panels were installed, to enable them to be directly charged by renewable energy. In the project's first year the cars have travelled more than 10,000 kilometres. The project encourages behavioural change by promoting car-pooling and a focus on CO<sub>2</sub> emissions, while contributing to a reduction in the Brisbane Airport staff commuting footprint. They also save about three tonnes of CO<sub>2</sub> per year from the substitution of petrol by solar energy.

Comprising 41,000 solar panels, Indianapolis International's 12.5 megawatt solar farm covers over 30 hectares of previously unused land and will be used to power the airport's terminal. It is estimated that the array will reduce the airport's carbon emissions by 10,000 tonnes per year – the equivalent of taking 2,000 cars off the road. Denver International Airport's four solar arrays now have the capacity to generate 10 megawatts of electricity, enough to power around 2,595 typical Denver-area homes, or cut CO<sub>2</sub> emissions by 11,465 tonnes each year.

## AT LEAST 100 AIRPORTS WORLDWIDE HAVE SOLAR POWER PLANTS:



The Airports Authority of India plans to generate 50 megawatts from solar plants at 30 airports by the end of 2015. At least eight of India's 130 airports, including those owned by private companies such as the Indira Gandhi International Airport in the capital, New Delhi, already have solar power systems used for aeronautical ground lighting systems installed at the airport's three runways, taxiways and parking stands.

Palau International Airport's solar installation is the largest to be completed in the island nation. The solar modules are installed on the top of shade structures in the airport car park. Due to the high occurrence of typhoons on the island, the back side of the modules have been reinforced with extra support bars for enhanced wind-pressure resistance. The system is expected to produce an annual power output of 250MWh, off-setting roughly 80 tonnes of CO<sub>2</sub> per year.

**COCHIN INTERNATIONAL AIRPORT IN INDIA HAS BECOME THE FIRST AIRPORT IN THE WORLD TO BE POWERED COMPLETELY BY SOLAR POWER. THE AIRPORT'S SOLAR POWER PLANT COMPRISES OVER 46,000 PANELS, STRETCHED ACROSS 18 HECTARES OF LAND. THROUGH THE USE OF THIS RENEWABLE ENERGY SOURCE, COCHIN AIRPORT AIMS TO SAVE OVER 300,000 TONNES OF CO<sub>2</sub> OVER THE NEXT 25 YEARS.**





# AN UNDERGROUND SUCCESS

Aéroports de Paris



[www.aeroportsdeparis.fr](http://www.aeroportsdeparis.fr)



AT FULL CAPACITY, THIS  
GEOTHERMAL PLANT  
AVOIDS 9,000 TONNES  
OF CO<sub>2</sub> PER YEAR.

LOCAL AIR QUALITY IS  
GREATLY IMPROVED BY  
THIS CLEAN TECHNOLOGY.

\$1,981,926 SAVED IN  
ENERGY BILLS DURING  
THE COURSE OF THE  
PLANT'S FIRST YEAR.

**THE PARIS REGION HAS AN ABUNDANCE OF NATURALLY HEATED WATER DEEP UNDERGROUND, WHICH HAS THE POTENTIAL TO PROVIDE A WEALTH OF SUSTAINABLE ENERGY. DISCOVER HOW AÉROPORTS DE PARIS TAPPED INTO THAT ENERGY WITH SUPERB RESULTS.**

At Paris-Orly airport, a 10 megawatt geothermal power plant takes advantage of deep underground water naturally heated to 74°C. This technology makes it possible to heat all the terminal buildings with renewable energy, allowing for vast reductions in greenhouse gas. This project was initiated and conducted by Aéroports de Paris and the plant inaugurated in 2011.

The geothermal power plant draws hot water from a depth of more than 1,700 metres from the Dogger aquifer in the Paris basin and uses it to heat the site facilities. It provides heating mainly to the terminals, but also to office buildings and hotels at the site. The life span of the geothermal plant is up to 30 years.

Aéroports de Paris received an incentive from a government agency ADEME (Agency for Energy Management and Environment) to help finance this project. During the works, which took place from September 2009 to November 2011, the digging required particular expertise and precision because of the constraints of working in an aviation environment, which required close coordination with the French Civil Aviation Authority.

In 2014, the plant generated 30,100 MWh of thermal energy, providing 64% of the power required for internal heating and 23% of the total energy needs of the airport.

Orly's sister airport, Charles de Gaulle, installed a wood-fuelled heating system in 2013 which cuts CO<sub>2</sub> emissions by 18,000 tonnes per year. All this is part of a group-wide goal to reduce emissions by 25% between 2009 and 2015.

# CATCHING THE RAYS IN GENEVA



**WHEN GENÈVE AÉROPORT WANTED AN INNOVATE NEW WAY TO COOL AND HEAT ITS TERMINAL BUILDING, IT DIDN'T HAVE TO LOOK FAR – AT THE OTHER END OF THE AIRPORT IS CERN, THE EUROPEAN NUCLEAR RESEARCH AGENCY AND HOME OF THE LARGE HADRON COLLIDER.**

But the famous Higgs boson particle experiment is not the only thing the team at CERN do, its researchers also developed the technology behind ultra-high vacuum solar panels. These panels, built by SRB Energy and financed with Genève Aéroport assistance, produce around 600 MWh worth of heat each year by capturing the energy of the sun.

Unlike traditional solar panels, these don't convert the sun's rays into electricity, but capture the energy in a special high-temperature fluid. The 282 panels are connected to the main heating/cooling system of the airport. In the summer, the thermal fluid is heated to 130°C and injected into an absorption machine to cool the buildings of the airport.

During the spring and the autumn, the fluid is heated to 90°C and injected into the main building heating system. During the winter, the thermal fluid is heated to 40°C and is used directly for the heating of the building on which the panels are installed.

The funding and use of these panels is just one part of Genève Aéroport's climate strategy. The airport is also home to 8,900 m<sup>2</sup> of traditional photovoltaic solar panels.

It is pushing passengers and staff to use public transport – the airport authority funds around 2,000 free public transport tickets a day for arriving passengers.

Another project has gradually equipped 36 of the airport's stands with fixed electrical ground power which removes the need for aircraft to run on-board generators when on the ground. This leads to an annual saving of 26,000 tonnes of carbon dioxide, as well as 52 tonnes of nitrogen oxides (NOx), and less noise on the airport site.

## Genève Aéroport

SRB Energy, CERN (European Nuclear Research Agency).



[www.gva.ch](http://www.gva.ch)

GENÈVE AÉROPORT  
ESTIMATES CO<sub>2</sub>  
REDUCTION OF 55 TONNES  
A YEAR FROM THIS FIRST  
SOLAR INSTALLATION.

20% OF GROUND SERVICE  
VEHICLES OPERATING ON  
THE AIRFIELD AT GENEVA  
AIRPORT ARE 'ECO-  
FRIENDLY' (ELECTRIC,  
HYBRID OR NATURAL  
GAS). GOAL: 25% BY 2016.

ENERGY EFFICIENCY  
EFFORTS HAVE AVOIDED  
70 GWH WORTH  
OF ENERGY IN THE  
LAST TEN YEARS.



# USING SNOW IN THE SUMMER

Oslo Airport, part of the  
Avinor Group

Enova.



[www.avinor.no](http://www.avinor.no)



REDUCES CO<sub>2</sub> BY 31  
TONNES PER YEAR,  
HOWEVER THE MAIN  
BENEFIT IS A REDUCTION  
IN ENERGY USE OF 2 GWH  
PER YEAR (OSLO AIRPORT  
ALREADY PURCHASES  
100% RENEWABLE  
ELECTRICITY).

THE RETURN ON  
INVESTMENT FOR THE  
PROJECT IS ESTIMATED  
AT NINE YEARS.

OSLO AIRPORT  
AIMS TO ELIMINATE  
EMISSIONS OF FOSSIL-  
BASED GREENHOUSE  
GASES FROM ITS OWN  
CORPORATE ACTIVITIES  
ENTIRELY BY 2020.

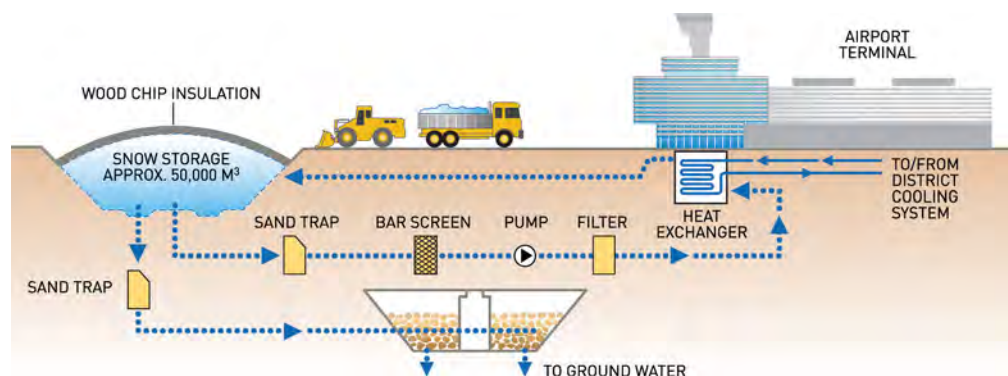
**WHAT DO AIRPORTS DO WITH ALL THE SNOW THAT FALLS ON THE AIRFIELD DURING WINTER? OSLO AIRPORT HAS DEVELOPED A UNIQUE SOLUTION THAT HELPS USE THE SNOW AND CUT ENERGY CONSUMPTION – COOLING THE TERMINAL!**

When building a new terminal extension, authorities at Oslo Airport investigated ways to help cool the building during summer as efficiently as possible. They turned to the huge amounts of snow which are stockpiled each winter at Oslo Airport. The snow is divided into two categories, pure and impure (whether it contains chemicals from runway and taxiway de-icing).

The impure snow is treated at a municipal facility and the pure snow has traditionally been allowed to melt naturally into the ground. Now, however, in a world-first system, the pure snow is collected in a large holding basin. When it is full, the basin is covered with wood chips (an excellent insulating material).

The cold meltwater from the snow storage area is transferred to heat exchanges in the terminal through a pipe system, where it helps to cool the building on hot summer days. The water is then returned back to the snow storage area and the process repeated. As the snow and ice melts, clean meltwater is released gradually into the ground, helping to maintain the water balance in the soil.

Oslo Airport is also phasing out the use of fossil fuels in its own vehicles and is testing different technological solutions such as biofuel, electricity and hydrogen. In fact, a hydrogen refuelling station was opened in 2015 and the airport is trialling the use of a fuel cell electric vehicle for airport operations.





# A STRATEGIC APPROACH TO ALTERNATIVE FUELS



**SUSTAINABLE ALTERNATIVE FUELS ARE RIGHTLY SEEN AS ONE OF THE MAIN WAYS OF REDUCING NET CO<sub>2</sub> EMISSIONS IN AVIATION. WHILE MANY AIRLINES HAVE EXPERIMENTED WITH BIOFUEL FLIGHTS, ONE IN PARTICULAR IS SHOWING SIGNIFICANT COMMITMENT WITH A STRATEGIC INVESTMENT IN ALTERNATIVE FUELS.**

In August 2014, Hong Kong flag carrier Cathay Pacific Airways made a surprising move for an airline – investing directly in a new energy company. Fulcrum BioEnergy is a US-based developer which makes biojet fuel from municipal waste.

The fuel produced through this process will not only reduce lifecycle CO<sub>2</sub> emissions by over 80%, but it will also prevent the municipal waste used being put into landfill sites and producing subsequent methane emissions.

As well as investing in the company itself, Cathay Pacific has drawn up a long-term supply agreement with Fulcrum for an initial 1.42 billion litres of renewable jet fuel over ten years, which represents roughly 2% of the airline's current total annual fuel usage. This significant investment – worth over \$1 billion – is part of Cathay Pacific's strategy to kick-start the alternative fuels business for aviation.

Fulcrum will begin to construct its first commercial plant later in 2015 and will build large-scale, waste-to-renewable jet fuel plants at multiple locations, including locations strategic to the Cathay Pacific network, primarily in North America.

The relationship between Cathay Pacific and Fulcrum is an example of how aviation as a whole can move forward and achieve carbon-neutral growth from 2020.

## Cathay Pacific Airways

Fulcrum BioEnergy.



[www.cathaypacific.com](http://www.cathaypacific.com)

[www.fulcrum-bioenergy.com](http://www.fulcrum-bioenergy.com)

OVER 80% LESS CO<sub>2</sub>  
EMISSIONS OVER THE  
FUEL'S LIFECYCLE.

PREVENTS MUNICIPAL  
WASTE BEING PUT  
INTO LANDFILL.





# EFFICIENCY IN THE AIR

IT'S NOT JUST ABOUT WHICH AIRCRAFT WE FLY OR WHAT FUEL WE USE, BUT ALSO HOW WE FLY OUR PLANES. FROM TAKE-OFF TO LANDING, OPERATIONAL EFFICIENCY IS VITAL TO OUR STORY.

An aircraft's natural environment is in the sky – it is built to fly. So we are working on ways to make sure that the flight is as efficient as possible. Technology plays a major role here, but just as important are new ways of thinking.

These examples should inspire aviation partners to always strive for better operational efficiency.



# RESPONSIVE WEATHER NAVIGATION SYSTEM

## American Airlines

National Aeronautics and  
Space Administration (NASA).



[www.aa.com](http://www.aa.com)



THE SYSTEM CAN SAVE  
AN ESTIMATED 636  
LITRES OF FUEL PER  
FLIGHT AND MORE THAN  
1.3 TONNES OF CO<sub>2</sub>.

WILL HELP PASSENGERS  
ARRIVE AT THEIR  
DESTINATION ON TIME  
AND THE AIRCRAFT'S  
SUBSEQUENT FLIGHTS  
ARE LESS LIKELY  
TO BE DELAYED.

**A NEW NASA WEATHER SOFTWARE PROGRAMME IS HELPING AMERICAN AIRLINES SAVE FUEL AND EMISSIONS BY REPLACING A PRE-SET FLIGHT PLAN WITH FLEXIBLE NAVIGATION THAT CAN REACT AND ADJUST TO CHANGING WEATHER PATTERNS, TO PROVIDE THE MOST EFFICIENT ROUTE.**

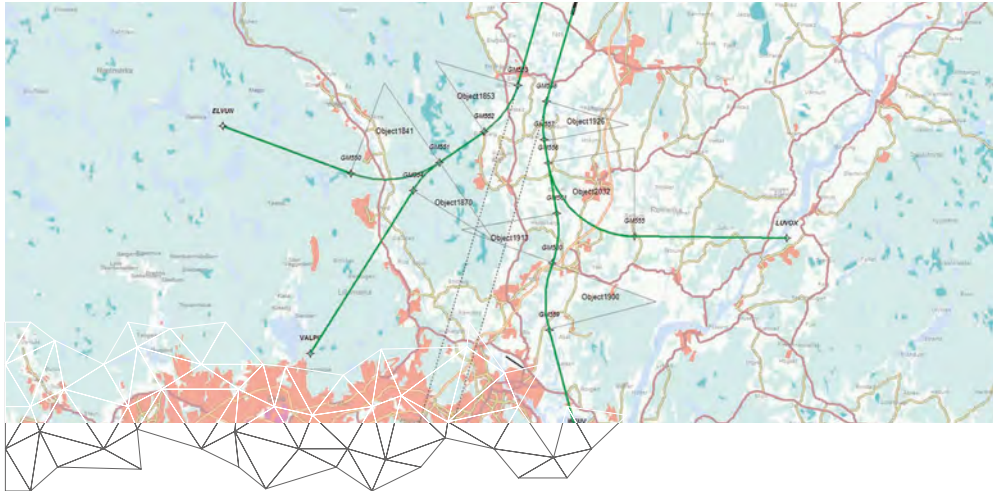
Flight plans always allow for anticipated severe weather that an aircraft might encounter during a flight. However, several hours may elapse after the flight plan is generated, during which time weather patterns may change and more efficient routings may become available. The task of the Dynamic Weather Routes System is to aid dispatchers in capturing these opportunities whilst never compromising safety.

The system continuously analyses current weather conditions and a flight's trajectory to find safe re-routes that are more efficient than the original flight plan. When the system finds an alternative route around severe weather that will save time and fuel, it will display the proposed re-route and estimated time and fuel savings for the dispatcher to evaluate. If the dispatcher needs to make an adjustment to the proposed re-route, they can easily do so. With every adjustment, the system automatically updates the time and fuel savings. The proposed re-route can be sent to the flight crew for approval, after which the flight adjustments can be sent to air traffic control.

The system was developed by NASA and has been tested by American Airlines over the course of two years. During the test period, the system helped American Airlines save approximately seven minutes per flight during convective weather days, saving 455 to 1,137 litres of fuel per flight, depending on aircraft type.

American Airlines continues to successfully use the system to reduce the customer and environmental impact of convective weather.

# A BOLD NEW APPROACH TO APPROACHING



## Avinor

Oslo Airport, Avinor,  
Scandinavian Airlines (SAS),  
Norwegian and Novair.



[www.avinor.no](http://www.avinor.no)

**UTILISING MODERN NAVIGATIONAL CAPABILITIES TO REDUCE FUEL, NOISE AND CARBON EMISSIONS IS A WIN-WIN SITUATION FOR THE AIRLINES, THE AIRPORT VICINITY AND THE CLIMATE. AVINOR AND PARTNERS ACHIEVE THIS WITH A NEW APPROACH SYSTEM AT NORWAY'S BUSIEST AIRPORT.**

Oslo Airport implemented a sequencing tool for arriving aircraft called the 'point merge' system in April 2011 to increase airspace capacity, enhance safety and improve environmental performance. Introducing point merge means that aircraft arrival sequencing takes place in the system's pre-determined arcs. This avoids conflicts with departing traffic and also allows continuous descent approaches from further out.

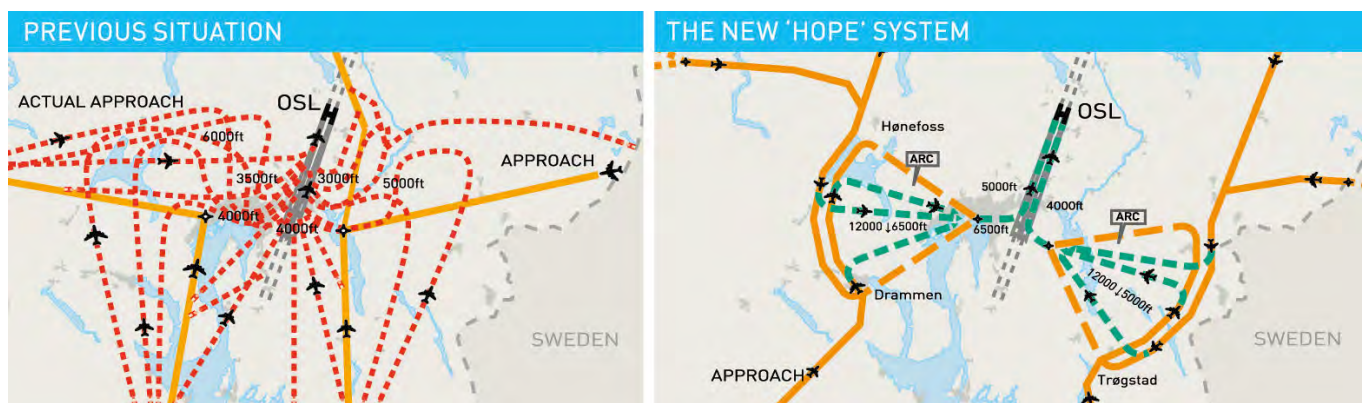
The Harmonisation of Oslo Procedures and the Environment project worked to shrink the point merge arc sizes and move the merge points closer to the airport. Then they looked at the potential of performance-based navigation as an environmental tool, supplementing the point merge system when traffic permits and potentially reducing the effects of noise and carbon emissions. Curved landing approach is an element within performance-based navigation that reduces CO<sub>2</sub> and improves operations in challenging terrain. This is enabled by satellites and modern aircraft navigational capabilities and offers the opportunity to make flight tracks shorter and more precise.

These procedures have been successfully tested and will be implemented as a supplement to conventional approaches at Oslo. In addition, the experience provides a useful benchmark for implementing this type of procedure at other Avinor airports in Norway.

**AS OF JUNE 2015, CLOSE TO 6000 APPROACHES HAVE BEEN CARRIED OUT, SAVING A TOTAL OF 1,400 TONNES OF CO<sub>2</sub>.**

**AN ESTIMATED 75 KILOGRAMS OF FUEL IS SAVED ON EACH APPROACH.**

**THE PROCEDURES AT OSLO AIRPORT ARE DESIGNED TO AVOID DENSELY POPULATED AREAS. NOISE MAPPING CREATES A REDUCTION IN NOISE EXPOSURE FOR THE AIRPORT'S NEIGHBOURS.**



# COAST TO COAST

## NATS and Nav Canada

[www.nats.aero](http://www.nats.aero)

[www.navcanada.ca](http://www.navcanada.ca)

ANNUAL ENABLED FUEL  
AND CO<sub>2</sub> REDUCTIONS  
OF 38,800 TONNES  
AND 123,400 TONNES  
RESPECTIVELY.

WORKING  
COLLABORATIVELY HAS  
CLEARLY DEMONSTRATED  
HOW AIR NAVIGATION  
SERVICE PROVIDERS  
CAN SUCCESSFULLY  
DELIVER SIGNIFICANT  
ENVIRONMENTAL  
IMPROVEMENTS IN  
THE WORLD'S BUSIEST  
OCEANIC AIRSPACE  
WHILST ENSURING THE  
SAFETY OF OVER 420,000  
FLIGHTS AND THEIR  
PASSENGERS ANNUALLY.



**COAST IS A COLLABORATIVE CHANGE PROGRAMME BETWEEN THE UK AIR TRAFFIC MANAGEMENT ORGANISATION, NATS, AND ITS CANADIAN COUNTERPART, NAV CANADA, THAT IS DELIVERING SIGNIFICANT IMPROVEMENTS IN EFFICIENCY FOR AIRLINES OPERATING IN THE WORLD'S BUSIEST OCEANIC AIRSPACE, THE NORTH ATLANTIC.**

The first delivery of COAST (Collaboration on Oceanic Airspace, Systems and Tools) saw NATS deploy the Nav Canada GAATS+ (Gander Automated Air Traffic System) to the NATS Oceanic operation. GAATS+, used now by both organisations from their Operations Centres in Prestwick, Scotland and Gander, Newfoundland, safely controls approximately 1,200 North Atlantic aircraft movements daily from the Americas, to Europe and the Middle East.

In addition to improving safety, GAATS+ also offers controller support tools that routinely identify and target fuel saving opportunities for individual flights, whilst delivering workload reductions for controllers.

GOFLI, a controller support tool within GAATS+, searches for more efficient flight levels, comparing each flight with other flight trajectories along its route to find one that can be assigned. Controllers, using controller-pilot satellite datalinks, then offer these more efficient levels to the aircraft.

Since the transition to GAATS+ in November 2014, the NATS team is on track to achieve a reduction of over 120,000 tonnes of CO<sub>2</sub> during this first year, an opportunity welcomed by airlines due to a \$20 million per year savings in fuel costs.

With GAATS+, the COAST programme has more opportunities ahead for efficiency gains. Further planned reductions in lateral and longitudinal separations will create more capacity at the most fuel efficient levels to deliver even greater efficiency. COAST will also be able to utilise the additional capabilities enabled by combining real-time satellite communications and ADS-B aircraft surveillance expected in 2018, transforming the efficiency of flight operations across the world's busiest oceanic airspace.



# ASPIRING TO EMISSIONS REDUCTIONS ACROSS THE PACIFIC



**ROUTES ACROSS AND AROUND THE PACIFIC ARE AMONG SOME OF THE LONGEST IN THE WORLD AND COVER VAST AREAS OF VIRTUALLY EMPTY AIRSPACE. THE ASIA AND PACIFIC INITIATIVE TO REDUCE EMISSIONS (ASPIRE) PROGRAMME BRINGS TOGETHER A UNIQUE COLLABORATION TO HELP CUT EMISSIONS.**

One example of the collaborative effort paying off was with Singapore Airlines. The programme started with a demonstration flight operating from Los Angeles to Singapore via Tokyo, where aviation authorities in Singapore, the United States and Japan worked together to ensure optimal traffic conditions. In total, 10 tonnes of fuel and 33.7 tonnes of carbon emissions were saved on that one flight. Whilst that route has been discontinued, the lessons learned and the collaborative partnerships have continued and are now being implemented on other routes, in an effort known as ASPIRE Daily.

For all flights now from Singapore to Melbourne, Sydney, Auckland and Christchurch, the ASPIRE partnership is put into action. Examples of air traffic management best practice include measures which allow: pilots to take full advantage of atmospheric conditions, such as prevailing winds, to reduce separation between aircraft and shorten flight time; and planning with air traffic management agencies to allow aircraft to fly with engines set at idle mode in continuous descent from a high altitude during the landing phase of the flight, reducing fuel burn.

Each ASPIRE Daily city pair is star-rated, based on the number of best practice procedures employed, with three stars representing the minimum required and five stars indicating that all best practices are employed. In collaboration with government agencies, airlines, regulators and other aviation industry stakeholders, ASPIRE aims to accelerate the development of gate-to-gate operational procedures to reduce fuel burn and emissions for all phases of flight.



## Singapore Airlines

Civil Aviation Authority of Singapore, Airways New Zealand, Japan Civil Aviation Bureau, Federal Aviation Administration, Air Services Australia, AeroThai, Air New Zealand, United Airlines, Qantas, Japan Airlines, Cathay Pacific.



[www.aspire-green.com](http://www.aspire-green.com)

**SINGAPORE AIRLINES HAS REALISED 2,536 TONNES OF ANNUAL CO<sub>2</sub> SAVINGS FOR AUSTRALIA AND NEW ZEALAND FLIGHTS.**

**THERE ARE CURRENTLY 22 ASPIRE DAILY CITY PAIR ROUTES ACROSS THE PACIFIC OCEAN.**

**THE GROWING NUMBER OF ASPIRE CITY PAIRS HAS SHOWN THAT THE KEY ELEMENTS OF BEST PRACTICE FROM DEMONSTRATION FLIGHTS CAN BE REPEATED IN DAILY OPERATIONS.**

*Each of these routes takes part in ASPIRE Daily flights, with collaboration between airlines and air traffic management experts across the Pacific.*



EFFICIENCY  
IN THE AIR



SEATTLE,  
UNITED STATES

# GREEN SKIES OVER SEATTLE

## Seattle-Tacoma Airport and Alaska Airlines

Federal Aviation  
Administration, Boeing



[www.portseattle.org/Sea-Tac](http://www.portseattle.org/Sea-Tac)

[www.alaskaair.com](http://www.alaskaair.com)



25,600 TONNES CO<sub>2</sub>  
FORECAST TO BE  
SAVED PER YEAR IF  
ALL APPROPRIATELY-  
EQUIPPED AIRCRAFT  
FLYING INTO THE AIRPORT  
USE THE PROCEDURE.

REDUCES AIRCRAFT  
NOISE EXPOSURE FOR  
AROUND 750,000 PEOPLE.

WILL REDUCE FUEL  
COSTS BY AROUND  
\$5.5 MILLION PER  
YEAR FOR AIRLINES.

**IMPROVING EFFICIENCY OF FLIGHT PATHS NATURALLY RESULTS IN LESS CO<sub>2</sub> EMISSIONS. TO ACHIEVE THIS, A PARTNERSHIP IN THE PACIFIC NORTHWEST OF THE USA HAS PACKAGED TOGETHER A SET OF NEW TECHNOLOGIES TO DELIVER FUEL, TIME AND CO<sub>2</sub> SAVINGS.**

Dubbed “Greener Skies over Seattle,” the project brings together several satellite-based flight guidance technologies and new flight procedures to allow aircraft to descend more efficiently into Seattle-Tacoma Airport. This method cuts down on fuel burn, as the engines are left on low or idle power settings more often during the approach.

The procedures which have been implemented combine a set of different innovations: optimised profile descents (where the aircraft essentially glides in idle to the runway threshold); area navigation (RNAV) arrivals (which are GPS-guided arrivals); and required navigation performance (RNP) approaches (which takes RNAV to an additional level of precision).

Alaska Airlines reports that its use of the Greener Skies approach has resulted in an average nine minutes less flying time per flight and has cut 14,350 tonnes of CO<sub>2</sub> per year. Whilst Alaska Airlines has led the way on this project, the procedures are now being used by any properly-equipped airline.

In addition to increasing the efficiency of flights in and out of the airport, Greener Skies provides opportunities for increased capacity by reducing standard separation, as the aircraft are able to be tracked precisely.

Taken on as a Next Generation project by the United States’ Federal Aviation Administration in 2010, Greener Skies was fully implemented in April 2015. The ultimate aim of the FAA is to use the reduced aircraft separation standards at 12 other airports across the United States that have similar runway configurations to Seattle-Tacoma and there is, of course, potential for the system to be repeated at airports across the world.



# ECO-EFFICIENT MORNINGS IN ZURICH



**THE SWISS GREENER WAVE PROJECT HAS COMBINED THE COLLECTIVE EXPERTISE OF SKYGUIDE, SWISS INTERNATIONAL AIRLINES AND ZURICH AIRPORT TO IMPROVE ARRIVAL EFFICIENCY AND CUT CO<sub>2</sub> EMISSIONS.**

Traditionally, a number of Swiss International Airlines long-haul flights arrived at Zurich Airport in the early morning, creating a “queue” of sorts in the air as they waited for their chance to land once the curfew was lifted each day. This collaboration has created a system that assigns a 4-dimensional slot at a pre-defined point and time between 20 to 120 nautical miles away from Zurich Airport. Flight crews can then adjust their speed during the cruise part of the flight to arrive at the assigned point exactly on time, without the need for unnecessary delaying of arrival.

This system allows approaching aircraft to fly a more continuous, fuel-efficient descent. The new focus on airport arrival efficiency has led to modifications of the standard arrival procedures for Zurich Airport, which has decreased track miles flown and cut CO<sub>2</sub> emissions. In fact, half a tonne of CO<sub>2</sub> emissions per flight are now able to be avoided through the collaborative project.

The improved air traffic operation has led to an increase in efficiency and capacity at Zurich Airport without any changes to infrastructure. Zurich residents have also enjoyed a significant decrease in early morning noise due to the near elimination of extra air traffic controller actions and aircraft holding. The Greener Wave project has paved the way for other research and development initiatives in Europe (for example Fairstream and iStream projects) to validate this new concept of operations in different environments.

## Skyguide

Swiss International Airlines, Flughafen Zürich, SESAR Joint Undertaking as part of the Atlantic Interoperability Initiative (AIRE).



[www.skyguide.ch](http://www.skyguide.ch)

**2,100 TONNES OF CO<sub>2</sub> EMISSIONS SAVED EVERY YEAR.**

**AN EVALUATION OF OVER 15,000 FLIGHTS DURING THE PROJECT SHOWED A 90% DECREASE IN AIRCRAFT HOLDING TIME AND A REDUCTION OF FOUR MINUTES' FLIGHT TIME.**

**FUEL SAVING WORTH \$777,283 PER YEAR.**

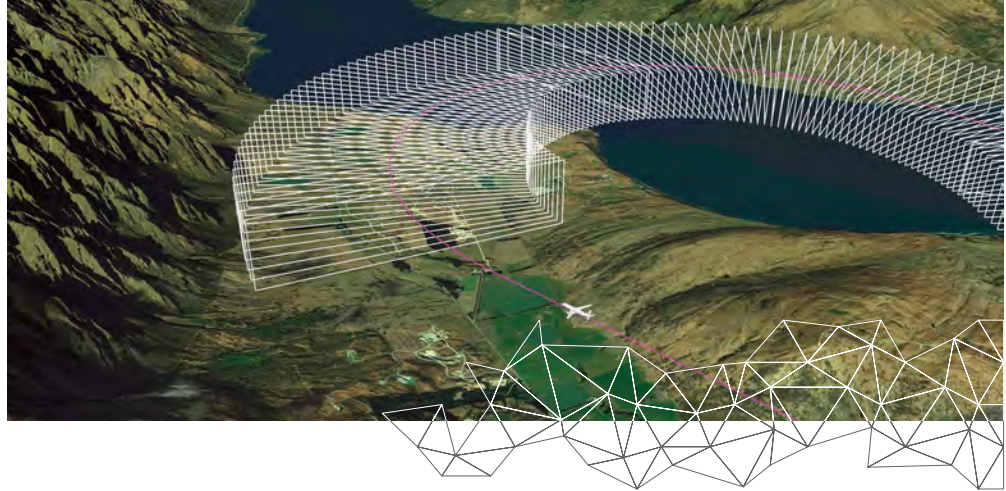




# WHEN LANDING BECOMES A PERFORMANCE

Latam Airlines Group,  
airBaltic, Airways  
New Zealand, Qantas,  
Honeywell

GE Aviation, SESAR, Airbus  
Prosky, Latvijas Gaisa  
Satiksme, Riga International  
Airport, Latvia CAA, Peru  
CAA, China CAA and the Air  
Traffic Management Bureau,  
Boeing, Airbus, Hughes  
Aerospace, Shandong Airways  
and China Eastern Airlines



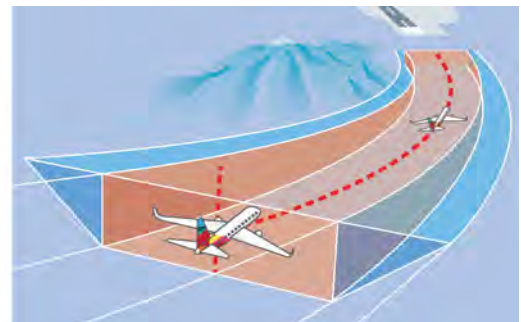
**MANAGING AIRSPACE IS A COMPLEX BUSINESS. IT'S BEEN LIKENED TO PLAYING 3D CHESS, BUT WITH THE PIECES MOVING AT 900 KILOMETRES PER HOUR AND THE ADDED IMPACTS OF WEATHER, RESTRICTED AIRSPACE AND THE NEED TO MAINTAIN THE HIGHEST LEVELS OF SAFETY.**

Little wonder that when you have a system that handles these things well, you don't want to change it too much. But the way air traffic has been controlled over the past half century is starting to cause issues, particularly with capacity. At the same time, new technology has enabled a mind-shift in the way that air traffic is able to be handled. Aircraft will no longer need to be "controlled" throughout their flight, but the system can be "managed", making use of the technology available to plan the most optimal route possible for each flight and then managing the airspace to ensure safe operations. It is based on the performance possibilities of the modern aircraft flying our skies, not simply on the position of ground equipment such as radar stations and navigation beacons.

Particularly relevant to aircraft as they approach and land at airports is the concept of "performance-based navigation", made up of a number of different technologies and procedures. Each of these can help reduce congestion, improve safety even further, cut down on weather issues, usually reduce noise impacts and cut CO<sub>2</sub> emissions.

At its most advanced level of performance, the procedures enable aircraft to precisely fly optimal, predetermined paths by using a combination of modern flight management computers, global positioning system (GPS) technology and innovative procedure design. In addition to helping aircraft navigate safely in challenging terrain and weather, these flight paths reduce flight distances and utilise lower thrust settings, saving fuel and reducing emissions.

## AN EVOLUTION OF AIRCRAFT NAVIGATION



SMALL SELECTION OF PERFORMANCE-BASED NAVIGATION PROJECTS. THESE ARE BEING ROLLED-OUT WORLDWIDE AND CAN HELP REDUCE CONGESTION, IMPROVE SAFETY EVEN FURTHER, CUT DOWN ON WEATHER ISSUES, USUALLY REDUCE NOISE IMPACTS AND CUT CO<sub>2</sub> EMISSIONS.

EACH APPROACH PATH MUST BE SPECIALLY-DESIGNED TO ACCOUNT FOR LOCAL GEOGRAPHY, WEATHER, RUNWAY COORDINATES AND COMMUNITY LOCATIONS.

The amber project (arrival modernisation for better efficiency in riga) demonstrated turboprop aircraft capability to fly tailored approach procedures together with continuous descent operations, in order to shorten arrival tracks and reduce CO<sub>2</sub> emissions, as well as to reduce the noise impact over populated areas where possible. Airbaltic-operated bombardier q400 aircraft have been used for the project, making it the first such application on turboprop aircraft in europe. The results show that up to 20 nautical miles worth of flight can potentially be saved for each arrival — reducing emissions by 232 kilograms. Over a year, over 3,000 tonnes of CO<sub>2</sub> can be saved.

Alaska Airlines pioneered the use of performance-based navigation and RNP approaches at many of its airports. In fact, the method was developed by one of its pilots. It has equipped 100% of its fleet with the technology needed and saves 1.5 million litres of fuel per year because of it. Its subsidiary company Horizon Airlines, flying Bombardier Q400 turboprops, saves 660,000 litres of fuel a year through RNP approaches.

In China, collaboration between a number of different aviation partners at Shanghai Pudong International Airport has resulted in the potential for significant savings of fuel and CO<sub>2</sub>. By blending performance-based navigation with a new aircraft landing technology developed by Honeywell, SmartPath GBAS, the demonstration showed that an arriving aircraft could reduce emissions by over a tonne of CO<sub>2</sub> — meaning that even if these optimised approaches were used by just a quarter of flights using the airport, it could cut CO<sub>2</sub> emissions by 100,000 tonnes a year. Additionally, the precise nature of the 3D approaches means that noise can be reduced for local residents. The system is now available for airlines and airports equipped with the correct technology.

Meanwhile, GE Aviation continues to expand the RNP network in China by implementing procedures with Air China, Sichuan Airlines, China Southern, China Eastern, Hainan Airlines, Sichuan Airlines, Xiamen Airlines, Chengdu Airlines, Chongqing Airlines, Lucky Air and West Air at eight other airports in China.

PERFORMANCE-BASED NAVIGATION IS IN USE AT INCREASING NUMBERS OF AIRPORTS AROUND THE WORLD.

Qantas, in partnership with ANSPs such as Air Services Australia, was the first airline outside of North America to implement RNP and was the first airline in the world to achieve operational approval for the highest accuracy RNP procedure (known as RNP 0.10). Beyond initial deployment in Queenstown NZ in 2004, Qantas has gone on to deploy RNP procedures at more than 17 destinations within Australia, including medium density traffic ports. Other Qantas Group airlines such as Jetstar are also participating in this programme. The CO<sub>2</sub> savings made by using RNP over the conventional instrument approach can be up to 300kg per flight, or nearly one tonne of carbon.

In Peru, Chile and Ecuador, the airlines of the Latam Group (LAN and TAM) worked with GE Aviation to implement RNP at 31 of their destinations. The technology is particularly useful when flying in the mountainous terrain of the Andes, where it allows much more controlled approaches to airports often surrounded by high peaks. The navigation system allows a perfect landing, even in inclement weather and has reduced significantly the number of delays and cancellations because of a lack of visibility. It has also increased safety, reduced the workload of pilots and air traffic controllers during critical parts of the flight and helped to keep the communities in those regions in touch with business, social and tourism connections. LATAM has estimated that in one year alone, use of RNP in these three countries has cut its fuel use by 3.7 million litres and reduced CO<sub>2</sub> emissions by 8,600 tonnes. It credits the collaboration between the airline, GE Aviation and government authorities in Peru, Chile and Ecuador for helping to demonstrate the benefits of the system.

Queenstown Airport serves one of New Zealand's tourism hotspots, where traffic growth has been exceptional. It is also situated in very challenging mountainous terrain that is often impacted by low cloud conditions. Since the start of performance-based navigation manoeuvres into and out of the airport, local air traffic management provider Airways New Zealand estimates a reduction in CO<sub>2</sub> emissions of around 2,300 tonnes per year (and over \$600,000 worth of fuel). Due to the difficult terrain, implementation took over two years to complete and the project redesigned local airspace and utilised a range of performance-based navigation concepts.

THE INDUSTRY IS ENCOURAGING COLLABORATION WITH GOVERNMENTS TO INCREASE THE USE OF PERFORMANCE-BASED NAVIGATION WHERE POSSIBLE AND SUITABLE.

# SPACE-BASED NAVIGATION

## Aireon

Nav Canada, ENAV, Irish Aviation Authority, Naviar, Iridium Communications.



[www.aireon.com](http://www.aireon.com)



THE AIREON PROJECT WILL LEAD TO A CUT OF AN ESTIMATED 300,000 TONNES OF CO<sub>2</sub> PER YEAR.

FUEL SAVINGS FOR AIRLINES OF AT LEAST \$100 MILLION ANNUALLY.

MORE CAPACITY AVAILABLE AND SHORTER FLIGHT TIMES.

**TAKING ADVANTAGE OF NEW TECHNOLOGY TO TRACK AIRCRAFT MORE CLOSELY CAN HELP SIGNIFICANTLY REDUCE CO<sub>2</sub> EMISSIONS AND FUEL USE. TRADITIONALLY, AIR TRAFFIC CONTROLLERS HAVE USED RADAR TO TRACK AND CONTROL FLIGHTS. RADAR REQUIRES GROUND STATIONS AND IS FAIRLY HIGH-MAINTENANCE.**

Remote areas of land (such as vast swathes of Canada, Africa, Russia and Australia) have not been covered by radar and neither have the oceans. In these areas, commercial flights have always followed very strict 'highways' and had to stick to rigid timing, flight level and speed to ensure that safe separation is maintained. Aircraft are kept well apart, but it is also not particularly efficient, with very wide safety margins.

A new technology, Automatic Dependence Surveillance – Broadcast (ADS-B) allows tracking of aircraft using a network of stations on the ground. Instead of installing a whole radar position, a small cabin and antenna can help keep track of flights, allowing them to fly closer together and take advantage of the best flying conditions. This technology is now installed in many parts of the world, with some significant results. When set up across Canada's Hudson Bay area, ADS-B allowed Nav Canada to reduce the separation between aircraft from 80 nautical miles to 5 nautical miles. This will help cut an estimated 757,000 tonnes of CO<sub>2</sub>e by 2020.

However, the oceans have still not been covered. By 2018, a new consortium, Aireon, will use the Iridium NEXT satellite constellation, placing ADS-B receivers on all 66 low earth orbit satellites (plus six spare orbiting satellites and nine ground spares). Each satellite will be cross-linked, creating a dynamic network to ensure continuous availability of coverage in every flight information region on the globe with low latency and update rates suitable for air traffic surveillance.



- 1 Aircraft coordinate their position from the GPS satellite constellation.
- 2 Then they broadcast their position and other data to any aircraft or ground station equipped to receive it.
- 3 ADS-B signals are sent via Aireon satellites and ground receivers in less busy or remote areas.
- 4 Radar is used over busy and built-up areas.
- 5 ADS-B, radar and Aireon information combines for full ATM surveillance picture.



# NARROWING GAPS TO SAVE FUEL



## FedEx Express

Federal Aviation  
Administration, WakeNet.



[www.csr.fedex.com](http://www.csr.fedex.com)

**BY CHALLENGING AIRCRAFT SEPARATION STANDARDS THAT WERE BASED ON DATED TECHNOLOGY, FEDEX AND ITS PARTNERS HAVE INTRODUCED NEW AIRCRAFT SEPARATION STANDARDS WHICH HAVE IMPROVED ARRIVALS AND DEPARTURE EFFICIENCY BY UP TO 20%.**

Aircraft create 'wake vortices' when they fly, disrupting the air behind them. Generally, larger aircraft create larger such vortices and turbulence which can cause issues for any other aircraft lining up to land or take-off behind. Separation standards set the minimum distance to avoid flying in unstable air upon arrival and departure.

Together, FedEx and the United States Federal Aviation Administration redefined the protocol in order to decrease separation, reduce taxi and flying time, save fuel and increase airport capacity – all without compromising safety which remains the number one priority for the industry.

At Memphis International Airport in November 2012, a cross-disciplinary FedEx team used the latest scientific techniques to calculate the minimum safe distance between aircraft. This included new software that displayed wake turbulence separation in real time, helping air traffic controllers to better judge spacing. The team found that, on average, separation standards between trailing and leading aircraft could be reduced by approximately 1.61 kilometres.

Now more than 4,200 FedEx pilots use the new standards, saving an average of 1,400,196 litres of jet fuel a month. Capacity was increased at Memphis International Airport resulting in 99 arrivals per hour compared to 84 arrivals per hour.

The successful implementation at Memphis International Airport led to expanded adoption at other US airports with a similar fleet mix. The FAA rolled out the new standards in Louisville, Atlanta and Cincinnati. Charlotte, John F Kennedy, Newark, Chicago, San Francisco and Houston airports are soon to follow.

TO DATE, OVER  
100,000 TONNES OF  
CO<sub>2</sub> EMISSIONS HAVE  
BEEN SAVED.

PROJECT IS ONE OF MORE  
THAN 45 "FUEL SENSE"  
PROGRAMMES THAT HAVE  
COLLECTIVELY SAVED  
OVER 1.25 BILLION LITRES  
OF JET FUEL SINCE ITS  
INCEPTION IN 2007.

NEARLY \$30 MILLION IN  
CUMULATIVE AVIATION  
FUEL COSTS AVOIDED.



# CONTINUOUS DESCENT

## Kenya Airways, Sustainable Aviation, PildoLabs and NATS

International Air Transport Association, HungaroControl, Wizz Air, Kenyan Civil Aviation Authority and others.



[www.aireon.com](http://www.aireon.com)

AIRLINES ARE PARTNERING WITH AIR TRAFFIC MANAGEMENT ORGANISATIONS, AIRPORTS AND TECHNOLOGY PROVIDERS TO DELIVER NEW LANDING TECHNIQUES.

CONTINUOUS DESCENTS NOT ONLY SAVE FUEL AND CO<sub>2</sub>, BUT CAN ALSO CUT NOISE IMPACTS AT SOME AIRPORTS.

CONTINUOUS DESCENT OPERATIONS (CDOs) CAN ALSO BE CALLED CONTINUOUS DESCENT APPROACHES (CDAs).



**'CONTINUOUS DESCENT OPERATIONS' ALLOW AN AIRCRAFT TO APPROACH AND LAND ON THE RUNWAY IN ONE SMOOTH MOTION, RATHER THAN THE TRADITIONAL 'STEPPED' APPROACH TO AN AIRPORT, WHERE ENGINE POWER WAS NEEDED TO LEVEL OFF AT MULTIPLE ALTITUDES BEFORE LANDING.**

This saves fuel and can also reduce noise burdens on communities. Given the different types of airport environment – some have very congested and complex airspace – the technique is not always possible and is individually designed to suit each airport.

Continuous descents are now in operation at many airports worldwide; here are three examples of the concept in action:

At Budapest Airport in Hungary, aeronautical engineering company PildoLabs worked with HungaroControl and Wizz Air to implement the technique, which has been made available to all airlines operating there since March 2013. The trials demonstrated that fuel use and CO<sub>2</sub> could be cut by 48% for each arrival, reducing CO<sub>2</sub> by 323 kilograms for each aircraft that uses it. The project, known as REACT-Plus, is co-financed by the SESAR initiative.

Kenya Airways has worked with the Civil Aviation Authority and IATA to implement the technique at Nairobi's Jomo Kenyatta International Airport. In the six years the airline has been using continuous descents, it has been able to undertake the procedure on 85% of arrivals at 15 airports and has avoided five million tonnes of CO<sub>2</sub>. By 2020, Kenya Airways aims to have 100% of arrivals use the process and roll it out to airports across Africa.

Improved continuous descent techniques across 15 airports in the United Kingdom have cut CO<sub>2</sub> emissions by 20,000 tonnes in nine years, with a project to increase use of the techniques by 5% in the coming years, saving a further 10,000 tonnes of CO<sub>2</sub> with 30,000 quieter flights.



# CONTINUOUS CLIMB



**LIKE CONTINUOUS DESCENT OPERATIONS, CONTINUOUS CLIMBS ALLOW AN AIRCRAFT TO TAKE-OFF AND REACH ITS CRUISING ALTITUDE IN ONE SMOOTH MANOEUVRE. THE FLIGHT CAN ATTAIN THE MOST FUEL-EFFICIENT FLYING CONDITIONS QUICKLY AND ALSO REDUCE THE FUEL USED BY LEVELLING-OFF AT DIFFERENT ALTITUDES.**

Whilst the benefits are often not as great as with continuous descents, there can be emissions and noise reductions. The ability for air traffic management to work with airlines and airports to implement such measures depends on the capacity conditions and complexity of the airspace, but continuous climbs have been implemented at a number of airports including:

The Sustainable Aviation partnership has promoted continuous climb techniques at UK airports, with the procedure being used up until 10,000 feet. From 55% of departures using the technique in 2006, implementation has grown to 67% in 2014. Sustainable Aviation is also promoting best practice in take-off and landing cycle operations through the publication, in partnership with others, of codes of practice.

As part of the REACT-Plus project of the SESAR programme, at Budapest Airport in Hungary, aeronautical engineering company PildoLabs worked with stakeholders to implement continuous climbs on nearly all departures from the airport as of March 2013.

Part of another SESAR project, the Atlantic Interoperability Initiative, looked at the benefits of continuous climbs from the two main Paris airports and was jointly investigated by Air France and the French air traffic management provider DSNA. The demonstrations showed around 100 kilograms of CO<sub>2</sub> savings per departure at Charles de Gaulle Airport and about 300 kilograms at Orly Airport.

## Sustainable Aviation, PildoLabs

SESAR, Air France, DSNA, Wizz Air, HungaroControl and many others.



[www.csr.fedex.com](http://www.csr.fedex.com)

CLIMBING TO OPTIMUM CRUISING ALTITUDE AND OUT OF CONGESTED AIRSPACE CAN REDUCE CO<sub>2</sub> PER DEPARTURE BY 100-300 KILOGRAMS.

IN SOME SITUATIONS, IT CAN ALSO HAVE AN IMPACT ON DEPARTURE NOISE, REDUCING ANNOYANCE FOR LOCAL COMMUNITIES.

DIFFERENT AIRPORTS AND AIRSPACES WILL REQUIRE DIFFERENT DESIGNS.





# FREE IN THE AIR

**DFS Deutsche Flugsicherung, Eurocontrol Network Manager, Qantas**

Air Services Australia, HungaroControl, Lufthansa



[www.dfs.de](http://www.dfs.de)

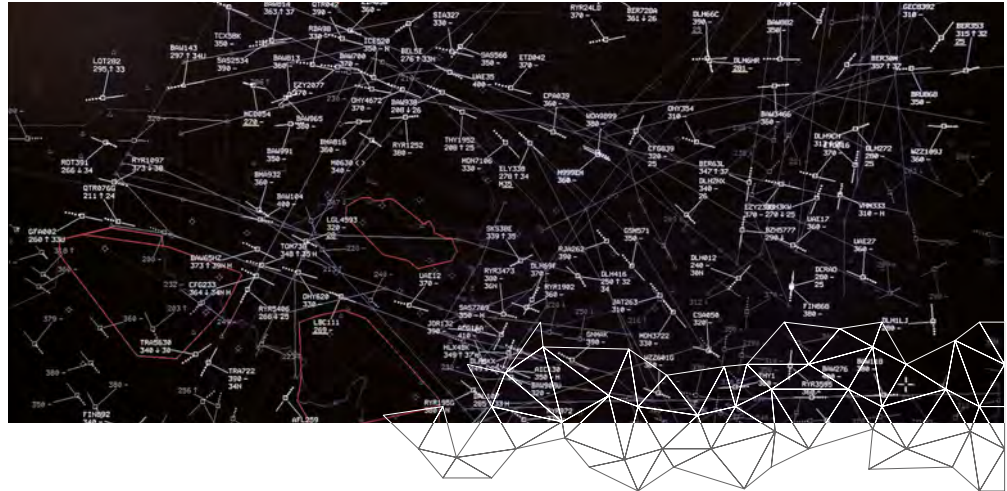
[www.eurocontrol.int](http://www.eurocontrol.int)

[www.qantas.com](http://www.qantas.com)

**ANNUAL SAVINGS OF 500,000 TONNES OF CO<sub>2</sub> EMISSIONS ARE ESTIMATED (IN PART 2).**

**FINANCIAL SAVINGS OF \$140 MILLION IN REDUCED FUEL COSTS TO AIRLINES.**

**27,000 FLIGHTS PER DAY BENEFIT FROM THIS PROJECT, PEAKING AT 33,000 DURING THE SUMMER SEASON.**



**EUROPEAN AIR NAVIGATION SERVICE PROVIDERS AND EUROCONTROL NETWORK MANAGER ARE PROGRESSIVELY ALLOWING AIRSPACE USERS TO PLAN ROUTES INDEPENDENT OF THE FIXED-ROUTE NETWORK AND BASED ON CURRENT AIRCRAFT EQUIPMENT. THE EUROPEAN FREE-ROUTE AIRSPACE IS EXPECTED TO BE AVAILABLE AT AND ABOVE 31,000 FEET BY 2022.**

Within free route airspace, flights remain under air traffic control, but irrespective of previous structured routes pilots can plan a route based on the optimum flightpath, adapting especially to the wind conditions at cruising level.

To help achieve the environmental targets set by the Single European Sky legislation, and to enable airlines to operate more efficient and flexible routes, Eurocontrol Network Manager initiated the development and implementation of Free Route Airspace in 2008 through a partnership approach involving various, organisations and bodies, both civil and military.

The German air navigation service provider, DFS, has taken an important step towards this system. In their project titled Free Route Airspace Maastricht and Karlsruhe (FRAMaK), co-funded by the SESAR Joint Undertaking and in partnership with Eurocontrol Network Manager and Lufthansa, an average route length reduction of 3.7 nautical miles (corresponding to 56.4 kilograms less fuel and 178.1 kilograms less CO<sub>2</sub>) was achieved per flight. The total potential benefit was estimated at an annual reduction of route length of 1.5 million nautical miles corresponding to 30,000 tonnes of CO<sub>2</sub>.

Full implementation has already taken place in Portugal, Sweden, Denmark, Ireland and Hungary, with partial implementation during the night in a large number of European states. A significant implementation will continue in 2015 with all the Scandinavian and Baltic States implementing full free-route airspace.

» A very similar concept is 'user-preferred routing', which Qantas has deployed in tandem with Air Services Australia, bringing annual saving of up to 360 tonnes of CO<sub>2</sub> for the airline on its domestic flights.

# ENGAGE TO MAXIMISE AIRSPACE EFFICIENCY



*NavCanada and colleagues from KLM, SESAR and Air France meet to work on efficiency measures through the ENGAGE programme.*

**IN A TRUE DISPLAY OF COLLABORATIVE ACTION ACROSS OCEANS AND SKIES BRINGING EMISSIONS REDUCTIONS, NAV CANADA, AIR FRANCE AND PARTNERS COLLABORATED TO SAFELY CHALLENGE TRADITIONAL OCEANIC AIR TRAFFIC MANAGEMENT RULES OF FIXED SPEED AND ALTITUDE... WITH IMPRESSIVE RESULTS.**

Traditionally, flights fly a fixed route, speed and altitude to cross the Atlantic, limiting air traffic controllers' ability to always offer the most efficient routes where there is no radar. The Engage project demonstrated the safety and viability of varying speeds and changing altitudes to take advantage of the jet stream and air traffic patterns during flight.

The implementation of radar and a new type of aircraft tracking technology known as ADS-B on the east coast of Canada and in Greenland enabled the application of significantly reduced aircraft separation standards. The additional surveillance opened flight levels, routings and flexibility in the airspace surrounding southern Greenland increasing capacity in the area, creating opportunities for a greater number of carriers to vary speed and altitude which allows for impressive fuel economy benefits.

Nav Canada led a group of air traffic management providers and commercial air carriers in a collaborative project to use variable Mach (aircraft speed) and flight level in airspace over the North Atlantic from 2011 to 2013. The project consisted of two phases. Phase One began in August 2011 with NAV Canada conducting flight trials with NATS and five carriers. These trials tested the viability of flexible altitude change and corresponding change in aircraft speed.

Phase Two of Engage in 2014 involved further safety validations and focussed on implementing the concepts trialled in Phase One in the long term. The North Atlantic Systems Planning Group – a body established by ICAO – endorsed a proposal to amend its procedures, which would remove the requirement for fixed speed.

## Nav Canada and Air France

NATS, Isavia, Nav Portugal, KLM, Delta Air Lines, United Air Lines, British Airways, Air Canada



[www.navcanada.ca](http://www.navcanada.ca)

**BASED ON THE NORTH ATLANTIC FLEET, OVER ONE TONNE OF GREENHOUSE GAS EMISSIONS COULD BE AVOIDED PER FLIGHT.**

**WITH OVER 400,000 FLIGHTS PER YEAR, THE NORTH ATLANTIC IS THE BUSIEST OCEANIC AIRSPACE IN THE WORLD. THEREFORE, THE POTENTIAL ENVIRONMENTAL BENEFITS THAT CAN BE REALISED THROUGH THE PROCEDURES TRIALLED DURING THE ENGAGE PROJECT ARE SUBSTANTIAL.**

# TOP OF THE CLASS

## NATS

British Airways, Nav Canada, Airbus ProSky, Boeing, Barco Orthogon and part funded by the SESAR Joint Undertaking.



[www.nats.aero](http://www.nats.aero)

TOPFLIGHT PHASE ONE RESULTED IN HALF A TONNE OF CO<sub>2</sub> SAVED PER FLIGHT.

RESULTS MEASURED INFORM FURTHER SESAR WORK.

TOPFLIGHT IS JUST ONE EXAMPLE OF HOW NATS ARE TAKING PART IN THE WIDER SESAR INITIATIVE AND THE RESULTS ACHIEVED WERE TO THE BENEFIT OF ALL SESAR PARTNERS.



**AFTER CONDUCTING A 'PERFECT FLIGHT' TRIAL BETWEEN LONDON AND EDINBURGH IN 2010, WHERE EACH STAGE OF THE JOURNEY WAS DESIGNED TO ACHIEVE THE HIGHEST EFFICIENCY POSSIBLE, UK AIR TRAFFIC MANAGEMENT PROVIDER NATS LAUNCHED AN EVEN MORE AMBITIOUS TRIAL.**

This project, named 'Topflight', aimed to develop, demonstrate and integrate some of the aspects of the Single European Sky research initiative (SESAR) in a real world scenario and measure the results to see where gains were made.

In conjunction with partners, the first phase of this NATS led trial took place in 2013 and focussed on 100 British Airways flights across the North Atlantic between London and Toronto or Montreal. These flights aimed to achieve 'gate-to-gate' optimisation through using elements of SESAR, such as providing an initial Oceanic profile before departure, continuous climb and descent, direct routing, the flexible use of military airspace and reduced engine taxiing.

The full list of optimisation opportunities was developed and, of the hundred flights, a quarter were able to achieve all efficiency measures and 70% achieved at least half. These test flights not only resulted in an estimated half a tonne of CO<sub>2</sub> saved per flight, but also provided analysts with valuable information on which aspects of the trial produced the greatest savings. These results were then fed back to the team at SESAR to further inform their work.

The second and on-going phase, which began in early 2014, is called XMAN and is focussed on reducing the amount of time aircraft spend in holding stacks on arrival at Heathrow. To achieve better efficiency when significant delays are expected, NATS is working with neighbouring air traffic management organisations to slow down aircraft en-route, meaning they spend less time holding on arrival, burn less fuel and emit less CO<sub>2</sub>.



# HARDER, SAFER, LIGHTER, STRONGER...



**IN A DRIVE TO IMPROVE SAFETY BY DEVELOPING HI-TECH FIRE RESISTANT CONTAINERS, UPS FOUND IT HAD ALSO CREATED MUCH LIGHTER CONTAINERS, SAVING SIGNIFICANT AMOUNTS OF FUEL. SIMILAR PRODUCTS ARE NOW BEING DEPLOYED BY OTHER AIRLINES.**

Fire resistant container research began as a safety enhancement at UPS. These containers include panelling made from a plastic composite material called MACROLite, which is reinforced with fibre and similar to the material used in bulletproof vests. This project began as an in-flight safety enhancement and resulted in a stronger, more efficient air container.

Along with the fire resistant properties, the panels are more durable and lighter-weight than current polycarbonate designs. Testing revealed that adding stress to the MACROLite material strengthens rather than weakens it. While supporting the safety strategy for UPS, the new containers also resulted in fuel savings of over 1,287,040 litres and the avoidance of 3,200 tonnes of CO<sub>2</sub> emissions in 2014.

All the cargo networks of LATAM Airlines Group have rolled out similar cargo and luggage containers made of high-strength and low-weight Kevlar material that is five times stronger than steel and a third lighter. These containers have cut maintenance time, allowed the airlines to carry more cargo and, importantly, have reduced fuel use and CO<sub>2</sub> emissions – 3,000 tonnes avoided annually.

Finnair has also benefited from purchasing the Nordisk containers as part of their 'weight watchers' programme, where the airline expects to save around 800,000 kilograms in fuel and more than 2,500 tonnes of CO<sub>2</sub> annually.



UPS Airlines, cargo affiliates of Latam Airlines Group (LAN Cargo, TAM Cargo, LAN Cargo Colombia and MasAir) and Finnair

MACRO Industries, Satco and Nordisk Aviation Products



[www.ups.com](http://www.ups.com)

UPS SAVED OVER 1,287,040 LITRES OF FUEL AND DECREASED CO<sub>2</sub> EMISSIONS BY 3,200 TONNES IN 2014 THROUGH THIS PROJECT.

THE NEW UPS CONTAINERS HAVE PROVEN MORE DURABLE, LEADING TO A 69% REDUCTION IN REPAIR COST PER CONTAINER.

FOR THE LATAM AIRLINES GROUP, THE MOVE TO KEVLAR CONTAINERS CUT THE FUEL BILL BY \$600,000 PER YEAR.

# DEPLOYING TABLET COMPUTERS TO SAVE FUEL

**FedEx Express, United Airlines, American Airlines and many airlines worldwide**

Jeppesen and other suppliers.



[www.fedex.com](http://www.fedex.com)



**ALASKA AIRLINES, JETBLUE, SOUTHWEST, BRITISH AIRWAYS, KLM, AIR FRANCE, QANTAS AND IBERIA ARE AMONG THE MANY OTHER AIRLINES ALSO USING THE SYSTEM.**

**IT SEEMS A SIMPLE SOLUTION – USING CONSUMER ELECTRONIC DEVICES SUCH AS IPADS AND OTHER TABLET COMPUTERS TO REPLACE THE HEAVY PAPER FLIGHT MANUALS, MAPS AND CHARTS THAT PILOTS ARE REQUIRED TO CARRY.**

In aviation, these moves are rarely simple, however, as safety requirements and reliability tests require a thorough process to determine suitability for use of these devices on the flight deck. Once they were approved, airlines have been quick to pick up on the opportunities provided by the technology.

Aside from allowing pilots to update their manuals faster and more easily, file flightplans and manage schedule changes and weather disruptions, there is a significant environmental benefit. An iPad weighs as little as half a kilogram. Many pilots and flight decks routinely have to carry up to 20 kilograms worth of maps, manuals and charts. A typical paper flight plan for a Dallas to Tokyo flight could be almost nine metres long! By putting most of it on a tablet computer, airlines can save paper, save pilots from having to carry it all around and, most importantly, save fuel and CO<sub>2</sub>.

FedEx is one such airline, implementing the paperless cockpit in 2013. It found that the manuals on board each aircraft consumed 32 tonnes of paper each year across its operation and, by going paperless, 768 trees are conserved annually and nearly 3,500 tonnes of CO<sub>2</sub> are saved.

Similar impacts have been achieved at the dozens of airlines now undertaking the transition to tablets on the flight deck including: United Airlines (3,208 tonnes of CO<sub>2</sub> saved per year); Delta (12,000 tonnes); Malaysia Airlines (720 tonnes); and Air Canada (up to 200 tonnes).



# FIRST CLASS FUEL EFFICIENCY



**WHEN BRITISH AIRWAYS CONSULTED ITS TEAM OF IN-HOUSE EXPERTS TO FIND FUEL SAVING SOLUTIONS, THE RESULT WAS A STATE-OF-THE-ART FUEL MANAGEMENT SYSTEM, INCORPORATING NEW SOFTWARE, HARDWARE AND PRACTICAL PROCEDURAL SOLUTIONS. COLLABORATION WITHIN THE AIRLINE AND WITH ITS BUSINESS PARTNERS IS REALLY PAYING OFF.**

British Airways' comprehensive fuel efficiency programme encompasses both flying and ground activities. A dedicated team has focussed on flight operations, network operations and engineering, resulting in the creation of a fuel economy guide. Employees are encouraged to submit fuel saving ideas and pilots have been issued with iPads with access to fuel management software.

One such solution is XMAN. This is a bespoke tool developed by NATS in conjunction with several air navigation service providers and British Airways. The principle behind it is to reduce the amount of time aircraft spend in a holding pattern when arrival delays are unavoidable. XMAN works by slowing aircraft down at approximately 350 nautical miles from the destination, which reduces delays and saves fuel. In the near future this horizon will be extended to 550 nautical miles, saving even more fuel.

Single engine taxiing is now a normal procedure on British Airways' A320 family fleet. Pilots begin the taxi phase out on one engine and then start the second engine nearer the runway, resulting in an average saving of 70 kilograms of fuel per taxi out at Heathrow.

En-route wind optimisation for wide body aircraft. Previously, the crew would climb according to the flight plan, which may be many hours old. This new method updates the flight management system with wind data just prior to a climb, resulting in more reactive and efficient route planning.

## British Airways

NATS, manufacturers and various other partners.



[www.ba.com](http://www.ba.com)

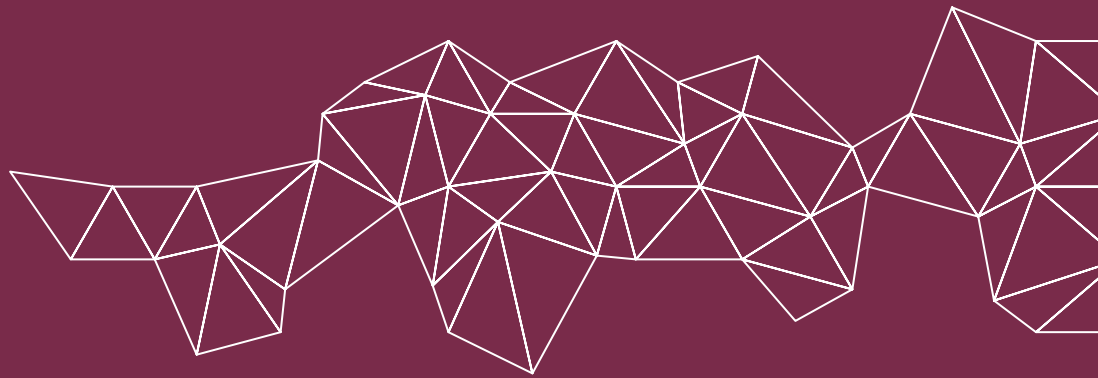
**THE BA FUEL EFFICIENCY DRIVE RESULTED IN SAVINGS OF 35,000 TONNES OF CO<sub>2</sub> IN 2014.**

**SINGLE ENGINE TAXIING SAVES 4,100 TONNES OF FUEL PER YEAR AT LHR ALONE, WHILE XMAN SAVED 2,200 TONNES OF FUEL IN 2014.**

**WIND OPTIMISATION IS SAVING FUEL IN THE REGION OF 50-200 KILOGRAMS PER FLIGHT, WHILE SHARKLETS SAVE UP TO 4% FUEL BURN ON A320S.**







# EFFICIENCY ON THE GROUND

**EVEN THOUGH WE TRY AND KEEP THE AIRCRAFT ON THE GROUND AS LITTLE AS POSSIBLE, THERE ARE ALSO THINGS WE CAN DO HERE TO CUT EMISSIONS.**

Airports are the gateway to the air transport system. They are also impressively engaged in energy efficiency measures as part of wider environmental programmes. Airlines and other partners are also working on ground-based efficiency.

These examples should inspire energy efficiency by airports and their partners.



# GROUND VEHICLES POWERED BY ALTERNATIVE FUELS

## Hamburg Airport



[www.hamburg-airport.de](http://www.hamburg-airport.de)



CO<sub>2</sub> EMISSIONS HAVE BEEN REDUCED BY APPROXIMATELY 500 TONNES PER YEAR, PROJECTED TO INCREASE TO 2,000 TONNES BY 2020.

COST REDUCTIONS DUE TO HIGHER FUEL EFFICIENCY ARE EXPECTED.

AUTOMOBILE WORKSHOP CREWS GAIN EXPERTISE ON NEW AUTOMOBILE TECHNOLOGY AND STAFF MEMBERS ARE INSPIRED TO USE SIMILAR CARS IN THEIR PRIVATE LIVES.

**WITH THE FOCUS ON AIRCRAFT, IT IS EASY TO FORGET THAT GROUND OPERATIONS OFFER GREAT POTENTIAL FOR ENERGY SAVING. HAMBURG AIRPORT SEIZED THIS OPPORTUNITY WITH A PROJECT THAT COMMITS TO RUNNING HALF THEIR GROUND FLEET ON ALTERNATIVE FUEL BY 2020.**

Hamburg Airport has a ground fleet of about 400, comprising buses, cars and various light – and heavy-duty vehicles. Their project “Mobility Concept 2020”, kicked off in 2013 and aims to reduce the environmental impact of this fleet by ensuring that at least 50% of these ground vehicles use alternative fuel by 2020.

To achieve this, the project team keep themselves apprised of any new technological developments, whilst ensuring that all new vehicles run on alternative fuel such as compressed natural gas (CNG), electricity or hydrogen.

The supporting infrastructure has been installed, including a CNG fuelling station and electric charging stations. In addition, a preliminary hydrogen station has been constructed to be used in a practical test for hydrogen powered vehicles.

Alternative fuel already powers 32% of the ground fleet at Hamburg Airport, demonstrating that ground support can take a significant step towards being climate neutral.





# MAKING A GREEN TAXI FLEET POSSIBLE



Stockholm Arlanda  
Airport, operated  
by Swedavia

Apcoa Parking.



[www.swedavia.com](http://www.swedavia.com)

[www.apcoa.com](http://www.apcoa.com)

**AIRPORTS ARE HUBS OF TRANSPORTATION, NOT JUST IN THE AIR BUT ON THE GROUND TOO. EVEN AN AIRPORT WELL-CONNECTED WITH PUBLIC TRANSPORT LIKE STOCKHOLM'S ARLANDA WILL HAVE A LARGE NUMBER OF TAXIS PICKING UP AND DROPPING OFF PASSENGERS.**

In order to help manage the hundreds of taxis and have a real impact on their carbon footprint, Swedavia (the operators of Stockholm Airport) teamed up with Apcoa Parking to develop a taxi metering system that has had a big impact on the efficiency of taxis serving not just the airport, but the whole city.

Taxi drivers arrive at a remote holding position where they are automatically given a queue number. They can then park their cars. When their queue number gets called, they drive to the allocated terminal to pick up passengers. This reduces emissions as taxis are not sitting idling their engines. But the real benefits come from the fact that eco-taxis (low-emission electric, hydrogen and natural gas cars) are given priority and jump forward in the queue. This had a massive impact, with the share of environmentally-friendly taxis at Stockholm Airport jumping from 16% in 2009 to 84% in 2014.

In addition, for several years passengers who travel to the airport in their own green car can park in the best spaces in parking facilities. Those driving an electric car can recharge the vehicle at no cost.

Swedavia's target is to have zero fossil fuel-produced CO<sub>2</sub> from its own operations by 2020. The airport's own fleet is gradually being replaced with green vehicles. Stockholm Arlanda was the first airport in the world to have its own biogas buses. Today, all of the airport's buses are biogas or hybrid buses.

AN ESTIMATED 12,000 TONNES OF CO<sub>2</sub> IN 2012 WERE SAVED THROUGH THIS TECHNOLOGY, WITH 45,000 TONNES IN SPILL-OVER ACROSS THE REGION.

THE POLICY OF STOCKHOLM AIRPORT HAS HELPED TRANSFORM THE NUMBER OF ECO-TAXIS ACROSS THE CITY.

FEWER TAXIS WAITING AT THE TERMINAL WITH ENGINES ON MEANS LESS PARTICULATE MATTER AND NOISE.



# FIXED ELECTRICAL GROUND POWER

## Aéroport Nice Côte d'Azur

Zurich Airport, Heathrow Airport, Hong Kong Airport, Barcelona El Prat Airport and hundreds of other airports worldwide.



[www.nice.aeroport.fr](http://www.nice.aeroport.fr)



HEATHROW AIRPORT'S USE OF FIXED ELECTRICAL GROUND POWER IS HELPING TO CUT EMISSIONS BY 100,000 TONNES PER YEAR.

AT ZURICH AIRPORT, WHERE THE USE OF THIS FACILITY IS MANDATORY, 33,000 TONNES OF CO<sub>2</sub> PER ANNUM IS AVOIDED.

WHEN HONG KONG AIRPORT BANNED THE USE OF AUXILIARY POWER UNITS, THE AIRPORT INVESTED NEARLY \$8 MILLION TO UPGRADE ALL ITS FIXED GROUND POWER AND PRE-CONDITIONED AIR SYSTEMS, WHILST PREPARING GROUND STAFF THROUGH PREPARATORY MEETINGS AND TRIALS.

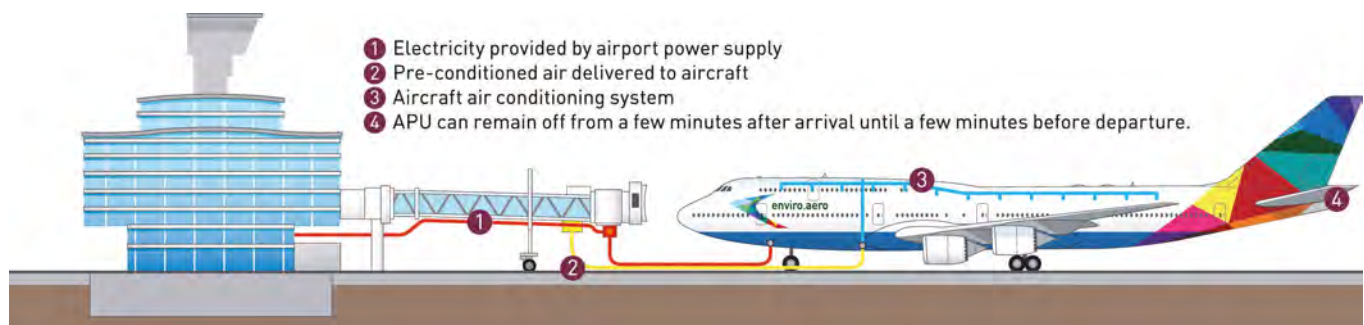
**MOST AIRCRAFT USE AN AUXILIARY POWER UNIT (APU), A SMALL ENGINE WHICH PRODUCES POWER FOR THE AIRCRAFT WHEN IT IS ON THE GROUND AND THE MAIN ENGINES ARE TURNED OFF. THIS ALLOWS CLEANERS TO PLUG IN THEIR EQUIPMENT AND AIR CONDITIONING TO RUN WHEN PASSENGERS ARE BOARDING.**

The APU is located in the tail of the aircraft and runs off normal jet fuel. Whilst APUs are useful at airports where there is little ground support, most airports have now started installing fixed electrical ground power and pre-conditioned air, usually at the gate.

These fixed supplies allow the aircraft to get electricity straight from the local grid (or even solar power – see page 52) and use the airport's air conditioning to control the temperature on board. Because the auxiliary power unit is needed to help start the main engines, it can be switched on just before the plane is due to depart.

Nice Côte d'Azur Airport installed such a system for its general aviation departing area in 2014, and the use of the system has cut annual CO<sub>2</sub> emissions by 416 tonnes. It has also reduced noise on the apron. The system at Nice is on remote stands, away from the terminal. The connections are therefore provided in an innovative 'pop-out' system which comes up from the tarmac. Training was carried out with ground handlers to encourage the use of the system.

A number of airports have made it mandatory to switch off the APU when aircraft are parked at the gate. Barcelona El Prat Airport mandates use of its fixed ground power and pre-conditioned air from two minutes after the aircraft arrives at a terminal gate until five minutes before it leaves, saving 58,000 tonnes of CO<sub>2</sub> per year. Other Spanish airports with mandatory use include: A Coruña, Madrid-Barajas, Alicante-Elche, Fuerteventura, Gran Canaria, La Palma, Lanzarote, Palma de Mallorca, Tenerife Norte, Tenerife Sur, and Vigo.



# GOING ELECTRIC ON THE GROUND



Alaska Airlines  
and Seattle-Tacoma  
International Airport.



[www.alaskaair.com](http://www.alaskaair.com)

**WHEN EVALUATING EMISSION REDUCTION OPPORTUNITIES AT AIRPORTS, AIRCRAFT USUALLY GET THE MOST ATTENTION, BUT RUNNING AN ON-TIME AIRLINE ALSO REQUIRES A RELIABLE FLEET OF GROUND SUPPORT VEHICLES. SUCH VEHICLES ARE TYPICALLY USED TO TRANSPORT BAGGAGE, TAXI AIRCRAFT TO AND FROM THE TERMINAL AND REFUEL THE AIRCRAFT.**

Alaska Airlines and Seattle-Tacoma International Airport partnered to replace fossil-fuel-powered ground vehicles, including belt loaders and baggage tugs, with electric vehicles. This multi-million-dollar investment improved air quality, eliminating around 2,000 tonnes of CO<sub>2</sub> annually.

In recent years, many airports have begun to offer cleaner fuelling options for airline ground equipment. Alaska Airlines joined forces with the Seattle-Tacoma International Airport, which installed electric charging infrastructure and offered 98% carbon-free electricity to airline customers. In 2013, Alaska replaced more than 200 fossil-fuel-powered vehicles with electric versions. The carrier aims to convert 44% of its ground fleet to electric by 2020.

Of course, electrifying its ground support equipment is not the only emission-reduction measure Alaska is taking. The airline is also focused on purchasing new, more fuel-efficient aircraft; using sustainable aviation biofuels; and aggressively adopting weight-saving measures as part of its environmental strategy.

2,000 TONNES OF CO<sub>2</sub>  
SAVED ANNUALLY.

IMPROVING LOCAL  
AIR QUALITY.





# ECOPOWER ENGINE WASH

## EcoServices

Joint venture of VT Systems  
and Pratt & Whitney.



[www.ecopower.aero](http://www.ecopower.aero)



ECOPOWER SAVES  
AIRLINES SOME 190  
MILLION LITRES OF FUEL  
AND 500,000 TONNES  
OF CO<sub>2</sub> EACH YEAR.

THE SYSTEM IS  
CURRENTLY IN USE  
BY OVER 65 AIRLINES  
WORLDWIDE AND OVER  
60,000 WASHES HAVE  
BEEN PERFORMED.

**MOTORISTS EXPERIENCE THE ACCUMULATION OF INSECTS AND DIRT ON THEIR WINDSCREEN AFTER A LONG DRIVE. WHEN AIRCRAFT FLY – AND PARTICULARLY WHEN THEY TAKE OFF – THE SAME THING CAN HAPPEN TO THE INSIDES OF JET ENGINES.**

All aircraft engines become soiled during normal operations by airborne contaminants such as sand, dust, soot, salt, insects and pollution. These can cause engines to operate inefficiently and lead to overall deterioration in engine health. As a result, an engine burns more fuel and operates at higher temperatures which can result in the premature engine maintenance. Every kilogram of fuel saved eliminates 3.15 kilograms of CO<sub>2</sub> emissions.

The EcoPower engine wash system has demonstrated the ability to effectively remove contaminants from compressor airfoil surfaces, restoring engine compressor performance, reducing fuel burn and maintenance. A cooler, cleaner running engine offers long-term maintenance cost savings. Fuel use can be reduced by up to 1.5% using EcoPower on a regular basis.

The EcoPower engine wash is a closed-loop system that protects the environment and offers a mobile, fast, repeatable, and efficient process. Deionised, heated and atomised water is sprayed to clean the engine components. There are no toxic chemicals or detergents. The water is collected and filtered to produce pure, deionised water for reuse. This minimal waste stream is approved by airport environmental authorities around the world. Consequently, EcoPower can be performed right at the gate, eliminating the requirement to tow the aircraft to a remote location.

# BRIGHTER, WHITER, STRONGER, LONGER



Munich Airport



[www.munich-airport.com](http://www.munich-airport.com)

**MUNICH AIRPORT HAS SET ITSELF A TARGET OF CARBON-NEUTRAL GROWTH ABOVE 2005 LEVELS, TO BE REACHED BY 2020. PART OF THIS STRATEGY IS BEING ACHIEVED WITH A FOCUS ON LIGHTING SYSTEMS AND THE MOVE TO LEDS.**

Starting in 2009, the airport began replacing traditional lighting fixtures with LEDs, in the road, car parks and, for the first time at a large commercial airport, on the apron as well. Munich Airport pioneered the use of LED lighting on the airfield, on masts up to 34 metres high. Not only do the new lights reduce energy consumption, but they are also providing a better and safer working environment for ramp staff, with a brighter and more even illumination at night, compared to the sodium-vapour lamps traditionally used.

Complementing the new lighting is the deployment of smart lighting control systems. Parking and check-in areas are fitted with motion control sensors to ensure that energy is only being used when people are using the areas. On the apron, the switching on and off of the lighting is coordinated with flight plans, allowing an additional 600 tonnes of CO<sub>2</sub> savings a year. The airport has continued the programme, replacing lighting in hangars and workshops with LEDs.

In one of its 200 other energy efficiency projects, Munich Airport covers around 75% of its annual heating energy requirements through its own highly efficient on-site tri-generation plant that combines cooling, heating and power generation in a single facility. The airport meets the remainder of its heating needs from a local utility company via a pipeline. Half of that heat is generated by a biomass-fired cogeneration plant which causes no carbon emissions.

THE MOVE TO LED LIGHTING WILL REDUCE MUNICH AIRPORT'S CO<sub>2</sub> EMISSIONS BY AROUND 7,000 TONNES A YEAR.

WHILST THE CAPITAL COSTS OF LED INSTALLATION WAS HIGH, THE ENERGY SAVINGS MEAN A BREAK-EVEN INVESTMENT PERIOD OF THREE TO FOUR YEARS.

FROM A HUMAN FACTORS PERSPECTIVE, RAMP EMPLOYEES SHOW FEWER SIGNS OF FATIGUE, COLOUR RECOGNITION IS IMPROVED AND APRON SAFETY IS INCREASED.



# KEEPING ENGINES SWITCHED OFF AT THE GATE

## FedEx Express

NASA, Federal Aviation  
Administration.



[www.csr.fedex.com](http://www.csr.fedex.com)



34,000 LITRES OF JET  
FUEL SAVED AND 86  
TONNES PER MONTH OF  
CO<sub>2</sub> EMISSIONS AVOIDED.

FEDEX HAS AVOIDED  
NEARLY \$2.8 MILLION  
IN FUEL COSTS SINCE  
THE EFFORT BEGAN.

TOTAL SAVINGS EQUATES  
TO TAKING 2,015  
PASSENGER CARS OFF  
THE ROAD FOR A YEAR.

**PUSHING BACK FROM THE TERMINAL AND MAKING YOUR WAY TO THE RUNWAY WITH ENGINES RUNNING AS SOON AS POSSIBLE SEEMS LIKE THE OBVIOUS PROCEDURE FOR A TIME-SENSITIVE DELIVERY ORGANISATION. BUT IN A BOLD EXPERIMENT, FEDEX FOUND A NEW WAY OF SAVING ON FUEL AND EMISSIONS WHILST NOT COMPROMISING CUSTOMER SERVICE.**

To avoid burning fuel whilst waiting for aircraft departure, this project keeps aircraft at the gate with engines off until a runway slot becomes available for immediate take-off. It sounds simple, but in a culture built around reducing delays for customer service reasons, it was initially a counter-intuitive move.

Airlines in the United States compete for departure slots around the clock; traditionally the first to call in for departure gets the first slot. Pushing out as early as possible from the gate reduces the risk of causing a delay – the top priority in a time-sensitive business model. The team at FedEx was willing to challenge this thinking and worked with the Federal Aviation Administration, NASA and Northwest Airlines (prior to its merger with Delta) to explore whether there was such a thing as a “good delay”.

After a multi-year research project, FedEx added new departure metering standards in 2011. The effort has since saved a total of 3.8 million litres of fuel (around \$2.8 million worth) and avoided almost 10,000 tonnes of CO<sub>2</sub> emissions. Departure metering was implemented at both Memphis and Indianapolis airports with no impact to customer service quality.

Through a series of operational trials and algorithm development, the FedEx ramp tower controllers were equipped with the tools to decide the optimal time for departure. While FedEx now uses volunteer metering at its two largest domestic operations, Memphis and Indianapolis, the project has gone on to inspire other metering initiatives in the United States, including at New York's JFK and Charlotte.



# ONE IS SOMETIMES BETTER THAN TWO



**WHILST MOST AVIATION EMISSIONS ARE PRODUCED BY AIRCRAFT IN THE AIR, A SMALL PROPORTION OCCURS ON THE GROUND, AS PLANES TAXI FROM THE GATE TO THE RUNWAY. AN INCREASING NUMBER OF AIRLINES WORLDWIDE ARE WORKING WITH PILOTS TO START TAXIING ON HALF THE NORMAL NUMBER OF ENGINES.**

Depending on the aircraft, either one or two engines can be shut down for taxiing. Virgin Atlantic has updated the guidance manuals for pilots across the whole fleet. In 2014 the airline trialled a behaviour change and communications drive on this procedure. As a result, it saw a massive improvement via fuel management software, with over 2,362 tonnes of CO<sub>2</sub> being saved.

Other initiatives being rolled out through Virgin Atlantic's fuel efficiency programme include a weight saving scheme. Engineers identified a calcium build-up in the aircraft plumbing and trialled a descaling technique. They flushed the system through to break down the calcium deposits which, as well as saving on weight, will reduce pipe blockages and improve the reliability of the toilets. This procedure will be used across the fleet in 2015 with estimated savings of 2,122 tonnes of CO<sub>2</sub> annually.

At the end of 2014, Virgin Atlantic also removed a secondary tow bar fitting on all of its A330-300 fleet which was surplus to operational requirements. During 2015, this will save 38 tonnes of CO<sub>2</sub>.

The airline is also looking at how it uses water on board. By analysing water and passenger data to understand how much water is used, Virgin Atlantic has been able to reduce the amount of drinkable water loaded on to aircraft. In 2014, this helped save 781.8 tonnes of CO<sub>2</sub>.

All these initiatives are made possible by multiple teams working together and are underpinned by Virgin Atlantic's fuel efficiency software which is used to model and monitor progress.

Virgin Atlantic



[www.virgin-atlantic.com/  
changeisintheair](http://www.virgin-atlantic.com/changeisintheair)

**VIRGIN ATLANTIC HAS REDUCED ITS CO<sub>2</sub> FOR EVERY CUSTOMER AND FREIGHT TONNE FLOWN (REVENUE TONNE KILOMETRE) BY 10% SINCE 2007.**

**THE AIRLINE HAS A TARGET TO REDUCE AIRCRAFT CO<sub>2</sub> EMISSIONS BY 30% PER RTK BETWEEN 2007 AND 2020.**

**VIRGIN ATLANTIC RECORDED ITS LOWEST CO<sub>2</sub> EMISSIONS (SINCE 2007 BASELINE) IN 2014 EVEN THOUGH IT FLEW MORE PASSENGERS ON MORE FLIGHTS THAN ANY PREVIOUS YEAR.**





# PEOPLE

THE AIR TRANSPORT SECTOR DIRECTLY EMPLOYS NEARLY NINE MILLION PEOPLE WORLDWIDE. EACH OF THEM IS AN EXPERT IN THEIR PART OF THE BIGGER PICTURE.

Not only have many of these examples found ways to empower their employees to develop new and more efficient practices, but they are also working on ways of getting their teams to work in better ways. There are even solutions encouraging customers to be better.

These examples should inspire ideas to come from anywhere!



# FOOD DELIVERY AT 36,000 FEET

Airlines including:  
American Airlines,  
Qantas, Finnair,  
Thai Airways, Singapore  
Airlines, SriLankan  
Airlines, Malaysia  
Airlines, China Airlines,  
British Airways  
and others



BY REDUCING THE  
QUANTITY OF MEALS  
CARRIED, AIRLINES  
CAN REDUCE WASTE,  
CUT WEIGHT AND  
CO<sub>2</sub> AND INCREASE  
PASSENGER CHOICE.

**CHICKEN OR BEEF? IT'S A QUESTION FAMILIAR TO ANY TRAVELLER, PARTICULARLY ON LONG-HAUL FLIGHTS. IN BUSINESS AND FIRST CLASSES ESPECIALLY, AIRLINES TRY TO AVOID RUNNING OUT OF OPTIONS – PASSENGERS PAY FOR PREMIUM SERVICE AND EXPECT TO HAVE THE MEAL THEY'D LIKE.**

This means that airlines end up carrying more food than is required, to try and satisfy as many passengers as possible. It leads not only to more waste than is necessary, but also increased CO<sub>2</sub> emissions from extra weight being carried. On an aircraft like the Boeing 777, a typical airline might carry 75 catering trolleys and although airlines are investing in new light-weight models (see page 36), if they can leave a few at the airport by carrying less food on board, it is a bonus!

An increasing number of airlines are trying to avoid over-catering by encouraging premium passengers to choose their meals before they even reach the airport. This not only means that the airline has to carry just the required meals, but that it also can offer a wider variety of options to passengers. Some airlines are also implementing the system for economy passengers.

When a passenger books their flight (or in the 'manage my booking' section of their website), they are given meal choices which can be completed usually up to 24 hours in advance of the flight. The order is then passed to the catering company and the correct meals loaded on board.

Thai Airways has gone one step further. It was the first airline to introduce carbon footprint information for its menu on board for passengers in 2009, showing the amount of greenhouse gases released in the production process starting from acquiring the raw materials, production, adding ingredients, packaging and storage as well as waste management.

In 2014 Thai Airways introduced carbon footprint information for 30 on-board menu choices and applied for certification from the GHG Management Association. Whilst this helps passengers make informed meal choices, it has also helped the airline to work with suppliers on identifying opportunities for emissions reduction in the on-board meal production process.

# MAINSTREAMING THE ENVIRONMENT



**AIR TRAFFIC MANAGEMENT HAS A NATURAL ENVIRONMENTAL ASPECT. MORE EFFICIENT NAVIGATION MEANS LESS TIME IN THE AIR FOR AIRCRAFT, LESS FUEL BURNED AND, OF COURSE, LESS CO<sub>2</sub>.**

The British air traffic management provider, NATS, has taken great care to ensure that environmental issues are at the forefront of employees' minds with their extensive Environmental Awareness Programme, which has played a major role in achieving NATS' self-set target of 4% increase in flight efficiency since 2008.

The programme is made up of a number of complimentary elements, such as tailored environmental awareness courses, which have now been delivered to over 200 people at locations across the NATS estate. As part of these courses, NATS ran "Dragon's Den"-style sessions, where NATS staff pitched their ideas to colleagues, much like the British television programme. Many of these ideas have now been brought into practice.

As well as classroom-focussed activities, NATS run an online self-guided environmental awareness module, which has been completed by over 1,000 staff and is also available to external partners.

In February 2012 NATS held its first 'Lunchtime Lecture' for staff who may not normally be involved directly in NATS' environmental activities. This 'Challenge the Expert' session gave staff the chance to ask questions of a world-renowned climate scientist. The excellent debate prompted some staff to try to reduce their own environmental footprint.

One of the tools the teams use to assess efficiency is now also used to financially regulate the company. The "3Di" score is an environmental metric developed by NATS, which measures the efficiency of how aircraft are routed through UK airspace. The metric compares the actual trajectory an aircraft takes with an optimal trajectory which minimises fuel burn and CO<sub>2</sub> emissions.

Each flight is given a 3Di score and in 2014 NATS evolved its use of 3Di further to bring it closer to its air traffic operation and to move from monthly performance reporting to near real-time performance monitoring. The flight optimisation system, or FLOSYS, is a bespoke tool which was developed by NATS, Altran UK and Lockheed Martin. It takes real radar data, updated every three minutes, and combines it with NATS' 3Di airspace efficiency metric to produce a graphical representation of every flight in UK airspace.

This means NATS controllers can now immediately see the 3Di score for every flight they handle through every phase of flight and airspace sector, as well as compare it against other flights along the same route up to 12 months ago, including the average and best performing. By having access to this data, controllers and airspace managers can identify the opportunities for operational improvements that will save airlines fuel and cut carbon emissions.

## NATS

Altran UK, Lockheed Martin.



[www.nats.co.uk](http://www.nats.co.uk)

**NATS ENABLED A 4.3% CO<sub>2</sub> REDUCTION ON AVERAGE PER FLIGHT THROUGH THE DELIVERY OF ITS '4% PROGRAMME' – THIS EQUATES TO ALMOST ONE MILLION TONNES OF CO<sub>2</sub> SAVINGS ENABLED PER ANNUM COMPARED TO A 2006 BASELINE.**

**THE SUCCESS OF THE ENVIRONMENTAL AWARENESS PROGRAMME IS EVIDENT IN THE FACT THAT DISCUSSION IN ALMOST ANY FORUM NOW INCLUDES THE ENVIRONMENT AND MANY OF NATS' BEST IDEAS FOR OPERATIONAL IMPROVEMENTS HAVE COME FROM WITHIN ITS WORKFORCE.**

# LAB'LINE FOR THE FUTURE

## Air France and KLM

DGAC France, Safran-Snecma, Total-Amyris, Aéroport Toulouse-Blagnac, Airbus, BETC, Coca-Cola Enterprises, EDF Energy, Hertz, Orange, Région Midi-Pyrénées, Thales, Veolia, Zodiac Aerospace.



[www.airfrance.com](http://www.airfrance.com)



LAB'LINE FLIGHTS POWERED BY BIOFUELS HAVE BEEN PROMOTING THE DEVELOPMENT OF SUCH AN INDUSTRY IN FRANCE.

INCREASE AWARENESS OF SUSTAINABILITY ISSUES AMONGST PASSENGERS AND PROMOTES CIRCULAR SUPPLY CHAIN AND WASTE REDUCTION.

AIR FRANCE-KLM IS TARGETING A 20% IMPROVEMENT OF THE ENERGY EFFICIENCY IN BOTH FIXED INSTALLATIONS AND AIRCRAFT BY 2020, COMPARED TO 2011.

TO RAISE AWARENESS OF THE CHALLENGES AND INNOVATIVE SOLUTIONS OF AVIATION SUSTAINABILITY AMONG THE GENERAL PUBLIC, AIR FRANCE-KLM LAUNCHED A PROJECT IN SEPTEMBER 2014 WITH 14 PARTNERS FROM A RANGE OF CONNECTED INDUSTRIES WHICH ARE GIVEN THE OPPORTUNITY TO SHOW THE PUBLIC THE COMMITMENT TO SUSTAINABLE TRAVEL.

'Lab'line for the future' has been developing specific themes for each two-month period and provides passengers with the opportunity to ask professionals any questions they might have about sustainability issues during special events.

For example, the company's efforts in waste reduction and eco-design, take the entire life cycle into account when introducing new products. It is also working with various partners to promote circular economy initiatives in the area surrounding Paris Charles de Gaulle airport, as CO<sub>2</sub> emissions relating to air travel are not linked only to the flight, but also to passengers' and employees' journeys to and from the airport.

As part of the project, Air France operated regular biofuel-powered flights from Toulouse to Paris Orly for more than a year ending in January 2016. Air France ensures that the feedstocks used to produce their biofuel is sustainably sourced and does not compete with food production.

The Lab'line project is connected to Air France-KLM's overall climate action plan, an overarching initiative aimed at reducing the company's environmental footprint. Throughout the Air France-KLM network, the average fuel consumption has been reduced by an impressive 6.7% compared to 2011, to reach 3.45 litres per passenger per 100 kilometres. This has been achieved through various means, such as fleet modernisation, involving staff in climate action plans and supporting environmental protection programmes.



# MAKING THE MOST OF THE TOOLS YOU HAVE



**WHILE SOME FUEL SAVINGS AND CONSEQUENT CO<sub>2</sub> SAVINGS COME ABOUT PURELY THROUGH THE TECHNOLOGY BEING USED, OTHER SAVINGS CAN BE MADE BY USING THE TECHNOLOGY YOU ALREADY HAVE MORE INTELLIGENTLY.**

Bombardier recognises the fact that these operational improvements can make all the difference when it comes to cutting unnecessary fuel burn, so that is why it has developed a tailored fuel efficiency manual for the Q400 and plans a future edition for the CRJ.

These documents, aimed not just at pilots, but at other airline workers too, act as a guide for airlines to maximise their operational and performance techniques, enabling them to generate significant fuel savings across all mission profiles and phases of flight.

The manuals suggest that: properly planned and executed descent profiles can offer some of the best fuel savings, that the overall weight of the aircraft be closely monitored, as extra weight adds fuel use and flight planning that is based on previous performance monitoring.

These manuals were developed by engineering teams at Bombardier, who naturally know the potential of the technology the best, and were improved with the comments of various stakeholders, such as the marketing department, client support and also with feedback received from airlines, particularly the significant input from Flybe in the UK.

**Bombardier**



[www.bombardier.com](http://www.bombardier.com)

**IMPLEMENTING ALL  
PROCEDURES DESCRIBED  
IN THE MANUALS SHOULD  
LEAD TO A 481 TONNE  
REDUCTION IN CO<sub>2</sub> PER  
YEAR, PER AIRCRAFT.**

**REDUCING OVERALL  
COSTS FOR THE AIRLINE.**

**CONTRIBUTES TO  
MAXIMISING OVERALL  
AIRCRAFT AND AIRLINE  
PERFORMANCE.**

# THE GREEN IDEAS FACTORY

TUI Group, including TUIfly Nordic, Thomson Airways, TUIfly, Jetairfly and Arkefly



[www.tuigroup.com](http://www.tuigroup.com)

TUI AIRLINES REDUCED CO<sub>2</sub> PER PASSENGER KILOMETRE BY 10.3% IN SIX YEARS.

69.9G OF CO<sub>2</sub> EMISSIONS PER REVENUE PASSENGER KILOMETRE (RPK) ACROSS TUI AIRLINES.



*TUI Group Green Ideas Factory competition winners Dieter Bruneel and Dimitri Panneels saw their ideas come to life as Jetairfly introduced electric cars for ground staff at Brussels Airport.*

**EMPOWERING YOUR TEAM TO PRESENT NEW IDEAS FOR ENERGY EFFICIENCY AND EMISSIONS SAVING IS A GREAT WAY TO ENGAGE EMPLOYEES ON CLIMATE CHANGE ISSUES – AND CAN HAVE LONG-LASTING BENEFITS FOR THE BUSINESS TOO.**

TUI launched the Green Ideas Factory in 2012 and saw 120 sustainability concepts submitted from colleagues across 18 countries with nearly 1,500 people voting for their favourite ideas. Ten finalists went on to develop their concept with the help of mentors from within the business and Forum for the Future.

As a result of the competition, subsidiary airline Jetairfly introduced electric cars for ground staff at Brussels Airport. The cars offer energy savings of 70% and reduction in maintenance of 30%. The electric vehicles will be used to transport ground support agents and technicians to the aircraft before departure and on arrival. The use of the vehicles airside for short distances is an ideal application for electric vehicles; with a full battery they have a range of around 100 kilometres.

Jetairfly has its headquarters and maintenance hangar at Brussels Airport with two charging stations for its electric cars. Arkefly, the sister airline in the Netherlands, is also now using electric vehicles airside.

Colleagues from Arkefly also suggested a central hub for new airline sustainability ideas. The TUI Group has since established a dedicated network of airline environmental managers from across TUI, who meet regularly to share best practice.

# ENERGY SAVINGS THROUGH SMART BUILDING MANAGEMENT



*Cork Airport's Head of Asset Care Bill Daly joins Managing Director Niall MacCarthy in celebrating the success of building management efficiency measures.*

**IN AN EFFORT BEING REPEATED AT AIRPORTS AROUND THE WORLD, CORK AIRPORT HAS BRILLIANTLY DEMONSTRATED THE POSSIBILITY FOR ORGANISATIONS TO REDUCE ENERGY CONSUMPTION YEAR ON YEAR AT VERY LOW COST, THROUGH ENERGY MANAGEMENT AND LOW/NO COST PRACTICES.**

The result was significant cost and consumption reductions. This was achieved through increasing awareness, staff participation, training, management and operational control.

The first steps of this energy performance improvement programme involved the identification of significant energy users and key staff, followed by a series of challenging targets and objectives. Frequent meetings were held to review progress and encourage participants. The site was regularly inspected to monitor performance and identify further opportunities. Energy savings measures include:

- » Implementation of monitoring to ensure energy use in the terminal building matched passenger and staff occupancy levels
- » Training of key personnel on building management system
- » Commissioning of greener variable-speed drive motors and reduction of fan speeds across air handling units
- » Switching off the chilled water system for the winter period and the boilers in summer
- » Optimisation of all air handling unit schedules to minimum requirements.

As the most significant energy user at Cork Airport, the heating, ventilation and air conditioning system is a key focus for energy savings. Improvements involved optimising operating settings as well as their timing, resulting in very significant savings.

Cork Airport has achieved savings of 33% (total energy consumption) resulting in considerable cost and CO<sub>2</sub> reductions, without significant capital expenditure. Having improved operating efficiency so significantly, Cork Airport is now in a much better position to consider investment in energy efficient technology. For example, the airport will target road lighting, car-park lighting and airfield lighting in an effort to continue to reduce energy usage.

**Cork Airport**



[www.corkairport.com](http://www.corkairport.com)

**ANNUAL CO<sub>2</sub> EMISSIONS ARE NOW AROUND 3,000 TONNES LOWER THAN IN 2008, DESPITE A GROWTH IN PASSENGER TRAFFIC.**

**ENERGY COST SAVINGS OF NEARLY \$1M SINCE 2008.**

**SITE INSPECTIONS ARE COMPLETED ON A REGULAR BASIS TO CONTINUALLY MONITOR PERFORMANCE AND IDENTIFY FURTHER OPPORTUNITIES FOR ENERGY SAVINGS.**



# FREE ELECTRIC CHARGING AND WORLD CLASS PUBLIC TRANSPORT

## Oslo Airport



[www.avinor.no](http://www.avinor.no)



ALLOWING FREE ELECTRIC CHARGING ENCOURAGES THOSE WITH ELECTRIC CARS TO USE THEM FOR JOURNEYS TO AND FROM THE AIRPORT, FURTHER CUTTING BACK ON CO<sub>2</sub> EMISSIONS.

68% OF PASSENGERS USING OSLO AIRPORT DO SO BY PUBLIC TRANSPORT.

22% OF THE CARBON FOOTPRINT AT OSLO AIRPORT ORIGINATES FROM SURFACE ACCESS. IMPROVING PUBLIC TRANSPORT SERVICES WILL REDUCE CO<sub>2</sub> EMISSIONS FROM THIS ACTIVITY.

**THE PARKING AREA AT OSLO AIRPORT HAS EUROPE'S LARGEST CHARGING FACILITY FOR ELECTRICAL VEHICLES. BUT OSLO AIRPORT ALSO HELPS TO KEEP CARS OFF THE ROAD BY PROVIDING TOP-CLASS PUBLIC TRANSPORT TO AND FROM THE AIRPORT.**

Not content with providing a high percentage of surface access, Oslo Airport also wants to accommodate for the use of zero emissions vehicles at the airport.

During 2014 to mid-2015, 109 new charging points were installed at Oslo Airport, bringing the total number of charging points at Oslo Airport to 193, with a further 40 under construction, to be completed by the end of 2015. This is probably Europe's largest charging facility and is free of charge to all passengers and employees. There are also plans to establish high capacity chargers by the end of the year. Airports are useful drivers of wider change in such technologies – particularly amongst the staff that work there.

Oslo Airport has the highest percentage of passengers travelling to and from the airport using public transportation in Europe and it aims to increase this further. Environmental concerns were high on the agenda from the airport's inception, with a reliable express train providing a substantial part of the transport needs of the airport. Besides the airport express train, other regional trains stop regularly at the airport, amounting to more than 300 train arrivals and departures each day.

Additionally, many airport buses (express, city and regional) take the passengers to their final destinations. Daily bus arrivals and departures amount to more than 500.

Today the airport is working to encourage even more passengers onto public transport by placing informative and detailed information screens throughout the arrival areas in 2015 and is planning more for the luggage pick up area in the near future. They have complemented this with the introduction of a specially designed app.



# PLANES, TRAINS AND (SHARED) AUTOMOBILES



Heathrow Airport



[www.heathrowairport.com](http://www.heathrowairport.com)

**AIRPORTS ARE SMALL CITIES, PROVIDING THOUSANDS OF JOBS AND OPPORTUNITIES FOR BUSINESS TO THRIVE. BUT ALL THOSE STAFF HAVE TO GET TO WORK SOMEHOW AND AIRPORTS ALSO PROVIDE AN EXCELLENT PLACE TO TEST NEW WAYS OF THINKING WHEN IT COMES TO COMMUTING.**

One airport that recognises the environmental impact of colleague commuting is Heathrow. With 420 organisations working out of Heathrow, with a combined total of 76,000 employees, a substantial amount of transport is needed to service them.

To dissuade workers from travelling to the airport by single occupancy car and to engage with carbon reduction issues more generally, Heathrow has put in place a sustainable travel programme called the Heathrow Commuter.

The programme diversifies and decarbonises staff travel in a range of different ways. For example, Heathrow maintains the only airport cycle hub (heavily discounted repairs and bike equipment) and offers employees use of a 'cycle to work' scheme. This, of course, is good not only for the environment, but also for workers' health.

Heathrow operates the largest single-site car share scheme in the world, with nearly 8,000 participants across 250 companies. Participants get matched with suitable car share colleagues, priority parking spots and, because airports are shift operations, access to 24-hour emergency rides home should they need to stay later than planned.

In addition to staff discounts on public transport further afield, the airport also subsidises the Heathrow Free Travel Zone. This allows colleagues, passengers and members of the local community to take advantage of free travel on 15 bus services, London Underground and Heathrow Express in the area immediately surrounding the airport.

The sustainable travel programme also extends to airline passengers through the Terminal 5 Onward Travel Zone, which exists to provide passengers with the knowledge and tools to choose the quickest, cheapest, most convenient and sustainable onward travel option. Information is displayed by mode on a bank of screens and supported by a leaflet which is picked up by over 2,000 passengers a week.

**ADDITIONAL SALES OF RAIL SEASON TICKETS IN 2014 ACCOUNTED FOR A CO<sub>2</sub> SAVING OF 977 TONNES.**

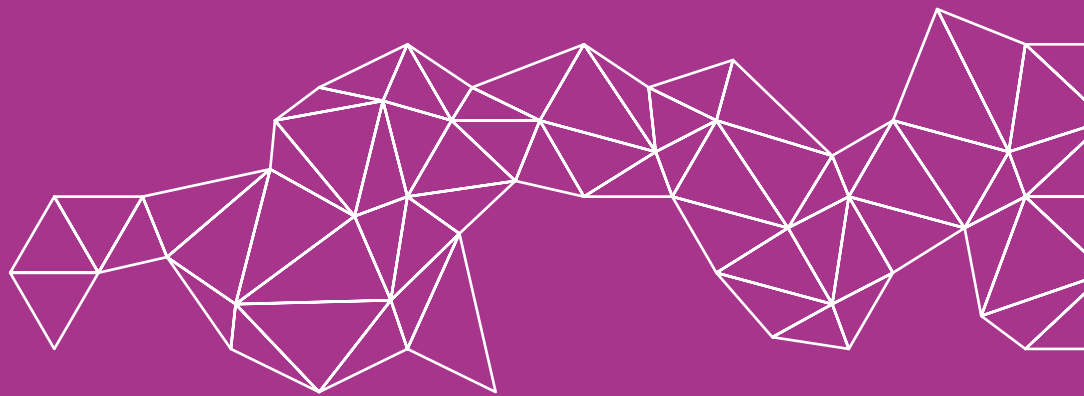
**LESS CONGESTION AROUND THE AIRPORT.**

**HEALTHIER, MORE RELAXED EMPLOYEES.**









# BUILDING AND CONSTRUCTION

THE EFFICIENCY WITH WHICH OUR AIRCRAFT AND TERMINALS RUN IS ONE THING, BUT INDUSTRY PARTNERS ARE ALSO WORKING ON WAYS TO IMPROVE THE MANUFACTURING AND BUILDING PROCESS ITSELF.

Aircraft assembly lines and component factories are huge industrial sites, employing highly-skilled engineers. All manufacturers are working on efficiency processes for these plants and there are some examples here. At the same time, the building of airport terminals is leading the way in efficient construction practices, often in difficult conditions.

These examples should inspire us to not only think of aircraft operations for climate action opportunities.



# CUTTING CO<sub>2</sub> FROM AIRCRAFT MANUFACTURING

Rolls-Royce



[www.rolls-royce.com](http://www.rolls-royce.com)



COMPANY-WIDE ENERGY USE HAS DECREASED BY 16% COMPARED TO 2010, WHILE GREENHOUSE GAS EMISSIONS, NORMALISED BY REVENUE, HAVE REDUCED BY NEARLY 19%.

TECHNOLOGY USED TO MINIMISE SOLAR HEAT GAIN REDUCED COOLING COSTS BY UP TO 25%.

**WHILST MANUFACTURERS ARE RIGHTLY FOCUSED ON REDUCING THE ENERGY USE OF THEIR PRODUCTS, THEY ALSO SPEND TIME FINDING WAYS TO INCREASE THE EFFICIENCY OF MANUFACTURING AND ASSEMBLY FACILITIES. ROLLS-ROYCE IS A GOOD EXAMPLE, HAVING SET GOALS FOR EFFICIENCY IMPROVEMENTS.**

Baselined on 2014 performance, these targets are to: reduce energy use by 30% (normalised by revenue) by 2020 and reduce greenhouse gas emissions by 50% (absolute) by 2025 (excluding product test and development).

Sustainable infrastructure is key to meeting these challenging goals. Rolls-Royce invested more than \$450 million in the development of Seletar, a large aerospace campus in Singapore in 2012. The facility was designed with sustainability criteria in mind – primarily energy efficiency, water efficiency, environmental protection, indoor environmental quality and high environmental building performance.

The building cooling system has been optimised to provide best practice system efficiency, with a heat recovery system to control building humidity and condensate water recycling. The buildings are also orientated to minimise solar heat gain. A system which manages storm water, collects rainwater and irrigates the grounds, is also in place. The buildings were all constructed using sustainable construction materials.

The Seletar campus has been awarded a platinum rating by the Singapore Building Construction Authority Green Mark scheme. The scheme recognises the highest levels of environmental design in construction and the use of green building technologies.

Meanwhile, in Bristol, UK, a state-of-the-art new LED lighting system will result in an estimated 78% reduction in lighting energy consumption at the site, as well as reduced maintenance costs. Prior to the new lighting system being installed a trial was carried out to encourage employees to feedback on their personal preferences on a range of different LED lighting options. On completion of the trial a light was chosen with superior illumination levels and the most natural feel.

# NEW ION NITRIDING PROCESS FOR CRANKSHAFTS



Lycoming Engines



[www.lycoming.com](http://www.lycoming.com)

**DISCOVER HOW A SWITCH FROM GAS NITRIDING TO ION NITRIDING TURNED OUT TO BE A WIN FOR THE ENVIRONMENT, LYCOMING, MANUFACTURER OF HALF THE WORLD'S PISTON GENERAL AVIATION ENGINES, AND ITS CUSTOMERS.**

Nitriding is a process to harden the surface of a metal component. Lycoming uses this process to heat-treat crankshafts in their engines, increasing wear and fatigue resistance. Traditionally, gas nitriding or ammonia nitriding was used.

Lycoming made a capital investment to implement an ion nitriding process for crankshaft surface hardening, enabling Lycoming to significantly reduce environmental impacts from the previous process. It eliminated hazardous waste streams, reduced emissions, and improved product quality and production efficiency.

Lycoming also constructed a more energy-efficient facility within the manufacturing plant for the new equipment. Features include skylight tubes that allow natural light in, motion and light sensors to complement natural light, and reuse of waste heat from the air compressor to heat the new section of the facility in its entirety.

Ion nitriding utilises high voltage electrical energy and small amounts of nitrogen and hydrogen gases to efficiently harden the outer surface of the metal. The process eliminates environmental and safety hazards while improving product quality and production efficiency.

The company also has an employee Green Team which reviews and leads green projects around the plant, benchmarks against other facilities, and supports environmentally friendly activities to encourage employee participation.

**ANNUAL CO<sub>2</sub> EMISSIONS  
REDUCED BY 544 TONNES  
AND ELECTRICITY USAGE  
BY 110,000 KWH.**

**SAVINGS OF 1,818,437  
LITRES OF WASTE  
WATER PER YEAR.**

**CHEMICAL EXPENDITURE  
REDUCED BY \$46,900  
PER YEAR.**





# NEW MODEL TERMINAL 2

## Heathrow Airport



[www.heathrow.com](http://www.heathrow.com)



THE T2 ENERGY CENTRE IS ONE OF THE UK'S LARGEST BIOMASS INITIATIVES AND AT FULL LOAD SAVES 13,000 TONNES OF CO<sub>2</sub> PER YEAR.

HEATHROW AWARDED A 15 YEAR CONTRACT TO BIOMASS ENERGY COMPANY LC ENERGY, CREATING A SUSTAINABLE END-TO-END SUPPLY CHAIN.

THE SPECIALLY-COMMISSIONED CONSTRUCTION ACADEMY HAS PROVIDED PRE-EMPLOYMENT TRAINING TO 369 PEOPLE AND PLACED 214 PEOPLE FROM THE LOCAL COMMUNITY INTO JOBS.

**HEATHROW'S NEW TERMINAL 2 IS DESIGNED WITH SUCH ENVIRONMENTALLY SYMPATHETIC INGENUITY THAT IT HAS BEEN USED AS A MODEL FOR THE WORLD'S FIRST BESPOKE ENERGY EFFICIENCY ASSESSMENT CRITERIA FOR AIRPORT TERMINALS BY THE UK'S BUILDING RESEARCH ESTABLISHMENT.**

T2 has been Heathrow's largest airside construction project, taking two and a half years to complete and seeing its first flight on 4 June 2014. It was built with sustainability as a guiding principle and its detailed planning, innovation and collaboration with contractors saw T2 completed on time, under budget with no impact on operations.

Terminal 2 is Heathrow's most sustainable terminal and the first BREEAM (Building Research Establishment's environmental assessment methodology) certified airport terminal. It has set the standard for environmental efficiency both in new developments at Heathrow and in airport terminals worldwide. This dynamic approach to sustainability, led to collaboration with BRE to create its first bespoke assessment criteria for airport terminals, using T2 as a model.

Examples of construction innovation include: 99% of construction waste being diverted from landfill; LED lighting for site boundaries reducing energy consumption by 50%; design layout reduces aircraft taxi times and CO<sub>2</sub> emissions; windows designed to maximise natural light and reduce the need for artificial lighting; water efficiency measures projected to reduce water consumption by 30%.

The new T2 Energy Centre provides 20% renewable power to T2 and is one of the UK's largest biomass initiatives, improving energy efficiency by 40% more than required through building regulations. Ensuring 75% of the 25,000 tonnes of woodchip required per year is sourced within an 80 kilometre radius has reduced haulage costs and associated CO<sub>2</sub> emissions, whilst supporting local jobs and businesses.



# FIVE STREAMS OF MANUFACTURING EFFICIENCY



Airbus



[www.airbus.com](http://www.airbus.com)

**IF EVERY LARGE ORGANISATION FOCUSED ON DECREASING ITS ENVIRONMENTAL FOOTPRINT AND INCREASING ITS SOCIAL RESPONSIBILITY, THE GLOBAL IMPACT WOULD BE VAST. AIRBUS LAUNCHED THE BLUE5 PROJECT, WHICH SETS OUT THE ROADMAP FOR REDUCING THE ENVIRONMENTAL FOOTPRINT OF ITS MANUFACTURING ACTIVITIES.**

This initiative – named after the five key streams of efficiency – oversees large industrial and building projects but also enables all employees to contribute, through the small changes each person can make to reduce the environmental footprint.

An innovative solar cooling system is used to replace air conditioning at an Airbus production facility in Toulouse. The key advantage of this process is the ability to produce cold temperatures with solar energy. A new biomass boiler also covers two thirds of the site's heating needs and uses renewable energy; the 22,000 tonnes of wood burnt annually come from sustainable local forests certified PEFC and situated less than 50 kilometres from the site.

At Airbus' facility at Filton in the United Kingdom, hundreds of people have embraced an inter-building "How Low Can You Go?" challenge to save energy; while in Broughton in Wales, employees have been learning how to save fuel by driving more economically via a simulator provided by the Energy Saving Trust.

But energy saving and CO<sub>2</sub> reductions are not the only focus – the other three parts of Blue5 include water, waste and volatile organic compounds.

In Spain, recycled rivets from production are donated to an NGO that exchanges them for lentils, provided to disadvantaged communities. The reduction of drinking water use at the Hamburg plant is achieved by taking water from the River Elbe for industrial usage. And a reduction of solvent use is achieved at all Airbus' European sites through using impregnated wipes, encapsulated spray guns and water-based primers.

AIRBUS HAS ACHIEVED  
A REVENUE-BASED  
CO<sub>2</sub> REDUCTION OF  
50.7% SINCE 2006.

IN ABSOLUTE TERMS, CO<sub>2</sub>  
EMISSIONS FROM AIRBUS  
FACILITIES HAVE BEEN  
CUT 17.3% SINCE 2006.

THE SOLAR COOLING  
SYSTEM IN TOULOUSE  
SAVES 120 TONNES OF CO<sub>2</sub>  
EMISSIONS PER YEAR.



# CLEAN ENERGY ON THE GROUND

**Qantas**

GridX.



[www.qantas.com/electricity](http://www.qantas.com/electricity)

THE PLANTS WILL  
REDUCE CO<sub>2</sub> EMISSIONS  
FROM THE QANTAS  
BUILDINGS BY 23,000  
TONNES A YEAR.

THE AIRLINE'S 2020  
GOAL IS TO REDUCE  
ELECTRICITY USE BY 20%  
COMPARED TO 2009/10  
CONSUMPTION.



**QANTAS HAS BUILT AUSTRALIA'S LARGEST COMMERCIAL TRI-GENERATION (COOLING, HEATING AND ELECTRICITY) PROJECT IN SYDNEY WHICH USES NATURAL GAS TO PRODUCE MORE EFFICIENT, LOWER CARBON ENERGY FOR ITS HEADQUARTERS, CATERING CENTRE, JET MAINTENANCE BASE AND DOMESTIC TERMINAL.**

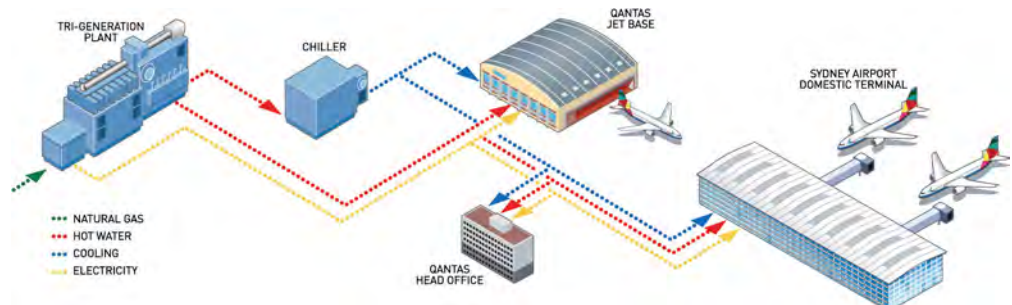
A tri-generation system can provide power, hot water, space heating and air conditioning from a single system. Generators produce heat as they create electricity. A tri-generation facility captures this heat that would otherwise be lost and uses it to generate both hot and cold water.

The chilled water is created by an absorption chiller, which is generated by the excess heat and which operates similar to a refrigerator. It creates low temperature water for use in air conditioning.

The tri-generation facility at Qantas uses natural gas, the most common fuel for tri-generation due to its relatively low cost, ease of transport (via pipeline), wide availability and lower greenhouse gas intensity per unit of energy.

Tri-generation facilities can achieve overall energy efficiencies of 75-85% by avoiding losses associated with the transport of electricity. This is compared to only 35% efficiency on average for conventional supply of electricity from the regional grid.

The airline has also recently completed a major refurbishment of its corporate headquarters, close to Sydney Airport. The refurbishment and tri-generation power plant will result in the buildings rising from an average Australian Government energy efficiency rating of 1.5 stars to 5 stars. Between 2009/10 and 2013/14 Qantas reduced total electricity consumption by 9.2% despite growth in its operations.





# TEAMING UP TO GO GREEN



Gulfstream Aerospace



[www.gulfstream.com](http://www.gulfstream.com)

**FOR LARGE ORGANISATIONS, MAKING REAL CO<sub>2</sub> REDUCTIONS CAN OFTEN REST ON MAKING SURE EMPLOYEES KNOW EXACTLY HOW THEY CAN HELP. TO SPREAD AWARENESS AMONG ITS GROWING EMPLOYEE POPULATION AND CO-ORDINATE OVERALL ENVIRONMENTAL GOALS, GULFSTREAM CREATED 'GREEN TEAMS'.**

With 25 Green Teams and more than 525 team members, the business aviation manufacturer has been able to develop a long-term renewable fuels agreement, establish 'Design for Environment' training, improve energy efficiency and create an emerging base of engaged, sustainability-minded employees.

The Green Team initiative began at Gulfstream in 2012, following several months of development. From the very beginning, Green Team activities (and the sustainability strategy that supported them) were guided by an imperative to reduce energy use (including jet fuel in the build and testing process), waste (solid and hazardous), greenhouse gas emissions and water (drinking and waste).

During the initial "boot camp" event, teams walk their facility with new eyes for new ideas, and then spend time iteratively refining and prioritising what they discovered until they have a consolidated list of their most important tasks. Each Green Team develops its own list of projects within the broader company reduction goals. Thousands of projects and initiatives have been identified, focusing on behaviour changes.

A Green Team contest reduced energy consumption 3.1% at Gulfstream's Research and Development Centre in Savannah, Georgia. Another long-term initiative incorporates renewable fuels into daily flight operations with CO<sub>2</sub> savings of over 50%. One facility was able to divert 100% of its previous landfill waste into recycling or energy recovery.

Today, the Green Teams have grown from relatively isolated groups of employees working on general goals that reduce environmental impact to specialised teams that focus on high-impact, high-interest activities across sites that directly support corporate sustainability strategies.

**CUTS CO<sub>2</sub>, ENERGY CONSUMPTION AND WASTE FROM THE PRODUCTION, RESEARCH AND FLIGHT TESTING ACTIVITIES OF THE BUSINESS.**

**INCREASES AWARENESS AND ENGAGEMENT AMONG GULFSTREAM EMPLOYEES.**



# BUILDING IT GREEN

## Galapagos Ecological Airport



[www.ecogal.aero](http://www.ecogal.aero)

100% OF THE AIRPORT'S  
ENERGY COMES FROM  
RENEWABLE SOURCES.

THE BUILDING ITSELF  
USED 80% RECYCLED  
MATERIAL FROM THE  
OLD TERMINAL.

THE AIRPORT PROVIDES  
A VITAL LINK FOR LOCAL  
RESIDENTS AND FOR AN  
ECO-TOURISM INDUSTRY  
THAT SUPPORTS  
THE ECONOMY.



**WHEN YOU BASE AN AIRPORT IN AN ECOLOGICALLY SENSITIVE AREA, IT IS IMPORTANT THAT THE BUILDING IS IN KEEPING WITH ITS SURROUNDINGS AND DOESN'T HARM THE NATURAL ENVIRONMENT. THAT IS EXACTLY WHAT HAS HAPPENED IN THE GALAPAGOS ISLANDS.**

Galapagos Ecological Airport was opened to the public in 2012 and was built with environmental best practice at the core of its design.

The airport is run by Corporación América, an Argentinian company that operates 53 airports throughout Latin America and the Caribbean. The design strictly follows the guidelines set out by the United States Green Building Council, which are seen as a gold standard of ecological building practices worldwide. Ecogal was granted 'Gold' level accreditation in the worldwide certification 'Leadership in Energy and Environmental Design' (LEED) in December 2014.

The airport's green credentials are proven in a number of ways. The building itself is made from 80% recycled material from the old terminal and the structure that supports the new terminal was built from recycled petroleum exploration pipes, which were recovered from the Ecuadorian Amazon. In keeping with the ecological theme of the airport, even the furniture at the gates and in the coffee shops is also made of certified material.

The lighting and temperature regulation systems are also environmentally friendly. Alongside LED lights, the building is designed to take maximum advantage of natural light and the skylights automatically adjust themselves to allow more or less air inside, changing the temperature. For power generation, the airport takes advantage of a solar panel array and a wind farm currently being developed to get 100% of its energy from renewables.

To supply the airport with a sustainable source of water, the operator runs a desalination plant, which takes water from the ocean, treats it, then transports it to the storage tanks located next to the main building.

This holistic approach to airport design and construction is a prime example of what can be achieved when environmental policies are placed front and centre, creating a fully functioning airport with minimal CO<sub>2</sub> emissions.



# SETTING THE STANDARD



International Civil  
Aviation Organization



[www.icao.int](http://www.icao.int)

**MANUFACTURERS ARE ALWAYS TRYING TO BUILD MORE EFFICIENT AIRCRAFT AND ENGINES, REDUCING FUEL USE AND CO<sub>2</sub> EMISSIONS. THE UNITED NATIONS' SPECIALISED AVIATION AGENCY, THE INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO) IS TAKING THIS FURTHER AND DRAWING UP INTERNATIONAL REGULATIONS SETTING MINIMUM FUEL EFFICIENCY REQUIREMENTS FOR AIRCRAFT.**

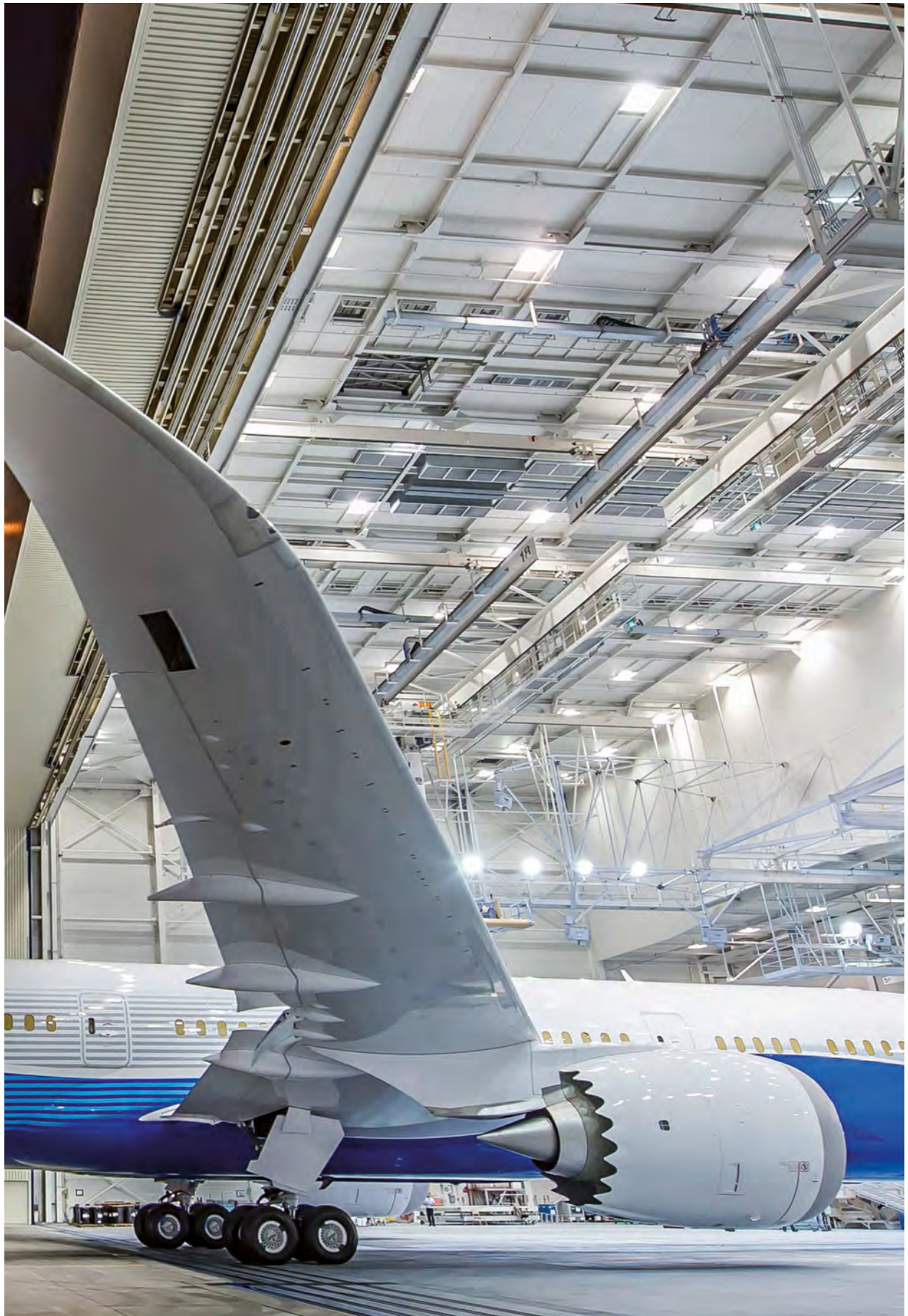
In 2013 ICAO's Committee on Aviation Environmental Protection (CAEP), which includes representatives from Member State governments, civil society and industry, approved the structure of a certification requirement for new aircraft models, requiring manufacturers to produce aircraft that meet the efficiency standard.

While the general policy behind the CO<sub>2</sub> standard is fairly simple and is fully supported by the aviation industry, the technicalities are a little more complex. The regulations drawn up tell manufacturers how to measure CO<sub>2</sub> emissions levels, taking into consideration size, weight and the varying stages of flight and conditions encountered.

In early 2016, CAEP members are expected to reach an agreement on the standard's stringency and applicability. Once the final political sign-off is agreed by ICAO Member States, the baseline will be set to ensure aircraft comply with a high standard of fuel efficiency.

AIRCRAFT WILL BE  
REQUIRED TO ACHIEVE  
A CERTAIN STANDARD  
OF FUEL EFFICIENCY  
BY INTERNATIONAL  
REGULATIONS.







# STEP-CHANGE TECHNOLOGY

ONE OF THE MOST VISIBLE SIGNS OF TECHNOLOGICAL PROGRESS IN AVIATION IS THE LAUNCH OF A NEW AIRCRAFT. IT'S A BIG MOMENT, FOLLOWING YEARS OF RESEARCH AND DEVELOPMENT.

These new aircraft do provide a step-change in technology... and emissions reductions. Often between 15% and 25% fuel and CO<sub>2</sub> improvement from the aircraft they replace. As they enter the fleet, the efficiency of the whole industry improves. Over 12,000 new aircraft will enter the fleet in the next few years.

These examples should inspire us to look at new aircraft as climate action machines!

# ATR-600 SERIES



**REGIONAL AIRCRAFT MANUFACTURER ATR FOCUSES PURELY ON TURBOPROP AIRCRAFT, WHICH ARE USED FOR SHORT-HAUL FLYING ON REGIONAL ROUTES, AND ITS AIRCRAFT ARE CURRENTLY OPERATED BY MORE THAN 190 AIRLINES IN OVER 90 COUNTRIES.**

Turboprops themselves are very fuel-efficient aircraft – indeed, per passenger emissions on a 500 kilometre sector are about 15% less than if they travelled in a car!

Indeed, a recent study conducted by ATR has shown that a passenger flying in one of its aircraft from Brussels to London will produce the same amount of CO<sub>2</sub> per kilometre as one taking the train.

The ATR-600 series entered service in 2012 and integrates new avionics, which result in lower carbon and noise footprints than its predecessor. ATR have taken advantage of lightweight materials in their 'Armonia' cabin design and have achieved weight savings equivalent to two passengers, which naturally saves on fuel burn and CO<sub>2</sub> emissions.

These latest technological developments in terms of navigability, operational flexibility and cabin configuration brought ATR new functions helping to further decrease fuel burn; improve flight efficiency and capacity to land anywhere, tying links with remote areas.

The concept of 'waste processing' and 'recycling' has always been at the core of the any technological upgrade for the 600 series aircraft, from the concept stage to the fitted process improvements. These early-stage eco-initiatives minimise the use of hazardous materials and use eco-friendly alternatives wherever possible. In fact, ATR is the first regional aircraft manufacturer to get the 14001 certification which means that from design to disposal and throughout the life of the aircraft, ATR gives priority to the environment.

**FUEL EFFICIENT ATR-600 AIRCRAFT HELP AIRLINES REDUCE EMISSIONS BY 12% COMPARED TO PREVIOUS MODELS.**

# E2 SERIES



**THE SECOND GENERATION OF COMMERCIAL AIRCRAFT PRODUCED BY BRAZILIAN MANUFACTURER – EMBRAER - BOASTS SIGNIFICANT STEPS FORWARD IN DESIGN AND EFFICIENCY, LEADING TO LESS FUEL BURN AND LESS CO<sub>2</sub> EMISSIONS.**

The E-Jets E2, the second generation of its E-Jets family of commercial aircraft, comprised of the E175-E2, E190-E2 and E195-E2, update their current models and have been constructed with advanced wings, engines and avionics. These jets, seating between 88 and 132 passengers, will enter into service from 2018.

The E-Jets E2 aircraft utilise high-aspect ratio wings with a distinctive, swept tipped wing structure that optimises the aerodynamics, reducing drag.

The application of advanced technologies for engines, wings and avionics provides airlines with substantial efficiency gains, whilst maintaining commonality with current E-Jets. New aerodynamically advanced, high-aspect ratio, distinctively shaped wings, improved systems and avionics, including 4th generation full fly-by-wire flight controls, and Pratt & Whitney's PurePower Geared Turbofan, engines will result in double-digit reductions in fuel consumption, emissions, noise and maintenance costs, and increased aircraft availability.

The E-Jets E2 will be capable of achieving similar costs per seat of larger re-engined narrowbody aircraft, with significantly lower costs per trip, thus creating new opportunities for lower risk development of new markets and fleet right-sizing by airlines.

Additional features include Honeywell's Primus Epic 2 advanced integrated avionics system with large landscape displays, advanced graphics capabilities, and Honeywell's Next Generation Flight Management System. This system is already in development with current E-Jets generation and will provide exceptional pilot situational awareness and flexibility for continuous innovation on the flight deck.

**THE E2 SERIES OF AIRCRAFT WILL BRING A 16-24% REDUCTION IN FUEL USE PER SEAT, BASED ON TYPICAL OPERATIONS.**



# C SERIES



**BOMBARDIER'S ALL-NEW C SERIES AIRCRAFT, WHICH SEATS 100-150 PEOPLE, WAS DESIGNED AND PURPOSE-BUILT WITH EFFICIENCY IN MIND AND WITH IMPRESSIVE CO<sub>2</sub> SAVINGS COMPARED TO THE AIRCRAFT IT REPLACES.**

Composed of the CS100 and the larger CS300 aircraft, the C Series family combines a number of factors to ensure a dramatically-reduced environmental footprint, resulting in a 20% increase in fuel efficiency.

Thanks to the use of advanced structural materials, with an advanced aluminium fuselage and composites wings, nacelle and rear fuselage, nearly a tonne of weight has been saved. The aircraft's structure has also been designed to provide the maximum aerodynamics, thereby reducing drag. Using computer modelling programmes and advanced wind tunnel testing, Bombardier has produced an aircraft family that is as aerodynamic as possible.

The C Series is equipped with the state-of-the-art Pratt & Whitney PurePower PW1500G Geared Turbofan engine, which drives up fuel efficiency and reduces noise.

The C Series' fuel efficiency is not just produced through structural technology. Improved navigation capabilities ensure that flights are more efficient and direct, cutting down on wasted time in the air.

Bombardier has also not just restricted their environmental concerns to fuel burn. Every stage in the production process is thought of in terms of a lifecycle analysis, from design to end of life. This includes ensuring the supply chain is as environmentally friendly as possible and that the manufacturing process uses as few hazardous materials as possible.

**20% INCREASE IN FUEL EFFICIENCY AND 50% LESS NO<sub>x</sub> EMISSIONS COMPARED TO THE AIRCRAFT IT REPLACES.**

# A320NEO



**THE A320NEO (NEW ENGINE OPTION) IS THE LATEST OF MANY PRODUCT UPGRADES AS AIRBUS CONTINUES TO INVEST OVER \$330 MILLION A YEAR IN INNOVATION AND UPGRADES FOR THE A320 FAMILY. COMING IN THREE SIZES (A319NEO, A320NEO, A321NEO), THE AIRCRAFT SEAT FROM 100 TO 240 PASSENGERS.**

The new aircraft's test and certification campaign is in full gear following the milestone first flights performed with each of the highly-efficient aircraft's two engine options: Pratt & Whitney PurePower PW1000G and the CFM International LEAP-1A.

The first A320neo aircraft commenced the flight test programme with a September 2014 maiden flight. Airbus has sold almost 4,000 of the aircraft to over 70 different customers, ensuring that airlines are getting the most fuel efficient aircraft in their fleets. Key innovations of the A320neo include latest-generation engines, Sharklet large wingtip devices and multiple cabin improvements.

The A320neo from day one offers a 15% fuel burn saving compared to current single-aisle aircraft operations, provided by its new engine options and Sharklets – wingtip devices which have been in service on the A320 family since 2012 and are demonstrating up to 4% reduction in fuel burn.

The A320neo is projected to provide a 20% reduction in fuel burn and CO<sub>2</sub> emissions by 2020 achieved through cabin innovations and further engine efficiency improvements.

In addition, the neo version has an improved noise footprint, and will be 15 Decibels below ICAO Chapter-4 requirements.

**UP TO 20% LESS CO<sub>2</sub> THAN THE AIRCRAFT IT REPLACES.**

## 737 MAX



**BOEING'S NEWEST SINGLE-AISLE AIRCRAFT, THE 737 MAX, HAS STARTED PRODUCTION AND IS SCHEDULED TO MAKE ITS FIRST FLIGHT IN 2016 AND FIRST DELIVERY IN 2017. IT WILL DELIVER A 20% INCREASE IN FUEL EFFICIENCY.**

The latest version of the aircraft reduces fuel use and CO<sub>2</sub> emissions by 20% compared to the original Next-Generation 737 that entered service in 1998. The MAX family of aircraft includes four variants (737 MAX 7, MAX 8, MAX 200 and MAX 9), designed for between 126 and 220 passengers (depending on airline configurations).

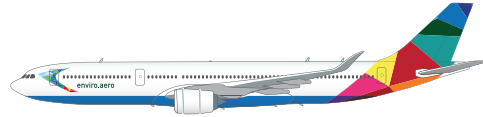
The 737 MAX 200 is a high-capacity variant based on the 737 MAX 8 which can accommodate more than 200 seats delivering an aircraft that is up to 20% more efficient than today's most efficient single-aisle planes.

The 737 MAX incorporates new CFM International LEAP-1B engines and other aerodynamic improvements to lower fuel use including Boeing's advanced technology winglet, which increases fuel efficiency by 1.8% compared to the current 737 winglet. This will result in less drag and further optimise the 737 MAX performance especially on longer-range missions

Boeing estimates that when compared to a fleet of 100 of today's most fuel-efficient aircraft, this new model will emit 350,000 fewer tonnes of CO<sub>2</sub>, which translates into more than \$112 million in cost savings, based on typical missions and utilisation.

**PRODUCES 20% LESS CO<sub>2</sub> THAN THE MODEL IT REPLACES.**

## A330NEO



**AIRBUS LAUNCHED THE A330neo IN JULY 2014, THE NEW MEMBER OF ITS WIDEBODY FAMILY, INCORPORATING LATEST GENERATION ROLLS-ROYCE TRENT 7000 ENGINES, AERODYNAMIC ENHANCEMENTS AND NEW CABIN FEATURES PROVIDING TOGETHER A 14% REDUCTION IN CO<sub>2</sub> EMISSIONS.**

The Airbus A330 covers the world with more than 100 operators at almost 400 airports and one takes off or lands every 20 seconds. Airbus has committed to continuously improving the programme since the A330's service entry. The company spends approximately \$165 million each year on enhancements and incremental improvements for the A330 jetliner family.

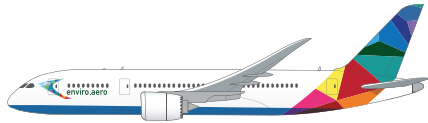
The A330neo (new engine option) is the logical evolution of the versatile A330 family, providing an optimal solution for airlines around the world looking to minimise their fuel and operating costs. The new version is leveraging a proven aircraft with a wide operator base and making it even more efficient with the latest innovations and technology developments.

The aircraft will feature incremental innovations, including aerodynamic enhancements such as new 'Sharklet' winglets and an increased wing span. Inspired by the curved wingtips on the A350 XWB, the A330neo's devices will increase overall wingspan from 60.3 metres to 64 metres while conferring increased lift with reduced drag.

The A330neo incorporates latest generation Rolls-Royce Trent 7000 engines. First deliveries of the newest A330 family members are scheduled to start in 2018.

**14% LESS CO<sub>2</sub> THAN THE AIRCRAFT IT REPLACES.**

# 787 DREAMLINER



**IN 2011, BOEING DELIVERED THE FIRST 787 DREAMLINER TO ITS LAUNCH CUSTOMER AND THE AIRCRAFT ENTERED INTO SERVICE. THE 787 FAMILY REDUCES FUEL USE AND CO<sub>2</sub> EMISSIONS BY 20-30% AND HAS A 60% SMALLER NOISE FOOTPRINT THAN THE MODELS THEY REPLACE.**

Because of its fuel efficiency, the 787 can fly further than its predecessors and has opened more than 50 new non-stop routes around the world.

What is truly innovative about the Dreamliner is the way it is constructed. New, lightweight composite materials make up half of the 787's primary structure, including the fuselage and wing. The aircraft's wing design and construction enable speed and fuel efficiency.

The 787 is also the first commercial widebody aircraft with a fuselage made of large one-piece barrel sections made from carbon composite material. This advanced approach eliminated 1,500 aluminium sheets and 40,000-50,000 fasteners per section, which makes the plane much lighter, more aerodynamically efficient and therefore more fuel efficient.

The 787 is powered by new, more fuel efficient models of jet engines produced by General Electric and Rolls-Royce.

**THE DREAMLINER FAMILY IS 20% TO 25% MORE FUEL EFFICIENT THAN AIRCRAFT THEY REPLACE.**

# A350 XWB



**THE A350 XWB IS AIRBUS' ALL-NEW FAMILY OF WIDEBODY AIRCRAFT DESIGNED FOR MEDIUM- TO LONG-HAUL AIRLINE OPERATIONS. OVER 70% OF THE A350 XWB'S AIRFRAME IS MADE FROM ADVANCED MATERIALS, COMBINING 53% COMPOSITE STRUCTURES WITH TITANIUM AND MODERN ALUMINIUM ALLOYS.**

Having entered commercial service in January 2015, this new-generation jetliner brings together the latest in aerodynamics, design and advanced technologies to provide a 25% step-change in fuel efficiency compared to the aircraft it replaces.

The A350 XWB's fuselage – built with carbon-fibre reinforced plastic – supports lower fuel burn and is corrosion and fatigue free, resulting in lower maintenance costs. Simultaneously, the aircraft's wings are more efficient and quieter. They have been designed to adapt during the flight, morphing while airborne, changing their shape for maximum aerodynamic efficiency throughout the various phases of the flight.

Other highly innovative elements on the A350 XWB include the fuel economy and overall efficiency of the brand new Rolls-Royce Trent XWB engines which generate 25% less CO<sub>2</sub> emissions. Also, the improved flight deck dimensions, built around an arrangement of six identical, interchangeable large displays, provide more comfort and clarity for the pilots.

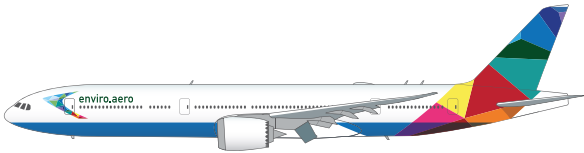
Compared to current CAEP6 (ICAO's Committee on Aviation Environmental Protection) regulations, the A350 XWB displays comfortable margins: 99% below the hydrocarbons limit, 86% below carbon monoxide limit, 60% below the smoke limit, and 35% below the mono-nitrogen oxide (NO<sub>x</sub>) limit.

The A350 XWB is also a quiet neighbour. Exterior noise levels are as much as 21 EPNdB (effective perceived noise decibel) below ICAO Chapter 4 requirements.

**25% LESS CO<sub>2</sub> EMISSIONS THAN THE AIRCRAFT IT REPLACES.**



## 777X



**THE BOEING 777X WAS LAUNCHED IN NOVEMBER 2013 AND WILL FEATURE A 20% FUEL EFFICIENCY IMPROVEMENT COMPARED TO PREVIOUS GENERATION AIRCRAFT.**

This newest Boeing family of twin-aisle aircraft builds on the original 777 that was launched in the 1990s. Production of the 777X is scheduled to begin in 2017 and first delivery is targeted for 2020. The family includes the 777-8X and the larger 777-9X, both delivering significant fuel efficiency improvements. This is due to its utilisation of advanced technology and design throughout the aircraft, but one aspect really stands out: the 777X will have the industry's longest composite wing.

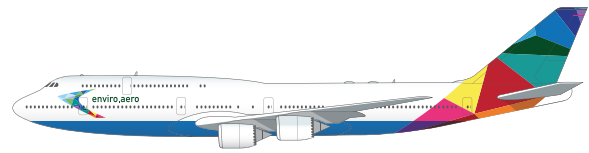
The fourth-generation 777X composite wing has a longer span - seven metres longer than today's 777 - to maximise fuel efficiency. Meanwhile, by incorporating a folding wingtip into the design, the airplane will have complete compatibility for airport gates that currently accommodate today's Boeing 777.

The 777X also makes use of one of the most advanced, fuel-efficient commercial engines ever built in GE Aviation's GE9X engine - see page 116 for details.

The combination of new engine technology, improved aerodynamics and the new high-efficiency composite wing will deliver substantial improvements in fuel efficiency and lower CO<sub>2</sub> emissions to the world's largest twin-engine jet.

**777X REDUCES FUEL USE AND CO<sub>2</sub> EMISSIONS BY 20% COMPARED TO PREVIOUS GENERATION AIRCRAFT.**

## 747-8



**BOEING DELIVERED THE NEW 747-8 FREIGHTER IN 2011 AND THE 747-8 INTERCONTINENTAL IN 2012, UPDATING THE ICONIC JUMBO JET WITH AERODYNAMICALLY IMPROVED WINGS AND MORE EFFICIENT ENGINES.**

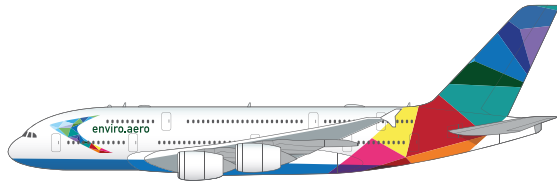
The 747-8, a programme launched in 2005, represents a new benchmark in fuel efficiency and noise reduction, allowing airlines to lower fuel costs and fly into more airports at more times of the day. The 747-8 Intercontinental (the passenger variant of the aircraft) improves fuel efficiency by 16% compared to the 747-400, and has a 30% smaller noise footprint, which complies with strict noise standards set by airports such as Heathrow.

The 747-8 has a new wing, based on the advancements made for Boeing's 787 Dreamliner; raked wingtips for aerodynamic performance; new high-efficiency engines and a range of other technologies that increase its fuel efficiency. The 747-8 Freighter provides greater efficiency with more cargo capacity than any other freighter in production today.

Boeing continues to improve the environmental performance of the aircraft. Since introduction into service in 2011, the 747-8's fuel efficiency has been improved by an additional 3.5%. That includes a performance improvement package introduced in 2013 with engine improvements, flight management computer software improvements and other changes to reduce fuel use and CO<sub>2</sub>.

**REDUCES CO<sub>2</sub> EMISSIONS BY 16% COMPARED TO THE PREVIOUS MODEL.**

# A380



**THE A380 – WHICH HAS BEEN IN COMMERCIAL SERVICE SINCE 2007 – IS AN ESSENTIAL PART OF THE SOLUTION TO ACHIEVING SUSTAINABLE GROWTH, DOING MORE WITH LESS: ALLEVIATING TRAFFIC CONGESTION AT BUSY AIRPORTS BY TRANSPORTING MORE PASSENGERS WITH FEWER FLIGHTS, MORE EFFICIENTLY AND WITH MUCH LOWER CO<sub>2</sub> EMISSIONS PER SEAT.**

The A380 was the first commercial aircraft to incorporate as much as 25% composites, saving up to 1.5 tonnes of weight and resulting in a very low fuel burn. The double-deck jetliner has a fuel burn of less than three litres per passenger per 100 kilometres.

The combination of lower weight, improved aerodynamics and new generation engines has brought fuel burn down by a massive 40%.

Alongside CO<sub>2</sub> emissions reductions, Airbus' efforts to reduce aircraft noise are underscored by its efficient jetliner families and leading the way is the flagship A380, which carries 60% more passengers than the aircraft it replaces, but produces 50% less noise energy on departure, as well as three-to-four times less when landing.

Developments in noise reduction include the automatic noise abatement departure procedure, which optimises the thrust and flight path to reduce noise over populated areas. Airbus is working in partnership with British Airways, Heathrow Airport and NATS to develop optimised departures and arrivals to further improve the noise performance of the A380.

**40% LESS CO<sub>2</sub> THAN THE AIRCRAFT IT REPLACES.**

# CHALLENGER 350



**IN ADDITION TO ENSURING HIGH ENVIRONMENTAL PERFORMANCE ON ITS C SERIES COMMERCIAL AIRCRAFT, BOMBARDIER HAS TAKEN THE SAME CARE OVER THE DESIGN OF THE LATEST MODEL OF ONE OF ITS BUSINESS JETS THE CHALLENGER 350 AIRCRAFT.**

The aircraft, utilising advanced design techniques and technology, entered service in June 2014 and is one of the most efficient business aircraft in the world.

Savings of up to 2% in fuel burn and therefore of CO<sub>2</sub> emissions compared to the previous model have been achieved through various technological developments, such as the design of the wing. The re-designed canted winglets, which cut down on drag, reduce fuel burn and boost the range of the aircraft.

The new Honeywell HTF7350 engine delivers increased thrust and contributes to the aircraft's fuel efficiency, and with its enhanced combustor, significantly lower emissions. Both of these technological aspects of the Challenger 350 business jet improve climb capability, enabling the aircraft to reach cruise altitude faster, a less fuel intensive stage of flight than the initial climb.

The improvements in design and technology in comparison to the earlier model, the Challenger 300 aircraft, equate to approximately 10 tonnes of CO<sub>2</sub> saved per year over the lifetime of the aircraft. This equates to removing 40 mid-sized cars off the road for one year in Canada.

**CO<sub>2</sub> SAVINGS OF AROUND 10,000 TONNES PER AIRCRAFT PER YEAR COMPARED TO ITS IMMEDIATE PREDECESSOR.**

# LEAP



**CFM INTERNATIONAL HAS DRAWN INSPIRATION FROM THE TEXTILE MANUFACTURING INDUSTRY TO PRODUCE NEW COMPOSITE 3D WOVEN CARBON FIBRE TECHNOLOGY TO LIGHTEN ITS NEW LEAP ENGINES, BEING USED BY THE AIRBUS A320NEO, AND BOEING 737MAX.**

The 3D woven carbon fibre blades and engine casings made by Snecma (Safran) and Albany International are incredibly strong and light, reducing the engine's fuel consumption by 15% compared with current CFM engines.

This technology was selected because of the significant weight reduction of about 500 kilograms per aircraft it brings relative to metal components. Using composite technology has allowed these new fan blades to be designed with an increased diameter, enabling greater efficiency of propulsion, which in turn saves further fuel. Composite technology also ensures a higher resistance to damage from foreign debris and resistance to temperature changes, without almost any maintenance. Using a 3D design also prevents delamination problems, which could occur on classical layered composites and all tests have shown excellent results.

To manufacture just one LEAP fan blade, seven kilometres of carbon fibres are needed. Specific facilities have been built in France and in the US to cover needs for production and spares and 30,000 individual blades are due to be constructed by 2020.

This breakthrough technology is being further refined and enhanced to enable future generation (post 2030) propulsion system architecture, in particular ultra-high propulsion efficiency options such as the open rotor concept, paving the way for further reduction in fuel burn and CO<sub>2</sub> emissions.

**COMPARED TO USING THE EQUIVALENT METAL PARTS, 36,500 TONNES OF CO<sub>2</sub> SAVED PER YEAR FOR EACH AIRCRAFT.**

# GE9X



**AS WELL AS COLLABORATING WITH SNECMA ON CFM INTERNATIONAL'S NEW LEAP ENGINE, AMERICAN MANUFACTURER, GE AVIATION, HAS ALSO BEEN HARD AT WORK DEVELOPING THE NEXT GENERATION OF WIDEBODY AIRCRAFT ENGINE, THE GE9X.**

GE Aviation's GE9X builds on the advanced technologies developed for GE engines, like the GENx, Passport and CFM International's LEAP. Built specifically for the new Boeing 777X aircraft, the GE9X offers a 10% improvement in fuel burn compared to the GE90-115B engine, and features several key technologies and material that make it unique.

GE continues its use of composite material in the fan blades and fan case of the GE9X, which at 340 centimeters will be the largest fan of any GE engine. Advances in design tools allow the reduction of the fan blade count to 16, which reduces weight and CO<sub>2</sub> emissions.

The use of ceramic matrix composites (CMC) in the combustor and turbine in the GE9X engine brings further fuel burn improvements and emissions reductions. The CMC material is not only lighter than the metallic alloys it replaces, saving CO<sub>2</sub> through weight reductions, but it can also withstand higher temperatures. This allows more air to stay in the flow path where it will improve fuel burn and cut CO<sub>2</sub> emissions.

The GE9X engine will also make use of the additive manufacturing process known as 3D printing for its fuel nozzles. This new manufacturing process is less energy intensive and cuts down on the additional materials previously needed when utilising forging manufacturing processes.

Alongside a record-setting highly efficient 27:1 pressure ratio compressor, these new technologies and materials ensure the GE9X will be one of the most fuel efficient engines in the world when it enters service in 2020.

**WILL PRODUCE 10% LESS CO<sub>2</sub> THAN THE MODEL IT REPLACES.**



# GEARED TURBOFAN TRENT XWB



**ONE OF THE MAIN WAYS THAT AVIATION EFFICIENCY HAS ADVANCED OVER THE YEARS IS THROUGH THE DEVELOPMENT OF NEW, LESS FUEL-HUNGRY ENGINES THAT PRODUCE LESS CO<sub>2</sub>. AMERICAN ENGINE MAKER PRATT & WHITNEY HAS PLAYED ITS PART IN THIS PROGRESS WITH THEIR NEW ENGINE.**

Following 20 years and a \$10 billion investment, Pratt & Whitney's PurePower Geared Turbofan engine family is expected to come into service towards the end of 2015 on the Airbus A320neo aircraft. Thereafter, in early 2016 the engine will enter service on the Bombardier C Series. And, in the future, it is slotted for production on the Embraer E2, the Mitsubishi Regional Jet and the Irkut MC-21.

Rather than being more complex than previous engines, it actually relies more on simplicity, with fewer parts being used. A gear system separates the engine fan from the low pressure compressor and turbine, leaving each of these parts unhampered by the others. This means that the fan can rotate slower, burning less fuel, and leaving the compressor and turbine to operate at a high speed, which is optimal for all of the components. Of course, the lighter weight produced by fewer components also provides CO<sub>2</sub> savings and the fact that the two major components are separated makes them easier to remove for maintenance.

The materials used are, of course, state of the art, with lightweight, heat-resistant composite materials featuring heavily. The manufacturing process, too, has become greener, with fewer hazardous chemicals being used due to Pratt & Whitney's investment in developing superior non-hazardous substitute materials.

**16% REDUCTION IN CO<sub>2</sub> COMPARED TO PREVIOUS MODELS.**



**AEROSPACE MANUFACTURERS HAVE A STRONG TRACK RECORD OF CONTINUOUSLY IMPROVING THEIR PRODUCTS. IN 2014, ROLLS-ROYCE, FOR EXAMPLE, INVESTED NEARLY \$2 BILLION IN RESEARCH AND DEVELOPMENT, AROUND TWO-THIRDS OF IT IN IMPROVING ENVIRONMENTAL PERFORMANCE INCLUDING LOWERING EMISSIONS AND NOISE.**

The fuel efficiency of the Rolls-Royce "Trent" engine family has improved by about 1% per year. This culminates in the Trent XWB, the sixth generation of the 3-shaft Trent family, which is over 15% more fuel efficient than the first Trent engine. It is the engine maker's most efficient - and lowest carbon emission - jet engine flying today.

Work on the engine started in 2005 when Rolls-Royce sat down with Airbus to look at how it could improve the performance of the A350 aircraft they were designing.

While design for low fuel-burn and CO<sub>2</sub> emissions is essential, a wider view has also been at the heart of all design activity, to deliver the right balance between fuel burn and life cycle costs, and ensuring high reliability and durability in all conditions.

Compressor blisk (a disk with incorporated fan blades) technology has enabled compression module weight savings of 15% as well as aerodynamic efficiency improvements, while an optimised internal air system reduces cooling and sealing air demand, which also reduces fuel burn. The engine has even higher operating temperatures to improve efficiency and reduce fuel burn, while the latest generation material technologies enable this improvement to be achieved without degrading reliability.

The swept hollow titanium fan blades have exceptional levels of aerodynamic performance and low noise, while being extremely light and strong enough to withstand multiple bird strikes.

**CO<sub>2</sub> SAVINGS OF AROUND 10,000 TONNES PER AIRCRAFT PER YEAR COMPARED TO ITS IMMEDIATE PREDECESSOR.**





# CARBON MANAGEMENT

ALTHOUGH THE INDUSTRY IS DOING A LOT TO CUT CO<sub>2</sub> EMISSIONS, A GAP REMAINS. HOW ARE BUSINESSES INNOVATING TO MANAGE THAT CARBON?

Solutions include system-wide fuel efficiency programmes and carbon offset mechanisms. And airports are getting in on the act too, with one of the most comprehensive carbon management programmes anywhere.

These examples should inspire us to count our carbon and look at ways to cut it to zero.





# AIRPORT CARBON ACCREDITATION

Airports Council  
International



[www.airportCO2.org](http://www.airportCO2.org)



IN THE YEAR FROM MAY 2014, AIRPORTS INVOLVED IN THE PROGRAMME HAVE REDUCED THE CO<sub>2</sub> UNDER THEIR DIRECT CONTROL BY 212,460 TONNES.

64% OF EUROPEAN PASSENGERS TRAVEL THROUGH AIRPORTS THAT ARE PART OF AIRPORT CARBON ACCREDITATION.

AIRPORTS REPRESENTING 28.5% OF GLOBAL PASSENGERS ARE NOW INVOLVED IN THE PROGRAMME.

**FOLLOWING THE GLOBAL AIRPORT INDUSTRY'S COMMITMENT TO REDUCE ITS CARBON EMISSIONS MADE IN 2007, THE INTERVENING YEARS HAVE SEEN A GROUNDSWELL OF AIRPORTS BECOME PART OF THE INDUSTRY CARBON MANAGEMENT INITIATIVE, AIRPORT CARBON ACCREDITATION.**

As of August 2015, the programme certified 129 airports in 41 countries worldwide. The programme independently certifies airports' efforts to manage and reduce carbon emissions through four increasing levels of certification: mapping, reduction, optimisation and neutrality (see graphic for further details).

Airports are at different points on the journey to become cleaner and more efficient. As the centre points of a complex web of aircraft movements, technical operations and surface access transport, airports can address their CO<sub>2</sub> emissions in a variety of ways, many outlined in other case studies in Aviation Climate Solutions. These can include: better insulation and energy efficiency; switching to green energy sources; investing in hybrid, electric or gas-powered service vehicles; encouraging employees, passengers and visitors to use public transport; working with airlines and air traffic management to reduce runway taxiing times; and implementing green landing processes.

The programme is administered by leading consultancy WSP | Parsons Brinkerhoff and overseen by an independent advisory board including representatives from the International Civil Aviation Organization, the United Nations Environment Programme, the European Commission, European Civil Aviation Conference, Eurocontrol, the Federal Aviation Administration and Manchester Metropolitan University.

Originally developed and launched by ACI Europe in June 2009, Airport Carbon Accreditation was extended to airports in Asia-Pacific in November 2011 (in partnership with ACI Asia-Pacific), to African airports in June 2013, (with ACI Africa), North American airports in September 2014 (with ACI North America) and Latin American airports in November 2014 (with ACI Latin America).





#### THE FOUR LEVELS OF AIRPORT CARBON ACCREDITATION:

##### MAPPING

IN WHICH AIRPORT OPERATORS DETERMINE THEIR OPERATIONAL BOUNDARY AND THE EMISSIONS SOURCES WITHIN THAT BOUNDARY, CALCULATE THEIR ANNUAL CARBON EMISSIONS, COMPILE A CARBON FOOTPRINT REPORT AND ENGAGE AN INDEPENDENT THIRD PARTY TO VERIFY THE CARBON FOOTPRINT REPORT.

##### REDUCTION

WHERE THE AIRPORT OPERATOR REDUCES EMISSIONS OF FACILITIES OVER WHICH IT HAS CONTROL (USUALLY AIRPORT TERMINALS, THE AIRFIELD AND COMPANY OFFICES, ETC), IT THEN MUST PROVIDE EVIDENCE OF EFFECTIVE CARBON MANAGEMENT PROCEDURES AND SHOW THAT REDUCTION TARGETS HAVE BEEN ACHIEVED.

##### OPTIMISATION

INCLUDES THE ABOVE ACTIONS AND THEN GOES FURTHER BY WIDENING THE SCOPE OF CARBON FOOTPRINT TO INCLUDE THIRD PARTY EMISSIONS AND THEN ENGAGING THIRD PARTIES AT AND AROUND THE AIRPORT SUCH AS AIRLINES, RETAILERS AND OTHER TENANTS.

##### NEUTRALITY

THE ULTIMATE STEP, WHEREIN THE AIRPORT OFFSETS THE REMAINING EMISSIONS TO BECOME CARBON-NEUTRAL, IN LINE WITH AIRPORTS COUNCIL INTERNATIONAL RECOMMENDATIONS IN 2007.

# OFFSETTING WITH ADDED BENEFITS

International Air  
Transport Association,  
Sri Lankan Airlines,  
Kenya Airways

TAP Air Portugal, South African  
Airways, Mango, Thai Airways.



[www.iata.org](http://www.iata.org)



PROVIDING AIRLINES  
WITH A QUALITY OFFSET  
PROGRAMME THAT THEY  
CAN BECOME PART OF  
AND INCORPORATE INTO  
THEIR OWN WEBSITES.

CHOSEN OFFSET  
PROJECTS NOT ONLY  
HELP TO CUT EMISSIONS,  
BUT ALSO HAVE  
IMPORTANT SOCIAL AND  
ECONOMIC DEVELOPMENT  
CO-BENEFITS.

TAP AIR PORTUGAL – THE  
PROGRAMME'S LARGEST  
PARTICIPANT – HAS  
CHOSEN PROJECTS IN  
BRAZIL, PROVIDING A  
LINK WITH A KEY MARKET  
FOR ITS PASSENGERS.

**INSTITUTING A CARBON OFFSETTING PROGRAMME CAN BE CHALLENGING FOR AIRLINES, PARTICULARLY FOR SMALL- AND MID-SIZED OPERATORS. THE GLOBAL AIRLINE ASSOCIATION, IATA, HAS DEVELOPED A SIMPLE STANDARD PROGRAMME INCORPORATING THE BEST PRACTICE IN USE WORLDWIDE.**

Importantly, the IATA Carbon Offset Program tries to ensure that the passengers' voluntary purchase of offsets for their flight is processed as part of the normal booking engine, not a 'click-away' to another website. This increases uptake and allows passengers to book and offset flights as one transaction.

The programme has been independently audited and approved by the world's highest standard for airline carbon offsetting – the Quality Assurance Standard. QAS-approved offsets are checked against a 40 point checklist which includes emissions calculations, carbon reduction project selection and information provision. IATA is one of only four organisations worldwide to meet this standard.

Sri Lankan Airlines will be using the offsets purchased by its passengers on a local project to develop Hapugastenne and Hulu Ganga small hydropower projects which generate electricity for local communities. By replacing conventional fuel oil or diesel powered thermal stations, these two projects will save CO<sub>2</sub>, improve air quality and the livelihoods of neighbouring communities, and reinforce electricity supply into the local and national grid.

Kenya Airways passengers are able to invest in the Kasigau Corridor project with Wildlife Works. This project aims to preserve a corridor for wildlife in the Rukinga Wildlife Sanctuary. It combines active wildlife protection, jobs creation, agricultural economic development and clean energy for local populations. The project, part of the REDD concept, will preserve 502,000 hectares of forest, support 100,000 livelihoods and cut emissions from deforestation.

Airlines are members of:





# READY, OFFSET, GO!



**THROUGH CARBON OFFSETTING, AIRLINE PASSENGERS CAN INVEST IN PROJECTS THAT REDUCE CO<sub>2</sub> EMISSIONS OR SEQUESTER CO<sub>2</sub> FROM THE ATMOSPHERE TO COUNTERBALANCE THEIR SHARE OF THE CARBON EMISSIONS PRODUCED BY THEIR JOURNEY AND/OR SHIPMENTS.**

While many airlines offer a form of carbon offsetting to customers, United Airlines run a particularly innovative scheme targeted at corporate customers, which allows them to track and offset the emissions associated with their business travel and freight shipments at the enterprise level.

United's 'Eco-Skies CarbonChoice' offsetting scheme for corporate customers was launched in 2014, to go along with the airline's long standing offset programme for individual passengers.

The programme provides corporate customers with regular cargo and/or passenger carbon emissions usage reports based on actual flight level data. The sophisticated system takes account of the type of aircraft, routes, seasonality, payload, and customer-specific business travel and cargo shipments and allows customers to accurately offset their carbon emissions at the enterprise level.

The proceeds from United Airlines' carbon offsetting are invested in a diverse range of projects coordinated by Sustainable Travel International.

One such project, Conservation International's Alto Mayo Forest Carbon Project in northern Peru, helps to protect a critical watershed for more than 240,000 people and many threatened species found nowhere else on Earth. The project also provides jobs for local families and incentivises new approaches to farming that support rather than undermine native forests. This project is an independently verified REDD+ carbon offset project registered under the Verified Carbon Standard.

United's domestic projects include the Garcia River Forest Project, which helps to conserve forestland, restore wildlife habitat and protect local forestry jobs in the heart of California's Redwood region, and the Capricorn Ridge Wind project, which helps to displace fossil fuel-based energy production with clean, renewable wind power. This project produces enough wind-based electricity to power approximately 220,000 homes annually.

## United Airlines

Sustainable Travel International,  
Conservation International.



[www.united.com/carbonchoice](http://www.united.com/carbonchoice)

IN JULY 2015, UNITED SECURED ITS OFFICIAL CORPORATE LAUNCH PARTNER FOR ECO-SKIES CARBONCHOICE, WITH WYNDHAM WORLDWIDE, ONE OF THE LARGEST HOSPITALITY COMPANIES IN THE WORLD GETTING ON BOARD. WITH THE SCHEME NOW UNDERWAY, UNITED IS EXPECTING MANY MORE ORGANISATIONS TO TAKE PART.

# CARBON-NEUTRAL GROWTH HAS ALREADY STARTED

Delta Air Lines



[www.delta.com](http://www.delta.com)



1.7 MILLION OFFSETS  
HAVE BEEN PURCHASED  
AND RETIRED IN 2013  
AND 2014 TO OFFSET  
THE 1.7 MILLION TONNE  
INCREASE COMPARED  
TO 2012 LEVELS.

DELTA'S EFFICIENCY  
PROGRAMMES HAVE  
HELPED CUT ABSOLUTE  
CO<sub>2</sub> FROM THE AIRLINE  
BY 135,156 TONNES  
IN 2014 ALONE.

CREATION OF LOCAL  
EMPLOYMENT  
OPPORTUNITIES AND  
IMPROVED HEALTH.

**WITH THE ENTIRE AVIATION SECTOR COMMITTING TO CAPPING CO<sub>2</sub> EMISSIONS FROM 2020 THROUGH CARBON-NEUTRAL GROWTH, ONE OF THE WORLD'S LARGEST AIRLINES HAS DECIDED TO GET STARTED A LITTLE EARLY.**

In 2013, Delta set itself a target of carbon-neutral growth, meaning that despite any increases in traffic growth, it would not increase its level of net CO<sub>2</sub> emissions past the 2012 baseline. In 2014, the airline transported 3.7% more traffic and used 1.7% more fuel (the difference showing the impact of efficiency programmes). To bridge this difference, the airline purchased carbon offsets to minimise the impact of its growth on the environment.

Delta invested in a number of offsetting schemes in Brazil, Peru, Mexico and South Korea, allowing them to make up the gap between their efficiency increases and traffic growth. The airline chose projects involving wind energy, landfill gas recovery, efficient cooking stoves, reduced emissions from deforestation and forest degradation (REDD+) and other environmental initiatives. They all meet recognised high standards for carbon offset projects and invest in a mix of projects that have been validated and verified by third-party authorities. Importantly, these projects were also chosen because they take place in communities that Delta serves.

In terms of efficiency programmes, Delta has reduced annual GHG emissions from flight and ground operations by 7.9 million tonnes, a 17.2% decrease over eight years since 2005. This was achieved through fleet restructuring – replacing older, less fuel efficient jets with more modern planes – as well as: strategic flight planning; removing unnecessary weight; improved operations; upgraded aircraft software; and winglets, among other projects.

# SMART FUEL PROGRAMME



**AS PART OF A HOLISTIC ENERGY EFFICIENCY DRIVE, LATAM AIRLINES GROUP (LAN AND TAM AIRLINES, BASED IN CHILE AND BRAZIL, BUT OPERATING ACROSS SOUTH AMERICA), WORKED WITH A TEAM OF STAKEHOLDERS TO GENERATE A STREAMLINED FUEL EFFICIENCY PROGRAMME, DELIVERING REMARKABLE RESULTS.**

The airlines took a broad view of a range of different innovations and technologies, ensuring that all possible avenues for fuel efficiency are being pursued. These include investing in a modern and efficient fleet, such as the Boeing 787 and the Airbus A321neo. The main fleet has been fitted with winglets and sharklets, allowing 4% fuel reduction.

Weight reduction measures have been deployed, such as minimising unnecessary onboard water, ultra-light service carts, optimising the fuel load according to destination, improving distribution of weight to have an optimal centre of gravity and the improvement of freight factor (the combination of passenger and cargo services).

Standardised operation procedures for approach and landing, as well as minimising the use of the auxiliary power unit when on the ground. LAN has also worked with GE Aviation to develop sophisticated and more efficient arrivals procedures at airports in its network.

Using sophisticated route planning software to calculate the best route according to wind, flight times and tax charging for air space. Latam has also invested in software that optimises cruising speed to boost efficiency and cut delays.

Using a periodically programmed engine wash that allows for more efficient combustion of fuel and reduces emissions in airport areas.

As a direct result of this programme, Latam Airlines Group was recognised in 2014 by the Dow Jones Sustainability Index as the leading company in eco-efficiency matters. The magnitude of this programme has allowed the company to improve its environmental performance and to enhance environmental awareness both within the company and externally.

## Latam Airlines Group

DGAC, JAC, GE Aviation Naverus, Airbus, McKenzie, Andes.



[www.latamairlinesgroup.net](http://www.latamairlinesgroup.net)

IN 2014, 120 MILLION LITRES OF JET FUEL WAS SAVED, CUTTING APPROXIMATELY 300,000 TONNES OF CO<sub>2</sub>.

DIRECT ROUTES AND FEWER DELAYS MEAN FEWER CANCELLATIONS.

REDUCED FUEL CONSUMPTION SAVED OVER \$93 MILLION IN 2014.

A member of:





# USING CARBON OFFSETTING TO PROTECT WILDLIFE AND COMMUNITIES

Qantas Airways



[www.qantas.com.au/flycarbonneutral](http://www.qantas.com.au/flycarbonneutral)

OVER TWO MILLION  
TONNES OF CO<sub>2</sub>  
OFFSET TO DATE.

PROJECTS ARE  
ACCREDITED BY VERIFIED  
CARBON STANDARD.

PROJECTS ARE CHOSEN  
THAT LEAD NOT  
ONLY TO EMISSIONS  
REDUCTIONS, BUT ALSO  
EMPOWERMENT OF LOCAL  
COMMUNITIES THROUGH  
JOB CREATION, TRAINING  
PROGRAMMES AND  
HEALTH AND EDUCATION  
INITIATIVES THAT WOULD  
OTHERWISE NOT EXIST.

**AROUND 50 AIRLINES WORLDWIDE HAVE VOLUNTARY CARBON OFFSETTING PROGRAMMES, PROVIDING A WAY FOR PASSENGERS TO OFFSET THE EMISSIONS OF THEIR FLIGHT. THE WORLD'S LARGEST AIRLINE OFFSET PROGRAMME IS RUN BY QANTAS.**

The airline's Fly Carbon Neutral programme commenced in 2009 and provides customers with an innovative carbon offset programme that educates as well as delivers measurable environmental, social and biodiversity outcomes. Recognising the increasing desire by passengers to contribute towards climate change solutions, Qantas developed the Fly Carbon Neutral Program with the objective to educate, inspire and enact measurable change. Examples of projects include:

- Indigenous savannah burning in remote northern Australia.
- Conservation of Tasmanian native forests.
- Distribution of healthier, fuel-efficient cooking stoves to Cambodian families which has developed a commercial supply chain with local stove producers and distributors. The project has also reduced household fuel expenses.
- Protection of virgin tropical rainforest in Papua New Guinea and Peru, where investment in the Brazil Nut industry supports local communities by creating a new economic value.

The Qantas Fly Carbon Neutral programme has also become an employee engagement tool which educates staff about the issue of climate change, how they can support the corporate effort and the on-ground benefits of such action.

Evolving the programme further, Qantas also offsets all of its own corporate travel and ground emissions. Recently, Qantas launched a corporate carbon offsetting product – Future Planet. Qantas Future Planet presents a unique opportunity for corporate customers to commit to sustainability through reducing and offsetting their emissions, engaging with their stakeholders and staff, and driving change within their own industries.

# FUNDING GREENER FLIGHTS IN THE NORTH



**THIS SERVICE INNOVATION ENABLES ORGANISATIONS AND INDIVIDUALS TO FLY ON SUSTAINABLE ALTERNATIVE AVIATION FUEL IN THE NORDIC REGION THROUGH OFFSETTING THE PREMIUM COST OF THE FUEL AND BY SUPPORTING THE DEVELOPMENT OF PRODUCTION IN THE REGION FROM LOCAL FEEDSTOCK.**

The FlyGreenFund will influence the market of bio jet fuel through showing both airlines and fuel producers that there exists both demand for sustainable jet fuel and a way to finance the high costs, today. In the long run the co-operation will result in Nordic production of sustainable jet fuel.

An initiative founded by SkyNRG, NISA and Karlstad Airport, the fund gives partners a platform to work together with supporters such as environmental groups; airline corporate customers which can choose to finance sustainable alternative fuel up to a certain part of their total jet fuel consumption in business travel; and individual air travellers.

The project aims to secure the necessary funding to kick-start the market for sustainable jet fuel in the Nordics by creating demand and at the same time supporting the development of production capacity from locally available feedstock. In the long term, the objective is to set up a fully functioning regional sustainable jet fuel supply chain based on locally available feedstocks (for example, forestry residue).

From the corporate customers' contribution, 75% goes to the fuel itself and 25% goes to supply chain projects, supporting the development of supply chains based on locally available feedstock and state of the art conversion technologies.

To engage people in the initiative more widely, the FlyGreenFund have run a number of campaigns such as selling 'biotickets' online during the Swedish political week in the summer of 2015. The revenue from this will be used to finance sustainable jet fuel for the participating airlines' use later in the year. Information seminars were also held during this week.

This industry can only thrive when all key stakeholders work together. That's why the FlyGreenFund is not just restricted to one airport or airline but welcomes all partners that are committed to make sustainable jet fuel a reality.

## Fly Green Fund, FGF Nordic Ekonomisk förening

SkyNRG, Karlstad Airport, the Nordic Initiative on Sustainable Aviation (NISA), Swedavia, SAS, Braathens, KLM, EFS European Flight Service.



[www.flygreenfund.se](http://www.flygreenfund.se)

WHEN PRODUCED IN AN OPTIMISED SUPPLY CHAIN, SUSTAINABLE JET FUEL CAN REDUCE CO<sub>2</sub> EMISSION WITH UP TO 80%, COMPARED TO FOSSIL JET FUEL.

ECONOMIC AND REGIONAL DEVELOPMENT OF BIOFUEL-RELATED BUSINESSES, JOB CREATION, A COMPETITIVE FOREST INDUSTRY.



# INDEX

BELOW YOU WILL FIND ALL PARTNER ORGANISATIONS LISTED IN *AVIATION CLIMATE SOLUTIONS* AND ON WHICH PAGE THEIR PROJECT APPEARED. THESE PROJECTS WOULD NEVER BE DELIVERED WITHOUT THE COLLABORATIVE EFFORTS OF ALL THESE COMPANIES, ORGANISATIONS AND THE THOUSANDS OF EMPLOYEES INVOLVED.

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