International Transport Forum

Reducing CO_2 Emissions from International Aviation

Policy Options to 2050

International Transport Forum: Global dialogue for better transport

The issue

What approach to mitigating aviation emissions?

International passenger aviation has been growing at an average annual rate of 5% since the 1990s. This trend is forecast to continue over the coming decades. Currently, international aviation is responsible for around 1.3% of global carbon dioxide (CO_2) emissions, or approximately 450 million tonnes (Mt) annually (2014 data). With a predicted doubling of the number of airline passengers by 2030, new measures will be required to mitigate and offset CO_2 emissions from aviation and limit its impact on climate change.

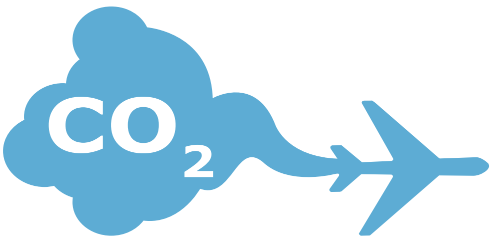
Because CO_2 from international aviation is not emitted within the borders of one country, its emissions are not part of negotiations under the aegis of the United Nations Framework Convention on Climate Change (UNFCCC). Instead, the International Civil Aviation Organization (ICAO) is working with its member countries to achieve a collective goals for the sector of improving fuel efficiency 2% per year and achieving carbon-neutral growth from 2020, with deployment biofuels and introduction of a global market-based measure (MBM) for offsetting emissions from international aviation, to be adopted at the 39th ICAO Assembly in September 2016.

In parallel, the airline industry, represented by the International Air Transport Association (IATA), has set itself ambitious goals. Over and above carbon-neutral growth from 2020, industry aims to bring aviation's CO_2 emissions down to half of their 2005 level by 2050.

To fulfil its commitments, the aviation sector counts on technical and operational measures to improve fuel efficiency and offsets to compensate for CO_2 emissions above the threshold for carbon neutral growth. In the longer term, the industry foresees that the use of advanced carbon biofuels will dramatically reduce CO_2 emissions from aviation.

This paper explores the size of mitigation and offsetting emissions reductions required to achieve carbon-neutral growth and the longer term goal of halving emissions under different scenarios for the development of international aviation.

CO_2 emissions from international flights



450 Mt of CO_2

2014 figure

Updated version: 17/05/2016

The approach

Modelling international aviation demand and emissions to 2050

The International Transport Forum (ITF) has developed a modelling tool to examine the growth of air passenger travel under different scenarios for the removal of market distortions in international aviation. The tool projects demand levels in response to more or less rapid progress in liberalizing air service agreements and opening markets to international investment, and plots associated CO_2 emissions over the coming decades.

The modelling approach combines a basic representation of demand mechanisms with several scenarios for the future evolution of the international airline network. The model assesses passenger flows between 310 world regions, with each region corresponding to a major economic centre. Passenger demand between pairs of regions is derived from the combination of two sub-models: a model for the prediction of origin-destination passenger volumes and a route-choice model for the assignment of the demand onto the air transport network.

Future passenger demand is projected according to three scenarios describing how the air network may evolve in the coming decades. The scenarios reflect the market outcomes of liberalisation, including on prices and connectivity. In the 'static network' scenario no evolution of the air transport network occurs after the base year 2010. In the 'dynamic network' scenario open skies agreements cover all international aviation and the air network is fully flexible, with more connections and increased competition among airlines globally. New direct connections between economic centres are modelled on observations made about the evolution of the air network between 2004 and 2013. An 'intermediate scenario' models a future where the creation of new direct flight connections between regions is limited to the origin-destination pairs with the strongest demand potential.

The results suggest that recent aviation industry forecasts of 5% or more annual increase in demand can only become reality if liberalisation of aviation markets continues, with accompanying reductions in prices and increases in the number of available connections. The biggest impacts are for middle income regions where the air network is not yet mature, especially Asia.

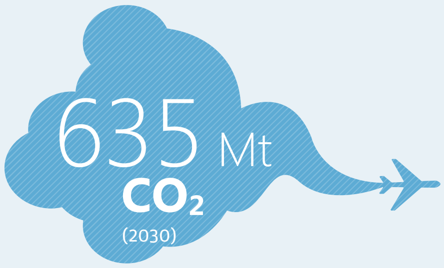
In all scenarios, growth slows down gradually over time, both as a result of slowing growth in global income and population and, in the fully liberalised scenario, because the potential for further liberalisation is eventually exhausted.

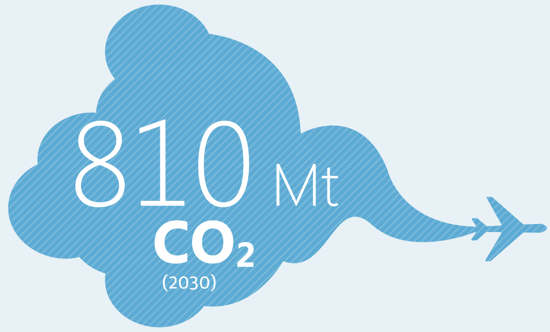
In the intermediate scenario (taken here as the central scenario for computing CO_2 emissions), the annual growth rate for international air traffic is 4.3% between 2010 and 2030. This is very close to IATA's forecast of 4.2% for the period 2013-33. The dynamic scenario provides an average growth rate estimate of 5.7%. Aircraft manufacturers' projections of over 5% were revised downwards in the last quarter of 2015 to 4.9% (Boeing) and 4.6% (Airbus) and now lie half way between the intermediate and fully flexible network scenarios.

The ITF model obtains past CO_2 emissions by mapping emission figures for various typical aircraft types (published by the European Environment Agency, EEA) with the aircraft type recorded in the global Innovata flight schedules database and according to distances flown. The quality of the model for the base year is then checked against regional fuel consumption data provided by ICAO and emission data published by some airlines. No dedicated model tackles the emissions associated with belly freight, which is grouped with passenger transport, but emissions from dedicated freighters are distinguished.

Emission levels for future years are derived by applying different efficiency gain scenarios to the current emission rates. The central projection assumes a global annual decrease in aviation emissions of 1.5% per passenger-kilometre, or tonne-kilometre. The central projection with slow liberalisation shows CO_2 emissions growing from 450 Mt in 2014 to 635 Mt in 2030. With rapid liberalisaiton, the dynamic network scenario shows emissions growing to 810 Mt by 2030.

Trends in aviation emissions



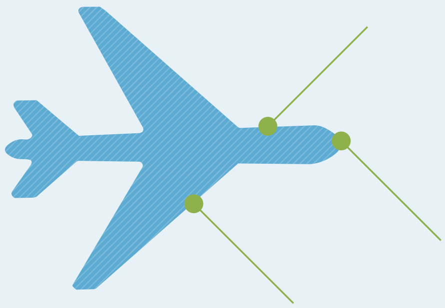


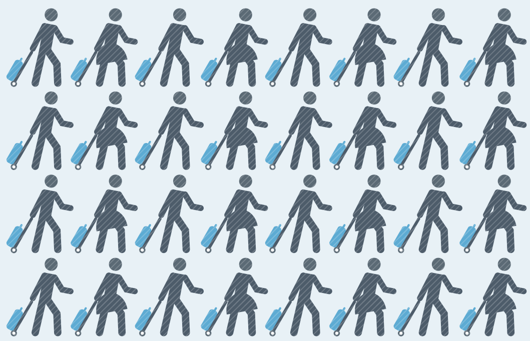
Potential for growth

If restrictions on air traffic rights and other distortions in international aviation markets are successfully removed, the potential growth could increase CO_2 emissions to 810 Mt by 2030.

Current trends

If aircraft technology and operations develop on similar trends to recent years with little change in international aviation markets, annual emissions might grow from 405 Mt in 2010 to 635 Mt in 2030.





Efficiency improvement

The aviation industry foresees a 1.5% improvement in overall fuel efficiency to 2030, in line with the trend over the last 20 years.

Better connectivity

Removing economic restrictions and distortions from international aviation markets would make air travel available to many more people, lowering prices and opening up new routes. The total passenger-kilometres from international air travel could reach between 6.7 trillion in an intermediate and 8.8 trillion in an optimistic scenario, up from 3 trillion in 2010.

The insights

Policies for greener international aviation

Under our central projections in the intermediate scenario for market liberalization, achieving carbon-neutral growth in international aviation from 2020 will require up to 630 Mt of cumulated carbon offsets during the decade between 2020 and 2030 (including any net offsetting CO_2 uptake in the production of biofuels used in aviation). In the year 2030 the offset required annually would reach 115 Mt. This is somewhat smaller than the figure other studies have suggested. There are two main underlying reasons. First, the average growth rate of the ITF scenario (4.3%) is lower than generally used growth rates (around 5%). Second, demand growth is not constant throughout the 2010-30 period. Due to slowing GDP growth and limitations in network expansion after 2020, annual growth is higher than the 4.3% average before 2020 and lower after this date.

At present, offset projects with the highest level of certification are those under the UNFCCC Clean Development Mechanism (CDM). Projects registered in the CDM in 2014 amounted to 100 Mt of Certified Emissions Units. The peak observed in new offsetting project registrations in 2012 when the European CO_2 Emissions Trading Scheme was introduced indicates that the supply in offsets shows strong responsiveness to demand surges but to ensure that the required supply of high-quality offsets materialises, mitigation efforts will need to be estimated and publicised well in advance.

The ITF projections assume that no demand is suppressed as a result of the cost of CO_2 mitigation. Available studies find that suppression is likely to be very small, around a few percent, because the demand for air travel in many market segments is relatively inelastic. However, a very high price for carbon offsets might alter the picture as in competitive markets the cost will be passed on to passengers.

Biofuels might deliver significant emissions reduction after 2030 but they need to become cheaper and their production more efficient. The aviation industry's plan to reduce CO^2 emissions after 2030 and bring them to half their 2005 levels by 2050 largely relies on the use of biofuels. There is a lot of uncertainty regarding the speed at which sufficient quantities of suitable biofuels can be phased in. What is clear is that the potential demand is high. Assuming biofuels have the same energy content as conventional fossil fuels, biofuels will need to represent about 65% of aviation fuels by 2050 and this share will only suffice if net CO_2 emissions of aviation biofuels are zero. If the carbon savings compared to conventional jet fuel were only 70% (a typical figure for current aviation biofuels) the industry target will require that biofuels power all international flights.

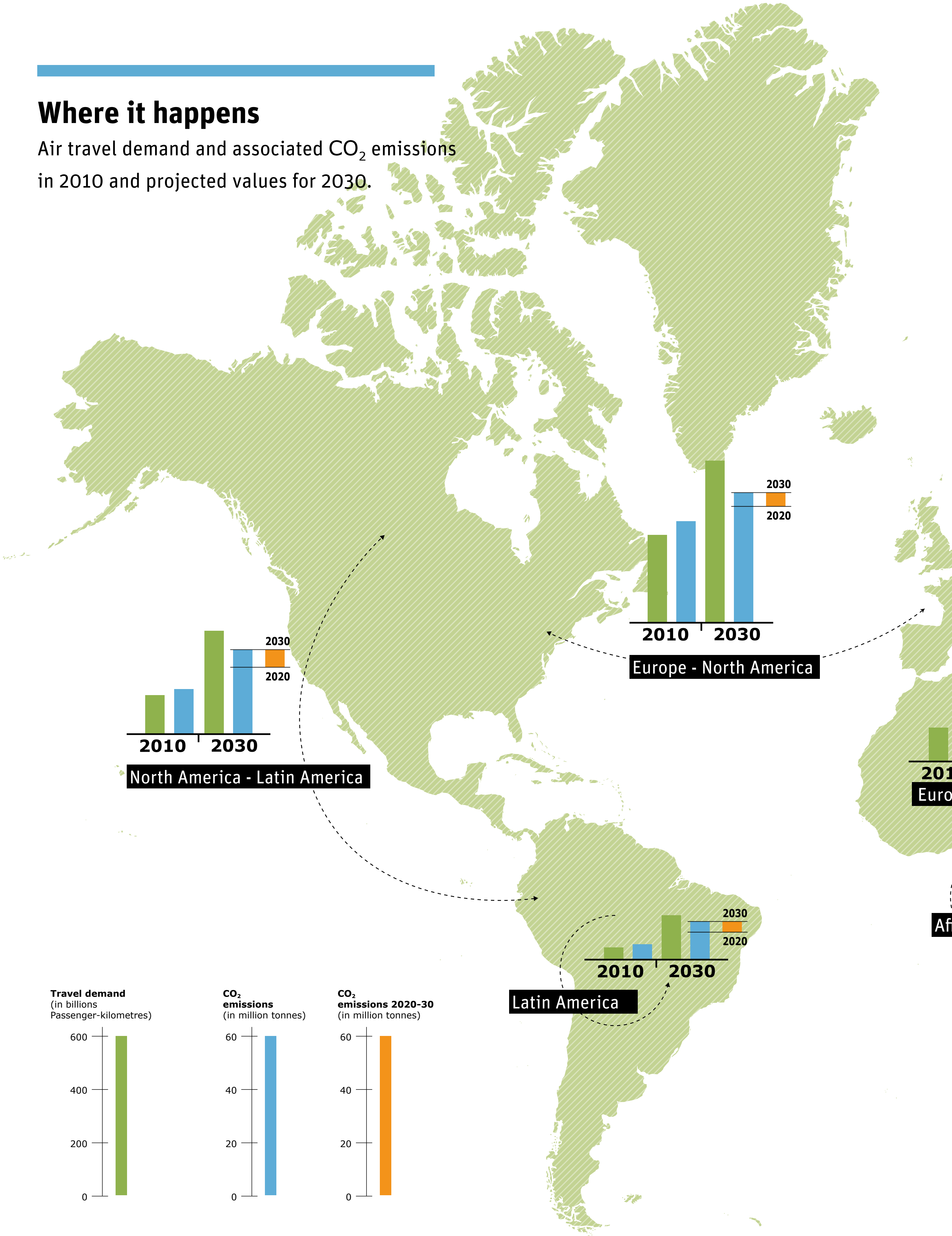
A 65% share for biofuels in aviation is ambitious, considering its current marginal relevance (less than 0.001% of aircraft fuel in 2014) and the planning assumptions of some government bodies. The United Kingdom Committee for Climate Change, for instance, states that a 10% share of biofuels in 2050 is reasonable. Advanced second-generation aviation biofuels are produced from algae or nonfood parts of crops, so do not compete with food production or necessitate the destruction of carbon sinks such as forests. However, this makes the production process significantly more complex and such biofuels cost up to twice as much as conventional kerosene. Cost is currently the biggest barrier to the broad introduction of biofuel in aviation.

In the dynamic network scenario, where the air network evolves without constraints and prices decrease, emissions (before offsets) would be at double their 2010 level in 2030. The overall requirement for offsets to achieve carbon-neutral growth would reach 1 000 Mt of CO_2.

Removing economic restrictions and distortions from international aviation markets would make air travel available to many more people, lowering prices and opening up new routes. Liberalised aviation markets achieve a number of benefits. The additional passenger demand translates into economic activity within and outside the aviation sector. The tourism industry, for example, stands to benefit and can be

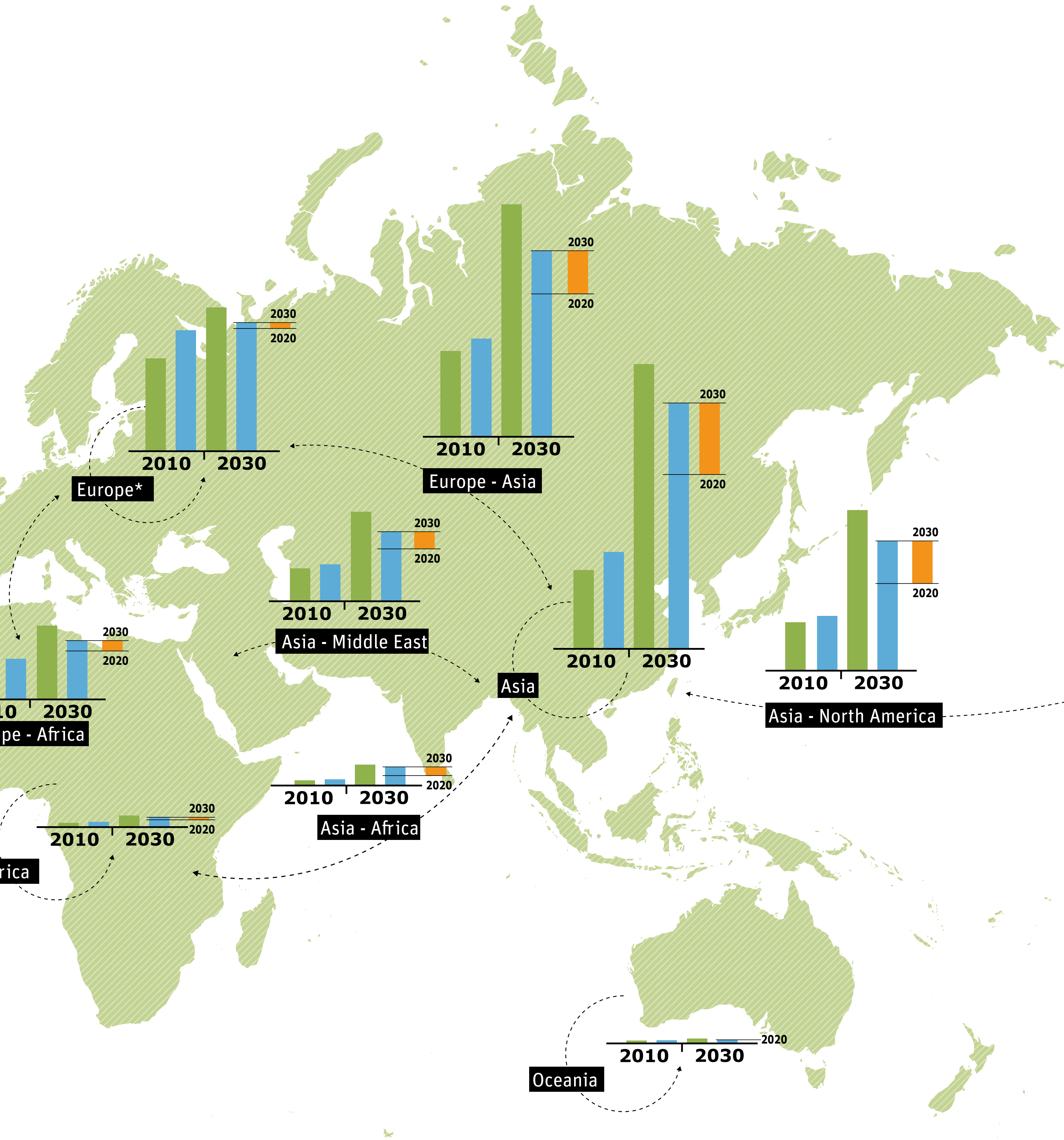
Where it happens

Air travel demand and associated CO_2 emissions in 2010 and projected values for 2030.

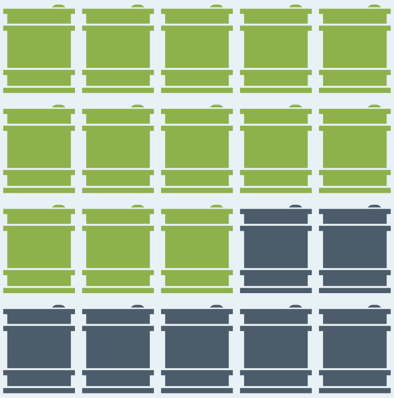


Baseline growth scenario with a global efficiency improvement rate of 1.5%.

* Emissions for Europe are shown before offset under the European ETS system.


2010
2030
2020
Europe*
Europe - Asia
Asia - Middle East
Asia
Asia - North America
pe - Africa
Asia - Africa
rica
Oceania

The scale of the issue



Biofuels

The aviation industry aims for advanced biofuels to account for 65% of jet fuel in 2050 with the objective of halving the increase in CO_2 emissions from international flights.

115 Mt

Offsets required in the year 2030 for carbon-neutral growth.

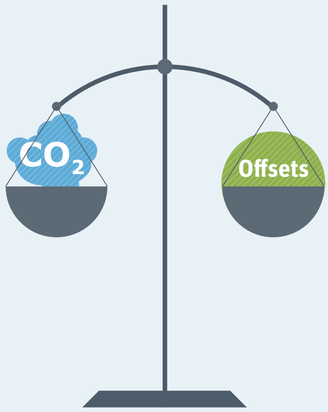
a powerful tool for economic development. Lower prices, better connections and higher flight frequencies stimulate demand for air travel. On some short haul routes this results from in passengers switching from rail, which can sometimes be more CO_2-efficient than air, but most of the increase in air demand is new and cannot be satisfied by other modes.

Liberalisation has enabled consolidation and efficiency including through the development of international aviation hubs. This has tended to add to flight distances through increased numbers of indirect journeys. In some cases, no direct flight is available, but many indirect journeys occur because of advantages (mostly lower price) of the indirect route. In 2010, indirect journeys represented 30% of all international journeys by air and 55% of long-distance trips. Of these, more than half occur on origin-destination pairs for which a direct flight is available. This has an impact on emissions. Under our dynamic network scenario, in 2030 around 55% of international aviation's CO_2 emissions will come from indirect journeys, with about 6% of the total resulting from the additional distance travelled where an alternative direct flight exists.

The efficient approach to any potential correction would be to charge aviation for the external cost of CO_2 emissions, per tonne of CO_2 emitted or litre of fuel consumed, through a fuel tax or an 'ideal' emission trading system, encompassing all sectors in all parts of the globe so that the cheapest mitigation measures are taken first. An emissions trading scheme sets a cap on the amount of permissible emissions. Permits for emitting CO_2 are issued and entities that emit less CO_2 than they hold permits for can sell them. Those who emit more need to buy additional permits. The price of carbon varies with demand for permits. The cost of carbon to airlines and passengers would fluctuate.

Emissions trading schemes tend to be complex and associated with a number of uncertainties and distortions. Because the price of carbon is not fixed, the impact on demand is hard to estimate in advance. The cap on emissions requires a political decision and may in practice bear little relation to damage cost estimates.

Setting a price for carbon



Emissions Trading Scheme

ETS set a cap on the amount of permissible emissions. Permits for emitting tonnes of CO_2 are issued and entities that emit less CO_2 than they hold permits for can sell them. Those who emit more need to buy additional permits. The price of carbon varies with demand for permits. The cost of carbon to airlines and passengers can fluctuate.

Carbon Tax

A carbon tax establishes a constant price for CO_2 emissions and produces public revenues. Revenues might be earmarked to stimulate innovation inside the aviation sector, support development of the sector in low income countries or used to achieve broader economic goals.

Also, the cap may vary over time, with relaxation as frequent as tightening, as has been the case with the European ETS. As a result, the price of carbon may fall too low to spur investment in a low-carbon economy. A low-carbon price, because it translates into low conventional fuel prices, can also hinder the uptake of cleaner but more expensive fuels.

A carbon tax would have somewhat different characteristics to an ETS. As with a trading cap, its level would be set by political decision and might or might not be determined by damage cost estimates. Assuming a stable tax level, it would provide a consistent incentive for CO_2-efficient behaviour to airlines and travelers, so long as it was index linked to inflation. If the entire cost of a carbon tax were passed on to passengers, a carbon tax of USD 40 per tonne of CO_2 would reduce global demand for aviation (expressed in passenger-kilometres) by 6% in 2030 according to our model while at the same time raising revenues of almost USD 25 billion. Around one quarter of the 6% reduction comes from passengers re-routing to (more) direct flights rather than from suppressed demand. A carbon tax would be particularly difficult to introduce in international aviation, however, as the need to avoid tax competition (different countries or airports taxing below the standard rate to attract business) has resulted in a longstanding international agreement to levy no tax on jet kerosene, zero being the most easily enforced harmonised rate.

A global system for purchasing certified carbon offsets in relation to emissions over and above an agreed target might provide the most viable alternative instrument. This would be simpler and more transparent than an emissions trading system with lower administrative cost. Projecting the offsets required under such an arrangement with modeling tools like the one described in this paper should help provide the lead-time needed to develop a sufficiently large market in certified offset projects.

Further reading

Air Transport Action Group,
Aviation Climate Solutions,
Geneva, 2015

International Civil Aviation Organization,
ICAO 2013 Environmental Report: Destination Green,
Montreal, 2013

"Market-based instruments for international aviation and shipping as a source of climate finance",
World Bank Policy Research Working Paper,
Washington, 2012

OECD/ITF,
Adapting Transport Policy to Climate Change: Carbon Valuation, Risk and Uncertainty,
Paris, 2015

About the International Transport Forum

Who we are
The International Transport Forum at the OECD is an intergovernmental organisation with 57 member countries. It acts as a think tank for transport policy and organises the Annual Summit of transport ministers. ITF is the only global body that covers all transport modes. The ITF is administratively integrated with the OECD, yet politically autonomous.

What we do
The ITF works for transport policies that improve peoples' lives. Our mission is to foster a deeper understanding of the role of transport in economic growth, environmental sustainability and social inclusion and to raise the public profile of transport policy.

How we do it
The ITF organises global dialogue for better transport. We act as a platform for discussion and pre-negotiation of policy issues across all transport modes. We analyse trends, share knowledge and promote exchange among transport decision-makers and civil society. The ITF's Annual Summit is the world's largest gathering of transport ministers and the leading global platform for dialogue on transport policy.

International Transport Forum

International Transport Forum

2016 Summit

Green and Inclusive Transport

18–20 May 2016

Leipzig, Germany

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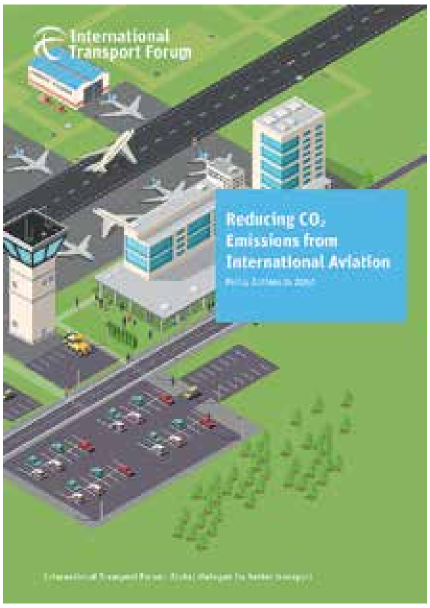

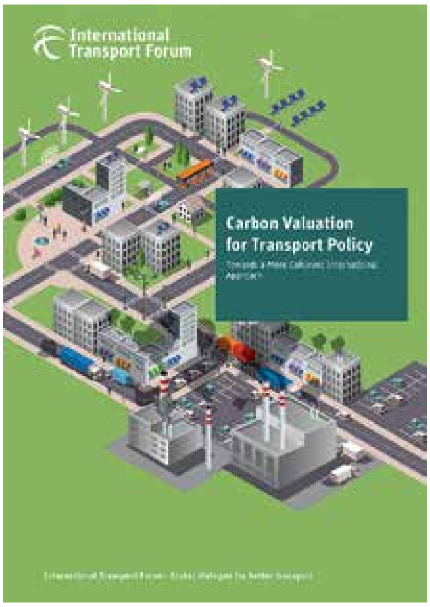

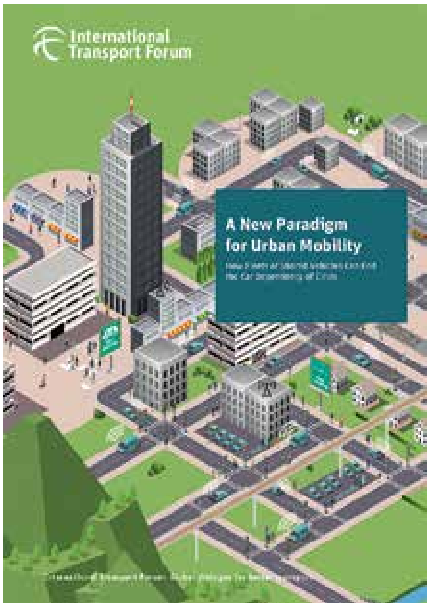

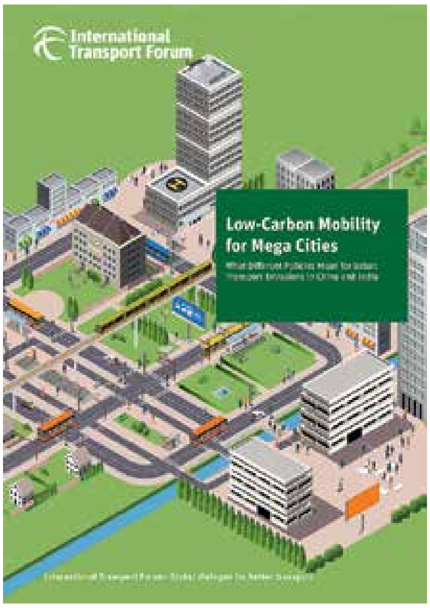

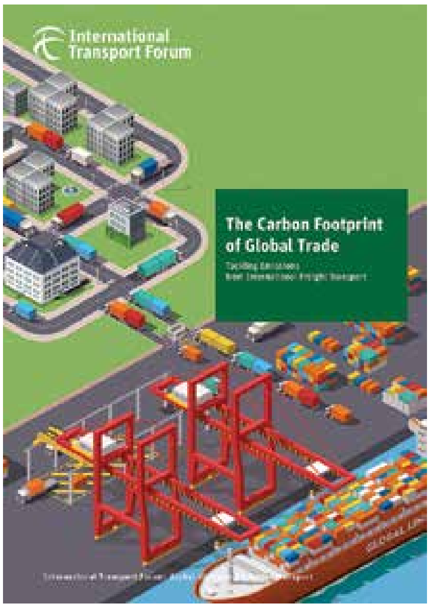

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