ICF INTERNATIONAL WHITEPAPER

Mind the Carbon Gap:

An Alternative Outlook for Aviation Emissions

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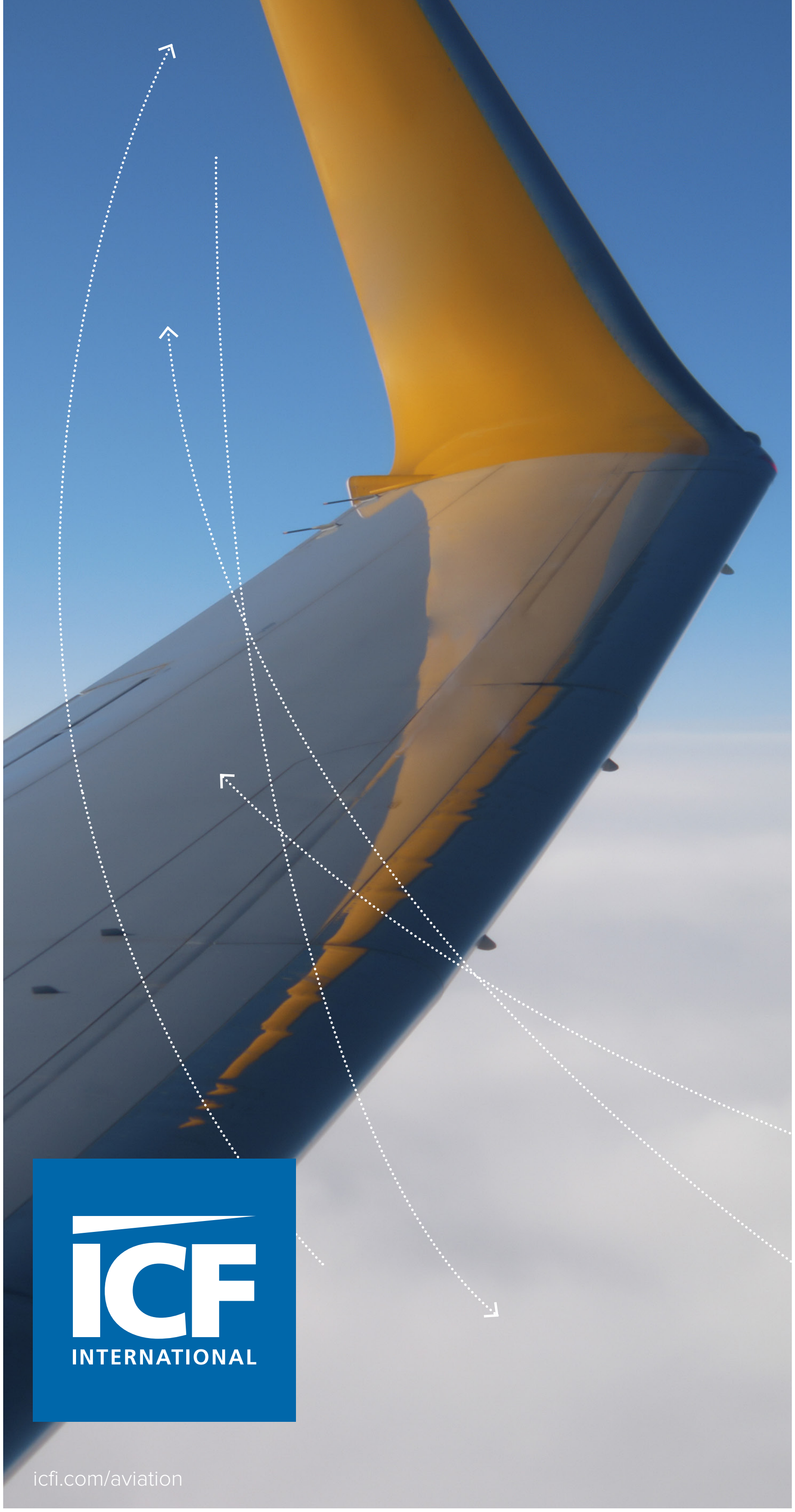

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Abstract

ICF International's industry-leading aviation carbon forecast shows that compared to most projections, slower growth in the number of passengers and planes in the air will ease the burden to meet published emissions targets. Nevertheless, without other improvements, commercial aviation will produce 53 percent more carbon in 2023 than today, leading to a 33 percent gap versus the industry's goals.

Aviation has options. Technology retrofits to current generation aircraft and widespread adoption of best practices in airline operations could together improve fleet efficiency by 5 percent. In addition, plausible levels of biofuel use could reduce carbon emissions by more than 3 percent. Taking into account these mitigation opportunities, ICF forecasts that aviation will produce 1.16 billion tons of CO2 in 2023, exceeding the industry's target by 23 percent. Offsets from cheaper carbon reductions in other industries are likely the most cost-effective way to close this remaining gap.

Although commercial aviation makes up less than 1 percent of the global economy, its value is many times greater. Last year, commercial airlines carried 3 billion passengers and more than one-third of the world's trade by value. By some estimates, the industry supports almost 60 million jobs[1], and even that is a fraction of aviation's total contribution to trade, technology, and economic development.

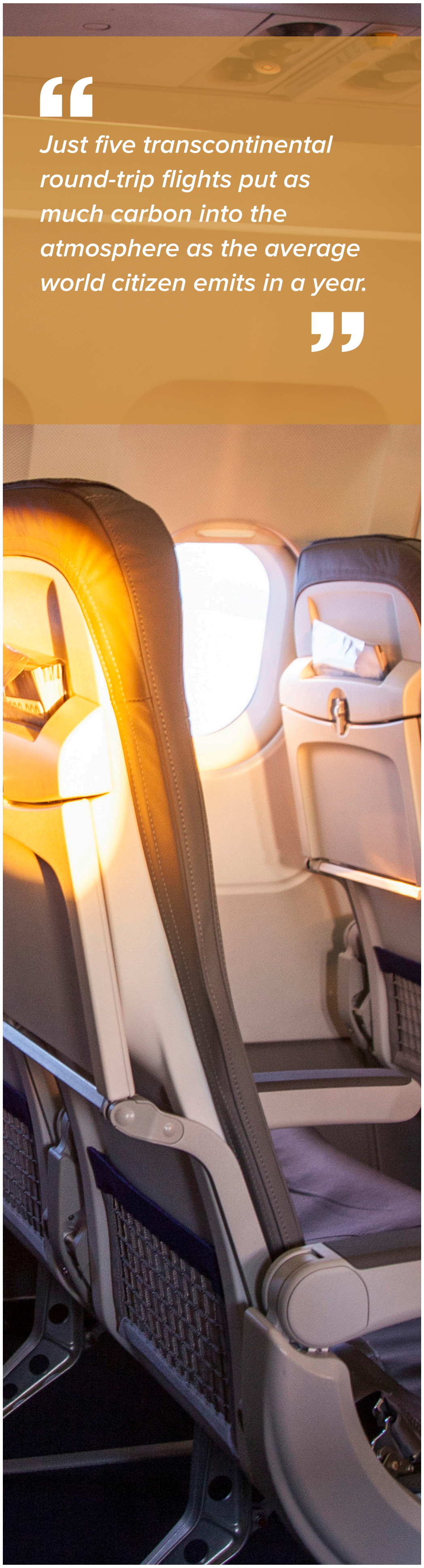
Against these benefits, aviation contributes 2 percent of the global greenhouse gas (GHG) emissions generated by humans. Even though this figure appears modest, industry growth, fueled in part by the emerging middle class in developing countries, threatens to make aviation one of the fastest-growing sources of emissions—unless something changes.[2]

The International Air Transport Association (IATA), an airline trade group, made public commitments in 2009 to cut fuel-related emissions while continuing to carry more passengers. These targets include:

- Cap total carbon output starting in 2020, implying that efficiency will improve each year thereafter to offset growth in flying
- Until 2020, improve efficiency by 1.5 percent per year

In other words, the industry committed to improving efficiency by 1.5 percent per year until 2020 and thereafter improving efficiency by the rate of traffic growth, which commonly cited forecasts peg near 5 percent.[3]

1. http://www.atag.org/facts-and-figures.html
2. Moreover, scientific findings demonstrate that contrails and aircraft-induced cloud formation generate climate impacts beyond direct CO2 emissions.
3. Airbus 4.7% from 2013 to 2033; Boeing 5% growth from 2013 to 2033.



> *Just five transcontinental round-trip flights put as much carbon into the atmosphere as the average world citizen emits in a year.*

ICF recently set out to test how close airlines are to meeting emissions targets. Combining decades of expertise in airline economics, aerospace strategy and environmental analysis, **ICF developed a new forecast of aviation carbon that quantifies the benefits of operating efficiencies and aircraft technology to reduce fuel consumption.** Even under optimistic scenarios, a gap exists between ICF's forecast and the industry's target.

Aviation Matters

Air travel is comparatively efficient. For most trips, carbon output per person is better than new generation hybrid and diesel automobiles. However, because we fly longer distances than we drive, air travel can produce outsized GHG emissions.

Other sectors, such as road vehicles and buildings, have potential for dramatic energy reductions at modest cost. For example, new cars will double fuel economy in the United States by 2025, and studies indicate that residential and commercial buildings can reduce energy consumption by one-third using existing products and retrofit approaches with quick paybacks.

Your Mileage May Vary

	Aircraft Fuel per Passenger*	Carbon per Passenger
NYC to San Fran	74 MPG	1,430 lbs.
Paris to Istanbul	6 l/100km	382 kg

*A320 or similar for round-trip direct flights

Source: ICF International

Aircraft manufacturers, on the other hand, have prioritized fuel efficiency for decades already, leaving less fat on the table. Moreover, the biggest improvements in fuel consumption come with the introduction of new aircraft and engine designs, which can take decades to filter into the global fleet.

Mind the Carbon Gap

At the core, aviation emissions grow as the number of flights increase. ICF's carbon forecast therefore builds on an *independent* forecast of air travel.

Our air traffic and fleet forecast is designed to assess a range of scenarios under which future growth in air travel could differ from the steady historical trends that underpin most industry forecasts. Among the issues we consider, for example, are the one-time installation of slimline seats that squeeze as many as 4 percent more passengers on the average narrowbody aircraft. This and other step changes in aircraft productivity reduce the number of flights that airlines need to operate in order to carry the same number of passengers.

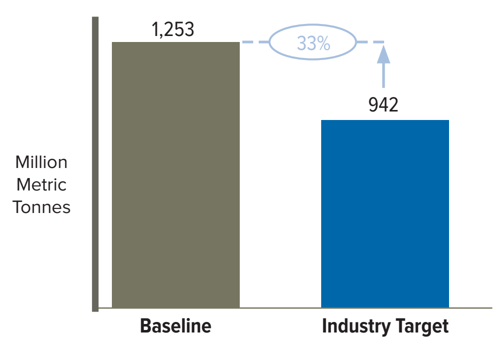
ICF's air traffic and fleet forecast also considers the possibility that the mega-carriers in the Middle East may ultimately adjust their growth plans. Recently, Emirates cancelled an order for 70 A350 widebodies, perhaps signaling a modest modulation in growth.

These and other plausible scenarios support our view that over the next 20 years, air traffic will grow by 4 percent, and the fleet required to carry that traffic will grow by just 3.1 percent annually as airlines carry more passengers on each flight. By contrast, most analysis of carbon output is based on higher manufacturer projections such as Boeing's forecast that the fleet will grow 3.6 percent each year.

ICF's view that flight hours will grow more slowly makes it easier to achieve the industry's target of carbon-neutral growth by 2020.

Even with a lower forecast of flying hours, however, the baseline outlook for aviation carbon still exceeds industry targets by 33 percent in 2023.

2023 Aviation Carbon
ICF Baseline Forecast vs. Industry Target



Source: ICF International

ICF explored how aircraft manufacturers and airlines could close the gap with:

- Aircraft technology improvements
- More efficient operations
- Biofuels

Aircraft Technology Improvements

For years, automakers protested that high fuel-efficiency requirements were unrealistic. SImilarly, aircraft manufacturers have resisted new efficiency mandates, saying meaningful improvements will have to wait until the next generation of aircraft comes to market. Recent work by ICF challenges this point.

In a study commissioned by the U.S. Environmental Protection Agency (EPA), ICF identified more than 70 ways to improve aircraft efficiency via retrofits to current aircraft or changes in the production of current generation aircraft. These technologies range from reducing drag on the trailing edges of wings to improving engine airflow with new seals.

Technology Improvements for In-Production Aircraft

- Drag reduction on trailing edge of aircraft wing
- Coatings to reduce gaps and drag on airframe
- Advanced wingtip devices
- Laminar flow controls
- Streamlining protrusions on aircraft such as APU and lights

Source: ICF International

Our work showed that technological improvements via retrofits can deliver 3.8 to 6.3 percent efficiency on any aircraft. ICF's aviation carbon forecast considers when the relevant aircraft enter and exit the fleet and how much traffic they will carry.

With conservative assumptions about adoption, these technologies will reduce the airline industry's total carbon output by 2 percent in 2020, partially closing the gap to industry targets.

New Airline Efficiencies

Over the past decade, most of the world's largest airlines have undertaken fuel- efficiency programs, with some success. Many have mastered the simple operational changes that together can reduce fuel consumption by 3.5 to 5 percent, such as using ground power units instead of the aircraft's auxiliary power unit (APU). Previously, it was common for many carriers to run the APU, the aircraft's onboard power, as much as 60 minutes between flights at the gate and during taxi time. Unnecessary APU use alone can account for up to 1 percent of an airline's entire fuel consumption.

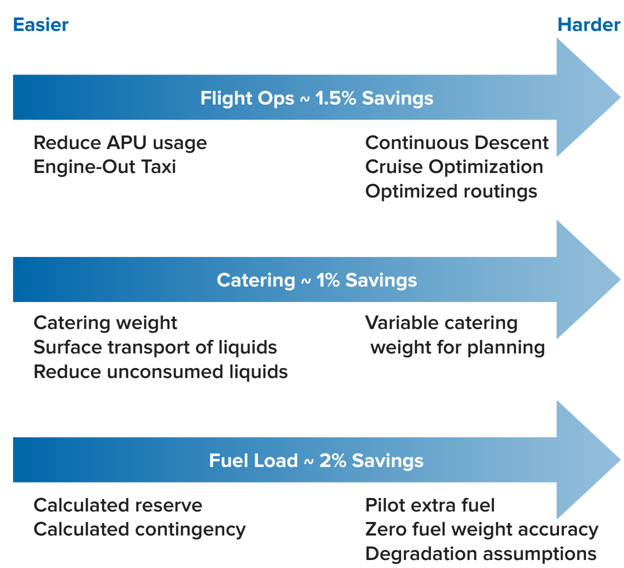
Another simple change includes reducing aircraft weight by eliminating surplus catering supplies and loading less potable water.

Equally valuable but more demanding is to reprogram flight planning software based on each flight's actual catering load rather than assuming the heaviest profile for every flight. Improvements related to catering can often yield another whole percentage point of fuel savings.

Few airlines have been able to capture all of the fuel savings, however. Many measures require technical expertise, changes in organizational culture, or both.

For example, new flight procedures, such as continuous vertical descent or more efficient routings, may require coordination with air traffic control authorities and pilots.

Fuel Savings from Airline Operations

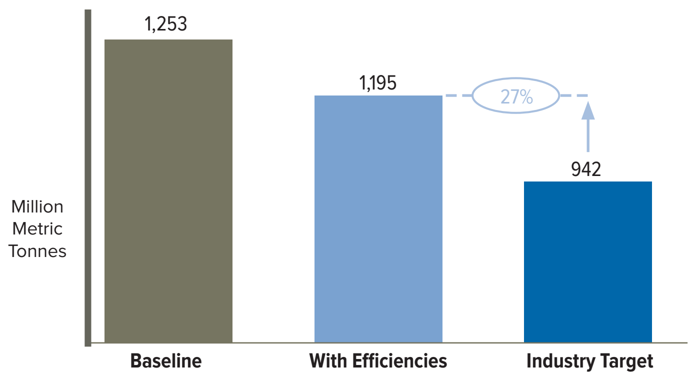


Source: ICF International

Similarly, programs to measure how much surplus fuel is onboard when aircraft land can highlight decisions by pilots to load extra "comfort" fuel but may threaten their sense of autonomy. Onboard tools measuring individual pilots' flying efficiency are sometimes blocked by unions or by legal interpretation of local labor laws.

ICF forecasted how aircraft technology improvements and streamlined operations will reduce fuel usage and carbon output.

2023 Aviation Carbon
ICF Forecast with Efficiencies
vs. Industry Target



Source: ICF International

Together, these improvements are projected to reduce aviation carbon output by 8 percent in 2023.

Yet there is still a gap between expected carbon emissions and the industry's commitments.

Biofuels

Industry groups and individual airlines have built up great hope—or hype—about biofuels as a solution to aviation emissions. This focus indicates an implicit recognition that even the most optimistic scenarios of efficiency improvements will be insufficient to meet the industry's commitments to carbon-neutral growth.

The most promising biofuels under consideration today, derived from Jatropha and Salicornia oils, result in 40 to 60 percent of the lifecycle carbon emissions produced by petroleum jet fuel. Although biofuels have lower carbon content than oil, energy consumed in production reduces benefits from CO2 absorbed from the atmosphere during cultivation.

The U.S. Federal Aviation Administration (FAA) estimates that by 2020, biofuels will make up approximately 6 percent of all aviation fuels. Applying the FAA's 6 percent assumption to ICF's baseline carbon forecast would reduce total aviation carbon output up to 3.6 percent during the forecast period.

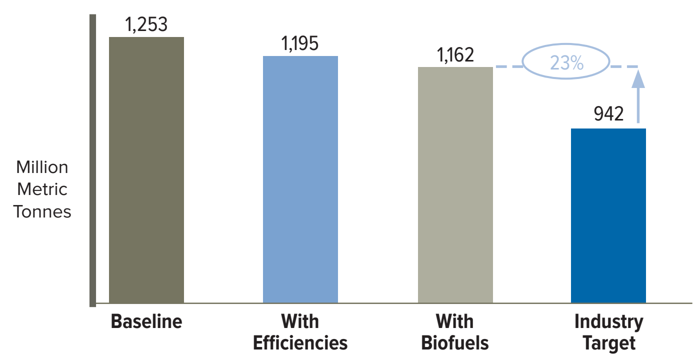
Unfortunately, this scenario will require a significant coordinated effort to achieve because of a number of obstacles to widespread use of biofuels, some technical and some economic.

Technically, biofuels must gain the trust of airlines and regulators as safe alternatives to kerosene, including the impact on engine maintenance and new methods to ensure safe handling at the airport and procedures for emergency response.

Current aircraft engines depend on aromatic components in petroleum, such as benzene, that help rubber seals expand during engine combustion. Barring development of new engine technology, biofuels will constitute no more than half the total fuel onboard. As a result, biofuels will require a parallel fueling infrastructure at airports to blend fuels in the right mix for each product.

Economically, biofuels may simply be too expensive for airlines to embrace on a wide scale. Biofuels currently cost at least $3.00 more per gallon ($993 per tonne) than jet fuel, or a premium of $15,000 for a typical transcontinental flight.

2023 Aviation Carbon
ICF Forecast with Biofuels
vs. Industry Target



Source: ICF International

Market forces do not appear aligned to make biofuels cost competitive with traditional kerosene in the near term or medium term. There is little appetite for government subsidies to cover this cost differential, as the United States historically did for corn-based ethanol production or as many governments have done to support renewable electricity.

Meanwhile, other industries are already willing to pay higher prices for bio-based polymers, further reducing market incentives to process feedstock into biofuels for aircraft instead of other purposes.

Unfortunately, biofuels are unlikely to close the full gap between projected aviation carbon and the industry's targets.

Market-based Measures

Assuming aircraft manufacturers and airlines implement widespread efficiency improvements, and assuming the airline industry is able to implement some biofuel use,[4] ICF's forecast still shows a gap between the outlook for aviation carbon and the industry's stated targets. This gap equates to 220 million tons of CO2 in 2023, or the equivalent annual emissions from 44 million cars.

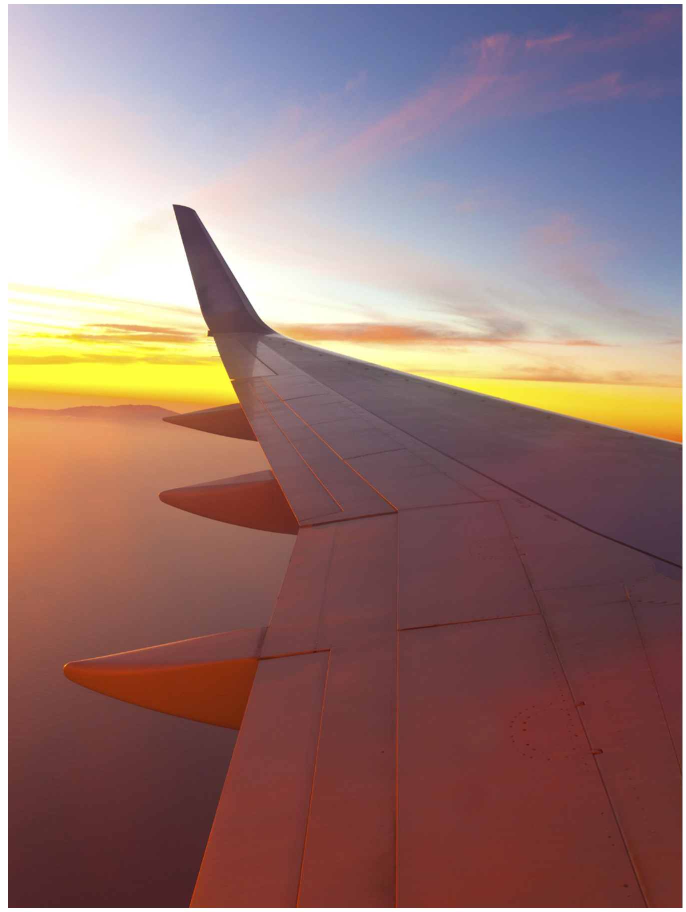
For the aviation industry to meet its emissions targets in 2023 and beyond, reductions in other industries will have to offset airline emissions.

There is precedent for reductions in GHG using such market-based approaches. In the Northeastern United States, the Regional Greenhouse Gas Initiative (RGGI) invested $700 million over 5 years to produce more than $2 billion in energy savings. RGGI works

4. We assume that North America and Europe achieve the biofuel usage levels predicted by the FAA and that the Middle East and Pacific Rim ramp up to European production levels by 2020.

How Offsets Work

Participants in an emissions trading scheme purchase certificates that prove a carbon reduction has been achieved in another industry or location. In one functioning example, the United Nations certifies carbon reduction actions, such as eliminating fugitive refrigerant emissions. To offset carbon produced in flight, airlines would purchase these certificates, thereby reducing global emissions at a lower cost than airlines would be able to achieve themselves.

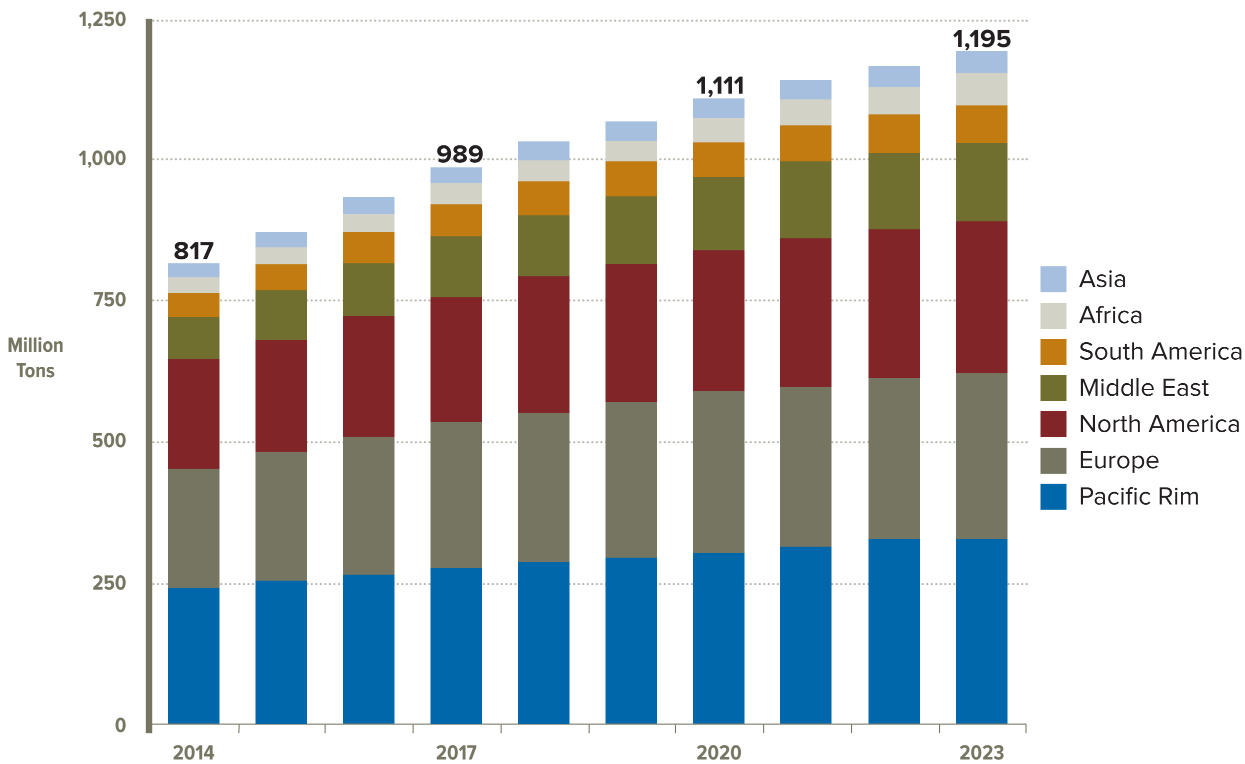


because producers with the highest emissions were able to purchase reductions from firms with the lowest cost to reduce emissions.

Similarly, after implementing prudent efficiencies in aviation, it is more cost-effective to reduce GHG emissions in other industries. It will simply cost less to install methane digesters on farms or to insulate buildings than to accelerate aircraft retirement.

ICF has experience developing offset programs to enable the most efficient outcomes. ICF gave some of the earliest guidance on aviation emissions to ICAO—the UN body responsible for aviation—and has provided analysis for the European Union's Emissions Trading Scheme. Currently, ICF is helping China design its future carbon trading program.

ICF Aviation Carbon Forecast (with efficiencies and no biofuels)



Source: ICF International

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