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# States' strategy to deal with international aviation CO<sub>2</sub> emissions: Mitigation Measures



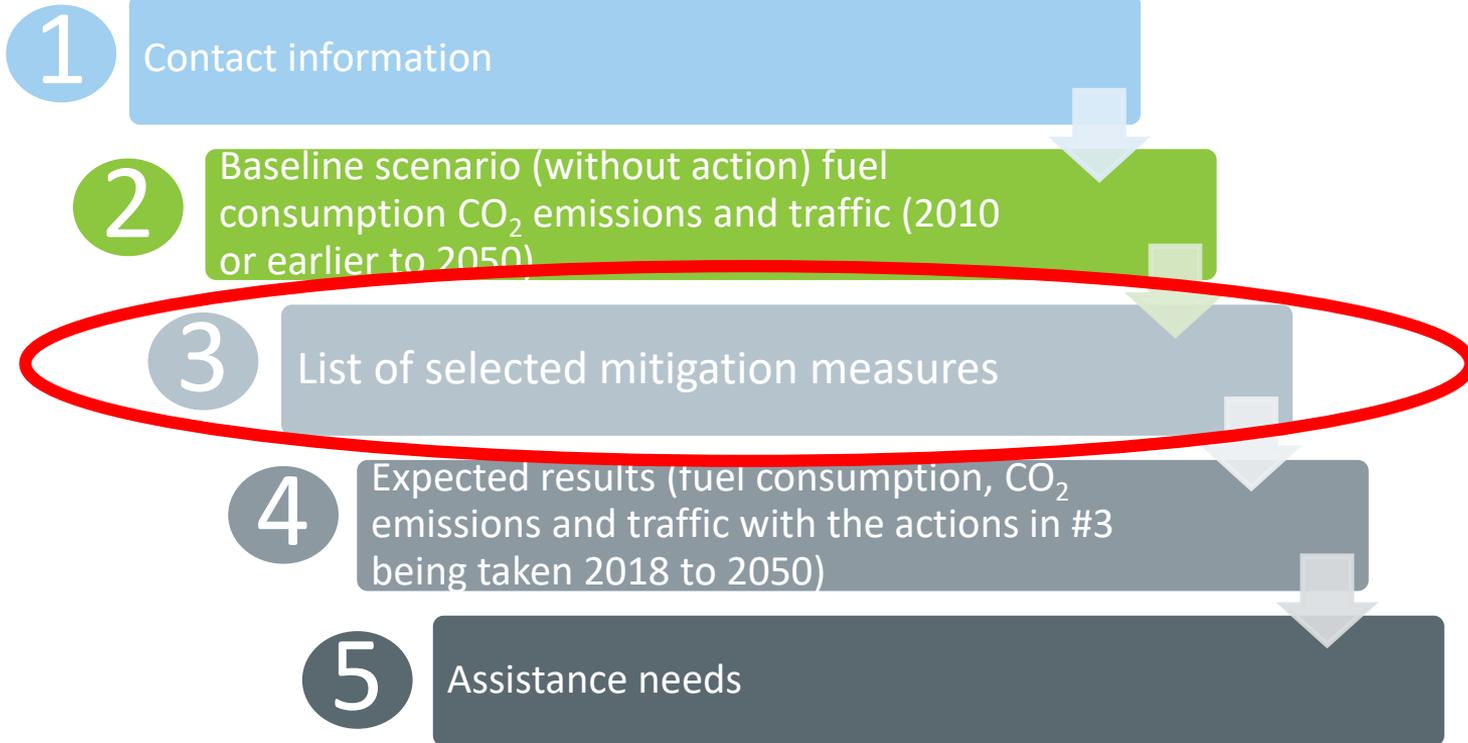


## Outline

- ICAO State Action Plan Minimum Content Review
- Defining ICAO's Basket of Measures
  - Mitigation Measures – Seven (7) categories of measures
  - Mitigation Measures – ICAO Basket of Measures
- Guidance on Selecting Measures
- Additional Guidance
- Additional Support
- Summary



# State Action Plan Minimum Content

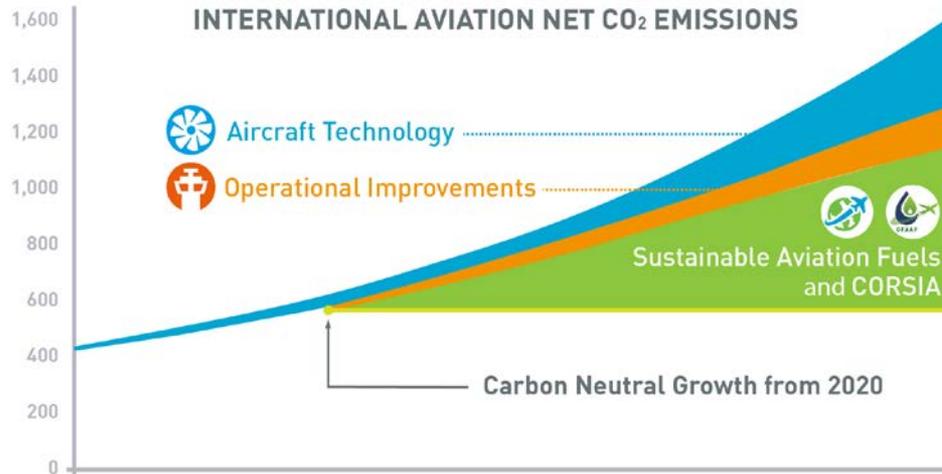




## ICAO Global Aspirational Goals (A40-18)

- ICAO aspirational goal - Carbon neutral growth (CNG) from 2020 onwards.
- To be achieved with a “basket of measures” for CO<sub>2</sub> reduction

CONTRIBUTION OF MEASURES FOR REDUCING INTERNATIONAL AVIATION NET CO<sub>2</sub> EMISSIONS



### ICAO Basket of Measures

- Technology and Standards
- Operational Improvements
- Sustainable Aviation Fuels
- Market-Based Measures (CORSIA)

Range of CO<sub>2</sub> reductions from Sustainable Aviation Fuels (SAF)





# Context within Doc 9988

- **Chapter 4** – Selection of measures and quantifying their expected results
- **Appendix A** – Basket of measures to limit or reduce CO<sub>2</sub> emissions from international civil aviation
- **Appendix C** – Key stakeholders, analysis methods and tools
- **Appendix D** – Reference material relevant to the implementation of mitigation measures
- **Appendix E** - Examples of measures selected in action plans
- **Appendix F** – Costs and benefits related to the basket of measures



## Defining ICAO's Basket of Measures

- High-level Meeting on International Aviation and Climate Change in October 2009 (HLM-ENV/09) endorsed the Programme of Action on International Aviation and Climate Change, which included:
  - global aspirational goals;
  - a basket of measures; and
  - the means to measure progress.



## Mitigation Measures – Seven (7) categories of measures:

1. aircraft-related technology development;
2. sustainable aviation fuels
3. improved air traffic management and related infrastructure use
4. more efficient operations
5. economic/market-based measures
6. regulatory measures/other; and
7. airport improvements



7 Categories of Measures

sustainable aviation fuels      airport improvements      more efficient operations

aircraft-related technology development      regulatory measures / other      improved air traffic management and related infrastructure use      economic / market-based measures

ICAO Basket of Measures

Aircraft technology	First-ever global CO <sub>2</sub> certification Standard for new types and in-production aeroplanes. Fast-paced innovation (new designs, composite materials, hybrid-electric aircraft, renewable energy sources, etc.).	
Operational improvements	CO <sub>2</sub> benefits from air traffic management; air navigation; green airports; etc.	
Sustainable aviation fuels	Around 200,000 commercial flights with drop-in aviation fuels; 6 conversion processes; 7 airports distributing drop-in aviation fuels	
Global market-based measure	Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)	



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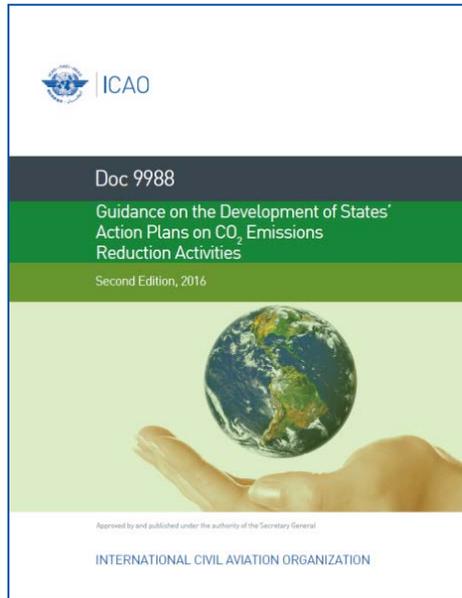
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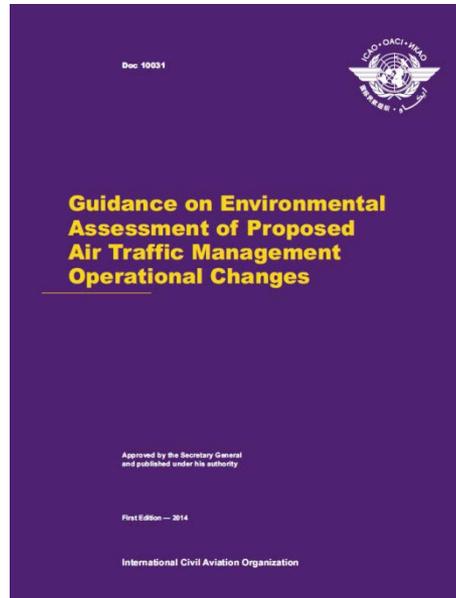


# Guidance on Selecting Measures

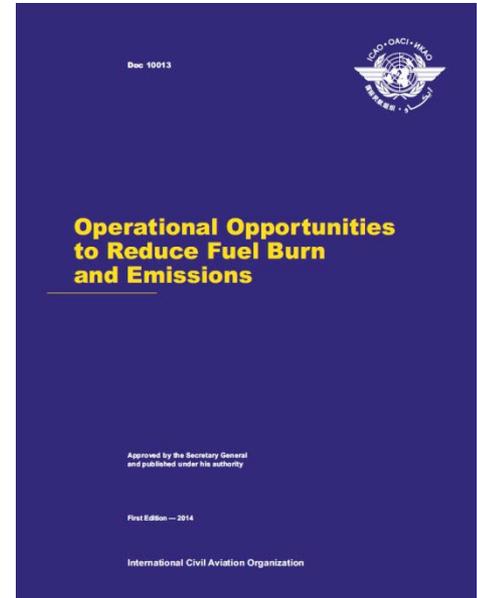
- Reference material:



**ICAO Doc 9988**



**ICAO Doc 10031**



**ICAO Doc 10013**



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# Additional Guidance Documents

TRANSFORMING GLOBAL AVIATION COLLECTION 104

**RENEWABLE ENERGY FOR AVIATION:**  
PRACTICAL APPLICATIONS TO ACHIEVE CARBON REDUCTIONS AND COST SAVINGS

ICAO ENVIRONMENT | UN DDP | GEF GLOBAL ENVIRONMENT FACILITY INVESTING IN OUR PLANET

TRANSFORMING GLOBAL AVIATION COLLECTION 204

**FINANCING AVIATION EMISSIONS REDUCTIONS**

ICAO ENVIRONMENT | UN DDP | GEF GLOBAL ENVIRONMENT FACILITY INVESTING IN OUR PLANET

TRANSFORMING GLOBAL AVIATION COLLECTION 304

**REGULATORY AND ORGANIZATIONAL FRAMEWORK TO ADDRESS AVIATION EMISSIONS**

ICAO ENVIRONMENT | UN DDP | GEF GLOBAL ENVIRONMENT FACILITY INVESTING IN OUR PLANET

TRANSFORMING GLOBAL AVIATION COLLECTION 404

**SUSTAINABLE AVIATION FUELS GUIDE**

ICAO ENVIRONMENT | UN DDP | GEF GLOBAL ENVIRONMENT FACILITY INVESTING IN OUR PLANET



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# Examples of Mitigation Measures





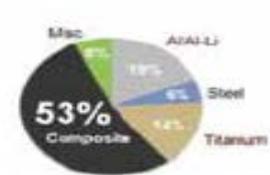
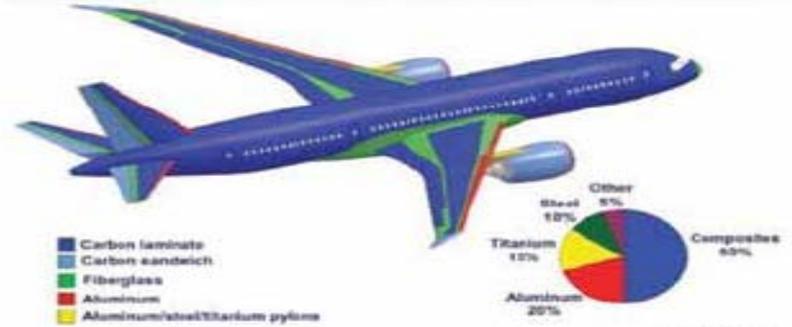
# Aircraft Technology Development

- To improve fuel efficiency there are continuous efforts in:
  - Aircraft structures – weight reductions
  - Propulsion
  - Aerodynamics
- For example:
  - Aircraft minimum fuel efficiency standards;
  - Retrofitting and upgrade improvements on existing aircraft;
  - Optimizing improvements in aircraft produced in the near- to mid-term;
  - Avionics;
  - Adoption of revolutionary new designs in aircraft/engines.



- Reductions in weight are a key factor in reducing fuel burn:
  - Use of Carbon Fibre Reinforced Plastic (CFRP) and advanced alloys is increasing;
- Airbus A380 contains 25% composites.
- Boeing 787 and Airbus A350 have pushed the composite use to 50%.

**787 Composite Solutions Applied Throughout the 787**



- Titanium
  - High load frames
  - Door surroundings
  - Landing gear
  - Pylons
- No corrosion tasks



- CFRP
  - Wing
  - Center wing box and keel beam
  - Tail cone (Section 11)
  - Skin panels
  - Frames, stringers, and doublers
  - Doors (Passenger & Cargo)
- No corrosion & fatigue tasks

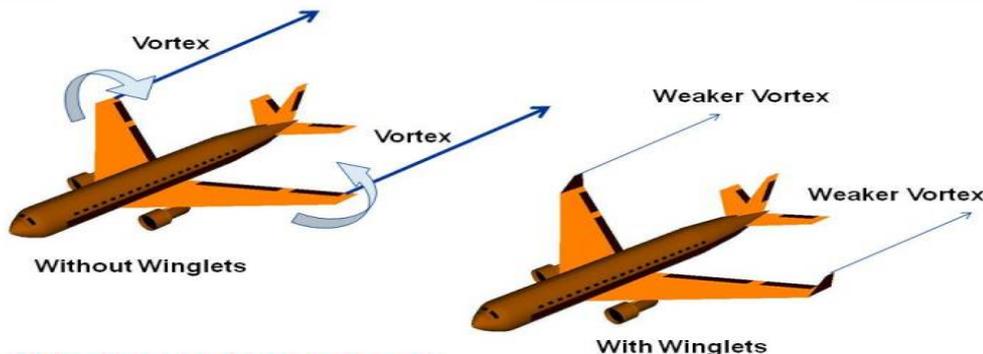
Source: ICCAIA



- Aerodynamics, for example:
  - Drag reduction technologies
  - Wingtip devices

National Aeronautics and Space Administration

### Winglets



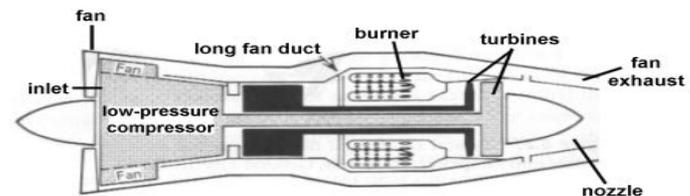
**Winglets reduce induced drag component.**



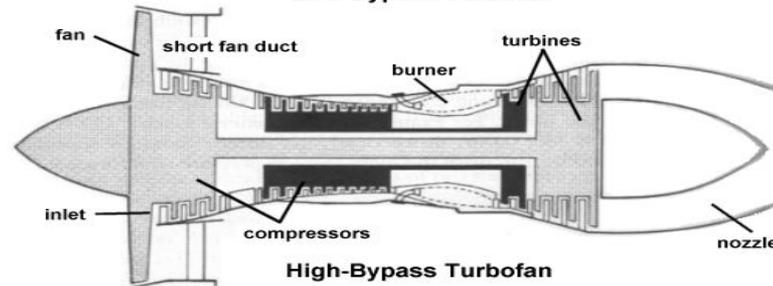
<http://www.airlinereporter.com/>



- Drive towards increased propulsive efficiency:
  - Higher by-pass ratio engines deliver thrust at lower fuel consumption
  - Lighter and higher temperature materials



Low-Bypass Turbofan



High-Bypass Turbofan

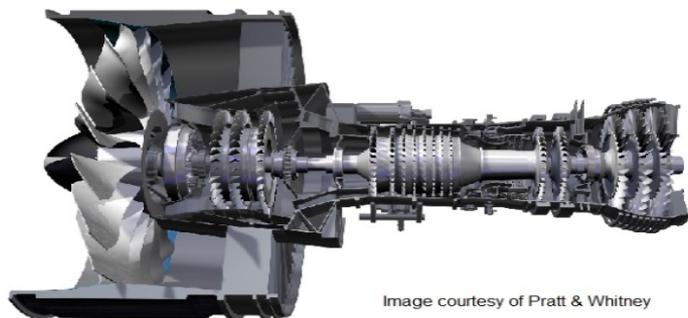


Image courtesy of Pratt & Whitney



<http://www.ecomagination.com/portfolio/genx-aircraft-engine>

<http://machinedesign.com/archive/fewer-trips-fuel-truck>



- Who should be involved?

**Airport**

If new aircraft are to be introduced, the airport may need to be informed

**ANSP**

If new aircraft or avionics are to be introduced, the ANSP may need to be informed

**Aircraft manufacturer**

Can provide fuel efficiency improvement data due to aircraft modifications or the purchase of new aircraft

**Aircraft operator**



# What is Sustainable Aviation Fuels ?

- Must meet the same safety standards as current aviation fuels (e.g. ASTM Specifications)
- In addition to safety standards, SAF needs to meet Sustainability Criteria – generate lower carbon emissions on a life cycle basis

(net GHG emissions of at least 10% on a life cycle basis – CORSIA eligible fuels )

## ICAO Assembly Resolution A40-18 (2019)

*A40-18: Acknowledging the need for such fuels to be developed and deployed in an economically feasible, socially and environmentally acceptable manner and the need for increased harmonization of the approaches to sustainability;*

*A40-18. Requests States to recognize existing approaches to assess the sustainability of all alternative fuels in general, including those for use in aviation which should achieve net GHG emissions reduction on a life cycle basis; contribute to local social and economic development, competition with food and water should be avoided;*



# Sustainable Aviation Fuels

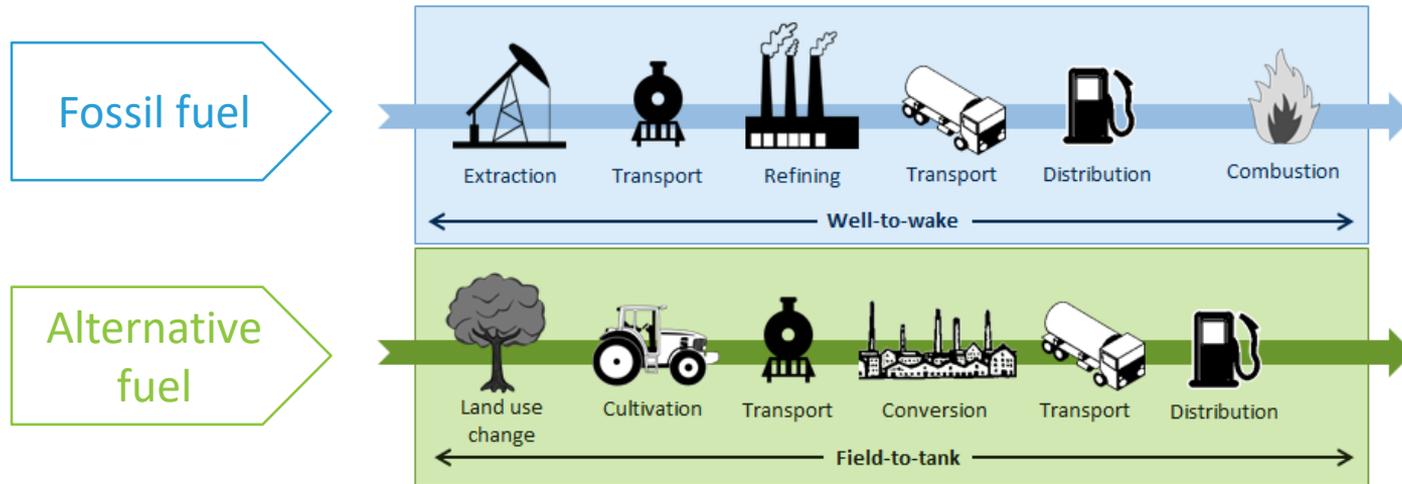
- Potential for significant emissions reductions
- Emissions reductions achievable with existing aircraft
- Benefits will depend on:
  - the availability of such fuels and the time profile of their deployment;
  - their actual lifecycle emissions reduction
- Challenges
  - Decreasing production cost
  - Investment in feedstock production and conversion facilities
  - Ensuring a sustainable deployment
- States' policy support is required



<http://lae.mit.edu/alternative-fuels/>



# How can a drop-in fuel reduce CO<sub>2</sub> emissions?



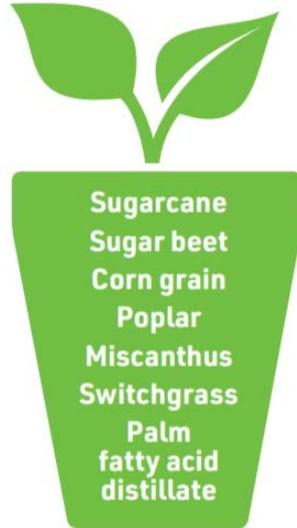
A SAF should generate lower carbon emissions on a life cycle basis

(net GHG emissions of at least 10% on a life cycle basis – CORSIA eligible fuels )

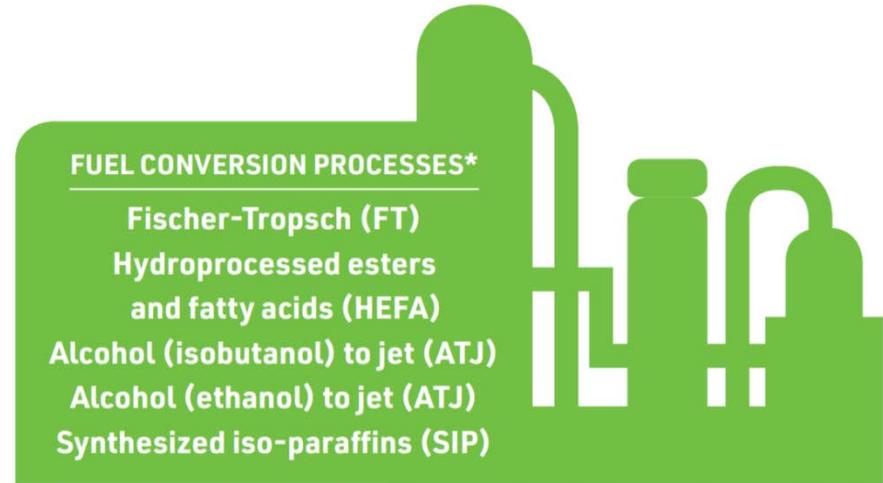


# How can SAF be produced today?

## FEEDSTOCKS



## FUEL CONVERSION



\*Reference: ASTM 7566 and ASTM 1655 – ensures the technical specifications of the fuel



## CORSIA Eligible Fuels (CEF)

- A sustainability certification process should be followed to determine if the fuel meets the CORSIA requirements.



- Fuel producers** use **Sustainability Certification Scheme (SCS)** as approved by the ICAO Council
- Fuel assessed against the Council-approved CORSIA Sustainability Criteria
- Aeroplane operators** can claim CEF emissions reduction from CORSIA offsetting requirements

Emissions reduction by the CEF depends on its **life cycle emissions values (LSf)**, with **default values or calculation methodologies** provided by ICAO.

**For the purpose of the State Action Plan, States may use the CORSIA default life cycle emissions values and the methodology for calculating actual life cycle emissions values.**



# ICAO Global Framework for Aviation Alternative Fuels (GFAAF)

[www.icao.int/environmental-protection/GFAAF/](http://www.icao.int/environmental-protection/GFAAF/)

- Started in 2009
- Database for relevant activities
  - Frequently asked questions
  - Facts and Figures
  - News and Activities – over 600 news
  - Initiatives and Projects



## Current Activities



Or to see more information visit the [News and Activities](#) page.  
*\*Zoom in for best results*

## Current Initiatives



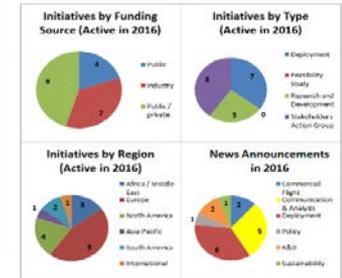
Or to see more information visit the [Initiatives & Projects](#) page.

## Frequently Asked Questions

1. [Why introduce alternative fuels in aviation?](#)
2. [What are sustainable alternative jet fuels?](#)
3. [What are the potential environmental benefit of alternative fuels?](#)
4. [Which alternative fuels can currently be used?](#)
5. [What are the challenges for the development and deployment of alternative fuels?](#)
6. [What are the initiatives worldwide for the development of alternative fuels?](#)
7. [What is ICAO doing in the field of alternative fuels?](#)

## Facts and Figures

Click the image below to view Facts and Figures from 2016





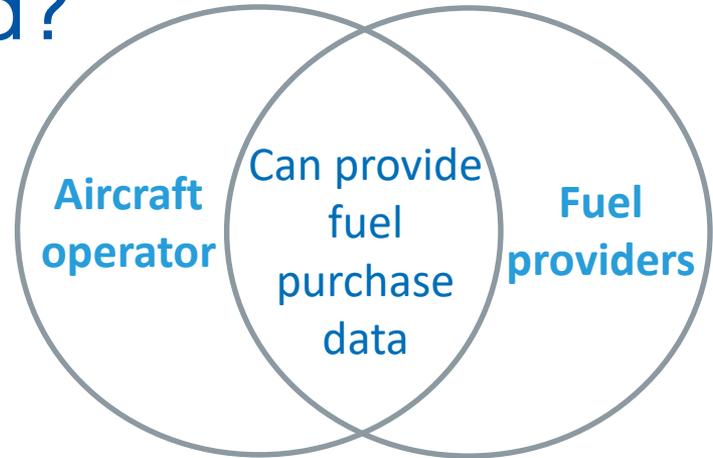
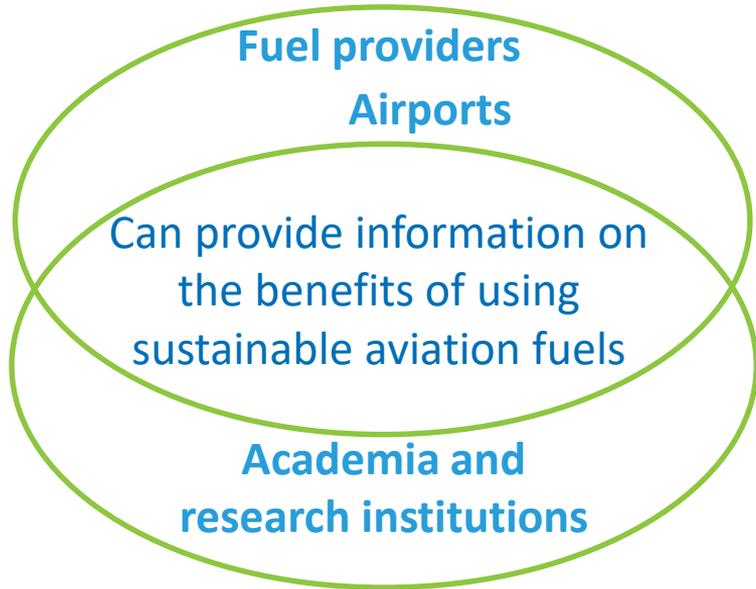
# ICAO is facilitating SAF Development and deployment

- Establishing policies and measures
- Developing globally-accepted sustainably criteria and life cycle methodologies
- Organizing events for information sharing and outreach
- Sharing information and best practices

**ICAO work on SAF is supporting the ICAO 2050 Vision**



## • Who should be involved?



**Other Government entities**  
If standards requiring the use of sustainable aviation fuel are to be introduced



## Improved ATM and infrastructure use

- Lead to moderate emissions reductions (significant in some cases)
- Involve substantial investments (ANSPs, air carriers)
- Other performance dimensions (safety, reliability, cost, capacity, etc.)
- Examples
  - more efficient Air Traffic Management (ATM) planning, ground operations, terminal operations (departure, approach and arrivals), en-route operations, airspace design and usage, aircraft capabilities;
  - more efficient use and planning of airport capacities;
  - collaborative research endeavours.



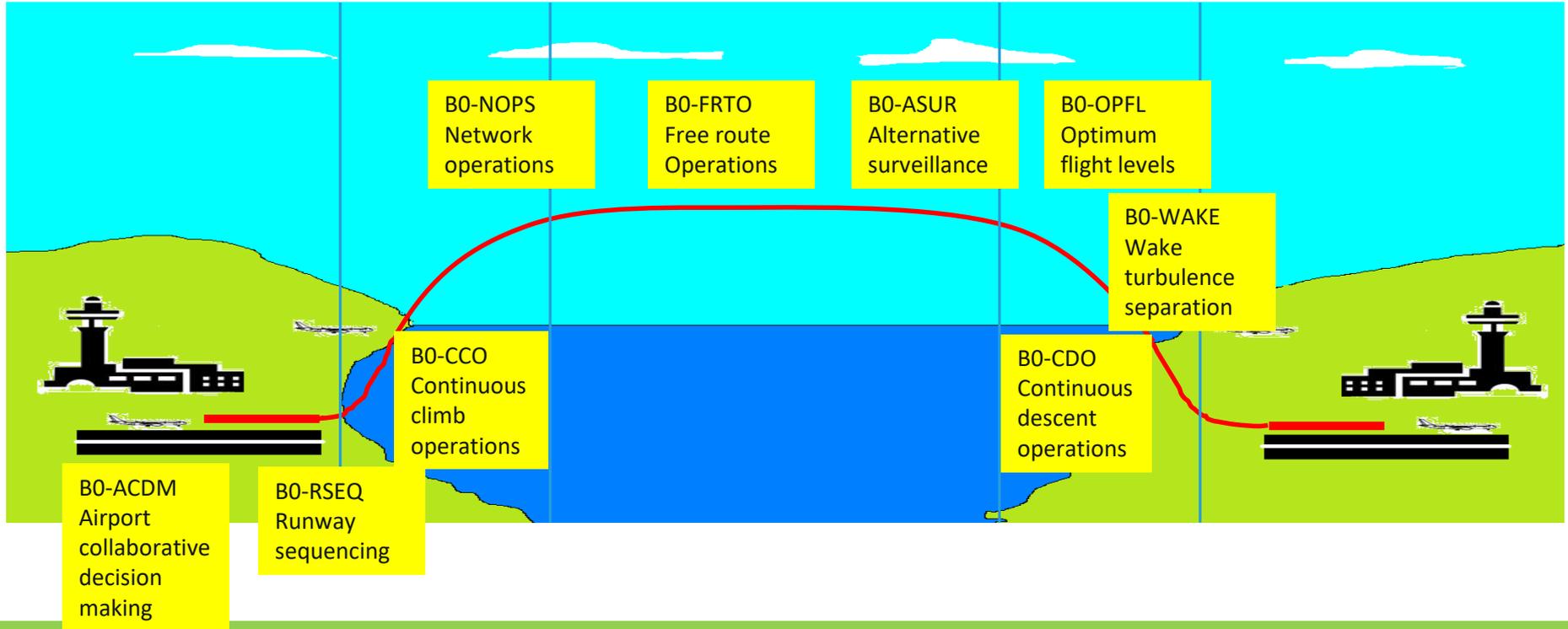
Departure

Climb

Cruise

Approach

Arrival





## Resource list:

- ICAO's Global Air Navigation Plan (Doc 9750)
- ICAO's Global Air Navigation Report – April 2014
- ICAO's PIRGs' environmental initiatives
- ICAO's Aviation System Block Upgrades
- The Global Air Traffic Management Operational Concept (Doc 9854)
- Manual on Air Traffic Management System Requirements (Doc 9882)
- Manual on Global Performance of the Air Navigation System (Doc 9883)
- Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes (Doc 10031)



## • Who should be involved?

### Aircraft operator

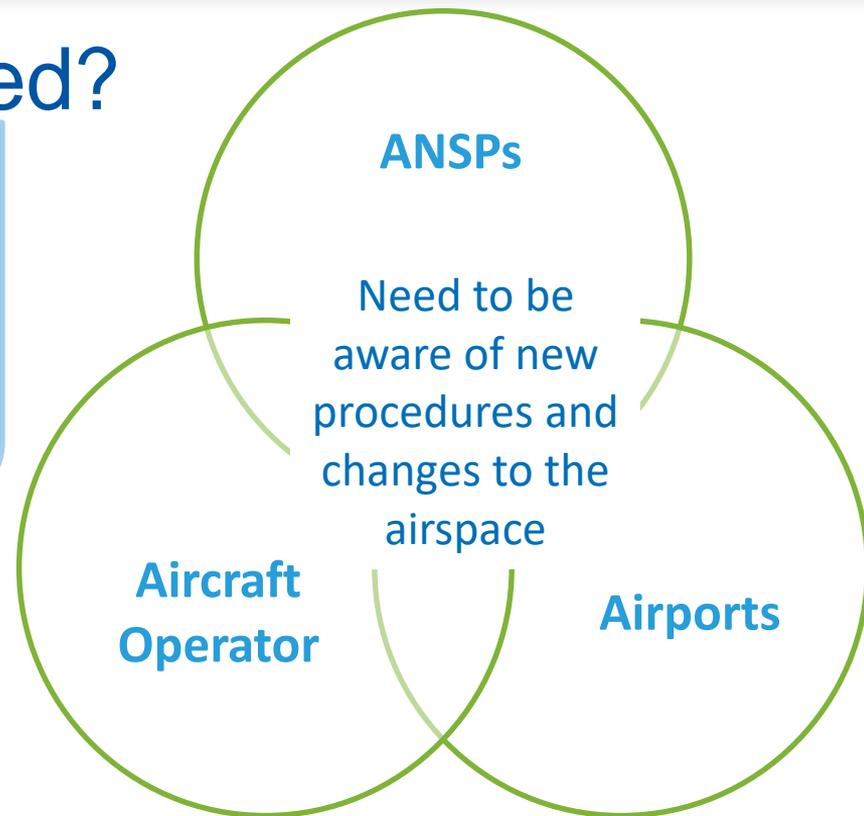
Can provide data on how changes impact fuel burn

### Other Government entities

Will be involved if procedural changes will become standards

### Community groups

Should be informed if changes to flight paths will impact communities





- Best practices in operations – ICAO Doc 10013;
- Optimized aircraft maintenance;
- Selecting aircraft best suited to the mission.



Engine washing



Use of Ground Power Units



## Assessment

- Short-term
- Lead to moderate emissions reductions (significant in some cases)
- Require minimal (or no) investment

## Resource List

- ICAO's *Procedures for Air Navigation Services — Aircraft Operations* (Doc 8168),
- *Operational Opportunities to Minimize Fuel Use and Reduce Emissions* (Doc 10013),
- Airbus' *Getting to Grips with Fuel Economy* (and technical documentation and guidance)
- Boeing's *Fuel Conservation Strategies: Descent and Approach* (and technical documentation and guidance).



- Who should be involved?

**Airports**

May need to be involved for operational procedures impacting ground support

**Aircraft operator**

Can determine the most realistic changes to their operations

Can provide data on how changes impact fuel burn



# CORSIA and State Action Plans



## Synergies between States' Action Plans and CORSIA

- **CORSIA can be one of the measures to be included in States' Action Plan**
- Para 20 A40-19 all States whose aircraft operator undertakes international flights need to undertake a monitoring, reporting and verification (MRV) of CO<sub>2</sub> emissions from international flights starting from 1 January 2019
- State Action Plans containing a robust data collection, monitoring and reporting mechanism provide a good basis, from which the CORSIA MRV can be derived
- State Action Plans can reflect the **results of CO<sub>2</sub> emissions offsetting for international flights** under CORSIA by (voluntarily) participating States **from 2021**

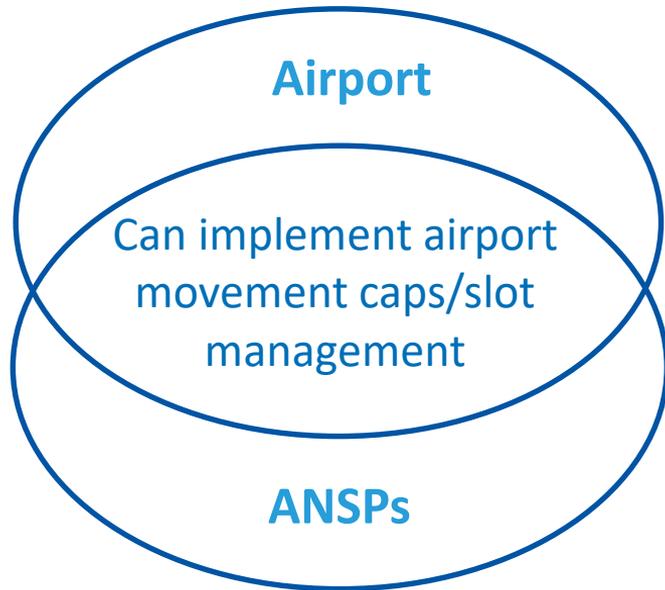


## Regulatory measures/other

- airport movement caps/slot management
- enhancing weather forecasting services
- requiring transparent carbon reporting
- conferences/workshops
- other



- Who should be involved?



### Aircraft operator

Can determine the most realistic changes to their operations

Can provide data on how changes impact fuel burn

### Other Government entities

Can enact regulatory changes



# Airport Improvements

- Offer significant potential for emissions reduction, however, not all of those changes will directly affect international aviation emissions (“co-benefits”)

Airfield improvements

power generation ( photovoltaic panels)

fuels

access



PUBLIC TRANSPORTATION

<http://arabianindustry.com/construction/photos/2012/mar/20/pictures-chinas-hefei-xinqiao-airport-project-3534908/>

<http://www.passengerterminaltoday.com/viewnews.php?NewsID=36516>

<http://www.globalgse.com/>

<http://www.rtcwashoe.com/section-public-transportation>



- Who should be involved?





## Including New Activities in a State Action Plan

- The adoption of new measures or technologies may require coordination with new stakeholders
  - Research organizations and academia
  - Start-up companies
  - Energy suppliers
  - Battery producers
  - New fuel suppliers
  - Waste management companies
  - NGOs and local communities



 ICAO  
INTERNATIONAL CIVIL AVIATION ORGANIZATION



ICAO COMMITTEE ON AVIATION ENVIRONMENTAL PROTECTION  
MARCH 2022



# How to describe the selected measures in your Action Plan? ICAO Doc 9988

<i>Measure</i>	<i>Benefit/cost</i>
	Benefit:  Relative potential gains:  Co-benefits  Cost:  Cost range:  Additional metric(s):

Title	
Description	
Category	
Measure	
Action	
Start date	
Date of full implementation	
Implemented by	(when there are benefits from the measures)
Economic cost	
Currency	
Reference to existing legislation	
Legislation is proposed	
Compliance	<input type="checkbox"/> voluntary <input type="checkbox"/> mandatory <input type="checkbox"/> N/A
Assistance needed	
Assistance needed (check more than one)	<input type="checkbox"/> finance <input type="checkbox"/> technology <input type="checkbox"/> technical support <input type="checkbox"/> education <input type="checkbox"/> research <input type="checkbox"/> other
Currency for financial assistance	
List of stakeholders involved	
Point of contact	



- Quantified results needed to assess the plan

3.3 Incremental improvements/benefits of each measure

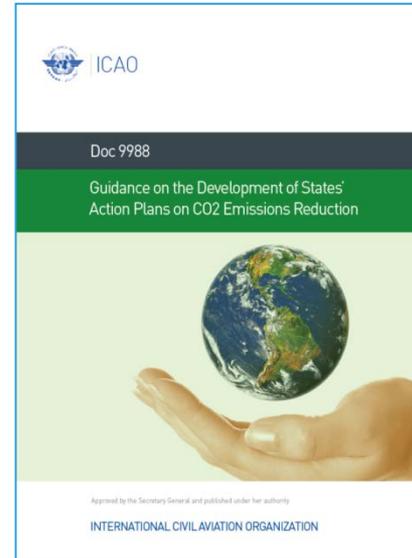
Please inscribe below the anticipated improvements/benefits associated with each specific measure. A measure can have several anticipated improvements for different years.

Year			
Improvement in total fuels (litres)			
Improvement in total fuels (%)			
Improvement in international fuels (litres)			
Improvement in international fuels (%)			
Improvement in total CO <sub>2</sub> emissions (kg)			
Improvement in total CO <sub>2</sub> emissions (%)			
Improvement in international CO <sub>2</sub> emissions (kg)			
Improvement in international CO <sub>2</sub> emissions (%)			
Anticipated co-benefits			



## For More Information...

- See Chapter 4 and Appendix C of the Guidance, Second Edition





## In Summary

- Selecting appropriate mitigation measures are an integral part of a complete State Action Plan
- ICAO has developed a collection of guidance materials to assist States in the process of selecting and implementing mitigation measures



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