Environmental regulation of the aviation sector

Supaero Master of Aerospace Engineering

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Agenda

- Exercise: Information review and questions (30min)

- What is the role of law? (5 min)

- Background (15min)
  - Sustainability definitions & overview
  - Aviation sector context
  - The international framework

- Regulated topics
  - Items regulated by ICAO CAEP
  - Carbon pricing, offsetting & trading
  - Energy
  - Circularity
  - Substances

Exercise: review and questions

1. In teams (~9) review the news that has been given to you

1. Answer together the following questions:
   - What is the environmental aspect that we are talking about?
   - Do you think there is a legal or regulatory framework in place? / if yes, which one (s)?
   - Why is there or there is not a legal and regulatory framework in place?

News links

1) EU carbon price hits record as gas shortages force return to coal
2) UN Officially recognises the human right to a clean, healthy and sustainable environment
3) Dutch Court Orders Shell to Reduce Emissions in First Climate Change Ruling Against Company
4) Cross-industry panel agrees on the urgency to upscale the volumes of renewable energy but planning and permitting remain a challenge
5) Renault Trucks Launches Vehicles “Dissambly Plant”
6) PulsESG, PE Firm Clayton, Dubilier & Rice Collaborate on ESG Measurement and Reporting for Portfolio Companies
7) Occidental Plans to Build World’s Largest Direct Air Capture Plant
8) Cefic President inspiring the chemical world
9) Israel banning jumbo jets from benguiron airport to cut noise pollution
10) UN: Heatwaves and wildfires to worsen air pollution

What is the role of law?

What is the role of law?

[…] 'When it comes to sustainable business, one attribute that marks out the leaders from the followers is the courage to push boundaries. Source: The Guardian - Sustainable Business

The role of law is to support innovation: predictable, clear, flexible: for example, the regulatory burden in respect of waste processing is heavy and can prevent, or at least discourage, businesses from finding innovative commercial uses for waste materials.

[…] For better or worse, regulation now appears to be a growth industry. Businesses around the world are coming under the regulatory microscope – at local, national and international levels – more than ever before, with proposals for new rules, restrictions and incentives across a wide spectrum of industries. Source: PWC Report on Regulation

The role of law is to support business strategy: essential to make sure that companies have effective, robust and reliable governance and compliance tools, and use them.

[…] The rule of law is a cornerstone for a better functioning economy that adheres to regulations, greater internal mobility, social cohesion and good governance […] WEF - Law and Sustainable Development

The role of law is to support transparency and accountability: every person is subject to the law, therefore laws in sustainable development aim to provide a common framework for action but also to understand the roles and accountability.

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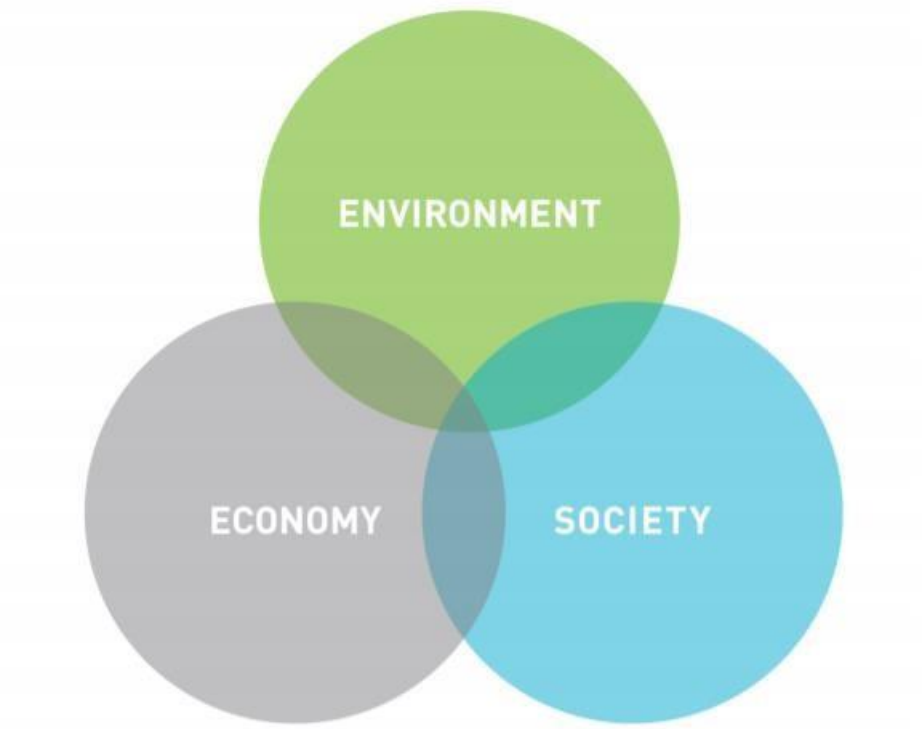
Background: Sustainability

Sustainable development

> **“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”**

UN-sponsored Bruntland Report 1987

Areas covered in Sustainable Development



Environment
Ecological integrity is maintained, all of earth's environmental systems are kept in balance while natural resources within them are consumed by humans at a rate where they are able to replenish themselves.

Economy
Human communities across the globe are able to maintain their independence and have access to the resources that they require, financial and other, to meet their needs. Economic systems are intact and activities are available to everyone, such as secure sources of livelihood.

Society
Human rights and basic necessities are attainable by all people, who have access to enough resources in order to keep their families and communities healthy and secure.

Communities have leaders who ensure that personal, labour and cultural rights are respected and all people are protected from discrimination.

Sustainable Development Goals (SDGs)

Source: UN Sustainable Development

Agreed in 2015 by UN Member States, this is an urgent call for holistic sustainable action

Aviation supports 15 of the 17 goal.

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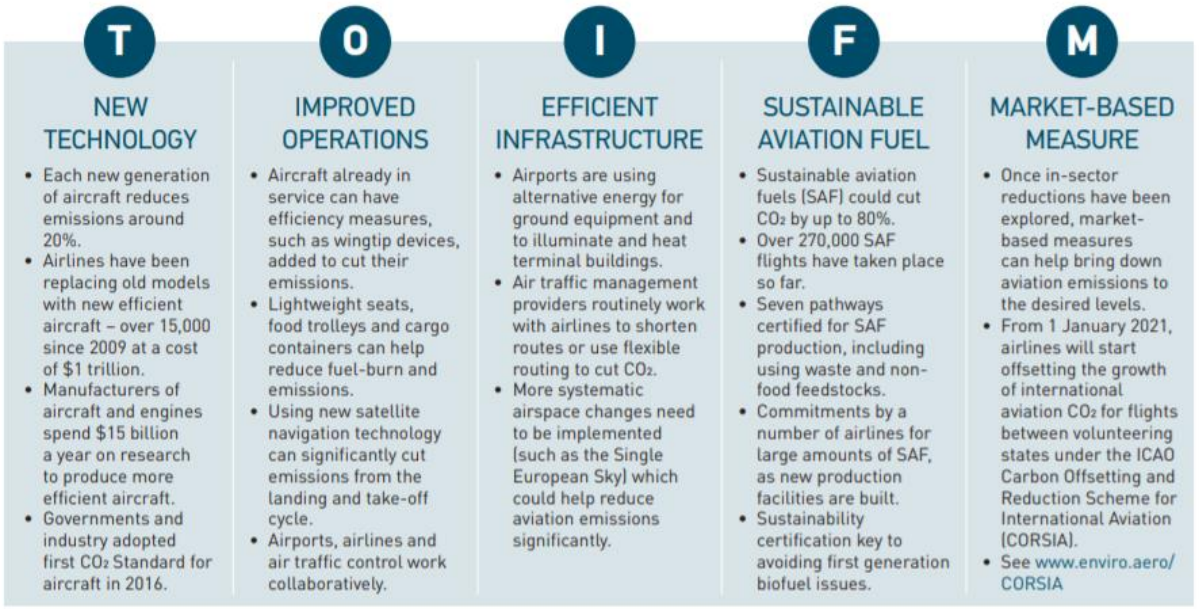
Aviation Industry & Environment

Climate

IPCC Special Report on 1.5: Aviation produces between **2% to 3%** of the World's emissions:

- The transport sector represents ~24% of global emissions and road represents ~18%



Proactive climate action from a key global sector through **3 global goals** underpinned by an **industry-wide strategy**

Air quality, noise are other environmental impacts of the sector….

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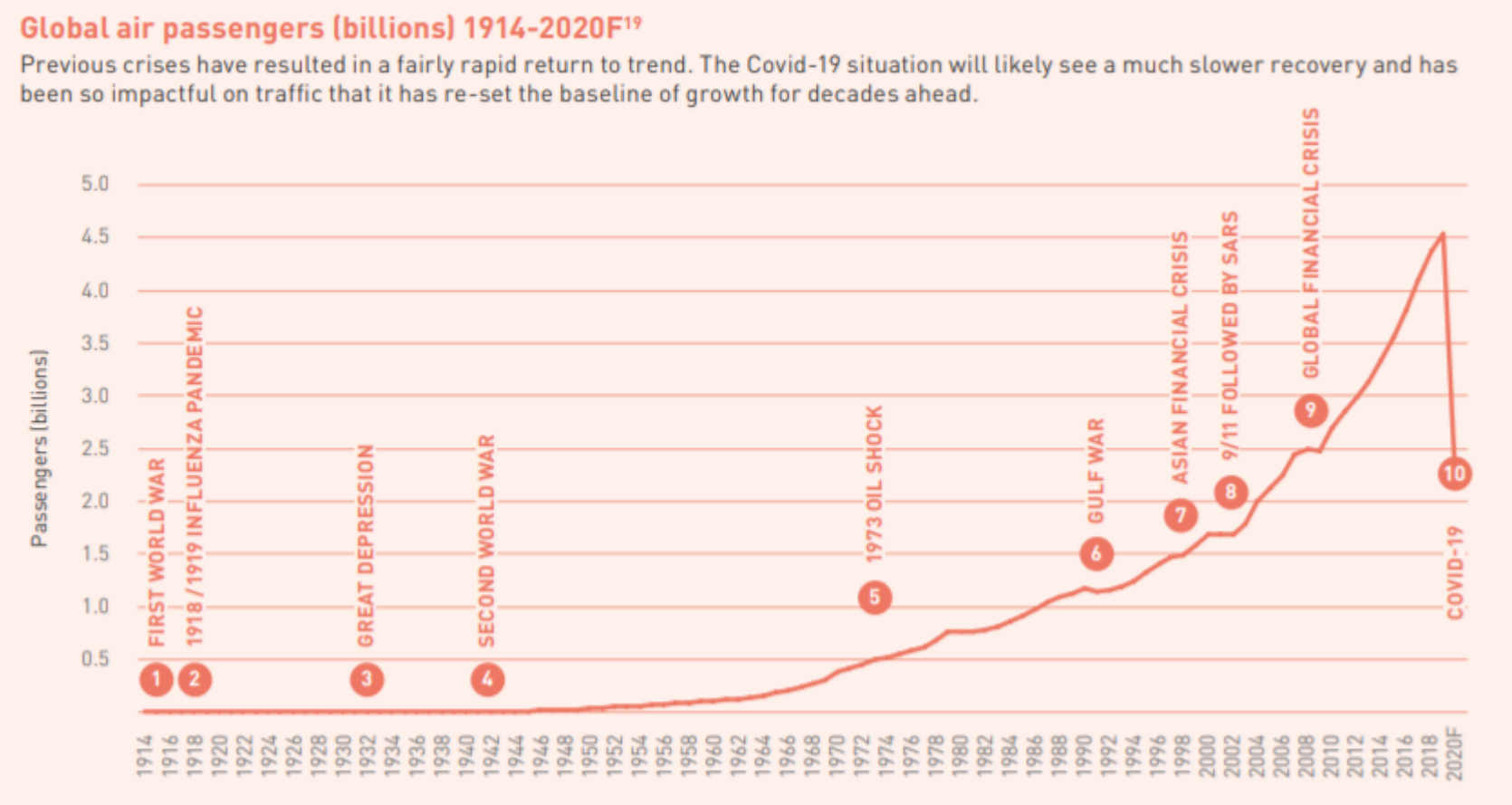
Aviation Industry & COVID-19



The IPCC forecasted that aviation share will increase to around 3% to 5% in emission (minimum) 2050 before Covid

Air travel was projected to grow into a $4.6 trillion worldwide market within the next 20 years.

A rising demand for travel was foreseen at around 4% growth per annum.

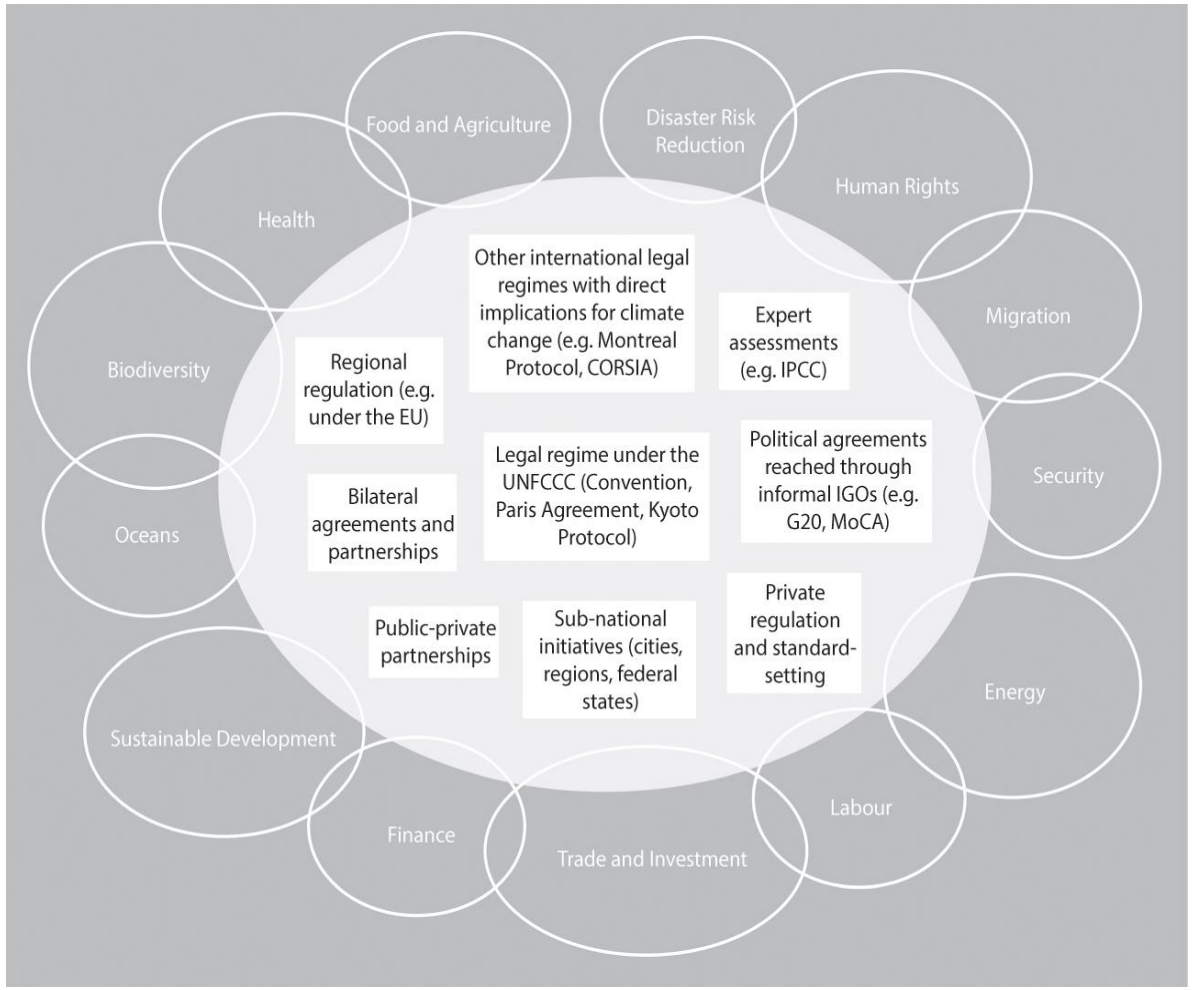
The effect of Covid-19 on the global air transport sector has been stark. At the peal of the shutdown, **traffic was down 94% compared to the same period in 2019.**

~⅔ of the World's commercial aircraft were parked or stored.

Source: ATAG Waypoint 2050 Report

Sustainable Regulations: Overview

Regulated topics applicable to aviation



Example of interaction of the different areas and schemes for Climate Change
Source: Global Climate Governance, Cambridge Elements

Climate Change

Energy

Biodiversity

Manufacturing

Chemicals & Materials

Human Rights

Sustainable Finance

Large areas many subtopics

Design & Innovation

Industrial activities

Aircraft in operation

End of Life

When do these apply? How they interact?

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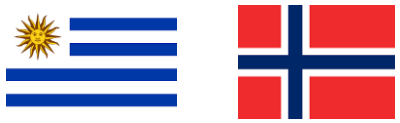
Climate Pledges (countries)

Many countries have announced their long-term climate pledges to reduce the emission of greenhouse gases.

Definitions:

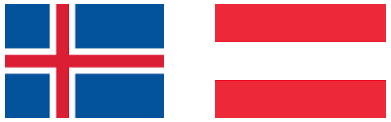
- **Net-zero CO2 emissions or carbon neutrality** is achieved when anthropogenic CO2 emissions are balanced globally by anthropogenic CO2 removals over a specific period.
- **Climate neutrality** is the concept of a state in which human activities result in no net effect on the climate system.
- **Net-zero emissions** are achieved when anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals over a specific period.

Carbon neutral – 2030
Uruguay, Norway

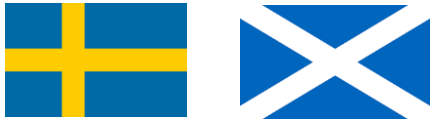


Carbon neutral – 2035
Finland

Carbon neutral – 2040
Iceland, Austria



Carbon neutral – 2045
Sweden, Scotland



Carbon neutral – 2050
Germany, France, Spain, Portugal, Belgium, Denmark, Ireland, Hungary, Slovakia, Switzerland, Canada, Chile, Costa Rica, Japan, South Korea, New Zealand, Fiji, Marshall islands, South Africa

Carbon neutral – 2060
China

Net Zero Emissions- 2050
United-Kingdom

Climate Neutral - 2050
European Union

EU Climate and Energy Legal Framework - Trends

EU Framework for Climate Change and Energy

2030 targets → Updated EU commitments driven by **Paris Agreement**

- **Reduce GHG emissions**
- **Transformation towards a low-carbon economy**

	2030 targets	2050 targets	
Cuts in GHG emissions (from 1990 levels)	55%	90%	
Share for **renewable energy**	38%	80%	
Energy efficiency improvement	36%	TBD%	

EU CLIMATE LAW

- EU legally binding target to reach climate neutrality, e.g. net-zero GHG emissions by 2050 and to balance out the residual ones
- Applicable to Member States at EU economy-wide level (all sectors to contribute) implemented domestically

ENERGY	ENERGY EFFICIENCY	GREENHOUSE GASES	CARBON PRICING	DISCLOSURE
Energy Union Governance Regulation	Energy Efficiency Directive	Effort Sharing	EU ETS - new sectors/removal	Non-financial reporting
Renewable Energy Directive	Energy Performance for buildings Directive	Deforestation & forest degradation	CBAM	Substantiating green claims
ReFuel EU Aviation/Maritime	Building Renovation incentives/regulation	LULUCF	Energy Taxation	Standard Reporting Initiative
Offshore wind power		F-Gas - ODS Regulation	*Non-CO2	Specific labels for aviation
Energy System Integration Energy Hydrogen Strategy		Methane Strategy		

National implementation and initiatives (e.g.: national energy and climate plans) - Financing - ongoing projects

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‘Fit for 55’ Coverage

Carbon pricing	Energy and fuels
Emissions reduction targets & removals	Other

Electricity **Industry (incl. Supply Chain)** **Transport** **Buildings**

EU ETS: System review + Aviation rules (incl. Allowances & CORSIA) + Extended to maritime + New adjacent ETS for building & road

Carbon Border Adjustment Mechanism (CBAM): Prevent carbon leakage + Allow level-playing field of specific sectors (primarily iron and steel, cement, fertiliser, aluminium and electricity generation)

Energy Taxation Directive (ETD): Tax on use of energy products as motor or heating fuels & electricity, extended to aviation & maritime

Effort-Sharing Regulation: Non-EU ETS emissions (waste, agriculture but also road & building – overlap with new ETS)

Renewable Energy Directive (RED): Increase of the share of renewable energy target, incl. buildings, heating & cooling, industry & transport

Energy Efficiency Directive (EED): Increase of the energy savings target, incl. heating & cooling, buildings & extending to ICT (e.g. data centres)

RefuelEU Aviation: Support to the uptake of SAF with mandatory targets

Fuel EU Maritime: Support to the uptake of sustainable fuels

Alternative Fuels Infrastructure Regulation (AFIR): Targets for sufficient infrastructure deployment for sustainable fuels

CO2 Standards for Cars and Vans

EU Innovation Fund: Demonstration of innovative low-carbon technologies + **EU Modernisation Fund**: Support 10 lower-income EU Member States to modernise energy systems and energy efficiency

Social Climate Fund: Address distributional & social effects of the transition in households and micro enterprises.

Land Use, Land Use Change and Forestry (LULUCF)

Overall EU target for carbon removals by natural sinks

FF55 Part 2 - Overview Gas Package

- As the second part of the ‘Fit for 55’ package, on 15th December 2021, the EU Commission released *the “*Hydrogen *and Gas Market Decarbonisation Package*” (also known as the ‘Gas Package’) alongside a legislative proposal on *methane emissions* and the *energy performance of buildings*. In addition, the Commission also published a communication on ‘*Sustainable Carbon Cycles*’.

- With this release the Commission finalises the *implementation* of the known ‘Fit for 55 package’ (‘FF55).

- Electrification remains the main decarbonisation option for the Commission.
  - Hydrogen is considered for to be used mainly in the areas where electrification is not an option, including today's energy-intensive industries (such as steel making) and certain heavy-duty transport sectors (e.g. aviation).

  - Developing a dedicated hydrogen infrastructure is necessary to release the full potential of this energy carrier for these specific end-use applications

Disclosure

+2900 TCFD Supporters.

26 companies under Aerospace & Defense, Air freight & Logistics and airlines perimeter.

WHAT IS TCFD | TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES

- In light of the climate emergency, upon the request of the G20, the Financial Stability Board created the TCFD in 2015.
- Its was aimed to build a framework for the global financial sector to consider the effects of climate change on how businesses operate into the future.
  - Based on **transparency and comparability** to allow and promote informed investment, credit and insurance decisions.
  - Considers revenue, cost and expenditure, assets and liabilities of the business due to climate change.
- The TCFD recommendations were published in 2017.

Governance
The organization's governance around climate-related risks and opportunities

Strategy
The actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning

Risk Management
The processes used by the organization to identify, assess, and manage climate-related risks

Metrics and Targets
The metrics and targets used to assess and manage relevant climate-related risks and opportunities

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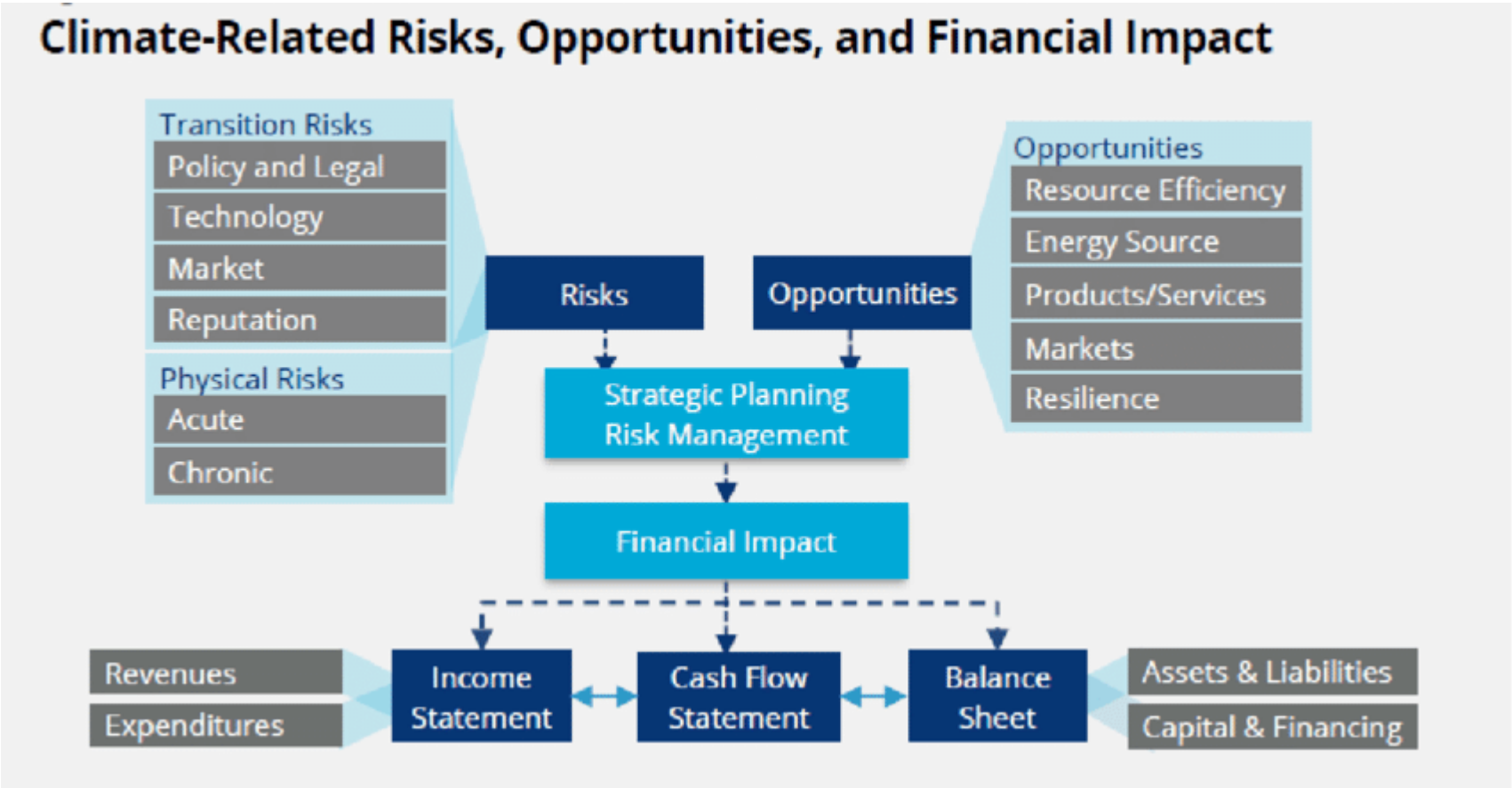
Disclosure

Implementation journey

- Understand climate related **risks & opportunities** (e.g. w/ scenario analysis)
- Set **climate ambition**
- Define high level **climate-strategy**
- Define climate-related **metrics**
- Estimate climate-related **financial impacts** (e.g. w/ scenario analysis)
- Set **target**s aligned with climate ambition
- Articulate transition planning **as part of climate strategy**
- **Report and disclose**



TCFD 2017

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The specific situation for aviation

Aviation impacting climate

- GHG emissions
- Non-CO2 effect

Climate Change impacting aviation

- Airports
- Flight turbulence may increase
- Flight time may increase

- UNFCCC has not been able to provide a clear solution for international sectors such as aviation and maritime
- IMO approach is through technology and efficiency improvements, carbon pricing at the moment will be done through states. Different to ICAO.
- **Need of overcoming international coordination problems**
- **Increasing competition**
  - CO2 calculators and airlines ‘less impactful flights’ as an advantage

Relevance of private governance in international aviation (e.g. ATAG, IATA)

Example 1: environmental requirements in the supply chain can support climate action

Example 2: pressure from investors and society is supporting climate action

Climate Change - Carbon Pricing

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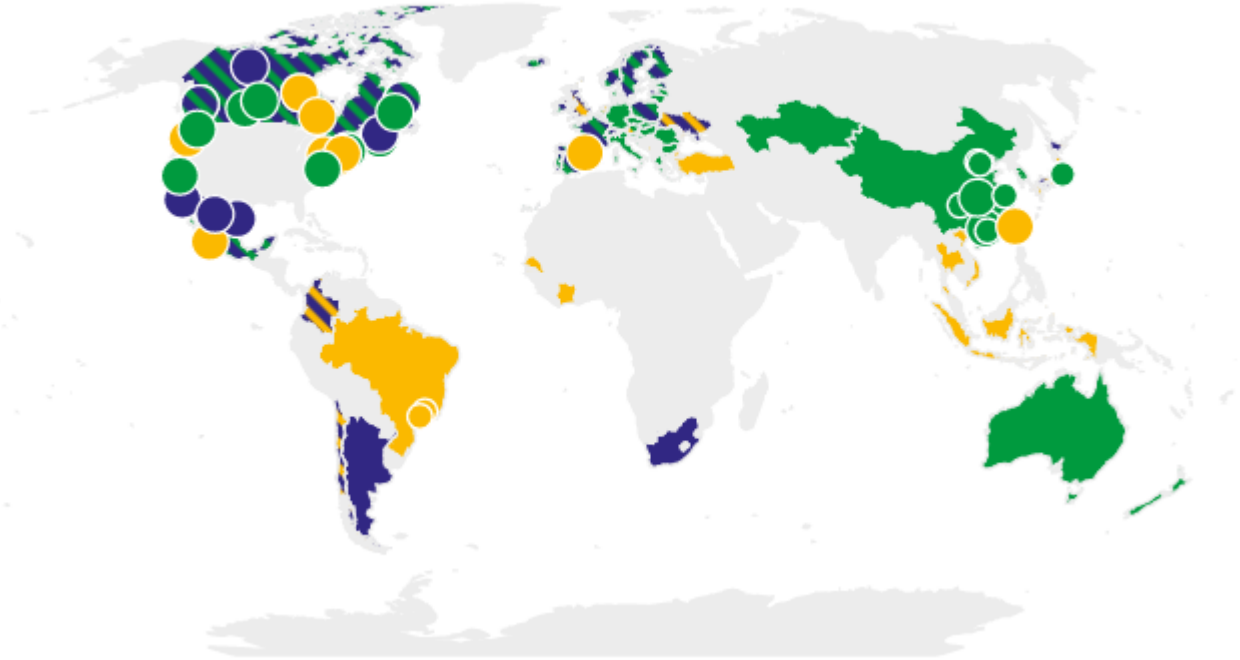
Carbon Pricing

Summary map of regional, national and subnational carbon pricing initiatives



- ETS implemented or scheduled for implementation
- ETS or carbon tax under consideration
- ETS implemented or scheduled, ETS or carbon tax under c...
- Carbon tax implemented or scheduled for implementation
- ETS and carbon tax implemented or scheduled
- Carbon tax implemented or scheduled, ETS under consider...

KEY STATISTICS ON REGIONAL, NATIONAL AND SUBNATIONAL CARBON PRICING INITIATIVE(S)

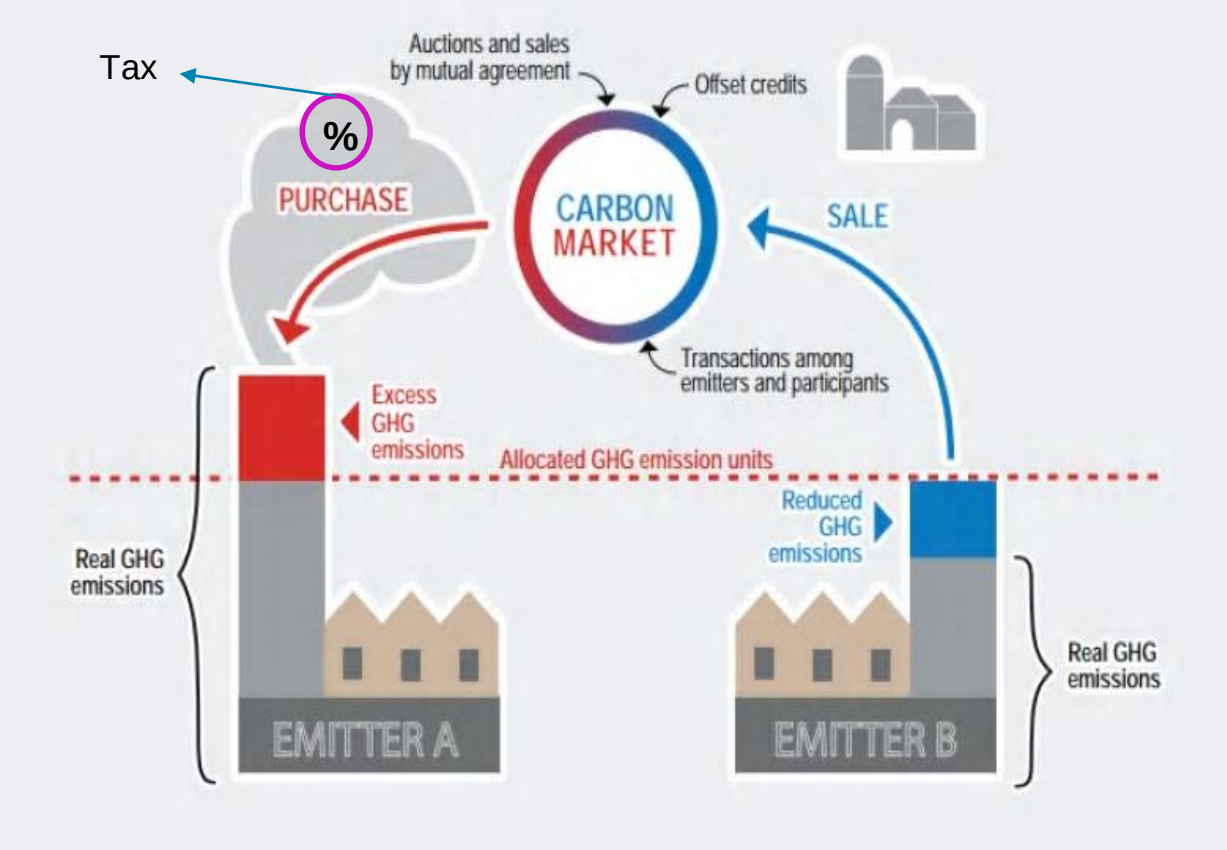
64	Carbon Pricing initiatives implemented or scheduled for implementation
46	National Jurisdictions are covered by the initiatives selected
35	Subnational Jurisdictions are covered by the initiatives selected

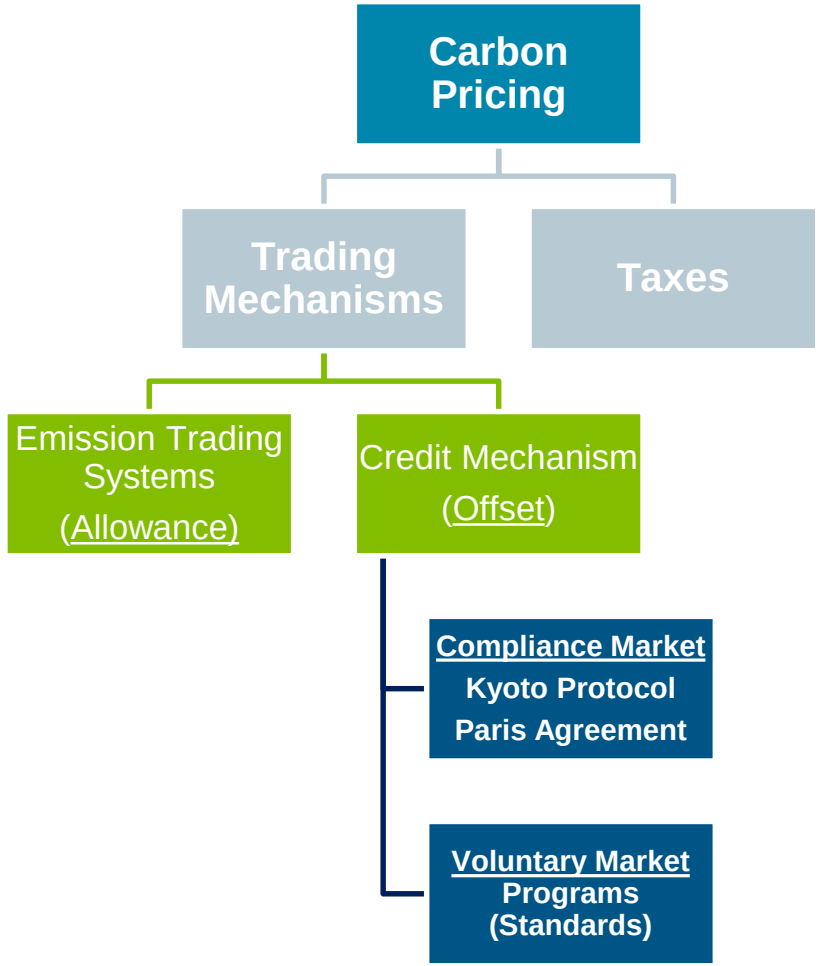
In 2020, these initiatives would cover **12 $GtCO_2e$**, representing **22.3%** of global GHG emissions

Source: World Bank Dashboard

Carbon Pricing

Polluter Pays Principle





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2020 – CAP AND TRADE SYSTEMS WW

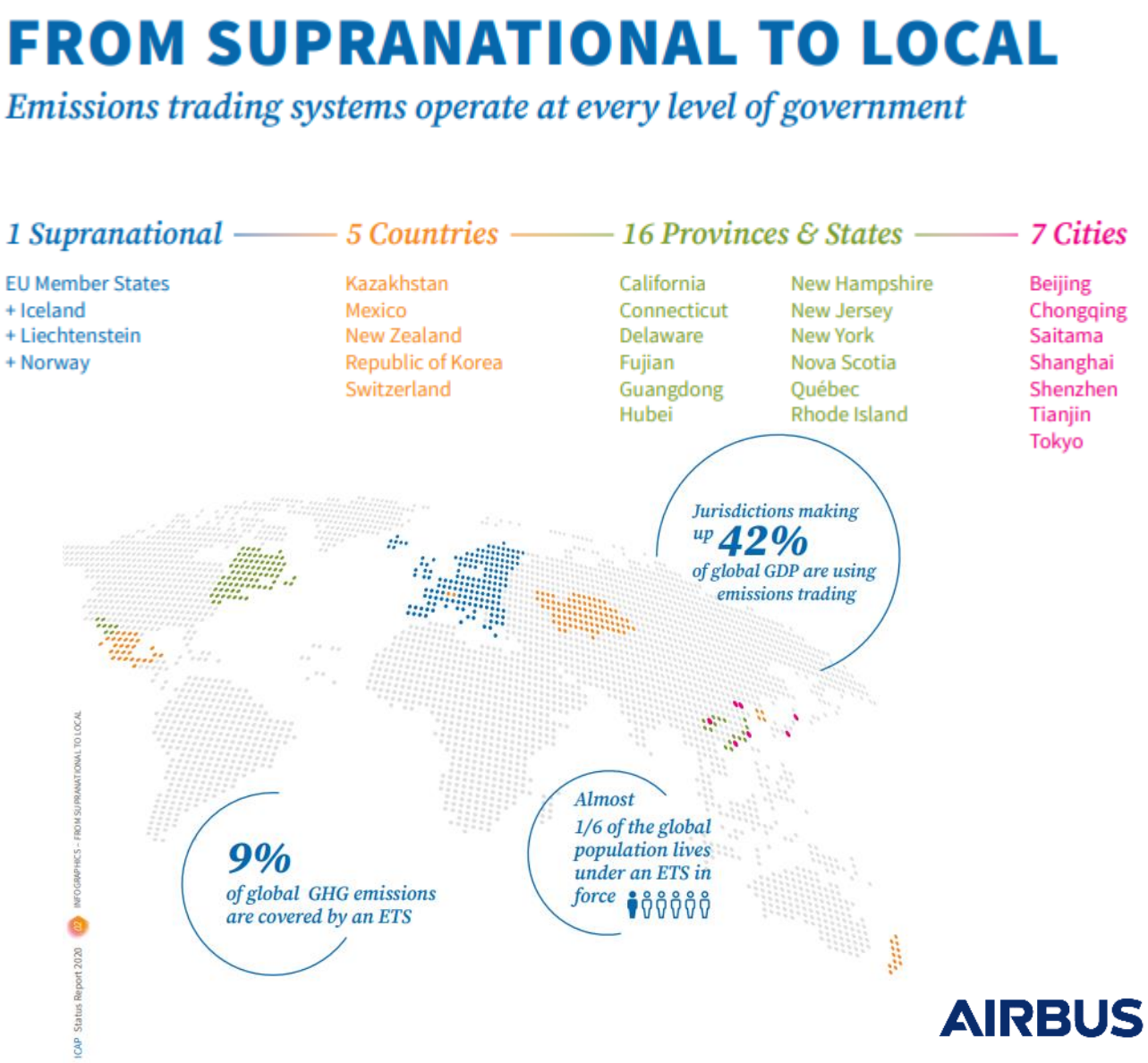
22 systems covering 29 jurisdictions with an ETS in force.

8 jurisdictions are putting one in place in the next few years, including Germany and Colombia.

15 jurisdictions including Chile, Turkey and Pakistan are also considering the role an ETS can play in their climate policy mix.

Only 5 ETS cover domestic aviation: EU ETS, Switzerland, New Zealand, Korea, and some Chinese pilot cases (national implementation should evolve into covering it).

ICAP : International Carbon Action Partnership



Cap-and-trade: EU ETS example

System for pricing carbon emissions

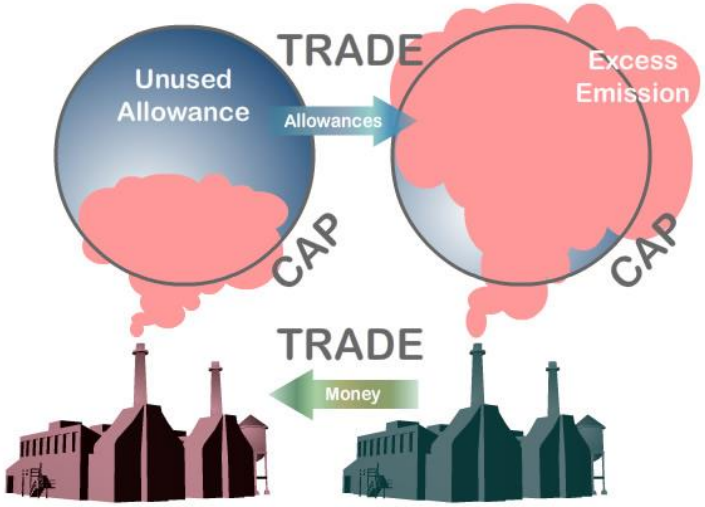
Covers about 45% of the GHG emissions in Europe

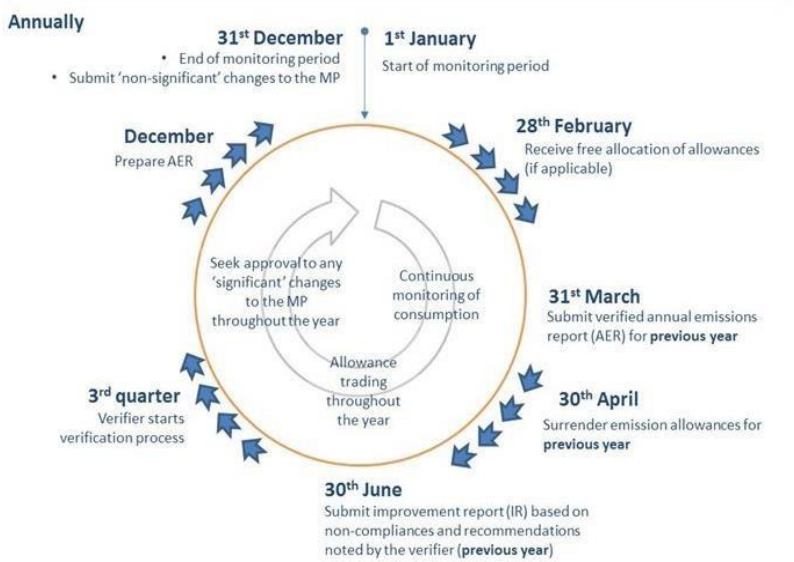
Based on a cap and trade principle

CAP: Limit for emissions = Limit allowances
Trade: Allowances are tradable
Non compliance = penalty of EUR100 + allowance
Transparency and strict Monitoring, Reporting and Verification (**MRV**) system for aircraft operators and industrial installations

Regulated by Directive 2003/87/EC

Scope (activities): power sector, manufacturing industry (combustion installation > 20 MW), and aviation limited to flights within the European Economic Area
Emissions covered (industrial installations): CO2, N2O, PFCs
Emissions covered (aviation): CO2
Emissions regulated: regulated GHGs





Cumulative verified emissions by sector EU ETS (2010-2019)

Main Activity Sector	
Aviation	510,951,948 tCO2e
Combustion of fuels	12,274,161,528 tCO2e
All stationary installations	17,952,162,073 tCO2e
All industrial installations (excl. combustion)	5,678,000,545 tCO2e

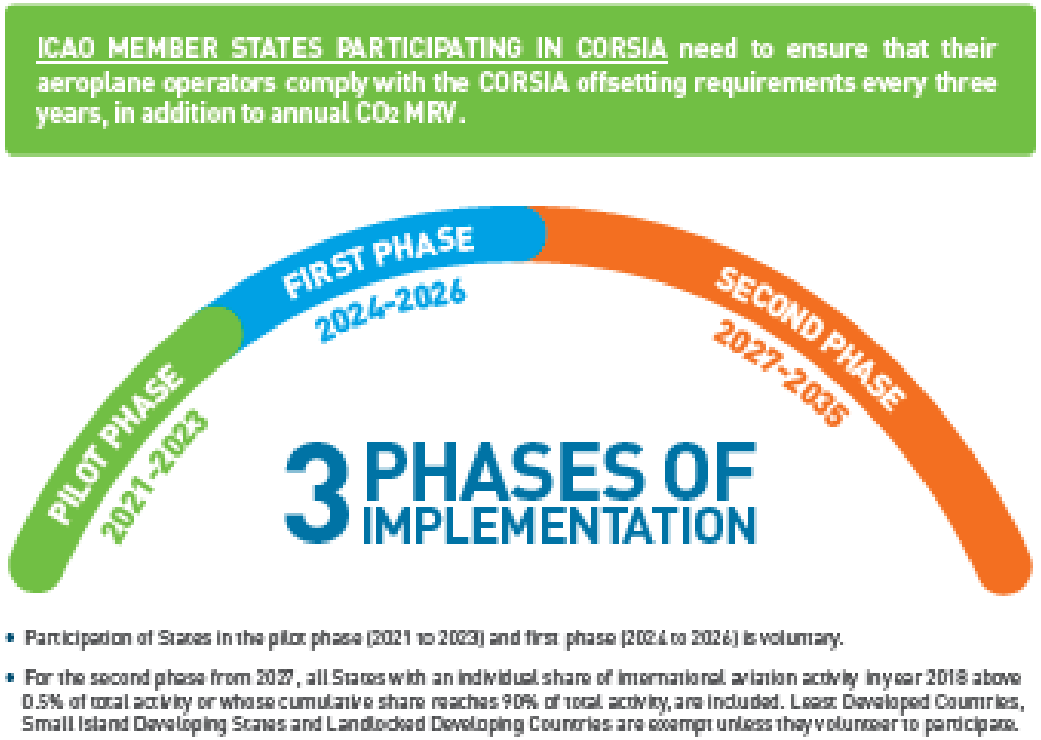
While emitting 68.1 million tonnes of CO2 emissions in 2019, airlines received free allowances covering 31.3 million tonnes of emissions, or 46% of the total. The remaining 54% were covered by allowances acquired from auctions (approx. 5 million) or from other sectors.

(85% free allocation variation due to increase of emissions)

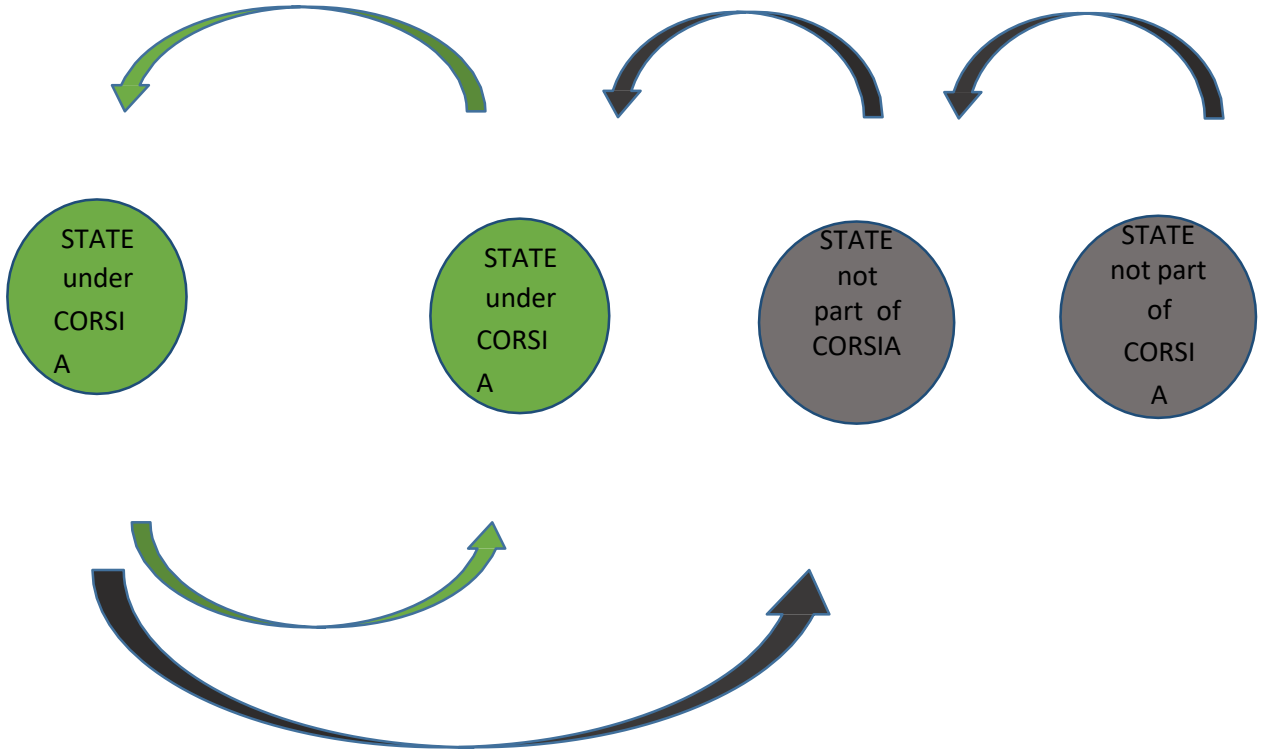
Source: Environment European Agency

Baseline and Credit System - CORSIA

- During the 39th Assembly of ICAO in 2016 governments meeting at the ICAO agreed the **Carbon Offsetting and Reduction Scheme for International Aviation** (CORSIA).
- This scheme is a global emission mitigation approach for the global aircraft operators industry addressing international aviation operations. **It is the world's first carbon offsetting scheme for any global sector with a concrete implementation plan.**
- **CORSIA was finally adopted by states in June 2018 in order to achieve the ICAO goal of Carbon Neutral Growth for International Aviation from 2020 onwards, representing a key pillar in the aviation industry's climate action plan.**
- **COVID-19: modification of the system, only using 2019 emissions levels not 2020.**



Baseline and Credit System - CORSIA



International flight: *when the departure and the arrival are in a different country.*

Therefore, specific rules needed to be implemented in order to organize how the flights will accounted for the CO2 emissions reporting and the offsetting part.

3 cases:

1. Between 2 non-CORSIA members: the route is not accounted.

1. Between 2 CORSIA members: the route is accounted within the offsetting system.

1. Between a CORSIA member and a non-CORSIA member, the route is not accounted within the offsetting system but reported.

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Compensation - Carbon Offsetting

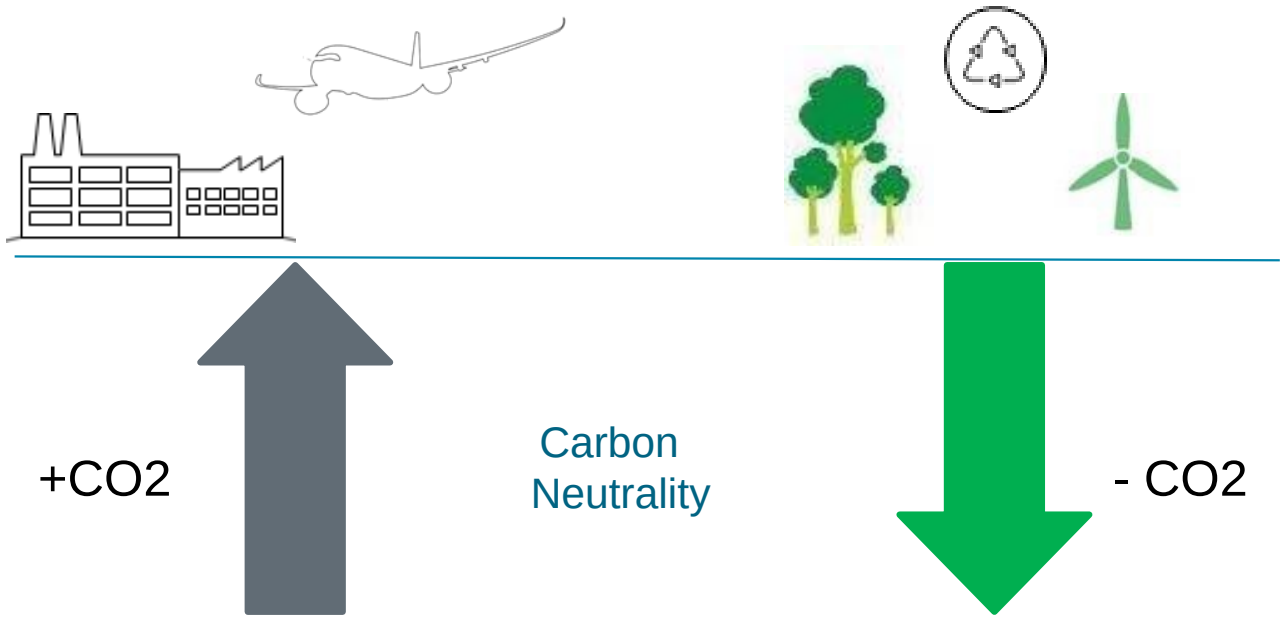
Carbon Management Hierarchy

- When it is not possible to avoid or further reduce emissions, *is moment for offsetting*
- This is a mitigation measure for **compensating emissions**

Compensation - Carbon Offsetting

A carbon offset is a unit representing ***1 tone of carbon dioxide equivalent avoided, reduced or removed*** from the atmosphere. Trend: difference between carbon removals and carbon offsetting as compensation.

Offsetting principle



High environmental integrity

Energy

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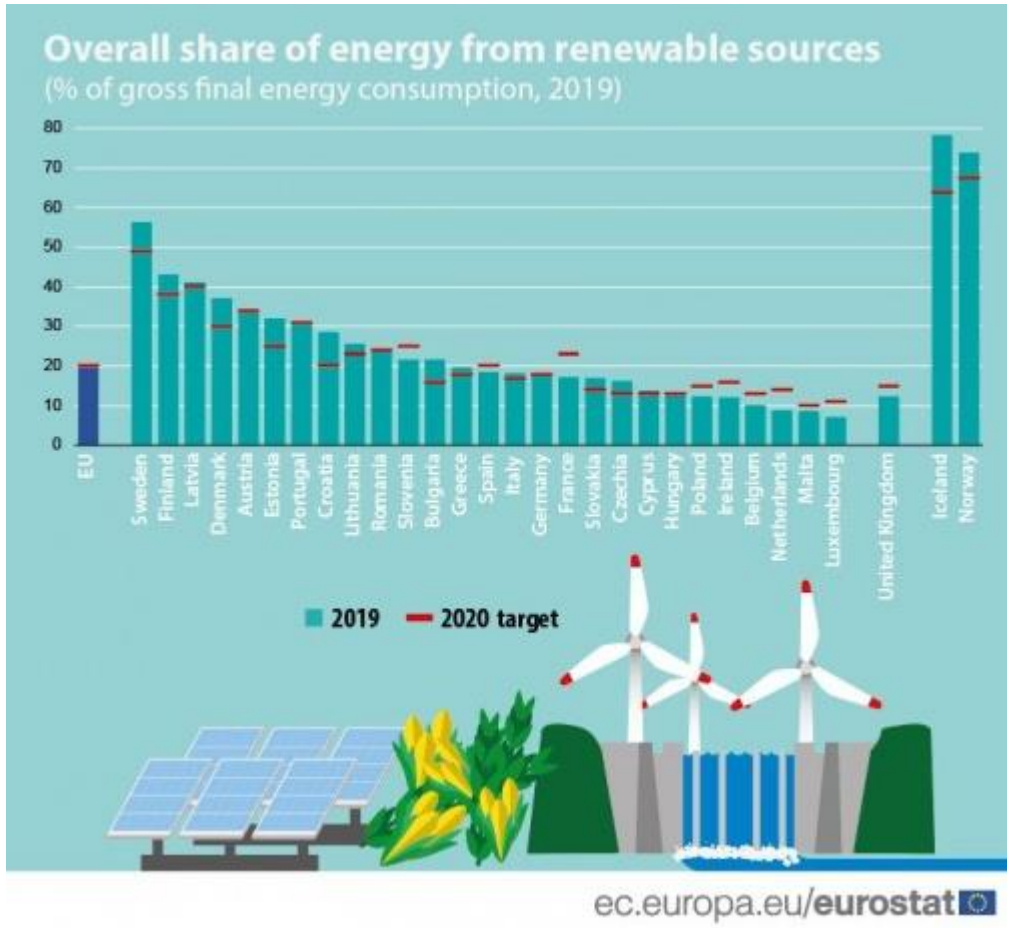
Renewable Energy in the EU



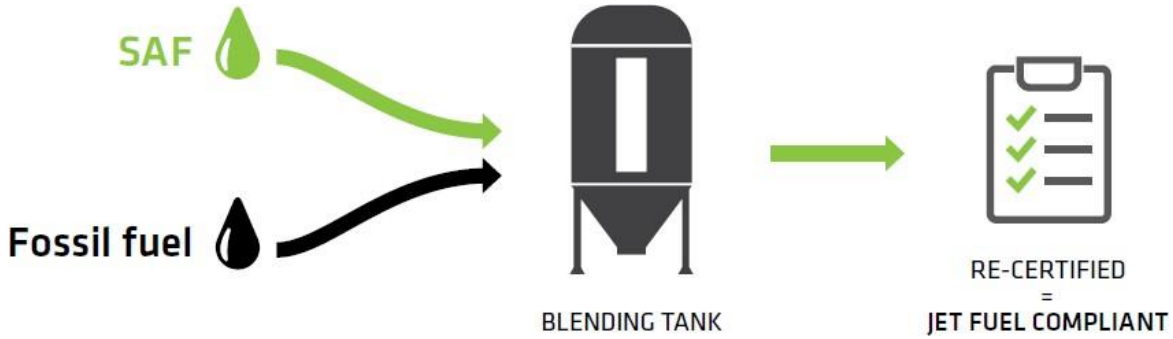
- According to Directive (EU) 2018/2001, renewable energy refers to energy from renewable non-fossil sources, namely wind, solar (both solar thermal and solar photovoltaic) and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas, and biogas.

- For aviation, sustainable aviation fuels would constitute a source of renewable energy.

Fuels – Sustainable Aviation Fuels

Sustainable Aviation Fuel (SAF) is JET A/A1 aviation fuel made from renewable raw material in replacement of fossil petroleum materials which comply with internationally recognised sustainability criteria (land use, water footprint, etc.) and GHG saving criteria.

SAF is made by mixing refined fuels from fossil and renewable sources. Is a broad category including biofuels and e-fuels.

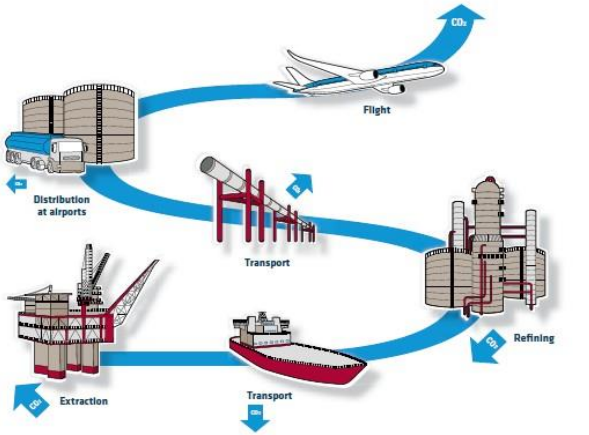


SAF has the potential to effectively reduce up to 80% overall CO2 emissions compared to conventional Jet fuel as they can recycle existing atmospheric CO2 rather than releasing carbon stored within fossil petroleum materials

Fuels – Sustainable Aviation Fuels

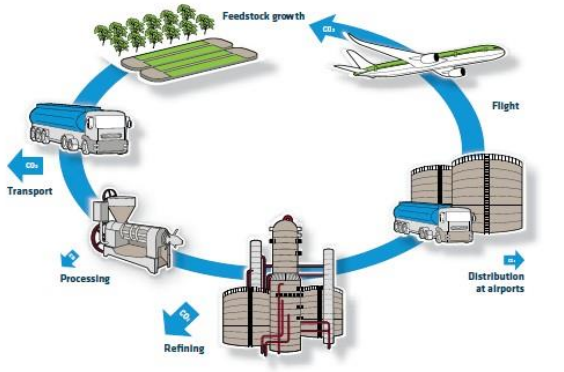
What is a feedstock?
Also known as raw material, it is the unprocessed material or primary commodity used to produce goods, finished products, energy or intermediate materials which are feedstock for future finished products.

Carbon lifecycle diagram: fossil fuels



At each stage in the distribution chain, carbon dioxide is emitted through energy use by extraction, transport, etc.

Carbon lifecycle diagram: Sustainable aviation fuel



Carbon dioxide will be reabsorbed as the next generation of feedstock is grown.
Note: *the diagram above does not demonstrate the lifecycle process of SAF derived from municipal waste.*

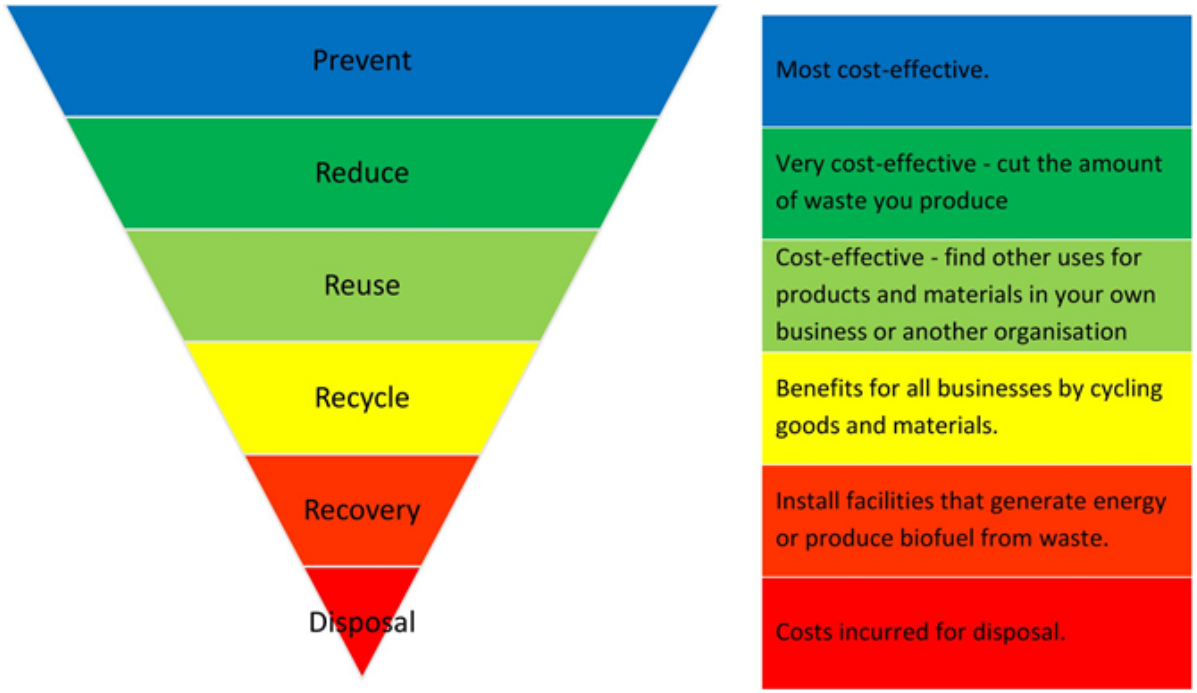
Challenges

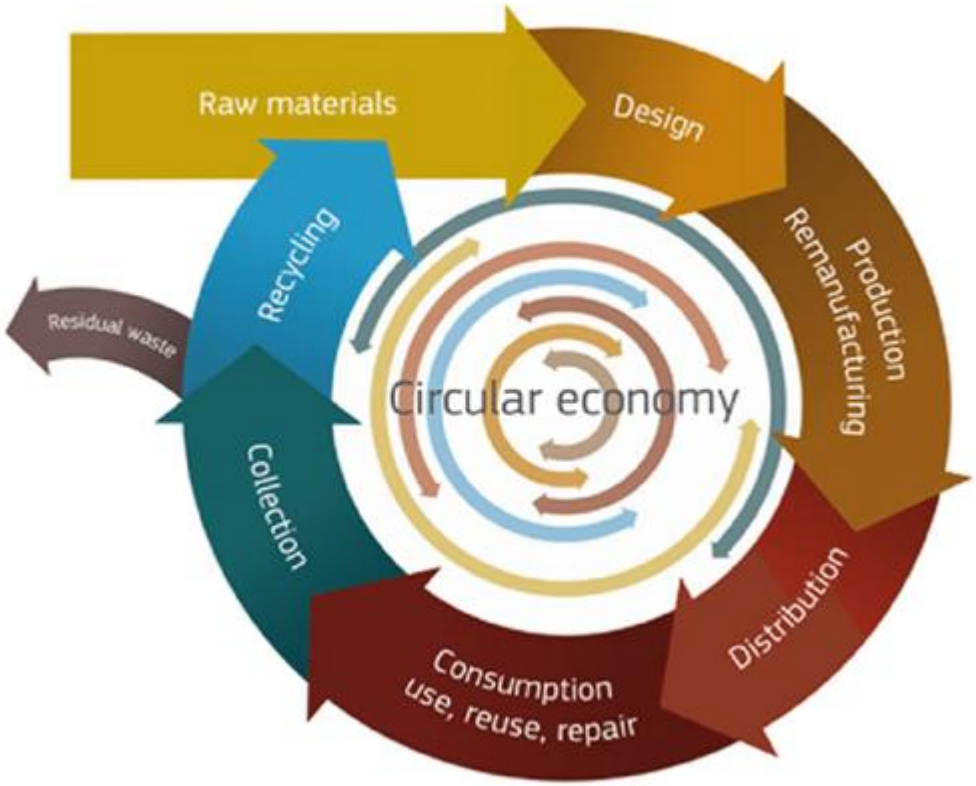
- The market does not exist
- Regular production still limited
- Price is very high compared to conventional fuels – relevance to level the playing field
- Fuel & Carbon – accounting rules
- How to improve regulation and the need of particular approach for aviation

Circularity

CIRCULARITY

- Circular Economy and Circular Carbon Economy
- Waste hierarchy
- Aircraft ‘End of Life’ (link to chemicals)





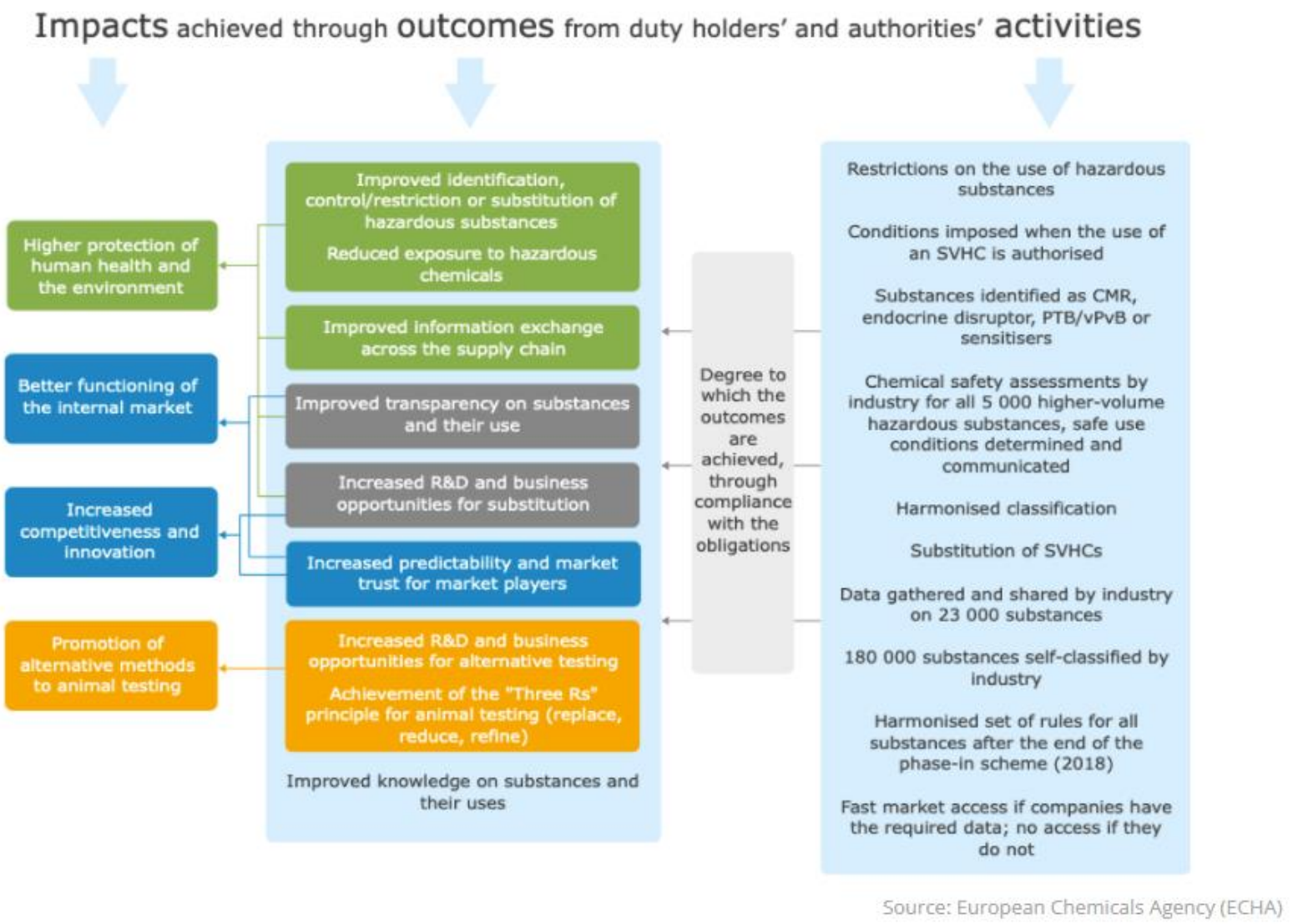
Chemicals

Chemicals

- **Key driver when thinking about substances**: condition to access to the market (EU or any market)

- **Why are substances regulated**
  - principle of protection of environment and human health (based on hazardousness) and;
  - market information: need of transparency (data provided, quality and comparability) for end users

- **Chemicals are in everything. It is necessary to approach them holistically (not only based on restrictions, for example)**
  - 96% of manufactured goods need at least 1 chemical in its production (CEFIC)



Multiple synergies with other areas and regulations (e.g. Climate, ODS, ecodesign, ecolabel, etc)

Items regulated by ICAO CAEP

ICAO ENVIRONMENT

The Committee on Aviation Environmental Protection (CAEP) is a technical committee of the ICAO Council established in 1983.

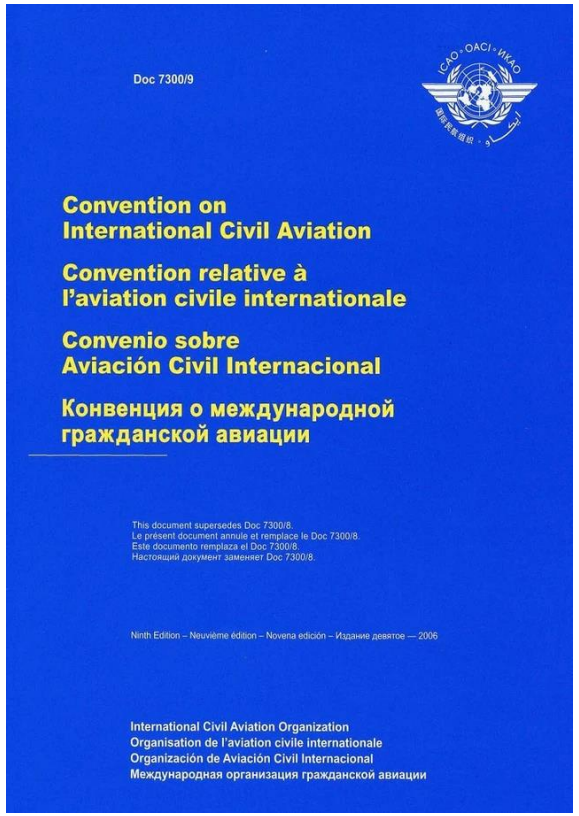
CAEP assists the Council in formulating new policies and adopting new ***Standards and Recommended Practices (SARPs)*** *related to aircraft noise and emissions, and more generally to aviation environmental impact.*

ICAO Committee on Aviation Environmental Protection (CAEP) Terms of Reference

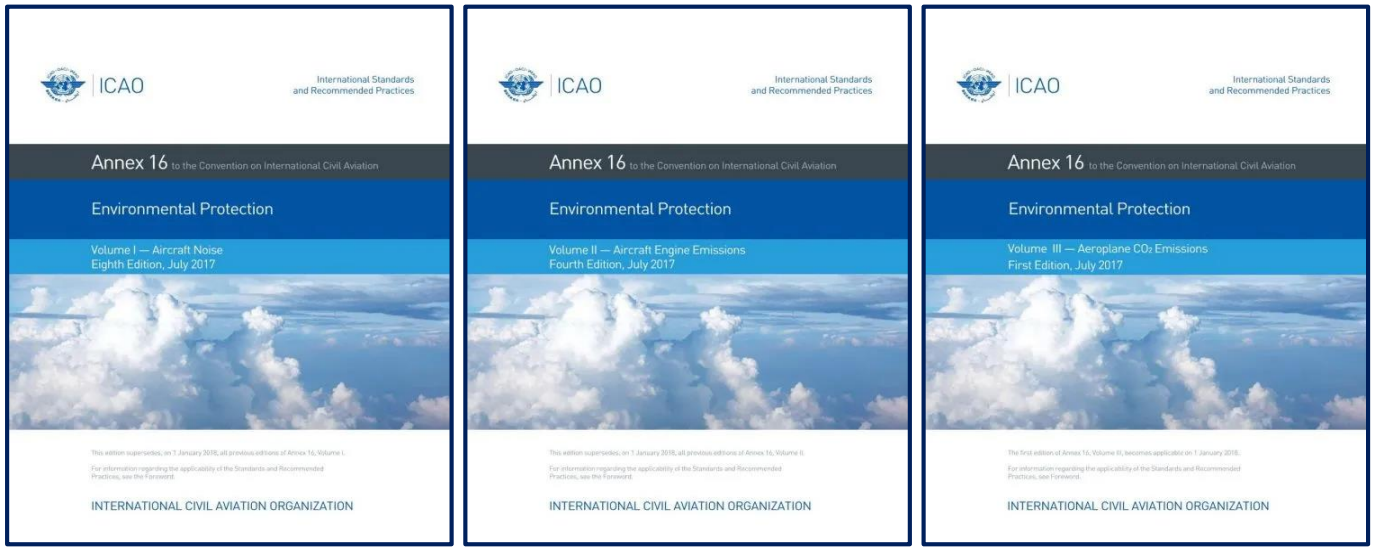
CAEP's assessments and proposals are pursued taking into account:

- *Effectiveness and reliability of certification schemes*
  - *technical feasibility, economic reasonableness and environmental benefit*
- *Developments in associated fields*
  - *land use planning, noise abatement operating procedures, emission control through operational practices, etc.*
- *International and national programmes of research*
- *The potential interdependence of measures*

Environmental impacts are regulated via annexes to the Chicago Convention



Annex 16 Volumes I, II and III contain the environmental certification standards that shall be observed by aircraft and engine designs.



*The development and update of the environmental certification Standards ensure that the benefits offered by technology are reflected in real **reductions of aviation environmental impacts**, while balancing **environmental benefit** with **technological feasibility**, **economic viability**, and the **interdependency** between environmental factors.*

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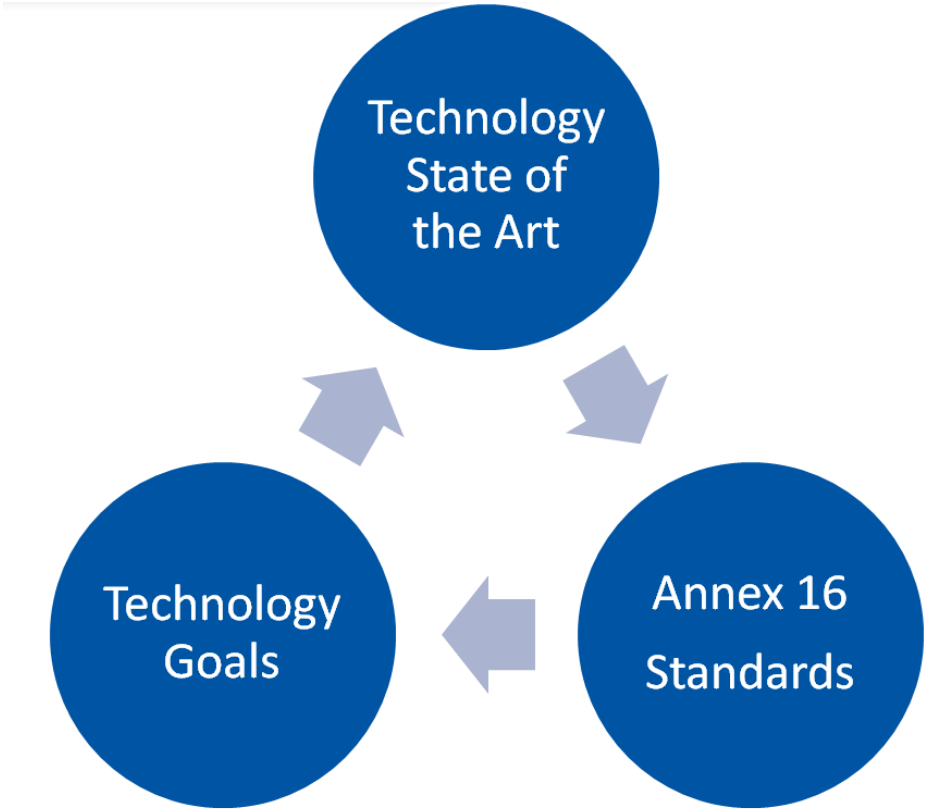
Standards and technologies

To foster the development of new technologies, ICAO regularly sets technology goals, with the purpose of providing targets for industry research and development, in cooperation with States.

Once the State of the Art of technology reaches these goals, consideration is given to updating the ICAO Environmental Standards to ensure the latest technologies are incorporated into aircraft and engine designs.

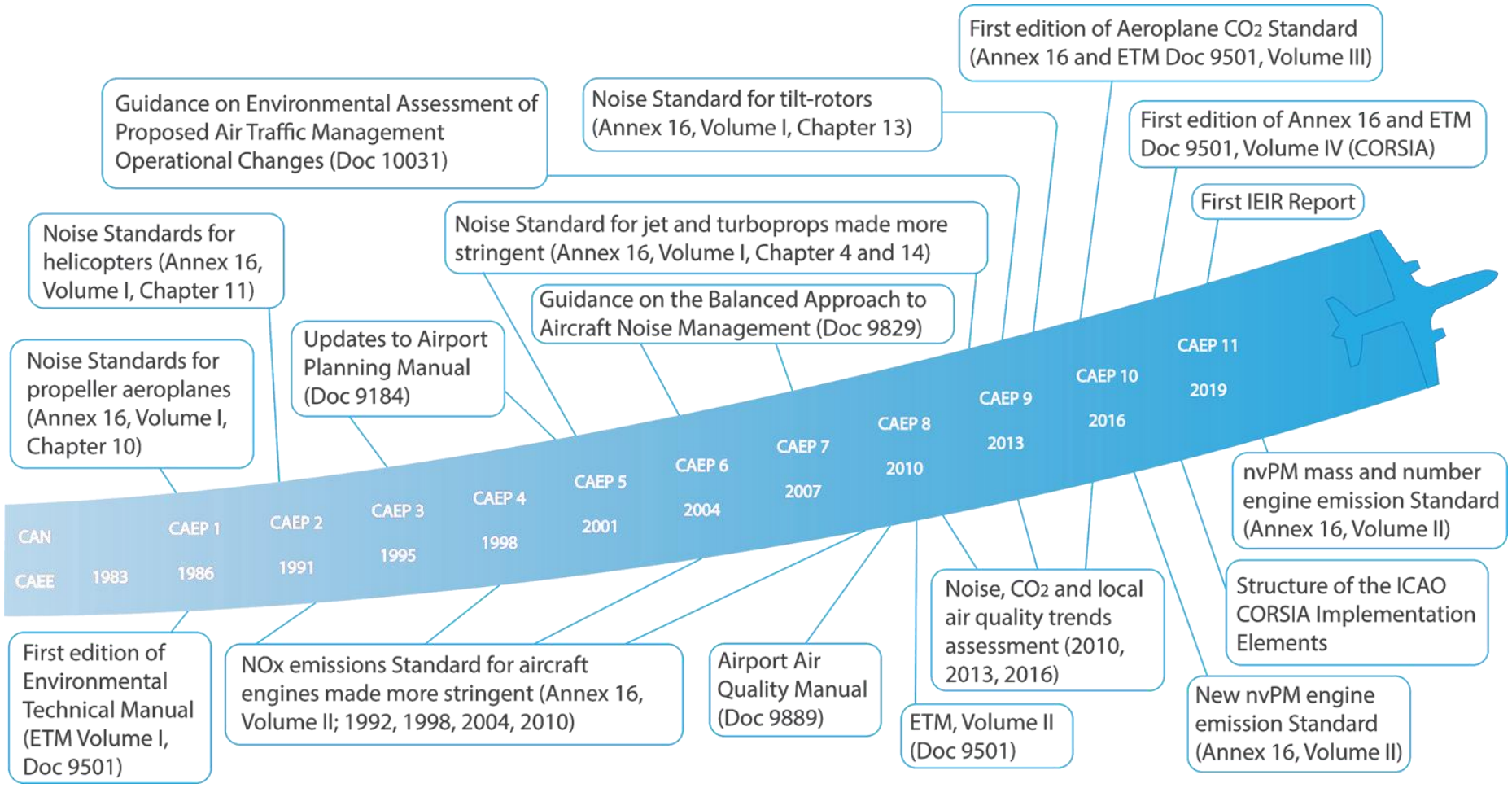


ICAO Standards have been set to follow the latest available technology in order to prevent backsliding. The goals defined by the Independent Experts need to be "challenging but achievable".

Ingredients of an environmental certification standard

CAEP metrics and regulations are designed to be performance-based and not technology-specific

ICAO Committee on Aviation Environmental Protection (CAEP) Regulatory Milestones



ICAO Committee on Aviation Environmental Protection (CAEP) Regulatory Milestones

Meeting	Year	Key recommendation on Annex 16 SARPs
Special Meeting on Aircraft Noise in the vicinity of airports	**1969**	**First Edition of Annex 16 – Aircraft Noise**
CAN2	1972	Noise Standards for light aeroplanes
CAN6	1980	Noise Standards for helicopters and supersonics with Type Certification submitted before 1 January 1975
CAEE2	1981	**First Edition of Annex 16, Volume II - Aircraft Engine Emissions**
CAEP1	1986	Noise Standards for light propellers
CAEP2	1991	Noise Standards for light helicopters
CAEP2	1991	Increase in Stringency of NO_x Emissions
CAEP4	1998	Increase in Stringency of NO_x Emissions
CAEP5	2001	Increase in stringency for turbojet and heavy-propeller noise Standards (Chapter 4)
CAEP6	2004	Increase in Stringency of NO_x Emissions
CAEP8	2010	Increase in Stringency of NO_x Emissions
CAEP9	2013	Increase in stringency for turbojet and heavy-propeller noise Standards (Chapter 14) Noise Standards for Tiltrotors (Chapter 13)
CAEP10	2016	nvPM engine emissions Standard
CAEP10	2016	**First Edition of Annex 16, Volume III - Aeroplane CO_2 Emissions**
CAEP Steering Group	2017	**First Edition of Annex 16, Volume IV (CORSIA)**
CAEP11	2019	nvPM mass and number emission Standard

Legend:

Noise	Local Air Quality	Climate Change

Source: ICAO, https://www.icao.int/environmental-protection/Documents/ICAO-ENV-Report2019-F1-WEB%20%281%29.pdf

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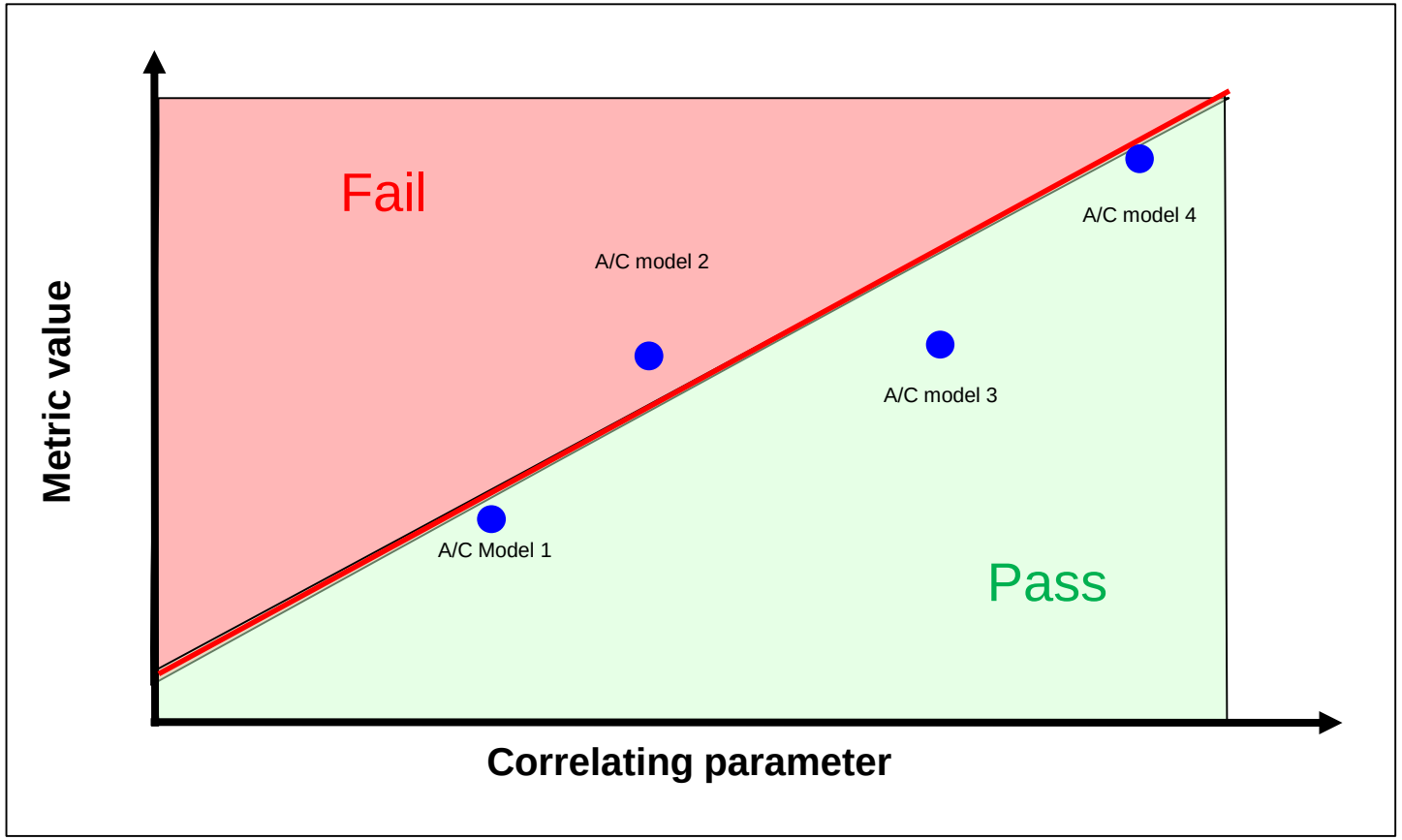
Architecture of an ICAO CAEP metric system



To be effective, metrics need to distinguish between different technological generations of aircraft.

Noise

Certification procedure: Measurement Points and Reference conditions

Take-off “lateral”

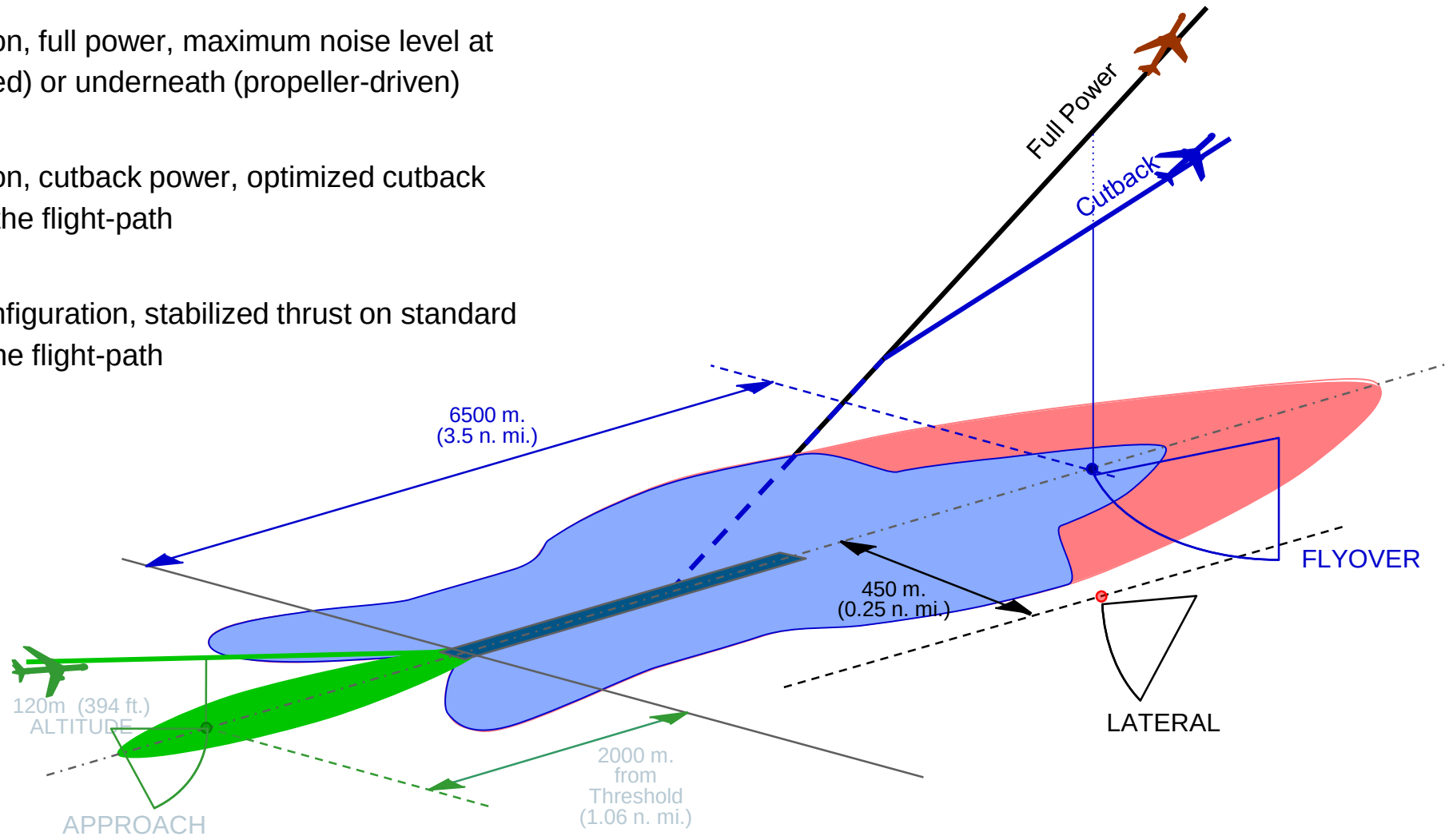
- take-off configuration, full power, maximum noise level at the side (jet-powered) or underneath (propeller-driven)

Take-off “flyover”

- take-off configuration, cutback power, optimized cutback height underneath the flight-path

Approach

- noisiest landing configuration, stabilized thrust on standard glide, underneath the flight-path



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Relevance to operations

Take-off “lateral”

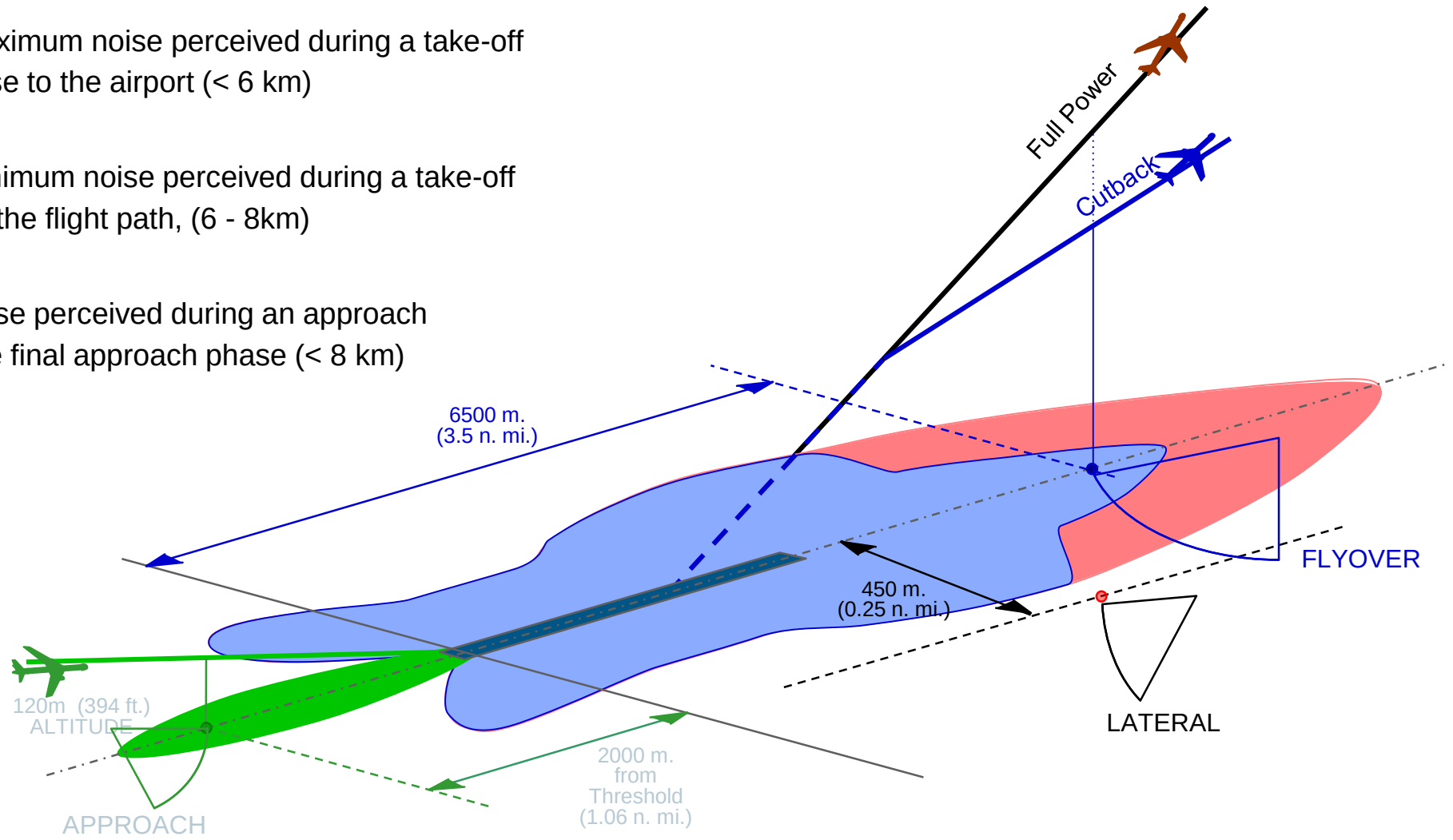
- Represents the maximum noise perceived during a take-off operation, very close to the airport (< 6 km)

Take-off “flyover”

- Represents the minimum noise perceived during a take-off operation, close to the flight path, (6 - 8km)

Approach

- Represents the noise perceived during an approach operation within the final approach phase (< 8 km)



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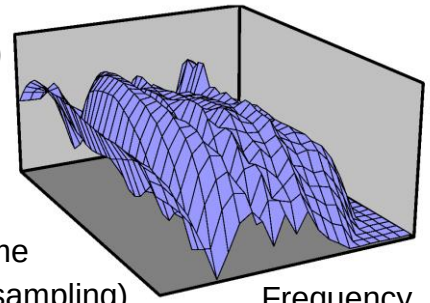
Noise certification metric

Measured sound pressure level

SPL(dB)
Sound
Pressure
Level



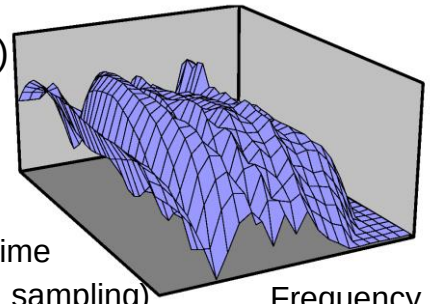
Time
(0.5 sec. sampling)

Frequency
(1/3 octave analysis)

Projection to reference
atmosphere & distance

Corrected sound pressure level

SPL(dB)

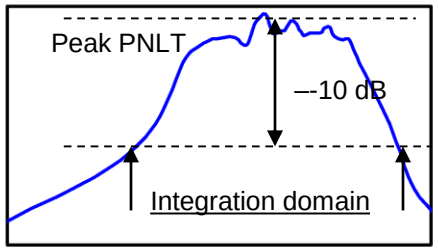


Time
(0.5 sec. sampling)

Frequency
(1/3 octave)

Frequency weighting
&
Tone correction

PNLT
Perceived noise level
With tone correction



Time

Adjustment for
reference a/c speed
& time integration

EPNL
Effective Perceived
Noise Level

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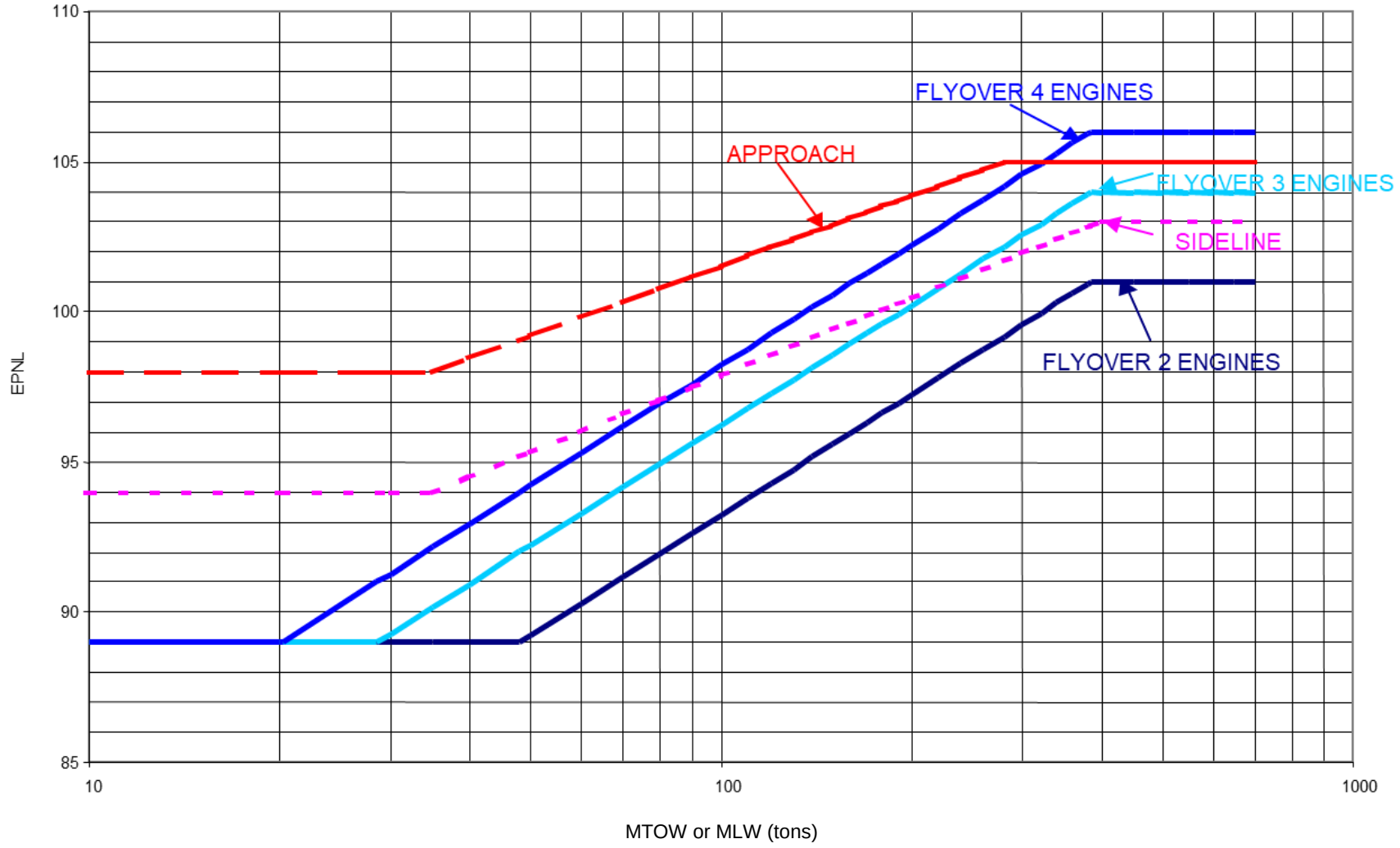
ICAO Annex 16 Chapter 3 / FAR 36 Stage 3 Noise limits



Why are there
3 curves for flyover?

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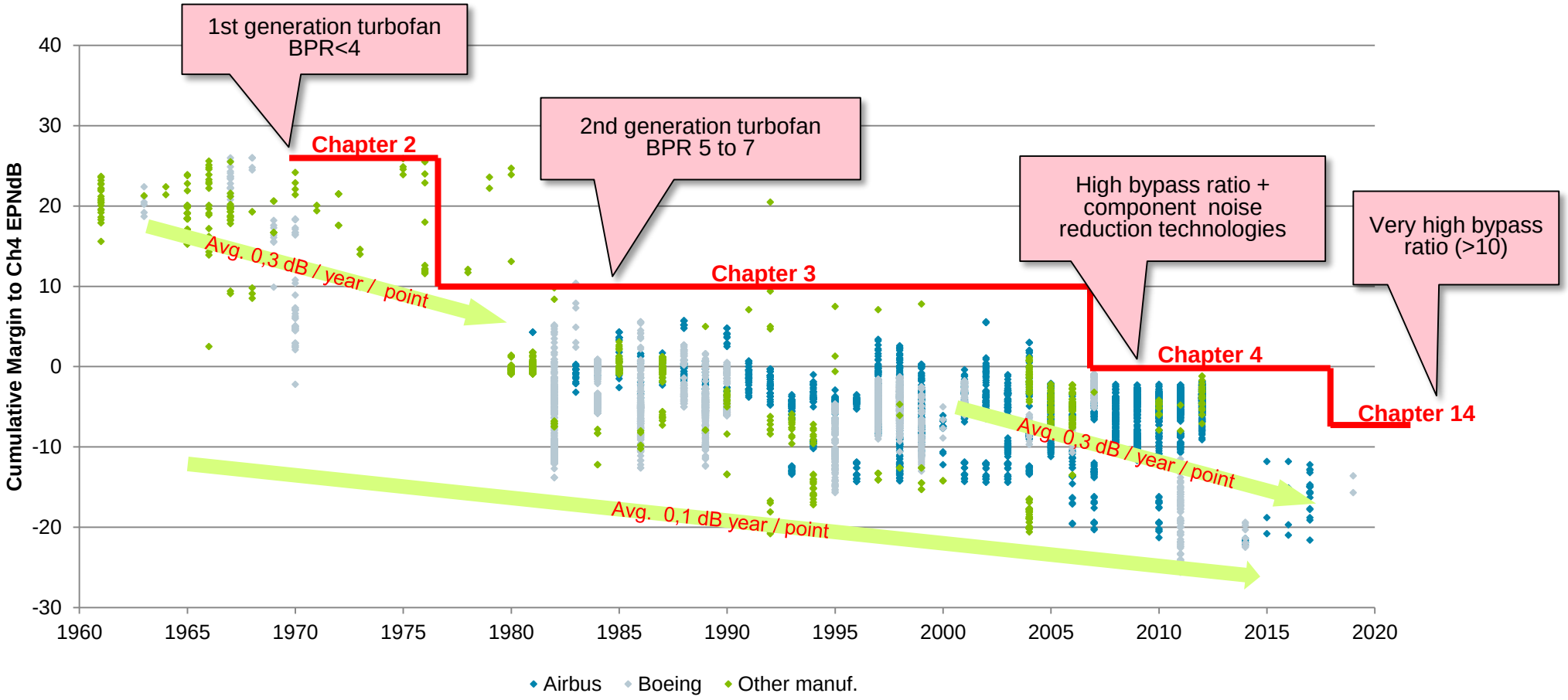
History of ICAO noise stringency, achievements & trends

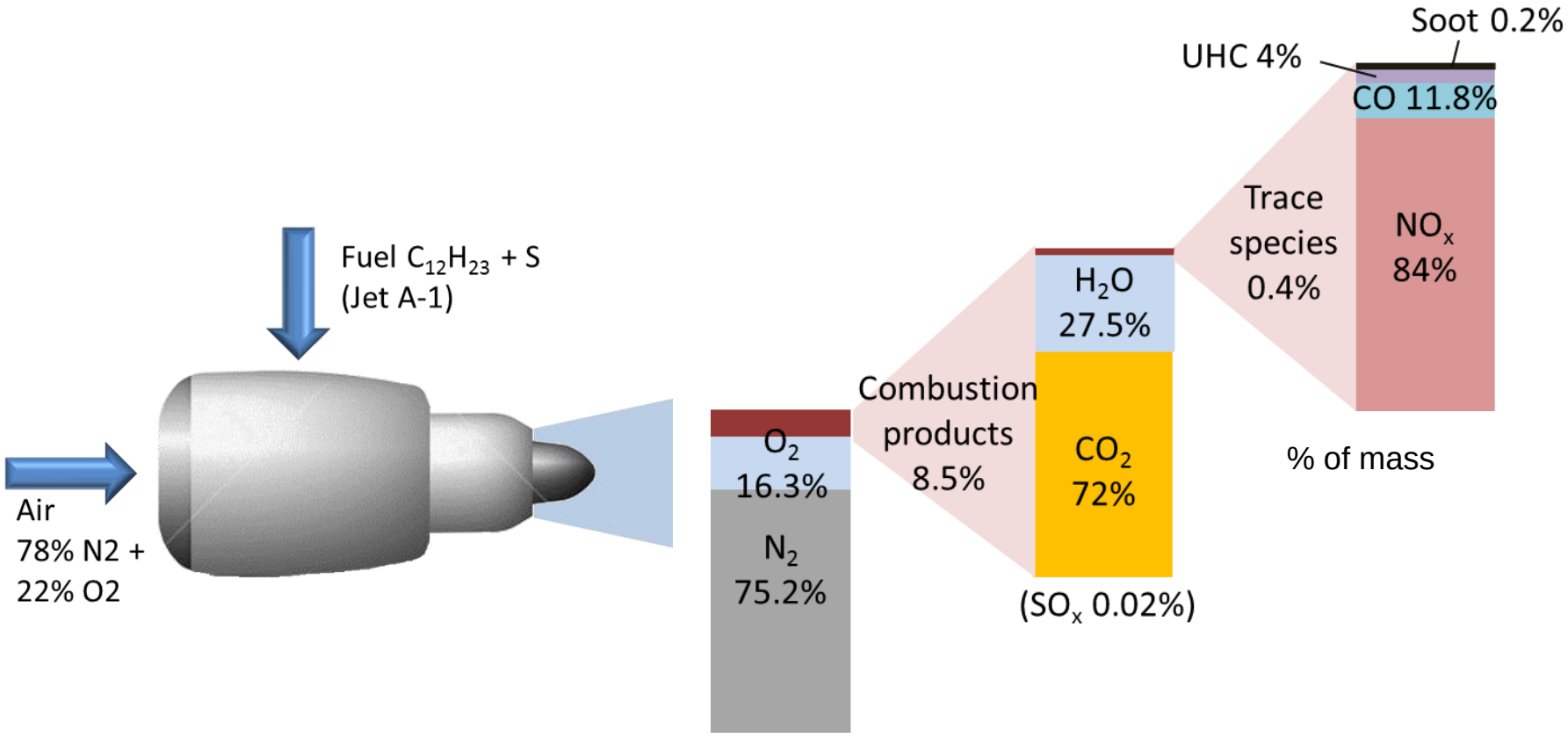


What is represented by the metric system?

Environmental impact	Metric value (Y-axis)	Correlating parameter (X-axis)	Additional factor(s)
Noise	Noise EPNL per LTO operation (EPNdB)	Weight (proxy for capability),	Number of engines (to take account of the impact of climb thrust on performance)

Landing & Take-Off Emissions

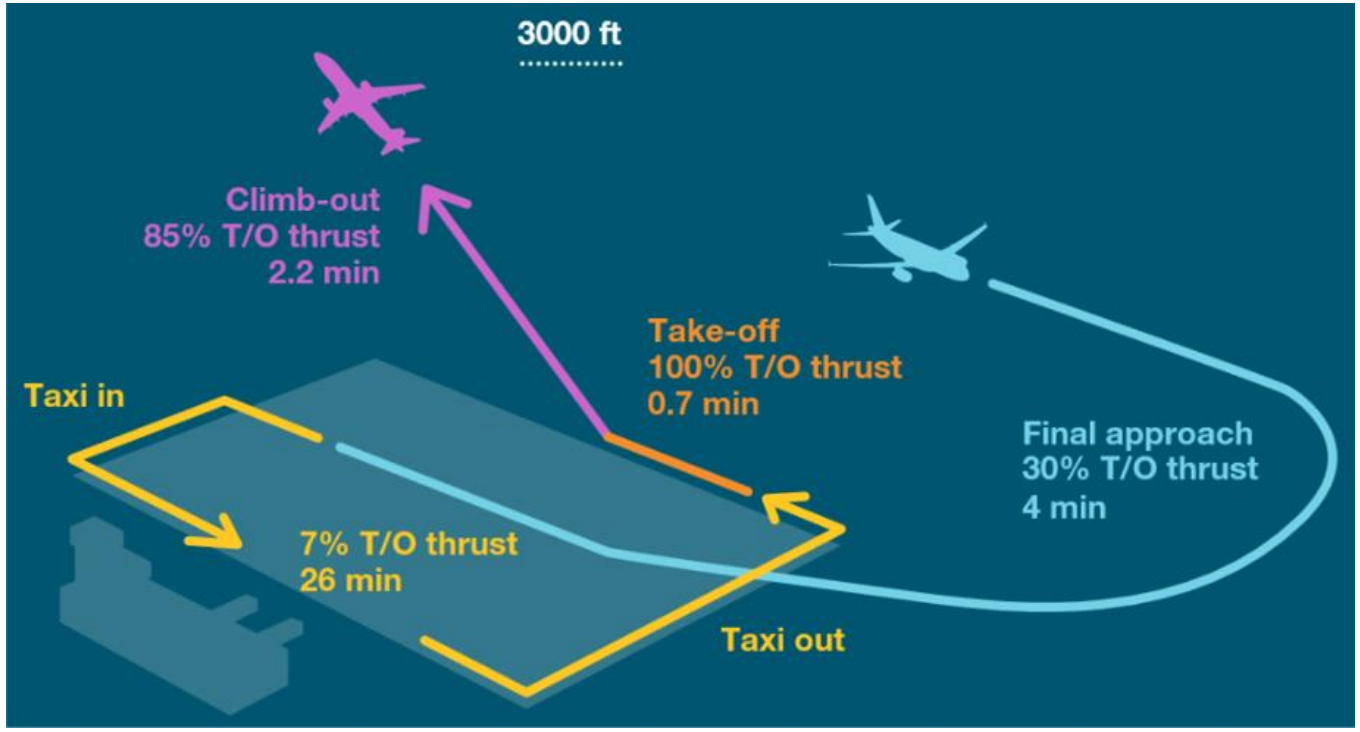
Aircraft engine emissions: Combustion Products



Due to their negative impact on human health and the environment,
NOx, CO, Unburnt Hydrocarbons (HC) & smoke (soot) are regulated by ICAO CAEP

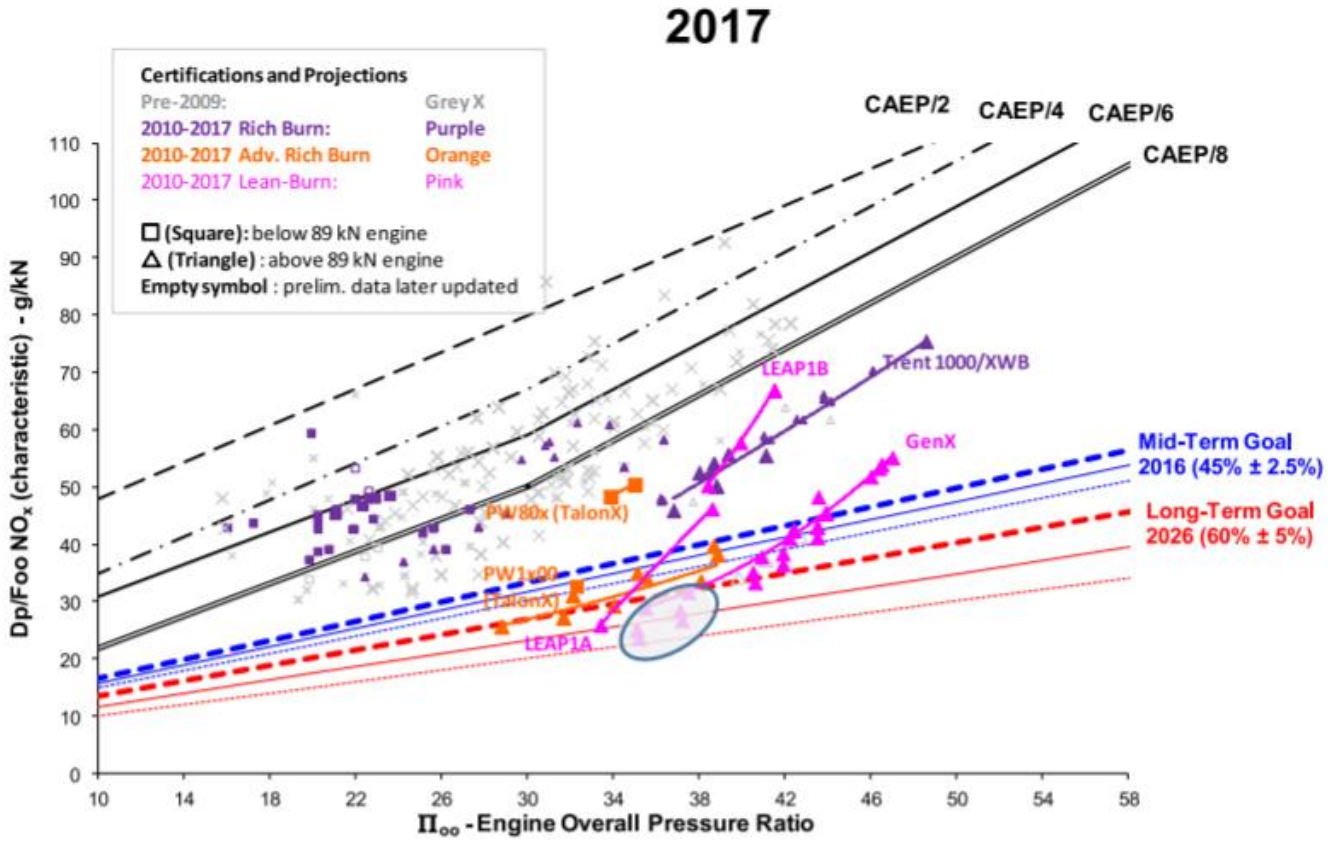
ICAO Emissions standards: The LTO (Landing & Take-Off) cycle

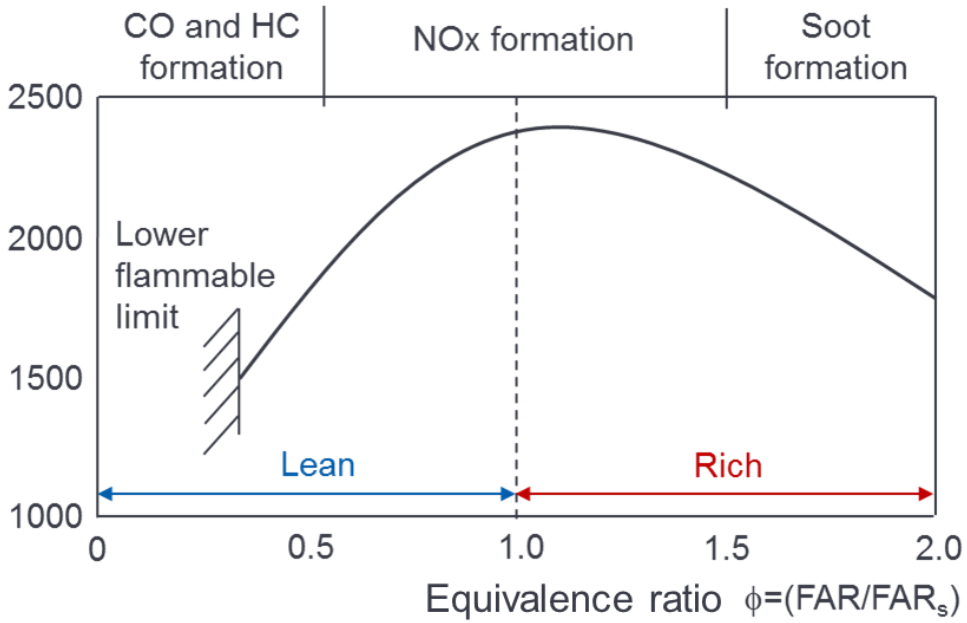
- NOx, CO, HC and Smoke emissions regulated as part of Engine Certification
- Regulation covers operations below 3000 ft Local Air Quality
- Based on engine certification tests on ground with measurement of emissions and fuel flow, covering the 4 reference Landing & Take-Off (LTO) cycle points:



Operating mode	Power setting (% std. day T/O thrust)	Time in mode (min)
1. Taxi / idle	7%	26
2. Take-off	100%	0.7
3. Climb	85%	2.2
4. Approach	30%	4.0

Illustration for NOx limits and achievements





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LTO emissions (NOx example)	Emissions per LTO operation normalised by engine thrust dP/Foo (g/kN)	Overall Pressure Ratio (to take account of the trade-off with fuel efficiency)	

CO2 Emissions

ATAG CO_2 emissions goals

Air Transport Action Group (ATAG)

The Air Transport Action Group (ATAG) is a highly respected not-for-profit association that represents all sectors of the air transport industry.
It is a global industry-wide body that bring together aviation industry players to promote aviation's sustainable growth for the benefit of communities around the world.

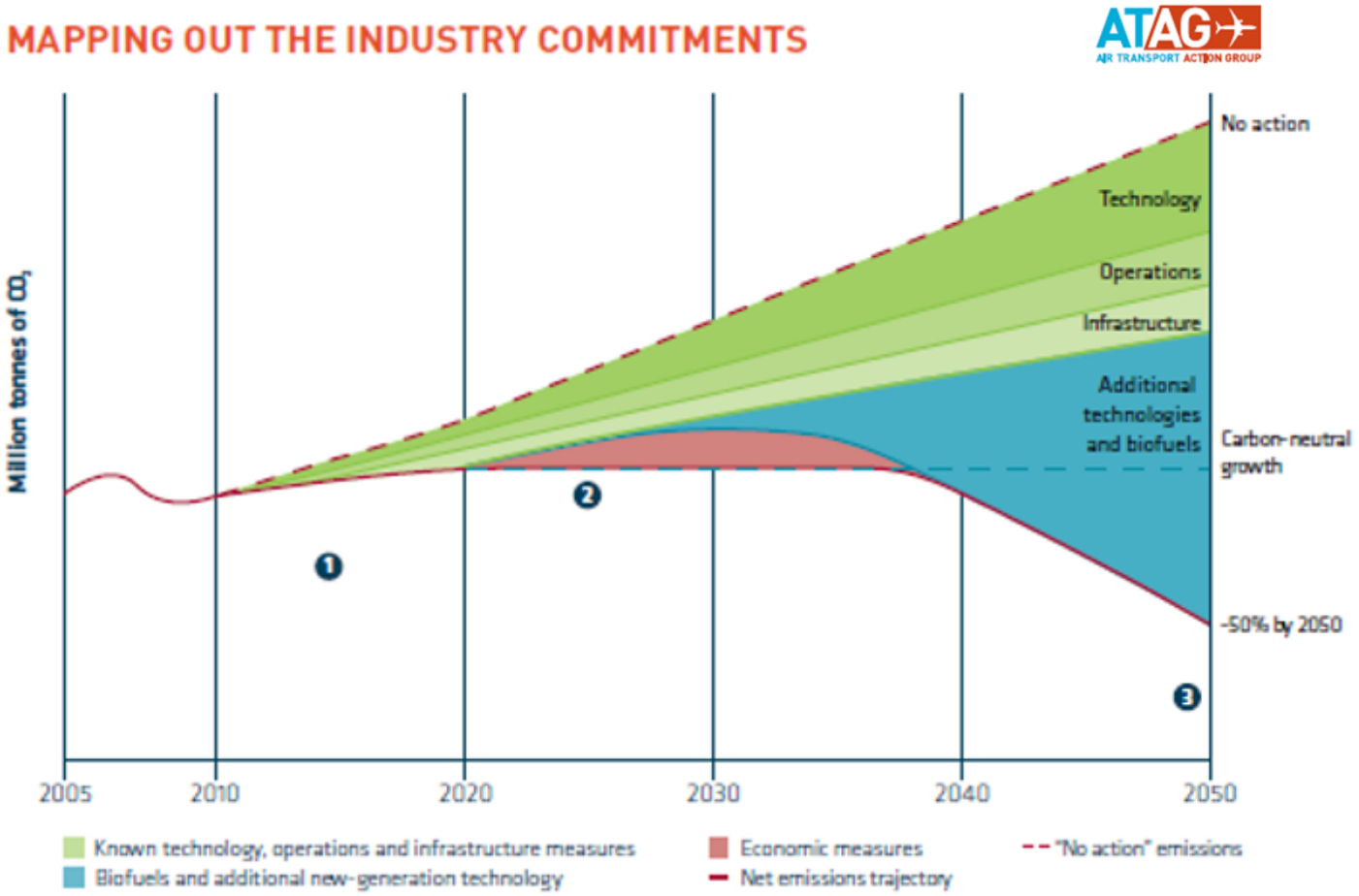
ATAG's mission is to define common positions on issues and to make expert and constructive contributions to the industry and governmental consultation process.

Airbus, along with airlines, airports, air traffic management and other manufacturers, committed in 2008 to the ATAG CO_2 emission goals:

Improve
fleet fuel efficiency of **1.5%** per year between now and 2020

Stabilise
from 2020, net carbon emissions from aviation will be capped through carbon neutral growth (CNG)

By 2050, net aviation carbon emissions **will be half** of what they were in 2005.



CO2 emissions standard

CO2 Metric Value

$$MV = \frac{\left[\frac{1}{SAR}\right]_{AVG}}{RGF^{0.24}}$$

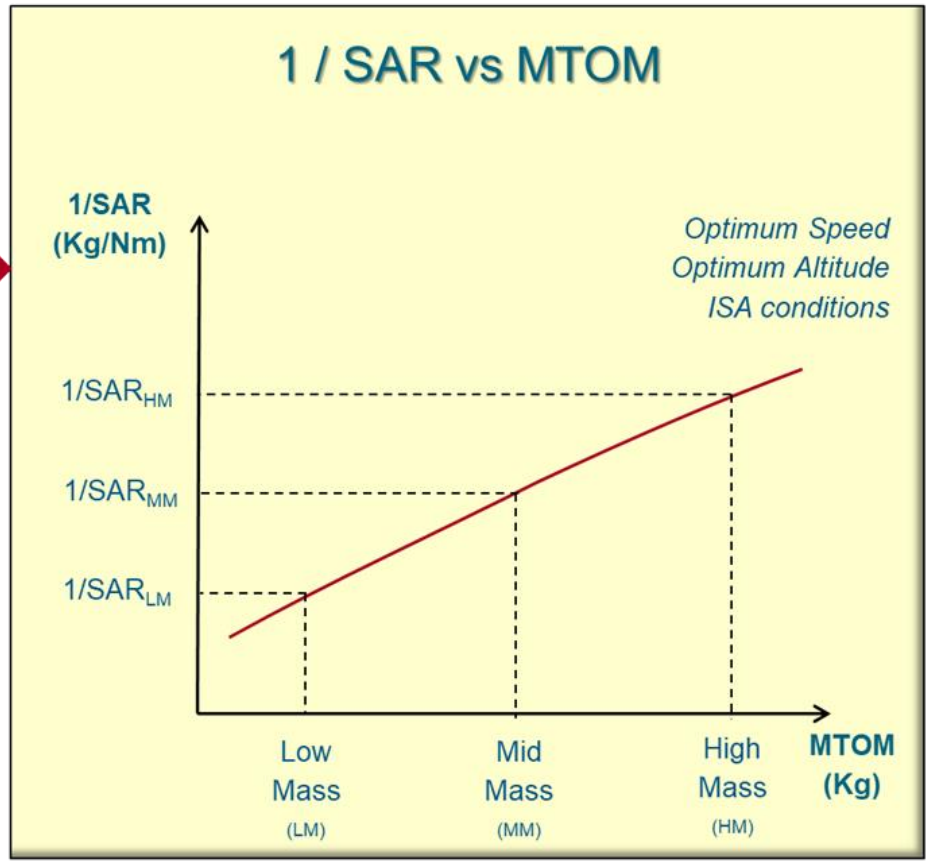
SAR = Specific Air Range

RGF = Reference Geometric Factor

Measured at three cruise points

at Optimum Altitude and Optimum Speed

- **High Mass** (92% of MTOM)
- **Mid Mass** (Average High and Low Mass)
- **Low Mass** ((0.45 x MTOM) + (0.63 x ($MTOM^{0.924}$))



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CO2 emissions standard

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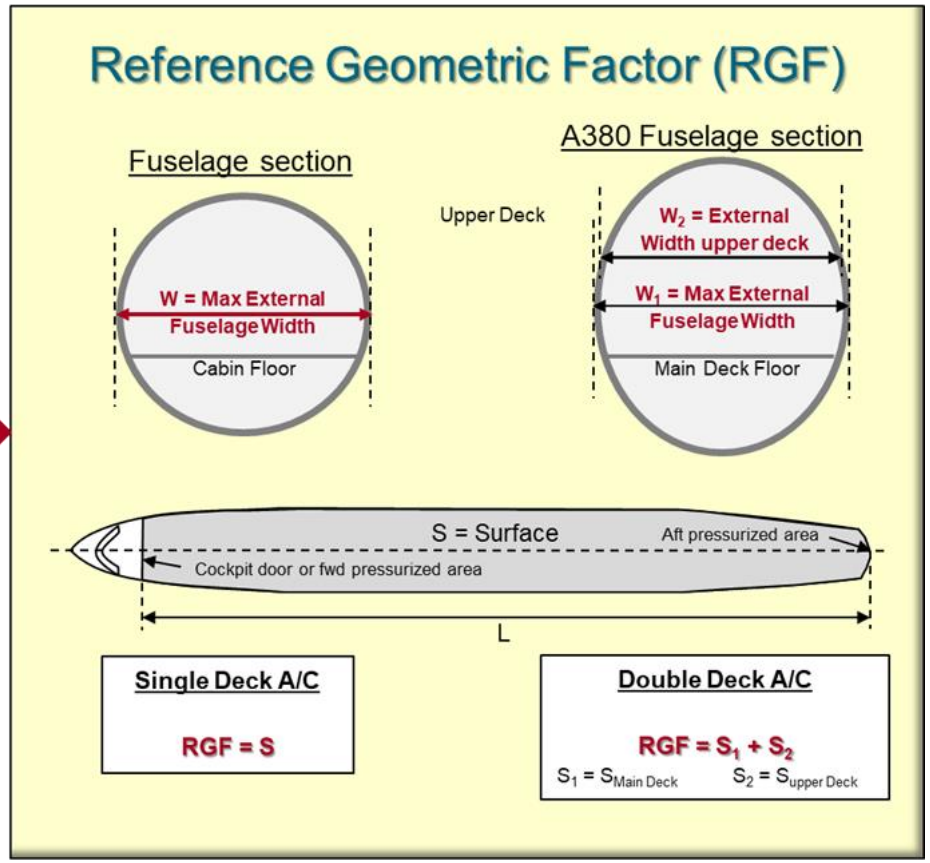
Reference Geometric Factor (RGF)



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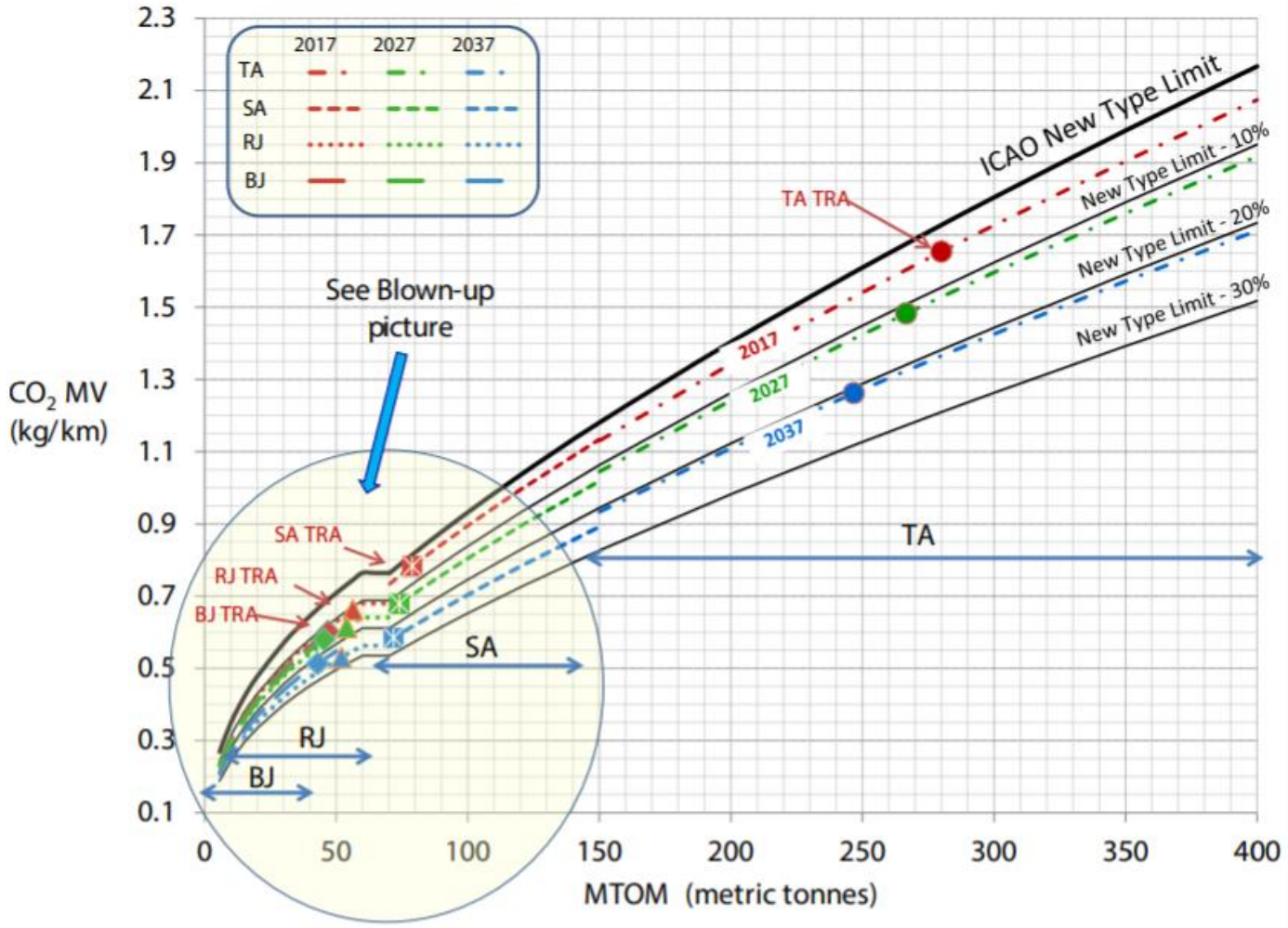
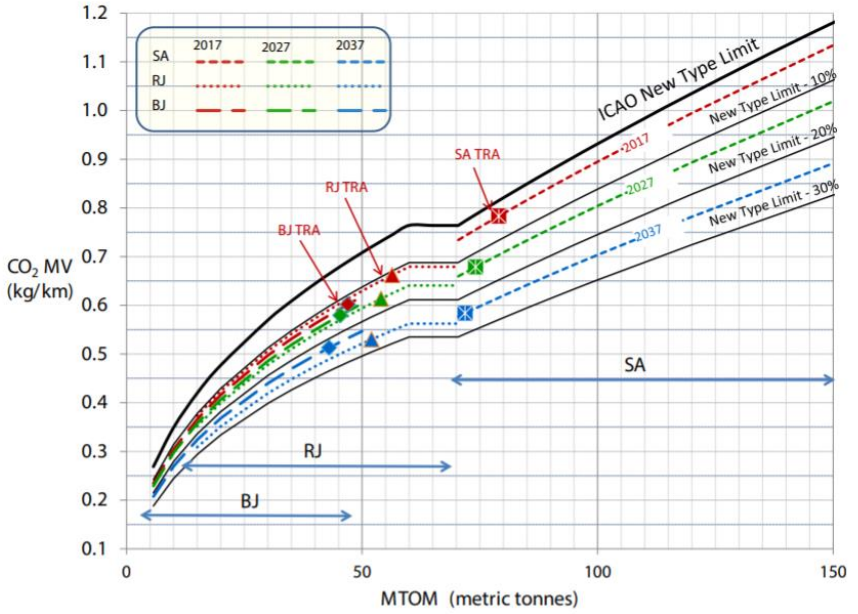
Summary of stringency goals recommended by independent experts





EIS Date	BJ	RJ	SA	TA
*2017 TRA**	-13	-11	-4	-4
2027	-15	-16	-14	-12
2037	-23	-26	-24	-21

*The 2017 numbers are not goals, but are shown for comparison purposes only.

https://www.icao.int/environmental-protection/Documents/EnvironmentalReports/2019/ENVReport2019_pg24-38.pdf

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LTO emissions (NOx example)	Emissions per LTO operation normalised by engine thrust dP/Foo (g/kN)	Overall Pressure Ratio (to take account of the trade-off with fuel efficiency)	
CO2 emissions	Emissions normalised considering cabin area (1/SAR)/$RGF^{0.24}$ (kg/km)	Weight (proxy for capability),	

Reminder of the ingredients of an environmental certification standard

CAEP metrics and regulations are designed to be performance-based and not technology-specific

ICAO Committee on Aviation Environmental Protection (CAEP)
Future study themes (CAEP 13 & 14)

Improvements to current certification standards will be investigated:

- Exploration of trade-offs between the 3 standards.
  - For example should aircraft be allowed to be noisier if they have lower CO_2 emissions?
- Definition of a methodology for accounting of NOx emissions above 3000ft.
  - Cruise NOx contribute to climate change, and possibly local air quality.
- Investigation of the variation of the NOx limit as a function of engine OPR (in the context of trade-offs)
  - Increasing engine OPR improves fuel burn and reduces CO2 emissions but leads to increased NOx.
- Studies to address non-CO_2 climate effects:
  - Historically, ⅔ of the climate impact of aviation is due to non-CO_2 effects (mainly aviation-induced cloudiness and NOx emissions).
  - Exploration of a contrails mitigation scheme, for *possible* regulation during CAEP/14.

Conclusion

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Conclusion

- Regulatory frameworks are a broad topic of concern when referring to Sustainability.
  - They can come from different authorities (international, regional or local)
  - They can be regulated in a legal text or can be a non-legislative document of reference (standards)
  - Transversal topics are every time more common to be regulated and interlinked

- Requirements
  - Not necessary in a legal text but maybe required by other stakeholders (sustainable finance and disclosure)

- Regulation can be an enabler not only a burden

- Regulating sustainability topics require of multifunctional teams. The same for understanding and implementing requirements

Thank you

7/9/2022 Environmental regulation of the aviation sector

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Historical look to international climate regulation

Nov .1988: Establishment of the Intergovernmental Panel on Climate Change (IPCC)

Nov. 1990: The IPCC releases the First Assessment Report

March 1992: United Nations Framework Convention on Climate Change (UNFCCC) was adopted

December 1997: Kyoto Protocol was adopted

Jan. 2005: EU ETS is launched and enters into force

Dec 2012: Doha Amendment is adopted

ICAO - MBM evaluation adoption

Sep. 2013: IPCC releases part of its Fifth Assessment Report (physical phenomena)

March 2014: IPCC releases the second part of the Fifth Assessment Report (impact, adaptation and vulnerability)

Dec 2015: Conference of the Parties in Paris (COP21).

2016: ICAO CORSIA agreement

Oct. 2018: **IPCC Special Report on 1.5°C degrees is published.**

Dec 2018: COP24 in Katowice, Poland.

Dec 2019: COP25 Climate Ambition

Nov 2021: UNFCCC COP26

Regulatory Review Summary - Fit for 55

- **Prescriptive Approach**: detailed regulation of relevant areas for decarbonising the economy with main focus in transport, building and energy. Small margin for delay for plan to succeed.

- **Imposing prohibitions to use or limit the access to fossil fuels as an energy source whilst promoting renewable energies**:
  - Enlarging the scope of the carbon market and increasing its price (EU ETS, CBAM, ETD);
  - Mandating minimum shares of use of sustainable fuels and renewable energies (RED, ReFuel EU Aviation, Fuel Maritime, AFIR)
  - Increasing the emissions reduction and energy targets of member states (EU ETS, Effort Sharing Regulation, LULUCF, RED);
  - Changes in tax rates (ETD)
  - Phasing out the use of fossil fuel for certain activities or importantly limiting (Vehicles standards, adjacent EU ETS, Energy Efficiency Directive)

- **Limited direct incentives for decarbonization**: main tools provided are EU ETS Innovation Fund, EU ETS inclusion of carbon contracts for difference, support of PPAs in RED.

- No address of Non-CO2 effect of aviation

EU Emissions Trading System Evolution

Phase 1 (2005-2007)

Key features:

- Covered only CO2 emissions from power generators and energy-intensive industries
- Almost all allowances were given to businesses for free
- Businesses allowed to use units only generated under the Clean Development Mechanism for EU ETS compliance.

Key achievements:

- Creation carbon market
- Free trade in emission allowances across the EU
- Infrastructure needed to monitor, report and verify emissions from the businesses covered.

Phase 2 (2008-2012)

Key features:

- Scope extended to aviation emissions from 1 January 2012 (Stop-the-clock /EEA internal flights only not international as originally proposed).
- Penalty for non-compliance increased from 40 € to 100 €/tonne of CO2.
- Businesses could use emission reduction units generated under Clean Development Mechanism (CDM) and Joint Implementation Mechanism (JI)

Phase 3 (2013-2020)

Key features

Annual Linear Reduction factor: -1.74%

Carbon Leakage list: 175 sectors including aviation and manufacturing of aircrafts

Key achievements

- A single EU-wide cap on emissions
- Creation of the Market Stability Reserve in 2018 for effective implementation in 2019.
- Reduction of free allocations and auction vs phase 2
- Limitation in the use of credits for compliance (CDM and JI)

Phase 4 (2021 -2030)
Entry into force 8 April 2018

Key features

EU ETS goal: - 43 % in 2030 vs 2005

Annual Linear Reduction factor: -2.2%

66 sectors included in the Carbon Leakage List - (no aviation and manufacturing aircraft)

Creation of the Innovation Fund

No international credits possible to be used to comply

Free allowances - modifications in the granting process Two periods of allocation.

New Regulation

MRV - monitoring and reporting and verification and Innovation Fund

Linkage ETS with Switzerland allowing regulated entities in both systems to use allowances from either ETS for compliance

Pending

Amendment to include CORSIA

CBAM

F-Gases and ODS (halon)