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Sustainability Management in the Aviation and Tourism Industry

Frankfurt University of Applied Sciences

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Section 4: Industry Action

Lars Kröplin

Fachbereich 3 Wirtschaft und Recht

Sustainability Management in the Aviation and Tourism Industry

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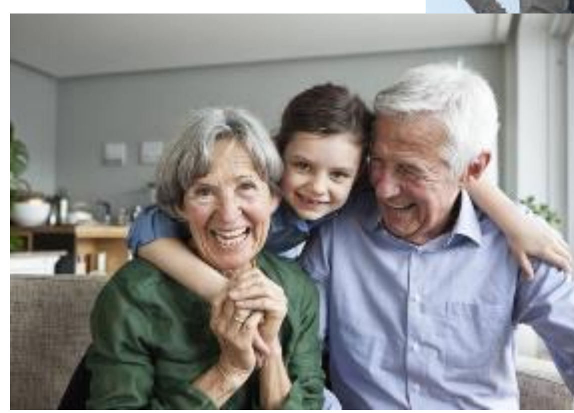
Content

How to preserve a connected world…?



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Industry Action

Introduction: Aviation Areas of Action

Technology – Fuel and Noise effective

Processes and Infrastructure

Sustainable Aviation Fuels

Compensation

Waste, Wildlife and Trafficking

Elements to drive Environmental Performance of Aviation

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Environmental Management System

Reduce climate impact	Increase energy- and resource efficiency	Foster active noise protection, reduce local gaseous emissions
▪ **fuel efficient new aircrafts** (fleet management, OEM) ▪ **operational measures** (flight ops, Airport) ▪ **infrastructural measures** (flight / ground ops, ATC, Airport) ▪ **carbon offsetting** (emission hedging, CORSIA, ETS) ▪ **alternative fuels** (fuel refinery, engineering)	▪ **energy efficiency measures** (facility management, Airport) ▪ **green energy** (procurement, Airport) ▪ **waste management (reduce / recycle)** (product management, caterer, Airport)	▪ **quite and low emission new aircraft:** (fleet procurement / management, OEM) ▪ **operational measures** (flight ops, Airport) ▪ **infrastructural measures** (flight / ground ops, Airport, ATC)

clear vision, quantified targets, projects & measures
environmental guidelines, defined accountabilities, certification (e.g. EMAS / ISO 14001)

Several options available for decarbonization of an airline

Overview of Options

	New technology	Fuel efficiency	Infrastructure	CO_2 compensation	Sustainable fuel (SAF)
What it means	**Evolution:** rollover current fleet to already available new jets **Revolution:** electrify aviation and develop new designs; hybrid electric flying as a first step	**Procedures:** optimize on-ground and in-flight procedures **Cabin weight:** intro-duce new materials to reduce aircraft weight	**Optimum flight path:** min. circuity resulting from fragmented air space; increased capacity to fly close to optimum; reduced on-ground / inflight holding	**Carbon credits:** industry-agnostic decarbonization for GHG emissions of another party (in developing countries, nature-based solutions)	**Biofuel:** HEFA from waste oil (used cooking oil) or municipal waste gasification **Synfuel:** power-to-liquid fuel produced from waste carbon and hydrogen
Decarbonization potential	**High:** new short- and long-haul types are 15-20% more fuel efficient compared to previous types	**Small:** airlines already focus on fuel (which accounts for 20-25% of operational costs	**Medium:** requires multinational collaboration of Air Traffic Management (ATM) providers	**High:** but not considered an industry-specific option; limited acceptance depending on quality of standard	**High:** SAF provides 70-100% CO_2 reduction compared to fossil kerosene, however at high costs
Impact 2050 vs. "do nothing"	30+%	3-5%	5-10%	Unrestricted net reduction	Up to 99% net reduction

Source: McKinsey & Company

In a climate ambition pathway, fossil fuels in aviation are entirely phased out by 2050

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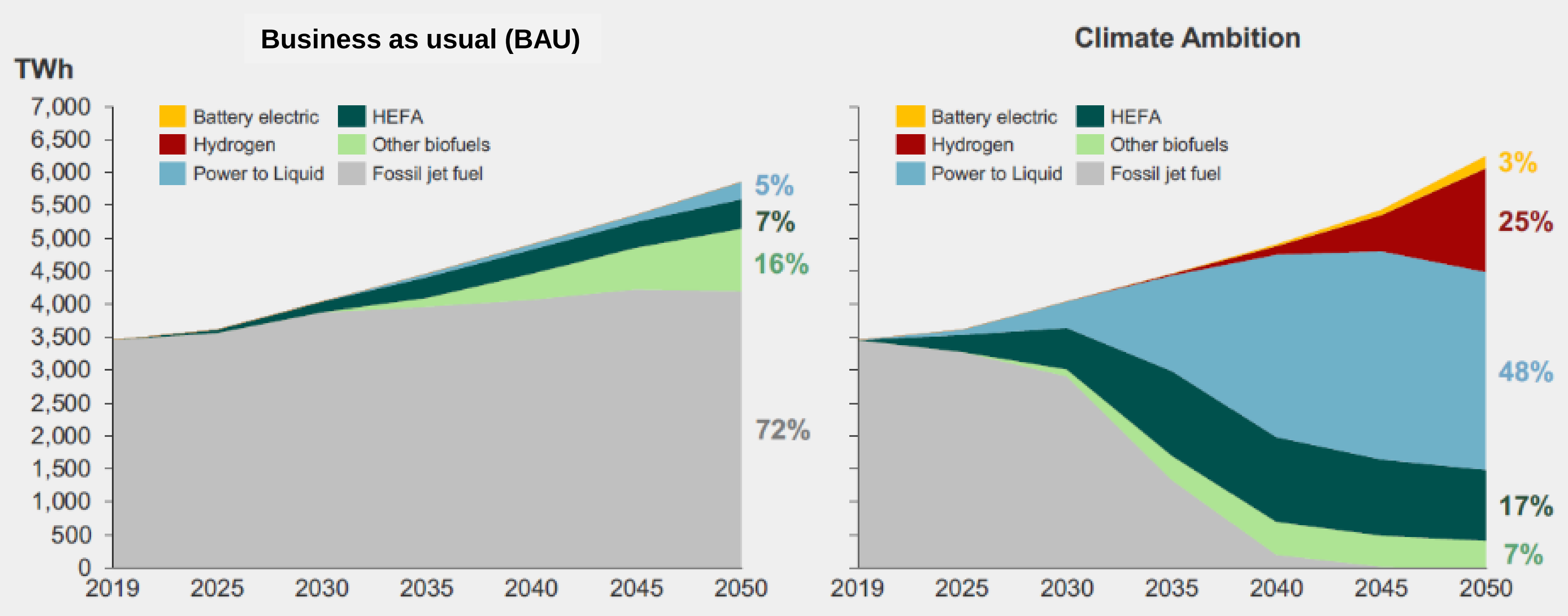

- The aviation sector’s final energy demand by technology to 2050 in a BAU pathway (left) and a climate ambition pathway (right)
- On the current path (left), SAF allocation stems from the planned use of SAFs in the United States and the European Union

Source: Mission Possible Partnership - Ten Critical Insights on the Path to a Net-Zero Aviation Sector, 2021

Known measures to reduce GHG will not lead to carbon neutrality in 2050 – Aviation is hard to decarbonize

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Potential reduction path of an airline vs. 2018

Abatement measure	Description	1.5°C vs. reference case emissions 2030	2050
Aviation demand reduction	**Modal shift** from short-haul flights (under 300 miles) to high-speed rail **Remote communication** technologies reducing the need to travel **Structural change in customer preferences and behavior** following COVID-19	-10%	-10%
Energy demand reduction	**Replacement of older aircraft models** with more efficient conventional-technology types **Retrofit of existing fleet** with energy-efficiency features such as winglets (to reduce aerodynamic drag) and light weight components **Optimization** of airport operations and air traffic control **Fuel efficiency** of aircraft operations	-6%	-13%
Electrification	By 2050, electricity would need to make up 6% of aviation fuel consumption through the development of battery-powered, hybrid- and turboelectric propulsion technologies. Electric aircraft would be limited to short-haul flights (batteries are not as energy-dense as fuel).	-2%	-6%
Sustainable aviation fuels (SAFs)	**Biofuels**: Crop-based biofuels (e.g. vegetable oil) and advanced biofuels (e.g. Camelina) would account for 20% of jet fuel by 2030 and 35% of jet fuel by 2050 - more types of advanced biofuels become economically and technically viable **Hydrogen-based synthetic fuels**: Synthetic fuels (from hydrogen & captured carbon) would need to account for 35% of jet fuel in 2050. In a best-case scenario, synthetic aviation fuels could become cost-competitive with fossil jet fuel between 2030 and 2040, as costs of inputs (i.e. electrolyzers, renewable energy) continue to fall	-17%	-52%
Emissions reductions compared to reference case		-35%	-81%

Source: McKinsey 1.5°C Scenario Analysis

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Long Range Aircraft Efficiency Development

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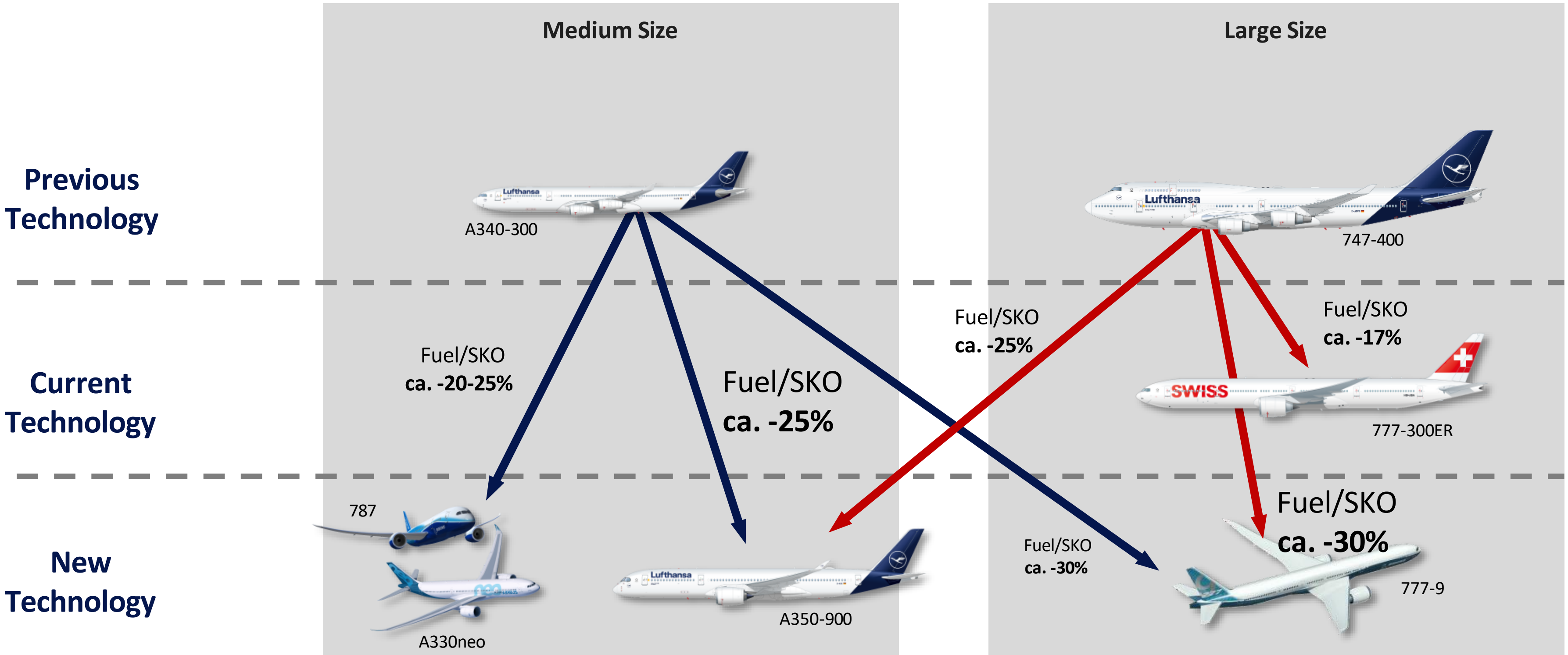

Based on generic, comparable capacitites

Source: LH A/C Management

Short Range Aircraft Efficiency Development

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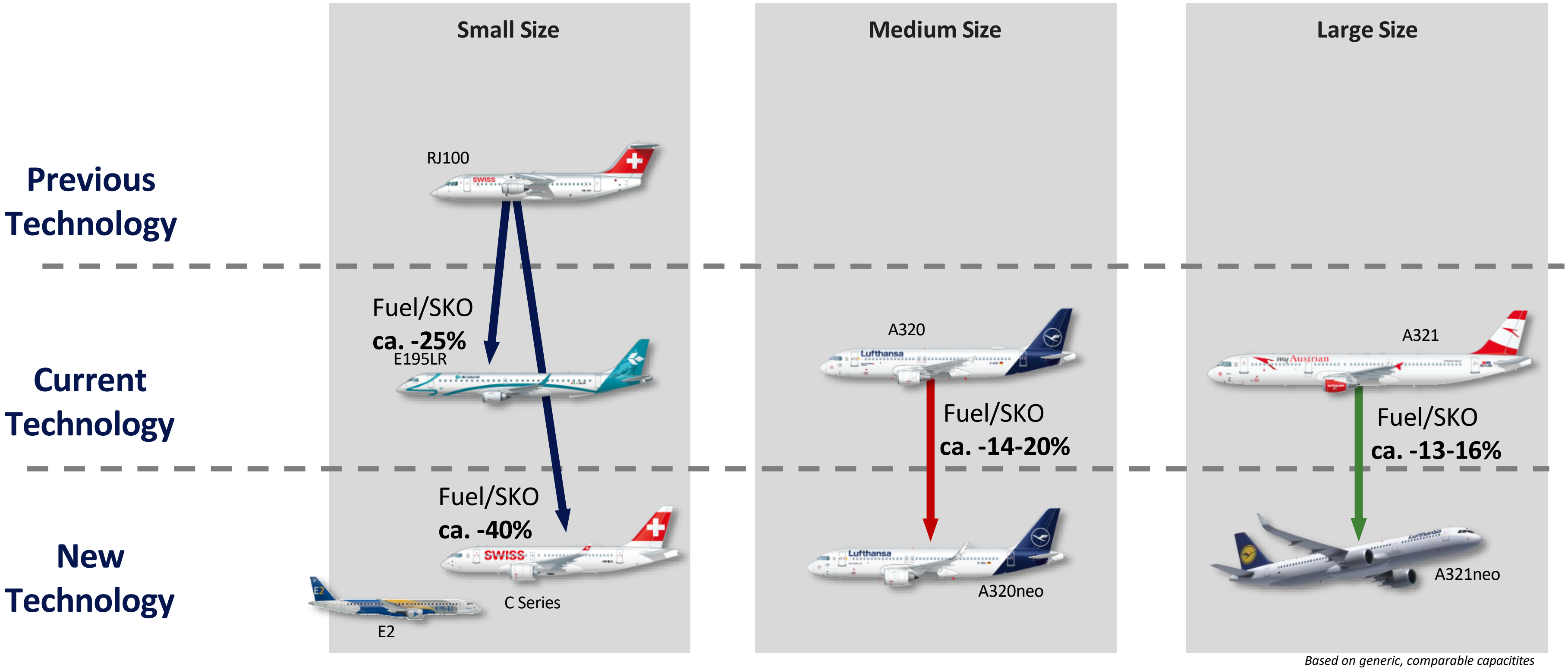
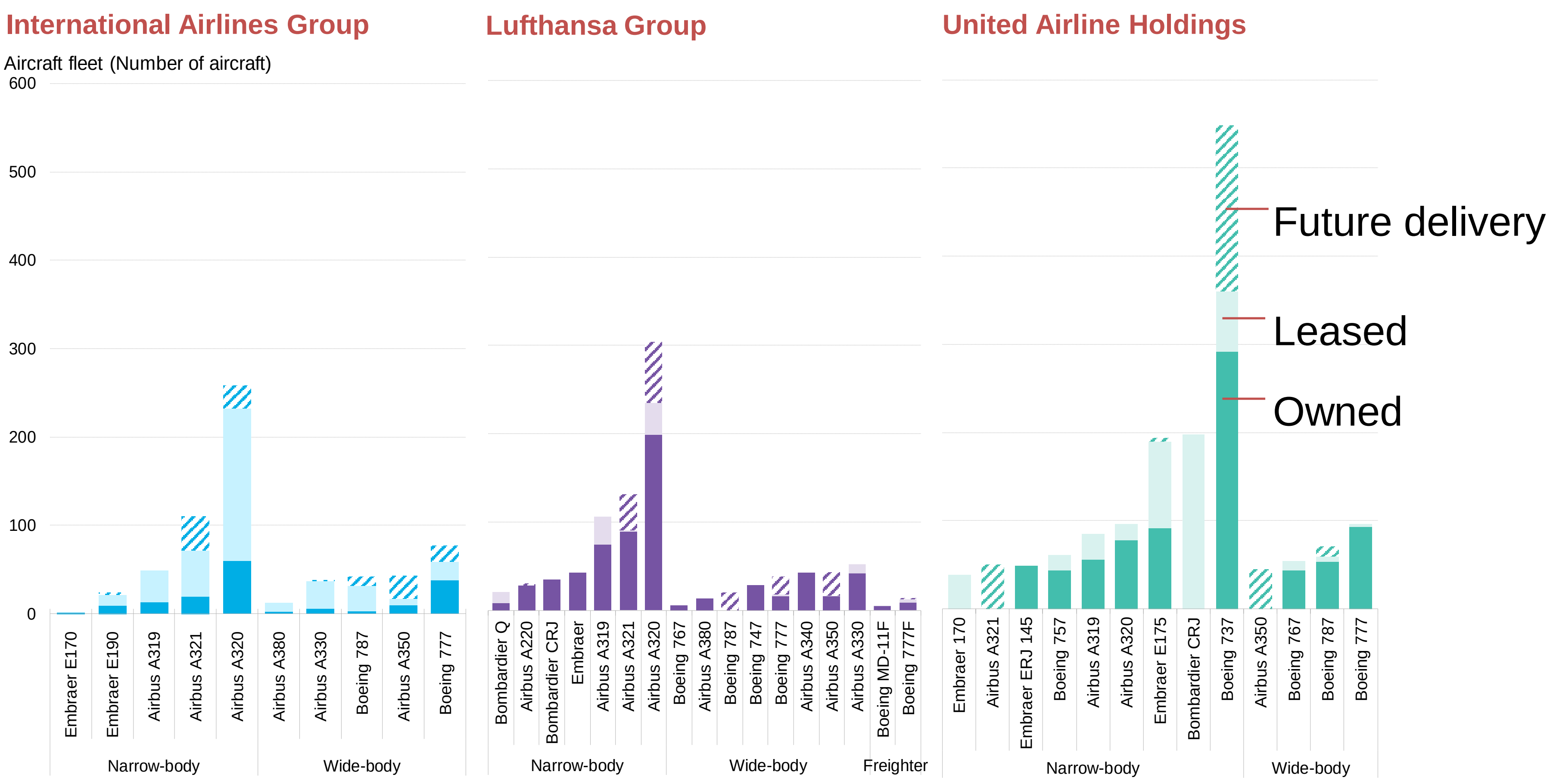


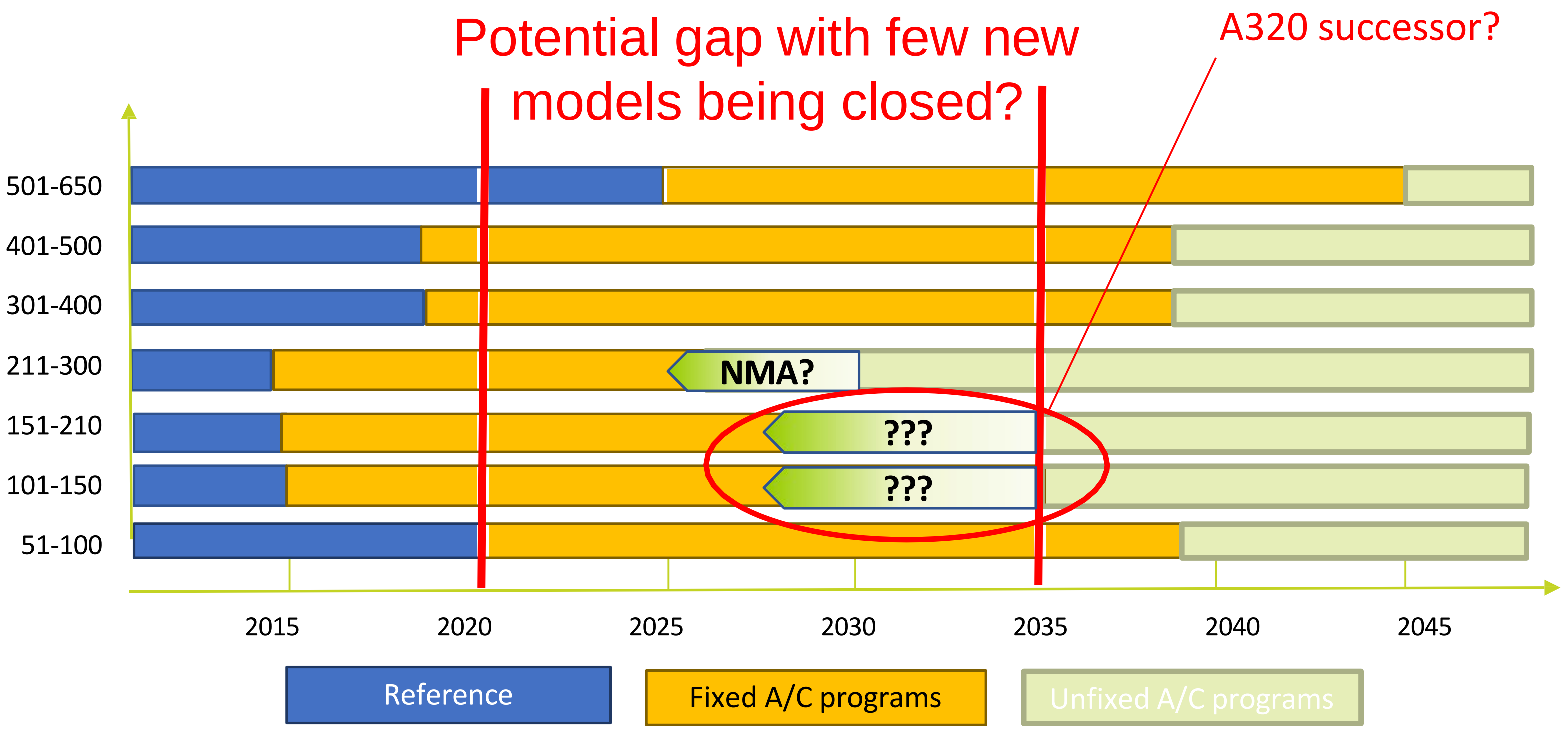
Source: LH A/C Management

Aircraft fleet modernization trends of selected three major airlines



Source: Airline annual reports, BloombergNEF. Note: Data as of 2021

Expected sequence of future aircraft generations – radical change needs another 20+ years



Source: Aircraft Technology Roadmap to 2050, IATA

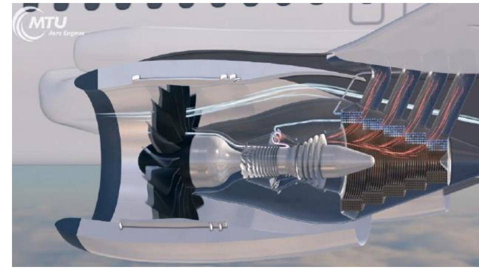
Is aviation ready to push disruption?

Aerodynamics

Boeing‘s Strut-braced wing concept „SUGAR“

Blended Wing Body (NASA/Boeing)

Engine



New engine technology (MTU)

Unducted fan (Safran)

Alternative Propulsion

Electric Regional Aircraft (Heart)

Airbus Zero-e concept (hydrogen powered aircraft)

Ideation cooperation

Bauhaus Luftfahrt (hydrogen long-haul A/C)

Source: OEMs et al.

New propulsion technologies with range issues – Sustainable fuels as only near term option

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Comparison vs fossil kerosene	1 Battery-electric	2 H_2 fuel cell	2 H_2 turbine	3 Sustainable aviation fuel
Climate impact[i]	100% reduction[ii]	75%-90% reduction	50%–75% reduction	30%-60% reduction[iii]
Aircraft design	Low-battery density limits ranges to 500km–1,000km	Feasible only for commuter to short-range segments	Feasible for all segments except for flights >10,000km	Only minor changes
Aircraft operations	Same or shorter turnaround times	1-2x longer refuelling times for up to short range	2–3x longer refuelling times for medium and long range	Same turnaround times
Airport infrastructure	Fast-charging or battery exchange system required	LH_2 distribution and storage required		Existing infrastructure can be used

Major advantages (green) Major challenges (yellow)

Assessment summary:

- Available: as of >2025s
- Challenge: H2 3x volume of kerosene
- Range Urban Mobility, Europe?

- Available: as of >2040s
- Challenge: H2 3x volume of kerosene
- Range Europe o.k. - Long Haul?

- Available (limited quantities)
- Challenge:Price difference to fossil
- Range Europe and Long Haul

i.Including CO2, NOx, water vapour and contrails ii. Assuming 100% renewable electricity iii. For e-fuels with fully decarbonized supply chain

Source: Clean Sky 2 JU & FCH 2 JU: Hydrogen-powered aviation report; expert interviews

Technology also drives Noise Reduction

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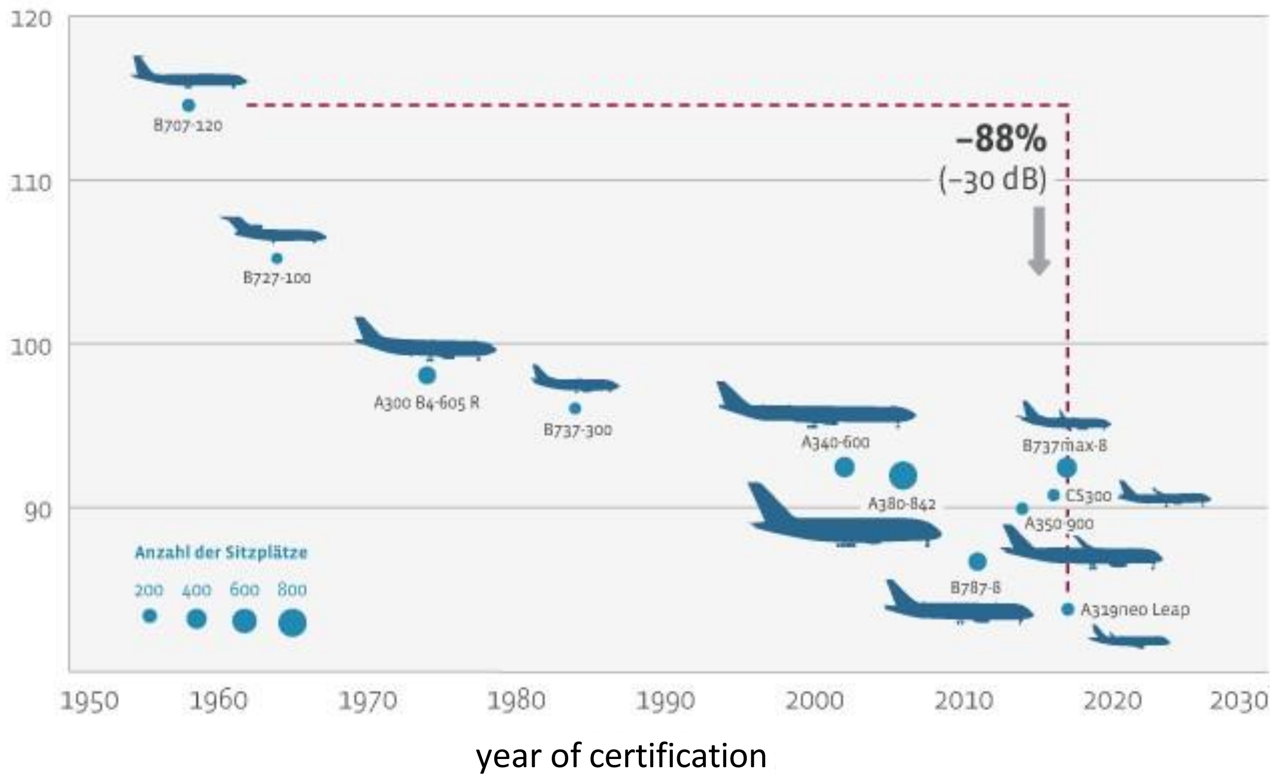
Noise development of aircraft: Reduction by 30 dB (equals 88%)
(metered at sideline, standard norm 500 kN)



Source: BDL Lärmschutzportal

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Compensation hallo

Waste, Wildlife and Trafficking Tourism

Air Traffic Management (ATM) : Pain points in the current set up are costly and cause extra emissions

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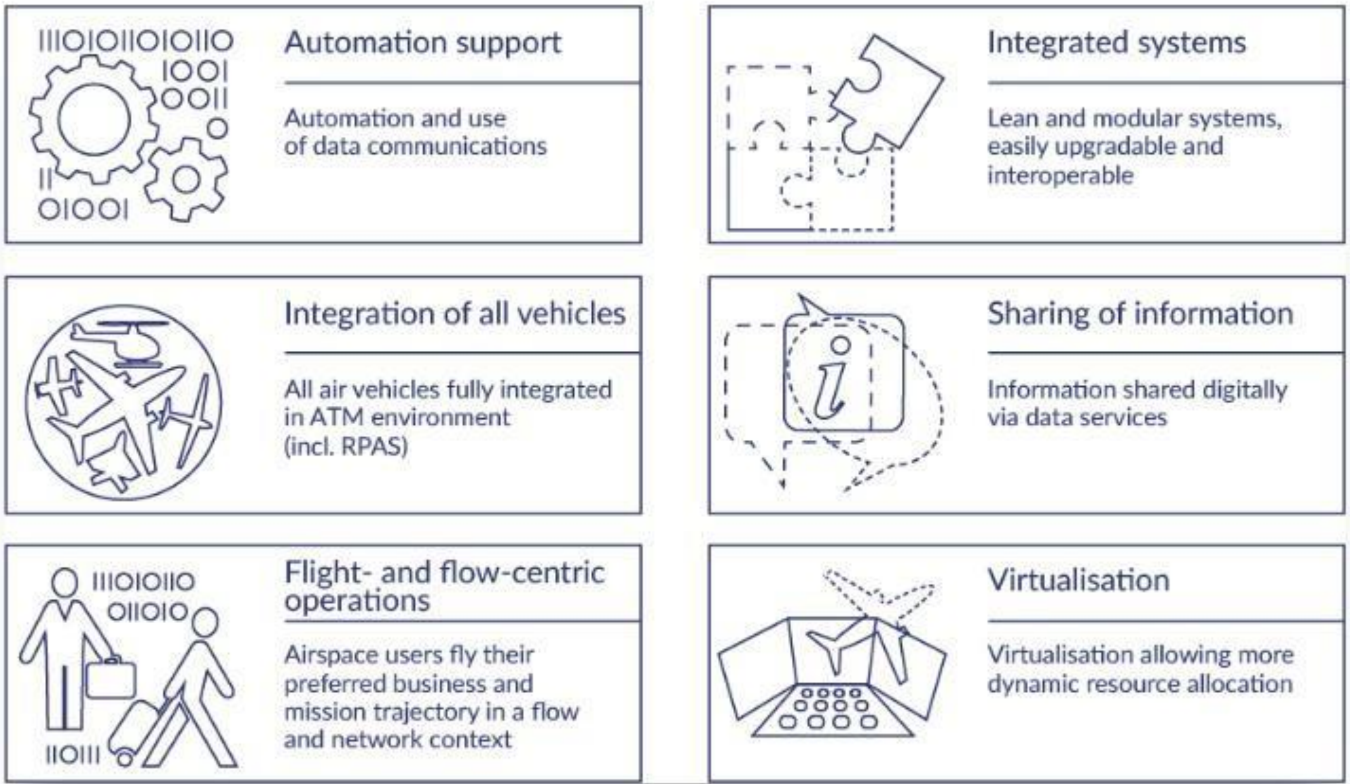
1. **Europe does not have a single sky** with air traffic control managed at European level.
2. **Ageing technologies** call for a fundamental change in air traffic management.

The '**capacity crunch**' due to constant increase in traffic can be avoided through new procedures, technological innovation and elimination of fragmentation.



"The fragmentation of the European air traffic management system is responsible for 3 billion Euro of extra costs a year and 50 million tons of CO_2." Source: EC Press Release Aviation, 2017

Source: https://www.sesarju.eu/vision

SESAR: modern European ATM by developing and delivering new/improved technologies/procedures

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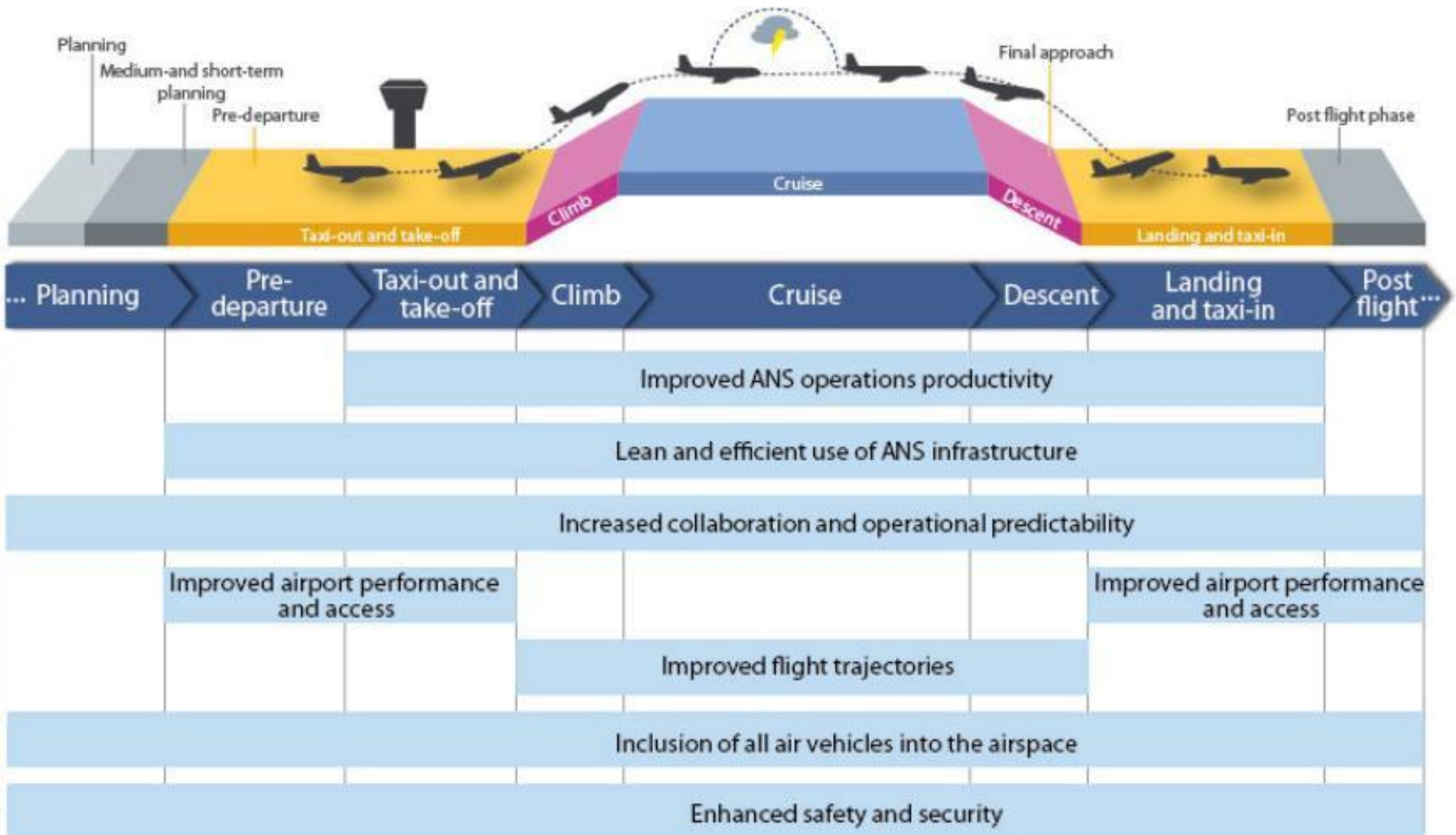

Source: https://www.sesarju.eu/vision

Airports are key nucleus to achieve less local emissions

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Operations related

- Shut off auxiliary power unit of aircraft
- E-mobility
- Energy efficient buildings
- Green energy
- Taxi boot
- Intermodal connectivity

Passenger related

- Waste management
- Responsible supply chain
- Responsible retail and shops

Source: https://www.sesarju.eu/vision

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Deep Dive SAF: HEFA is the most mature while Power-to-liquid, in development, has highest potential

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CO2 from BECCS can be used as feedstock




	HEFA	Alcohol-to-Jet[1]	Gasification/FT	Power-to-liquid
Description	Deoxygenating feedstock and hydrotreating to form hydrocarbons	Fermenting feedstock into an alcohol and processing into a hydrocarbon	Gasification of feedstock into a syngas, mix of CO2 and hydrogen, and combining with hydrocarbon	Producing a syngas by electrolyzing water and mix with captured CO2 to combine with hydrocarbons
Opportunity	Safe, proven, and scalable technology	← Potential in the mid-term, however significant techno-economical uncertainty	→	Proof of concept 2025+, primarily where cheap high volume electricity is available
Technology maturity	Mature	← Commercial pilot	→	In development
Feedstock	Waste and residue lipids, purposely grown oil energy plants[2] Transportable and with existing supply chains Potential to cover 5-10% of total jet fuel demand	← Agricultural and forestry residues, municipal sold waste, purposely grown cellulosic energy crops[4] High availability of cheap feedstock, however fragmented collection	→	Unlimited potential via direct air capture CO_2 and green electricity Point source capture as bridging technology
% LCA GHG reduction vs. fossil jet	70-85%[3]	← 82-94%[5]	→	85-100%[6]

1. Ethanol route;2. Oilseed bearing trees on low-ILUC degraded land or as rotational oil cover crops; 3. Some waste feedstock may also have lower GHG savings; excluding all edible oil crops;4. As rotational cover crops; 5. High share of plastic in MSW may result in lower GHG savings; excluding all edible sugars; 5. Based on CO2 from direct air capture; emission reduction can go up to 100% with a fully decarbonized supply chain

Source: CORSIA; RED II; De Jong et al. 2017; GLOBIUM 2015; ICCT 2017; ICCT 2019; E4tech 2020; Hayward et al. 2014; ENERGINET renewables catalogue; Van Dyket al., 2019; NRL 2010; Umweltbundesamt2016

SAF production is in an early start-up phase - less than 0.5% of industry demand is currently available on the world market

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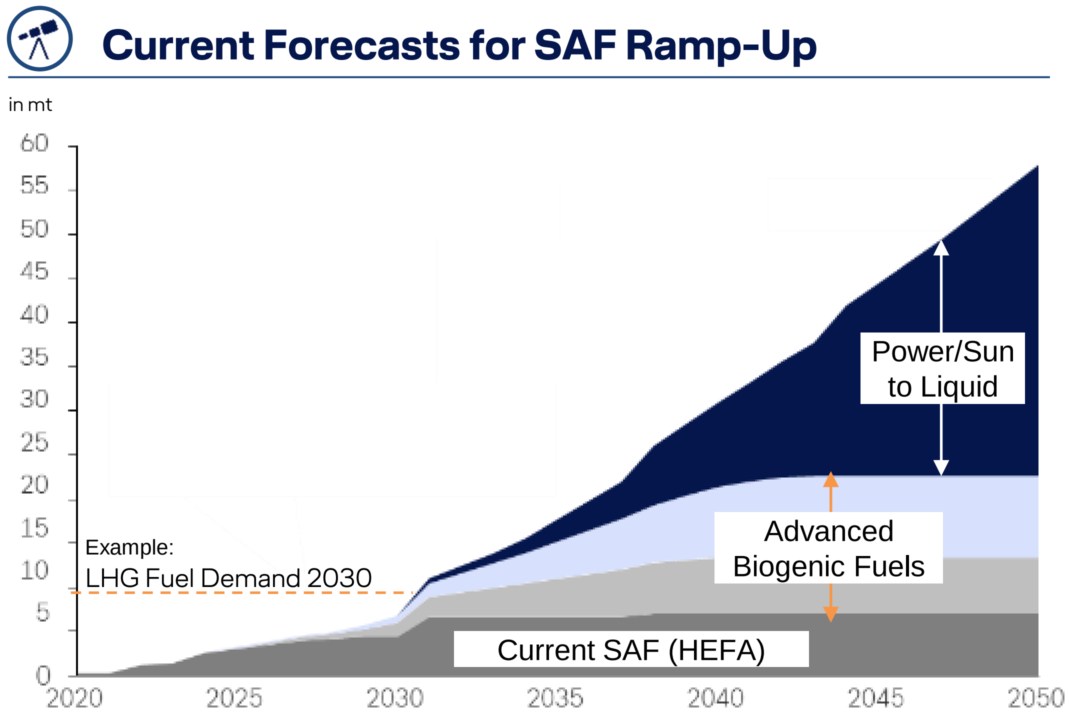

Quelle: WEF Clean Skies for Tomorrow, McKinsey Studien

- **Biogenic fuels** will dominate **until at least 2040**
- Numerous **industries compete for the same raw materials** for sustainable energy production
- **"Power to Liquid"** (PtL) fuels **most promising long-term solution**, but not/barely available in the short term

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What about bio fuel?

Proposition

The LH Group Airlines need a total of ~10 Mio. t fuel.

Bio fuel is best made from canola oil.

Reality

To generate 10 Mio t. of pure bio fuel we would have to cultivate canola on about 80.000km²

That is roughly the size of Lower Saxony and North-Rhine-Westphalia

Source: LH G calculation, own research

Power-to-Liquid (PtL) is a possible option, but is not yet available at large scale

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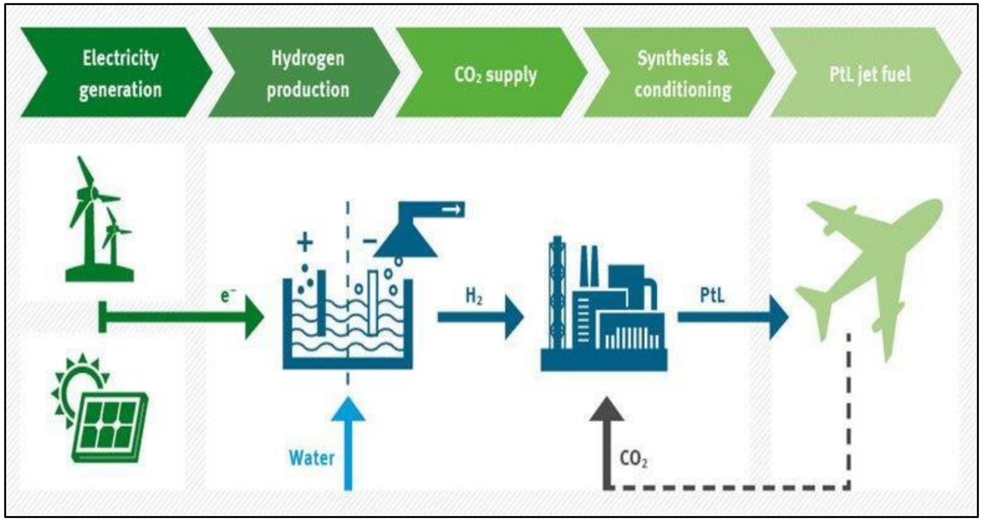
Basic structure of "Power-to-Liquid (PtL)" process



- **Production of hydrogen** from water and renewable electricity
- Use of hydrogen to **re-energize CO2**
- **Conversion** of carbon-hydrogen syngas into **liquid fuels**

Advantages

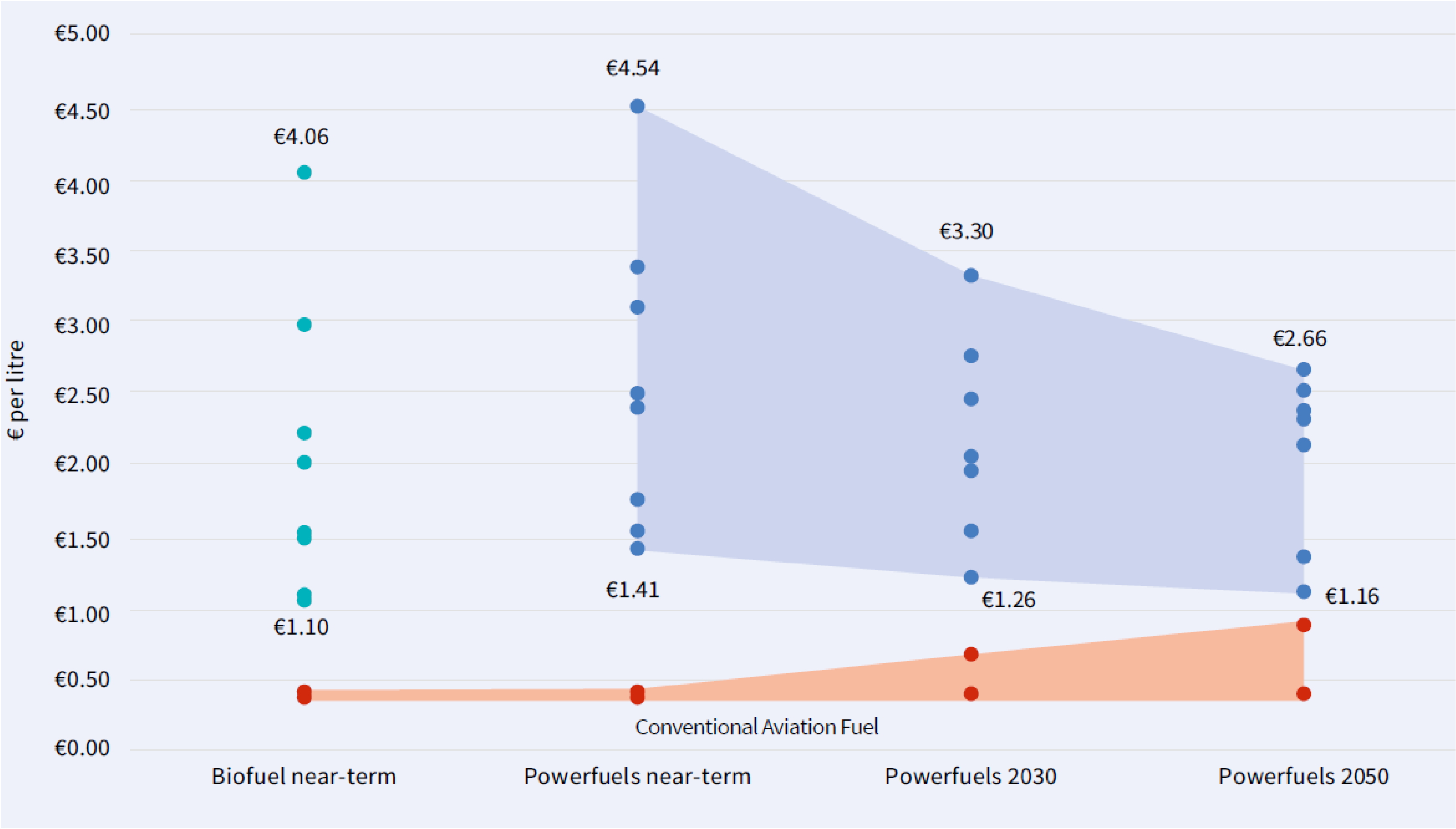
- Necessary **ressources** in principle **not limited**
- Potentially **good** political **support**
- **Compatible** with „Energiewende"
- Can be **integrated** into **existing logistics**

Critical issues

- Requires large scale **storage of hydrogen**
- Required to buffer **fluctuating** availability of **renewable electricity**
- **Availability of CO2** in suitable volume, concentration and purity
- Needs to work at **industrial scale**
- As of now **very expensive** (factor 10 times to fossil kerosene)

Source: SAFUG, BDL, own research

Hugh cost differences depending on estimates



Source: dena, Global Alliance Powerfuels - Powerfuels in Aviation, Oktober 2019

Hugh cost differences depending on location

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Note: Prices of natural gas and premium petrol are based on average values from scenarios by the World Bank and the IEA. Other cost reductions for PtG / PtL may result from advancements in PV, from battery storage that increases full load hours, and from especially large electrolysis facilities. Cost increases may result from higher cost of capital due to higher country risks.

* Offshore wind power
** PV and PV / wind systems
*** Geothermal / hydropower (total potential limited to 50 terawatt hours)

Note: 10 cents per kilowatt hour is equivalent to around 90 cents per liter of liquid fuel.

Source: *Frontier Economics, in: Agora Verkehrswende and Agora Energiewende (2018).*
Note: *Without network charges and distribution cost.*
PtX production cost in in North Africa and the Middle East include transportation cost to Europe.

8,84 kWh per ltr petrol or kerosene
Example calculation:
Price gasoline at station

before taxes*	51 ct/ltr
Energy tax	65 ct/ltr
VAT	22 ct/ltr
Total	139

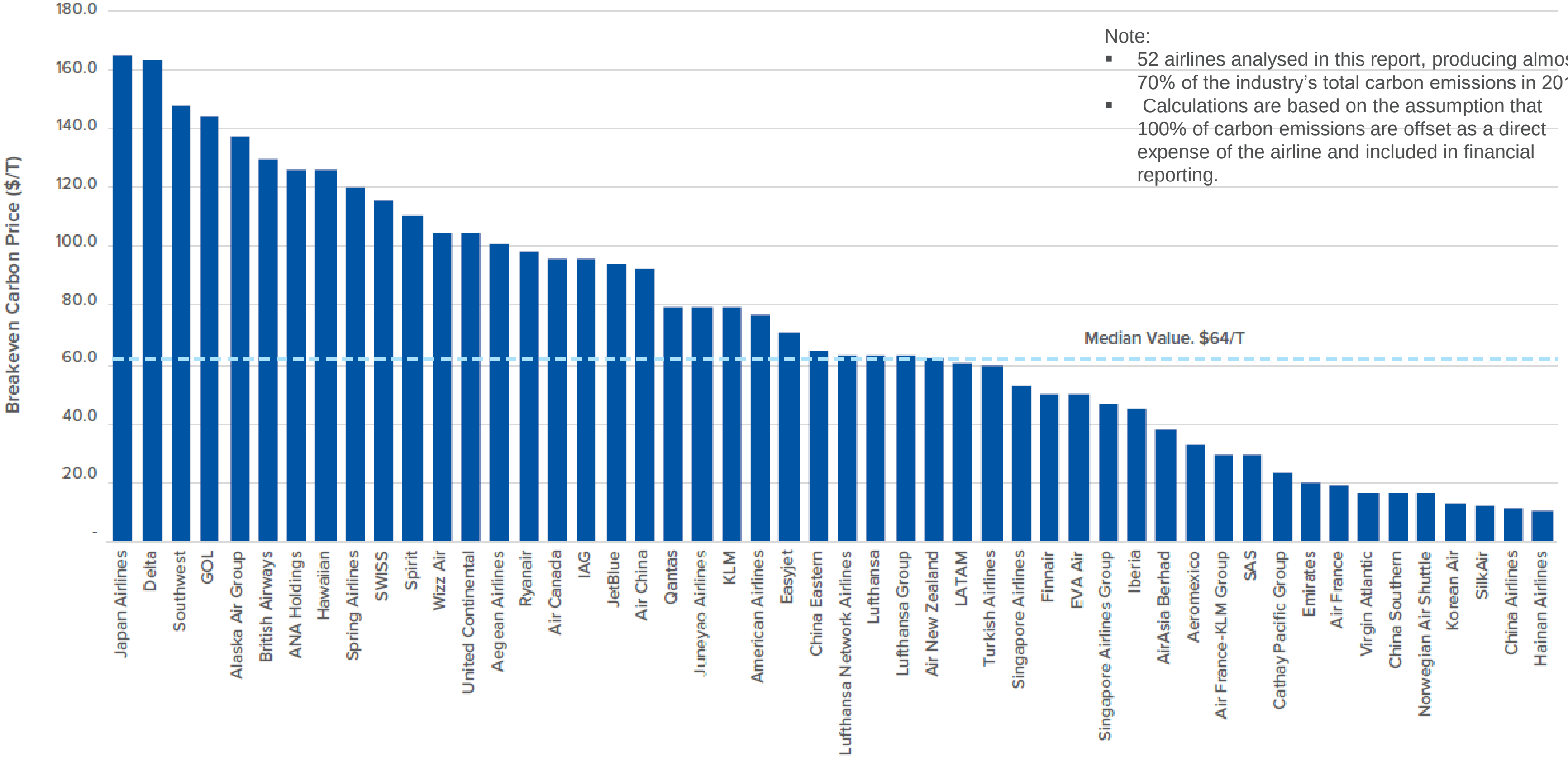
Cost per kWh:

Before tax*:	5,8 ct/ltr
Energy tax	7,4 ct/ltr
VAT	2,5 ct/ltr
Total	15,6

*) include transport, profit
Source: BMF 2018

Strong material disparity in breakeven carbon price for airlines

Breakeven Carbon Price by Airline in 2019

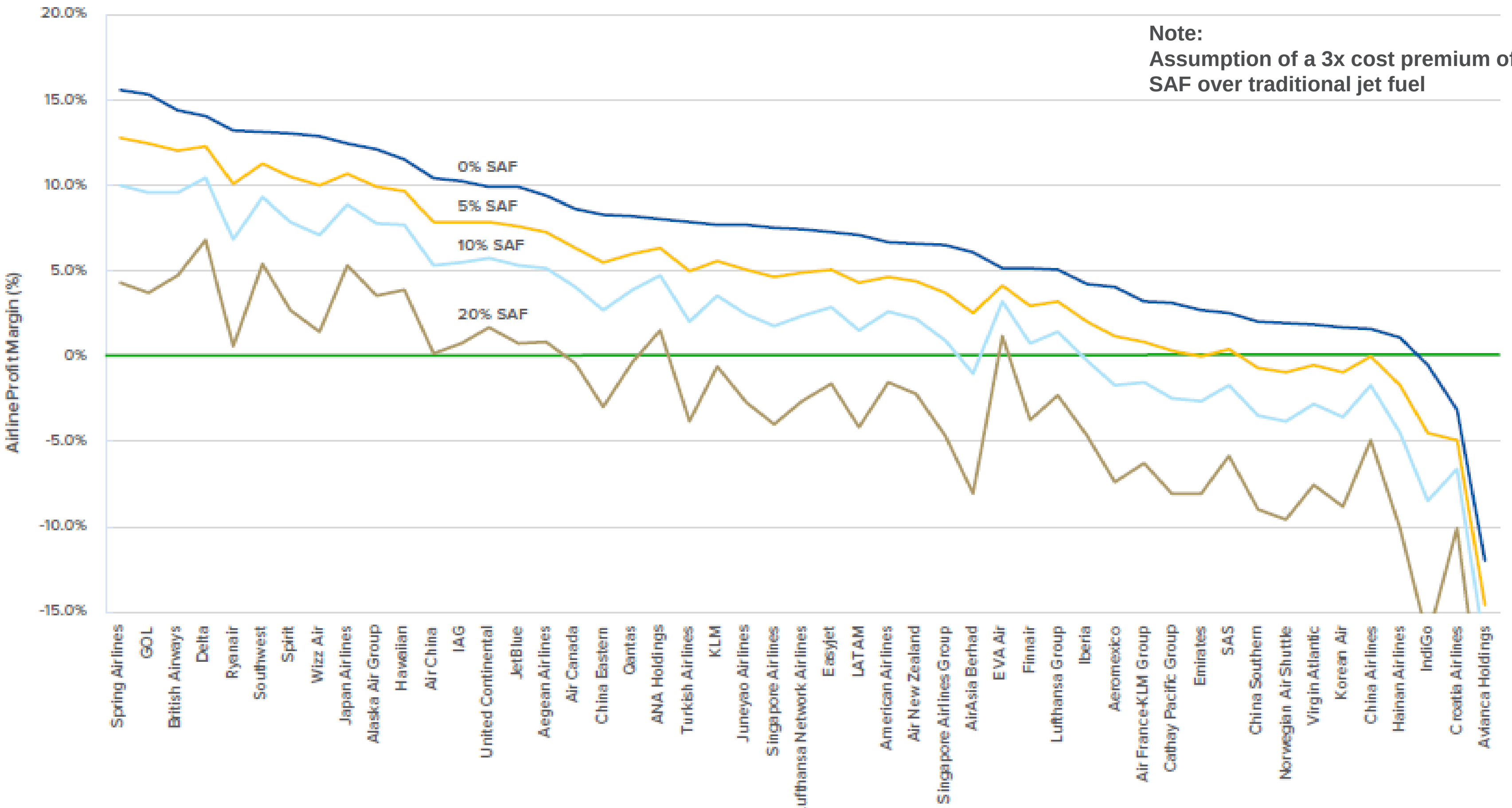


Note:
- 52 airlines analysed in this report, producing almost 70% of the industry's total carbon emissions in 2019
- Calculations are based on the assumption that 100% of carbon emissions are offset as a direct expense of the airline and included in financial reporting.

- The top quartile airlines could have absorbed a 2019 breakeven carbon price of USD133/tonne, the bottom quartile only USD19/tonne, a differential of over USD110/tonne
- External views on carbon pricing under the Paris Agreement are typically in a range of between $40 and $80 per tonne in 2020 and rising to levels closer to $100 per tonne by 2030

Source: CAPA – CENTRE FOR AVIATION, ENVEST GLOBAL AND AIRLINE REPORTS

Impact of Increasing SAF use - No Revenue Increase Resulting in Decreased 2019 Profit Margin

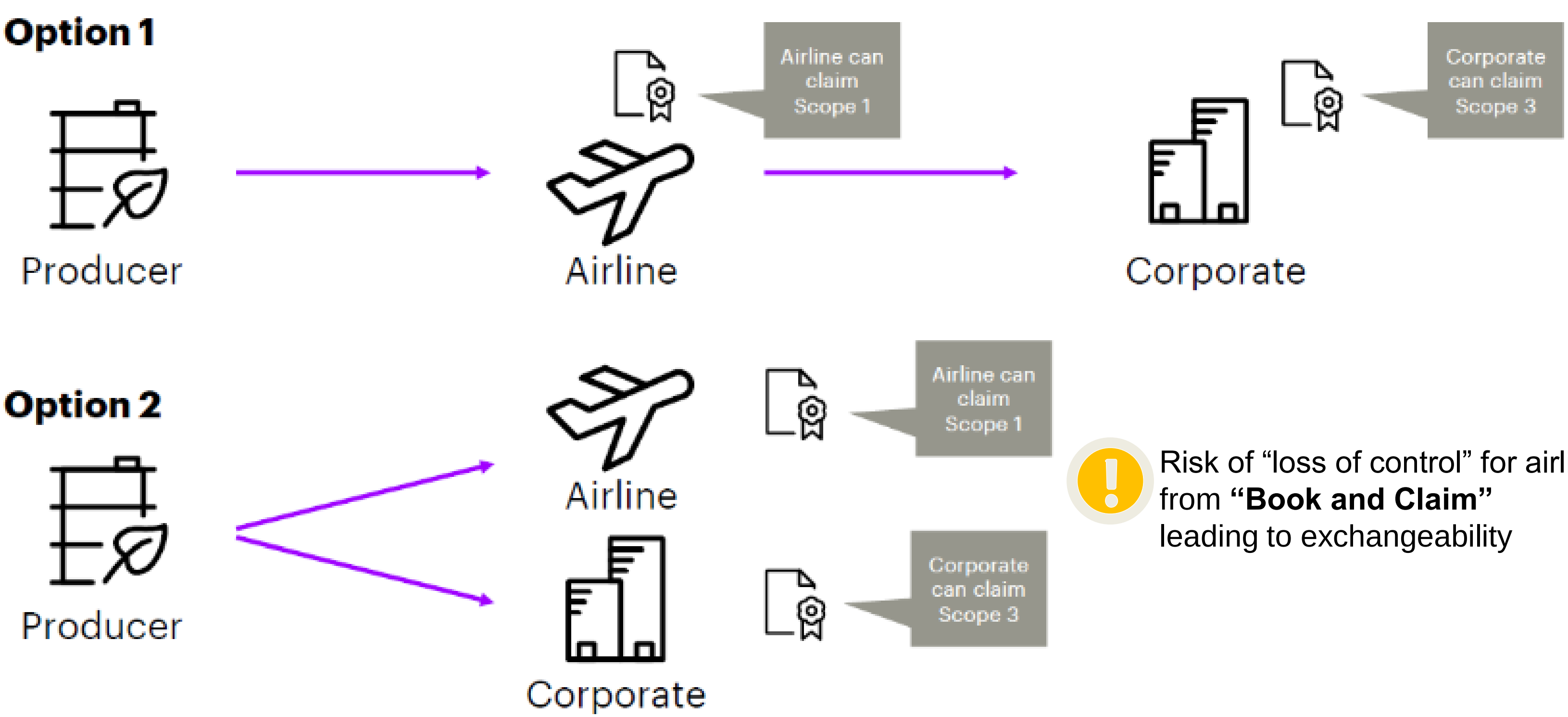


- At 5% SAF adoption, the top quartile of airlines would see operating profit margins reduce from 13.2% to 10.7% (-20%), Airlines in the bottom quartile a margin reduction from 1.7% to -0.9%
- At 10% SAF adoption, margins would drop to 8.2% and -3.5% respectively for the top and bottom quartile.

Source: CAPA – CENTRE FOR AVIATION, ENVEST GLOBAL AND AIRLINE REPORTS

Transaction Flows in change - Corporates can purchase SAF certificates from the producer or from the airline

SAF transaction flows in the market



Risk of “loss of control” for airlines from **“Book and Claim”** leading to exchangeability

Source: Accenture – Sustainability in Aviaiton

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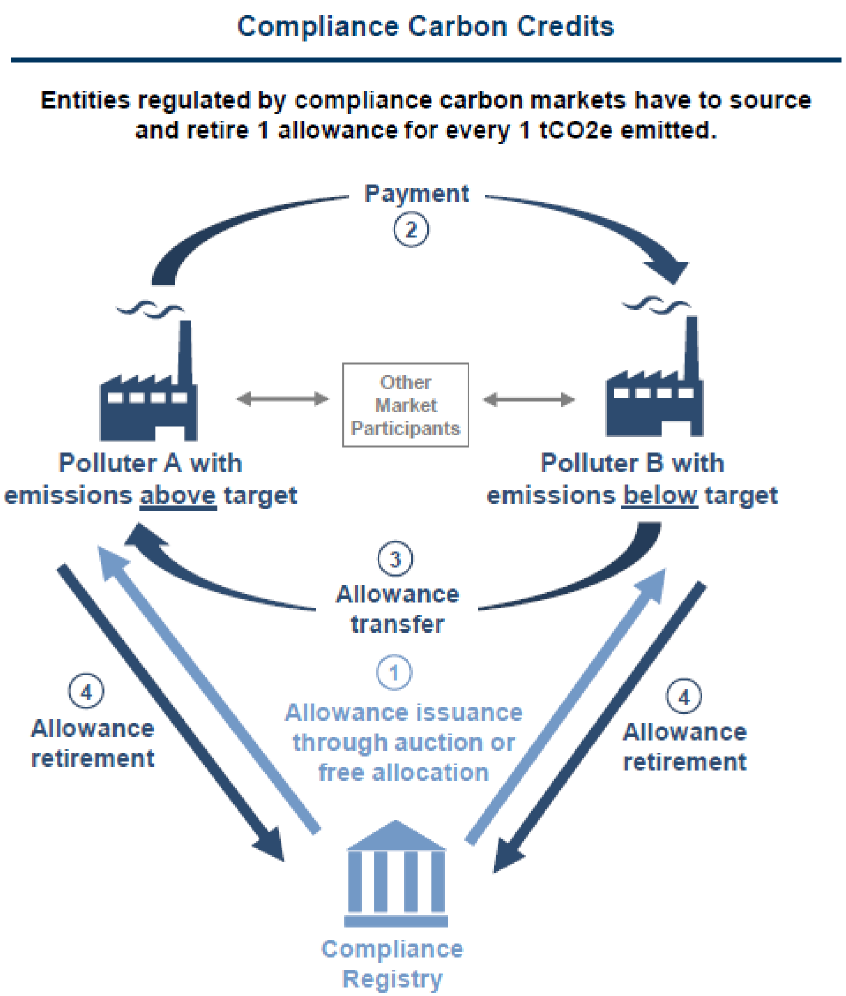
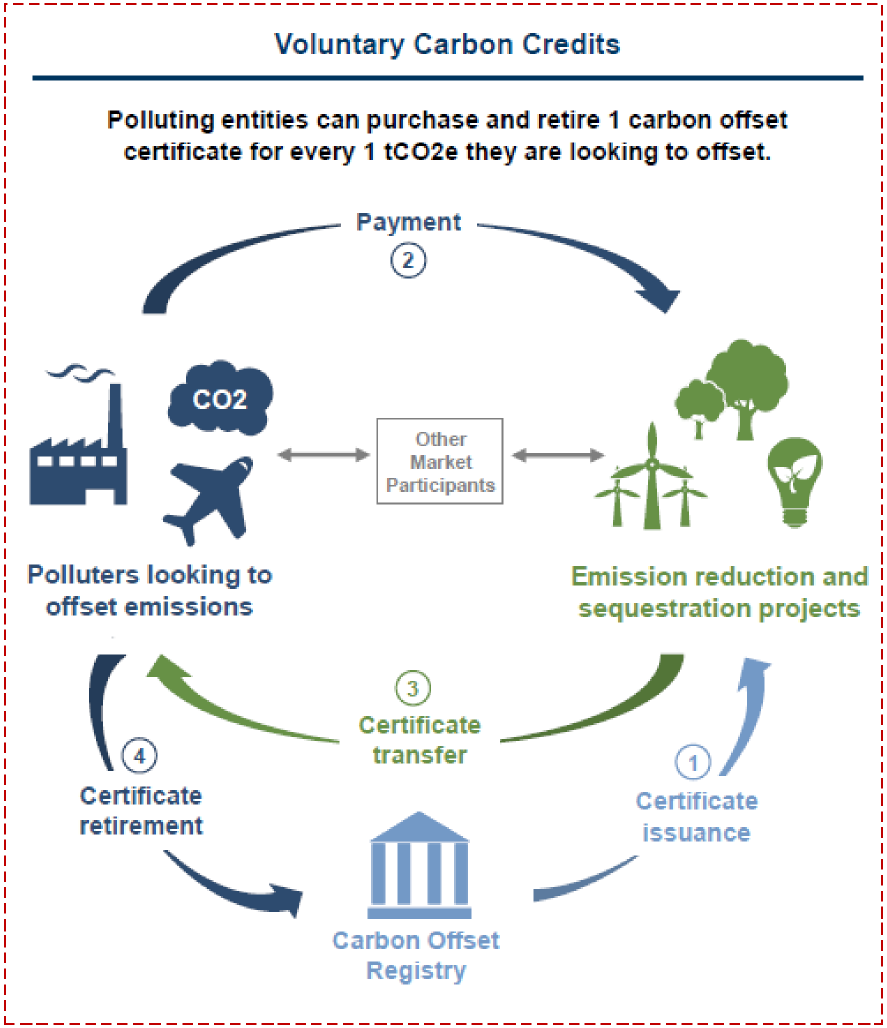
Comparison of Voluntary Carbon Credits vs. Compliance Carbon Credits





e.g. EU ETS

e.g. CORSIA

Source: Goldman Sachs Global Markets Division.

Complex universe of “classic” compensation types – New “technical” compensation emerging slowly

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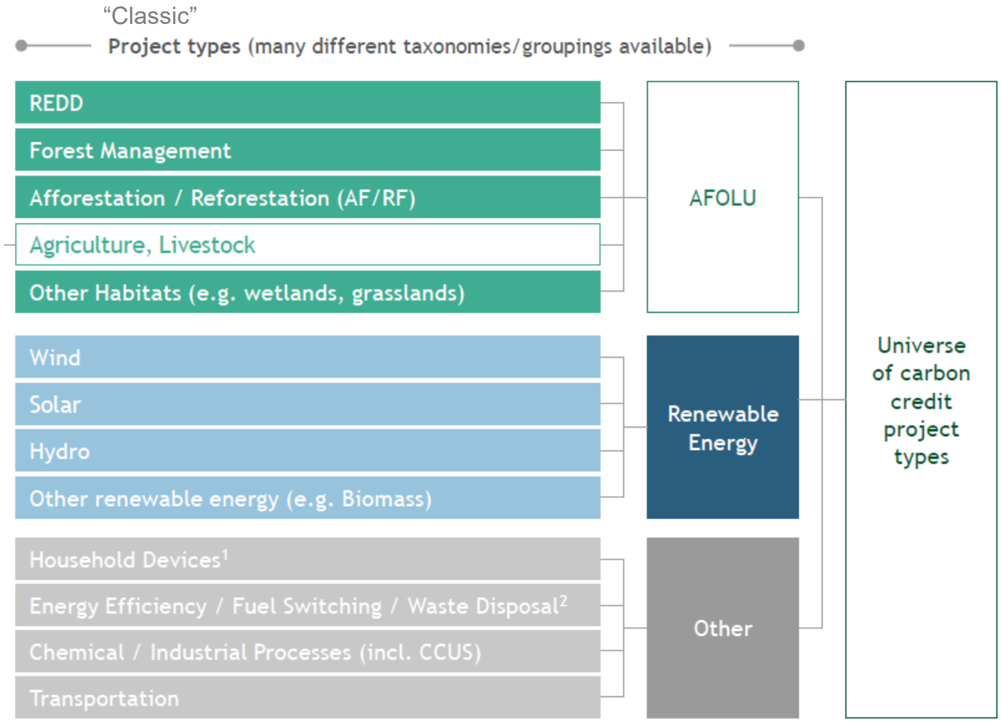

New (technical) compensation types (not exhaustive)

Hybrid strategies

Technological solutions


Ocean based removal


Direct Air Carbon Capture & storage


Biochar


Mineralization

Source: Boston Consulting, own research

Voluntary Carbon Offset Market Oversight

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Independent Framework and Rule-Making Bodies

- Independent organizations organize multi-stakeholder groups to discuss, design and recommend frameworks for carbon offset generation and application

IETA International Emissions Trading Association · ghg management institute · SEI Stockholm Environment Institute · WWF · Greenhouse Gas Protocol · ICROA International Carbon Reduction & Offset Alliance · PCAF · World Resources Institute · EDF Environmental Defense Fund · Science Based Targets

Universe of Voluntary Carbon Offset Standards / Approvers / Calculators

- Nonprofit and for-profit entities that set project requirements ("Standards") and rules for issuance, exchange and retirement of carbon offsets
- ICROA, an Independent Framework and Rule-Making Body, is widely accepted as the Standard filter. Standards that pass the ICROA test are typically widely accepted
- Some Standards (and the most broadly accepted Standards in particular) may establish a Registry where carbon offsets exist and are retired

American Carbon Registry · ART · puro earth · Verified Carbon Standard · USDA · Woodland Trust · FRESCOS · Gold Standard · Climate Action Reserve · NORI · Plan Vivo · UNFCCC

ICROA

Real	Unique
Permanent	Additional
Measureable	Independently Verified

ICROA-Approved Standards

American Carbon Registry · Gold Standard · Verified Carbon Standard · Climate Action Reserve · UNFCCC

Auditors

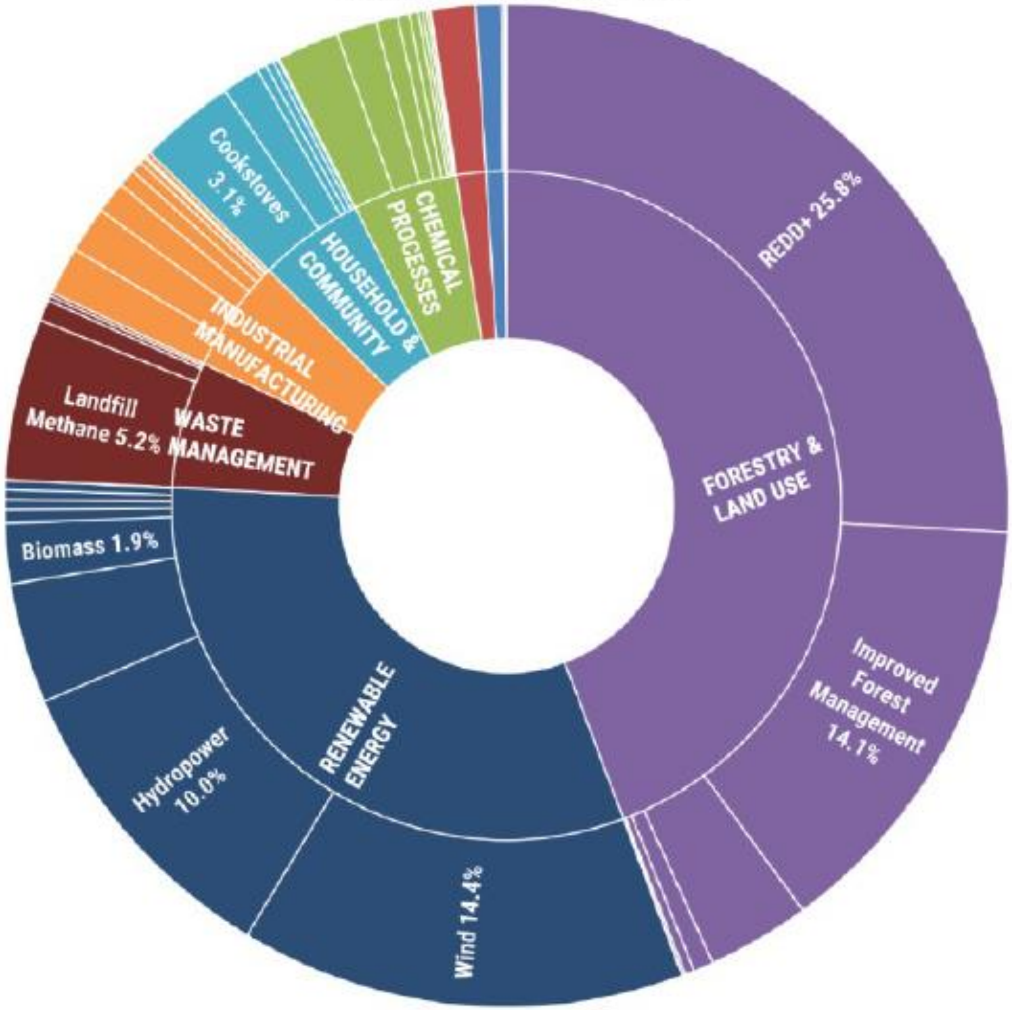
- Review and confirm information submitted to Standards for project certification and offset verification
- Audit End Users' application of offsets in accordance with framework(s)

EY · SCSglobal Services · pwc · KPMG · First Environment

Source: BofA Securties

Nearly half of carbon offsets issues in 2020 were forest and land use projects

Credits Issuances by Type



Source: Berkeley Carbon Trading Project, University of California, Berkeley

Offset prices expected to increase significantly driven by supply deficit from 2025 onwards

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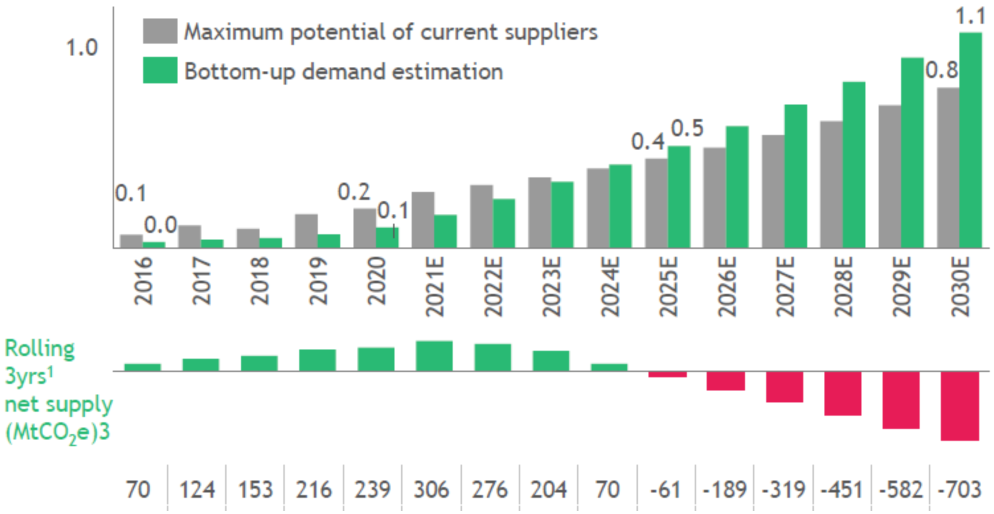
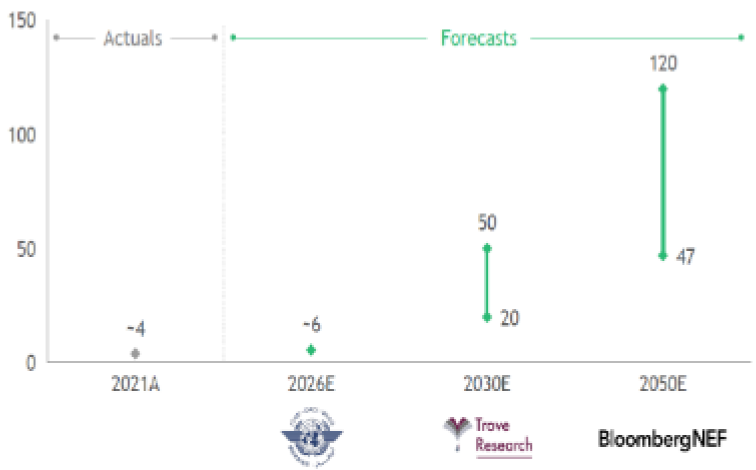
Demand & supply for voluntary carbon credits (GtCO2e p.a.)



Forecast for carbon offset prices ($/tCO2e)



1. 3 years represents general acceptance for offset vintages before they get discounted for their older age

Source: Forest Trends, Verra, Gold Standard, ACR, CAR, UN IPCC, industry interviews, ICAO, 2021; Trove Research, 2021; BloombergNEF, 2022; BCG analysis

Diverging Guidance on Offsetting

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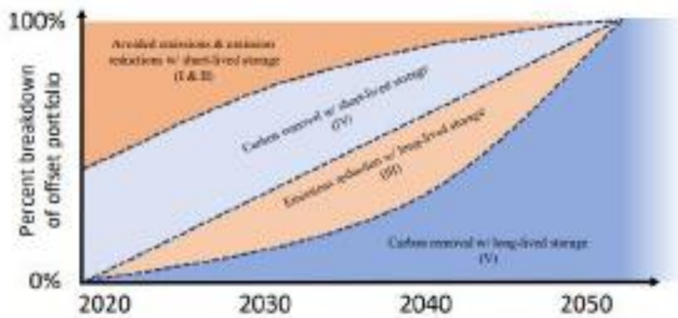
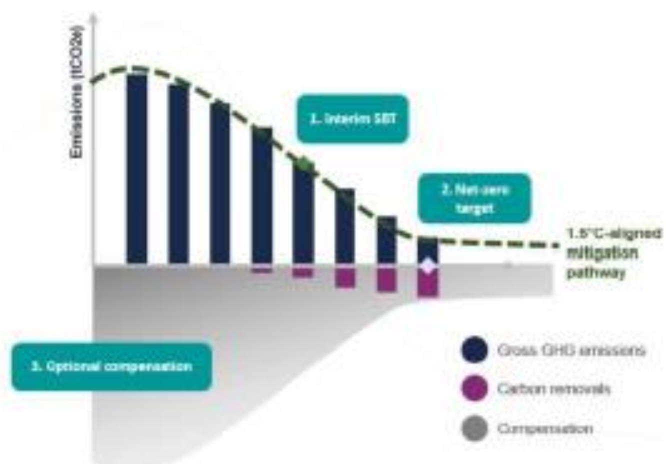
Oxford Offsetting Principles:

Recommend using **all offset types** (avoidance & removal; short- and long-term storage) but with a shift towards full carbon removal with long-term storage by 2050



Science-Based Targets:

Latest draft guidance suggests mandatory **carbon removal** for unabated emissions; avoidance offsets only considered as an optional tool



There is a lack of consensus in third party guidance on which types of offsets should be used on the path to net-zero. Clear trend towards removal offsets.

Source: Goldman Sachs Global Markets Division. Science Based Targets Initiative. Oxford University.

Why 2021 Might Prove An Important Year for the future of voluntary compensation

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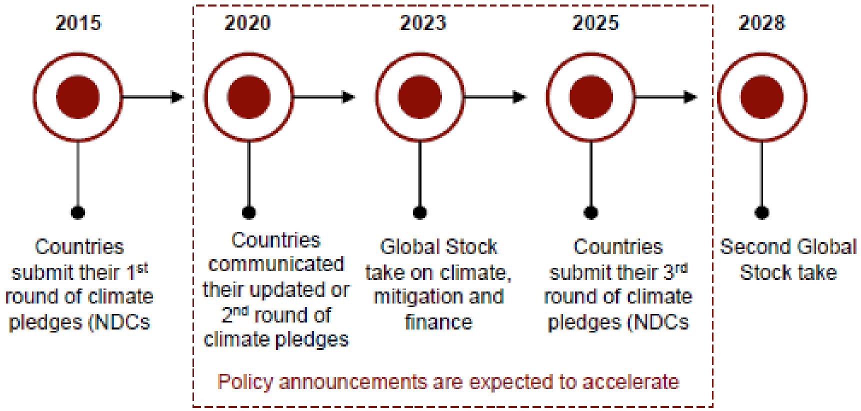
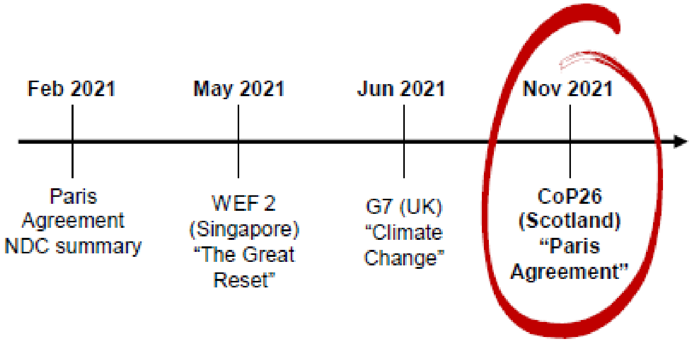
The broader context: Execution of Paris Agreement...



Several key events in 2021 despite Covid19...



...with global political will being more aligned than ever

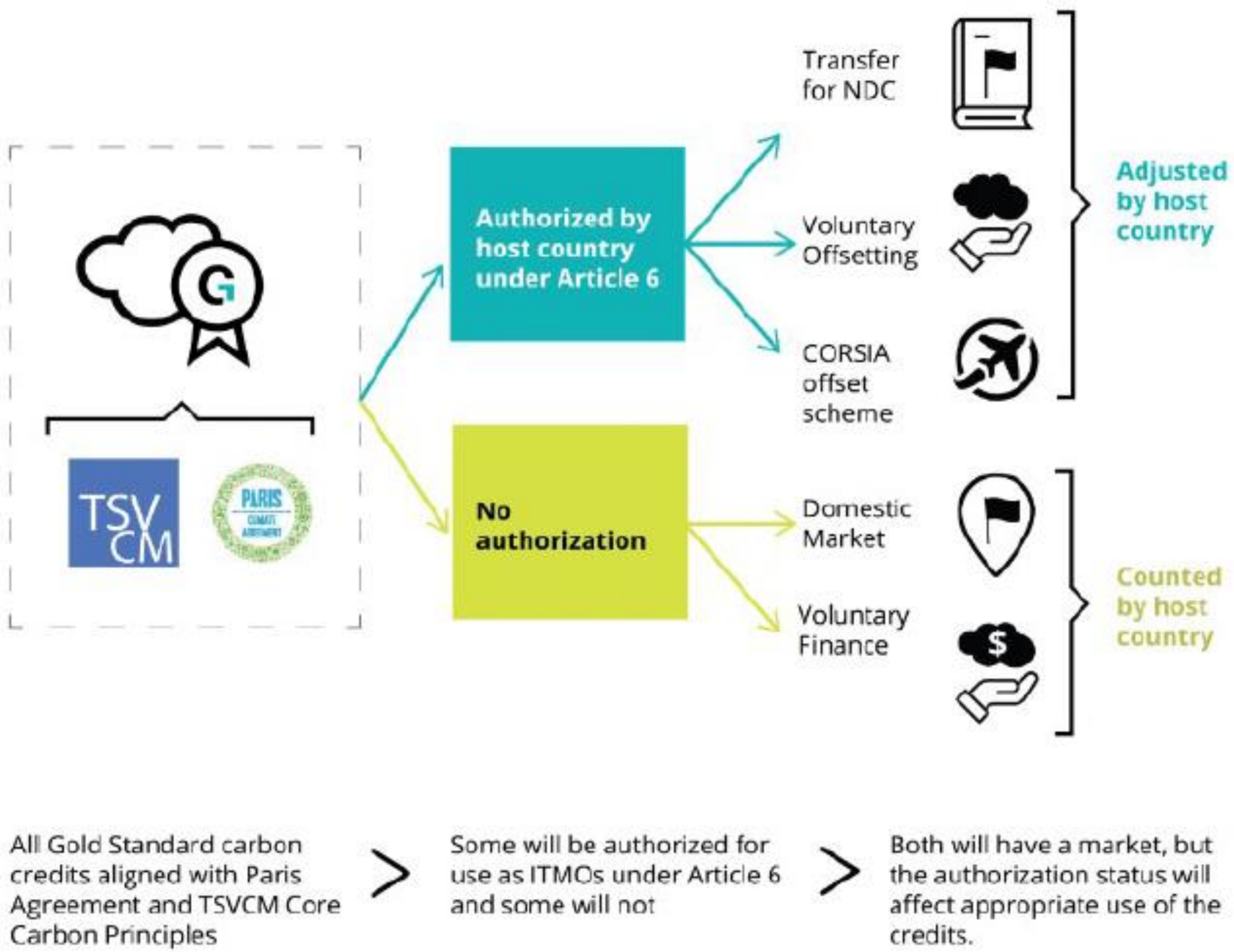
- **"Biden returns US to Paris climate accord"** Jan-2021
- **"China announces carbon neutrality by 2060"** Sep-2020
- **"EU makes legally binding commitment for net zero"** Mar-2020

...and big topics with carbon market impact on the COP26 agenda

Carbon Markets (Article 6)	Climate Change loss & damage
$100bn Climate Change Finance Target	Role of Nature-Based Solutions

Source: Goldman Sachs Global Markets Division.

Time after Article 6: Gold Standard sees a market split between authorized credits and non-authorized credits



Source: Gold Standard

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Industry Action

Introduction: Aviation Areas of Action

Technology – Fuel and Noise effective

Processes and Infrastructure– Fuel and Noise effective

Sustainable Aviation Fuels

Compensation

Waste, Wildlife and Trafficking

Human Trafficking and Wildlife Trafficking are important issues to be looked at

Source https://www.iata.org/policy/consumer-pax-rights/Documents/human-trafficking-guidelines-v1.pdf

Aviation is affected by Human Trafficking

Human Trafficking (HT) is a crime against humanity and a grave violation of fundamental human rights. It is the fastest growing and second largest criminal industry in the world. It is estimated that **24.9 million people** are trafficked globally, **more than 75% of which are women and children***.

It involves the "**recruitment, transportation, harbouring or receipt of persons by means of the threat or use of force** other forms of coercion, of abduction, of fraud, of deception, of the abuse of power or of a position of vulnerability or of the giving or receiving of payments or benefits to achieve the consent of a person having control over another person, for the purpose of exploitation**".

*International Labour Organization (ILO), Global Estimates of Modern Slavery, 2017 and United Nations Office of Drugs and Crime (UNODC), Global Report on Trafficking in Persons, 2016

** Protocol to Prevent, Suppress and Punish Trafficking in Persons, Especially Women and Children agreed at Palermo (2000)

Over 60% of victims are trafficked across international borders

Traffickers **misuse the speed and efficiency of aviation to transport victims** who may be traveling undetected on aircraft and through airports

The aviation industry is committed to playing its part to help governments and law enforcement tackle this issue by raising awareness and by training staff to spot the signs of potential human trafficking

Source https://www.iata.org/policy/consumer-pax-rights/Documents/human-trafficking-guidelines-v1.pdf

Wildlife Trafficking is a global Issue and "Business"

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7-23 bn $ estimated and annual volume of Wildlife Trafficing Crime (WTC)

- Ivory, rhino horn, reptiles and birds collectively account for over 60% of all trafficked wildlife, according to the United Nations Office On Drugs and Crime (UNODC).
- Other mammals, including pangolin (the world's most trafficked mammal), and marine species make up a further 20%.

HT & WTC bear risks for Airlines

- Negative press and impact on brand
- Liability for negligence and poor checks
- Financial risk arising from brand and legal risks
- Health and safety arising from animals on board

Commitment to Counteract

- Buckingham Palace Protocol signed by 61 Airlines
- Co-operation with Airports and Authorities (customs, police, NGO)
- Teaching stakeholders
- Training Staff

Sources: 'Flying Under The Radar', C4ADS, ROUTES 2017; 'In Plane Sight', C4ADS, ROUTES August 2018. IATA

Some data on waste…

40-50

Single use plastic products on a long haul flight

35-50.000t

Waste from Onboard Catering p.a.

104 tons

Reused ReOil Cups

(10 Mio cups collected by crew)

370 Mio

Single use plastic pieces per year to replace

65% of all consumers connect plastic with **pollution of oceans**

Waste **Composition** Onboard Service

13% Plastics
15% Recycling
34% Liquids
38% Residual

up to **70kg**

plastic waste per long-haul flight

4.900 t

Waste at SWISS in ZRH

74 % **burnt**

26 % **recycled**

Source: IATA

An European Project to tackle Cabin Waste showed the complexity of cabin waste reduction

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LIFE Zero Cabin Waste - Tackling international airline catering waste by demonstrating integral and safe recollection, separation & treatment

LIFE15 ENV/ES/000209

From 2016 until 2019, driven by IBERIA

ZERO CABIN WASTE

Objective and facts

- Air passengers generate 0.82 kg to 2.5 kg of waste per flight depending on distance and cabin class, with an average of 1.43 kg (IATA, 2014)
- According to the Airports Council International, this equates to around 9 billion kg of cabin waste annually
- Today cabin waste (both organic and inorganic) is usually incinerated or disposed in landfill
- Note: Catering waste coming from outside the EU, is restricted to landfilling according to Regulation EC 1069/2009
- LIFE Zero Cabin Waste aimed to create an integrated model to reduce, reuse and recycle waste collected on airplanes, and to establish processes to replicate

Results

- Waste generation was reduced by 12%, higher than the 5% target
- Only 42% of cabin waste was diverted from landfill instead of the expected 80%. While MSW cabin waste can be collected, its recovery as compost or some other option proved difficult
- Separation of waste on board has proven to be a possible practice for Iberia
- The objective of showing that international waste can be processed without risk to human or animal health was not achieved - changing of legislation needed
- Also, while the project succeeded in lowering the carbon footprint of cabin waste, the expected rate was not reached

Source: https://www.cabinwaste.eu/en/home, EU Commission-Life public database

Summary of Chapter 4

Key messages on the regulation of ESG in the aviation sector

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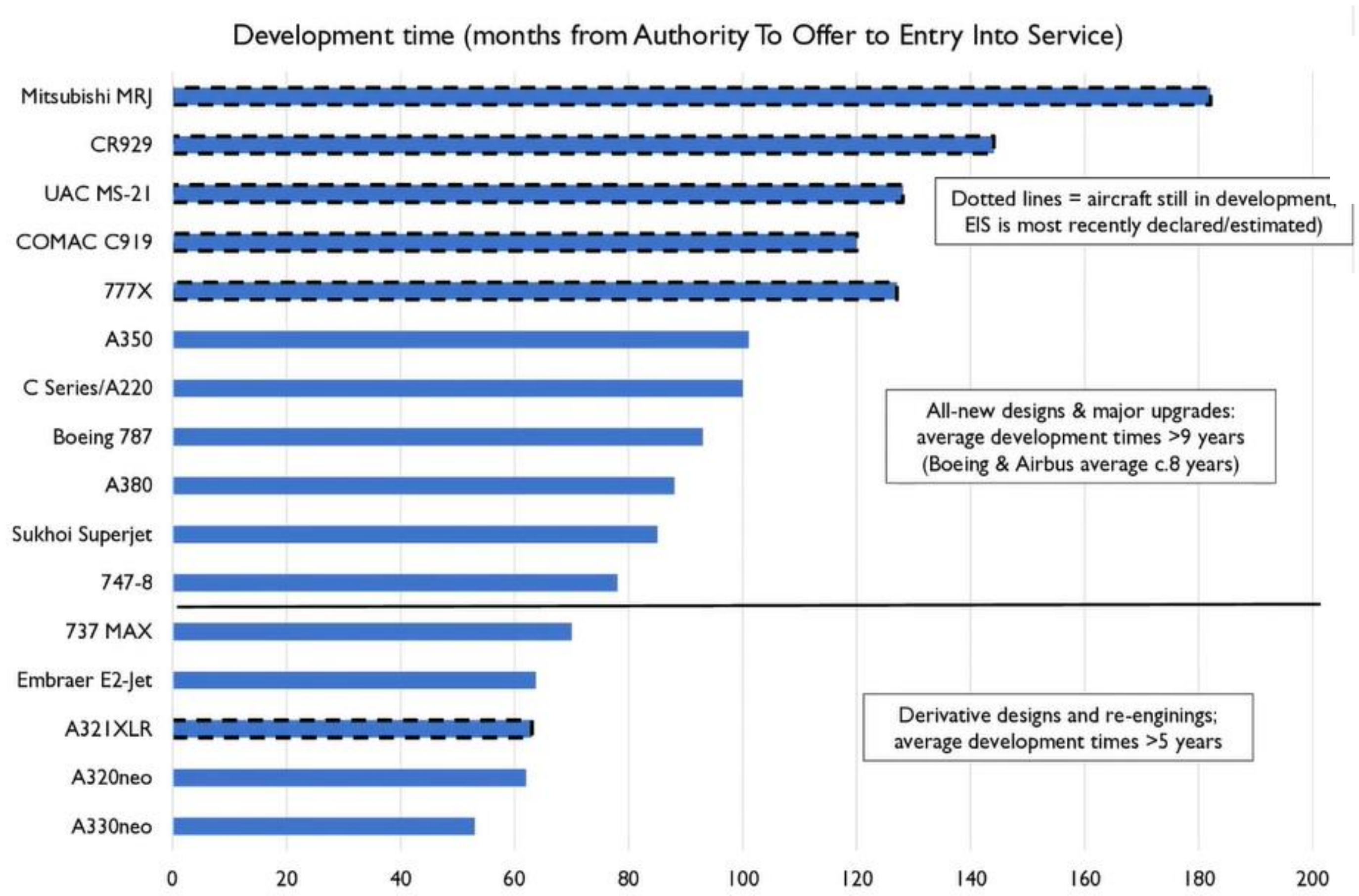
1. The only answer for a big reduction in CO_2 emissions of aviation in the mid-term are Sustainable Aviation Fuel (SAF)
2. New propulsion technologies like Hydrogen or Battery-Electric will only scale during the mid 2040s and be limited in range
3. Air traffic management has also a reasonable potential but is limited due to political restrictions e.g. in founding a Single European Sky
4. SAF needs time to scale, especially the very scalable Power to Liquid fuels
5. SAF will remain much more expensive than fossil fuels and will pose a profitability risk especially for financially weaker airlines
6. Compensation (voluntary) has to fill the gap until new technologies and SAF are widely available. It is a very fragmented industry and faces challenges after implementation of the Paris agreement

Backup SMAT 4

Is the aviation industry able to develop new technology aircraft in time?



Source: Agency Partners (Aviation Week Webinar)

Industry structure apt for risky innovations?

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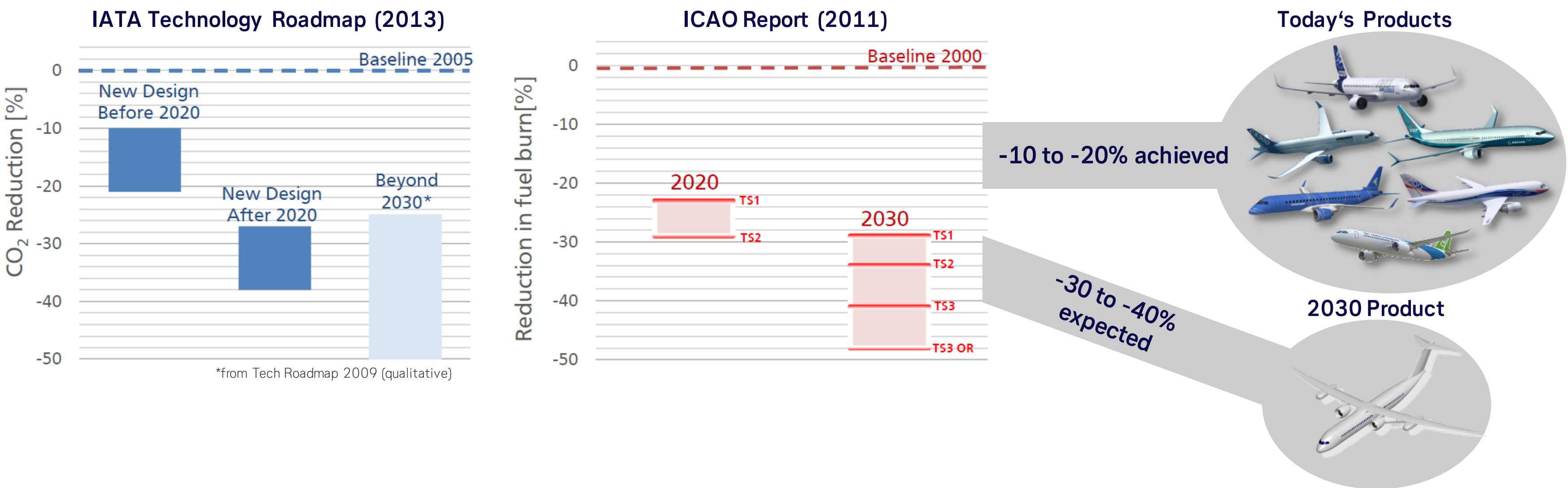


- Next Gen Aircraft requires **large investment**
- Aircraft will be **operated for decades** to come
- Without **quantum leap in technology** long term sustainability of air transport comes into question
- **WANTED**: Sustainable design with lowest DOC

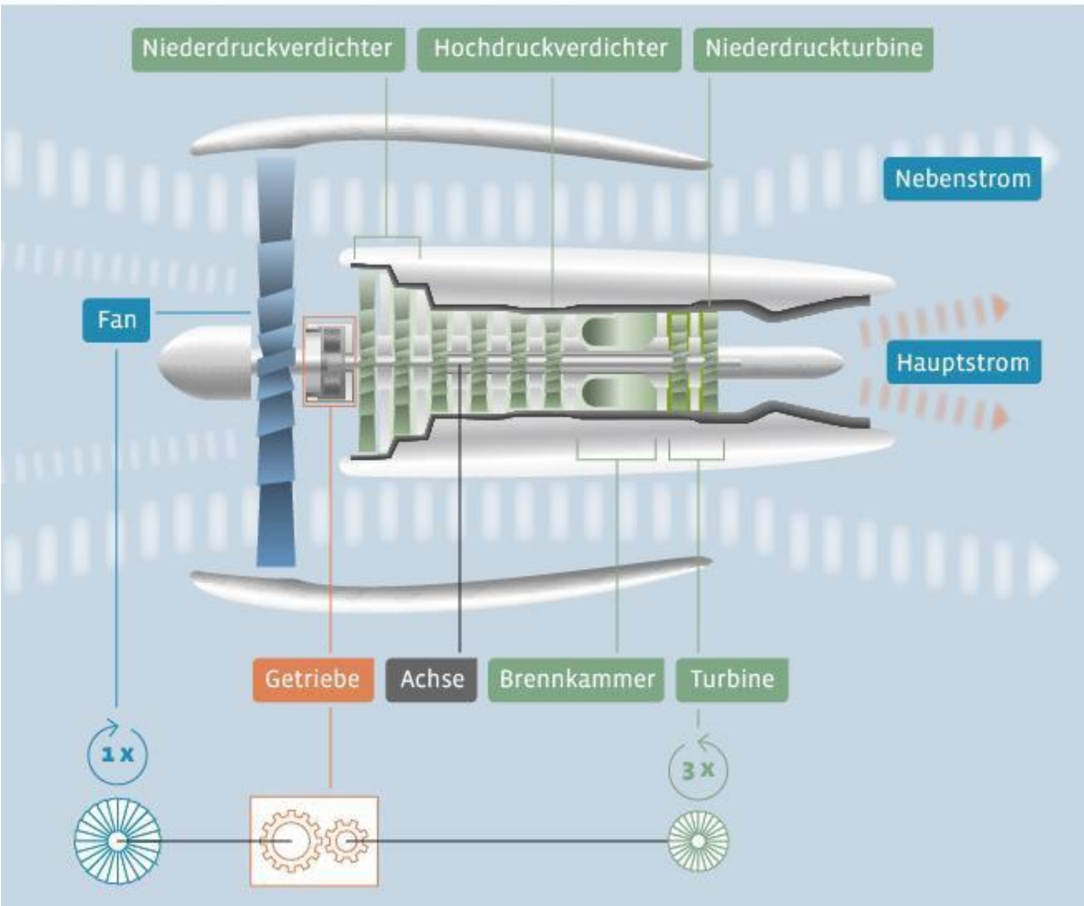
Source: Agency Partners (Aviation Week Webinar)

LUFTHANSA GROUP

New Engine Technology reduces Noise Pattern significantly

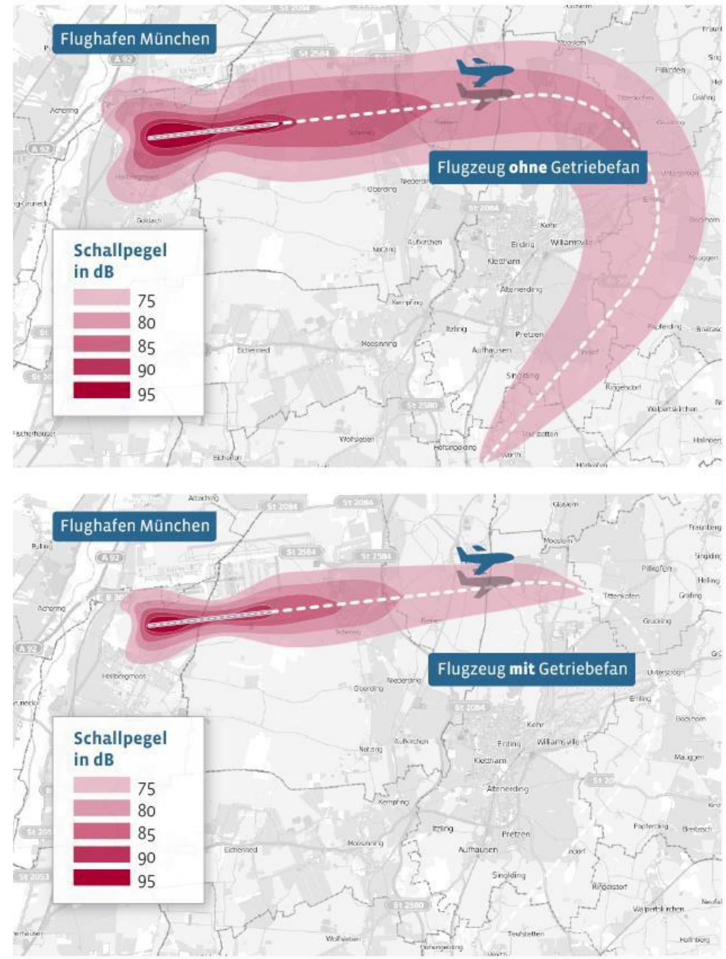
Weniger Fluglärm durch optimale Drehzahlen

Zwischen Niederdruckverdichter und Fan wurde ein Getriebe eingefügt



Weniger Fluglärm durch Getriebefan-Triebwerke

Ausbreitung der Fluggeräusche beim Start



Quelle: nach Informationen der MTU Aero Engines | Kartenmaterial: OpenStreetMap.org

Source: BDL Lärmschutzportal

Chevron nuzzle and transmission technology of the engine reduce noise

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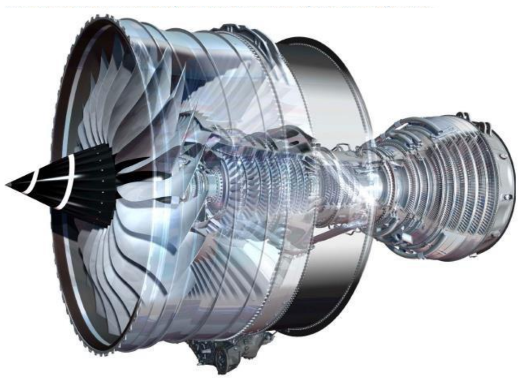
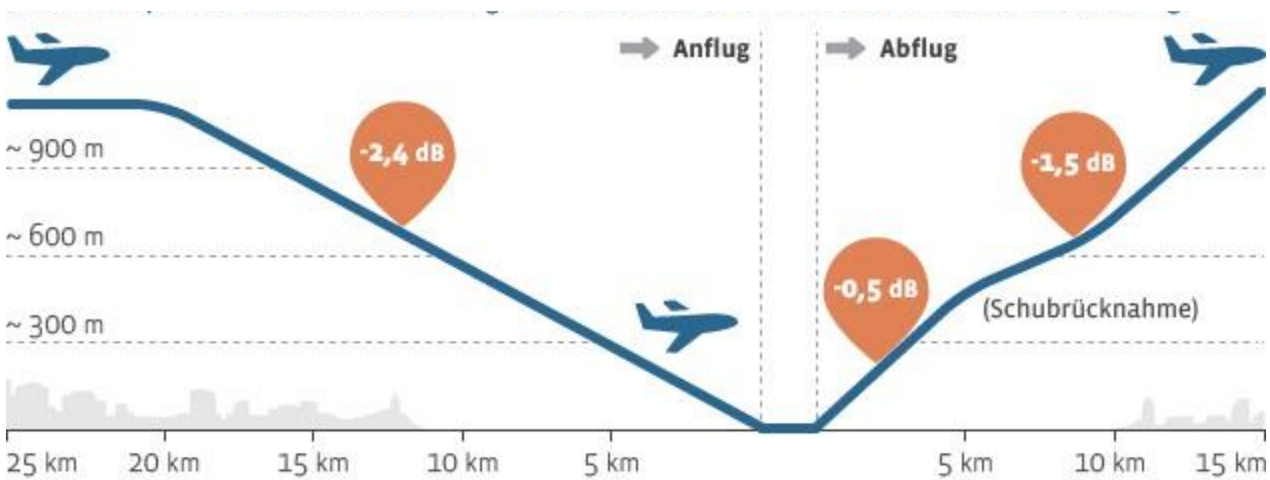


Quelle: Rolls-Royce

Quelle: TUIfly



Quelle: forum flughafen & region – Gemeinnützige Umwelthaus GmbH

Fuel Alternatives : E-mobility and Hydrogen Are No or Limited Alternatives to Kerosene

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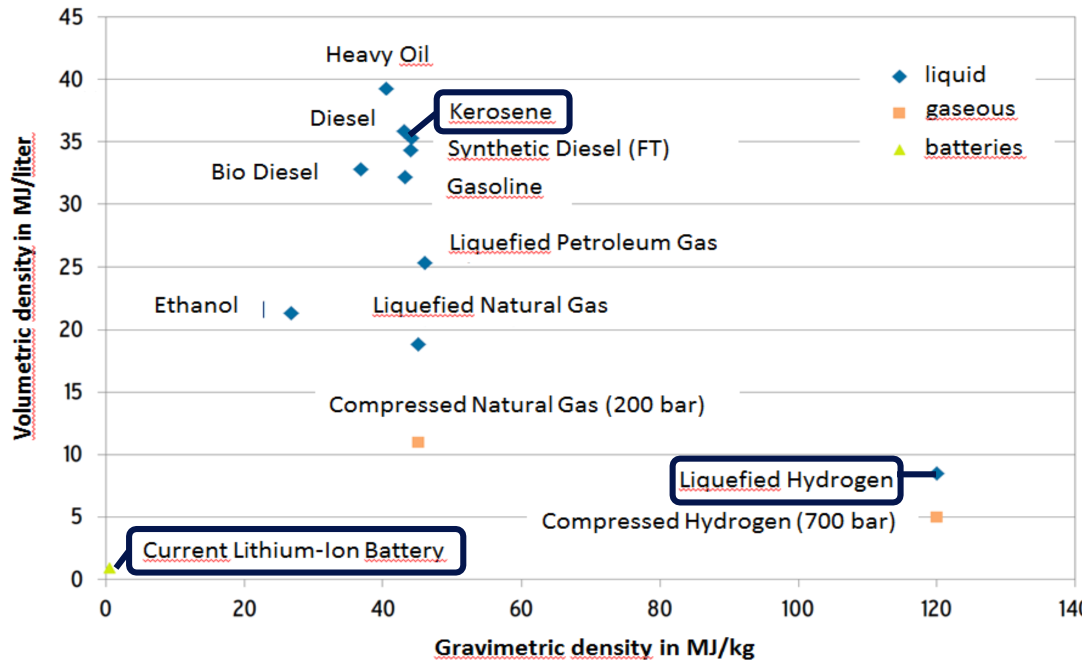
Electric propulsion

- Low energy density
- Hybrid propulsion could work for short distances and small planes in 2050 (still needs kerosene)

Hydrogen

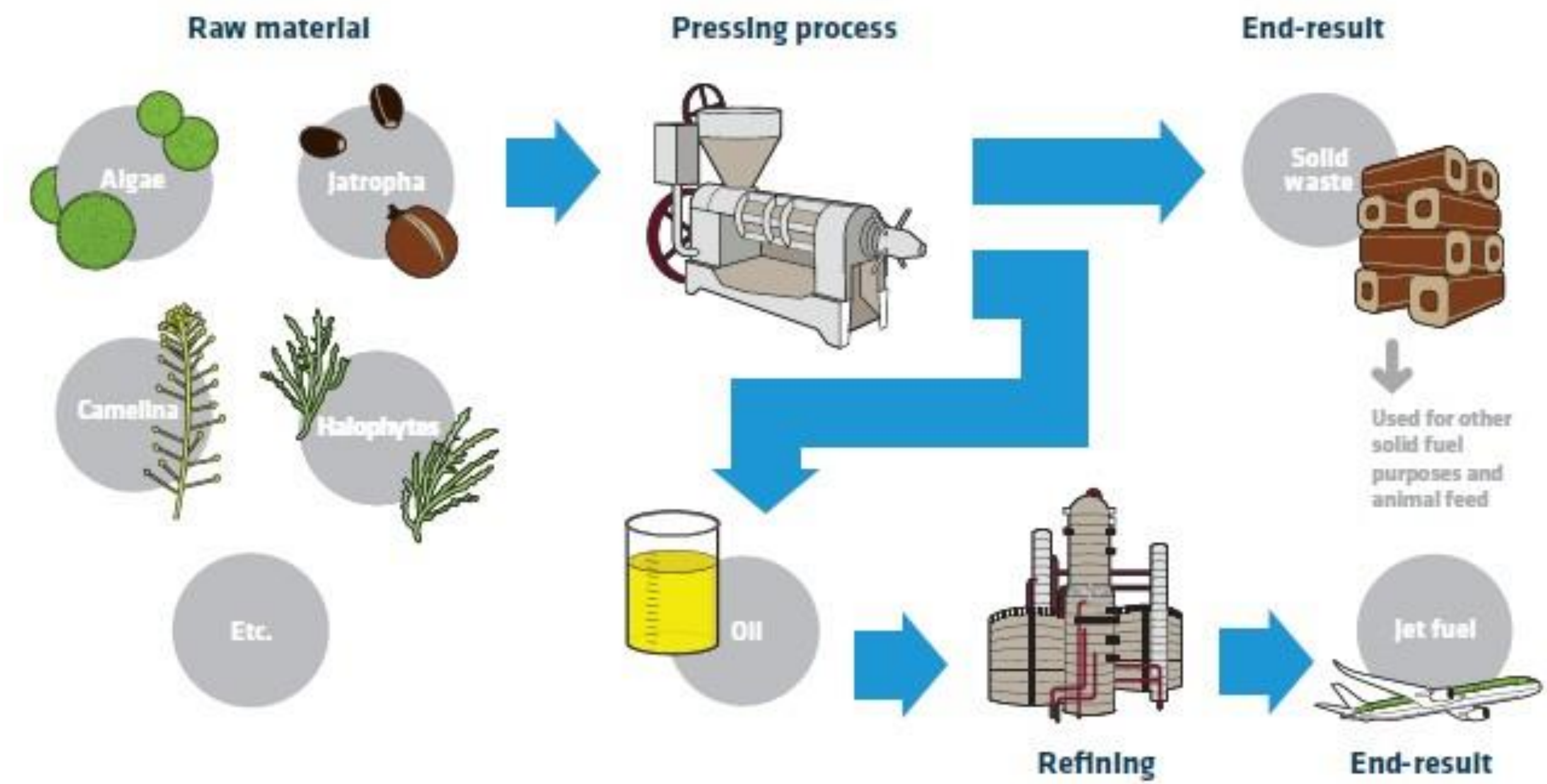
- Liquefaction needs a lot of energy
- Heavy fuel cells
- Needs completely different, larger aircrafts



- **A net reduction of CO_2-emissions needs regenerative, CO_2 neutral, hydrocarbon fuels**
- **Closed CO_2 -circuit with bio-kerosene and PtL is possible– Sustainable Aviation Fuel (SAF)**

Source: Umwelt-Bundesamt, Postfossile Energieversorgungsoptionen für einen treibhausgasneutralen Verkehr im Jahr 2050: Eine verkehrsträgerübergreifende Bewertung

Four Basic Processes to BioFuel (1/4): The HEFA Process



Although the processes are fairly complex, a simple explanation of the HEFA process (which is also known as hydrotreated renewable jet, or HRJ) is that biomass such as algae, jatropha or camelina is pressed to extract the oils inside, which are then refined into jet fuel in a similar way that crude fossil oil is refined. One of the other outcomes of the pressing process is a leftover substance: the meal. In many cases this meal can also be used. The solid residues left from the processing of jatropha, for example, can be used as fuel for burning on fires and in stoves. The meal from algae oil production can be used for fertiliser, animal feed and other purposes, and camelina meal can be used as animal feed.

Source: SAFUG Beginners Guide

Four Basic Processes to BioFuel (2/4): Biomass to Liquid Process

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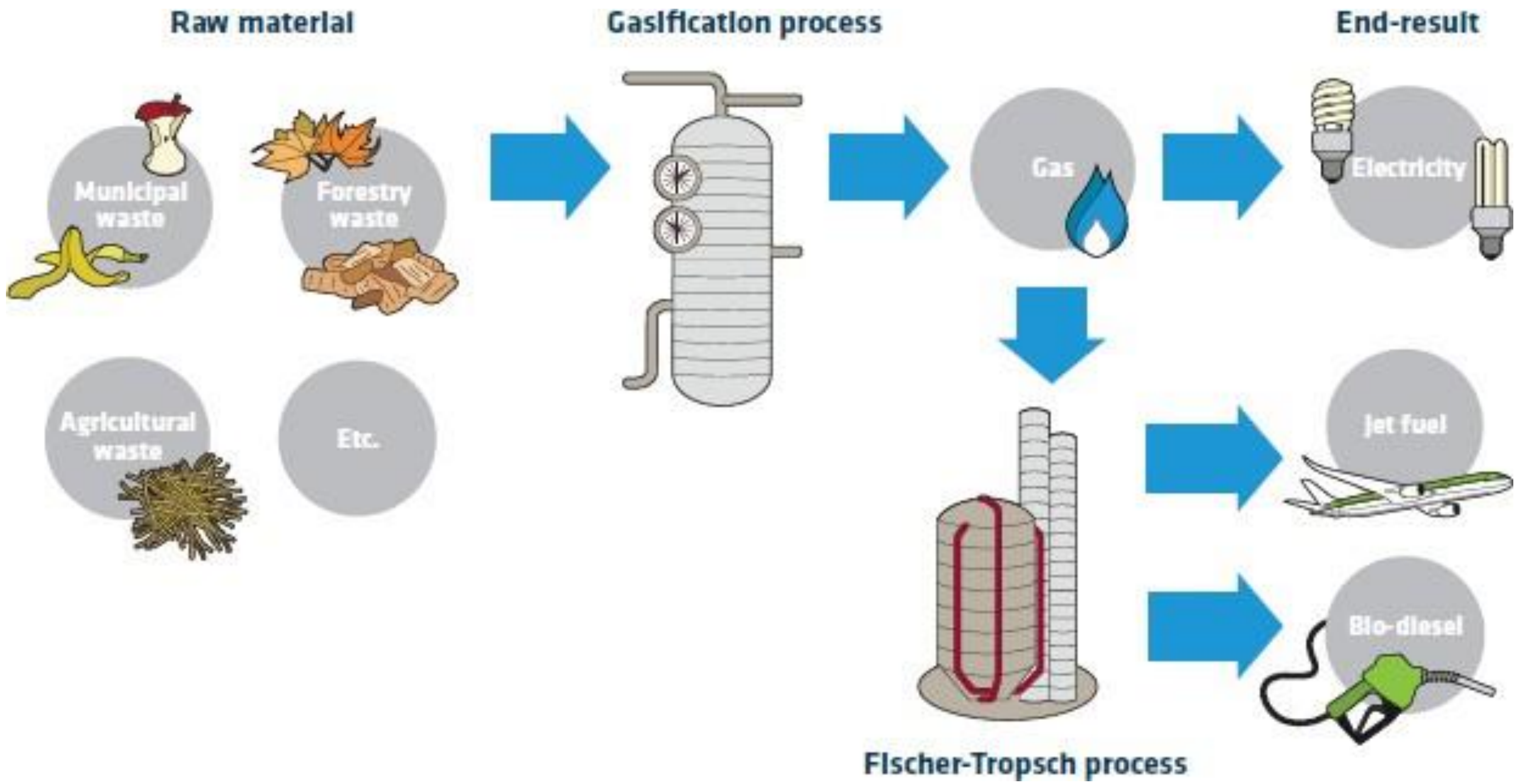
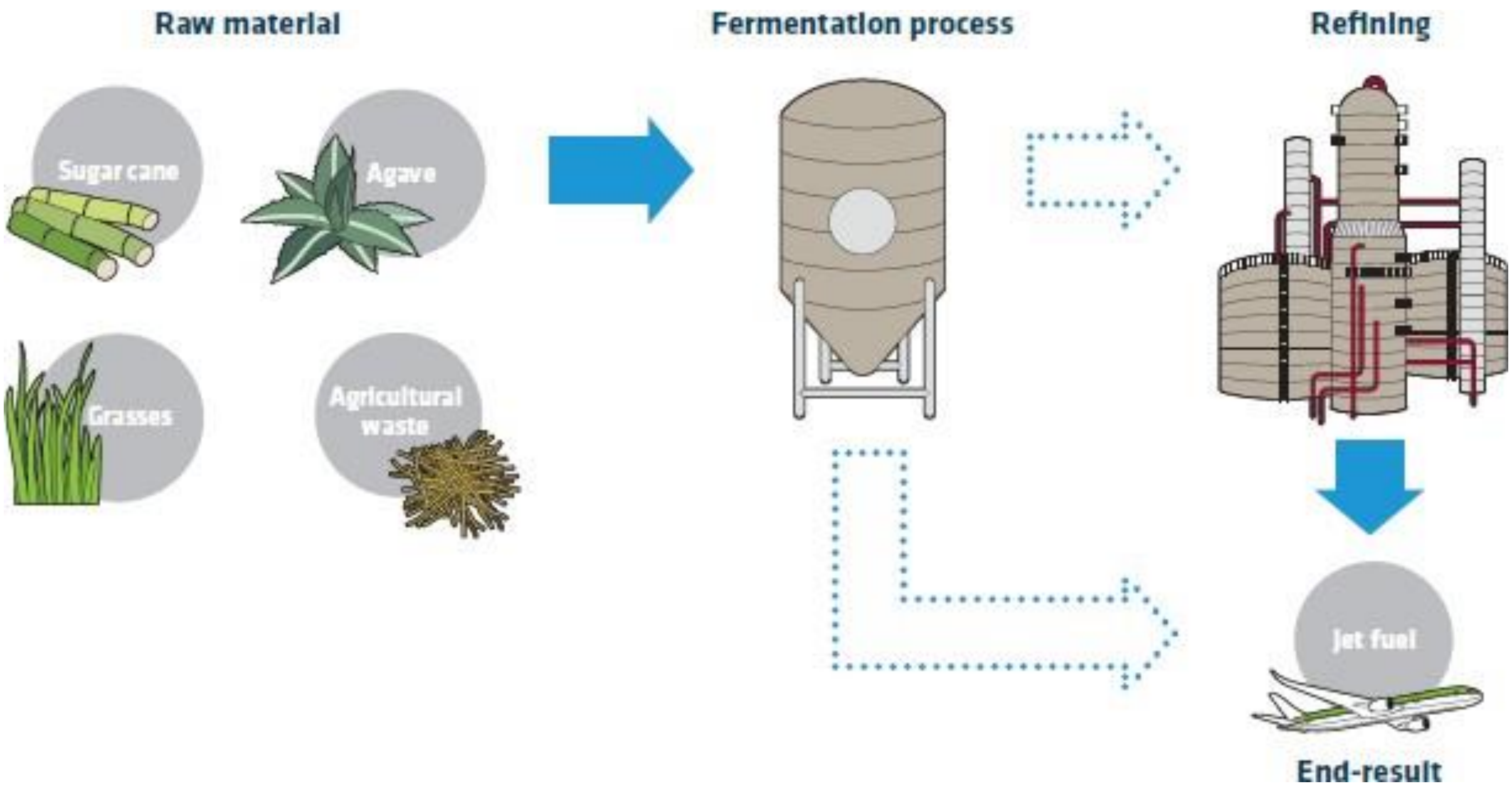


In the BtL process, the feedstock is broken down through gasification, a process by which the biomass is heated to an extremely high temperature which cracks the molecules and produces a gas. This gas is then converted into liquid jet fuel through the Fischer-Tropsch process. There are a few different BtL processes, but one being implemented in London, California, Australia and Italy will process municipal waste to produce some 16 million gallons of jet fuel a year from each plant. It will also produce electricity (which can be used to run the plant and also feed excess into the national grid) and bio-diesel for use in cars.

Source: SAFUG Beginners Guide

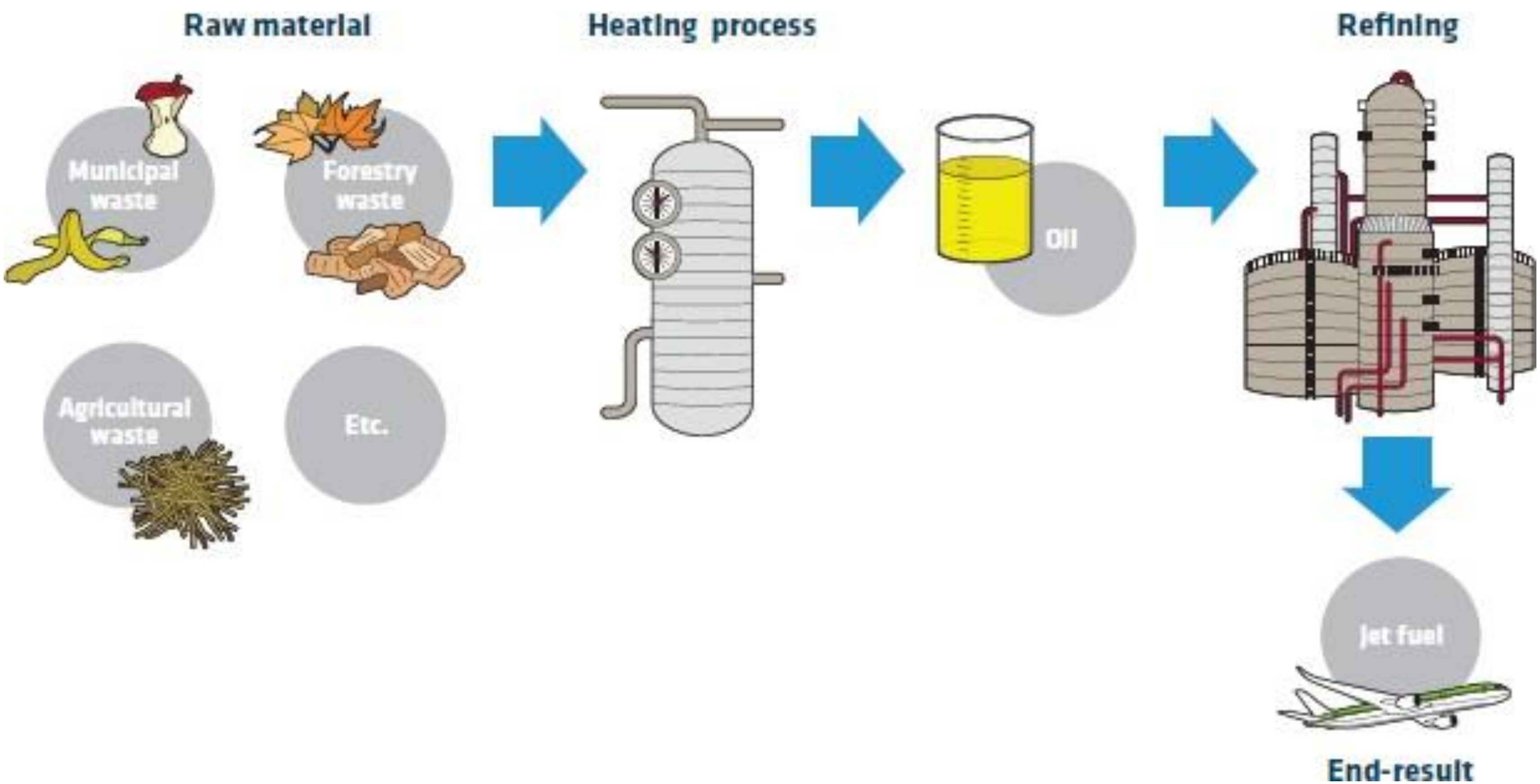
Four Basic Processes to BioFuel (3/4): Alcohol to Jet Process



Alcohol-to-jet is a process using the fermentation of cellulose and sugars. Various microbes, yeasts or bacteria are used to process agricultural waste products (stover, grasses, forestry slash, crop straws) to be converted either directly to jet fuel or through a group of alcohol conversion pathways. This is potentially a cheaper process, as the feedstocks are easy to obtain and don't cost a lot. It is also an efficient process that doesn't require much energy.

Source: SAFUG Beginners Guide

Four Basic Processes to BioFuel (4/4): The Pyrolysis Process



Pyrolysis of biomass is where the biomass (from industrial, agricultural, municipal or forestry waste) is heated in a special process to produce an oily substance, which is then refined to produce jet fuel. While creating jet fuel, this also solves the problem of using waste resources which would otherwise produce greenhousegases as they decompose.

Source: SAFUG Beginners Guide

The Full Life Cycle of a Carbon Offset

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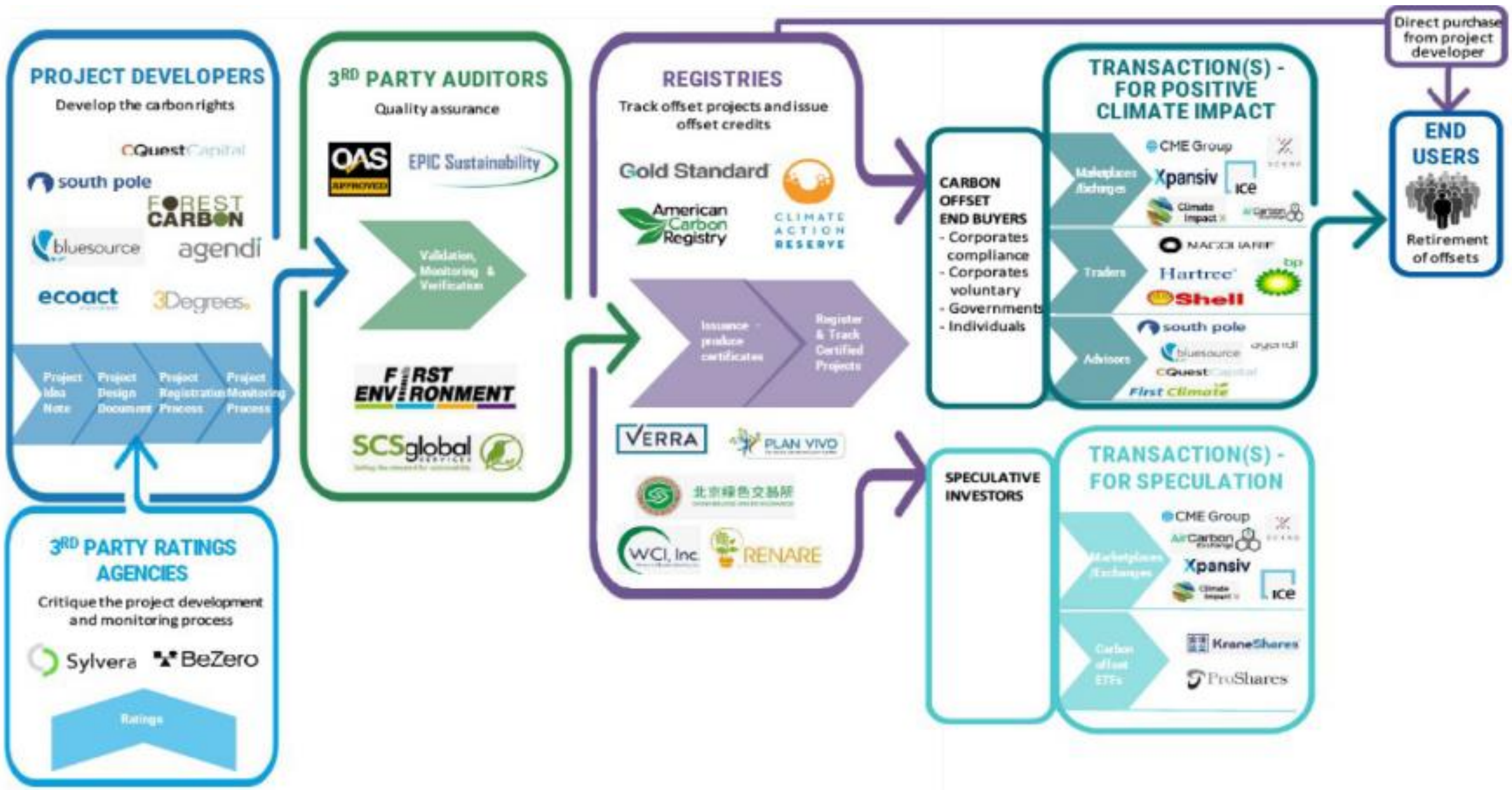
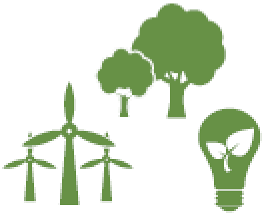


Source: Morgan Stanley Market Research

Common Principles for Assessing Carbon Offset Projects (1/2)



Carbon Offset

An offset is a verifiable action that compensates for the emission of one ton of CO2e by funding either:

A **Reduction & avoidance of CO2e** emissions

B **Removal of CO2e** for at least the atmospheric lifespan of the emitted ton

Principles	Details
Real	▪ The project must generate real outcomes measured in terms of emission reductions
Measurable	▪ Emission reductions must be quantified relative to a transparent and robust baseline using scientifically recognized methodologies and project-specific data
Independently verified	▪ Emission reductions must be verified by an independent certification body (i.e. a registry) to ensure all eligibility criteria are met
Permanent / Leakage	▪ Projects are permanent when they remove CO2 from (or prevent it from entering) the atmosphere for a period at least as long as the emitted gas is contributing to climate change, while putting in place safeguards to minimize the risk of reversal as well as mechanisms guaranteeing the replacement of "lost reductions"
Additional	▪ Emission reductions are additional when the underlying project activity was not required by law and would not have occurred in the absence of a carbon market, therefore resulting in higher GHG emissions (or: lower carbon sequestration)
Legally attributable	▪ Carbon credits generated must have a clear record of ownership all along their lifecycle (i.e., from project owner to retiring agent)
Unique	▪ Carbon credits generated must be held and retired on a registry to ensure that each ton of CO2 reduction is associated with a single carbon credit (no double-counting)

Source: Goldman Sachs Global Markets Division. VCS. Gold Standard. 3Degrees.

Common Principles for Assessing Carbon Offset Projects (2/2)

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	A Reduction & Avoidance Offset	B Removal Offset
Example Projects	■ Renewable energy ■ Fuel switches and energy efficiency ■ Reduce waste disposal ■ Deforestation avoidance (e.g. REDD+)	■ Nature based solutions (e.g., afforestation, reforestation, peatland restoration, regenerative agriculture) ■ Technology based solutions (e.g. CCS and DAC)
Pros	✓ Can have high co-benefits (e.g., avoided deforestation provides large biodiversity co-benefits) ✓ Often cheaper to avoid and reduce than to remove emissions ✓ Significant availability of supply (e.g. avoided deforestation of rainforests)	✓ Removes carbon from the atmosphere ✓ Projects are often able to more clearly demonstrate additionality ✓ Availability of supply at least in nature based solutions
Cons	✗ For certain sectors, projects have difficulties meeting high quality specifications on permanence and additionality ✗ Potentially more difficult to measure emission reduction and dependence on baseline assumptions ✗ Projects have attracted more significant negative publicity in the past	✗ Most cost-effective nature-based solutions may be depleted due to feasibility limits ✗ Leakage and permanence remain an important considerations for nature based solutions ✗ Technology based solutions are still expensive (multiple of nature based solutions) and require significant investment to make them commercially viable and scalable

Source: Goldman Sachs Global Markets Division. VCS. Gold Standard. 3Degrees.

Airlines need direct customer contribution to SAF/ compensation on the way to climate neutrality?

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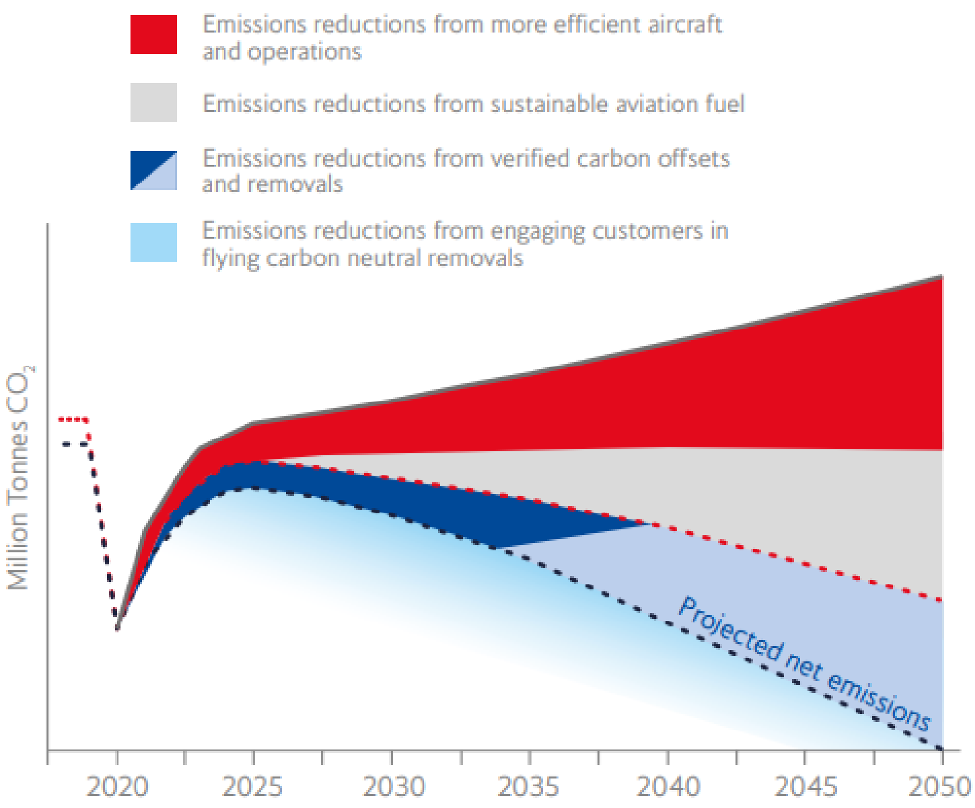
BRITISH AIRWAYS **OUR FLIGHTPATH TO NET ZERO BY 2050**



WHAT THE GRAPH SHOWS (adapted)

- With f no improvements aviation's carbon emissions would grow over time with demand (Top grey line on graph)
- Investing in new aircraft, changing how we fly and, in time, introducing new low- and zero-emissions aircraft, will deliver about a third of our emissions reductions by 2050. (Red wedge on graph)
- A further third of emission reductions will come from switching to sustainable aviation fuel, meeting about 50% of our fuel needs by 2050. (Grey wedge on graph)
- The final third will come from robust carbon reductions and removals in other sectors. (Blue wedge on graph)
- **We're also offering our customers the opportunity to fly carbon neutral today, that could mean together we could reach our destination sooner. (Aqua wedge on graph)**

Source: https://www.britishairways.com/cms/global/pdfs/information/sustainability-report-2021.pdf