ECODESIGN AT AIRBUS

Industrial Testimony – ISAE SUPAERO

Alexis MARTINET – AIRBUS Commercial
September 2022

AIRBUS

CONTENTS

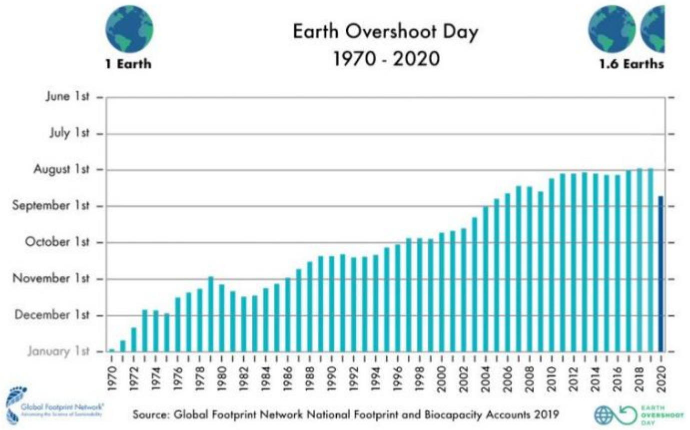
FRAMEWORK

Global, regulatory, industrial framework and SDGs.

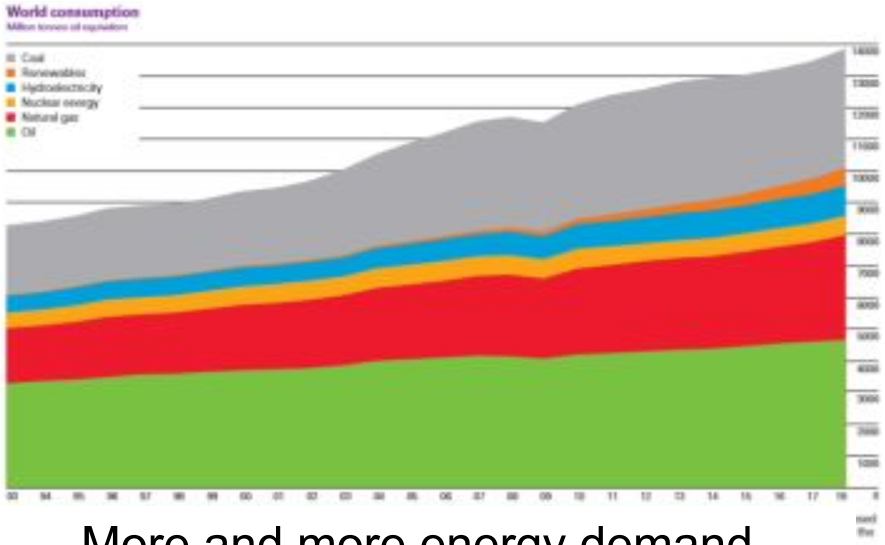
AIRBUS

ENVIRONMENTAL EMERGENCY

IN THE WORLD



Less and less resources



More and more energy demand

Intensification and increased number of natural disasters

Societal pressure increase

Flygskam = the shame of flying

EUROPEAN FRAMEWORK

GREEN DEAL

Investing in a climate-neutral and circular economy

Funding the European green deal through public and private finance.

A Climate Pact

Public consultation to bring together regions, local communities, civil society, business and schools

Circular Economy action plan

Changing the way we produce and consume by presenting initiatives to reduce waste, phase out single-use products and boost recycling.

A European Climate Law

Transforming promises into legal obligations

EU Biodiversity Strategy for 2030

The Biodiversity Strategy will put Europe's biodiversity on the path to recovery by 2030, for the benefit of people, climate and the planet.

Link to actions

Link to Circular Economy Action plan

EUROPEAN FRAMEWORK

- **EU NEW CIRCULAR ECONOMY ACTION PLAN** (2020): part of the European Green Deal
- **Directive 2009/125/CE** on ecodesign: replaces 2005/32/CE EuP (Energy using Products) – scope to be extended to materials.
- **ISO 14001** (2015 release): includes a life cycle perspective
- **DUE DILIGENCE**: worldwide regulations to set due diligence obligations for companies within their supply chain : French law on duty of vigilance of parent companies and contracting companies (2015), California transparency in supply chain 2010, UK Modern Slavery Act 2015, US Dodd Franck Act, EU Regulation on conflict materials, …
- **WASTE REGULATION** : classification (waste or by product / hazardous or non hazardous?), treatment, shipment…
- **ENERGY EFFICIENCY DIRECTIVE** (2012/27/EU): energy audit mandatory for big companies
- **REACH, ROHS** and **other substances requirements**
- **EU 2030 targets** on climate driven by COP21 objectives: cut in GHG emissions, share for renewable energy, energy efficiency. Warning: international agreement for the aviation industry. (Link)

EUROPEAN FRAMEWORK

European Commission

EU new circular economy action plan
Part of the European Green Deal

ErP COMPLIANT DIRECTIVE 2009/125/EC ECODESIGN

Directive 2009/125/CE on ecodesign

Waste regulation framework, Energy efficiency framework, EU 2030 climate target plan, etc.

ISO 14001

ISO 14001
Includes a Life Cycle perspective

REACH COMPLIANCE

REACH, ROHS and other substances requirements

END OF LIFE REGULATIONS

AIRCRAFT INDUSTRY

- In the world, aircraft are parked into “aircraft cemeteries” with the risk of non-compliance with environmental standards.The biggest aircraft cemeteries is located in Arizona and contains more than 4000 aircraft.

- No existing European directive → no existing sectoral regulation on end of life aircraft, and need to refer to the regional, national and local existing environmental legislation on aircraft end of life.

- In France, in a voluntary way, six industrial partners launched the first dismantling and recycling site (TARMAC) for aircraft.

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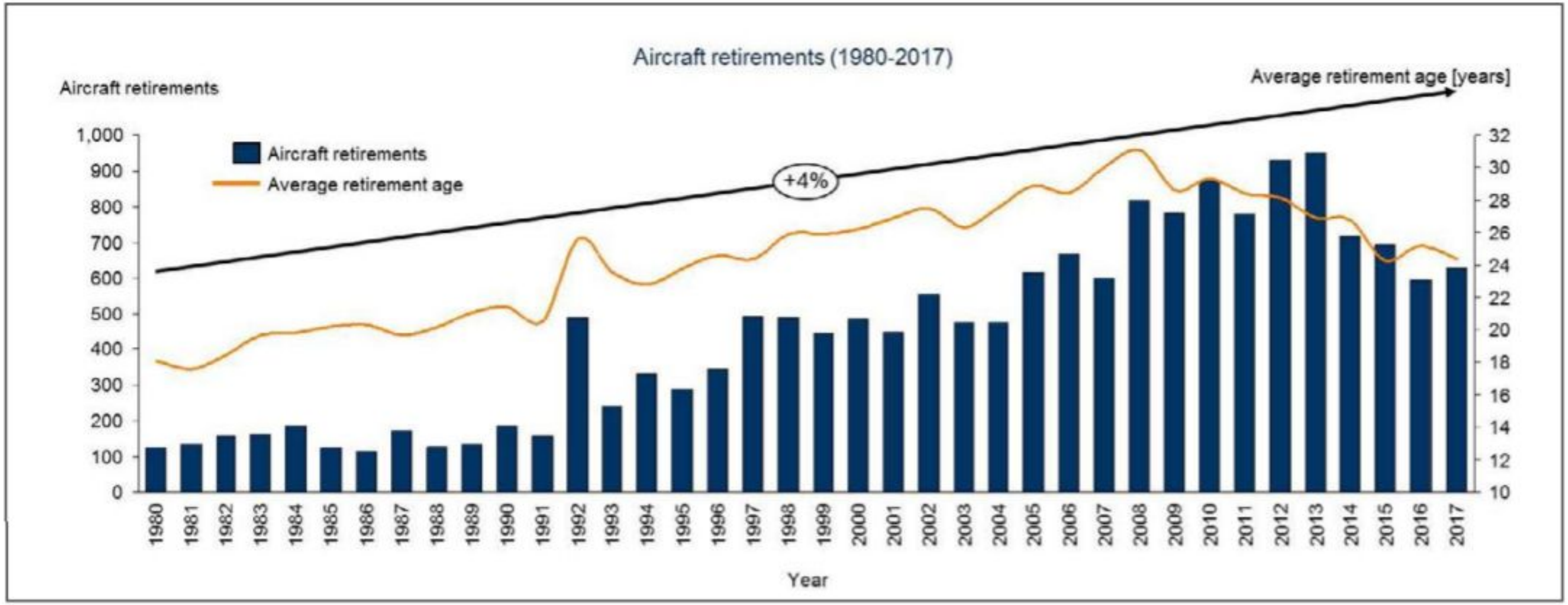
AIRCRAFT END OF LIFE

EVOLUTION OF THE RETIREMENT AGE OVER TIME



Age of retirement ≈ 24 years

https://www.icao.int/environmental-protection/Documents/EnvironmentalReports/2019/ENVReport2019_pg279-284.pdf

~600 -700 aircraft retired by year

BUT

It is estimated that more than 20,000 commercial aircraft will be retired over the next 20 years

EASA REQUIREMENTS

ICAO Aircraft Engine Emissions Databank

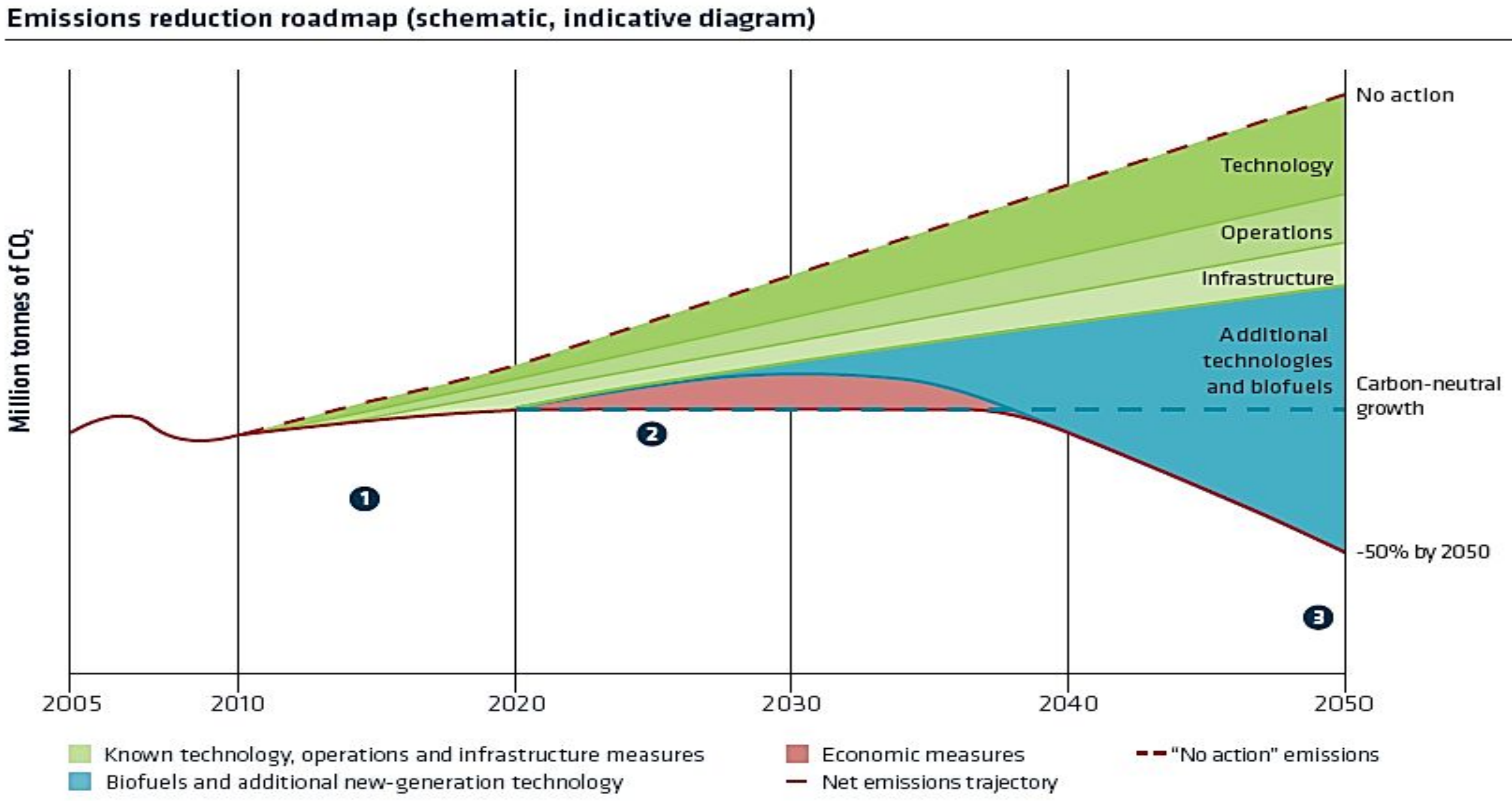
The ICAO Aircraft Engine Emissions Databank contains information on exhaust emissions of production aircraft engines, measured according to the procedures in ICAO Annex 16, Volume II, and where noted, certified by the States of Design of the engines according to their national regulations. The databank covers engine types which emissions are regulated, namely turbojet and turbofan engines with a static thrust greater than 26.7 kilonewtons. The information is provided by the engine manufacturers, who are solely responsible for its accuracy. The European Aviation Safety Agency (EASA) is hosting the databank on behalf of ICAO and is not responsible for the contents.

EASA certification noise levels

The EASA certification noise levels are approved by EASA as part of the aircraft certification process. These noise levels are established in compliance with the applicable noise standards as defined in ICAO Annex 16, Volume I. They are the basis against which the National Aviation Authorities of EASA Member States issue individual noise certificates to aircraft on their registers using the EASA Form 45.

Source: EASA website

AVIATION SECTOR COMMITMENTS – CO_2 EMISSIONS



Continue as today

Rethinking

Innovation

Ecodesign

The target

In October 2016, The International Air Transport Association (IATA) reaffirms commitments to reducing emission. The industry is on the right path to achieve its aim of lowering carbon emission to 50% of 2005 levels by 2050.

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AVIATION FRAMEWORK

EUROPE

2005 : European Union Emissions Trading System (EU ETS) - first large greenhouse gas emissions trading scheme

Research programs

Scope : new technologies

Scope : air traffic management

LINK TO ICAO ENVIRONMENTAL REPORT 2019

WORLD

2008: Commitment to Action on Climate Change, signed at the ATAG's Aviation and Environment Summit

2016 : United Nation's International Civil Aviation Organization's (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

Aviation Industry Commitment to Action on Climate Change

As leaders of the aviation industry, we recognise our environmental responsibilities and agree on the need to:

- build on the strong track record of technological progress and innovation that has made our industry the safest and most efficient transport mode; and
- accelerate action to mitigate our environmental impact, especially in respect to climate change while preserving our driving role in the sustainable development of our global society.

Therefore, we, the undersigned aviation industry companies and organisations declare that we are committed to a pathway to carbon-neutral growth and aspire to a carbon-free future.

To this end, in line with the four-pillar strategy unanimously endorsed at the 2007 ICAO Assembly, we will:

1. push forward the development and implementation of new technologies, including cleaner fuels;
2. further optimise the fuel efficiency of our fleet and the way we fly aircraft and manage ground operations;
3. improve air routes, air traffic management and airport infrastructure; and
4. implement positive economic instruments to achieve greenhouse gas reductions wherever they are cost-effective.

We urge all governments to participate in these efforts by:

1. supporting and co-financing appropriate research and development in the pursuit of greener technological breakthroughs;
2. taking urgent measures to improve airspace design including civil/military allocation, air traffic management infrastructure and procedures for approving needed airport development; and
3. developing and implementing a global, equitable and stable emissions management framework for aviation through ICAO, in line with the United Nations roadmap agreed in Bali in December 2007.

Our efforts and commitment to work in partnership with governments, other industries and representatives of civil society will provide meaningful benefits on tackling climate change and other environmental challenges.

We strongly encourage others to join us in this endeavour.

Robert J. Aaronson, Director General
James C. Cherry, Chairman
Alexander ter Kuile, Secretary General
Ashley Smout, Chairman
Giovanni Bisignani, Director General & CEO
Fernando Pinto, Chairman
Marion C. Blakey, Chair
Takatoshi Hosoya, Vice-Chair
Thomas Enders, President & CEO
Scott Carson, President & CEO
Steve Ridolfi, President, Regional Aircraft
Eric Bachelet, CEO
Frederico Fleury Curado, President & CEO
Scott C. Donnelly, President & CEO, GE Aviation
Stephen Finger, President
Mark King, President, Civil Aerospace
Philippe Rochat, Executive Director

3rd Aviation & Environment Summit; 22nd April 2008; Geneva, Switzerland

2017 : ICAO Aviation new CO_2 standard added to Chicago Convention App16 chapter3 – First global design certification standard governing CO_2 emissions for any industry sector.

EASA EXTENDED ECOLABEL

Environment

Ensuring sustainability is a huge challenge for the aviation industry, MSs and EASA. Sustainable aviation is about combatting climate change and reducing the health effects from aircraft noise and air pollution. It is also about ensuring that European industry stays competitive in a rapidly changing world. The introduction of novel technologies (including electric air taxis, drones and hybrid systems) requires particular attention from an environmental perspective.

Key actions:

- Implement ICAO Committee on Aviation Environmental Protection (CAEP) amendments
- Develop PM regulations and guidelines
- Obtain high-quality technical expert support on standardisation issues.

In addition, EASA is also involved in the following activities:

- Environmental fraud prevention
- Development of an ecoLabel/LifeCycle assessments concept
- Sustainable fuels project
- REACH[2] monitoring process together with the European Chemicals Agency

Source: EASA 2019-2023 EPAS Strategic priorities, enablers and key actions

INTERNATIONAL VOLUNTARY FRAMEWORK

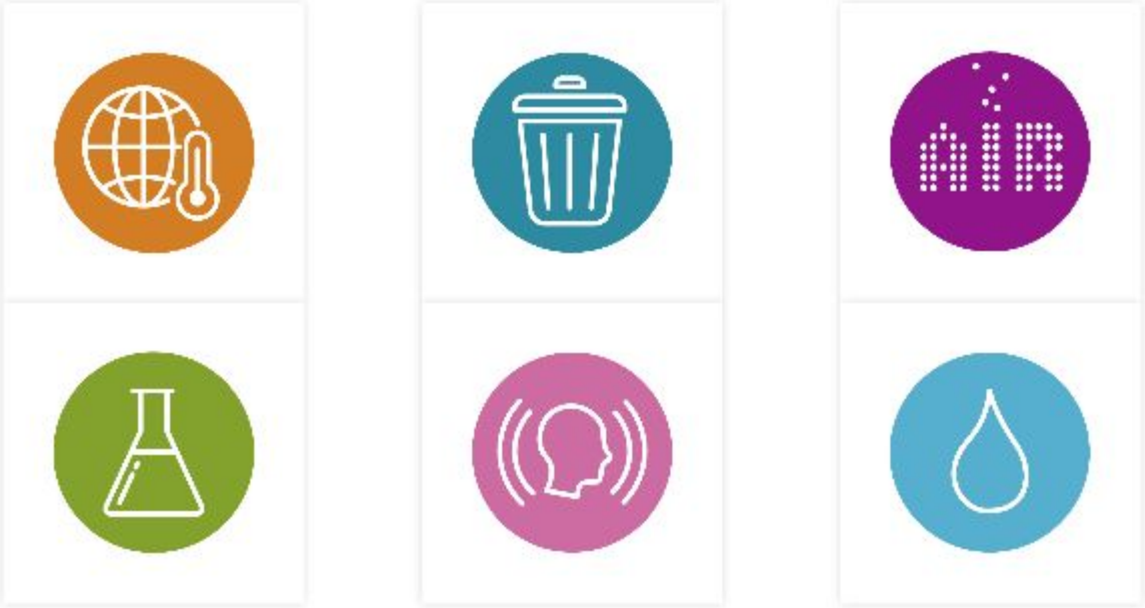
The Sustainable Development Goals are the blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice. The Goals interconnect and in order to leave no one behind, it is important that we achieve each Goal and target by 2030.

Source : https://www.un.org/sustainabledevelopment/sustainable-development-goals/

ENVIRONMENTAL IMPACTS OF THE AERONAUTICS INDUSTRY

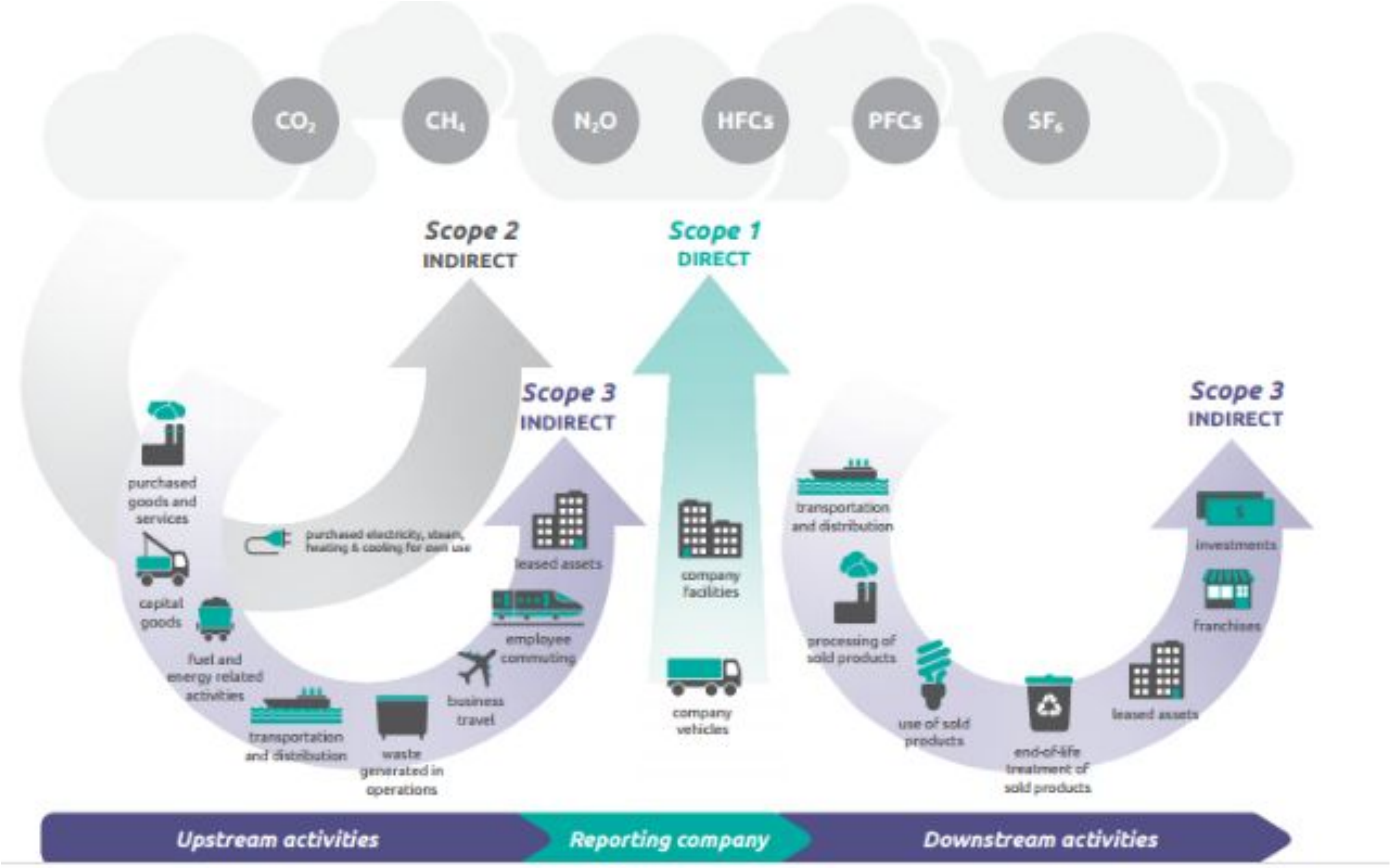
AIRBUS AND AVIATION MAIN ENVIRONMENTAL IMPACTS CATEGORIES

CLIMATE CHANGE | WASTE | AIR EMISSIONS



SUBSTANCES | NOISE | WATER EMISSIONS

GHG PROTOCOLE CORPORATE STANDARD



Source : https://ghgprotocol.org/blog/you-too-can-master-value-chain-emissions

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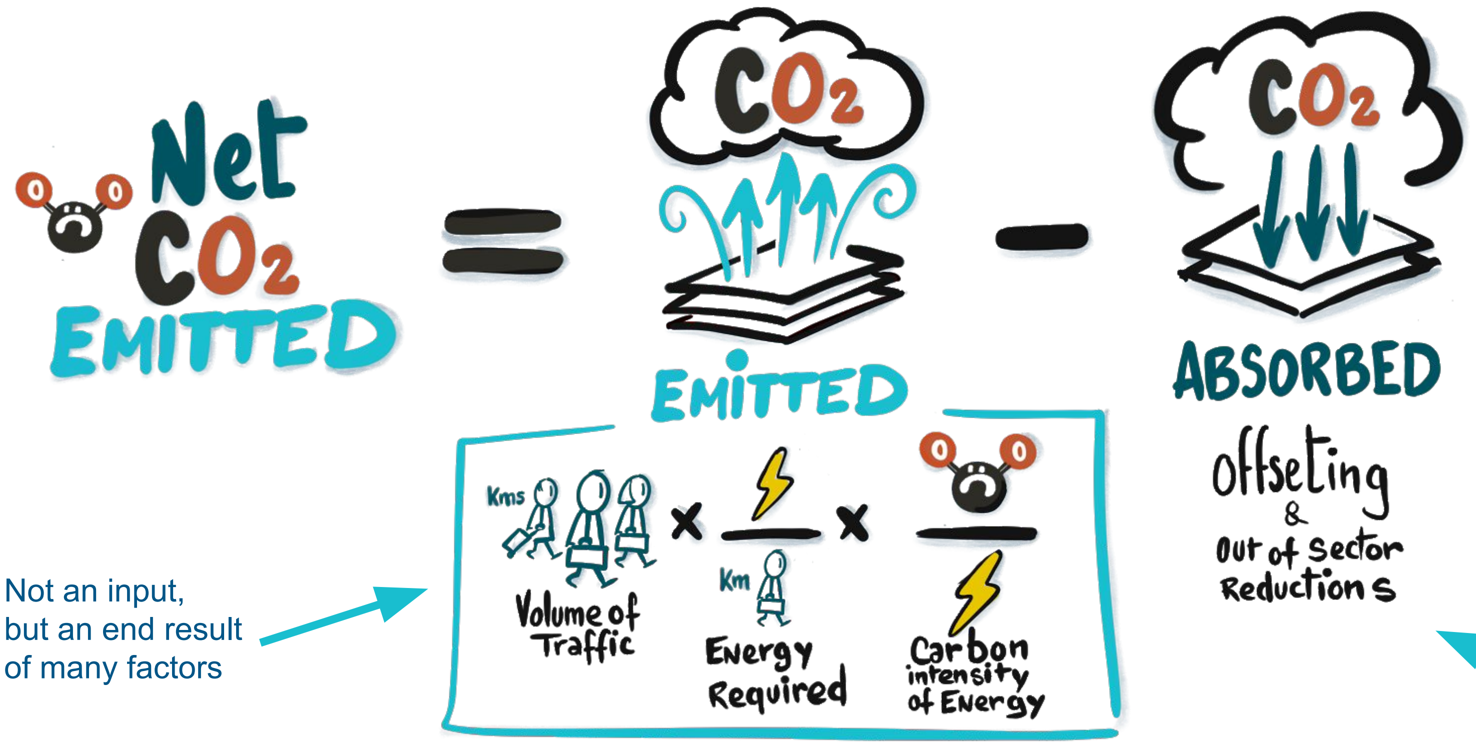
Levers – focus on CO_2 impact of flight operations



Not an input, but an end result of many factors

Improve A/C fuel efficiency

Improve A/C operations

Replace kerosene with Sustainable Aviation Fuel

Alternative energy carriers

Perform CO_2 absorption or reduction elsewhere

Inspiration:
- *ATAG Waypoint 2050*
- *The Kaya equation*

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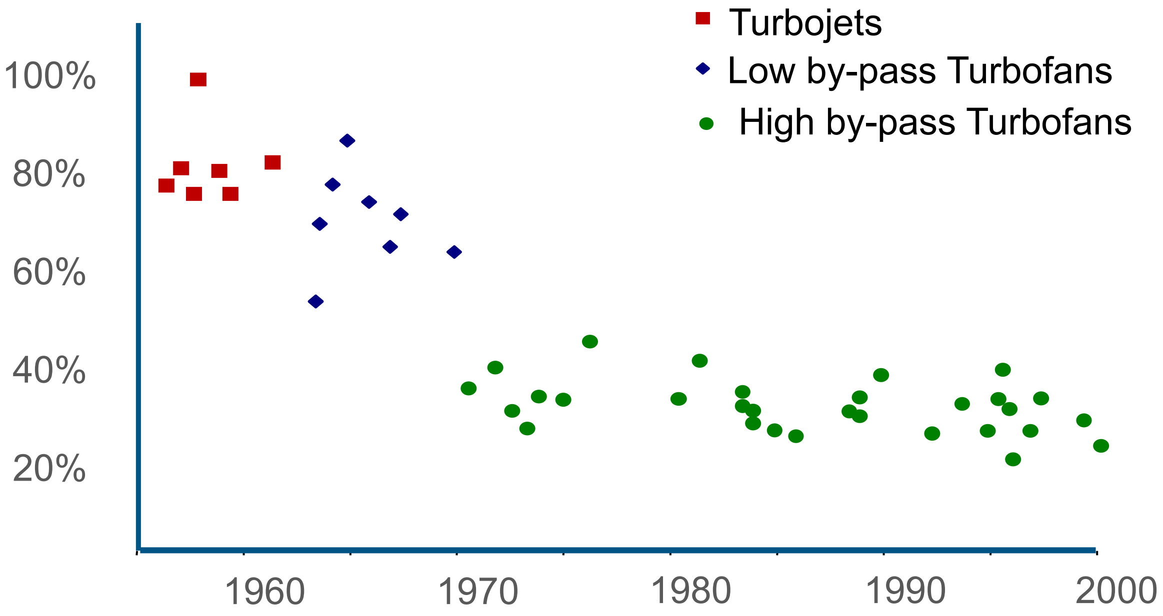
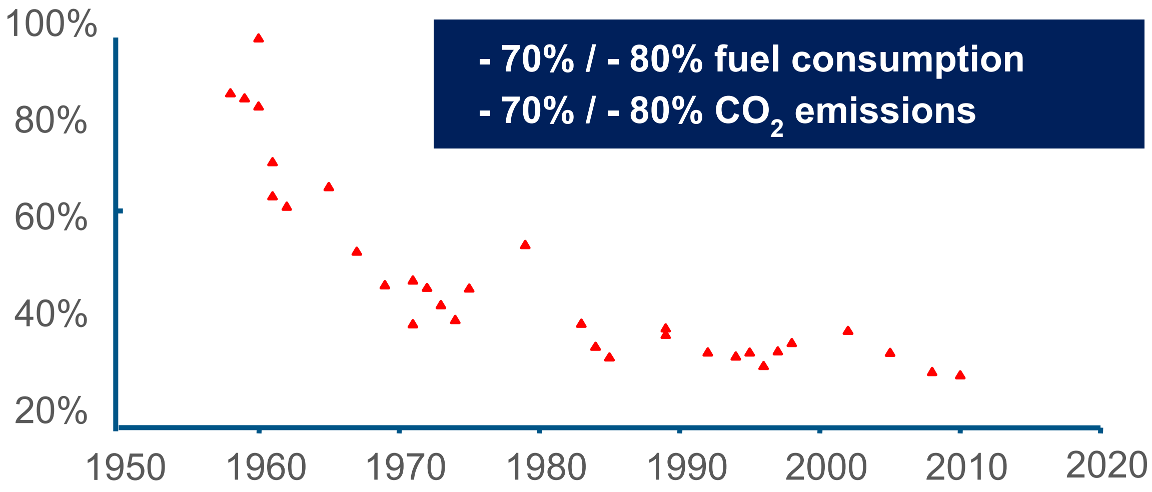
COMMERCIAL AVIATION ACHIEVEMENTS



Lateral Noise Level Corrected for Aircraft Thrust

- 20dB noise reduction



- 70% / - 80% fuel consumption

- 70% / - 80% CO_2 emissions

Relative Fuel Burn per seat

- A350 XWB -25%*
- A320neo -20%*
- A220 -20%*
- A330neo -14%*

*fuel burn/ seat km

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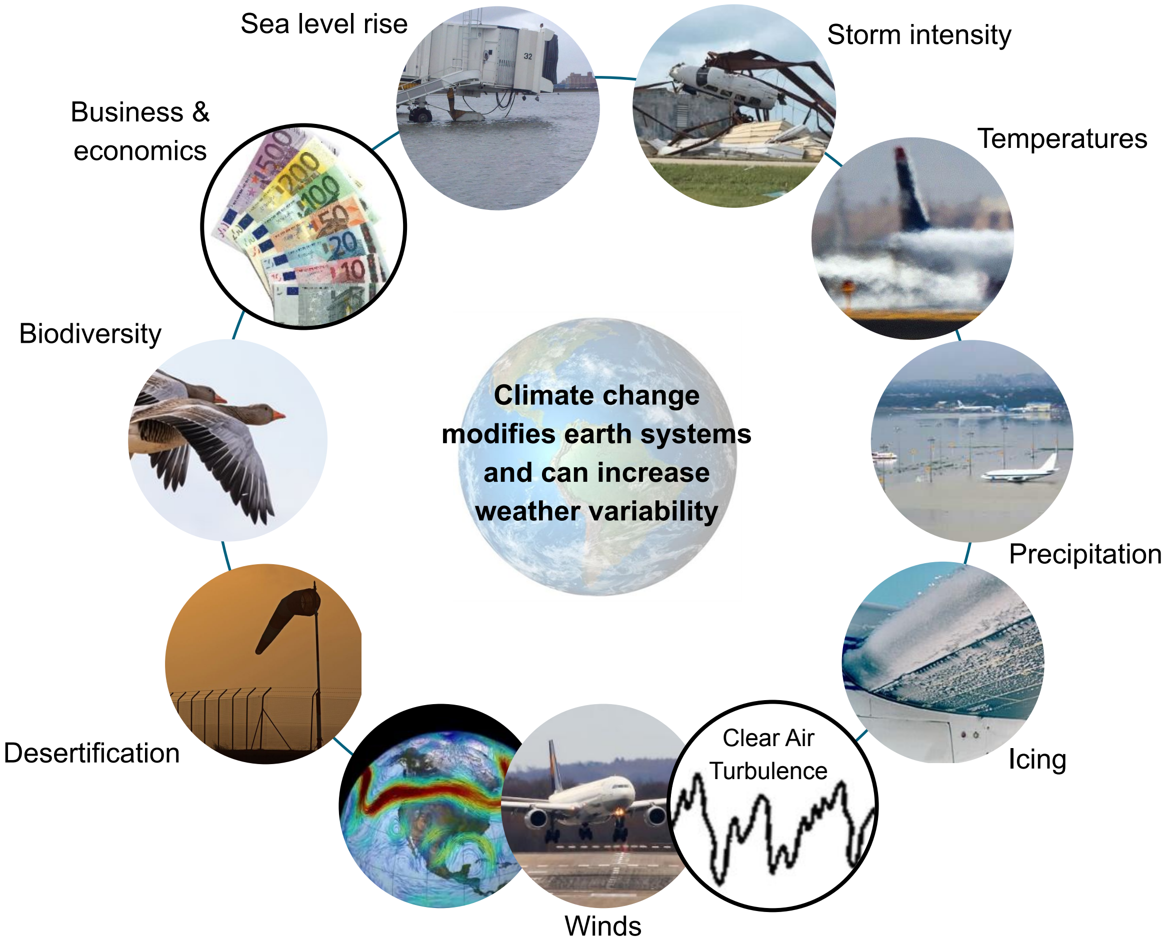
CLIMATE CHANGE IMPACTS ON AIRPLANES

- Design impacts (lightning impacts, storms)
- Flight envelope reduction
- Airports access issues (sea level rise, floodings, desertification)
- Market evolution due to people move
- Safety (winds, icing conditions, temperatures)

CLIMATE CHANGE IMPACTS ON AIRPLANES



ECODESIGN @ AIRBUS

ECODESIGN

DEFINITIONS

Directive 2009/125/EC of the European parliament: Ecodesign means the integration of environmental aspects into product design with the aim of improving the environmental performance of the product throughout its whole life cycle;

ISO 14062 Standard: Ecodesign is as an activity that integrates environmental aspects into product design and development.

Airbus' definition:
Ecodesign aims to integrate environmental criteria from the earliest conception phase to reduce the environmental impacts of products or services throughout their life cycle (extraction of raw materials, production, distribution, use and end of life,..). Ecodesign is a:

- multi-step approach (taking into account all stages of the life cycle)
- multi-criteria (taking into account the consumption of matter and energy, discharges into natural environments, effects on climate and biodiversity).

ENVIRONMENTAL EMERGENCY

IN AIRBUS

"Our goal **is completely emission-free flying.** Smaller test models, which fly completely electrically, are only the first step: If they are operational, we will gradually increase the machines," Until these electric aircraft could take off, "a few years would pass**, but not decades,"** said the manager. By the end of 2020 or the beginning of 2030, the start of a commercial operation would be conceivable.

Guillaume Faury

Only ten years ago, the idea of zero-emission flight within our lifetime was considered just a pipedream. Thanks to advanced technologies, it's closer to reality than ever.

At Airbus, we've embarked on this journey toward zero-emission flight. We are committed to reducing CO_2 emissions in the aviation industry because we're absolutely convinced it's the only way to ensure a more sustainable world for future generations.

I admit, it's not an easy task, but we're more than ready to take up the challenge by ***working on a combination of innovative and advanced technologies."***

Grazia Vittadini CTO, May 2019

Jean-Brice Dumont

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AIRBUS 2030 ENVIRONMENTAL VISION

SUSTAINABLE MANUFACTURING

Climate change	Comply with GHG emissions regulations (compatible with the global 2°C trajectory) and absorb production ramp up impacts.
Raw Materials and Waste	Divert 100% of the waste from landfilling & incineration, reducing the environmental footprint in proportion to the business growth.
Air emissions	Comply with air emissions regulations and absorb production ramp up impacts.
Water	Develop strong maintenance and rehabilitation programs to improve reliability and lower water costs.
Supply Chain	Deployment of environmental requirements and risk evaluation across a targeted scope of the supply chain. Enhance the use of environmental risk evaluation for consideration as a quantitative input during selection, contracting and supply chain control phases.

ECODESIGN & AIRBUS

Since 2006, Airbus is certified ISO 14001 for both SITES and PRODUCTS.

- “Site” approach: Manufacturing/plants and sites environmental impacts reduction
- “Products” approach: Aircraft environmental impacts reduction

BUREAU VERITAS Certification

1828

Certification

Awarded to

AIRBUS

1 Rond Point Maurice Bellonte, 31707 BLAGNAC CEDEX
FRANCE
And the sites listed in appendix

Bureau Veritas Certification certify that the Environmental Management System of the above organisation has been audited and found to be in accordance with the requirements of the management system standards detailed below

Standards

NF EN ISO 14001 : 2004

Scope of supply

MARKETING AND SALES, DESIGN AND ENGINEERING, MANUFACTURING, SUPPORT FUNCTIONS, MANAGEMENT OF INDUSTRIAL PARTNERSHIP, PROCUREMENT, AFTER SALE AND IN SERVICE SUPPORT OF AIRCRAFT AND ALL AEROSPACE PRODUCTS AND SERVICES IN CIVIL & MILITARY SECTORS (INCLUDING SPARES, TRAINING, SIMULATORS, TESTS, SOFTWARE AND ASSOCIATED PRODUCTS).

Original Approval Date 23rd May 2008

Subject to the continued satisfactory operation of the organisation's Management System, this certificate is valid until:
18th November 2010

To check this certificate validity please call: + 33(0) 4 78 66 82 60

Further clarifications regarding the scope of this certificate and the applicability of the management system requirements may be obtained by consulting the organisation

Date 23rd May 2008

File Number 1.788.311

Romain PETIT
Chief Executive Officer

cofrac

CERTIFICATION D'ENTREPRISES & DE PERSONNES

Since 2015, ISO 14001 new version includes life cycle considerations. A life cycle perspective is now expected.

A.6.1.2 Environmental aspects

An organization determines its environmental aspects and associated environmental impacts, and determines those that are significant and, therefore, need to be addressed by its environmental management system.

Changes to the environment, either adverse or beneficial, that result wholly or partially from environmental aspects are called environmental impacts. The environmental impact can occur at local, regional and global scales, and also can be direct, indirect or cumulative by nature. The relationship between environmental aspects and environmental impacts is one of cause and effect.

When determining environmental aspects, the organization considers a life cycle perspective. This does not require a detailed life cycle assessment; thinking carefully about the life cycle stages that can be controlled or influenced by the organization is sufficient. Typical stages of a product (or service) life cycle include raw material acquisition, design, production, transportation/delivery, use, end-of-life treatment and final disposal. The life cycle stages that are applicable will vary depending on the product or service.

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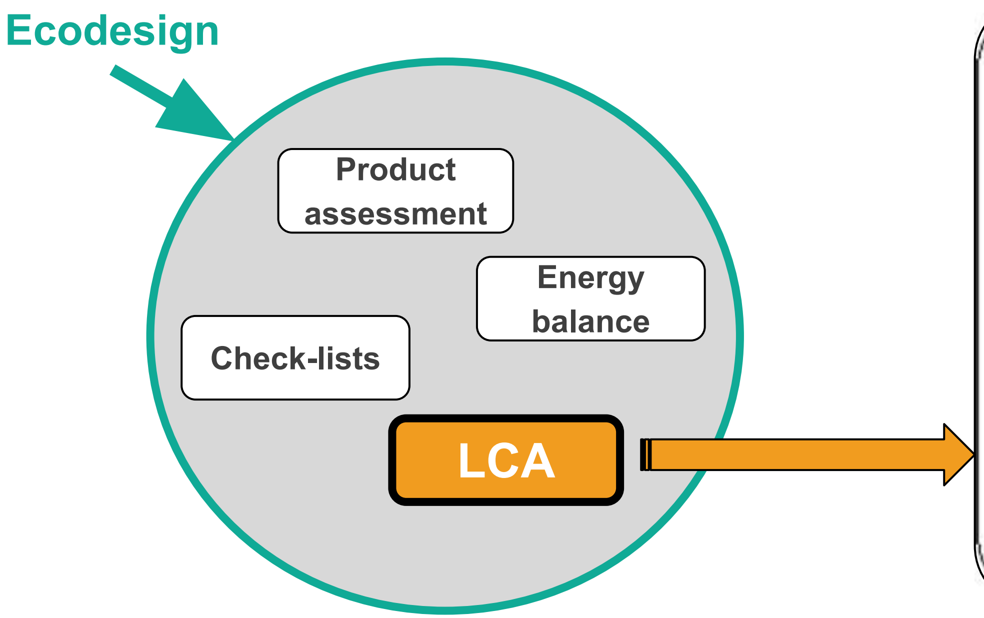
ECODESIGN & LIFE CYCLE ASSESSMENT

ECODESIGN

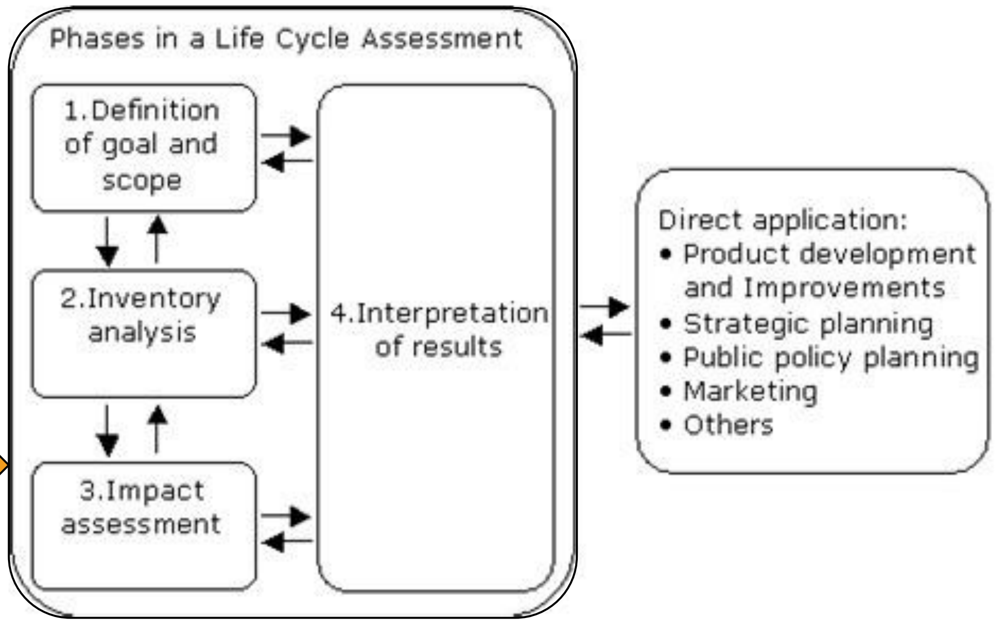
The aim of an ecodesign approach is to **reduce the environmental footprint** of a product, a system or a service.

LIFE CYCLE ASSESSMENT

Life cycle assessment is a methodology that aims to **identify environmental impacts** of a product, a system or a service along its full life cycle: from raw materials extraction to end of life.



ISO 14040/44 Methodology



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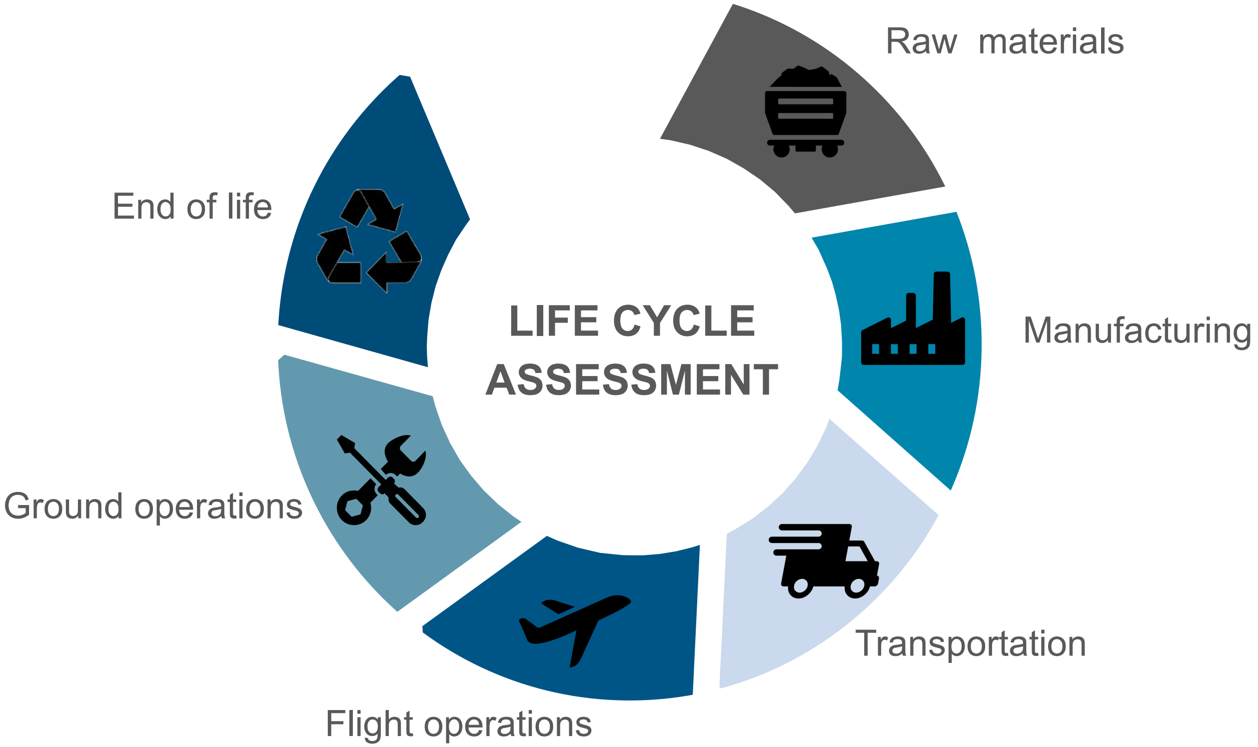
WHAT IS LIFE CYCLE ASSESSMENT?



Quantified, standardized and multi impacts

Climate Change

And also

Soil *Ozone* *Water*

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MULTI IMPACTS APPROACH : MATERIALS IMPACTS EXAMPLES

HUMAN TOXICITY

Copper : arsenic and zinc are emitted during sulphide mine tailings treatment

Steel : mercury used during manufacturing process and toxic substances rejected during manufacturing process

WATER ECOTOXICITY

Aluminium : ”red mud” (toxic waste) produced by bauxite processing – contains for example vanadium and chrome VI

RESOURCES DEPLETION

Steel : Galvanising process requires the use of zinc

ENERGY CONSUMPTION

Aluminium : manufacturing process is extremely energy consuming

Precious metals (gold and platinum group metals): need lot of energy to produce due to their low content (1 to 5 gr per ton) : 190,000 GJ per t for Pt

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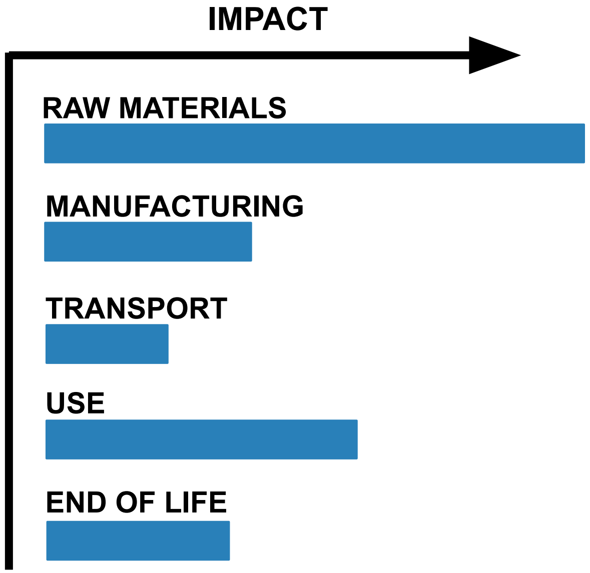
LIFE CYCLE ASSESSMENT

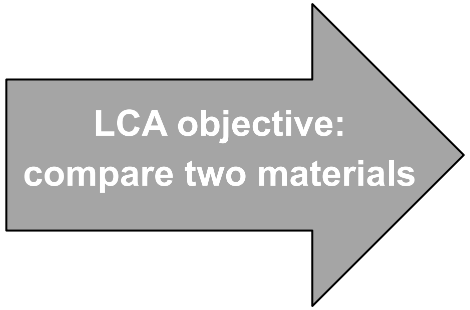
IMPACT TRANSFERT

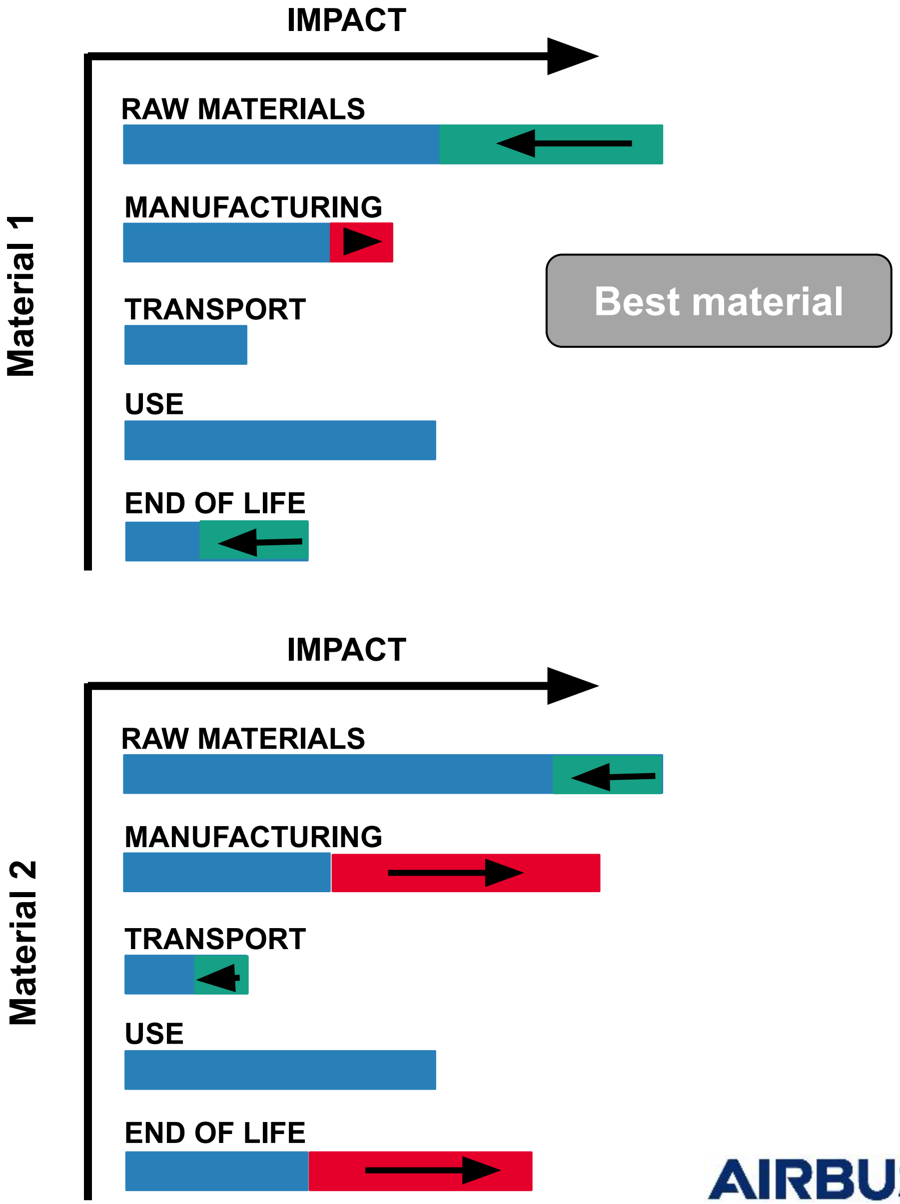
One of the keys of ecodesign using LCA is to **avoid impact transfer**, meaning that between different solutions some impacts could be the transferred from one life cycle stage to another.

Current product

Issue: high impact from a material point of view







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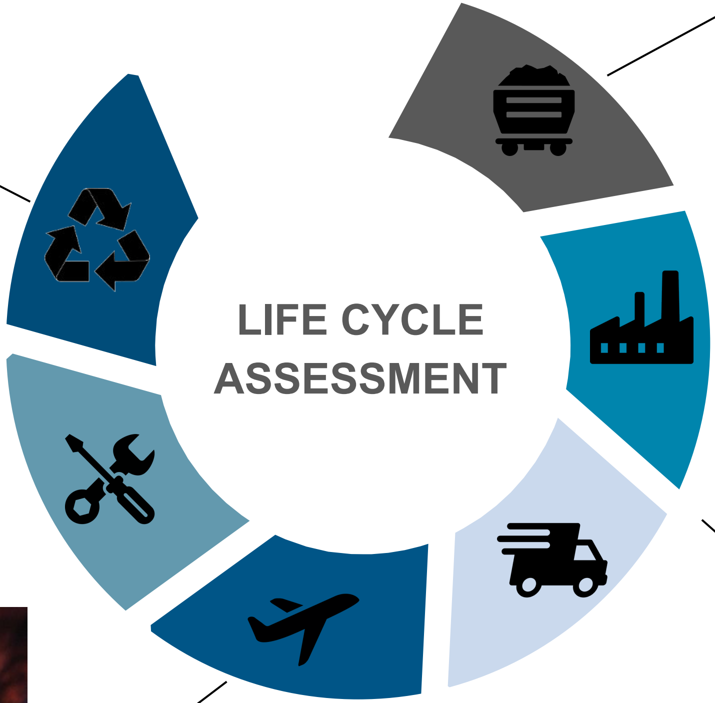
FULL LIFE CYCLE APPROACH

Davis-Monthan Aircraft boneyard (Arizona)




“THIS IS WHAT WE DIE FOR”

HUMAN RIGHTS ABUSES IN THE DEMOCRATIC REPUBLIC
OF THE CONGO POWER THE GLOBAL TRADE IN COBALT

AMNESTY INTERNATIONAL

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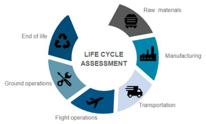
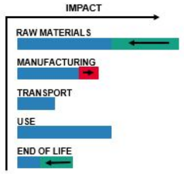
LCA USES

LCA is mostly used for

- Identifying **Environmental hotspots** 

- **Comparing** two products of systems
- Avoiding **transfers of impacts** 

- Improving the **Environmental Footprint**
- Complying with **Regulations** 

- **Communicating** on environmental performance

LCA AS AN ENABLER FOR ECODESIGN

BUILD KNOWLEDGE & SKILLS

Airbus/aeronautics
LCA Method

Existing A/C
LCA

Training

LCA database

Reinforce link
with suppliers

ENABLE ECODESIGN

NEW PRODUCTS SUSTAINABILITY

LCA in R&T : support new A/C design, systematic Environmental Assessments at R&T projects maturity gates.

Circular Economy : improve circularity

INTEGRATE IN TOOLS & PROCESSES

LCA in Designers and
Architects tools

LCA for MODS (Systematic)

LCA FOR AERONAUTICS - MAIN LIMITATIONS

DATA

- Missing data from suppliers
- No specific database (project in progress)
- No sectorial common rules

MODEL

- Climate impact assessment: impact of cruise NOx and Contrails
- High altitude cosmic rays impact on crew
- Noise modelling

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Audience reaction in front of LCA results…

KEY QUESTIONS

How to simplify LCA results ?

How to prioritize the impacts ?

How to set up targets?

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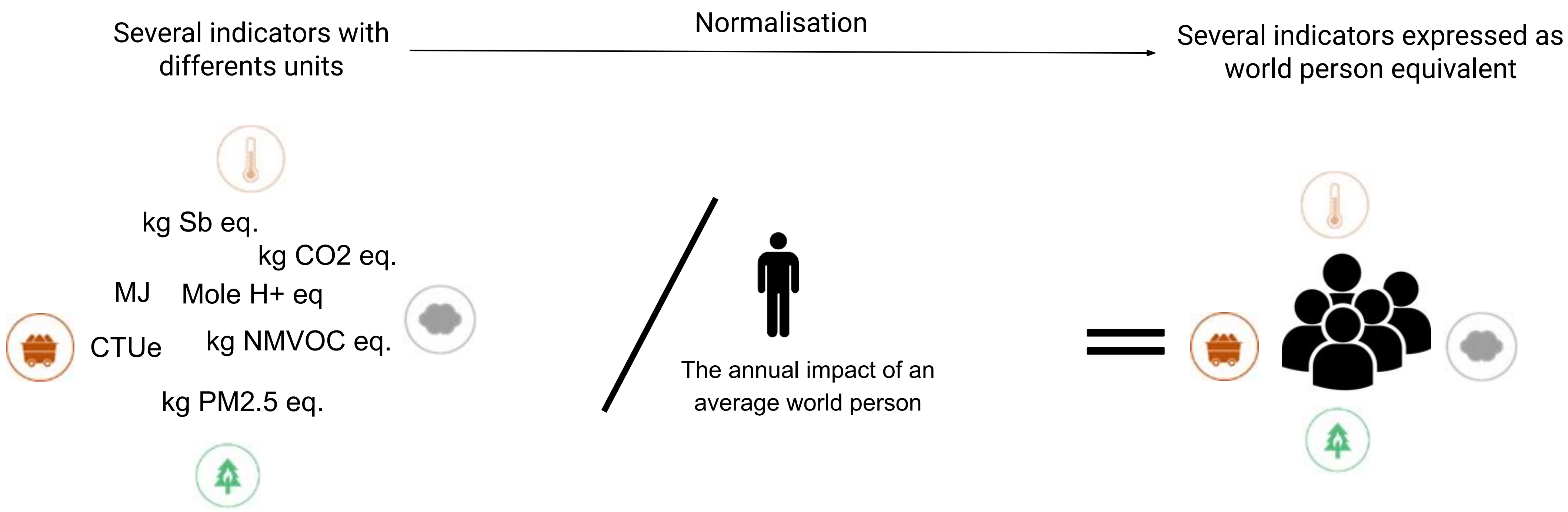
CONSUMPTION-BASED NORMALISATION



ie: Energy carrier = 500000 MJ

Normalization factor for Energy = 65000

500000/65000=0.7 eq.person

Normalization helps identifying the key indicators (where most of the impact occurs) & allows comparison between the indicators (that have different units)

Source : 1ACMME

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WEIGHTING

EF Impact Category	Unit	Final weighting factors (including robustness (%)
Climate change	kg CO_2 eq.	21.06
Ozone depletion	kg CFC-11 eq.	6.31
Human toxicity, cancer effects	CTUh	2.13
Human toxicity, non-cancer effects	CTUh	1.84
Particulate matter	disease incidences	8.96
Ionizing radiation, human health	kBq U^{235} eq.	5.01
Photochemical ozone formation, human health	kg NMVOC eq.	4.78
Acidification	mol H^+ eq.	6.20
Eutrophication, terrestrial	mol N eq.	3.71
Eutrophication, freshwater	kg P eq.	2.80
Eutrophication, marine	kg N eq.	2.96
Land use	pt	7.94
Ecotoxicity freshwater	CTUe	1.92
Water use	m^3 water eq.	8.51
Resource use, fossils	MJ	7.55
Resource use, minerals and metals	kg Sb eq.	8.32

Aggregating weighting set from survey

Criteria adapted from Soares et al 2006 has been selected to be used to assess the relevance of the different impact categories.

Criteria aims at reflecting aspects of the impacts which are inherentely related to the nature of the impact and the way it is exerted, namely related to questions such as:

- Where? ***Spread of impact***
- For how long? ***Time span of generated impact***
- *Is it reversible?* ***Reversibility***
- *Is the actual level close to planet carrying capacity?* ***Planetary boundary***
- *How severe are the impacts on ecosystem health, human health, or natural resource availbility?* ***Severity***

Robustness factors

Impact category	Model	Unit	Normalisation inventory coverage completeness	Normalisation inventory robustness	LCIA method level of recommendation
Climate change	IPCC, 2013	kg CO_2 eq	II	I	I
Ozone depletion	World Meteorological Organisation (WMO), 1999	kg CFC-11 eq	III	II	I

European Commission weighting proposal is based on a survey + a robustness indicator. No consensus can easily be reached. Weighting allows comparing environmental performances based on a single score.

Source : European Commission JRC Technical Report - Development of a weighting approach for the Environmental Footprint – Sala & al - 2018

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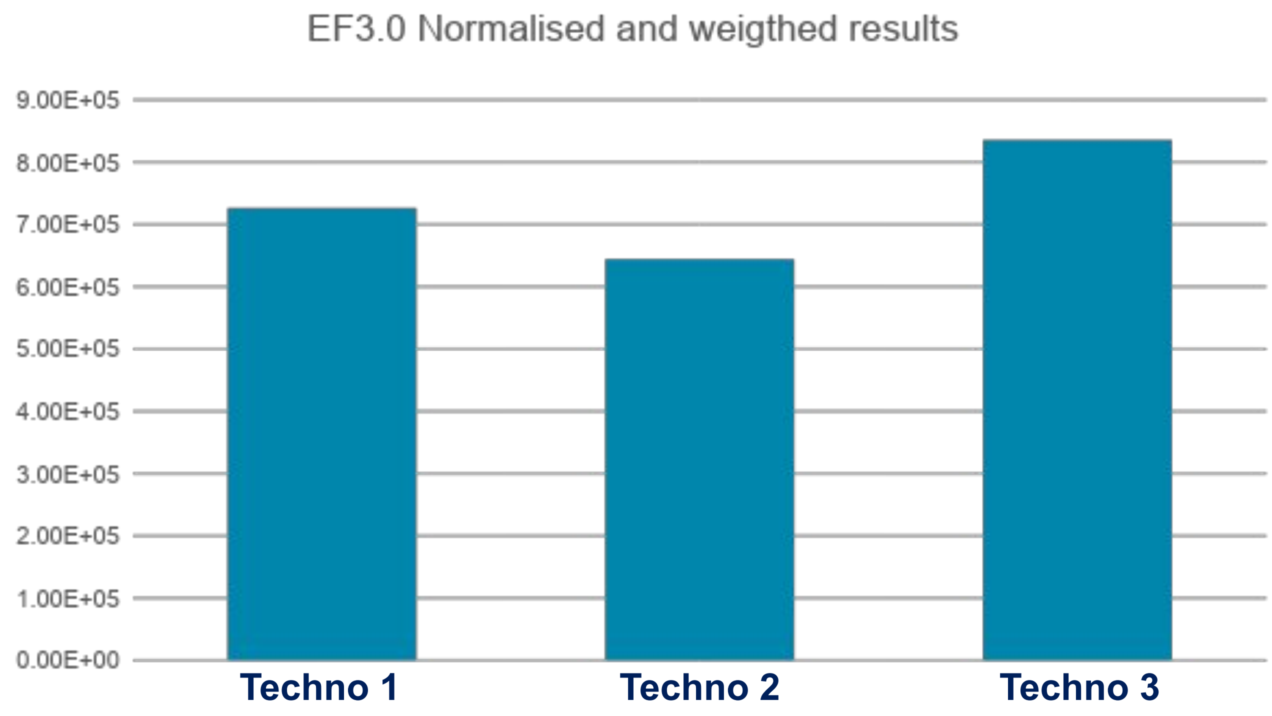
NORMALISED AND WEIGHTED RESULTS : EASY COMPARISON



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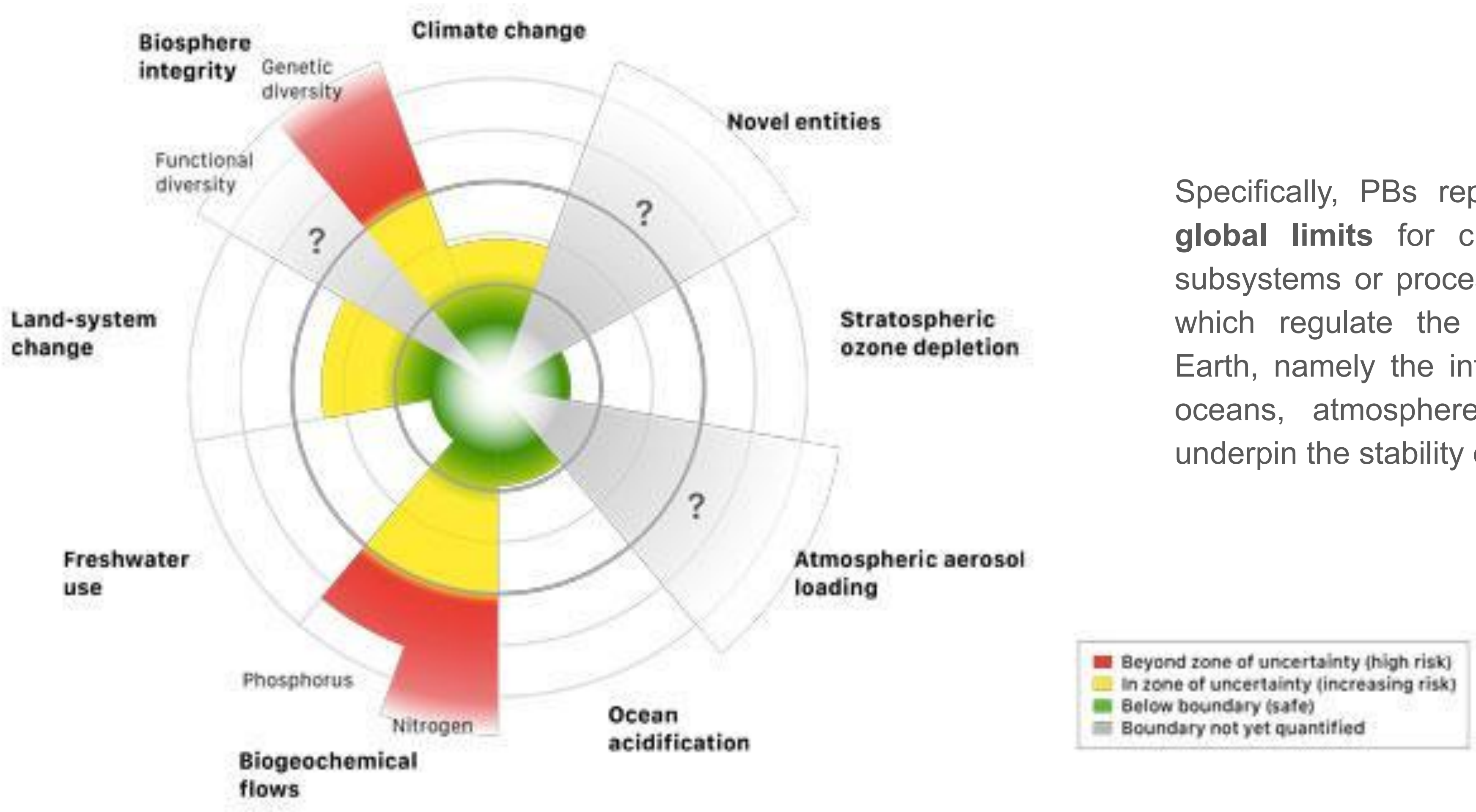
SETTING UP LCA-BASED TARGETS : PLANETARY BOUNDARIES CONCEPT



Specifically, PBs represent **a set of global limits** for critical biophysical subsystems or processes of the planet which regulate the resilience of the Earth, namely the interactions of land, oceans, atmosphere and life which underpin the stability of the planet.

AIRCRAFT END OF LIFE

- **TARMAC AEROSAVE SAS**: 750 A/C dismantled in around 10 years - Recycling rate : 92 %

- **A/C INDUSTRY**
  - 1700 A/C produced every year
  - Next 20 years : 15000 A/C retired
  - Today : 500 - 600 A/C retirements / year
  - From 2023 : 1000 A/C retirements / year

- **FUTURE CHALLENGES**
  - Composites recycling
  - New A/C lifetime? (mostly leasing companies)
  - Dismantling costs to be reduced and shared (today : last owner pays full dismantling)
  - Get new customers : and incentives (especially in the US)

Source : Pierre Bonnichon – Business development director – TARMAC during 20th of May 2019 conference at ENAC Alumni

AIRCRAFT END OF LIFE – TARMAC AEROSAVE

TARMAC AEROSAVE

ABOUT US

SHAREHOLDERS

AIRBUS	SAFRAN	SUEZ
33,6%	32,8%	33,6%

ACTIVITIES

AIRCRAFT STORAGE

AIRCRAFT MAINTENANCE

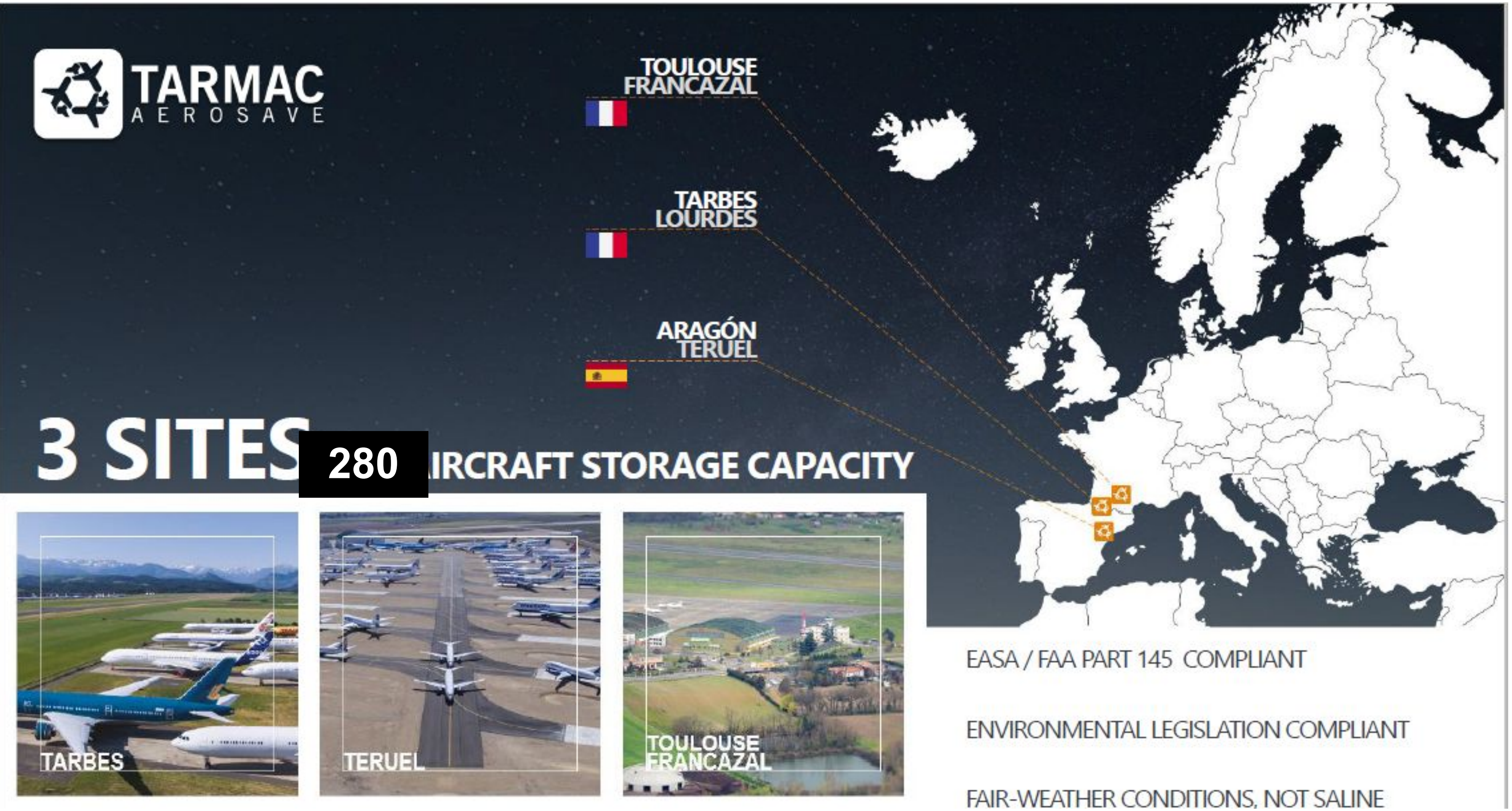
AIRCRAFT RECYCLING

ONE-STOP-SOLUTION PROVIDER

Economic

Environmental

〉 92% of the total weight of the aircraft is recovered.



Storage capacity – **100** A/C

Storage capacity – **140** A/C

Storage capacity - **40** A/C

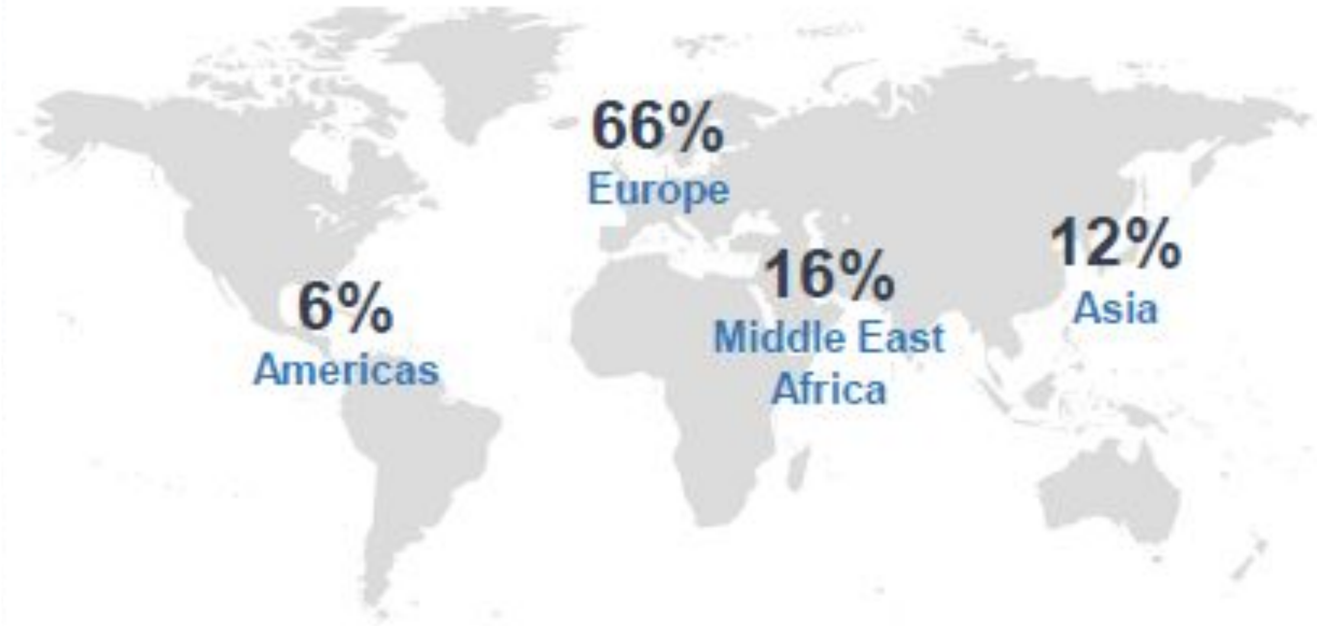
+

Airbus and partners to establish aircraft lifecycle centre in China

Facility will offer sustainable solutions to manage the entire lifecycle of aircraft, including dismantling and recycling

AIRBUS

Aircraft arrivals by origin (2018 data)



30% from airlines
70% from lessors

300 aircrafts recycled since 2007

vs 600 per Year …

Aircraft arrivals by type (2018 data)

AIRBUS

AIRCRAFT END OF LIFE – TARMAC AEROSAVE

Aircraft owner (decision to store, maintain or dismantle)

TARMAC AEROSAVE

MAINTENANCE
Aircraft is airworthy (CAMO)

STORAGE
Aircraft is airworthy (CAMO)

DISASSEMBLY
Aircraft may remain airworthy if it has a CAMO

☆ TARMAC inventory for selected parts, **valuable parts returned to owner** – parts are not airworthy

Parts must be recertified by EASA and can return to aerospace industry

Storage

Maintenance

Sold (directly or via broker)

Storage

FTA signature – remaining of aircraft becomes waste and **TARMAC property** – loses CAMO and airworthiness

Decontamination / depollution

Hazardous
- Recyclable
- Non-Recyclable

Non-hazardous
- Recyclable
- Non-Recyclable

☆ Aircraft owner's intention to discard aircraft remains formalised by TARMAC through FTA

FTA – Dismantling contract

CAMO – Continuing Airworthiness Mgt Org.

EASA European Union Aviation Safety Agency

AIRCRAFT END OF LIFE – TARMAC AEROSAVE

TARMAC uses 3rd party companies for WEEE recycling (electrical components) - selected on a call for tender (business driven)

CFRPs are currently not recycled by TARMAC but are landfilled

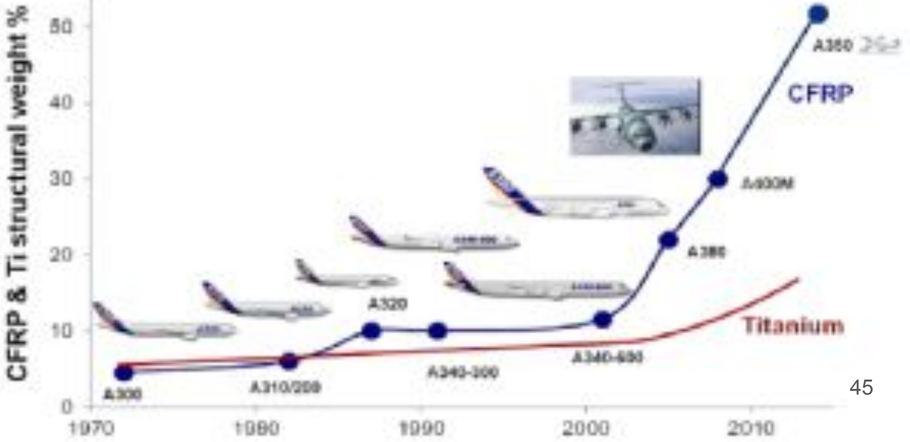
Cabin recycling process

1 - Segregation of electronic components

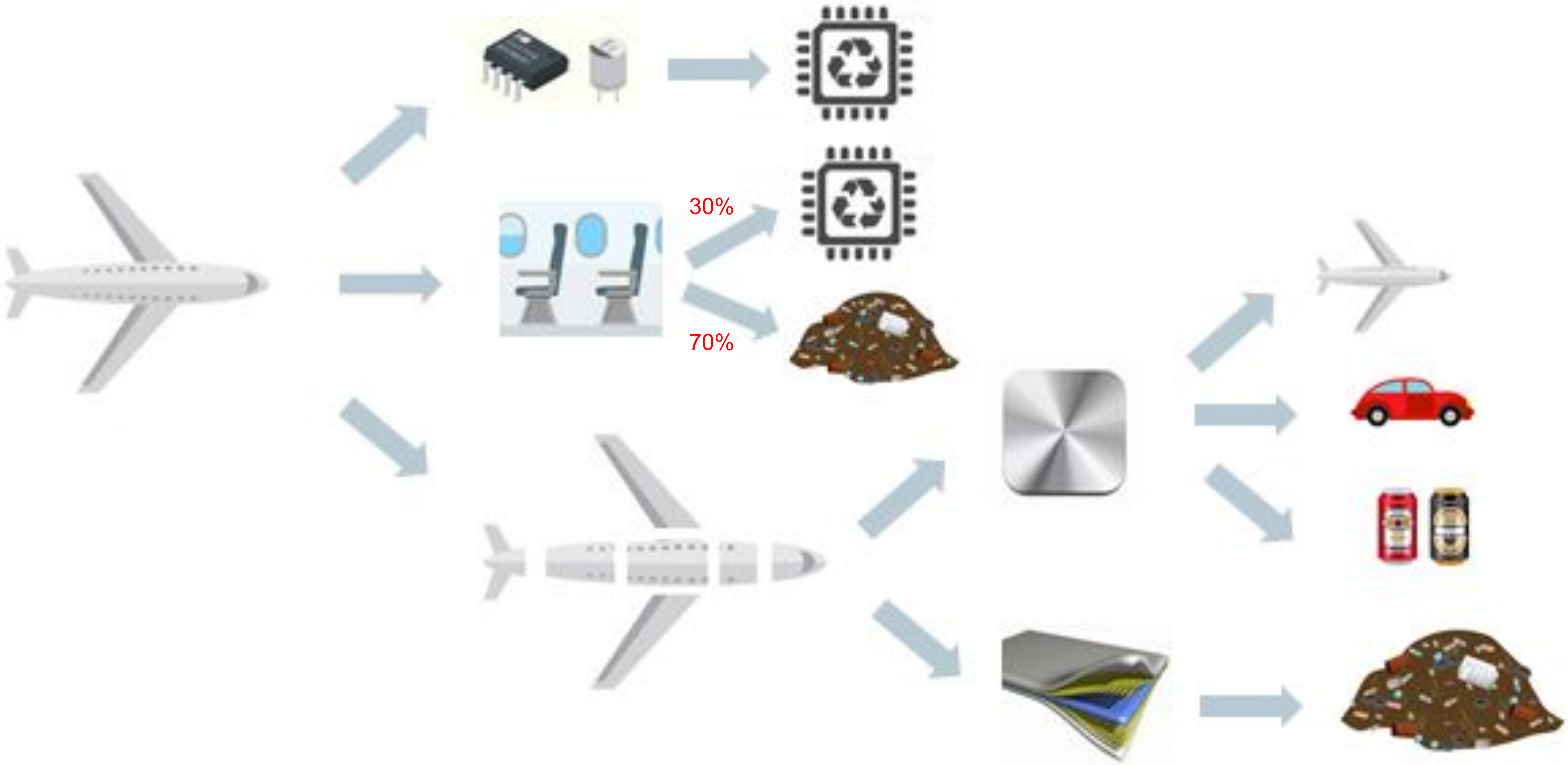
2 - **30%** of the cabin (seats and monuments) are removed

- Crushed and melted altogether
- Material separation (weight, density, magnetism etc)
- Recycled

3 - **70%** of the cabin is landfilled near TARMAC



AIRCRAFT END OF LIFE - CURRENT



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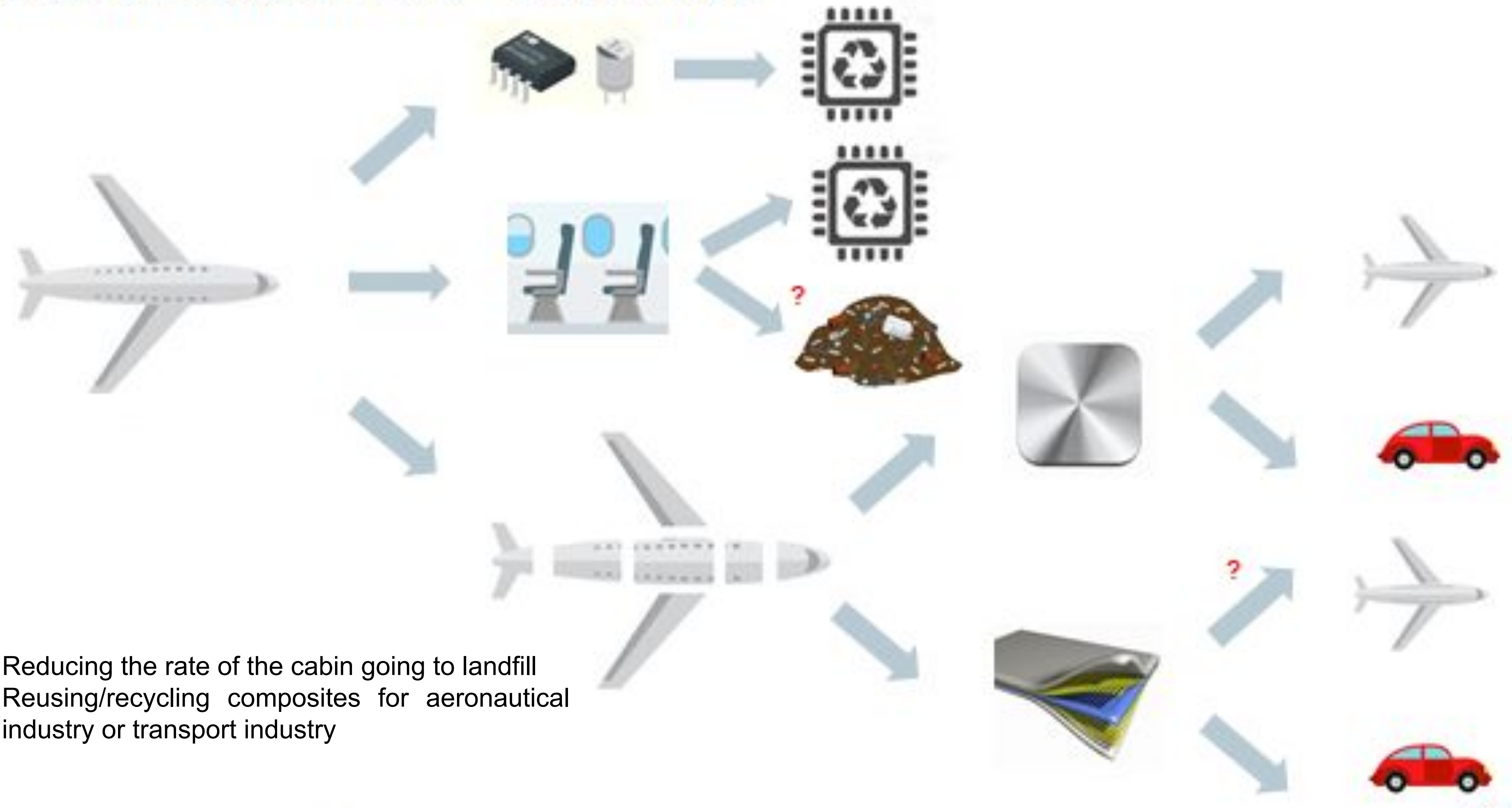
AIRCRAFT END OF LIFE - OBJECTIVE



- Reducing the rate of the cabin going to landfill
- Reusing/recycling composites for aeronautical industry or transport industry

THE FUTURE OF ECODESIGN

DIGITAL AND OPEN SOURCE

AIRBUS

DDMS

Digital Design Manufacturing & Services

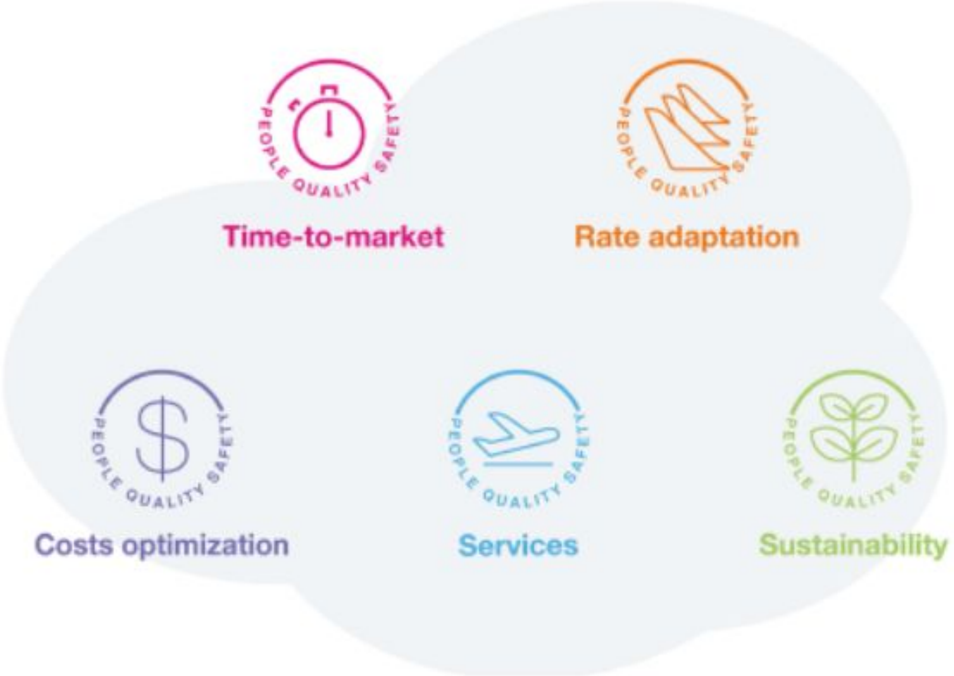
Design 4 Environment

Integration of Life Cycle Assessment into Architects and Designers Process, Methods & Tools

December 2020

Five key values drive DDMS ambition and set its trajectory

- **Time-to-market** aims at compressing our development time to deliver high quality standards products when requested by our customers.
- **Rate adaptation** consists in making our industrial system more flexible to answer product demand evolutions.
- **Costs optimization** drives profitability through cost reduction, whilst being focused on business value and societal expectations.
- **Support and Services** extend our footprint into customer daily operations while offering growth opportunities.
- **Sustainability** leads the development of all our daily activities at each stage of the product life cycle.



These DDMS values are essential to build AIRBUS' bright future on top of three fundamental principles: people, quality & safety. They steer the incremental development, deployment and adoption of our solutions.

AIRBUS

Sustainability

Design 4 Environment

Business objectives

We will integrate sustainability at all steps of NG program life...

...by enabling enlightened choices by...

...understanding the impact of our quickly changing environment on product positioning (cost and constraint of alternative energy, high level environmental impacts, resource depletion, climate change impact on global economy and on operations)

Sustainable positioning

...giving the architects & designers the means to assess and minimize the environmental impact of the product, the industrial system and services *(Eco-design approach and LCA capabilities at all steps of the development process)*

Sustainable design

...being able to assess, value and trade solutions considering their environmental footprint (Value referential, Sustainability KPIs and value, Assessment methods & tools, Target setting & cascading, Trades)

Sustainability value

...selecting a sustainable supply chain and exchanging openly relevant environmental data (*supplier selection, engagement & contractual commitments, open exchange of environmental impact data and monitor environmental performance and long term ethic commitments)*

Sustainable supply chain

...by ensuring long term environmental performance by...

…providing efficient means for the tracking of substances throughout product life *(Easy access to material & processes digital database, digital links between P/N, Standards, material, processes and substances, effective tracking up to delivery and means to maintain it up to end-of life)*

Sustainability Tracking

...providing efficient means for continuous monitoring the environmental performance of the industrial system, the product and the services (what, how, when to monitor along SOI life, ways to retrieve efficiently the data)

Sustainability Monitoring

…by making it part of our DNA by...

…a change of mindset towards Sustainability (Communication, Awareness sessions, Sustainability training, Workshops)

Sustainability New ways of working

…introduce sustainability requirements in all relevant Airbus business processes (high functional requirements)

Sustainability in ABP

We will integrate sustainability at all steps of NG program life...

[Airbus Amber]

DDMS Sustainable Design & Tracking

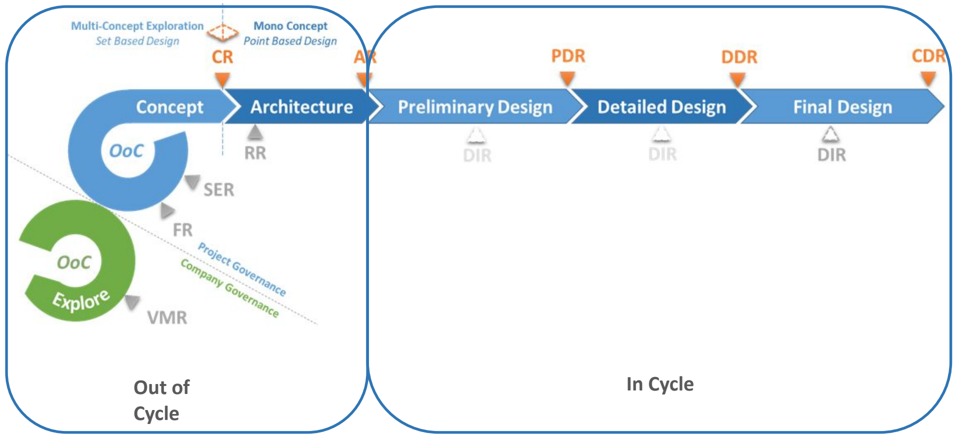
DDMS Budget: 3.3ME

Other Budget (BX): 810Ke

Environmental Assessment: Comply with Ecolabel (Future regulation)

Substance: Comply with regulation

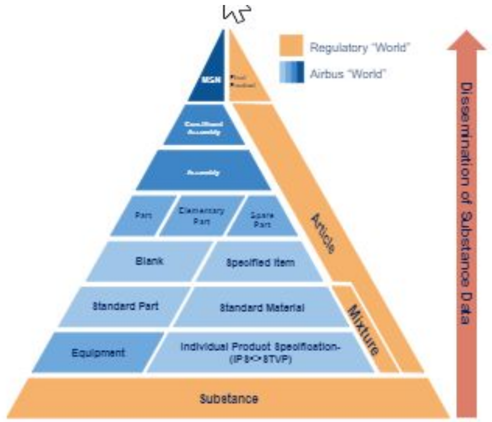
Sustainable Design



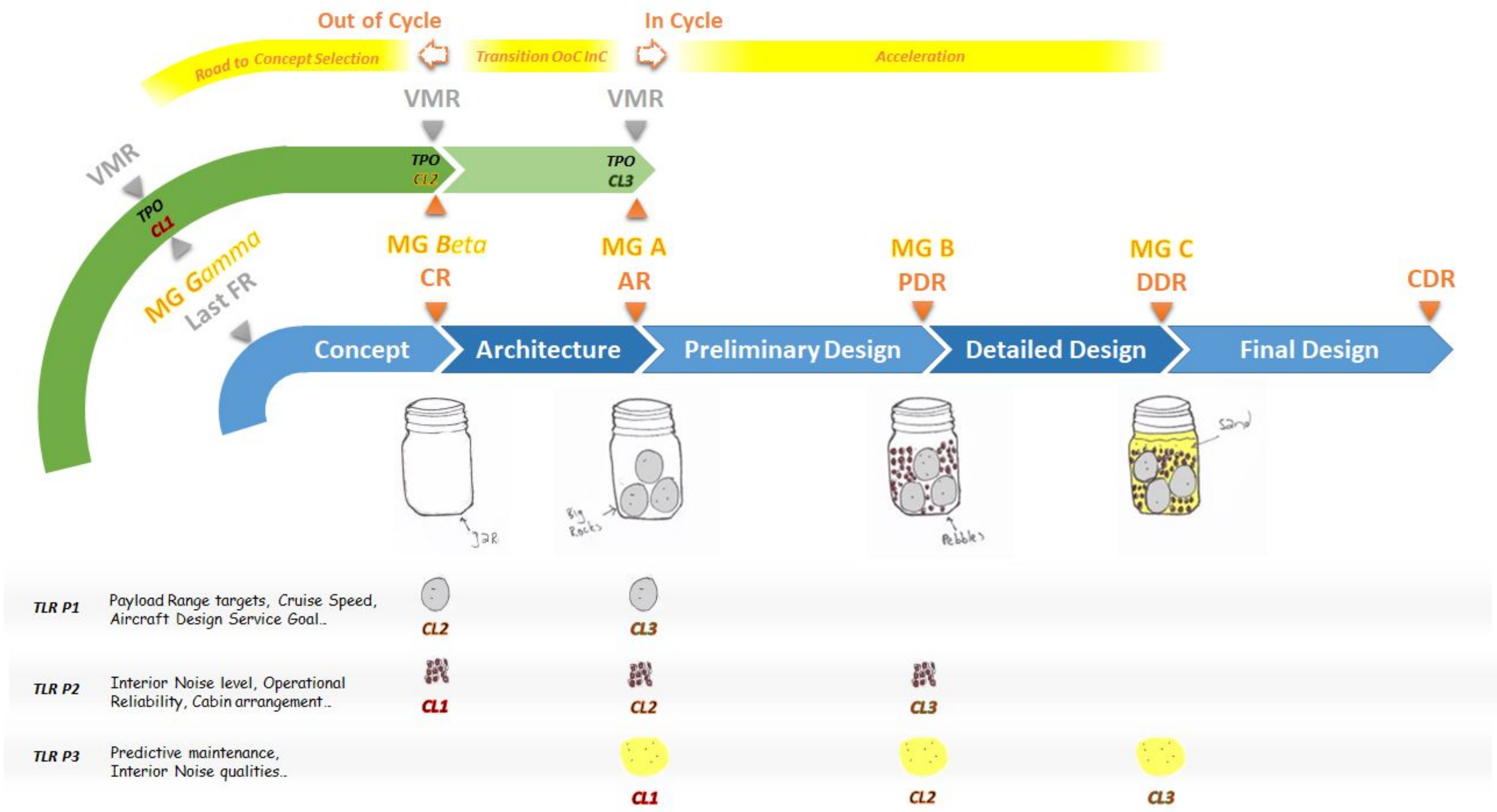
Giving the architects & designers the means to assess and minimize the environmental impact of the product, the industrial system and services

Ensuring efficient means for traceability of substances throughout product life - All *along the manufacturing process and enabling means to maintain it up to end-of life*

Sustainable Tracking

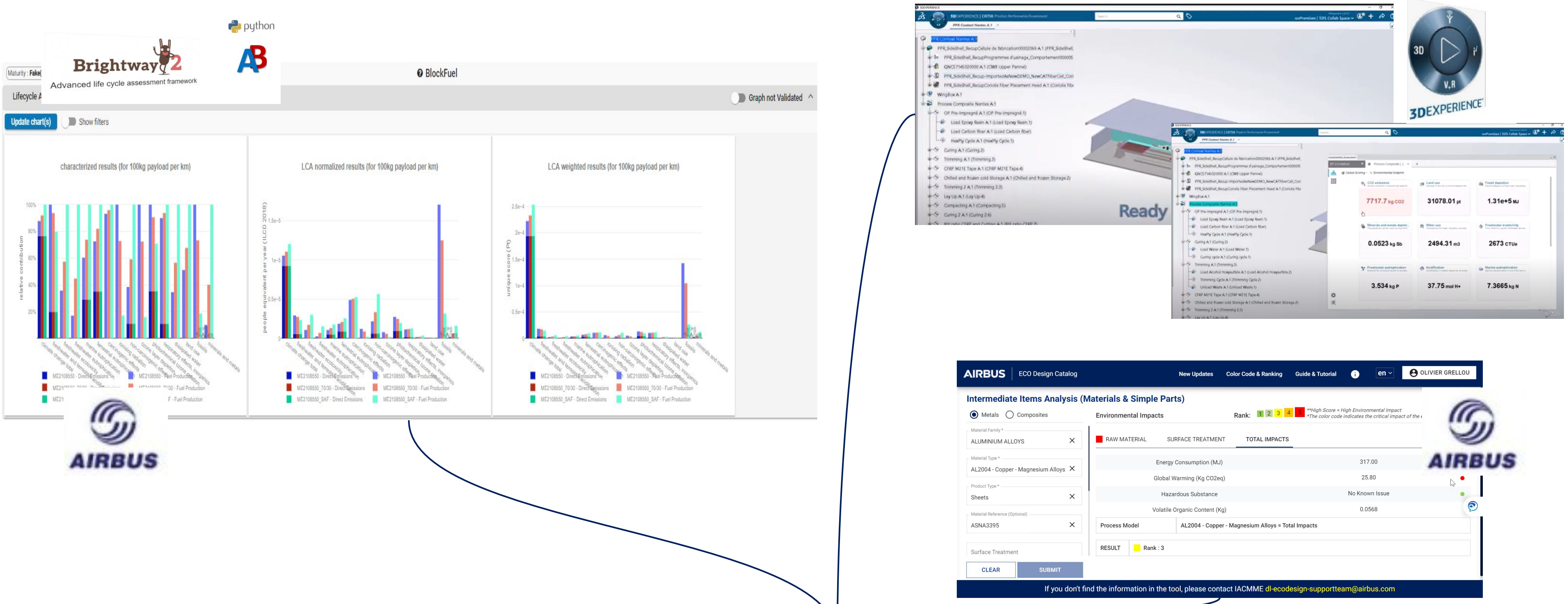


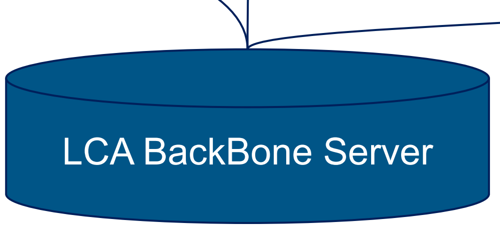
Product Development Plan of the Future



AIRBUS

Focus on Sustainable Design





Export Control Free

[Airbus Amber]

DDMS Sustainable Design & Tracking

Environmental Assessment (LCA) embedded in the PDPoF

Environmental Value part of the CoDevelopment Pattern for best candidate convergence

Support eAction CSR4

LCA Inventories structured and stored

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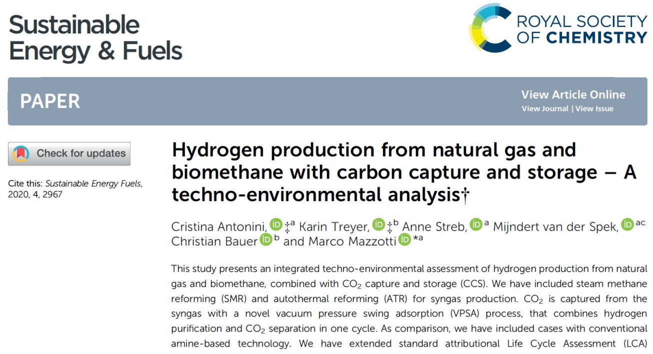
Exemple
Elegancy model exploitation (BW2, in various Airbus Environments)


Sustainable Energy & Fuels

ROYAL SOCIETY OF CHEMISTRY

PAPER

View Article Online
View Journal | View Issue

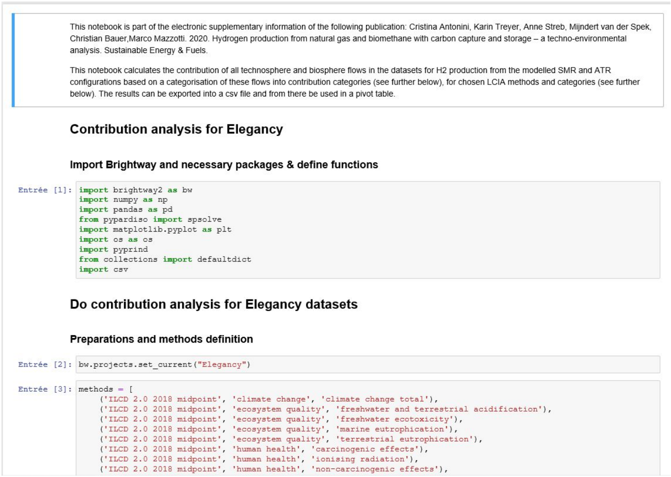
Check for updates

Cite this: *Sustainable Energy Fuels*, 2020, 4, 2967

Hydrogen production from natural gas and biomethane with carbon capture and storage – A techno-environmental analysis†

Cristina Antonini, [a] Karin Treyer, [b] Anne Streb, [a] Mijndert van der Spek, [ac] Christian Bauer [b] and Marco Mazzotti [*a]

This study presents an integrated techno-environmental assessment of hydrogen production from natural gas and biomethane, combined with CO_2 capture and storage (CCS). We have included steam methane reforming (SMR) and autothermal reforming (ATR) for syngas production. CO_2 is captured from the syngas with a novel vacuum pressure swing adsorption (VPSA) process, that combines hydrogen purification and CO_2 separation in one cycle. As comparison, we have included cases with conventional amine-based technology. We have extended standard attributional Life Cycle Assessment (LCA)


This notebook is part of the electronic supplementary information of the following publication: Cristina Antonini, Karin Treyer, Anne Streb, Mijndert van der Spek, Christian Bauer,Marco Mazzotti. 2020. Hydrogen production from natural gas and biomethane with carbon capture and storage – a techno-environmental analysis. Sustainable Energy & Fuels.

This notebook calculates the contribution of all technosphere and biosphere flows in the datasets for H2 production from the modelled SMR and ATR configurations based on a categorisation of these flows into contribution categories (see further below), for chosen LCIA methods and categories (see further below). The results can be exported into a csv file and from there be used in a pivot table.

Contribution analysis for Elegancy

Import Brightway and necessary packages & define functions

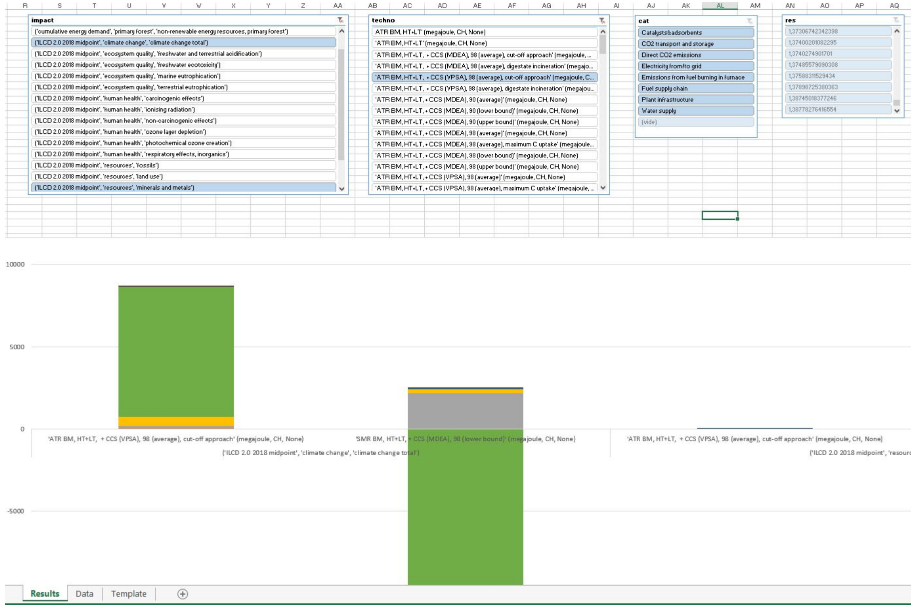
Entrée [1]:
```
import brightway2 as bw
import numpy as np
import pandas as pd
from pypardiso import spsolve
import matplotlib.pyplot as plt
import os as os
import pyprind
from collections import defaultdict
import csv
```

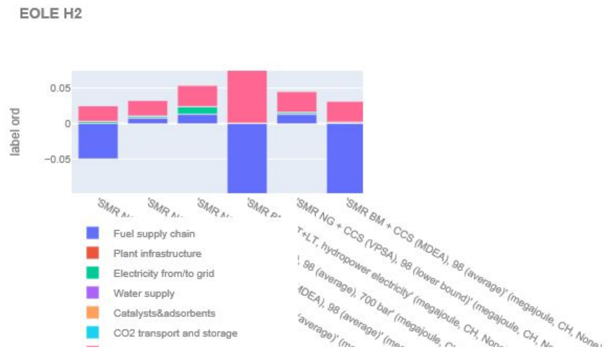
Do contribution analysis for Elegancy datasets

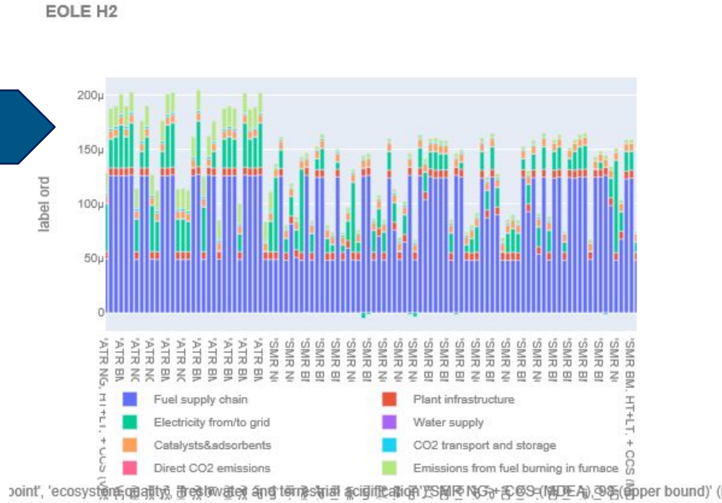
Preparations and methods definition

Entrée [2]:
```
bw.projects.set_current("Elegancy")
```

Entrée [3]:
```
methods = [
    ('ILCD 2.0 2018 midpoint', 'climate change', 'climate change total'),
    ('ILCD 2.0 2018 midpoint', 'ecosystem quality', 'freshwater and terrestrial acidification'),
    ('ILCD 2.0 2018 midpoint', 'ecosystem quality', 'freshwater ecotoxicity'),
    ('ILCD 2.0 2018 midpoint', 'ecosystem quality', 'marine eutrophication'),
    ('ILCD 2.0 2018 midpoint', 'ecosystem quality', 'terrestrial eutrophication'),
    ('ILCD 2.0 2018 midpoint', 'human health', 'carcinogenic effects'),
    ('ILCD 2.0 2018 midpoint', 'human health', 'ionising radiation'),
    ('ILCD 2.0 2018 midpoint', 'human health', 'non-carcinogenic effects'),
```







- 18 impacts categories from ILCD & Recipe & Cumulative Energy Demand
- 104 technological assessments
- 8 categories

⇒ + 14000 lines of data

Jupyter Notebook Python with BW2
H2 production ATR, SMR, Electrolysis

- **Excel like results exploitation for EOLE**
- **Specification for SoS integration**

Provide models to SoS environment

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ECODESIGN EXAMPLES

La nature, éternelle source d’inspiration et de performance pour l’aéronautique

Denis Darracq – Chef de la Recherche & Technologie Physique du Vol
Laure Couteau – Ingénieure calcul et écoconception

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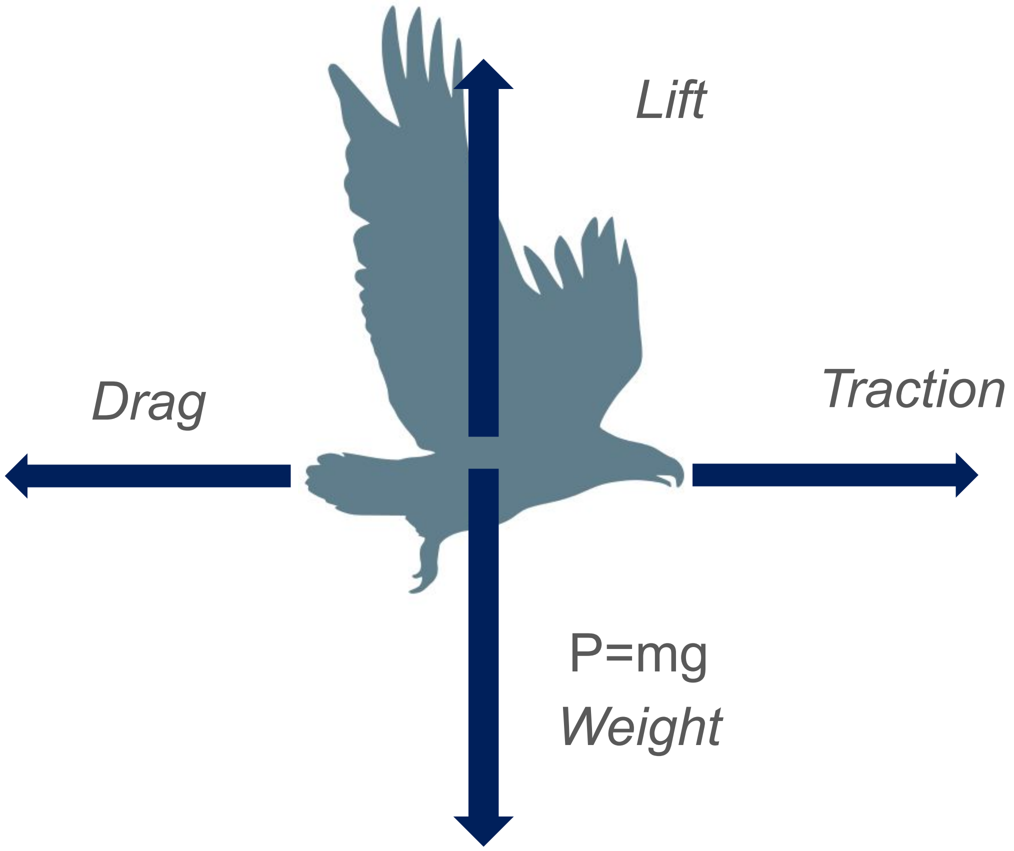
Flight: Aerodynamics



Airbus A320

Winglets : wing surface increase

Consumption : - 4%.

AIRBUS

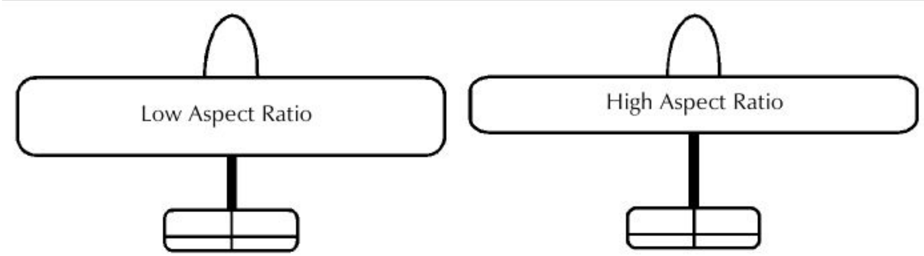
Shape

Laminarity

A340 laminar flow demonstrator

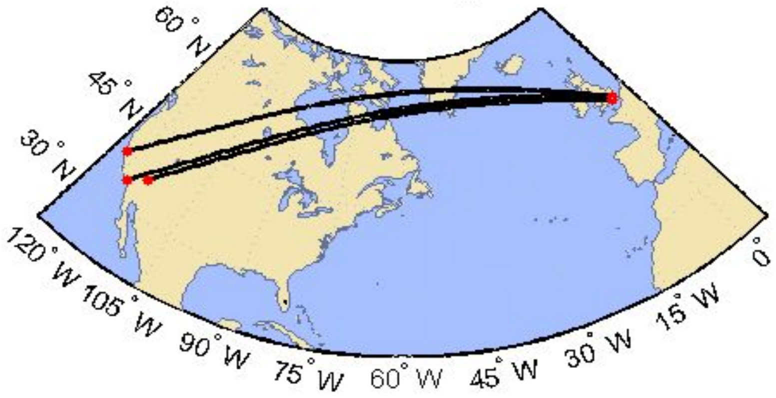
Aspect Ratio

“An albatross has an aspect ratio of about 18, whereas the aspect ratio of an Airbus aircraft is between 7.5 for an A380 and 9.5 for an A320, so there's a question as to why an albatross has such a high aspect ratio while passenger aircraft don't.”

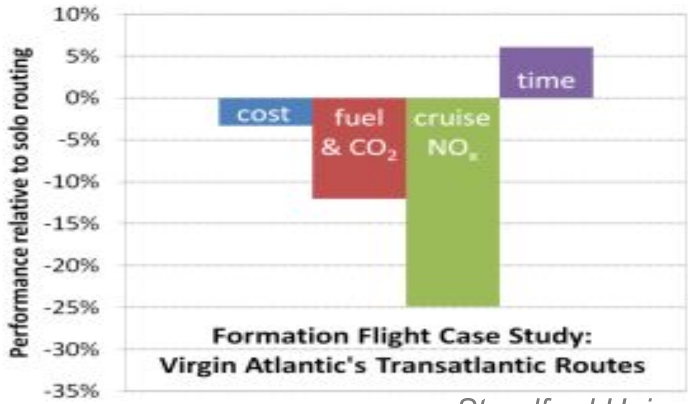


Tomorrow : formation flight?

Solo Routing



Formation Routing



Standford Uni.

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Fello fly 2020 update (from hub)

Inspired by biomimicry, fello'fly is based **on Wake Energy Retrieval (WER) to reduce aviation emissions**. WER replicates the behaviour of birds, which fly together to reduce their energy consumption. The technique of a follower aircraft retrieving energy lost by a leader, by flying in the smooth updraft of air the wake creates, reduces fuel consumption in the range of **5-10% per trip**.

Flight testing will take place throughout **2020** using two Airbus A350 aircraft, with the involvement of the airlines and [Air Navigation Service Providers] (ANSP) as early as **2021** in an oceanic airspace.

https://www.airbus.com/newsroom/press-releases/en/2020/09/airbus-joined-by-european-partners-to-demonstrate-reduced-emission-fellofly-operations.html?_lrsc=72a6b3bf-eef9-4f20-a49a-dadcae0d75ec

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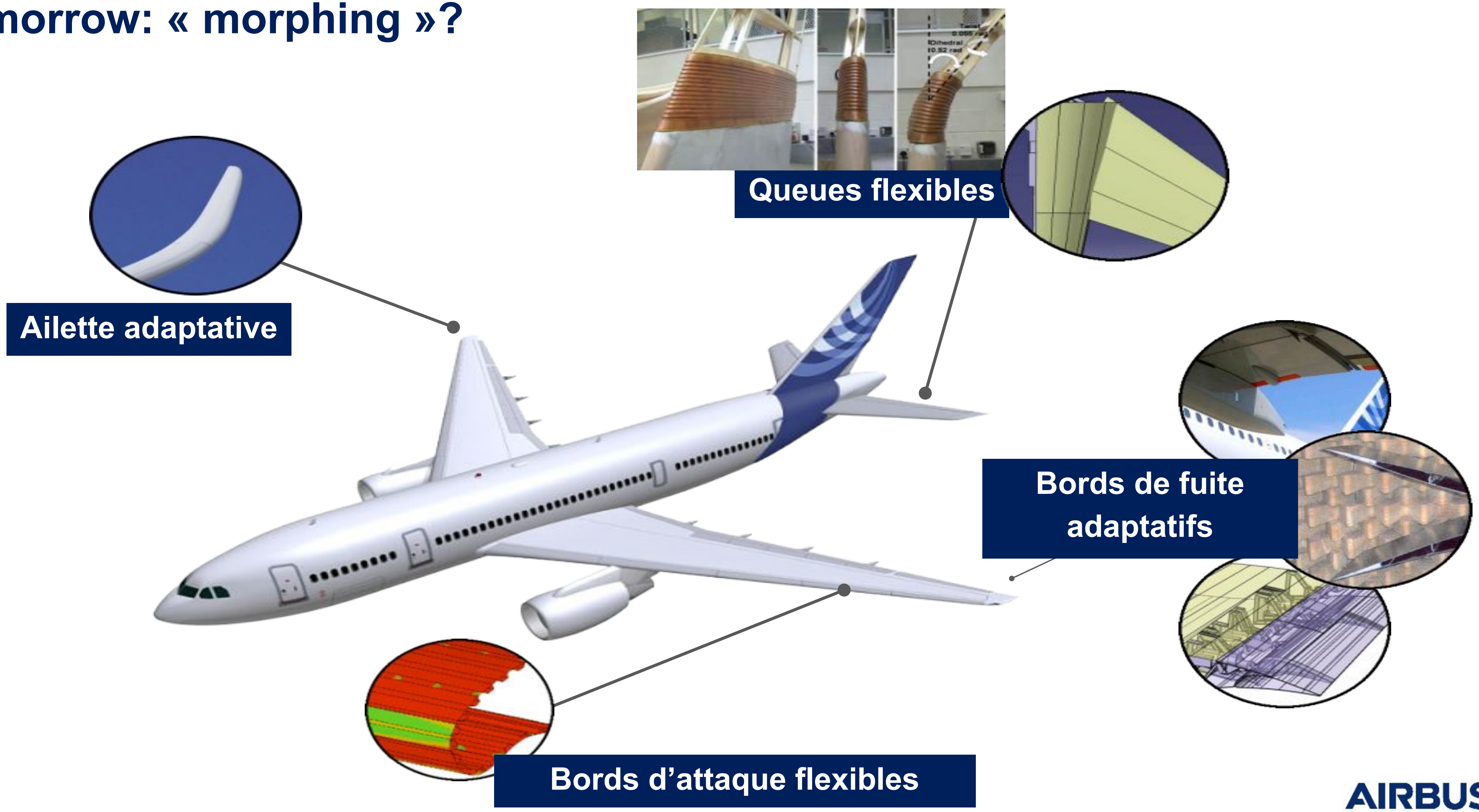
Tomorrow: « morphing »?



Additive manufacturing

airbus-bionic-partition-LQ.mp4

Lien

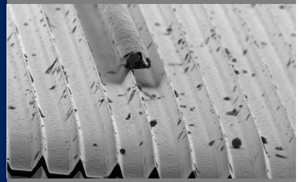
AIRBUS

La structure et la matière

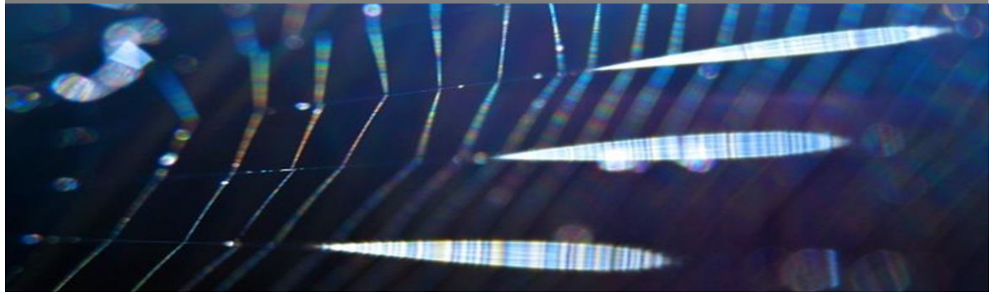
Micro-rainures

+ d’efficacité énergétique
+ de vitesse

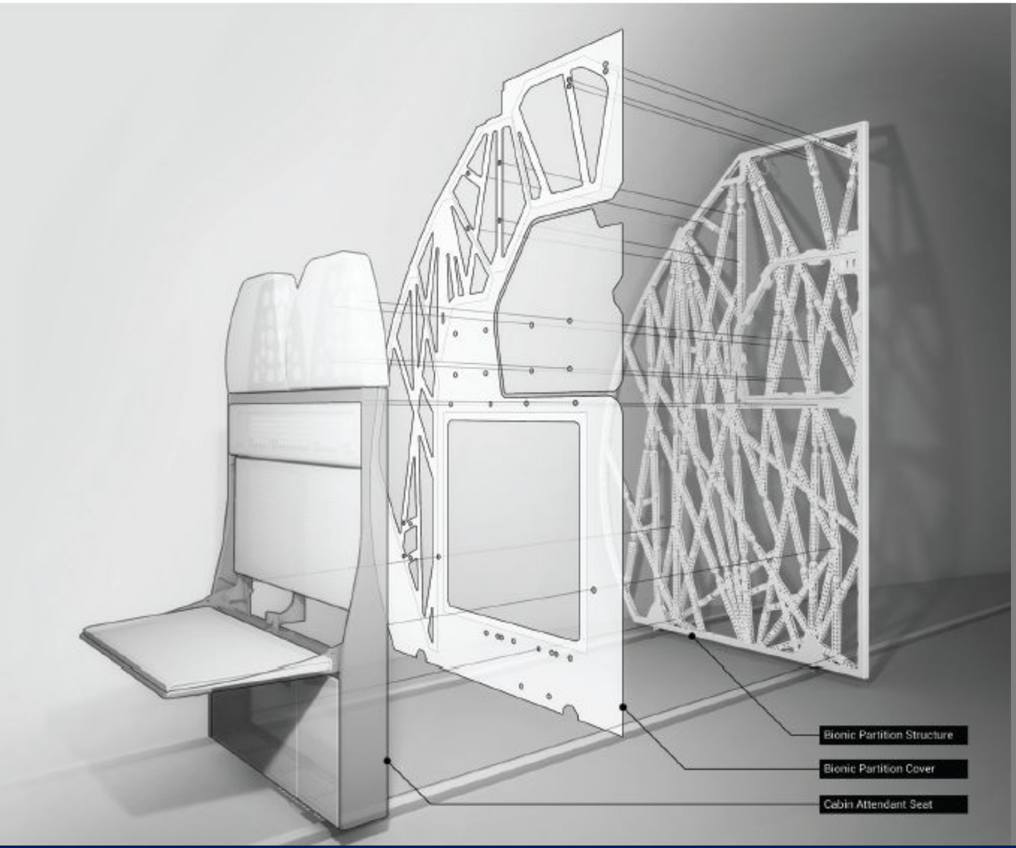
- de frottement
- de consommation



- ← La peau de requin,
- La fleur de lotus : super hydrophobie
- La toile d’araignée : contre les chocs
- La plume : propriétés moléculaires



3D printing : metals or composite?



Cabin panel - Autodesk & Airbus

Weight savings : 45% ie 500kg/aircraft

- 1kg/aircraft ⟷ *- 100 kg of kerosene per year*

Titanium Composite bracket

Weight savings: 25%
Tension allowable : 3.4t
Compression allowable: 0.7t

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Conclusion

- Context : innovation race
- Nature : maximum efficiency at lower energy consumption
- Very dynamic area, growing very fast : high innovation potential

→ So much to learn and discover from nature

Les futurs drones, entre biomimétisme et bio-inspiration

Deux grandes écoles d'ingénieurs, l'ISAE-Supaero et l'ENAC, vont présenter leurs prototypes à Toulouse inspirés d'animaux – Le monde 21/05/2019

LE MONDE | 21.05.2019 à 12h01 |

Par Jean-Michel Normand

Un drone qui, tel un albatros, planerait sur des centaines de kilomètres. D'autres qui se joueraient des turbulences avec l'aisance d'un faucon crécerelle, ou battraient des ailes comme le fait une libellule. Consacrée cette année aux drones, la rencontre annuelle entre l'ISAE-Supaero et l'ENAC, deux grandes écoles de l'ingénierie de l'aérospatiale et de l'aviation civile, fait grand cas de la bio-inspiration, voire du biomimétisme.

Le concept de « drone à extraction d'énergie » sera l'une des vedettes de ce « Rendez-vous aéro de l'innovation » qui se tient jeudi 23 mai sur le campus toulousain de l'ISAE-Supaero. Cet appareil entre dans la catégorie des aéronefs « bio-inspirés » et utilise les forces issues des variations de pression liées aux vents pour reproduire la technique de vol des oiseaux.

En récupérant l'énergie produite par les rafales atmosphériques, on pourrait gagner jusqu'à 40 % d'autonomie, selon les chercheurs. Pour « surfer » sur le vent relatif et s'orienter pour maximiser la portance, cette aile volante reçoit de multiples capteurs (sur le modèle des sondes Pitot) qui mesurent les différences de pression atmosphériques. Les données recueillies alimentent le calculateur de vol qui oriente les gouvernes du drone.

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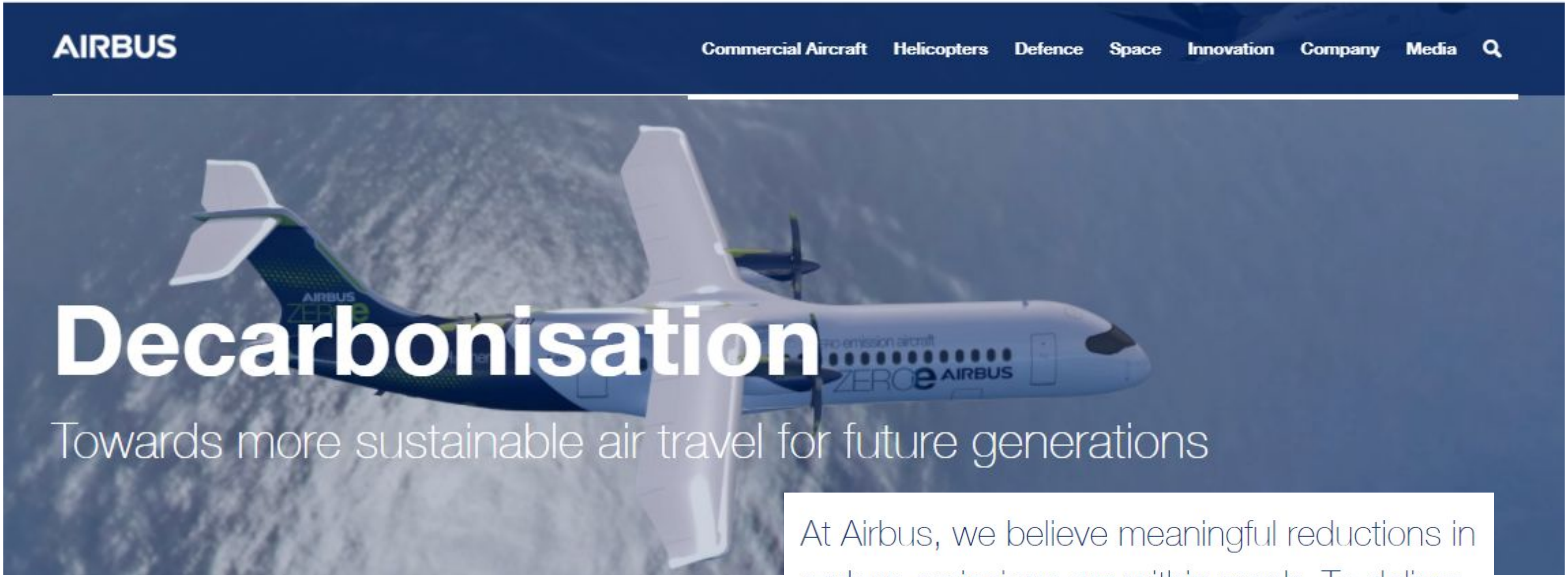
ENVIRONMENTAL CHALLENGES :
DECARBONISATION - SUSTAINABILITY

DECARBONISATION

AIRBUS



At Airbus, we believe meaningful reductions in carbon emissions are within reach. To deliver on our decarbonisation strategy, we have the ambition to develop the world's first zero-emission commercial aircraft by 2035 to ensure future generations can enjoy flying as much as we do.

https://www.airbus.com/company/sustainability/environment/climate-change/decarbonisation.html

Our climate action plan

Improving fuel burn of our existing fleet

Our latest-generation, fuel-efficient aircraft have enabled the aviation industry to surpass its first goal of reaching an annual fuel efficiency of 2.1% over the last decade. This has saved 10 billion tons of CO2 since 1990.

Investing in zero-emission technologies

Disruptively reducing the CO2 emissions of aircraft cannot be achieved using existing technologies. This is why we are investing in hybrid-electric and hydrogen technologies to accelerate the pathways needed to achieve our decarbonisation ambition.

Developing sustainable alternative fuels (SAF)

In the short term, SAF has the potential to drive significant CO2 reductions in aircraft. Since 2008, we have been actively involved in the SAF certification process, demonstrator flights, partnerships and policy advocacy. We also work with multiple airline customers to deliver aircraft that use a blend of sustainable fuels.

https://www.airbus.com/company/sustainability/environment/decarbonisation.html

AIRBUS

Optimising day-to-day aircraft operations

We leverage ATM solutions and ground-and-flight operational measures to reduce air travel's impact on the environment. We are also involved in the Single European Sky Air Traffic Management Research (SESAR) initiative.

Monitoring climate change

Our earth-observation satellites shed light on significant environmental issues, such as climate change, pollution, deforestation and natural disasters. These include the EarthCARE satellite for one of ESA's Earth Explorer missions and Sentinel earth-observation satellites for the Copernicus programme.

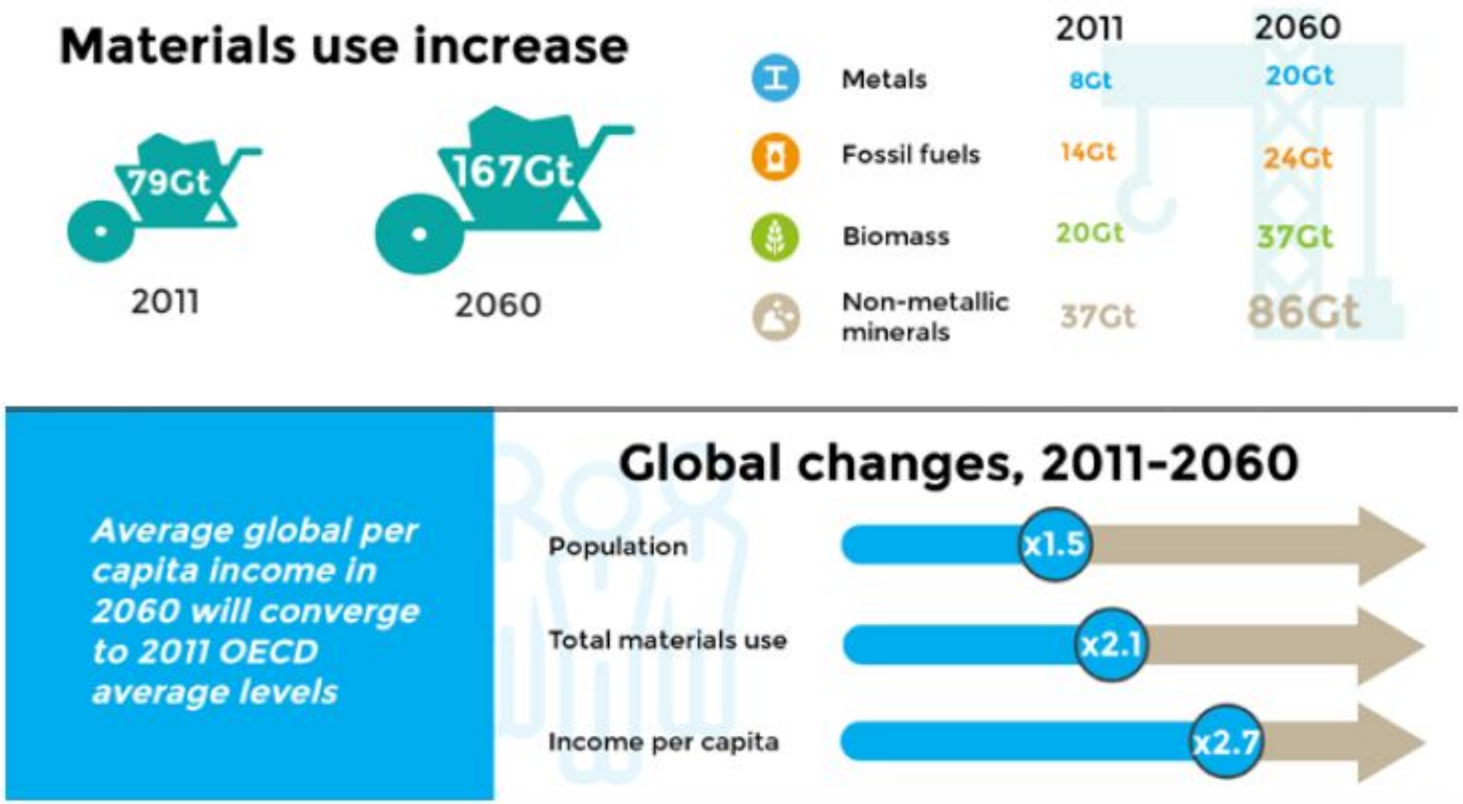
https://www.airbus.com/company/sustainability/environment/decarbonisation.html

SUSTAINABILITY
EXAMPLES OF CIRCULARITY AND CRM

CIRCULAR ECONOMY

CIRCULAR ECONOMY – CONTEXT

GROWING USE OF RESOURCES



Source : OECD **HIGHLIGHTS** Global Material Resources Outlook to 2060 – Economic Drivers and Environmental Consequences

END OF LIFE – RECYCLING RATES (GLOBAL)

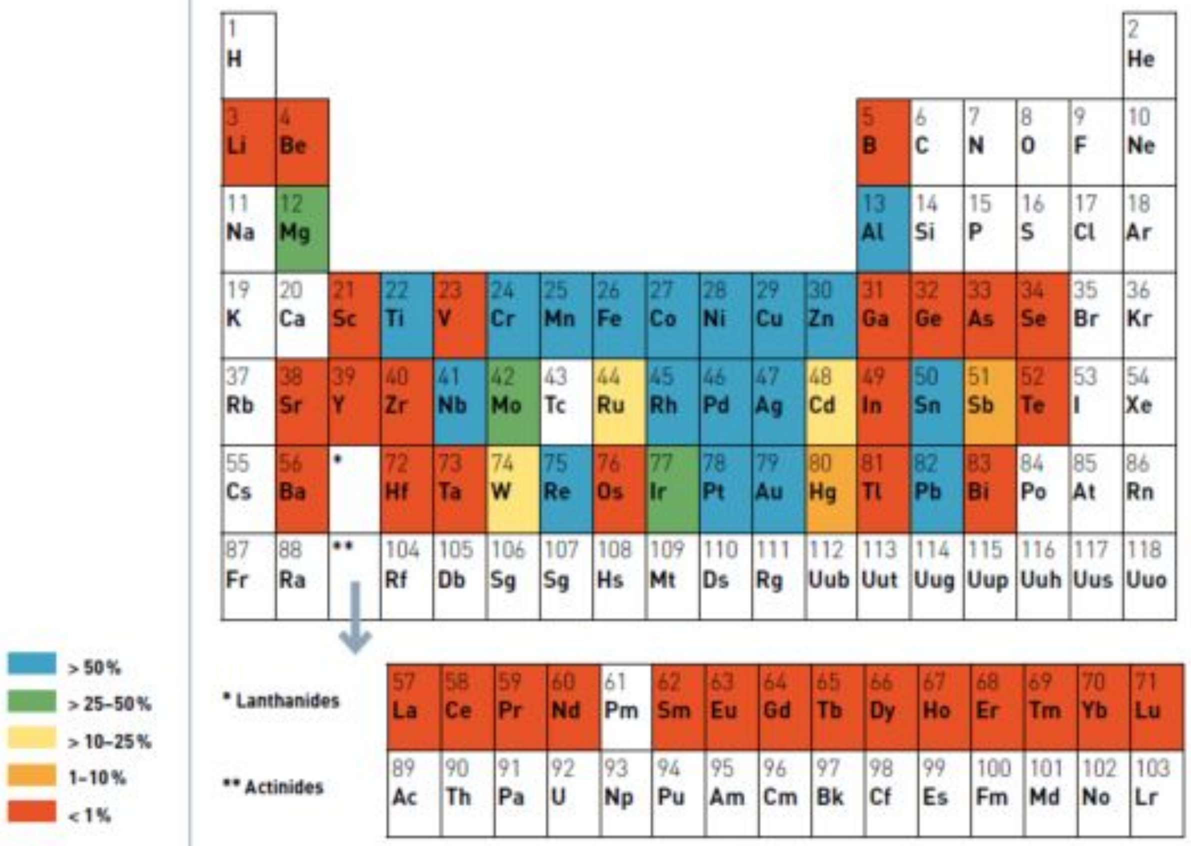
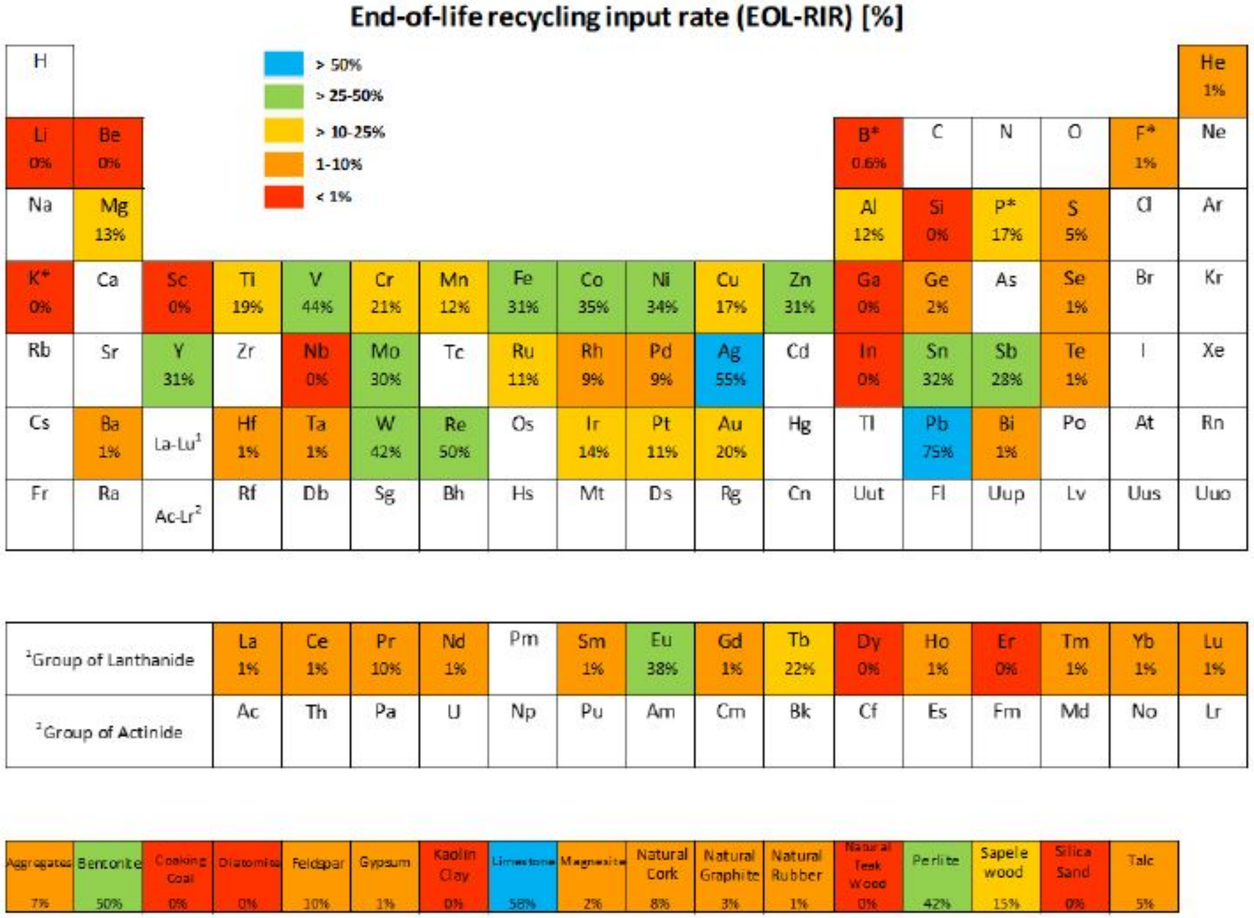


Figure 4. EOL-RR for sixty metals: The periodic table of global average end-of-life (post-consumer) functional recycling (EOL-RR) for sixty metals. Functional recycling is recycling in which the physical and chemical properties that made the material desirable in the first place are retained for subsequent use. Unfilled boxes indicate that no data or estimates are available, or that the element was not addressed as part of this study. These evaluations do not consider metal emissions from coal power plants.

Source : https://www.resourcepanel.org/reports/recycling-rates-metals

AIRBUS

END OF LIFE – RECYCLING INPUT RATE (EU)



* F = Fluorspar; P = Phosphate rock; K = Potash, Si = Silicon metal, B=Borates.

The **end-of-life recycling input rate** (EOL-RIR) measures how much of the total material input into the production system comes from recycling 'old scrap' (i.e. post-consumer scrap)

Source : EC JRC - Recovery of critical and other raw materials from mining waste and landfills, 2019

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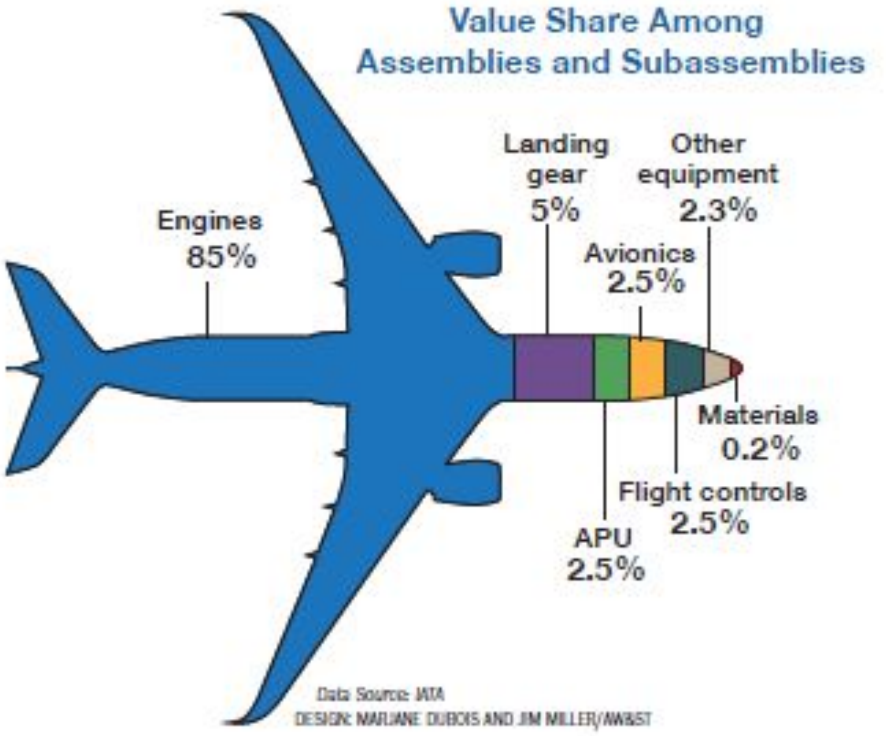
AIRCRAFT END OF LIFE – FINANCIAL VALUE
Source : Aviation Week, May 4-17 2020



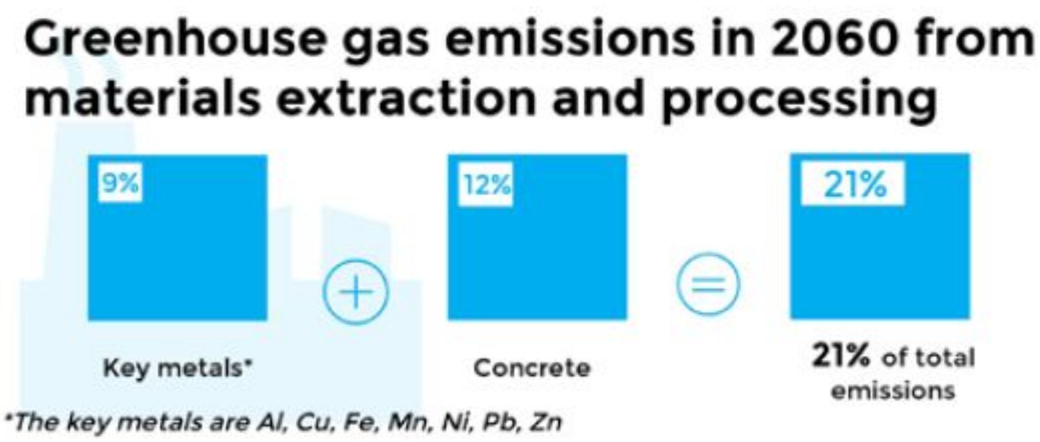
In terms of value, the purpose of dismantling an aircraft is to sell its components and parts.

The engines are by far the priciest element, even after two decades in service. “The engines are clearly the most valuable parts, with 70-80% of the end-of-life aircraft total marketing price [as indicated by leasing companies],” an IATA spokesperson says. Tarmac’s salespeople suggest engines represent as much as 85%.

The next most valuable parts—in order of importance, according to consultancy SGI Aviation—are the landing gear, the auxiliary power unit, electrical power units such as generators, flight controls and navigation systems. They are commonly referred to as high-value components, and together they comprise as much as 70% of the value of the airframe, excluding the engines. Other components with noticeable value include escape slides and flap tracks.

CIRCULAR ECONOMY – INCENTIVES

RESOURCES ENVIRONMENTAL IMPACTS



- More than half of all greenhouse gas (GHG) emissions are related to materials management activities. GHG emissions related to materials management will rise to approximately 50 Gt CO_2-equivalents by 2060.
- Fossil fuel use and the production of iron & steel and construction materials lead to large energy-related emissions of greenhouse gases and air pollutants.
- Metals extraction and use have a wide range of polluting consequences, including toxic effects on humans and ecosystems.
- The extraction and use of primary (raw) materials is much more polluting than secondary (recycled) materials.

Source : OECD **HIGHLIGHTS** Global Material Resources Outlook to 2060 – Economic Drivers and Environmental Consequences

CIRCULAR ECONOMY – INCENTIVES

RESOURCES ENVIRONMENTAL IMPACTS

FIGURE 3.13 **Metal production amounts and environmental impacts of metal mining and processing from 2000 to 2015 (selection of 10 metals covering > 95 per cent of global domestic extraction of metal ores in 2015, MFA database).**

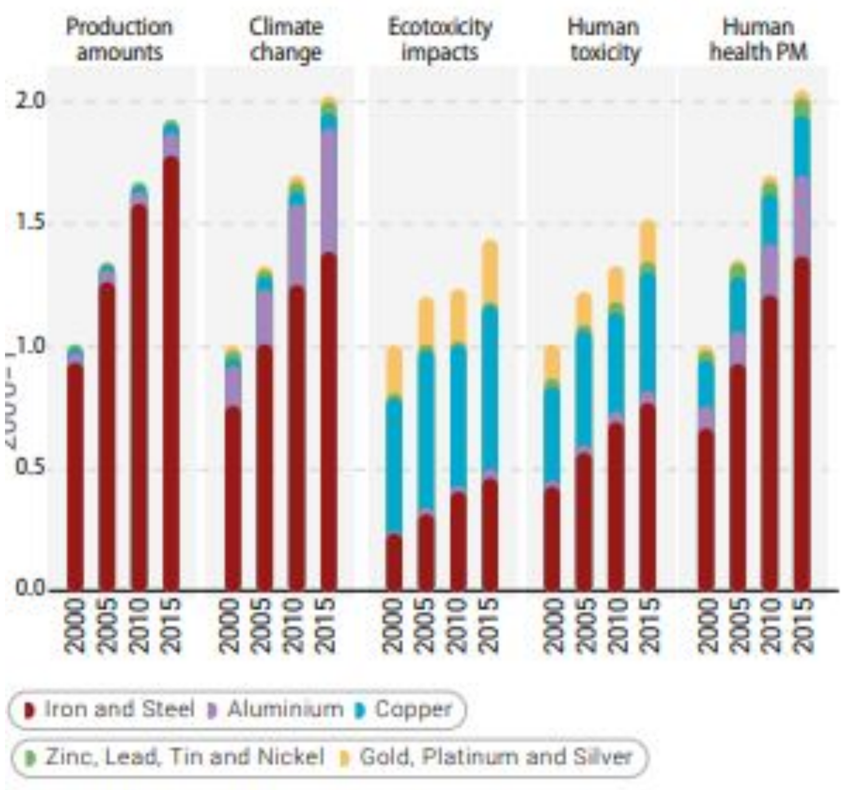
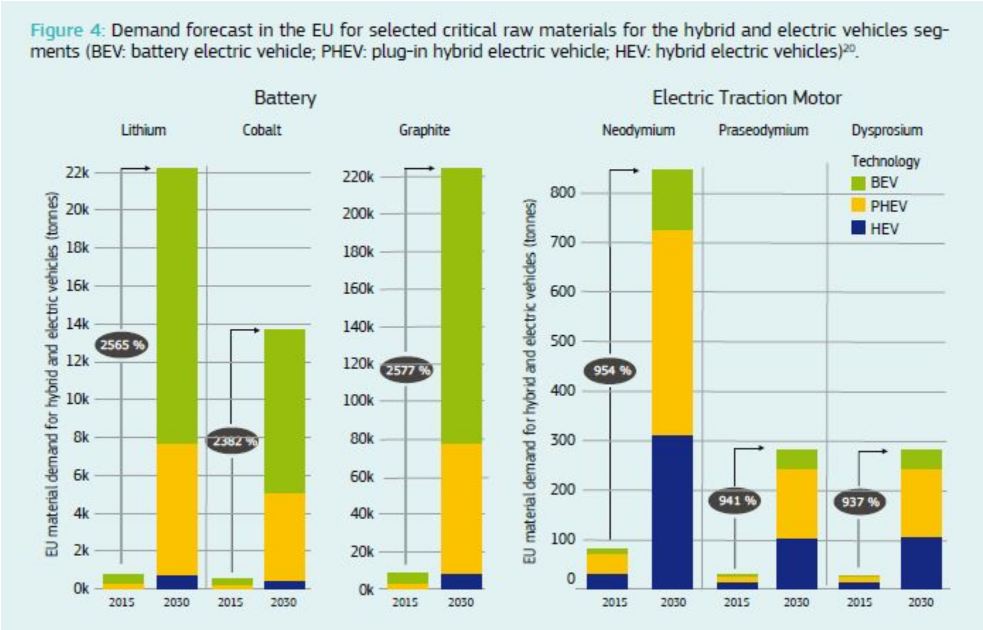


FIGURE 3.14 **Climate change impacts of metal recycling versus primary production**

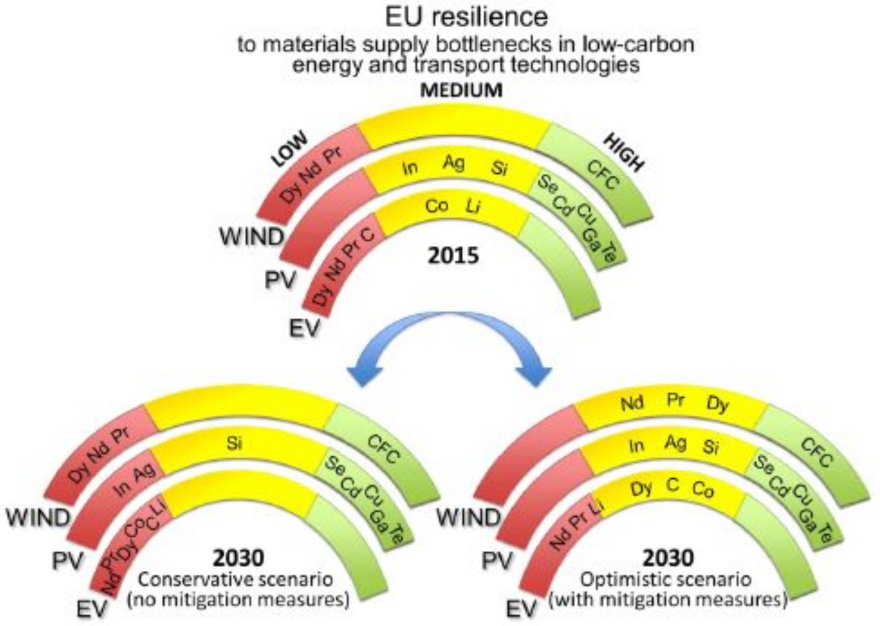
Source UNEP Global Resources Outlook 2019

CIRCULAR ECONOMY – INCENTIVES

RISK OF SUPPLY : competition for strategical materials



Source : Raw materials Scoreboards, European Commission, 2018



Source : Assessment of potential bottlenecks along the materials supply chain for the future deployment of low-carbon energy and transport technologies in the EU, 2016

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DESIGN FOR CIRCULARITY – OBJECTIVES AND ACTIONS

OBJECTIVE 1
MINIMIZE RESOURCES EXTRACTION

Design

Minimize Critical Materials (CRM) use

Optimize BtF ratio

Systems-integrated materials production

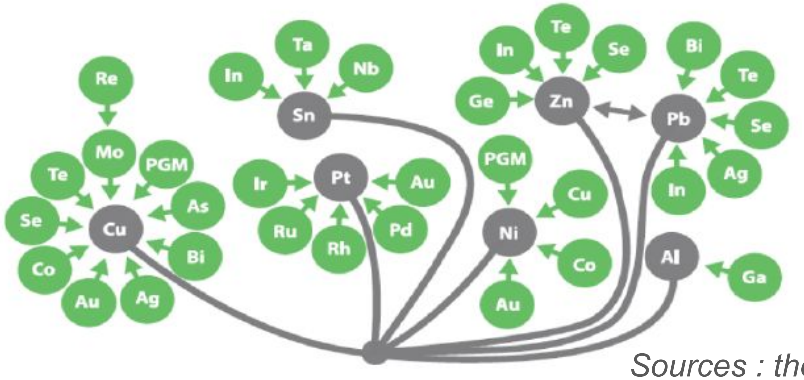
Production

Use renewable energy for production

Use materials from landfill

Maintenance – Use phase

Use second hands parts



Systems-integrated materials production, Report on CRM and the circular economy

OBJECTIVE 2
MINIMIZE DISPERSION AND LOSS OF MATERIALS

Design

Design for dismantling

Standardize for reuse

Production

Maximize production scrap reuse

End of Life

Reuse for high value applications

Maximize recycling :

See data management frame

Optimize existing technologies

Developp advanced technologies

Set up mandatory recycling rates

Improve CRM recycling rates

Economy of functionality

Sources : the circularity gap report 2020, Circle Economy; CEPS - The Role of Business in the Circular Economy Markets, Processes and Enabling Policies

KEY ENABLER : DATA MANAGEMENT

LEARN : create materials database (materials flows knowledge)

TRACK : use big data & data analytics to acquire information that can be used in product life-cycle management and supply chain planning

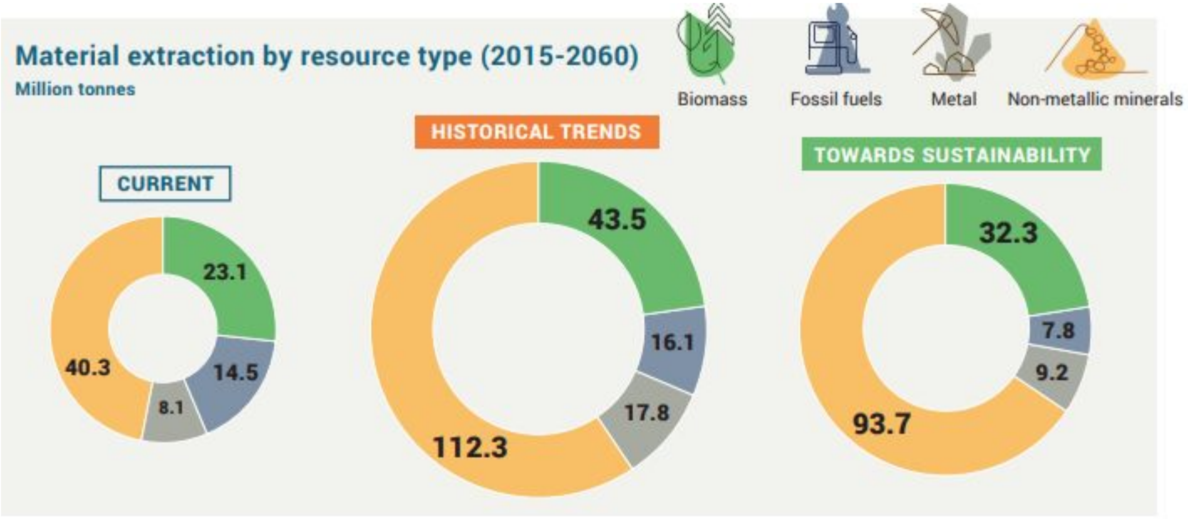
MONITOR PROGRESS : set up circular economy kpi

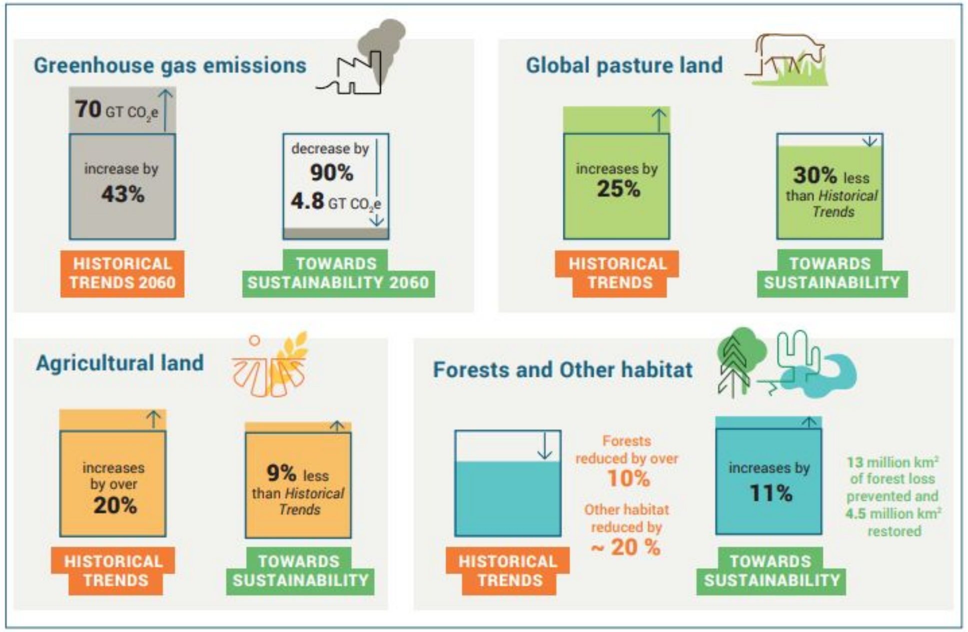
SHARE :

- provide recycling company clear data on materials and disposal guidance
- provide A/L informations on CRM, dangerous substances, regulations, recycling potential, develop new maintenance, etc

UNEP TOWARDS SUSTAINABILITY SCENARIO

The *Towards Sustainability* scenario shows that changes in policies and behaviors can achieve decoupling of natural resource use and environmental impacts from economic growth and human wellbeing.





Source : UNEP, Global Resources Outlook 2019

SUSTAINABLE SCENARIO : METAL EXTRACTION DIVIDED BY (ALMOST) TWO

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CRITICAL RAW MATERIALS

CRITICAL RAW MATERIALS – EU 2020 LIST

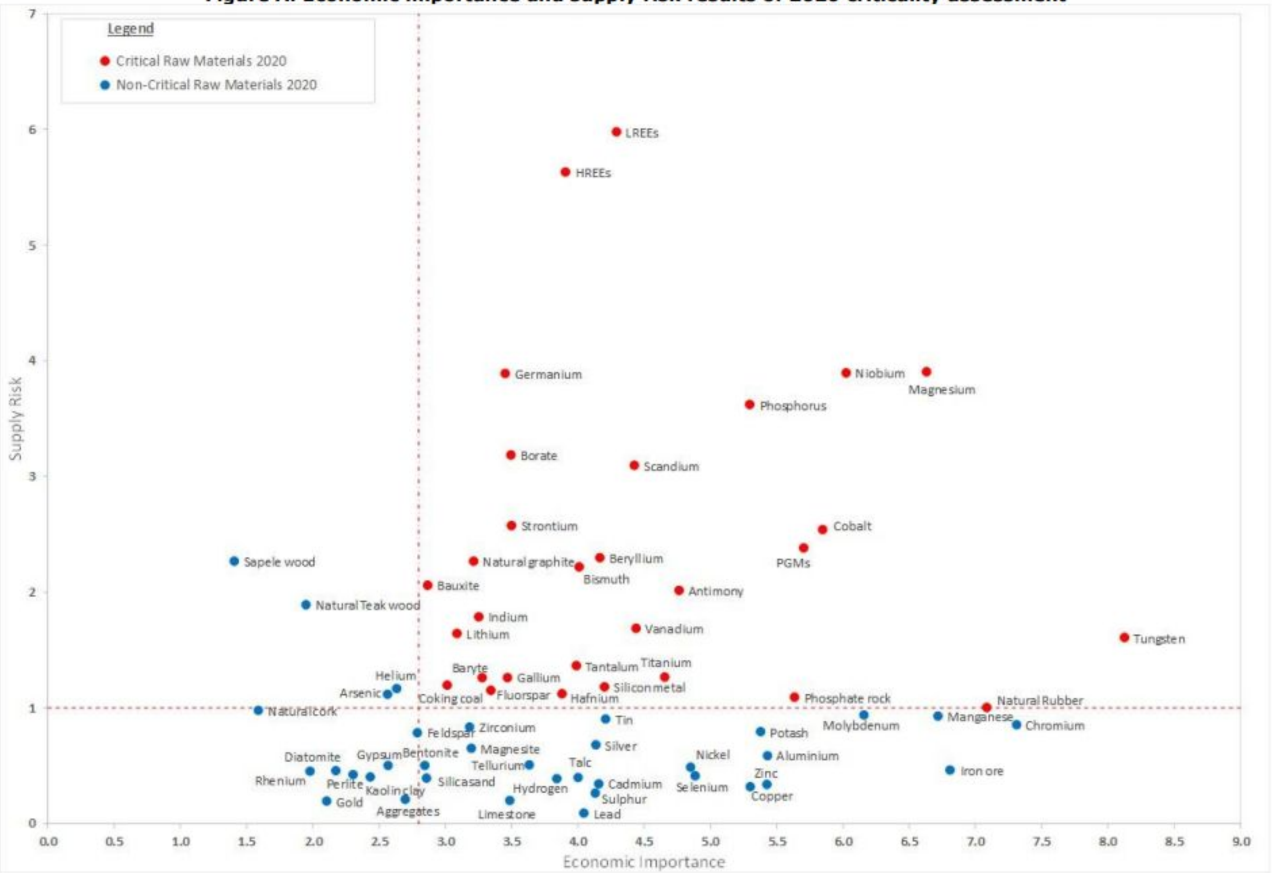
2020 - European Commission - List of critical raw materials for the EU (link)

Criteria : **Economic Importance** vs **Supply Risks**

Of the 83 individual (66 candidate) raw materials assessed, the following 30 were identified as critical in this assessment:

2020 Critical Raw Materials (30)			
Antimony	Fluorspar	Magnesium	Silicon Metal
Baryte	Gallium	Natural Graphite	Tantalum
Bauxite	Germanium	Natural Rubber	Titanium
Beryllium	Hafnium	Niobium	Vanadium
Bismuth	HREEs	PGMs	Tungsten
Borates	Indium	Phosphate rock	Strontium
Cobalt	Lithium	Phosphorus	
Coking Coal	LREEs	Scandium	

Figure A: Economic importance and supply risk results of 2020 criticality assessment



CRITICAL MATERIAL = STRATEGICAL MATERIALS + RISK OF SUPPLY

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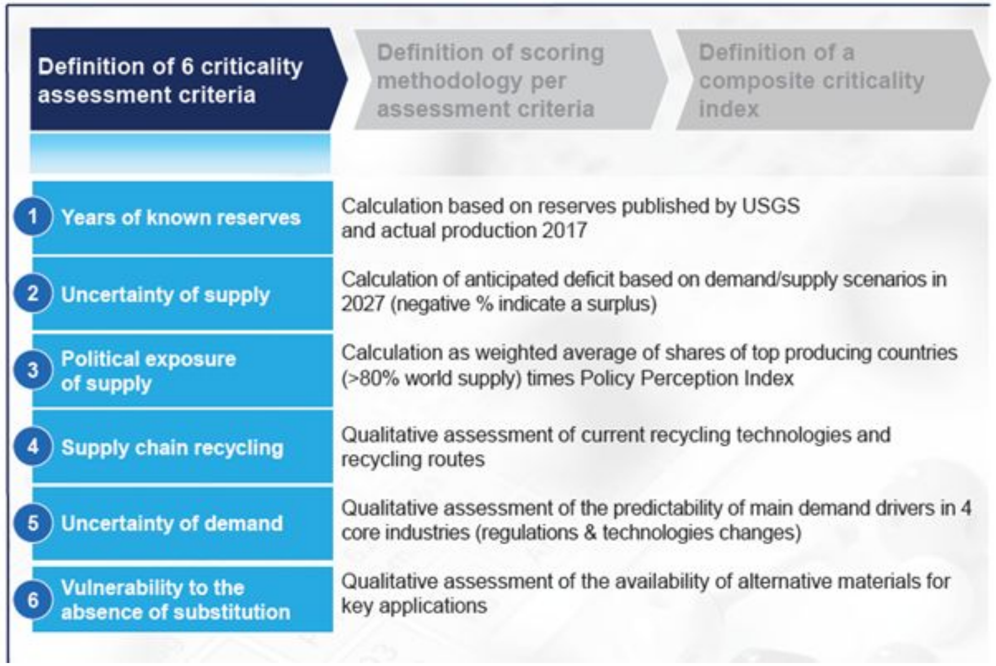
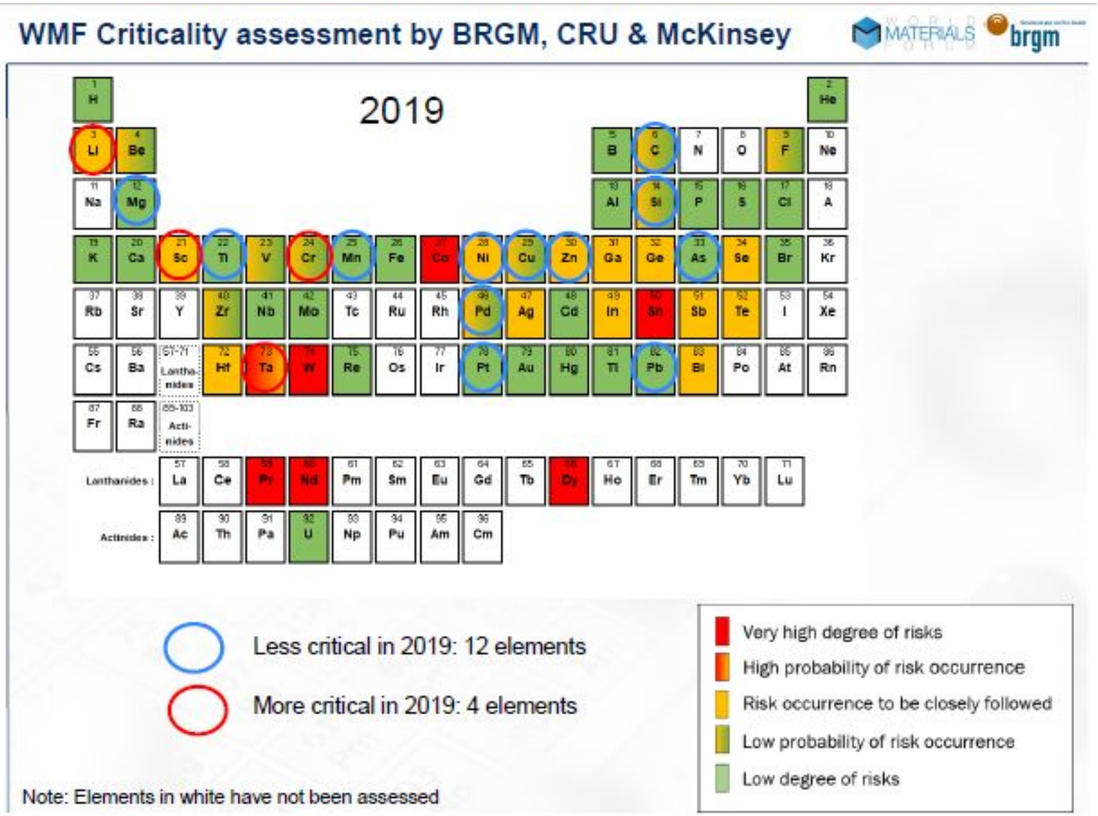
CRITICAL RAW MATERIALS – WMF 2019

BRGM, CRU and McKinsey - WORLD MATERIALS FORUM 2019



Definition of 6 criticality assessment criteria	Definition of scoring methodology per assessment criteria
1 Years of known reserves	Calculation based on reserves published by USGS and actual production 2017
2 Uncertainty of supply	Calculation of anticipated deficit based on demand/supply scenarios in 2027 (negative % indicate a surplus)
3 Political exposure of supply	Calculation as weighted average of shares of top producing countries (>80% world supply) times Policy Perception Index
4 Supply chain recycling	Qualitative assessment of current recycling technologies and recycling routes
5 Uncertainty of demand	Qualitative assessment of the predictability of main demand drivers in 4 core industries (regulations & technologies changes)
6 Vulnerability to the absence of substitution	Qualitative assessment of the availability of alternative materials for key applications



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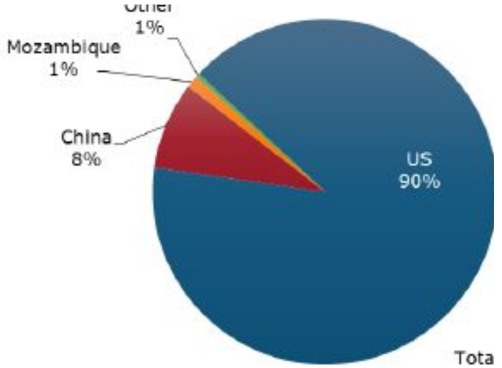
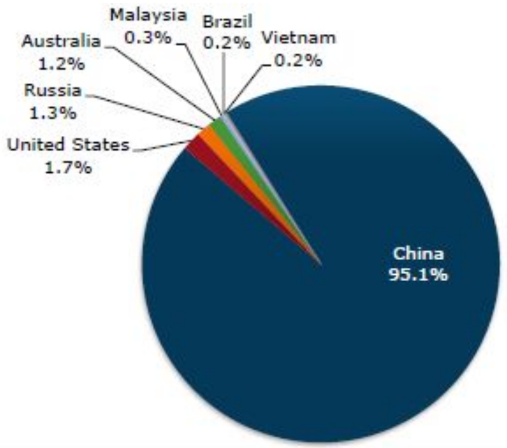
CRITICAL RAW MATERIALS – RISK OF SUPPLY

PRODUCTION SHARING

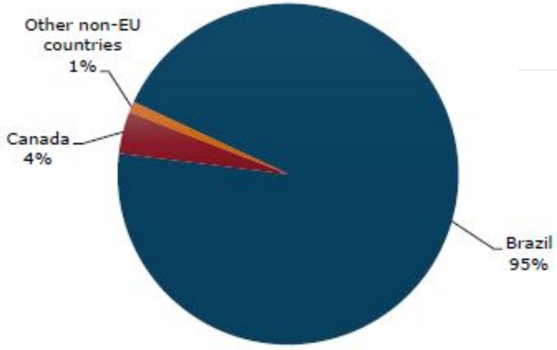
BERYLLIUM PRODUCTION



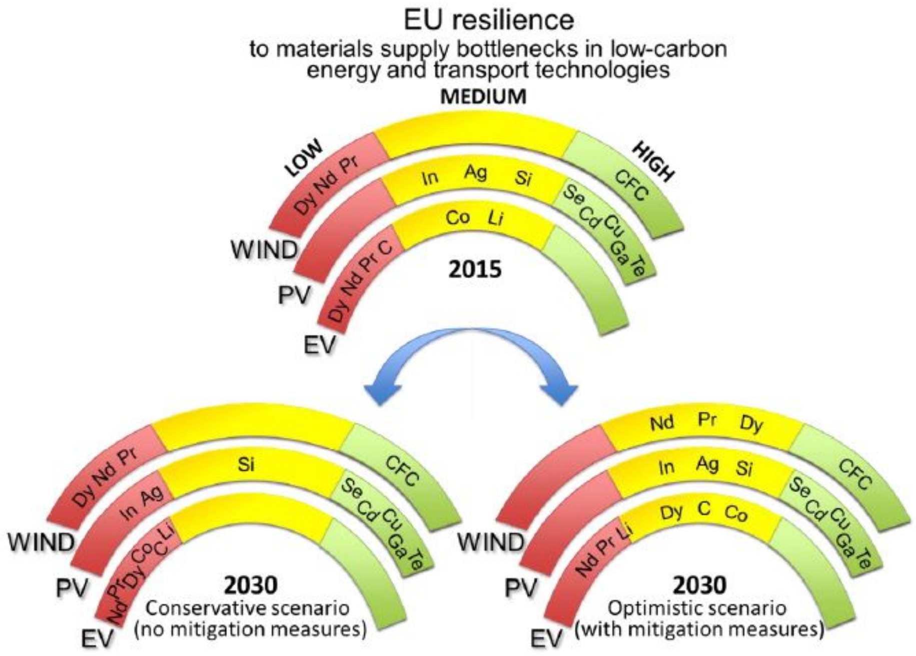
DYSPROSIUM PRODUCTION



NIOBIUM PRODUCTION



ENERGY TRANSITION TECHNOLOGIES



RISK OF SUPPLY : SINGLE SOURCING COUNTRY AND COMPETITION WITH OTHER INDUSTRIES

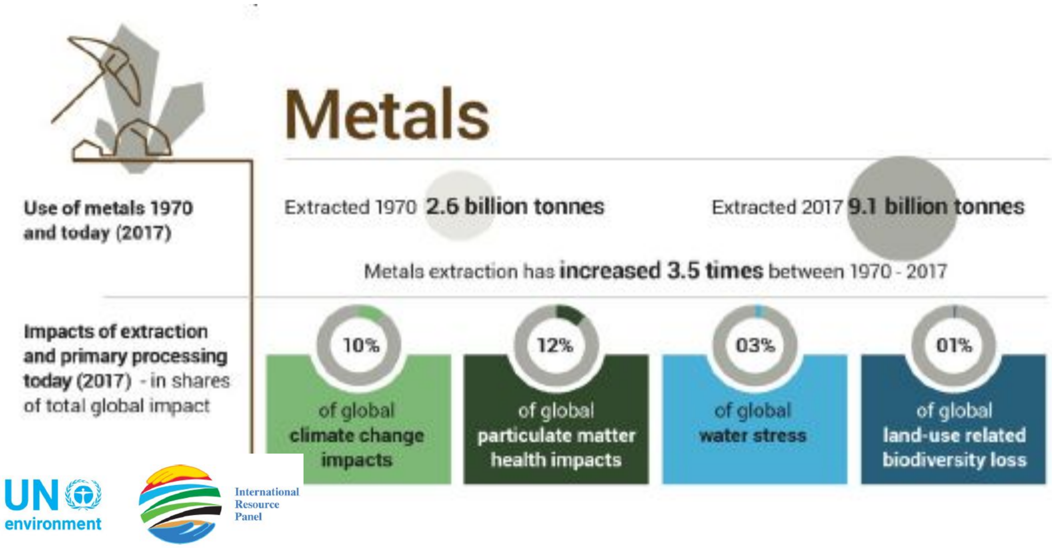
CRITICAL RAW MATERIALS – ENVIRONMENT AND SOCIAL

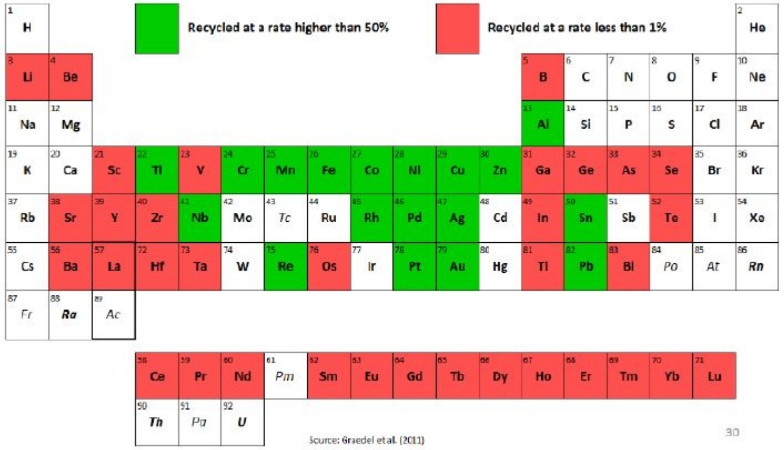
Battery-grade cobalt

- A report by Amnesty International published in 2016 shed heavy criticism over questionable mining practices carried out in the Democratic Republic of Congo (DRC). According to the report, 20% of the ore is mined through artisanal methods in the country (according to Amnesty International), by using hazardous techniques as well as child labour. This industry involves 110,000 to 150,000 *creusers* in the southern region of Haut-Katanga.
- Chronic exposure to dust containing cobalt can result in a potentially fatal lung disease, called "hard metal lung disease." Inhalation of cobalt particles can also cause "respiratory sensitization, asthma, shortness of breath, and decreased pulmonary function", and sustained skin contact with cobalt can lead to dermatitis, ... l operations are put to a halt and converted to ones

Nickel mining: the hidden environmental cost of electric cars

The extraction of nickel, mainly mined in Australia, Canada, Indonesia, Russia and the Philippines, comes with environmental and health costs





HIGH SOCIAL AND ENVIRONMENTAL IMPACTS DIFFICULT TO CONTROL WITH THE INCREASE OF DEMAND

Risks of high production concentration (from “La guerre des métaux rares” Guillaume Pitron)

- **An unexpected increase of the demand can cause supply disruption : example of Titanium (Ti)**

China produces around 50% of the world annual production. Between 2006 and 2008, the Chinese Ti consumption sudden increase led to a price increase by ten and serious supply difficulties for Dassault Aviation.

⇒ **As the number of actors is very limited, the supply risk also exists in case of new technology development, single supplier difficulties, etc**.

- **Market redistribution : Example of China and Indonesia**

Chinese strategy : offer low price on strategical resources and forces manufactures to be moved to China as soon as there is nor more competitor (against raw materials sales). The strategy failed for tungsten in the 1990’s but it is ongoing for many other resources (graphite, aluminium, iron **and eventually Li and Co**).
In the same idea, Indonesia has declared an embargo on most of its produced resources in order to sell final products instead of raw materials (tin, sand, nickel, gold, etc)

⇒ **China and mining countries now want to own the full value chain**

- **Embargoes on exports : example of Indonesia**

Embargo on the raw materials exportations announced in 2009 and implemented in 2014 for resources such as nickel, tin, chromium, gold and silver.
Many existing examples, as listed in “Export Restrictions in Raw Materials Trade: Facts, Fallacies and better practices” [OECD - 2014]. See also export restrictions mapping (link).

⇒ **Main reasons for this trend : producer countries are often emerging market countries that want to use their resources for their own development and that want to be paid a fair price for them, strategical lever of action against other countries (negotiation) and emerging environmental consciousness.**

- **Lack of data**

Data on resources are considered as strategical for mining countries : information on production, hidden stocks are not shared. For example, China has not joined the “Global reporting Initiative”.

=> Market is very hard to assess as some strategical data is kept by mining countries.

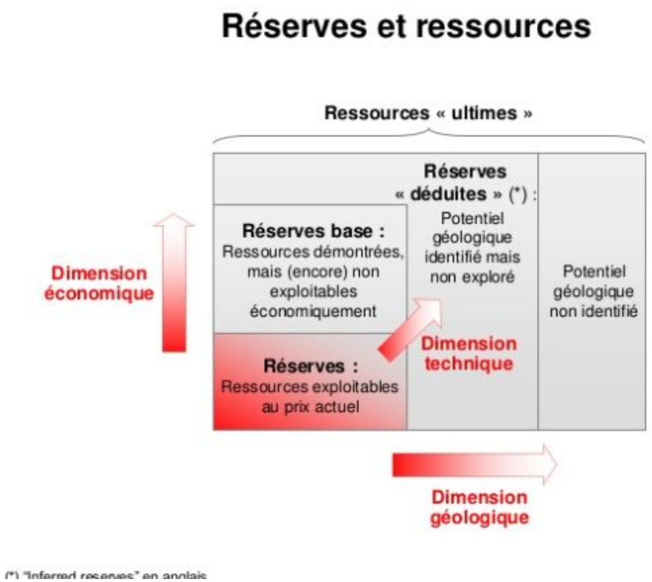
Resources availability – Important facts (1/2)

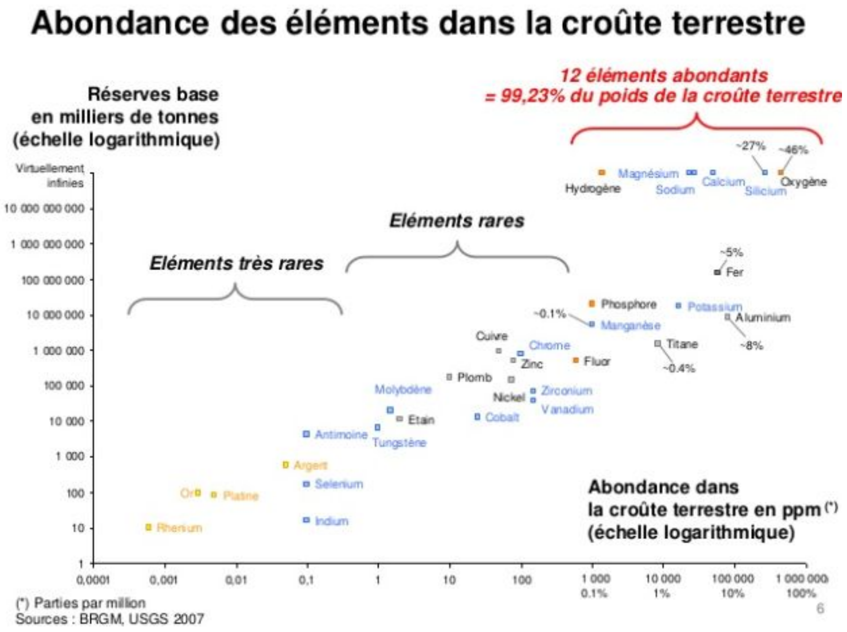
Data from "La guerre des métaux rares" Guillaume Pitron and Conférence from Florian Fizaine et Philippe Bihouix at MInesParisTech (jan2016, link)

- **Reserves** : technico-economical term – **dynamic** notion as : geological knowledge (new deposits are found) and profitable deposits to mine (technological progress) evolve. Warning : deposits discoveries do not follow demand increase

- **Number of years before ressource depletion:** very hard to define. Can't be assessed by calculating reserves/production as none of these two elements are constant. For example, a producer has no interest in looking for new deposits if he can ensure several decades of production (useless cost).

- Ressources : currently replaced by another notion : **earth crust concentration** that is much higher but would request always more energy, work and chemical to extract. **Actual limit is between these two values, but « where » is dfficult to define.**





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Resources availability – Important facts (2/2)

- The **average metal content of deposits** decreases because more and more deposits with lower metal content are now profitable to mine AND NOT because high metal contents deposits are depleted.

Trend: accessible ressources in a deposit are ≈X2 if the metal content is /2 BUT more increased need of energy, water and chemicals with decreased metal content.

- **Costs** : Explorating costs are increasing
  Prices have decreased during the last years because cost have decreased (technology improvments) but this might change (energy efficiency limits, demand increase and metal contents decrease)

- **Sub-production issue**: rare resources often are subproducts of more common metals (no specific producer). Even if the demand increases, metals producers will not produce more of the main metal they are producing (risk on the market and their benefits) for small quantities.

Recycling

Data from “La guerre des métaux rares” Guillaume Pitron and Conférence from Florian Fizaine et Philippe Bihouix at MInesParisTech (jan2016, link)

Recycling can’t be the only solution as the demand for resources is increasing.

- **Recycling limits :** 1) Dispersive usages (cosmetics, paints, agriculture : impossible to retrieve – Li for white color, Co for tyres glue)
  2) Alloys or very few quantities of rare materials in some components
  3) High levels of energy and work required for recycling

- **Japan and US army in circular economy**

Around 30,000t of Rare Earth estimated in Japanese WEEE – Ongoing circular economy strategy in order to collect WEEE and also studies on substitutes to decrease rare earth quantities in magnets.
In the US, the army now requires the soldiers to extract rare earth from their equipment before leaving a country/camp.

- **Challenges for industries**

For the industries, circular economy requires identifying not only suppliers anymore but customers.
Moreover, rare earth are mostly used in alloys, which make them very difficult to separate from the other materials and thus recycling is very expensive (recycling cost higher than value). The price of recycled metals could be competitive if the raw materials prices were higher. Rare earth recycling rate : from 0% to 3%.
Note on metal rates trend : Indonesia has created the Indonesia Commodity and Derivative Exchange to fix tin prices (control and stabilize the value) and to “skip” the London Metals Exchange (world metals stock exchange). This inspired China that could negotiate tin in future exchanges and in Malaysia some copper, nickel and zinc trading platform were created.

- **Recycling or exporting ?**

According to a study : 80% of the American WEEE are sent to Asia, despite the Bâle convention.
In Europe, the situation Is similar with second hand vehicles or with many illegal exports to Asia or Africa.

- Recycling French key actors : Terra Nova Développement, Morphosis, Valorema, Bigarren Bizi

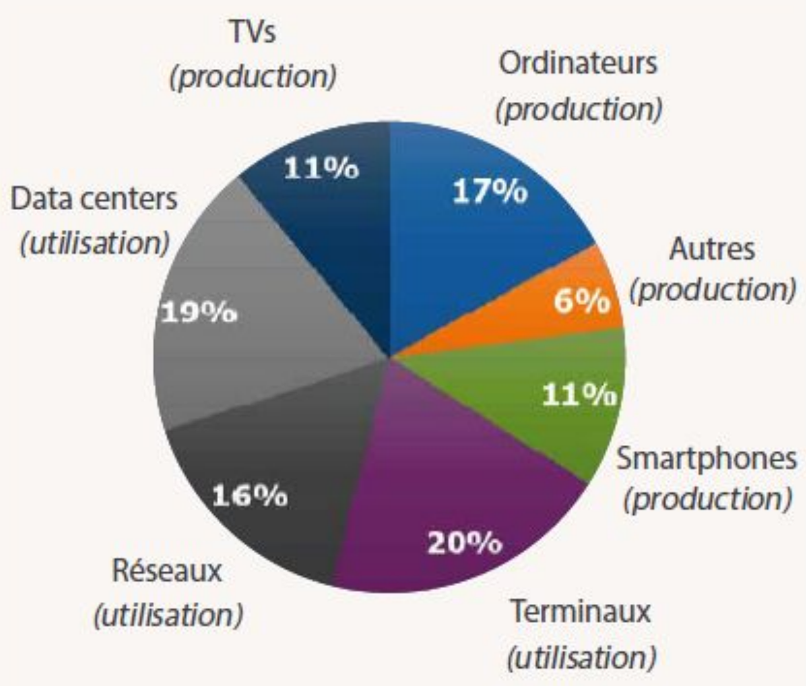
IT environmental impacts awareness

Jean-Marc Jancovici - The Shift Project

IT systems carbon footprint

- **Two years ago** : 2.5% of the world emissions
- **Today** : 3.7% of the world emissions
- **In two years** : equivalent to the car fleet in the world

Year of reference : 2019



Distribution de la consommation énergétique du numérique par poste pour la production et l'utilisation en 2017.

[Source : *The Shift Project* 2018, à partir de Andrae & Edler 2015]

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ECODESIGN TOOLKIT

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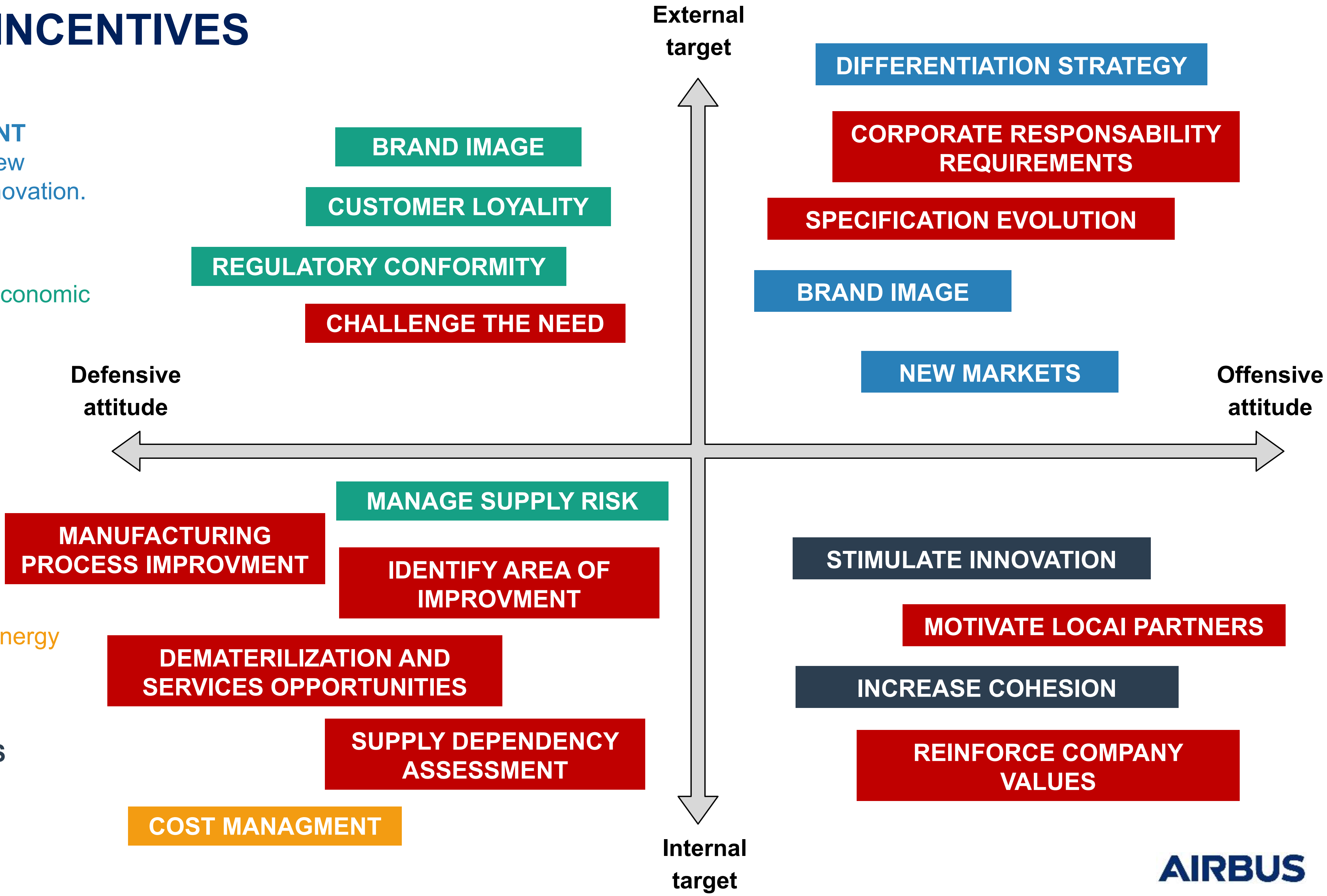
ECODESIGN INCENTIVES

SALES & PROCUREMENT
Increase and access to new markets, thanks to the innovation.

RISK MANAGEMENT
Regulatory, operational, economic or even image.

COST
Including raw materials, energy and/or logistics.

TEAMS AND PARTNERS FEDERATION



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ELEMENTS METHODOLOGIQUES

- Il n'existe pas de méthode ou d'outil permettant d'éco-concevoir de manière systématique
  - Plusieurs définitions de l'écoconception
  - Des ambitions, des stratégies et des objectifs différents

- Cependant certains éléments sont indispensables :
  - Engager la hiérarchie, les acheteurs et l'ensemble de la chaîne d'approvisionnement
  - Lancer un projet pilote
  - Généraliser la démarche

- Certaines compétences sont clés :
  - Expertise en environnement
  - Compétences techniques / conception des produits
  - Compétences juridiques

- Et certaines étapes sont inévitables :
  - Bien définir la cible et les objectifs
  - Evaluer l'impact du produit ou système choisi
  - Identifier les pistes d'amélioration

Pensez systémique et transdisciplinaire !

DESIGN IMPACTS - RECAP

REDUCING MATERIALS

- Weigh reduction
- Volume reduction
- Number of different materials reductions

USE IMPACTLESS MATERIALS

- Greener materials
- Renewable materials
- Less energy consuming materials
- Recyclable materials
- Recycled materials

OPTIMIZE PRODUCTION

- Substitute process
- Diminution of process
- Decrease energy consumption of process
- Use renewable energy
- Decrease wastes/non valorized coproducts

OPTIMIZE LOGISTIC & PACKAGING

- Decrease number of packaging
- Select low impact packaging
- Decrease transportation
- Emphasize local production and assembly

DECREASE USE IMPACTS

- Decrease energy consumption
- Reduction maintenance phase
- Increase reliability and durability
- Decrease noise and drag

END OF LIFE OPTIMIZATION

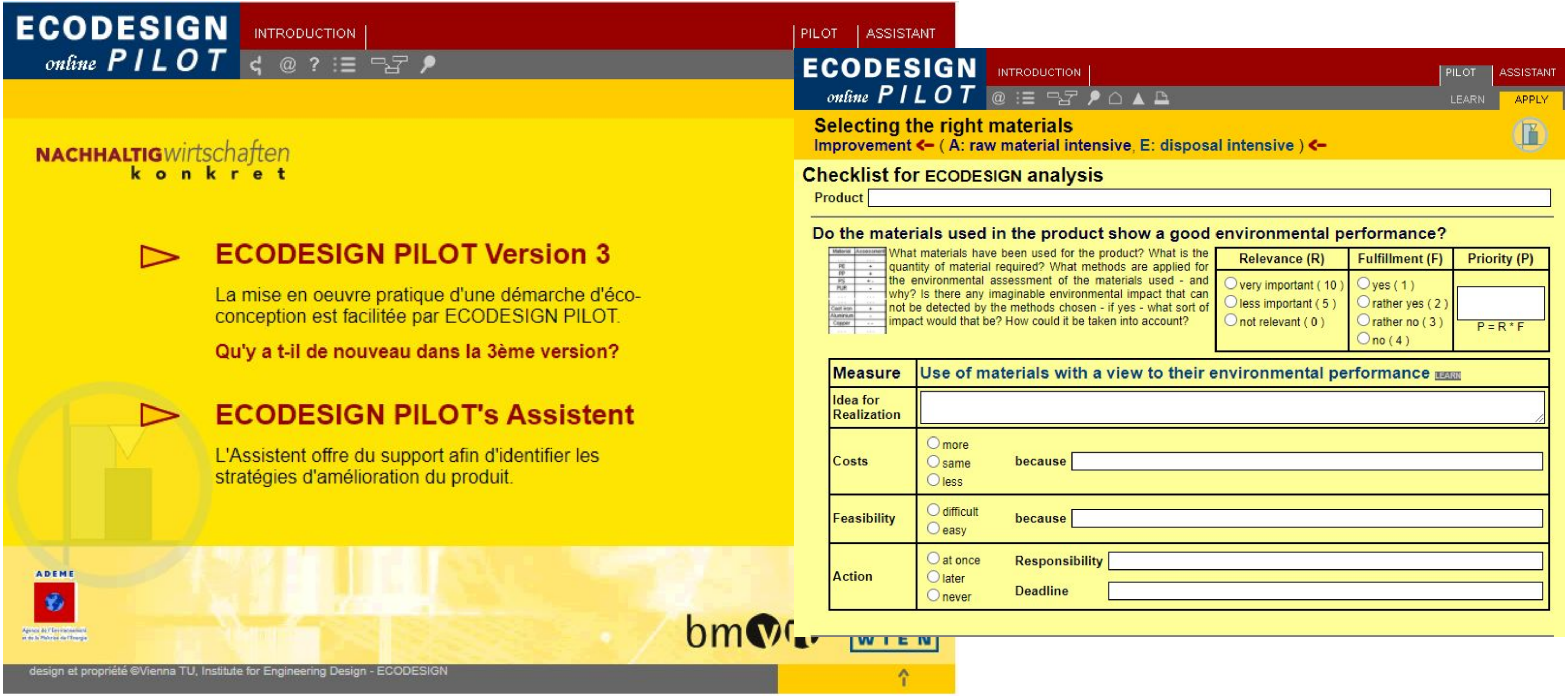
- Allow disassembly
- Allow reuse of the products/its component
- Recycle materials
- Emphasize valorization

INNOVATE

- Dematerialize
- Share use
- Include new functionalities without reshape the product

ECODESIGN PILOT

http://pilot.ecodesign.at/pilot/ONLINE/FRANCAIS/INDEX.HTM



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BASE IMPACTS – BILAN PRODUIT - ADEME

http://www.base-impacts.ademe.fr/

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H TEULON – GUIDE DE L'ECOINNOVATION

METHODOLOGY PROPOSAL TO ALLOW ECOINNOVATION

STEP 1 : IDENTIFY OPPORTUNITIES BY A SCREENING OF THE CONTEXT AND THE STAKEHOLDERS

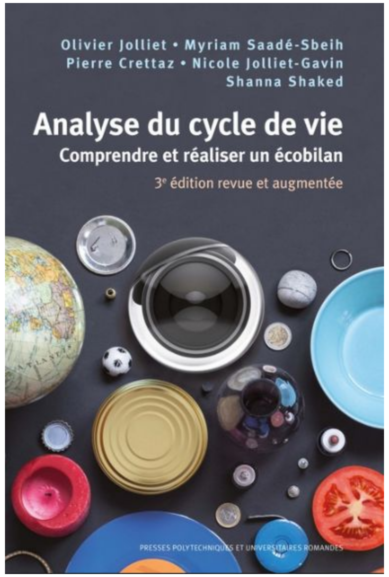
TO KNOW MORE

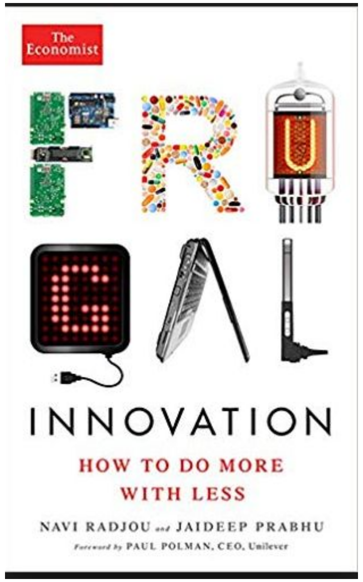
ODCE documents on due diligence :

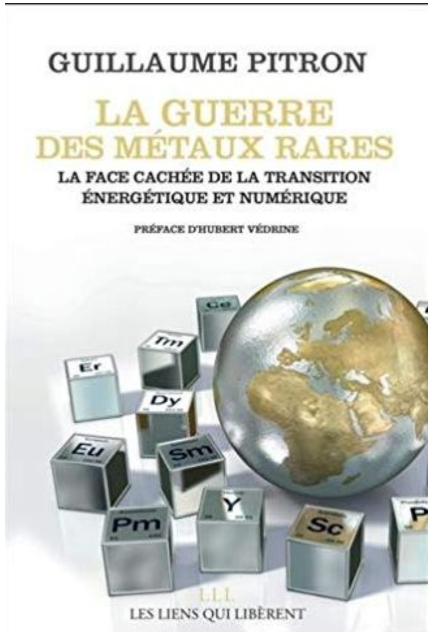
- http://www.oecd.org/corporate/mne/mining.htm
- http://mneguidelines.oecd.org/5%20Step%20Framework_A3.pdf

Life Cycle Initiative website : https://www.lifecycleinitiative.org/
EUROPEAN PLATEFORM ON LCA: https://eplca.jrc.ec.europa.eu/ilcdHandbook.html
MOOC ECO-CONCEVOIR DEMAIN : ensam, plateforme FUN

BOOKS







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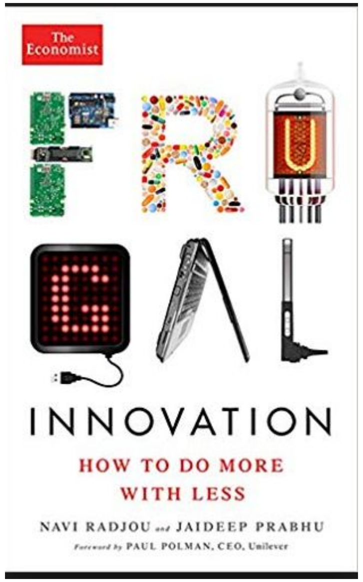
FRUGAL INNOVATION



- Frugal innovation book
  - Dacia
    - 50% fewer part than typical Renault vehicule
    - symmetrical rear-view mirrors
    - flatter than usual windscreen
    - 95 of recyclable parts
  - VW
    - Modularer Quebaukasten (MBQ): standardised production techniques so individual factories can manufacture multiple models using the same assembly line
  - MIT
    - → Continuous manufacturing
  - GE
    - new allows, parts and processes development using additive manufacturing
    - Ex: CFM leap jet engine fuel nozzle
    - Attend to build a global additive manuf ecosystem
  - BAE Systems
    - 3D printers spare parts for fighter A/C (ex Tornado Jet)
    - Components price around $160
  - SRI internation (DARPA)
    - smaller and cheaper robotic arms
    - ant-like micro robots ("labs on a chip")
  - Harley Davidson's
    - Sensors in manuf processes:
  - John Deere
    - Parts manuf in any factory : Design Anywhere Built Anywhere (DABA)
  - Northhrup Grumman
    - Predictive maintenance system
    - technicians to predict cracking on an AC weeks before they appear
    - avoid costly repairs and improves safety
  - Tarkett
    - Eco-friendly products
  - Qarnot computing
    - Digital radiators which contains microships that download and prosess computational jobs
    - Heat from the microprocessors to be used to warm homes and offices
  - Timberland
    - Higgs index to measure the environmental performance
  - Apple and GE
    - Identified risky elements (supply, costs and regulation)
    - Developped substitution elements for riskier ones
  - Expliseat
    - Lightest A/C seats in titanium
    - Weight : 4kg
    - Saving : up to $500,000 pr plane per year on fuel cost
  - Interface (carpets)
    - Do not sell but leases as a service

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Thank you

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