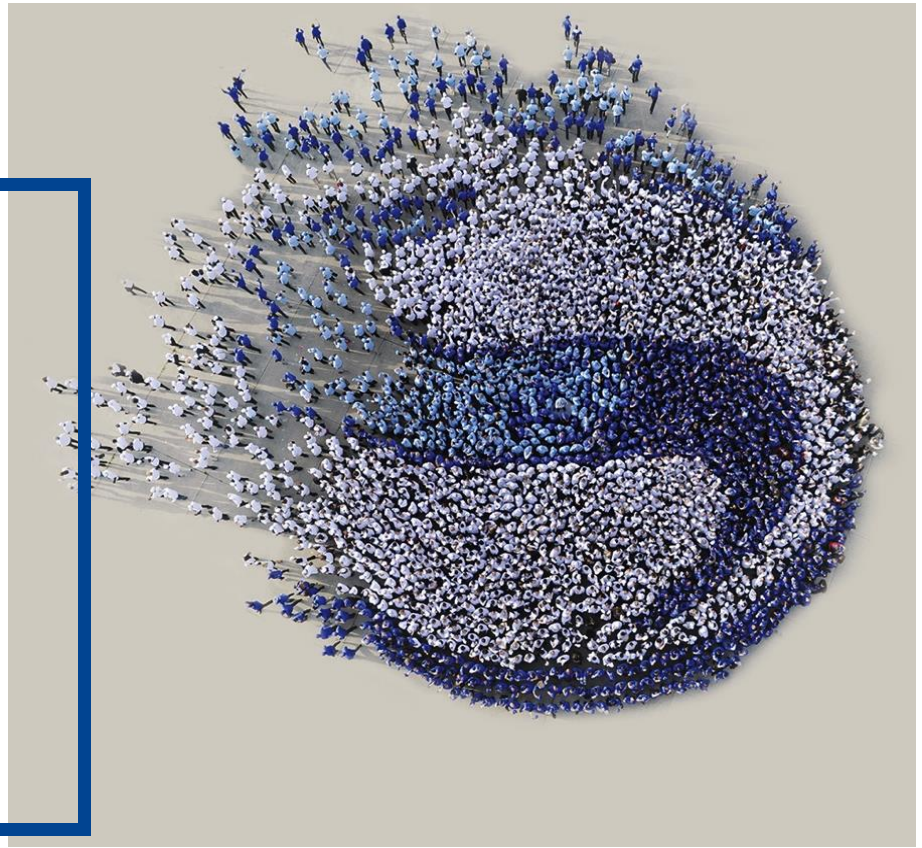
# AN OVERVIEW OF SAFRAN CONTRIBUTION TO AVIATION DECARBONATION

—

SAFRAN

# 1

# SAFRAN AT A GLANCE



# SAFRAN

AN INTERNATIONAL HIGH-TECHNOLOGY GROUP

**4 CORE BUSINESSES:**
Aerospace propulsion
Aircraft equipment
Aircraft interiors
Defense

**WORLD'S No.3 AEROSPACE COMPANY**
(excluding aircraft manufacturers)

Nearly **81,000 EMPLOYEES** in **30 COUNTRIES****

**€24.6 BILLION**
in revenue*

**€3.8 BILLION**
in adjusted recurring operating income*

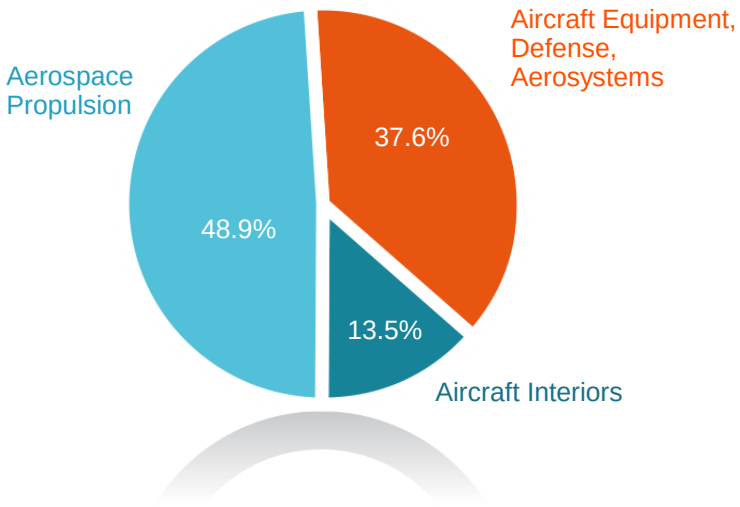
**€1.7 BILLION**
in R&D expenditures*

More than **1,200 FIRST PATENTS APPLICATIONS**
filed*

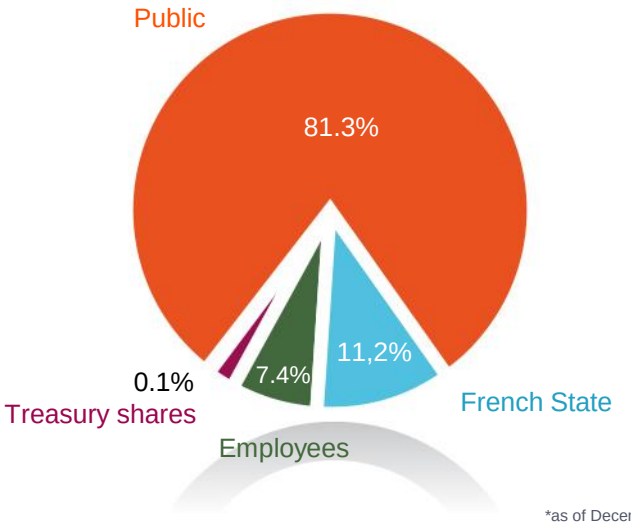
*as of 12/31/2019
**as of 09/30/2020

# FINANCIAL AND STOCK MARKET DATA

## REVENUE BY BUSINESS SECTOR IN 2019*




## CAPITAL SHAREHOLDING STRUCTURE**




*as of December 31, 2019
*as of July 31, 2020

# BOOSTING AIR TRANSPORT PERFORMANCE

## No.1 WORLDWIDE

- single-aisle commercial jets engines, in partnership with GE*
- helicopter turbine engines
- landing gear
- wheels and carbon brakes**
- electrical wiring interconnection systems for aircraft
- mechanical power transmissions systems**
- oxygen systems

## No. 2 WORLDWIDE

- electrical power generation
- aircraft engine nacelles

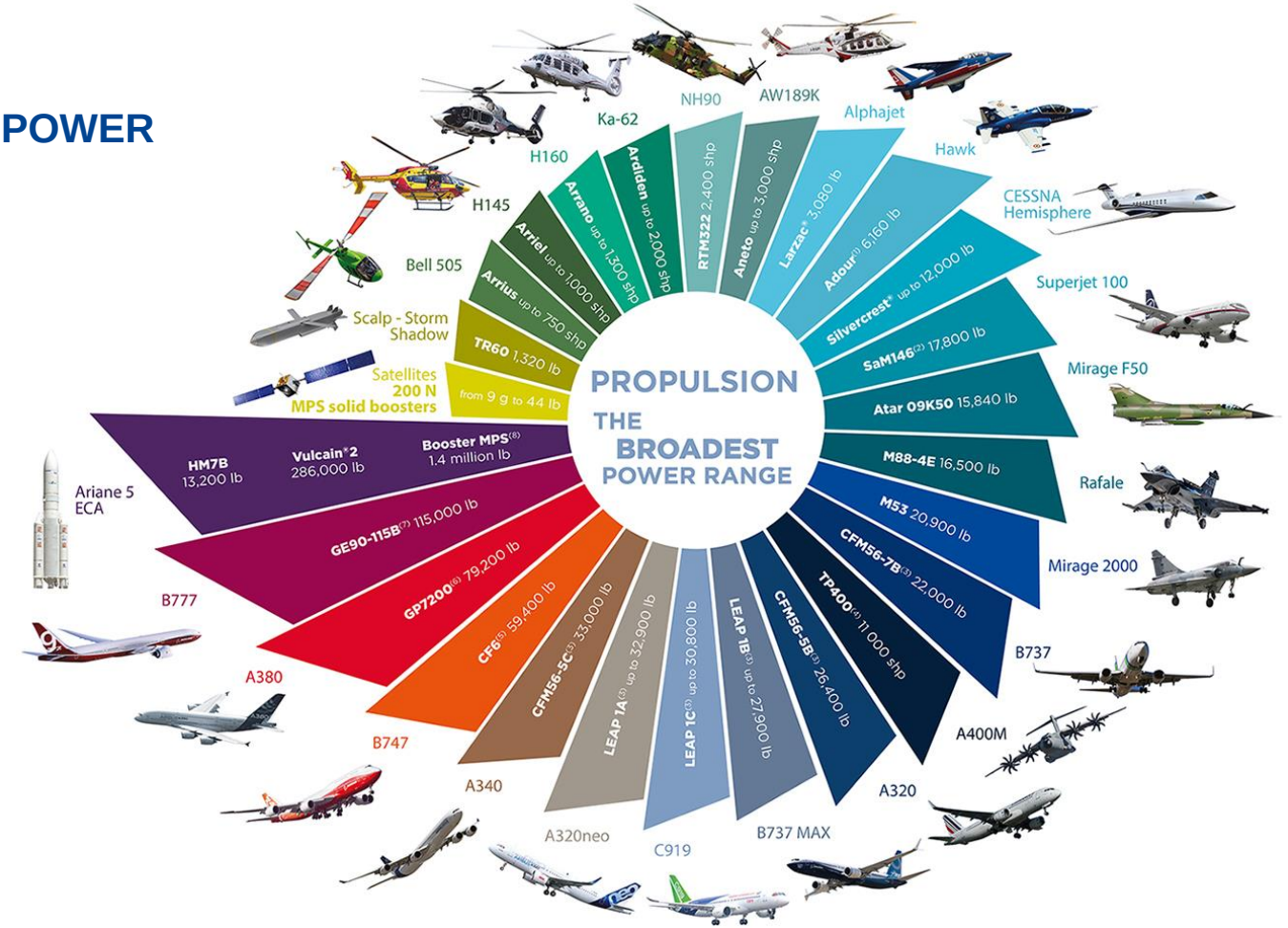
## A WORLD LEADER

- onboard power electronics
- fuel systems
- APUs for business jets, helicopters and military aircraft
- seats for commercial airplanes

*through CFM International, a 50/50 joint company between Safran Aircraft Engines and GE
**mainline commercial jets with over 100 seats

SAFRAN

# PROPULSION: THE BROADEST POWER RANGE




(1) Rolls-Royce Turbomeca Ltd, a 50/50 joint company between Safran Helicopter Engines and Rolls Royce

(2) PowerJet is a 50/50 joint company between Safran Aircraft Engines and UEC Saturn (Russia)

(3) CFM International is a 50/50 joint company between Safran Aircraft Engines and GE (USA)

(4) By Europrop International (EPI), a consortium of Safran Aircraft Engines, Rolls-Royce, ITP and MTU Aero Engines

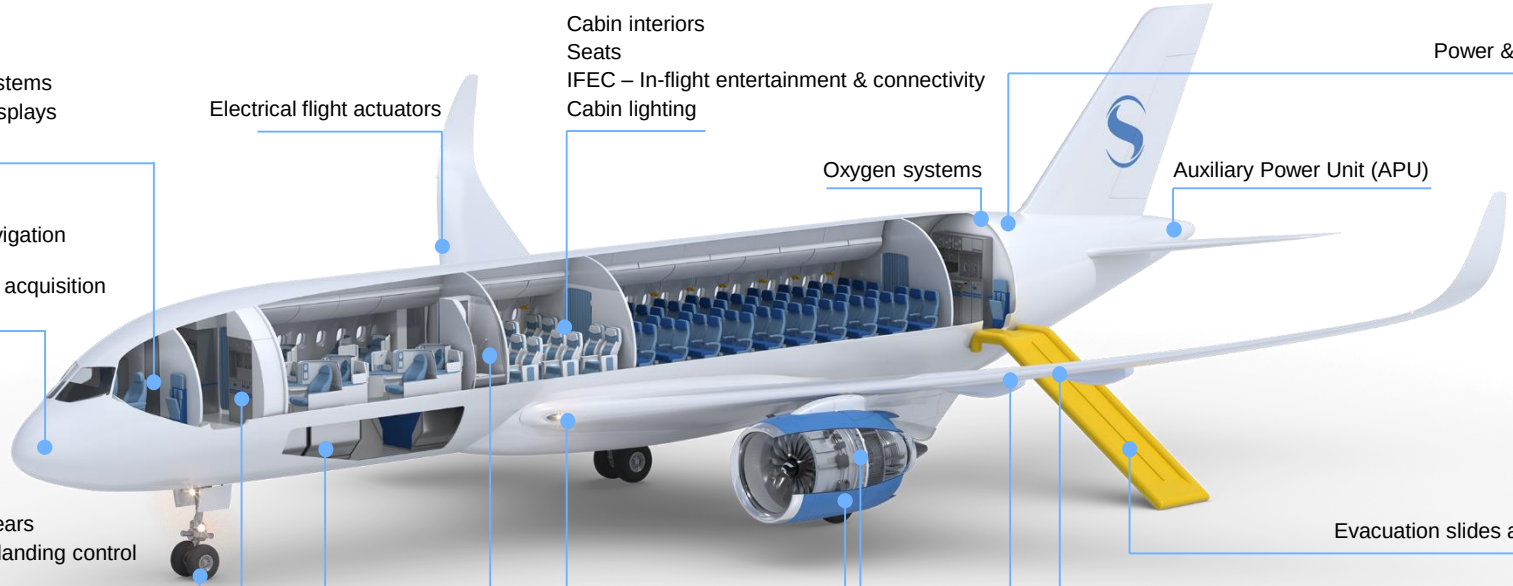
(5) In collaboration with GE (USA)

(6) Through the Engine Alliance (Safran Aircraft Engines 10%, Safran Aero Boosters 7.5%)

(7) In collaboration with GE (Safran Aircraft Engines 23.7%)

(8) Through Europropulsion, a 50/50 joint company between Safran and Avio (Italy)

# A COMPREHENSIVE RANGE OF AIRCRAFT PROPULSION SYSTEMS AND EQUIPMENT



**Cockpit**
Control systems
Panel & displays
Seats

Avionics
Inertial navigation systems
Flight data acquisition unit

Landing gears
Braking & landing control systems
Wheels and carbon brakes

Galleys & equipment

Electrical flight actuators

Cargo containers and pallets

Cabin interiors
Seats
IFEC – In-flight entertainment & connectivity
Cabin lighting

Exterior lighting

Lavatories, water & waste

Nacelles and components
Power transmission systems

Oxygen systems

Engines
Engine control systems (FADEC)
Power distribution and generation

Power & data wiring

Auxiliary Power Unit (APU)

Evacuation slides and life rafts

Anti icing & de-icing

Inerting & fuel systems

# SAFRAN, A KEY PLAYER ONBOARD CIVIL HELICOPTERS

**Cockpit**
Pilot seats
Autopilot
Cockpit controls
Cockpit panels
Flight control computer
Windshield wiper systems
Oxygen equipment

**Propulsion**
Engines from 500 to 3,000 shp
Engine control unit
Power transmission

**Auxiliary Power Unit (APU)**

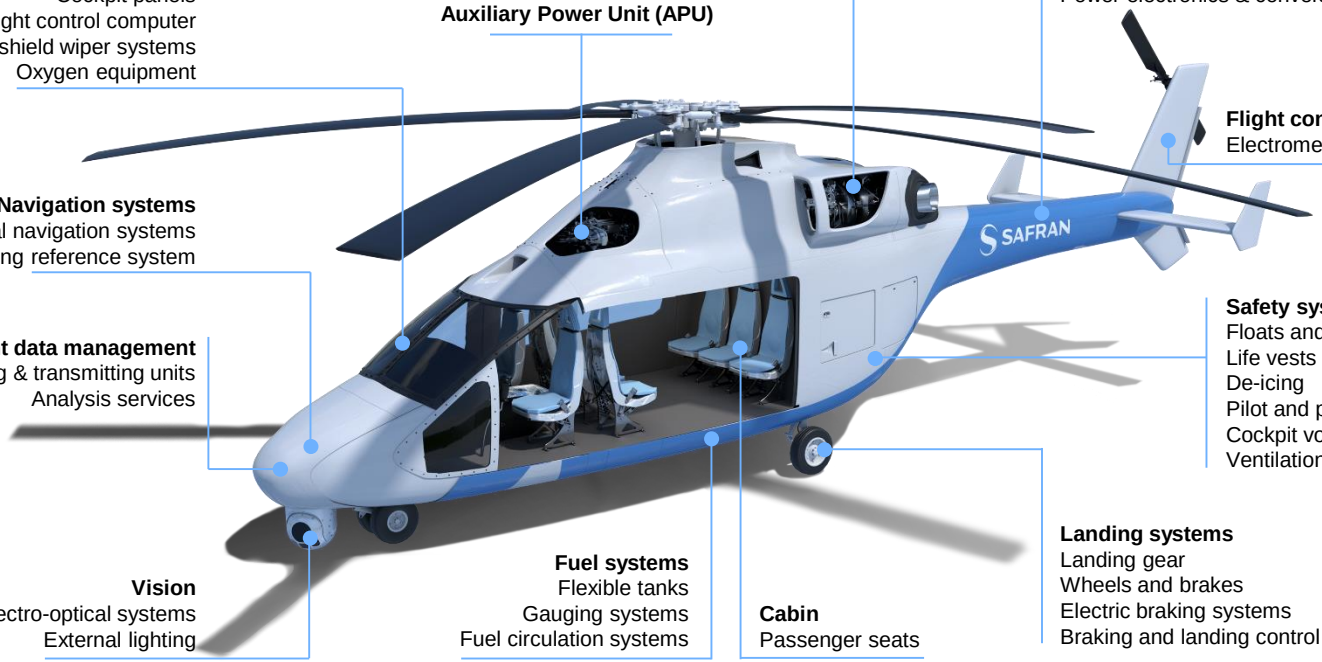
**Electrical systems**
Wiring
Electrical distribution
Electrical generation
Power electronics & conversion

**Flight control systems**
Electromechanical actuators

**Navigation systems**
Inertial navigation systems
Attitude & heading reference system

**Flight data management**
Recording & transmitting units
Analysis services

**Safety systems**
Floats and rafts
Life vests
De-icing
Pilot and passenger protection
Cockpit voice & flight data recorder
Ventilation systems




**Vision**
Electro-optical systems
External lighting

**Fuel systems**
Flexible tanks
Gauging systems
Fuel circulation systems

**Cabin**
Passenger seats

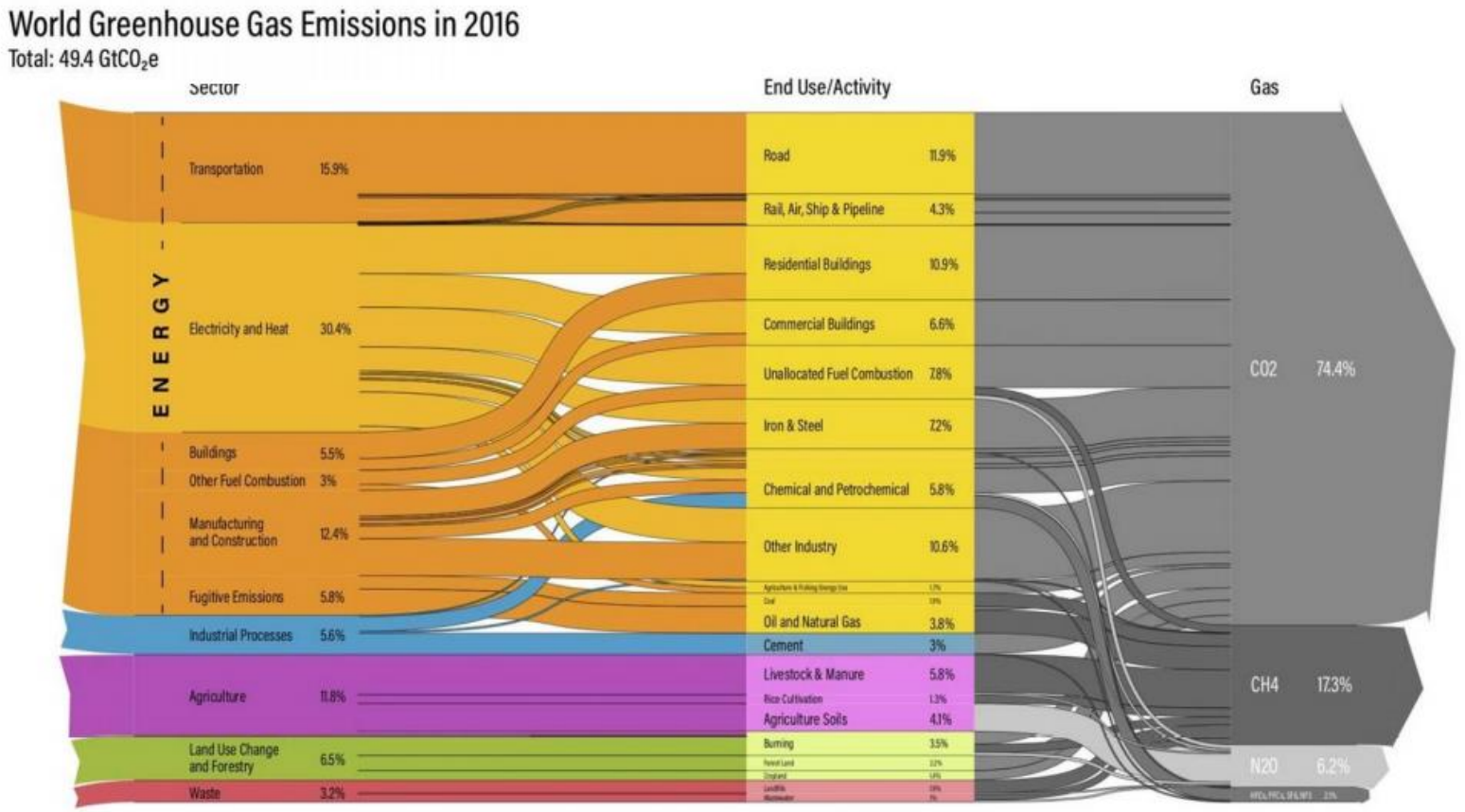
**Landing systems**
Landing gear
Wheels and brakes
Electric braking systems
Braking and landing control units and actuators

# 2

# R&T SAFRAN HOT TOPIC:

# AVIATION DECARBONATION

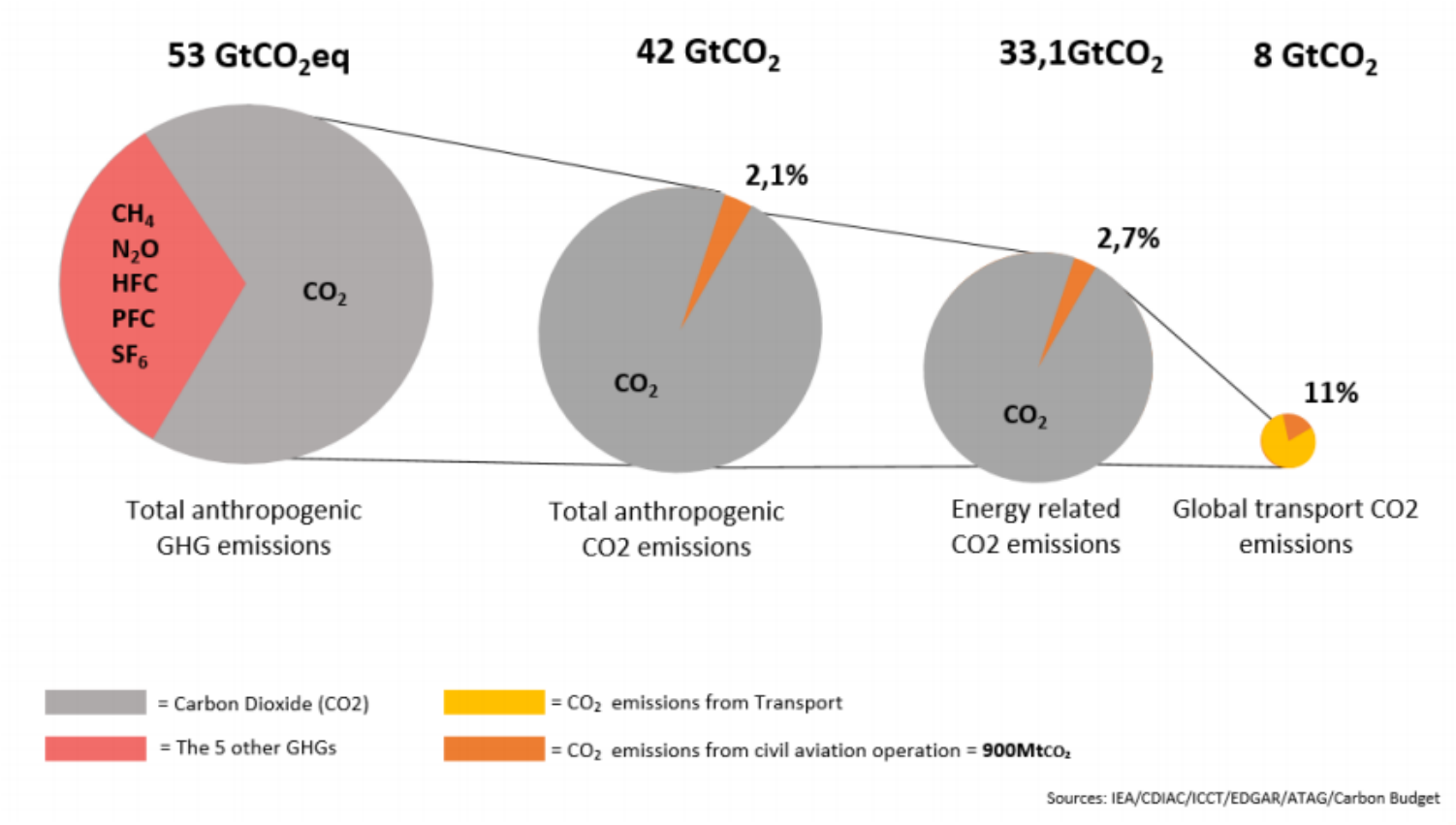
# WHERE DO WE START FROM ?



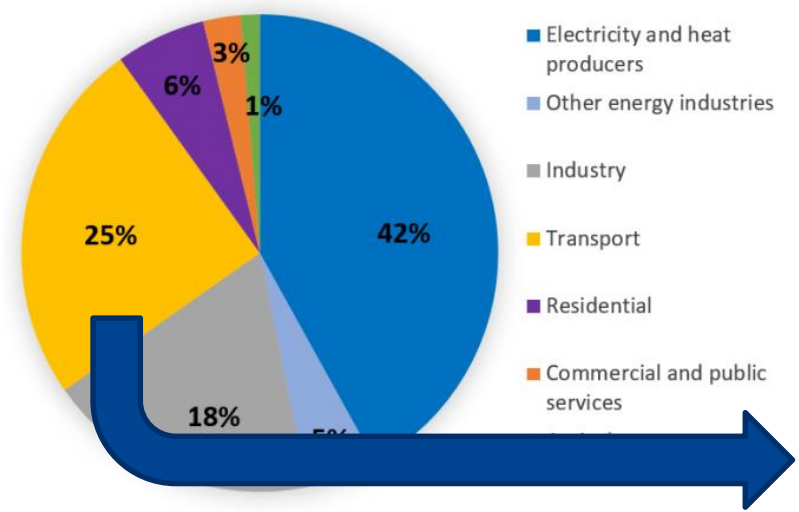

Source: Greenhouse gas emissions on Climate Watch. Available at: https://www.climatewatchdata.org

WORLD RESOURCES INSTITUTE

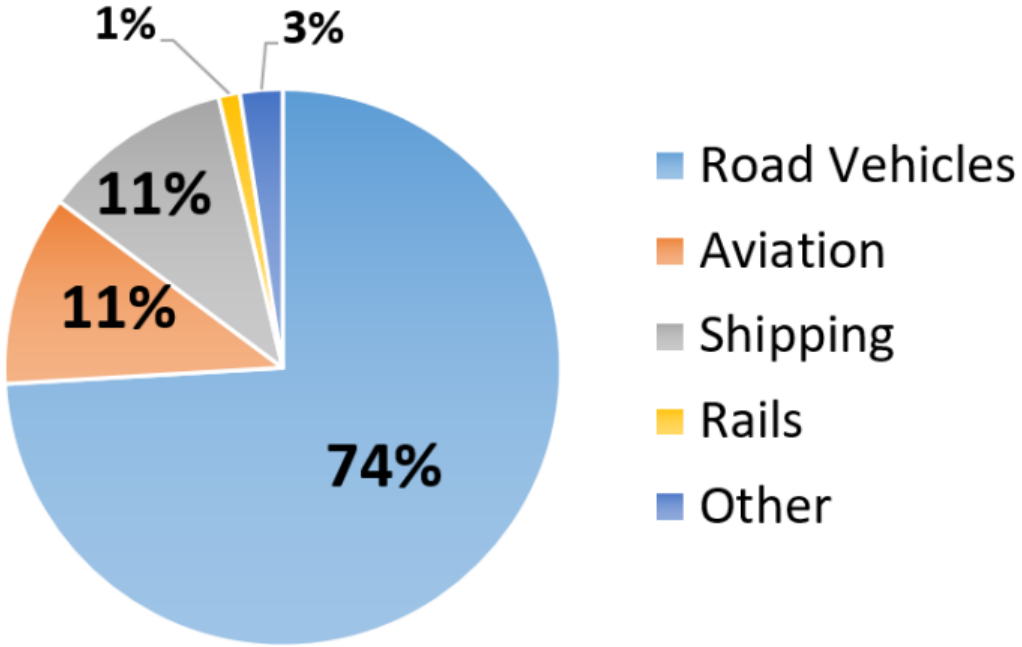
# 2018 GREENHOUSE GASES EMISSION : Civil Aviation ~ 900 Millions of Tons of $CO_2$



# FOCUS ON THE 33.1 GT OF $CO_2$ AND ON THE PART RELATED TO TRANSPORTATION




Sources:
IEA, CO2 emissions by sector, World 1990-2018



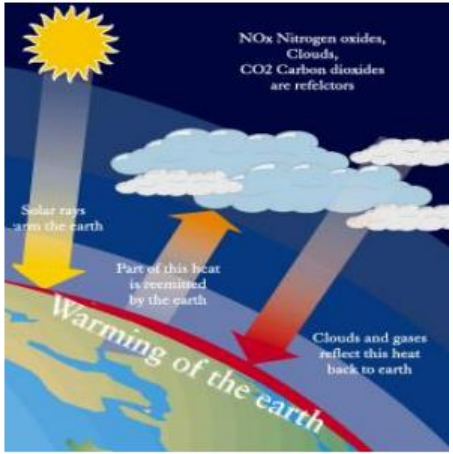

**Total related to the transport : 8 GT of $CO_2$**

# AVIATION MAIN DRAWBACKS

**Impacts**

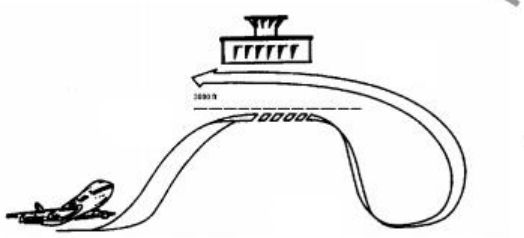
**GLOBAL**

**Greenhouse effect**
**Climate change**




**LOCAL**

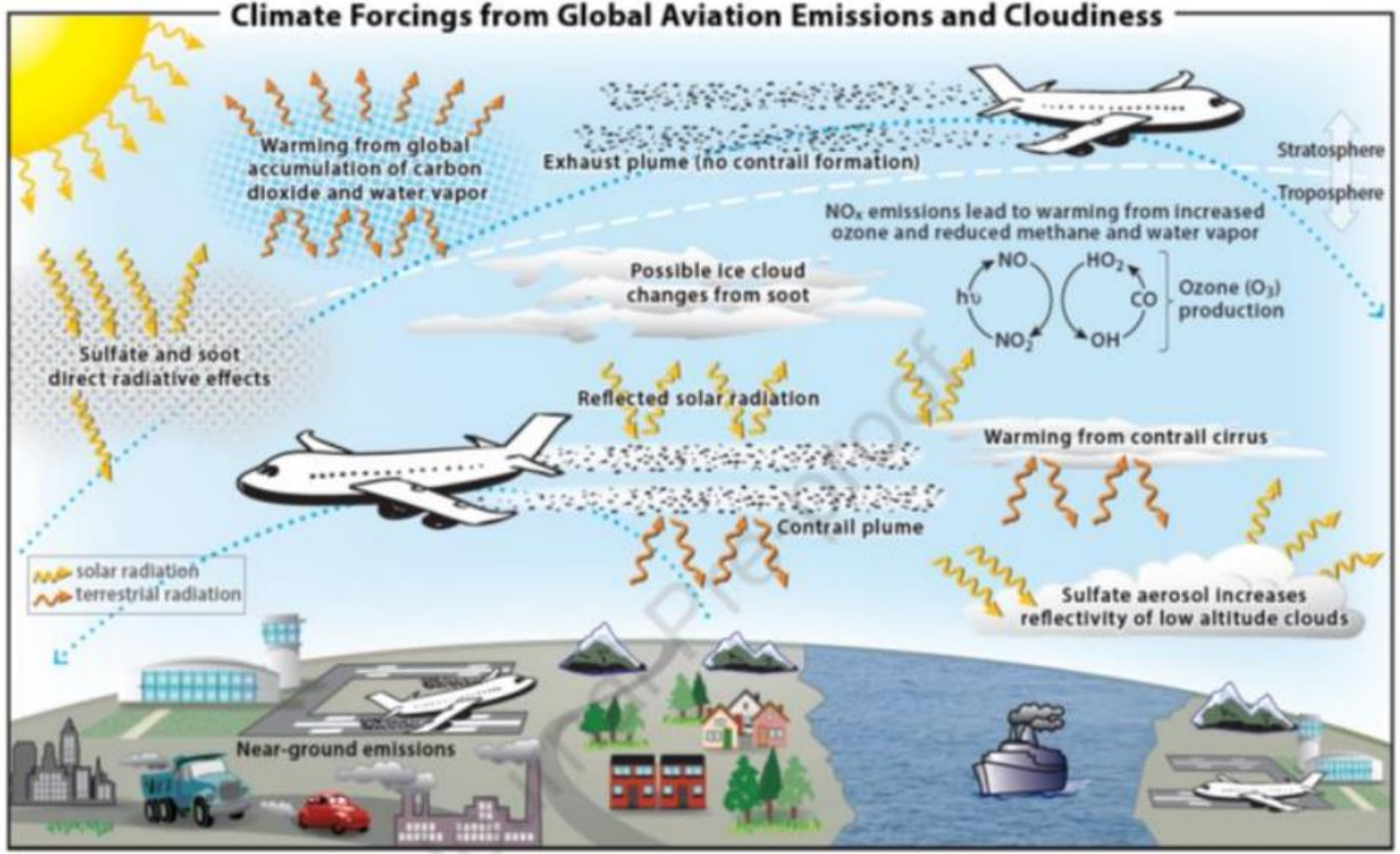
**Air quality & Noise**
**Effect on human health**



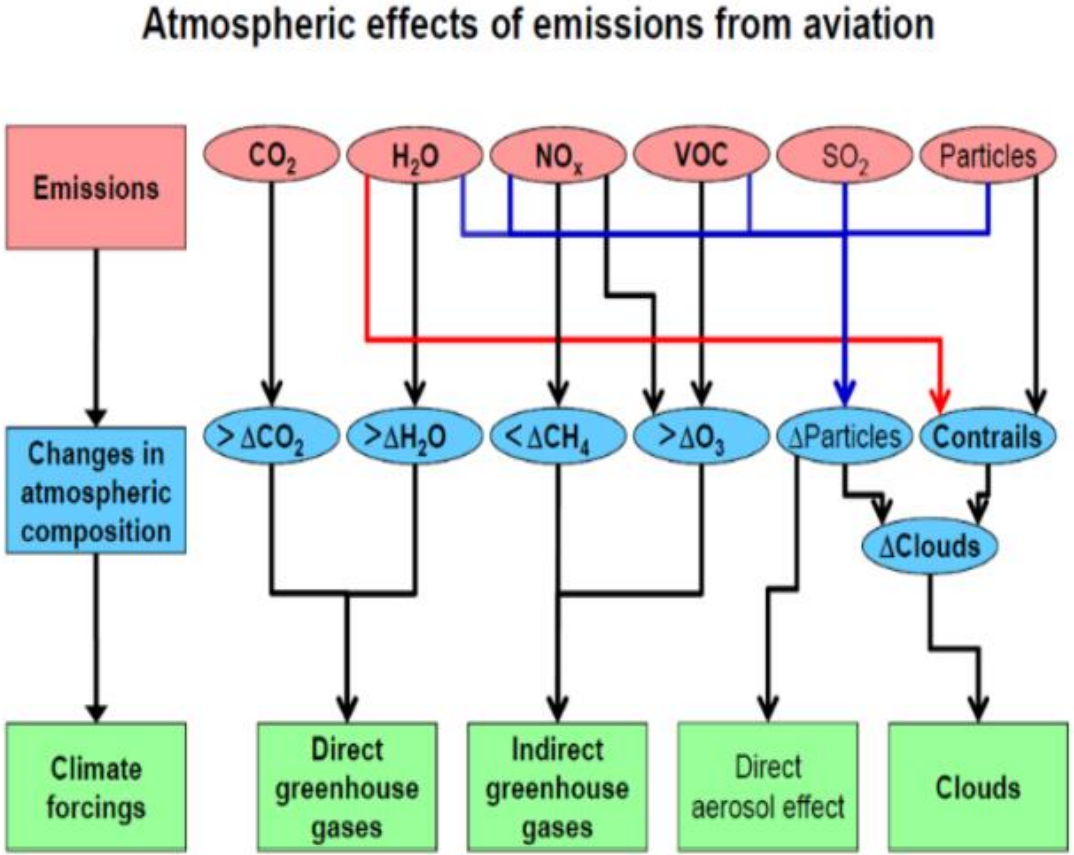
Operations close to airports

Overall aircraft mission

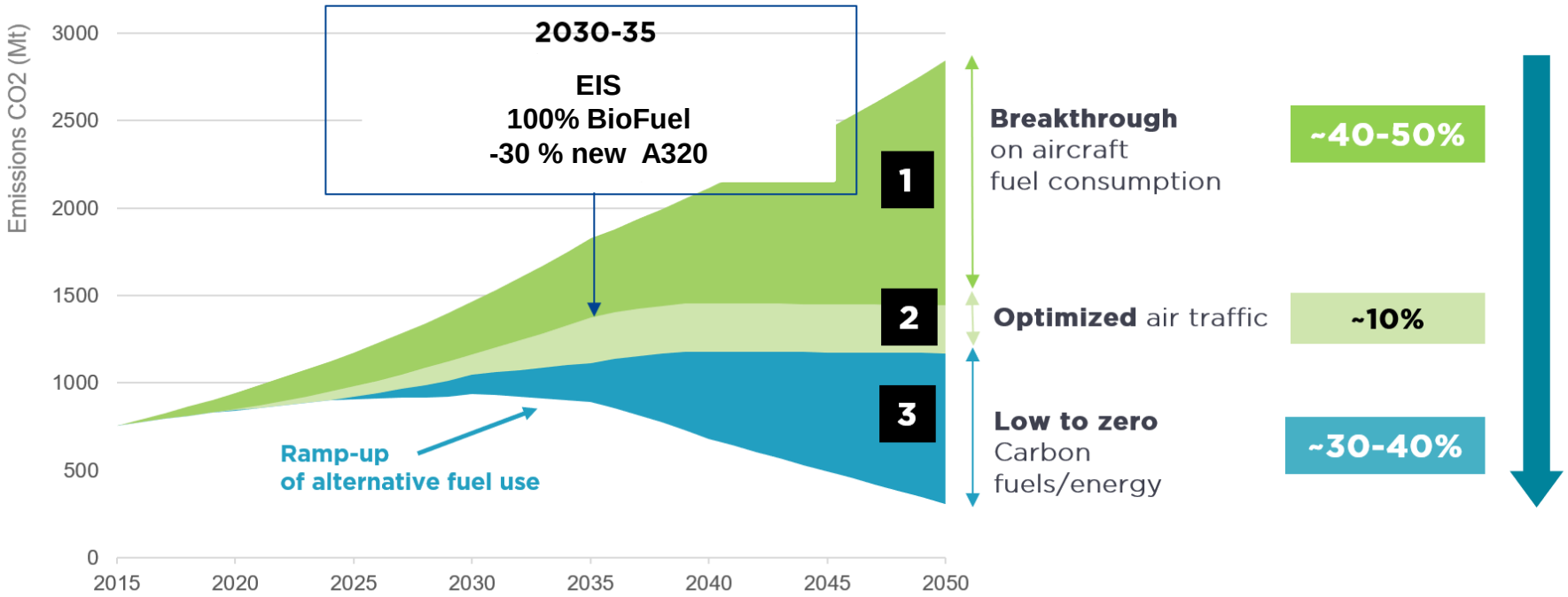
# NON $CO_2$ EMISSION AND RELATED PHENOMENA



# NON $CO_2$ EMISSION AND RELATED PHENOMENA



# DECARBONISING AVIATION: SAFRAN'S VISION






SAFRAN

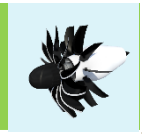
# 3 TOP PRIORITIES

01

ULTRA-EFFICIENT
**FUTURE AIRCRAFT**

30% lower fuel consumption

**ULTRA-EFFICIENT ENGINE**
successor to the LEAP (“New Generation Narrow Body“)



**E-TAXI – EMBEDDED TECHNOLOGY**
Electrification

**LIGHTENED EQUIPMENT AND MODIFIED**
aircraft configurations (thin wings, etc.)


02

ALTERNATIVE
**FUELS**

**OVERCOME TECHNICAL BARRIERS**
to the use of 100% alternative fuels

**ADAPT ENGINE/AIRCRAFT TO HYDROGEN FUELS**

03

ALTERNATIVE
**PROPULSION**

**NEW AIR MOBILITY, COMMUTER & REGIONAL A/C**
used as lab to test (electric/hybrid propulsion systems, fuel cells, etc.)



SAFRAN

# THE PATH TO SUCCESSFUL DECARBONIZATION

80% improvement in energy efficiency since the start of commercial aviation

## 2020

Long-haul

Regional
Short/medium-haul

Commuters
and
helicopters

**100% JET FUEL**

**Public policy and regulations** + **Technology**

## 2030-35

**"Skip a generation"**

**Disruptive aircraft with thermal propulsion, ultra-efficient** and greater use of **alternative fuels**

Small electric aircraft
Hybrid regional aircraft

New air mobility
Short-range

**LOW CARBON**

**Public policy and regulations** + **Technology**

## 2050

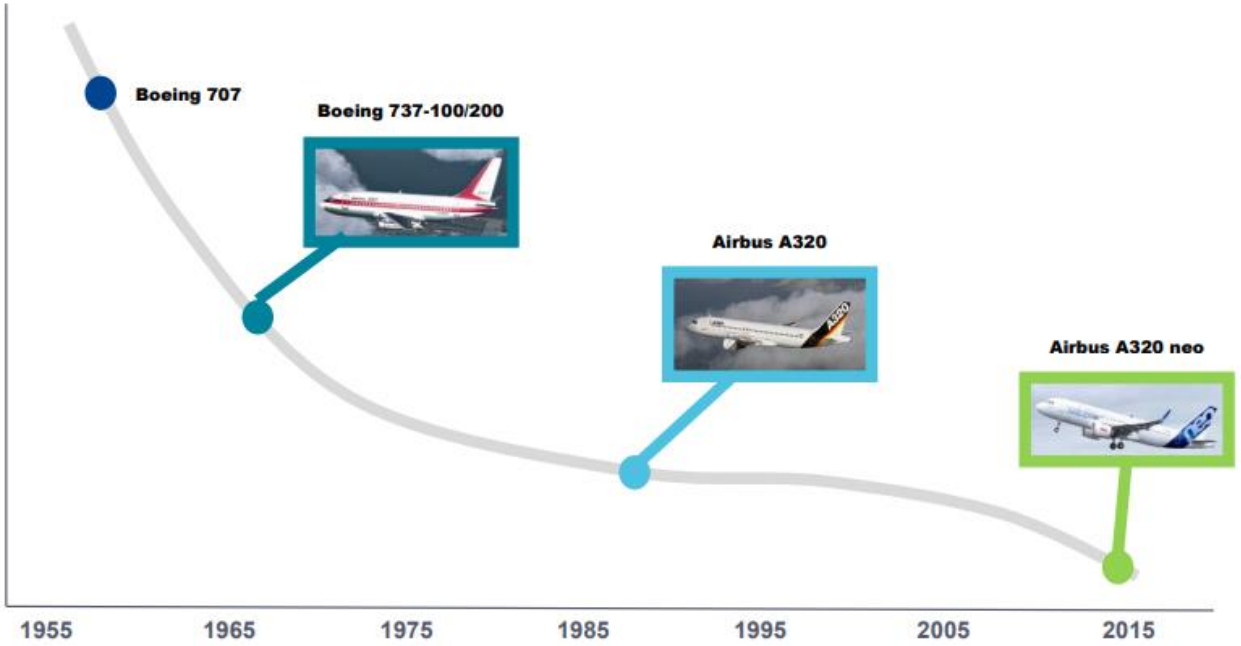
**Future aircraft with carbon-free energy source**

Green synthetic fuel
and/or
Liquid hydrogen
Fuel cells
Ultra-high energy density batteries

**ZERO EMISSIONS**

# ULTRA-EFFICIENT FUTURE AIRCRAFT : ULTRA-EFFICIENT ENGINE

Aviation consumption divided by 5 during the last 60 years
Among them, 70 % from the motor




# ULTRA-EFFICIENT FUTURE AIRCRAFT : ULTRA-EFFICIENT ENGINE

**Average fuel burn of flights departing from Europe = 3,4 l/100km/pax***

**Average CO2 emitted in Europe in 2018 = 3,4*0,8*3,16/100 = 86 g/pax/km****

**This average includes the freight which is transported in addition to passengerS**


* EASA European aviation environmental report
** Mass of $CO_2$ emitted by 1 Kg kerosene = 3,16 Kg
** Kerosene specific mass = 0,8 Kg/l

| Indicator | Units | 2017 | % change since 2014 | % change since 2005 |
|---|---|---|---|---|
| Average fuel consumption of commercial flights[1] | litres fuel per 100 passenger kilometres | 3.4 | -8% | -24% |

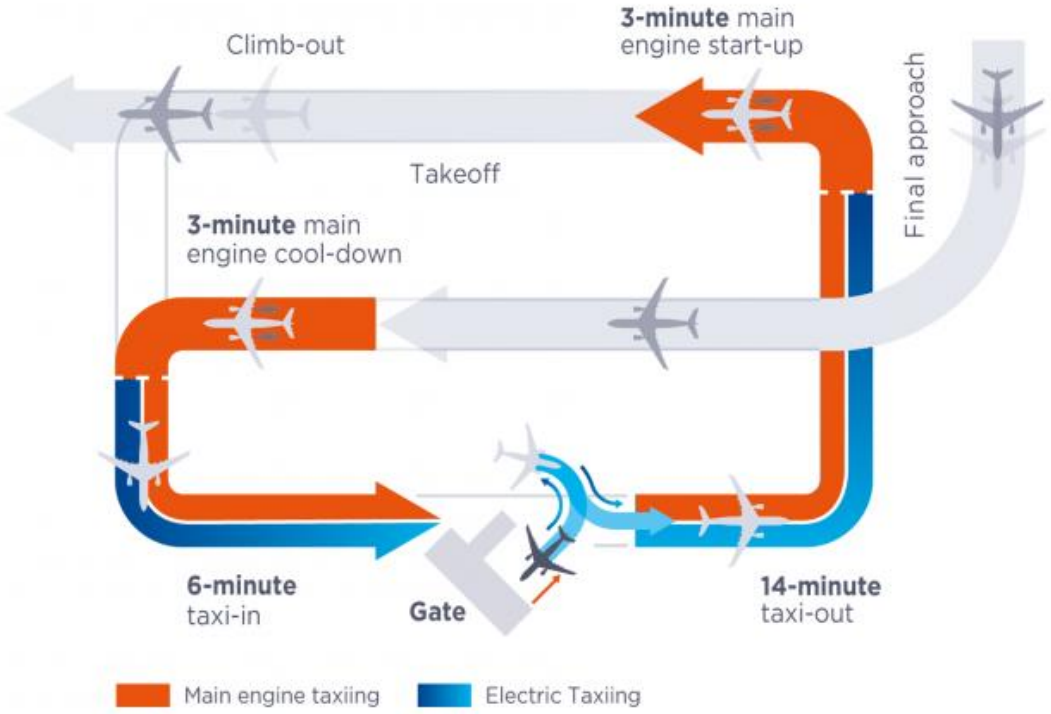
# 3

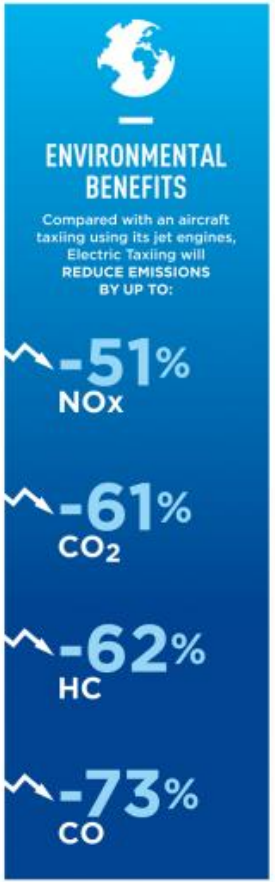
# MORE ELECTRICAL APPLICATIONS

# And

# ALTERNATIVE PROPULSION

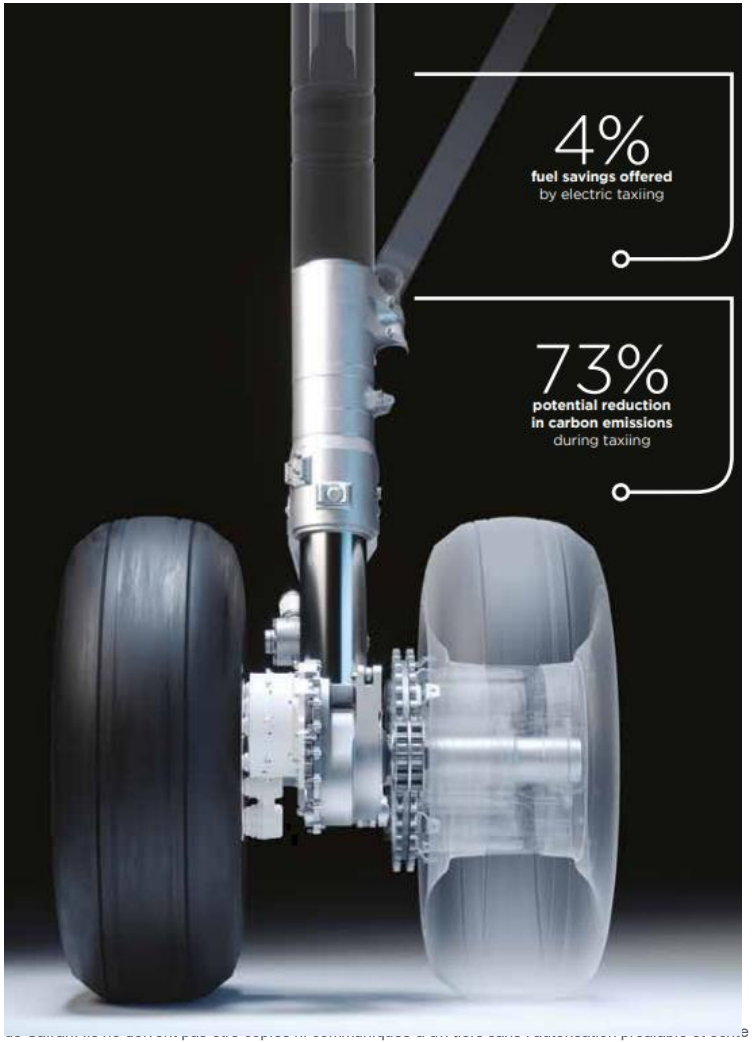
# E-Taxi




https://www.safran-landing-systems.com/systems-equipment/electric-taxiing-0

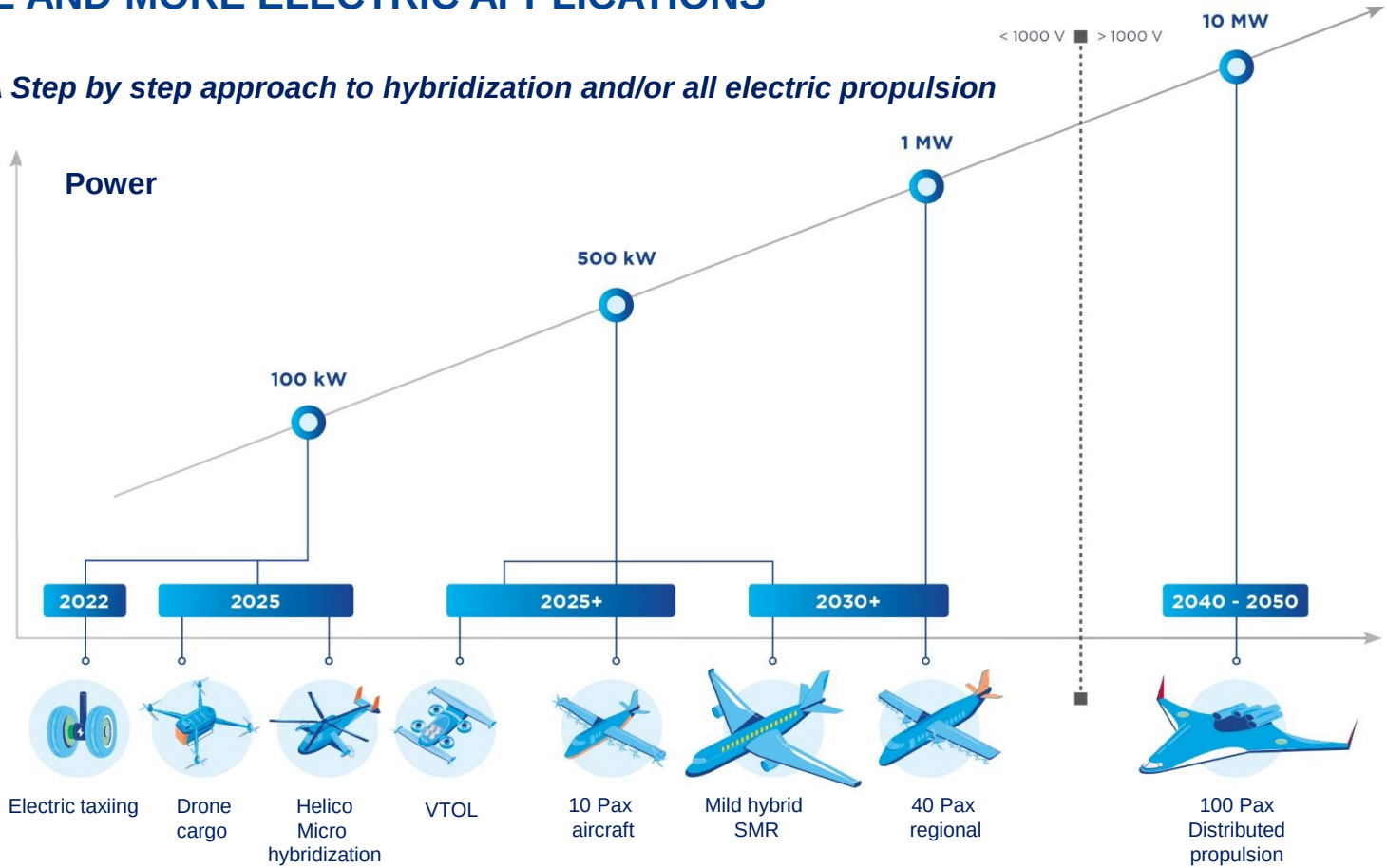
# E-Taxi



# E-Taxi

# MORE AND MORE ELECTRIC APPLICATIONS

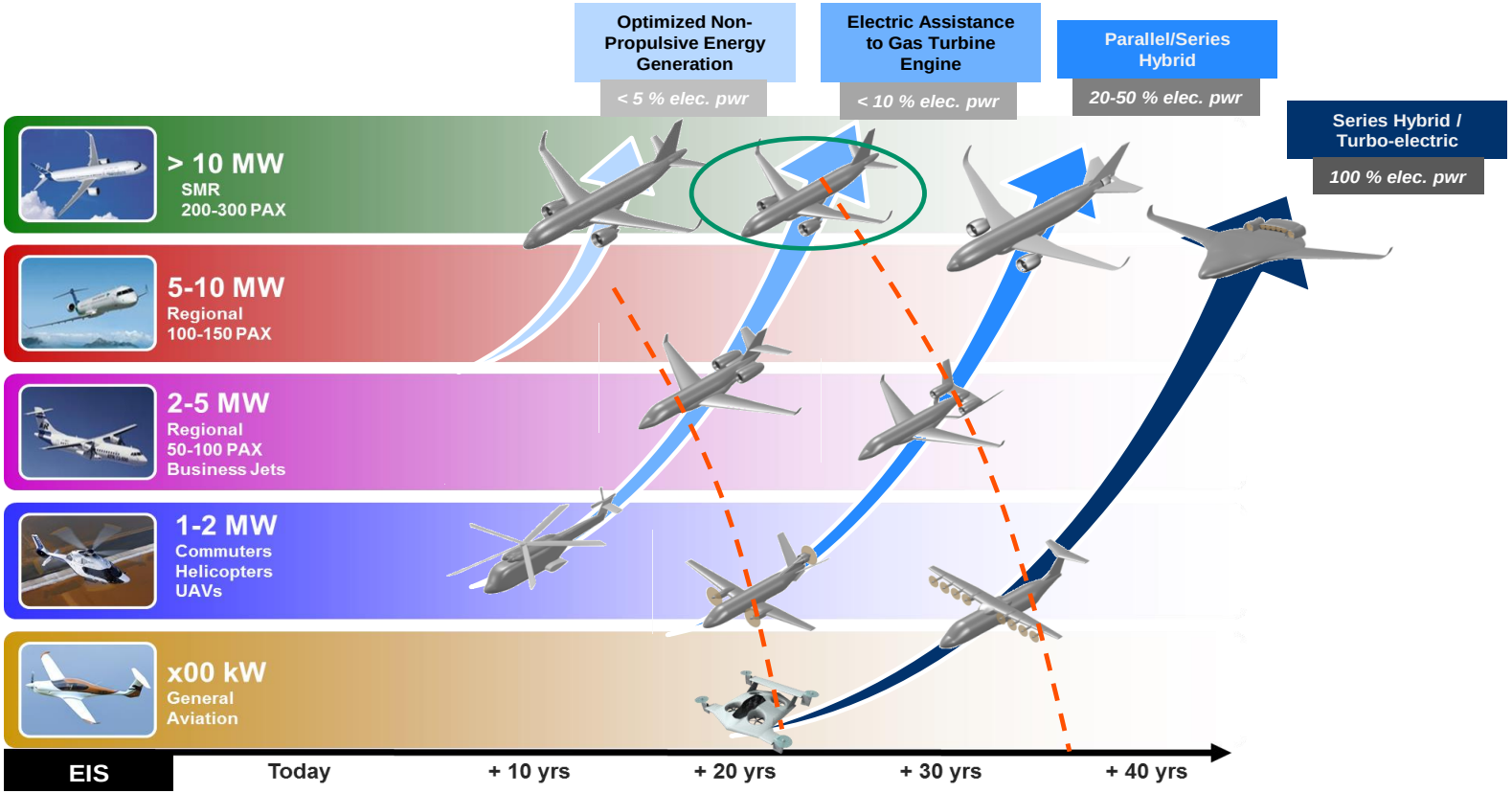
***A Step by step approach to hybridization and/or all electric propulsion***





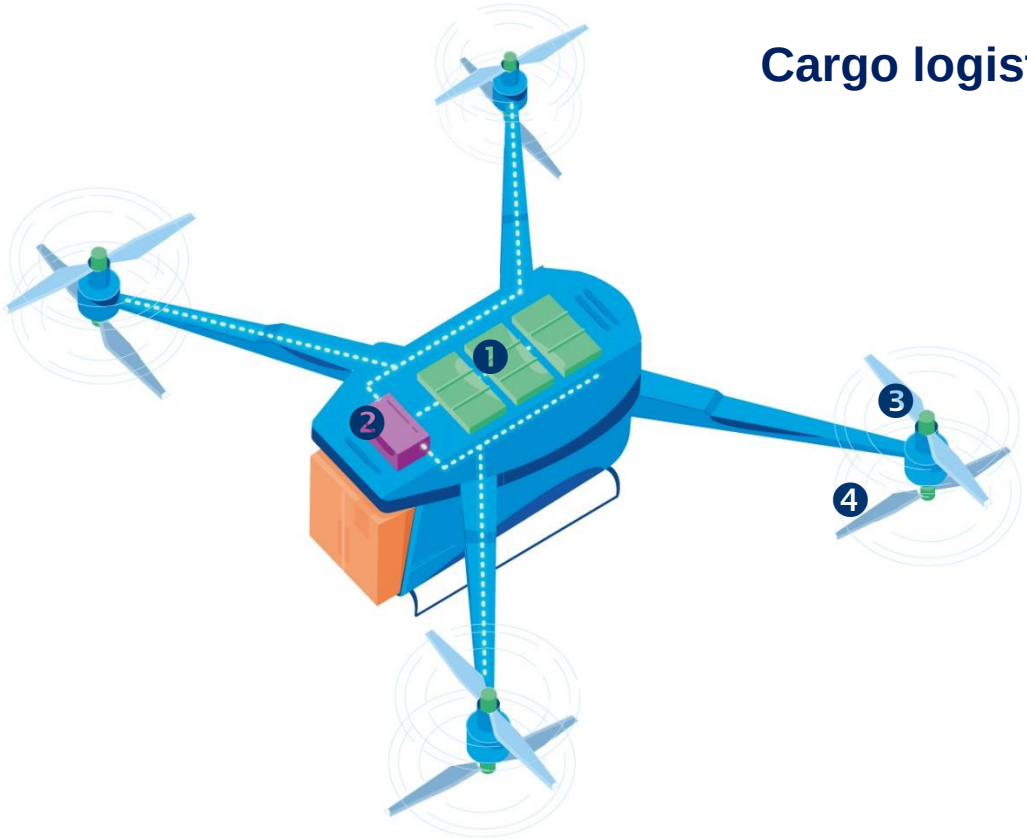

SAFRAN

# AIRCRAFT PROPULSION PROJECTION




***A Step by step approach to hybridization and/or all electric propulsion***

# NEW ARCHITECTURES, NEW APPLICATIONS



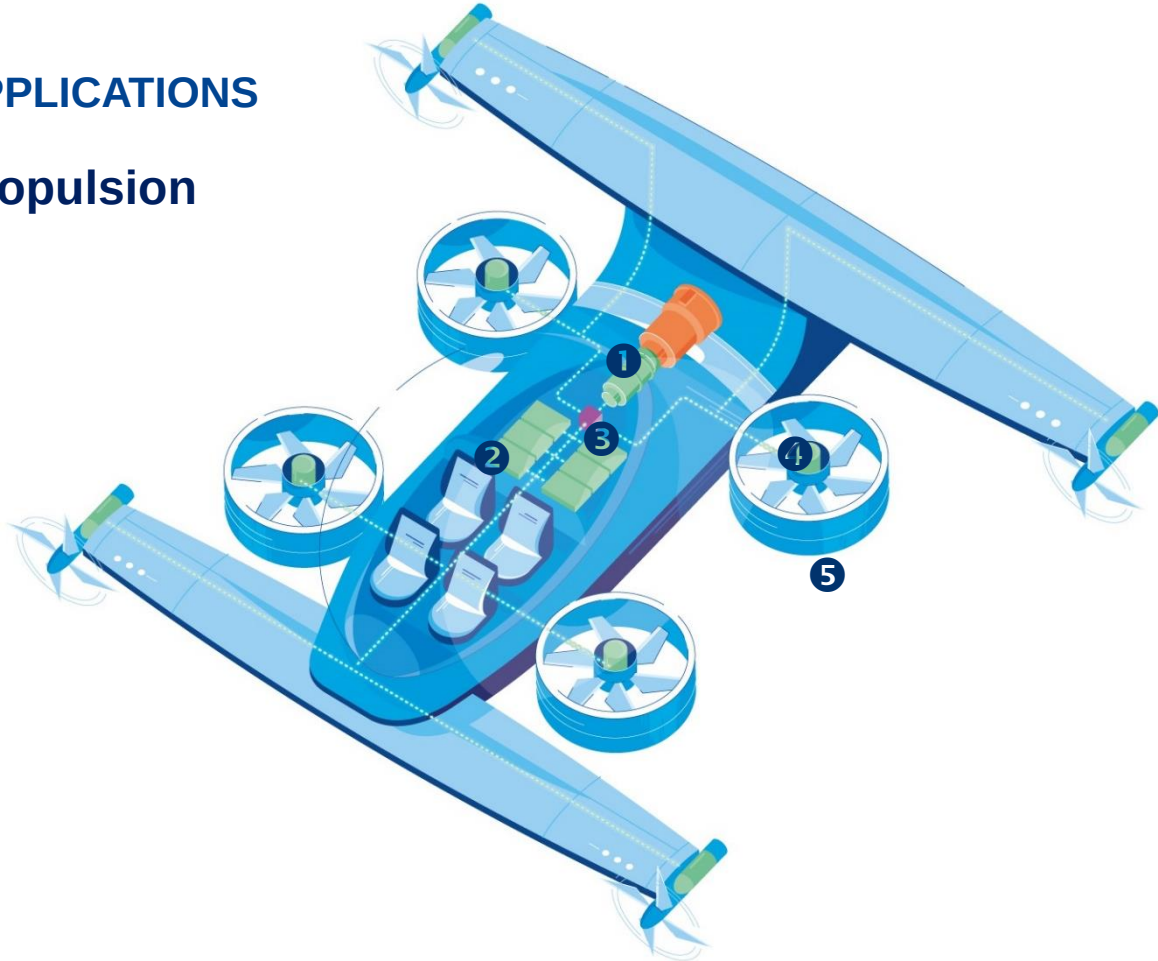

## Cargo logistics drone - Electric propulsion

1 - Batteries
2 - Power Management
3 - Electrical motors
4 - E-propellers

# NEW ARCHITECTURES, NEW APPLICATIONS

## Air taxi - Distributed hybrid propulsion

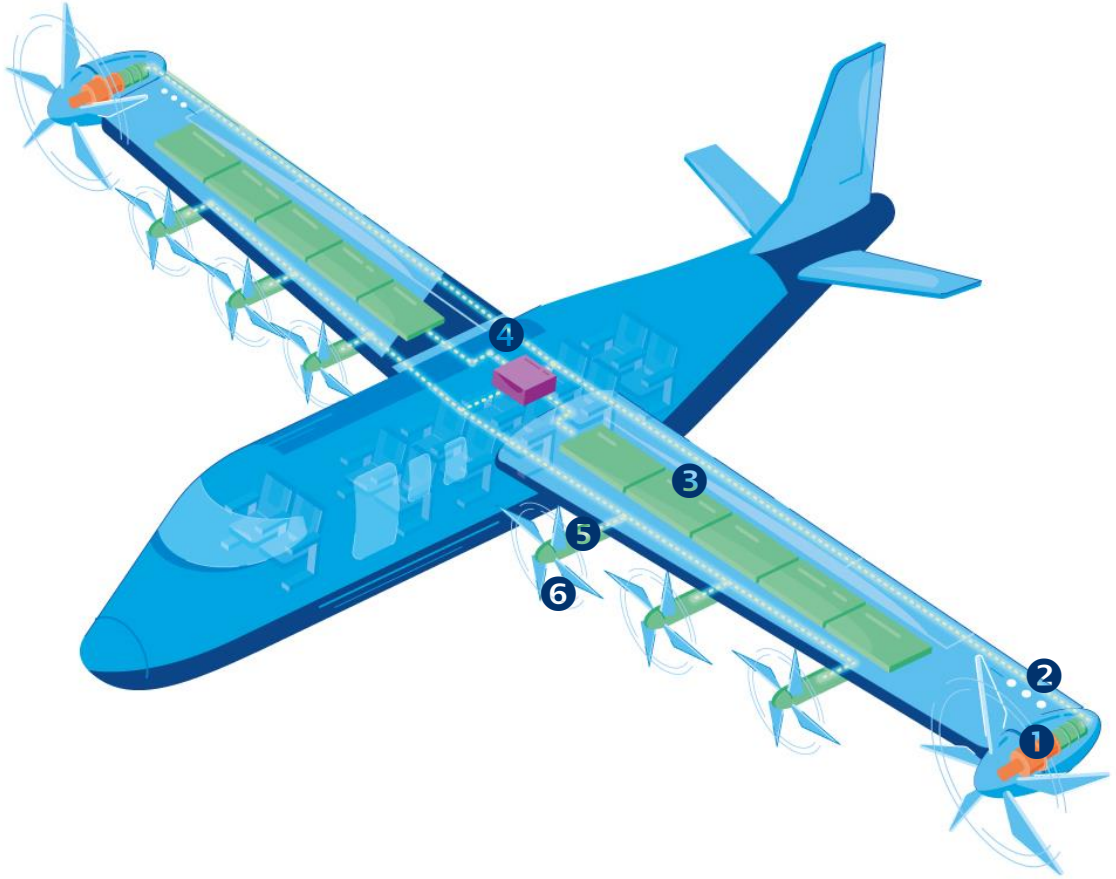
1- Turbogenerator
2 - Batteries
3 - Power Management
4 - Electrical motors
5 - E-propellers



# NEW ARCHITECTURES, NEW APPLICATIONS

## Commuter - Combined series / parallel hybrid propulsion

1- Turbojet
2- Generator
3 - Batteries
4 - Power Management
5 - Electrical motors
6 - E-propellers




# 5

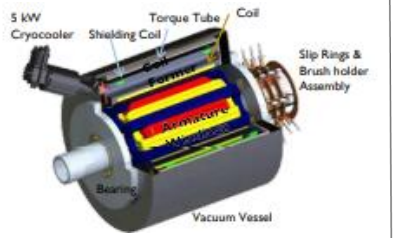
# SUPERCONDUCTIVITY VS HIGH VOLTAGE:

# TODAY'S CHALLENGE ?

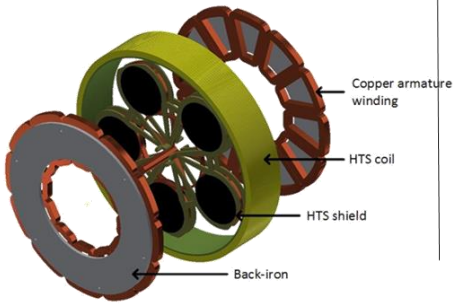


SAFRAN

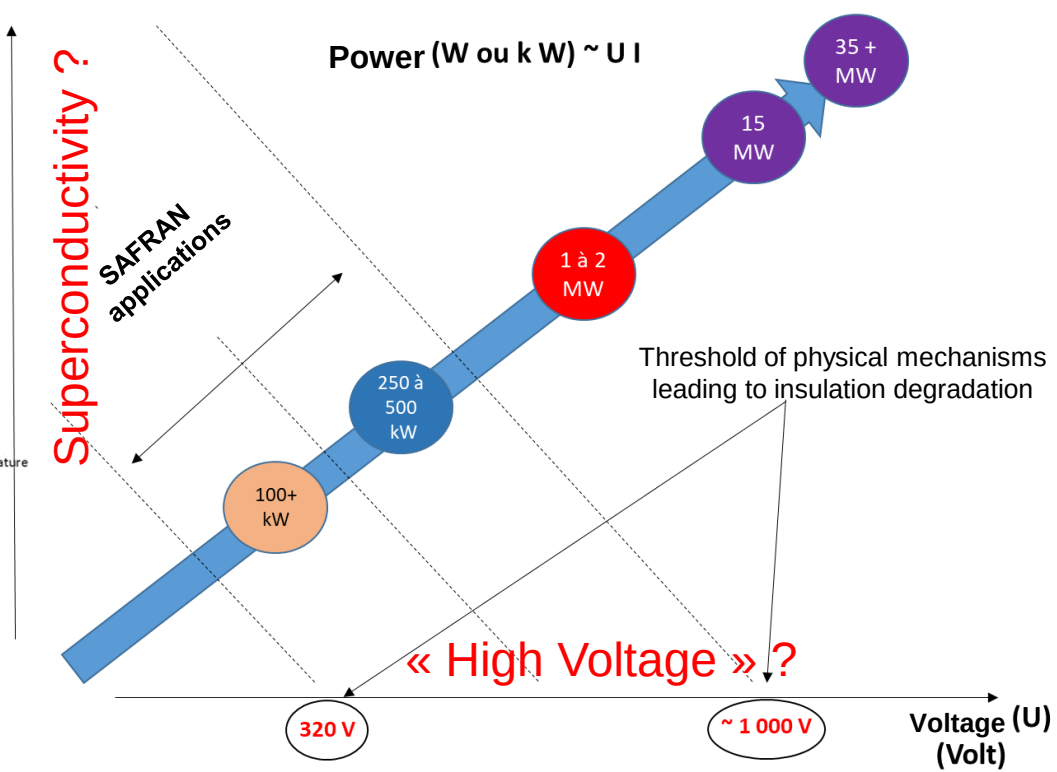
# APPLICATIONS IN A COMPLEX POWER RANGE

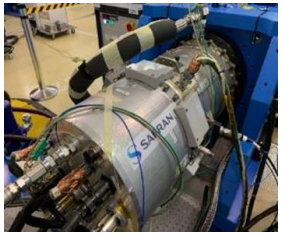



Univ. Illinois




GREEN Univ.Lorraine



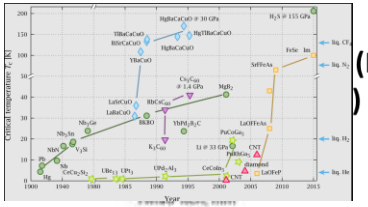



ENGINeUS 500

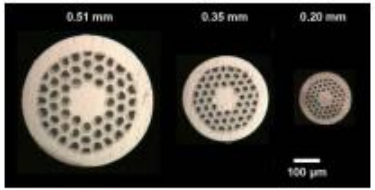
magniX 500

SAFRAN

# APPLICATIONS IN A COMPLEX POWER RANGE

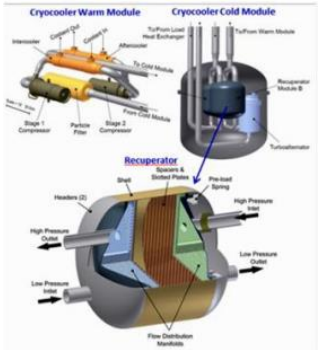


Wikipedia



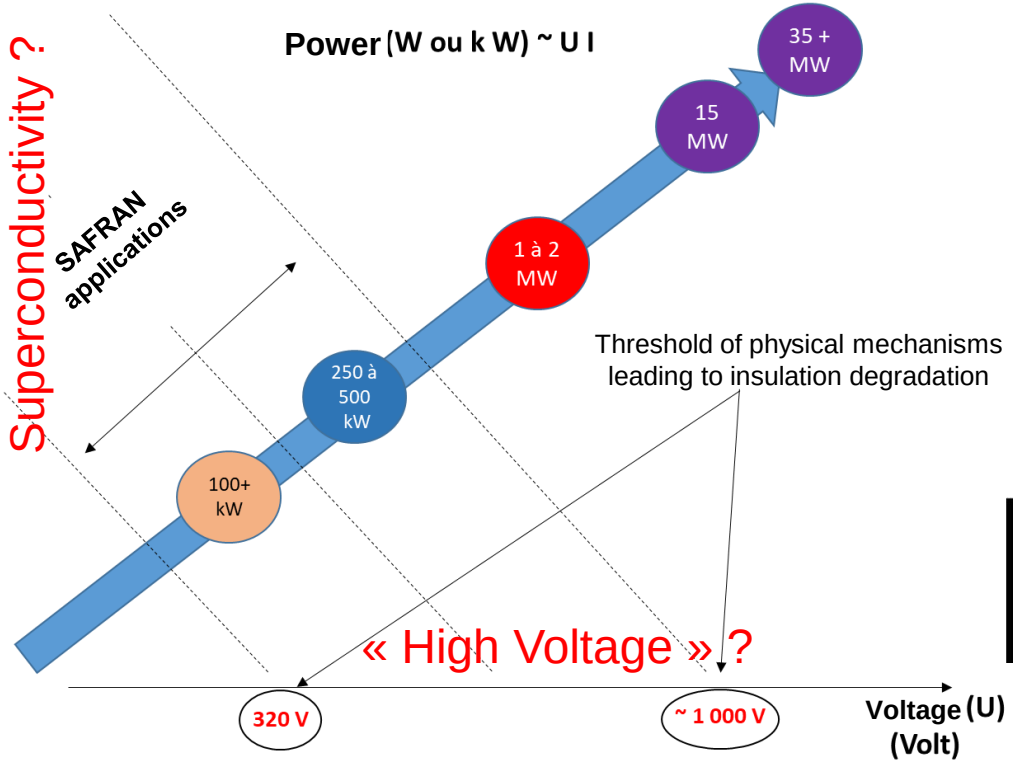

Madavan

**Materials (LTS, MTS, HTS) and Processes**




Madavan

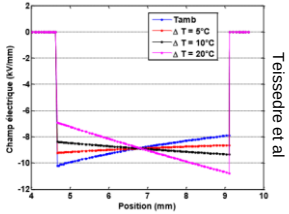
**Cooling**




Lebey et al

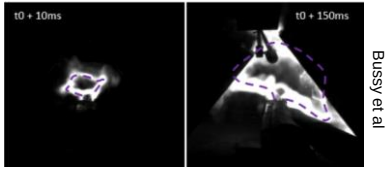
Cotton et al

**Partial Discharges**




Teissedre et al

**Space charge**




Bussy et al

**Electrical Arc**


# 7

# CONCLUSIONS ?

Climate changes drive the R&T works to reduce $CO_2$ fingerprint.

Electrification of an increased number of functions including the propulsion may appear as an enabler of this reduction.

More Electrical Power being necessary, such a penetration will only be possible if the voltage is increased or if superconducting concept and associated technologies are developed

Increasing the voltage may lead to consequences to be mitigated.

Specific efforts in the field of materials and processes are necessary for superconductivity to become a tangible technology .

**We are living a revolution**
**Enjoy what you do and have a great conference !**

# POWERED BY TRUST