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IHAC 2022

1 Sept. 2022
Glasgow UK



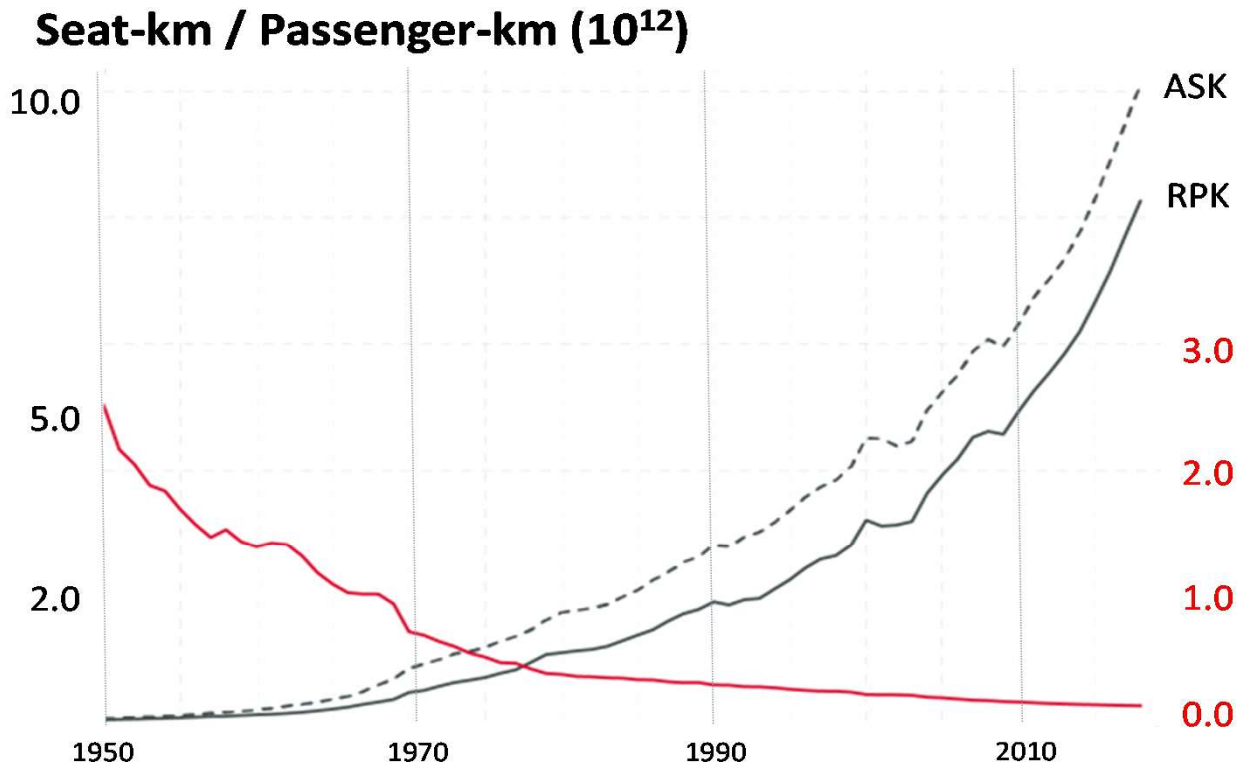
**UNLOCKING THE
POTENTIAL OF HYDROGEN
IN THE JOURNEY TOWARDS
A SUSTAINABLE CLIMATE-
NEUTRAL AVIATION SYSTEM**



**Co-funded by
the European Union**

THE CRUX OF THE ISSUE

Phenomenal progress in efficiency.
But growth has consistently outpaced these gains.



Source and copyright: OurWorldinData.org

kg CO₂ per RPK
2018: 0.125kg CO₂ per RPK

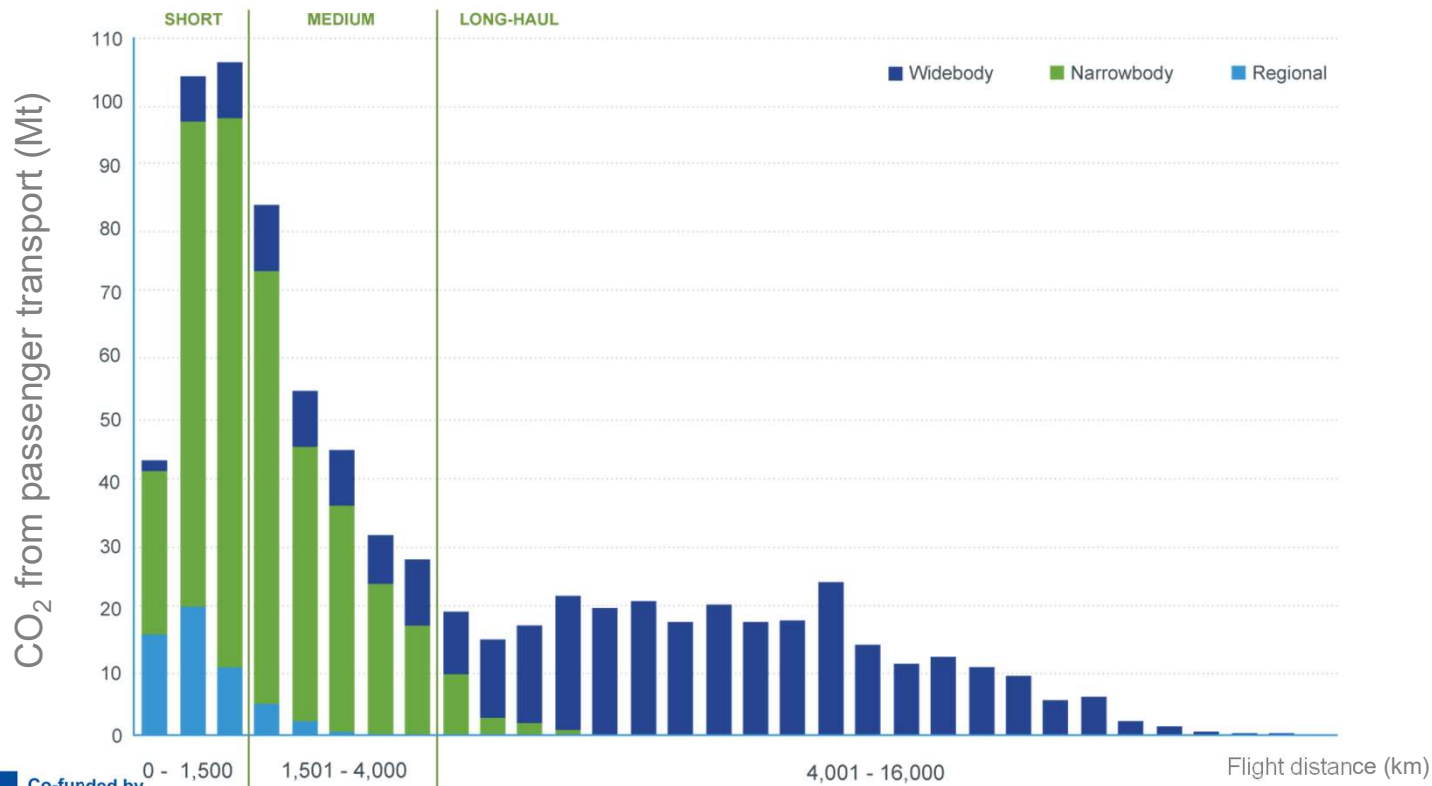


WHAT IS CLEAN AVIATION?

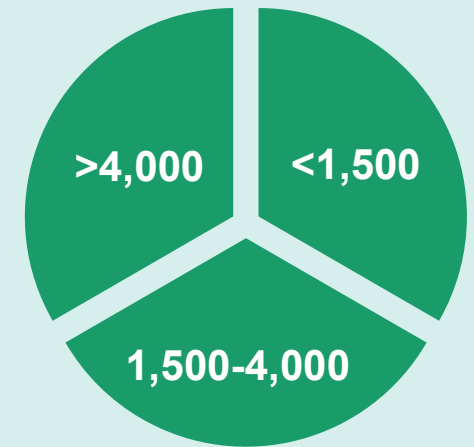
- **€4.1bn Public Private Partnership** to deliver **transformative impact**
- Aligned with the **European Green Deal** supporting the **Paris Agreement**
- **Disruptive technology** leveraging new fuel/energy sources for climate-neutrality
- **Central “hub”** in network with regional, national and other EU level programmes
- Running **2021 – 2031**

A CLOSER LOOK AT THE GLOBAL AVIATION SYSTEM

Share of passenger CO₂ emissions in 2019, by stage length and aircraft class



Source ICCT 2019 global air transport

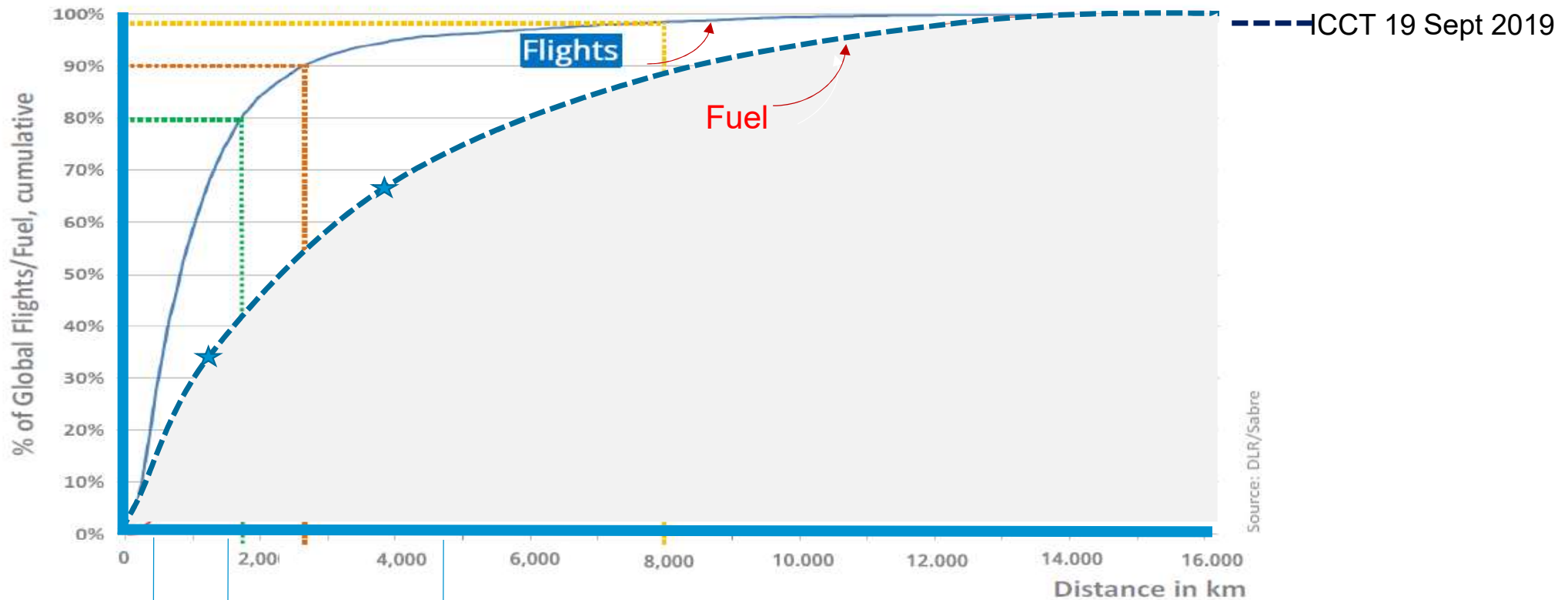


Distribution of emissions by flight distance (in km)

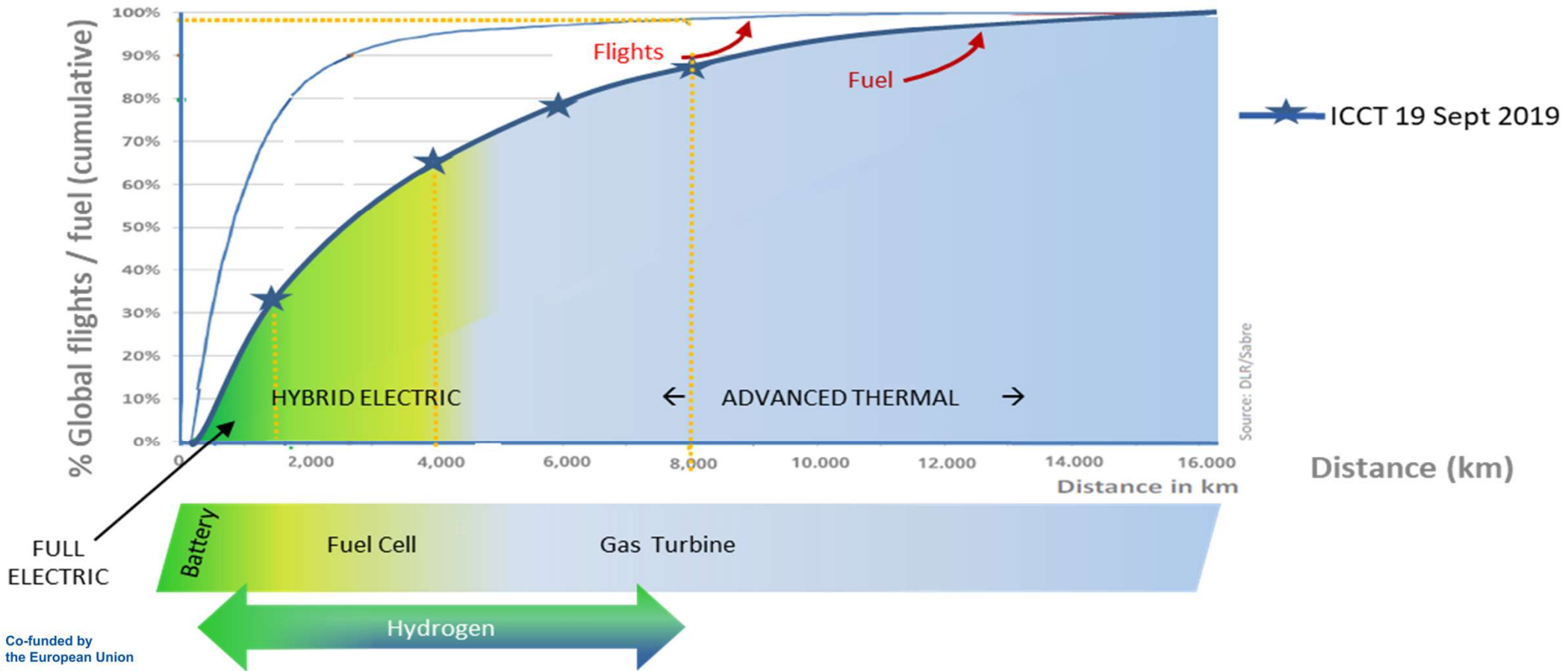
Long term trend shows relative increase in short/medium range emissions

CUMULATIVE VIEW

1/3 of global emissions are from flights <1500km. 2/3 of global emissions from flights <4000km.



MORE DIFFERENTIATION: SCOPE FOR DISRUPTION



AGE OLD FORMULA... AS RELEVANT AS EVER

Breguet Equation

Energy per unit of fuel mass

Addressing this is the new challenge and highlights the case for H2

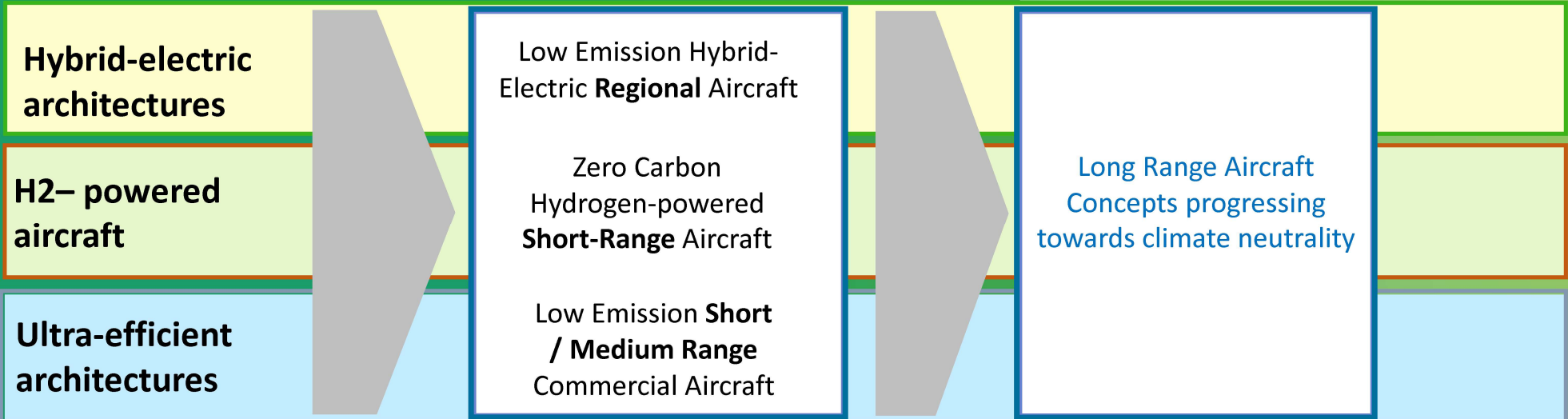
$$\text{Range} = \frac{\Delta h_{\text{fuel}}}{g} \eta_{\text{overall}} \frac{L}{D} \ln \left(\frac{W_i}{W_f} \right)$$

Propulsion technology

Structures and materials technology

Flight physics, aerodynamic efficiency

CLEAN AVIATION – THREE THRUSTS

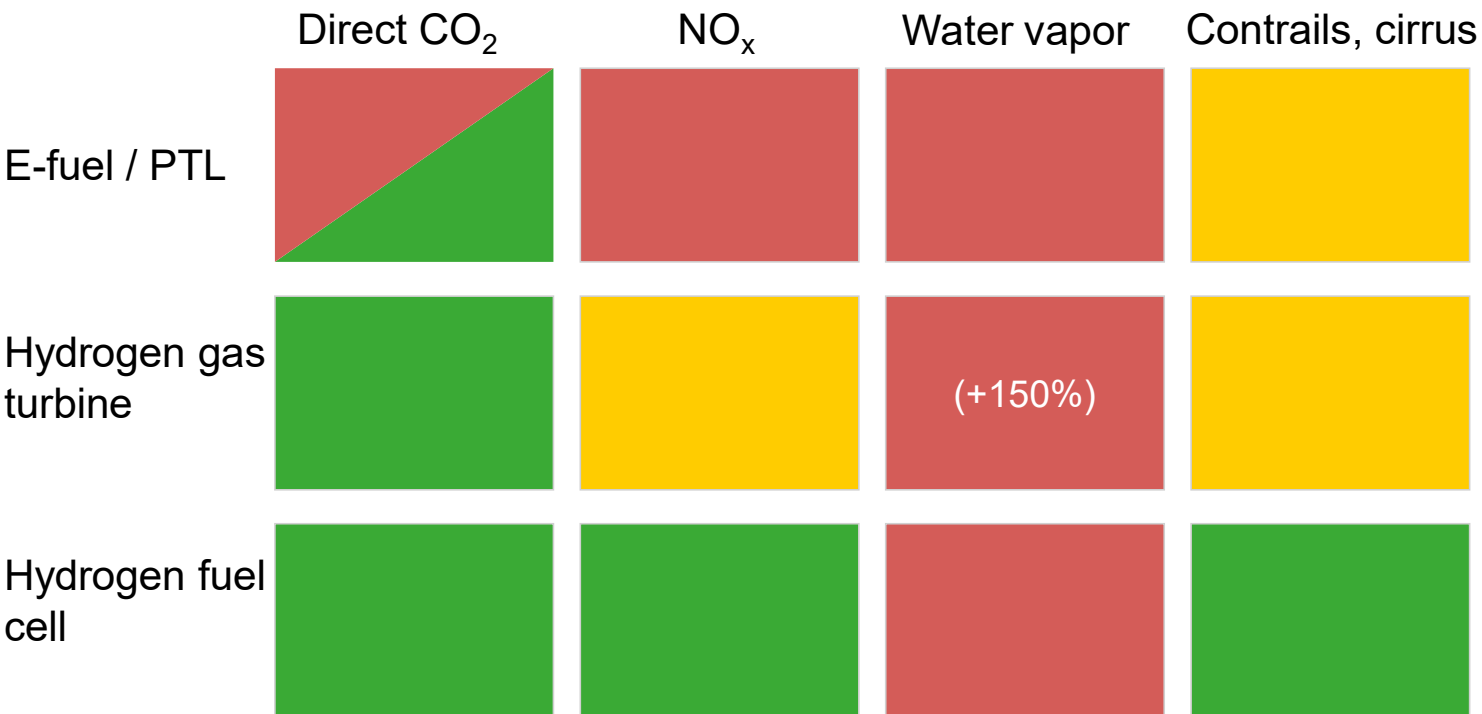


Flight demonstration within Clean Aviation and market entry by 2035

Development of disruptive technology options

H2: PROMISING, BUT NOT WITHOUT CHALLENGES

Change of in-flight emissions and related effects



Climate impact reduction potential

-30-60%

-50-75%

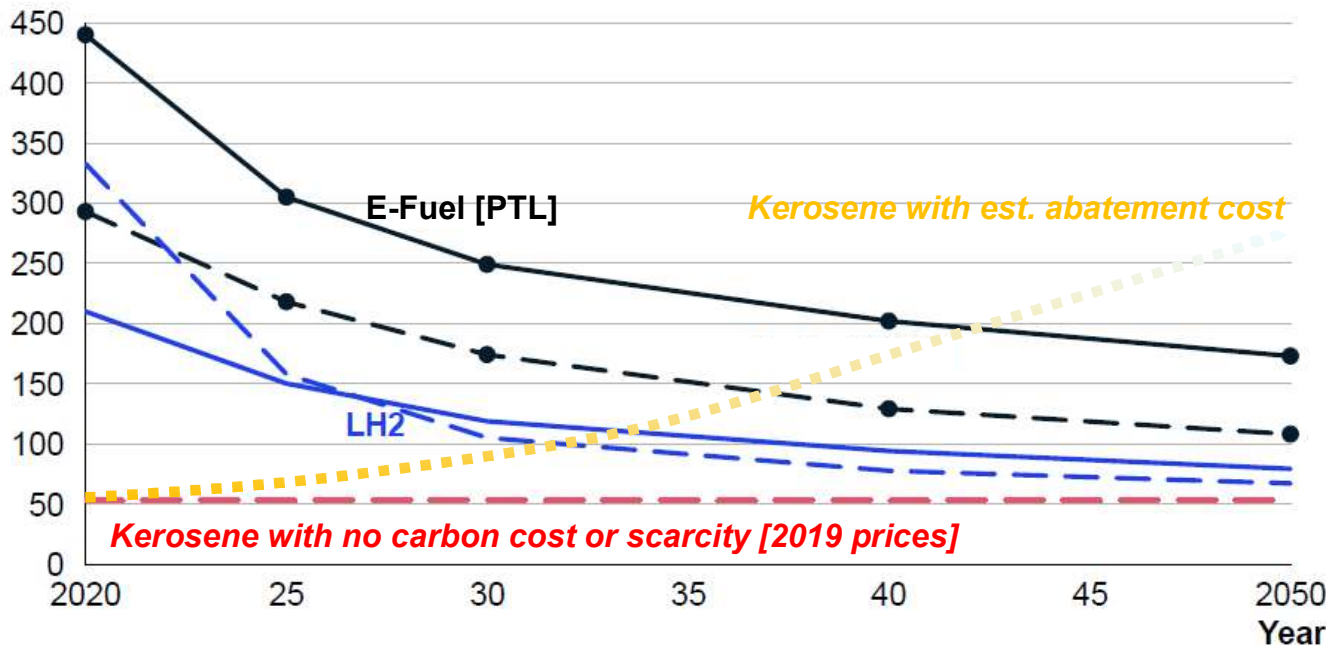
-75-90%

COST LH2 “AT THE PUMP” VS. SYNFUEL AND JET-A

—●— EU Direct Air Capture
 -●- ME Direct Air Capture
 — EU LH2 offshore
 - - ME LH2 solar
 - - - Kerosene

Projected cost for fuel at dispenser supplied to EU airport

2019 USD/MWh



Synfuel coming from direct air carbon capture requires a significant amount of energy – chosen since only full net-carbon neutral synfuel option

Costs decrease significantly over years due to scale effect and learning rate

Middle East synfuel and LH2 production with lowest costs for LH2 due to very low electricity costs – shipping costs neglectable for kerosene / synfuels, LH2 shipping to be cost competitive by 2025+

Source: Joint CS2 JU FCH JU study 2019

The
**MOST
EXCITING
TECHNOLOGICAL
DECADE**
for AERONAUTICS
**IS
BEGINNING**

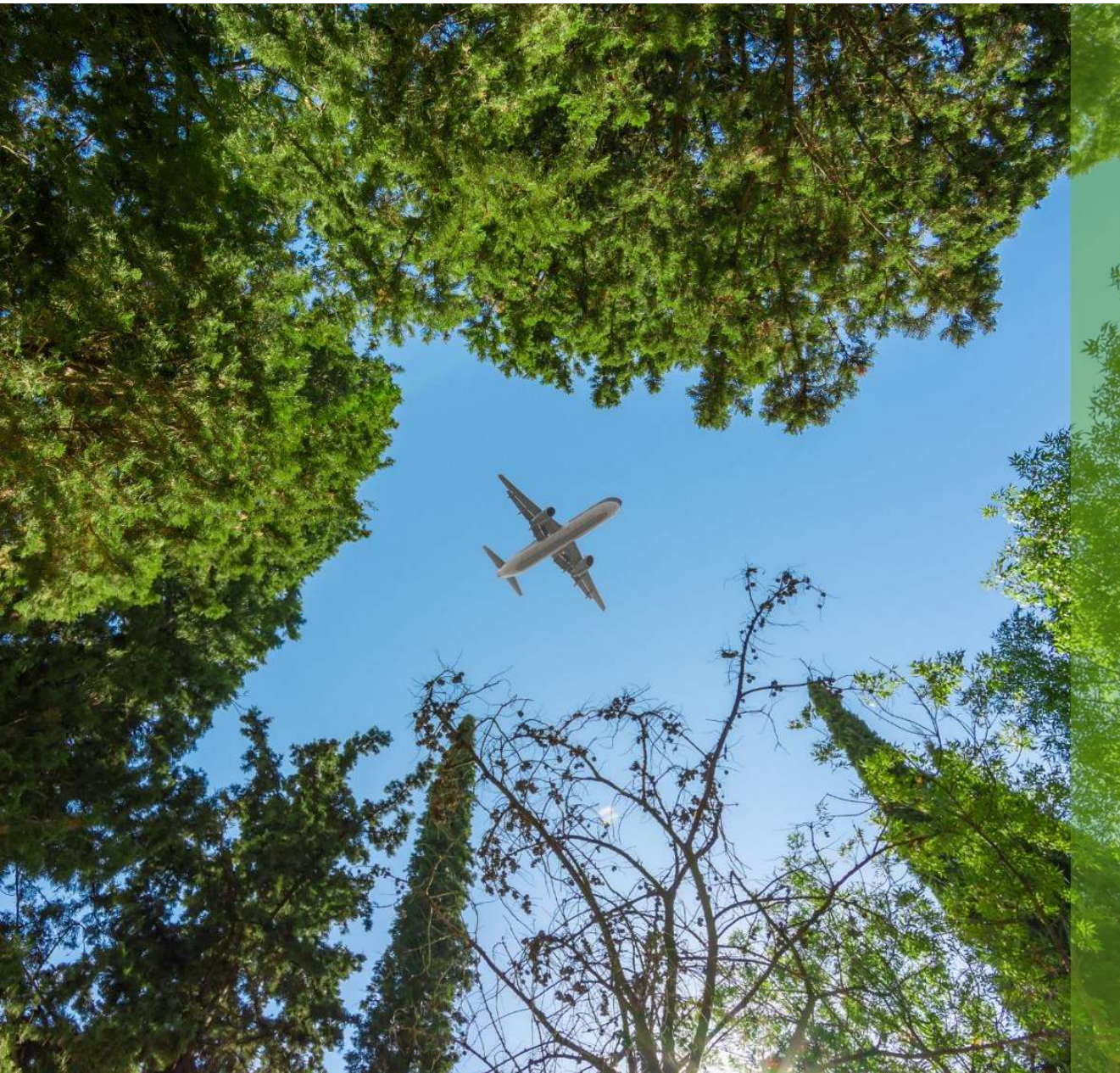
SKIP-A-GENERATION TECHNOLOGY LEAP

- »»»»»»» **Keep pushing the envelope in all ‘traditional’ aeronautical sciences**
- »»»»»»» **Non-traditional sciences and disciplines will bring key enablers**
- »»»»»»» **Manufacturing system**
(aim: replacing ~75% of the global fleet by 2050)
- »»»»»»» **Simulation, digital twin and innovative certification methods**
- »»»»»»» **Life-cycle aspects and recyclability**

THE JOURNEY HAS JUST BEGUN

European aviation ecosystem will need **further transformation**





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ENGAGE

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