Sustainability in the air transport sector

Research by Energy & Strategy - Politecnico di Milano

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Politecnico di Milano

PATTO PER LA
DECARBONIZZAZIONE
DEL TRASPORTO **AEREO**

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The objectives and structure of the study

Assessment of ***decarbonisation pathways that can be pursued by the air transport sector*** *(aviation and infrastructure sector), in order to provide scientific insight for the sustainability assessment of the air transport sector*

- Sustainable development and sustainable
- The sustainability of air transport according to an ESG logic
- EU regulatory developments on decarbonisation targets
- Analysis of the European and Italian emission
- The 'inertial' scenario: the emission dynamics of air transport
- Possible courses of action in the aviation and infrastructure sector
- Options for action in the 'Full Decarbonisation' scenario to 2050

The sustainability of air transport... at 360°.

- The air transport sector is **most relevant to the SDGs related to economic growth** (SDGs 8, 9 and 12). Likewise, **the climate impact assessment** (SDG 13) is high, given the importance of **emissions and decarbonisation of the sector.**

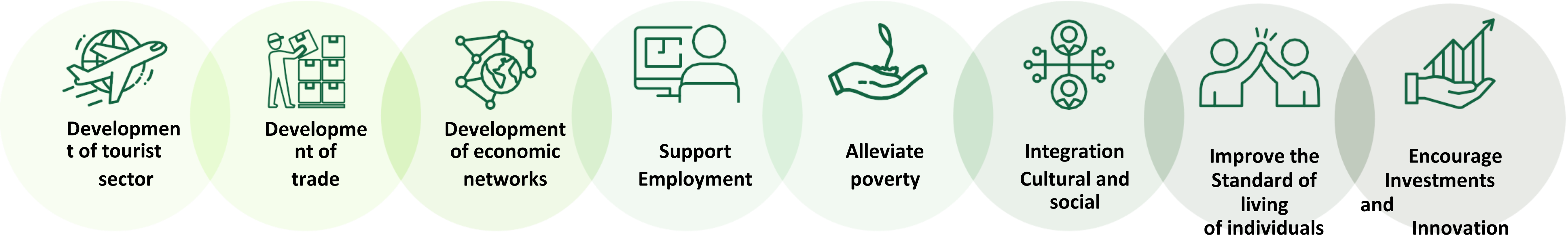
- The contribution to other areas of **social inequality, cultural interconnection and health** (SDGs 3, 4 and 5) is also significant, confirming the **enabling role of air transport compared to other industries**.

Source: Revised Energy & Strategy by ATAG

The sustainability of air transport... at 360°. The facilitative role of air transport compared to other industries

- Air transport is an integral part of any future transport ecosystem, providing global mobility and in many cases representing the only viable link in a national and international context.

- Air transport supports tourism and trade, provides jobs, improves the living standards of populations and alleviates poverty. In addition, connectivity contributes to improving productivity, encouraging investment and innovation, improving business operations and attracting employees.

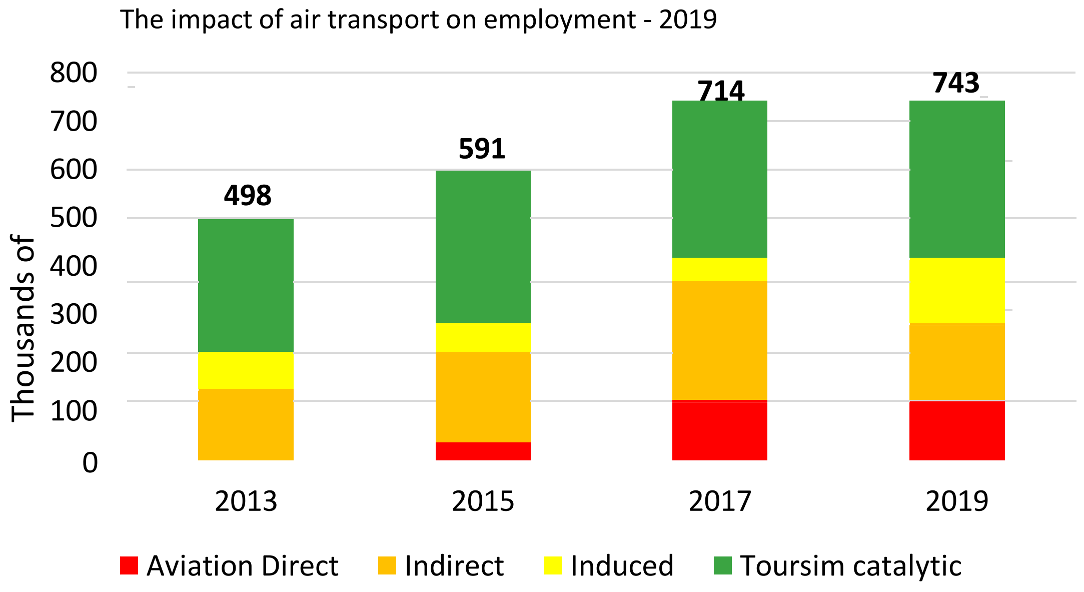


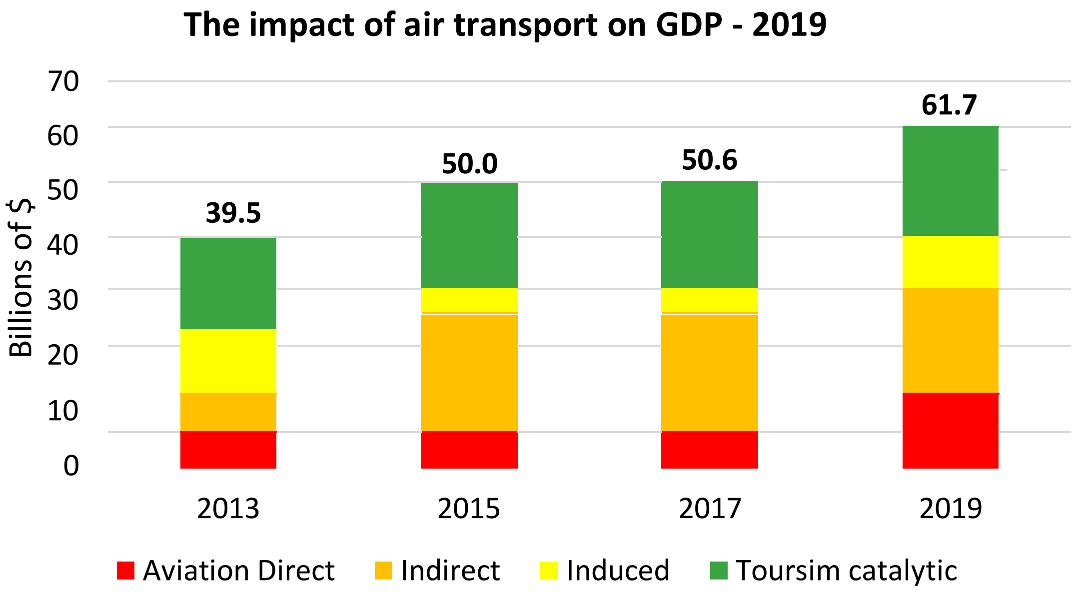
The sustainability of air transport... at 360°. The facilitative role of air transport compared to other industries

The impact of air transport on employment and
The Italian perspective

- The level of aviation-related employment reaches 743,000 in the year 2019 (+49% compared to 2013).

- Similarly, it can be highlighted that the GDP related to air transport reaches over $61.7 billion for the year 2019 (+56% compared to 2013).



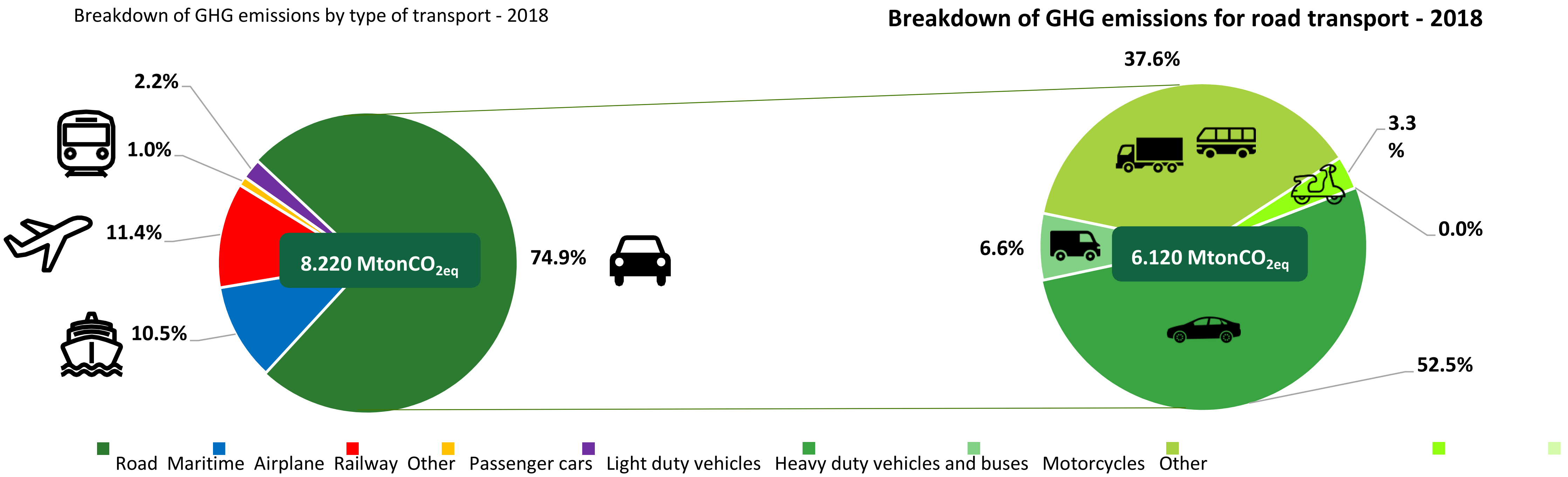


Source: Energy & Strategy revision from Air Transport Action Group - ATAG data.

Aviation and emissions: putting the problem into perspective

Transport and total sector emissions worldwide

- The last 3 decades have seen a sharp increase in global GHG emissions, from around 35 billion tonnes CO2eq in 1990 to over 49 billion in 2018 (+40%). The largest contribution is associated with energy industries (32.8%), while transport is the second largest sector in terms of GHG emissions (17.4%).



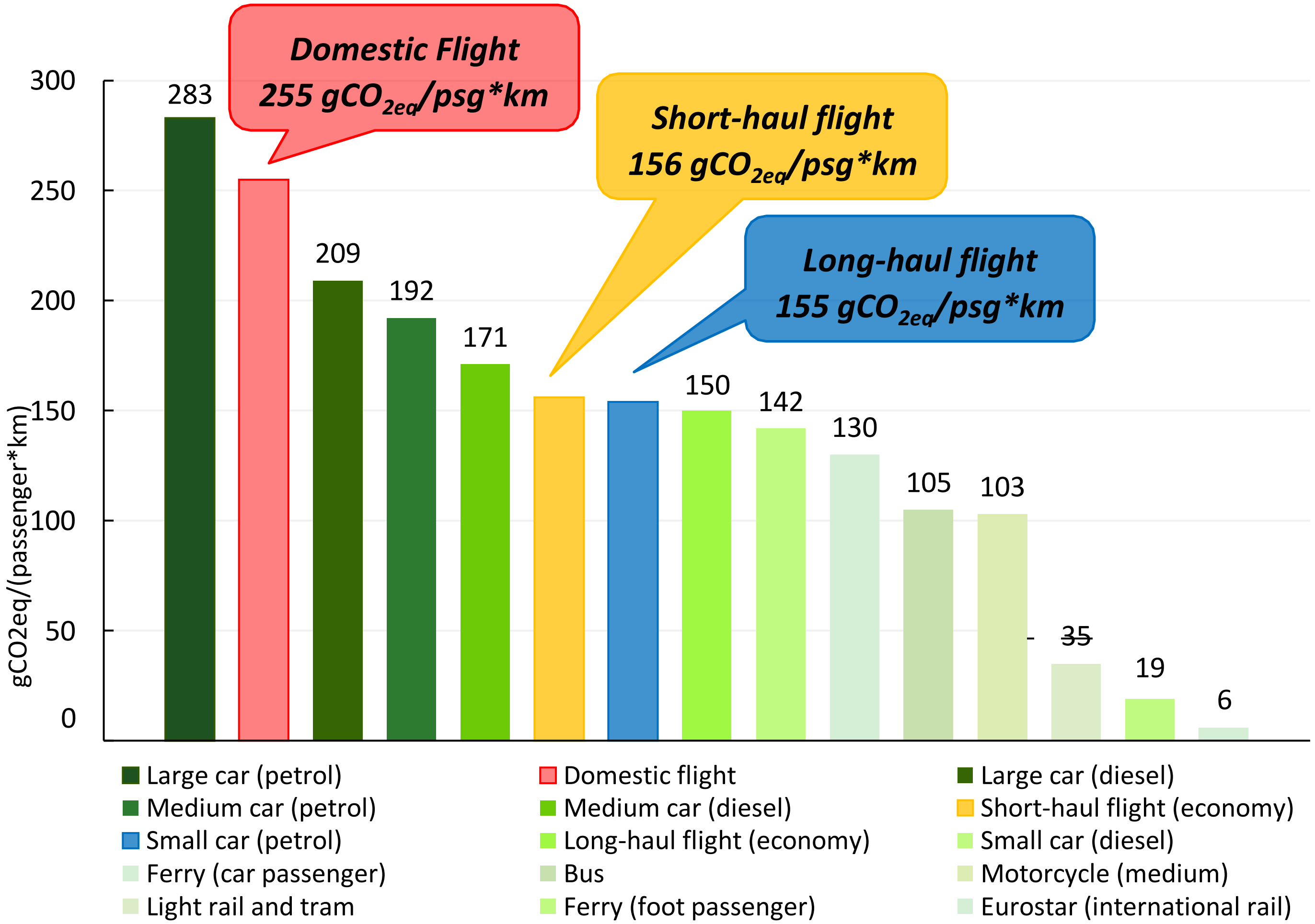
- **Thus, aviation accounts for about 2 per cent of the world's total GHG emissions.**

Source: Re-elaboration Energy & Strategy data EEA and World

Aviation and emissions: putting the problem into perspective

Environmental impact for different modes of transport

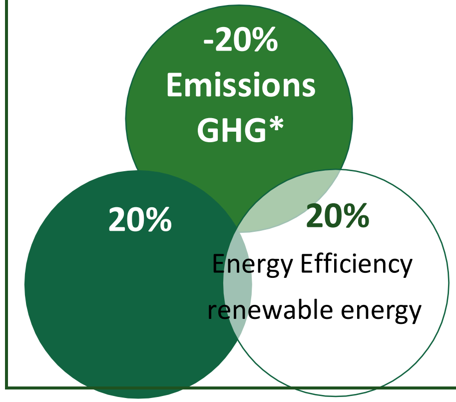
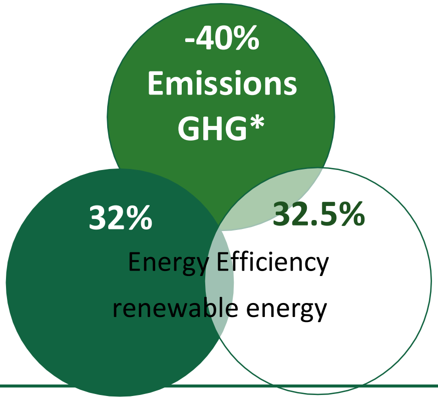
- Road transport (large car, medium car) has the highest overall emission values.
- For air transport, this assessment is more negative when comparing domestic flights (255 gCO2eq/psg*km) to long-haul flights (150 gCO2eq/psg*km).



Source: Energy & Strategy revision Our World in data

Aviation and emissions: putting the problem into perspective

Decarbonisation targets in Europe

Climate Energy Package Targets to 2020	Climate Energy Framework Targets to 2030	Green New Deal Targets to 2030	Long-term strategy to 2050
		-55% GHG emissions *	Zero climate impact by 2050, focusing on on a few strategic activities: ▪ Decarbonising energy supply ▪ Increasing European energy independence ▪ Clean, safe and interconnected mobility ▪ Maximising the benefits of energy efficiency ▪ Smart and connected networks ▪ Circular economy and industry modernisation ▪ More sustainable agriculture and land use ▪ Carbon Capture and Storage Technologies

- In order to reach the 2050 climate neutrality target, a number of policy updates have been proposed for 2030 through the 'Fit for 55' package and the 'RePowerEU'.

EU 2030 decarbonisation target

-55% GHG emissions compared to 1990 levels

→

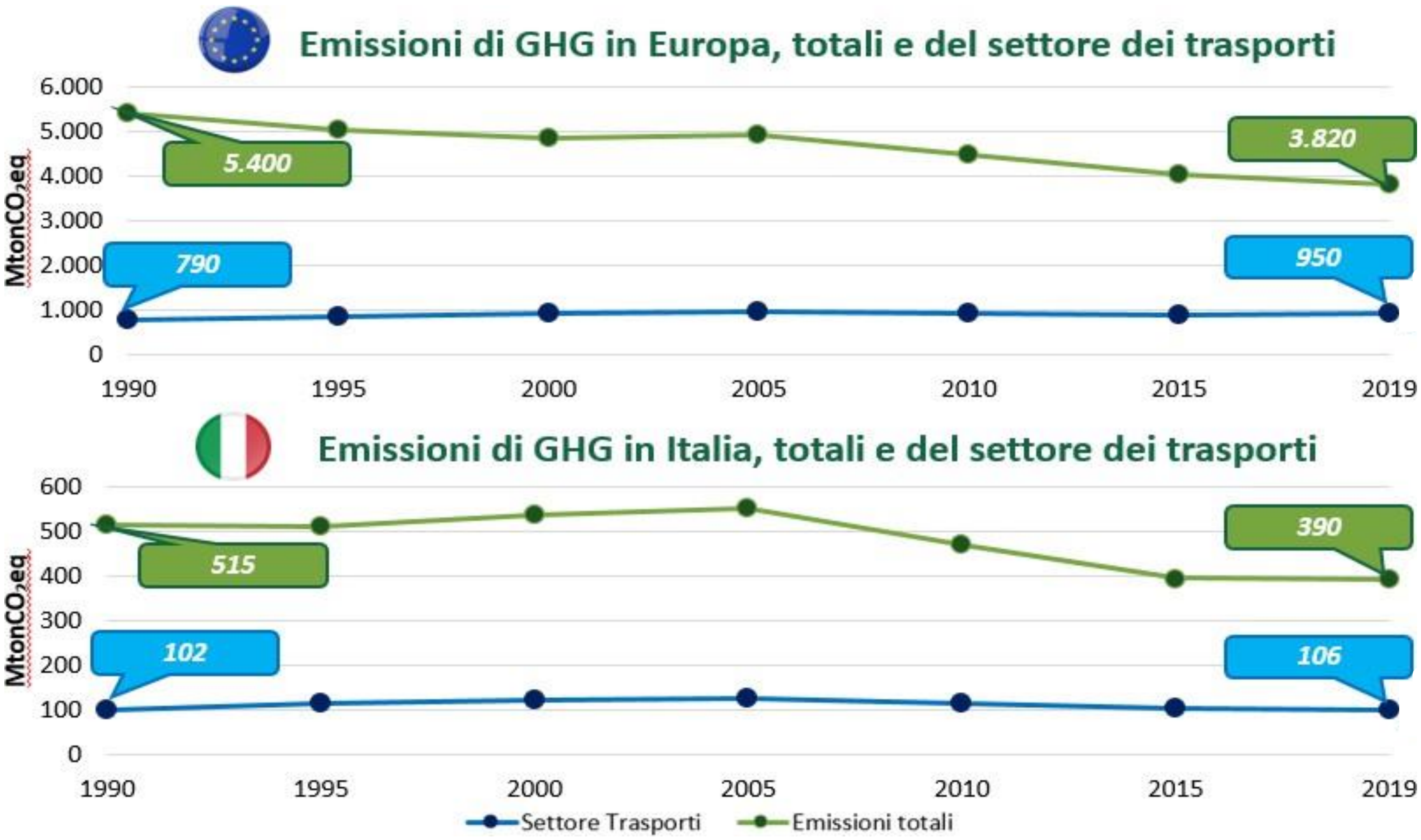
EU 2050 decarbonisation target

Climate neutrality: zero greenhouse gas (GHG) emissions at European level

(*) GHG reduction targets refer to 1990 levels

Air transport and emissions: the road already

Total and transport sector emissions at European and national level



Source: Energy & Strategy Revision by EEA

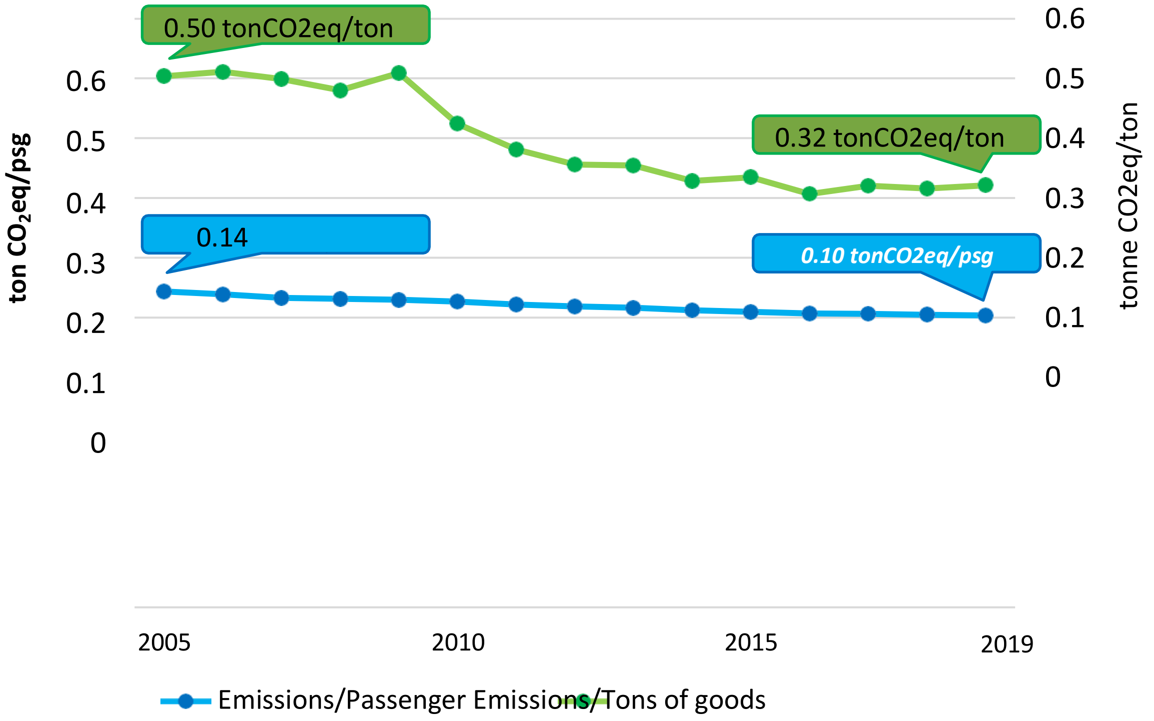
Air transport and emissions: the road already

Unit emissions of the transport sector at European and national level

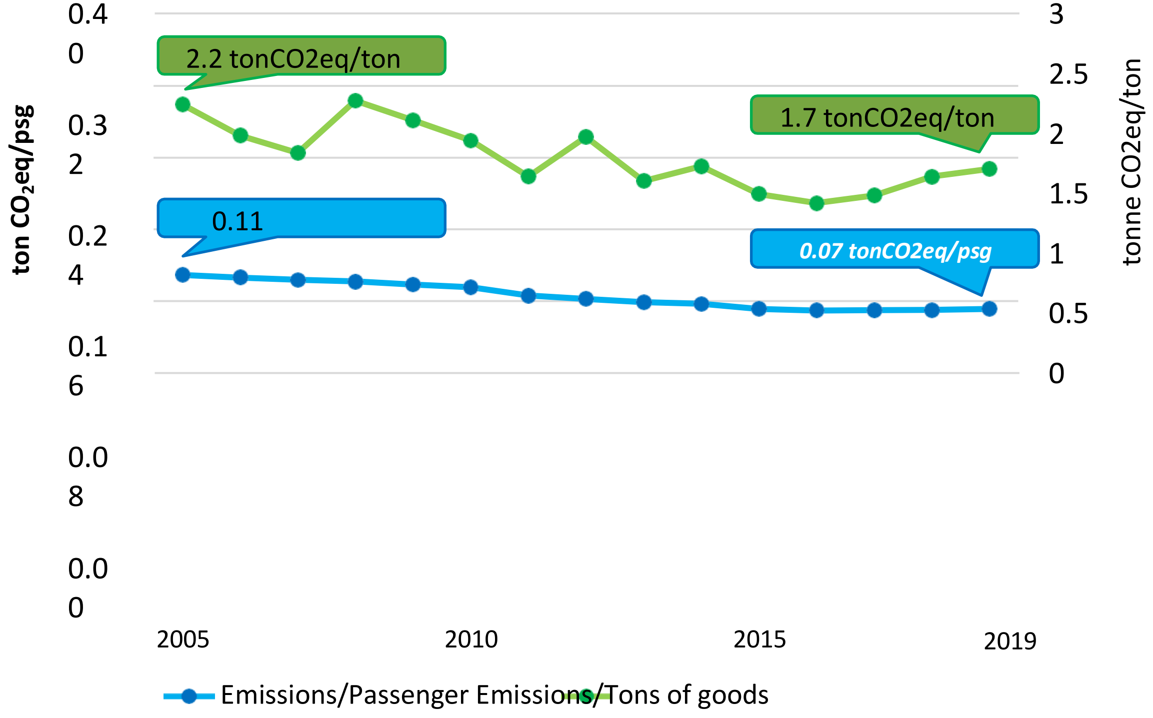
- In the European context over the past 15 years, a reduction in GHG emissions of around 30% has been recorded for passenger transport, while a reduction of 36% has been recorded for freight transport.

- In the Italian context for domestic transport there is a reduction in GHG emissions, specific per passenger, of about 36%, the same decreasing trend is also evident for specific emissions in the case of domestic freight transport, with a reduction of about 23% over the last 15 years.

GHG emissions for goods and passengers moved



GHG emissions by freight and passengers moved (*)



Air transport and emissions: the road already

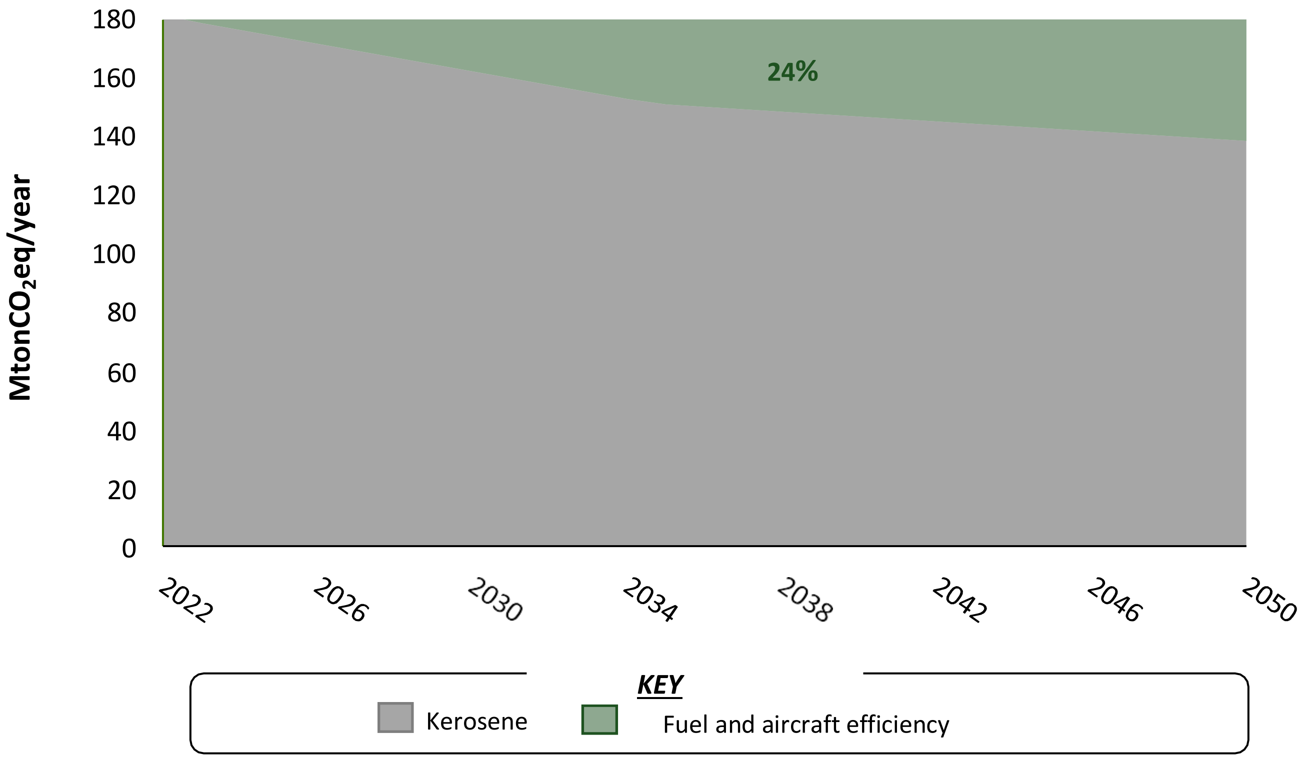
Source: Energy & Strategy Revision by Eurostat, EEA data
(*) View for domestic air transport

Air transport and emissions:

the inertial iso-technology scenario

- In the European context, by virtue of the current emission and technology mix, it is estimated that for the already started dynamics of fleet emission efficiency, progressive increase of intermodality, without considering the growth of air traffic, there would be a change in pollutant emissions to 162 MtCO2eq in 2030 and 138 MtCO2eq in 2050 vs 182 MtCO2eq in 2019.

GHG emission reduction trend



- A primary trend that has already commenced is to improve existing transport solutions, with the aim of making them more efficient and thus succeeding in reducing GHG emissions into the atmosphere. Such interventions include, for example, (i) use of lighter materials, (ii) adoption of higher-performance engines and (iii) changes in aircraft design to improve aerodynamics.

(*) Sustainable aviation fuels and imminent technologies – CO_2 emissions evolution towards 2050. Abrantes I. et al. 2021.

Air transport: a 'hard-to-abate' sector

- The application of current European decarbonisation regulations to the aviation sector, however, are far from easy to implement.

Continued growth in demand
CAGR +3% pax traffic 2024-2050

Reduced decarbonisation options

High costs

Source: Taking Off for 1.5°C. a transition strategy for a 1.5°C-Compliant, Net-zero, Aviation Sector. 2022.

Possible courses of action

- It is not possible to identify a single solving strategy to zero GHG emissions. On the contrary, it is necessary to develop a composite and organic path, covering all the activities and operations of which the sector is composed. In particular, the following areas of intervention can be identified in order to aspire to a path of total decarbonisation.

90% GHG emissions

Introduction of transport solutions using alternative fuels and propulsion systems

Efficiency of airport infrastructure

10% GHG

Introduction of CO_2 compensation measures, i.e. measures to absorb the negative effect of residual

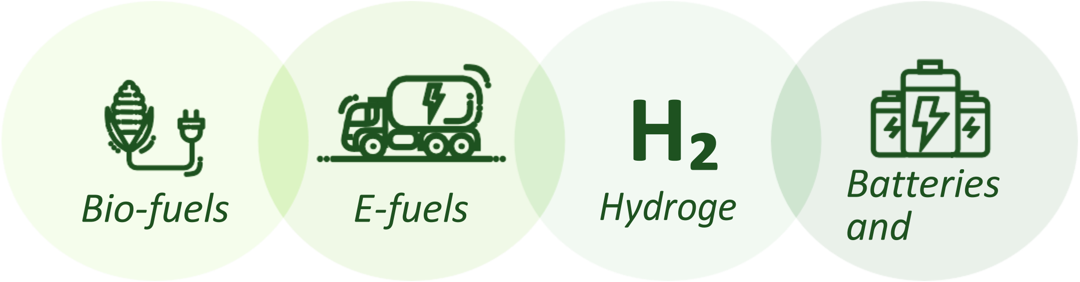
Possible courses of action

Possible courses of action

Alternative fuels and propulsion systems

- The bio-fuels used in aviation are in liquid form and use organic materials as primary sources; seven process sequences are currently certified by ASTM.
- To be used, these fuels are blended with conventional fuels according to different 'blending' percentages.
- Their technological development is at an advanced stage and their production costs are quite competitive with those of traditional fuels, although the availability of raw materials is limited compared to demand.

- The e-fuels used in aviation are in liquid form, characterised by higher energy density than conventional fuels and relatively easy and inexpensive storage.
- To date, technological advancement for their production is still low, partly due to the absence of ASTM certification for most production processes. The availability of raw materials for production is essentially unlimited, due to the fact that the feedstock supply chain is not consolidated and is developed from green hydrogen production.



- Hydrogen can be used in aviation in either a liquid or gaseous state, although the latter configuration presents critical storage issues.
- The use of liquid hydrogen, on the other hand, is characterised by the need to reach cryogenic temperatures for its storage.
- To date, technological progress is still low and the production of green hydrogen is still extremely limited due to limited availability from RES and the high costs associated with producing and storing green hydrogen.

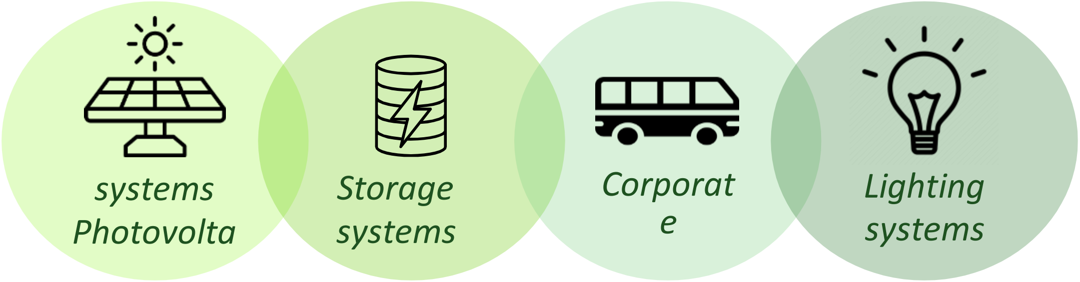
- The configuration of alternative aircraft using electric motors, although this is in its infancy, is not expected to be fully implemented before 2035.
- Among the main positive effects of their use is the clear reduction of climate-changing emissions if the power generation sources used in flight are 'green' and if the production chain of the power source (batteries or hydrogen plus fuel cells) is characterised by a reduced environmental impact (LCA perspective).

Possible courses of action

Airport infrastructure efficiency

- The installation of photovoltaic systems makes it possible to reduce the emission impact from the supply of electricity from the national grid.
- In particular, it can be estimated that through the installation of a 5 MW photovoltaic plant, an avoided CO_2 emission value of approximately 1,180 tonnes CO_2/year could be achieved, while through the installation of a 30 MW plant, an avoided CO_2 emission value of approximately 12,280 tonnes CO_2/year could be achieved.

- Thermal storage systems are the main solution to make the most of electricity production from renewable sources. These improve the energy efficiency of the building by being able to increase the share of self-consumed renewable energy for the production of thermal energy needed for heating or cooling the building.
- To date, there are different types and technologies that can be pursued, each characterised by specific criticalities and advantages that do not allow the identification of a preponderant technology.



- The possibility of efficient utilisation of the company fleet through its electrification can provide further support in reducing CO_2 emissions.
- In detail, an electric car saves approximately 1.37 - 1.46 ton_2/year. Similarly, a light electric vehicle and an electric bus would save approximately 3.28 - 3.46 tCO_2/year and approximately 13.2 - 19.9 tCO_2/year respectively (the range refers to a petrol and a diesel vehicle).

- Relamping traditional lighting systems with LED lamps can lead to non-negligible energy savings.
- In the case of relamping an office space with a total floor area of 1,000 m^2, energy savings of between 50% and 78% (depending on an increasing level of sophistication) and CO_2 savings of between 4.7 $tonCO_2$/year and 7.3 $tonCO_2$/year are achieved.
- In the case of relamping in a 'large station' environment with a total floor space of 9,800 m^2, energy savings of between 50% and 78% and CO_2 savings of between 72.4 $tonCO_2$/year and 108.6 $tonCO_2$/year are achieved.

Possible courses of action

Compensation Measures and Carbon Removal

Natural climate solutions realise the removal of CO_2 through natural processes of photosynthesis, within which land conversion (typically refers to reforestation) and land management (active forest management for carbon sequestration and agricultural land management for carbon sequestration) can be emphasised.

Engineered solutions use chemical solvents to capture CO_2 directly from the air and then store it in geological formations. An example of such solutions is Direct Air Carbon Capture and Storage (DACCS), which is a solution using chemical solvents to take CO_2 directly from the air and then transport and store it in long-term geological storage sites.

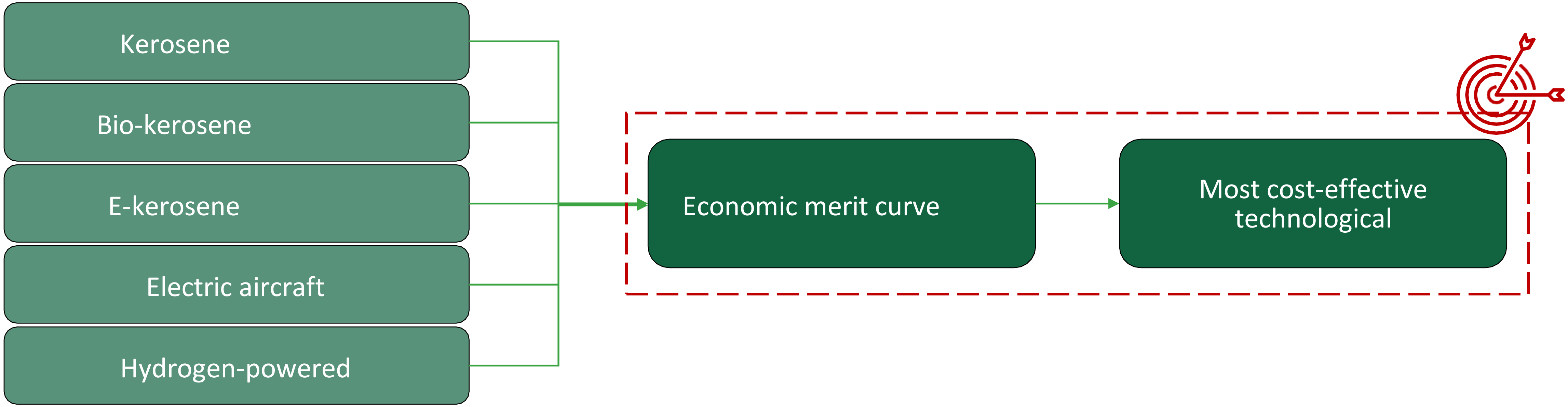
Hybrid solutions consist of techniques that combine natural photosynthesis with technology to achieve CO_2 capture and storage. These include Bioenergy with Carbon Capture and Storage - BECCS (biomass is used to produce energy, the resulting CO_2 is captured and stored in long-term geological storage sites).

A different scenario to 2050

The Politecnico di Milano model

- In order to identify in the 2022-2050 timeframe which technological solution is the most cost-effective for the decarbonisation of the aviation sector, different economic merit curves were constructed for each of the feasible solutions.

- The model focused on the introduction of transport solutions using alternative fuels and propulsion systems



A different scenario to 2050

The analysis range

- Fourteen different analysis scenarios were identified by crossing two dimensions (i) the average aircraft utilisation range and consequently the average number of passengers carried and (ii) the aircraft type.

Type of aircraft	Short range [700 NM e 100 psg]	Medium range [1.500 NM e 20
Kerosene	✓	
E-kerosene		
Bio-kerosene (SAF)	✓	
All-electric		
Hydrogen		

- The cost of each technological solution considered (LCOA, Levelised Cost of Aircraft) was modelled as the sum of four variables:

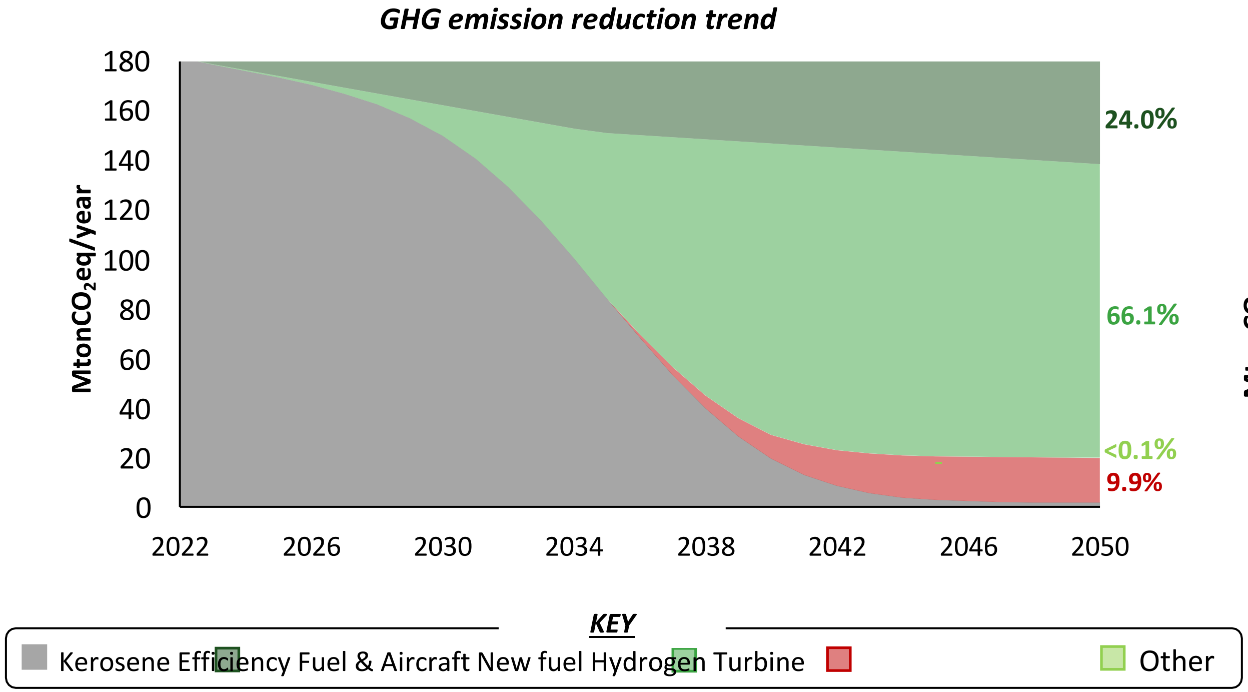
$$LCOA_i\ [€/km] = CAPEX_i + OPEX_i + Fuel_i + Carbon\ tax_i$$

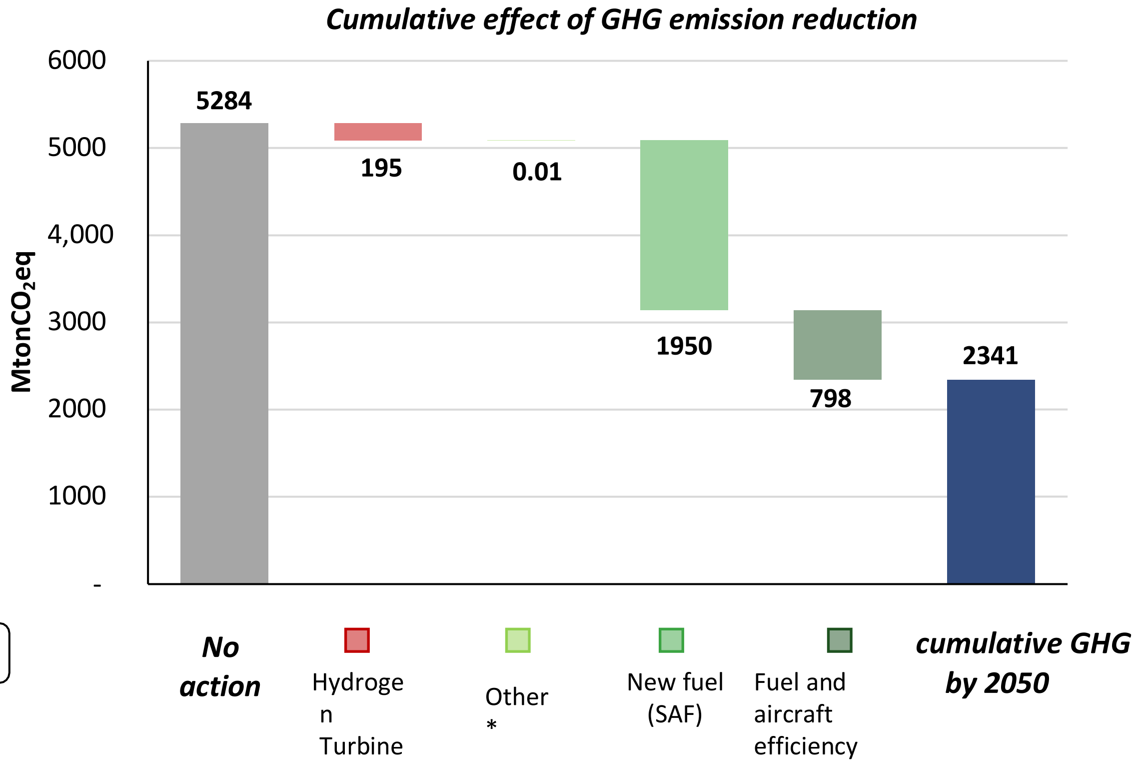
(*) Nautical Miles (1NM = 1,852 km).

A different scenario to 2050

The Net-Zero goal for 2050... and the alternatives available

- Economic support for technology development would make the goal of decarbonisation possible by 2050, with a 100% reduction in emissions (2022 vs. 2050), mainly through new fuels (SAF) and fuel & aircraft efficiency.





Note: The economic incentives are calculated using a methodology that maximises the decarbonisation effect of the sector. For this reason, the necessary incentives estimated by the model associated with e-fuels, hydrogen fuel-cells, and all-electrics turn out to be minor, as they would not guarantee the same emission reduction as the other evaluated solutions for the same investment.

(*) 'other' refers to the following all-electric and hydrogen-FC (fuel cell) technologies.

A different scenario to 2050

Summary of investments and actions to be carried out

Alternative fuels and propulsion systems	Availability	Main critical issues	Development Investments and Actions
Bio-fuel	Adoption in the short term and growing in the medium to long term, due to progressively decreasing fuel costs	• Lack of production facilities for large-scale dissemination • Limited 'feedstock' availability	• Setting up new bio-fuel production plants • Ensuring supply from sustainable feedstocks
E-fuel	Limited market presence from 2035 onwards due to high technology costs	• Limited technological development • High costs for production and storage • Green hydrogen production • Retrofit work on current fleet	• Development of the production and storage chain • Supporting the development of CO_2 capture technology • Investments in R&D • RES development
Hydrogen	Adoption from 2035, with increasing availability of green hydrogen and decreasing costs of the technology	• Green hydrogen production • High costs for production and storage • Currently low technological advancement • New propulsion system and/or retrofit	• Supply chain development, transport and storage • Supporting technology development • RES development
Batteries and Fuel cells	First trials started, first flights planned to be commissioned around 2025 and limited on the market until 2035 due to the high cost of the technology	• Limited technological development • High cost of technology adoption • Energy production from RES	• Supporting technology development • RES development

A different scenario to 2050

Strategies to support technological development

- The analysis, carried out with the aid of economic merit curves, does not, however, consider the possible constraint on the availability of the necessary feedstock that could arise in the future downstream of the massive adoption of such solutions.

- Although the adoption of electric aircraft is in the minority today, it will be important to support their development with support instruments that will progressively narrow the cost-effectiveness gap and thus foster their technological adoption in the future.

- In addition, a variety of parallel strategies will have to be pursued by promoting (where possible) (i) a modal shift to short-range rail transport, (ii) the adoption of energy-efficient measures for airport infrastructure and (iii) supporting the adoption of compensatory measures for CO_2 capture (carbon removal).

Sustainable development and sustainable finance

- Until the beginning of the 2000s, purely economic aspects were taken into consideration when assessing company performance. However, in accordance with the theme of sustainable development and in order to make the level of sustainability quantifiable and measurable in the economic/financial sphere, new criteria - of a non-financial nature - have been introduced since 2005, which have shown an increasing focus on aspects to measure the environmental impact, respect for social values and aspects of good management of a company: ESG criteria

- **Environmental**

Social

Governance

The BlackRock case

Blackrock in 2020 has in fact declared that it only selects companies for its investments that choose to improve their environmental impact and adopt governance that is attentive to the protection of staff rights. For a company that manages over $6.5 trillion in assets, to come up with a list of 244 companies around the world that are not doing enough to combat climate change is to provide very strong strategic indications in the direction of ESG policies and projects.

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