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A GREEN LOOK AT AVIATION IN SPAIN

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LIST OF ACRONYMS

EASA - Spanish Aviation Safety Agency
IEA - International Energy Agency
CORSIA - Carbon Offsetting and Reduction Scheme for International Aviation
CO2 - Carbon Dioxide
EASA - European Union Aviation Safety Agency
GHG - Greenhouse Gases
GtL - Gas-to-Liquid
H2 - Hydrogen
HEFA - Hydroprocessed Esters and Fatty Acids HEFA
ILUC - Indirect Land Use Change
R&D - Research, Development and Innovation
IRENA - International Renewable Energy Agency
LCA - Life Cycle Assessment
MITECO - Ministry of Ecological Transition and Demographic Challenge
NECP - National Energy and Climate Plan
PtL - Power-to-Liquid
ETS - European Emissions Trading Scheme
RED - Renewable Energy Directive
RFNBOs - Renewable Fuels of Non-Biological Origin
SAF - Sustainable Aviation Fuels
UCO - Used Cooking Oil
e-SAF/e-kerosene - Synthetic Sustainable Aviation Fuels

Executive summary

The climate crisis is leaving only one option for us: decarbonise to reduce greenhouse gas emissions.

Aviation accounts for 1.2% of GreenHouse effect Gases (GHG) Spanish domestic emissions[1] and 3.8% of the European Union's total CO2 emissions.[2] In the EU, the number of flights increased by 15% between 2005 and 2019, while passenger kilometres grew by 90%.

Stopping the burning of fossil fuels is the key measure, primarily through electrification, while in other sectors that are difficult to electrify, such as aviation, other alternatives such as fuel substitution are envisaged. The European Aviation Safety Agency (EASA) estimates that, by 2050, emissions will be reduced by 69%: 5% through green hydrogen and electric aircraft, while sustainable aviation fuels (SAF) will account for 37% of the reduction[3].

Sustainable aviation fuels (SAFs) are an alternative to fossil fuels and, if their challenges are addressed, can significantly reduce aircraft emissions. It is crucial to distinguish the origin of the raw materials used in their production, and to take into consideration the multiple facets and consequences of their production.

In the case of aviation biofuels, derived from waste or crops, production is increasing. However, these biofuels face e.g. problems of fraud, feedstock shortages and external dependency.

In this context, renewable fuels of non-biological origin (RFNBOs) are considered the most sustainable option for aviation. RFNBOs, such as hydrogen and synthetic fuels, are produced from renewable feedstocks such as the sun and water, and can replace fossil fuels in various applications, including aviation and maritime transport.

EU Plan **REPowerEU** and the **Spanish National Energy and Climate Plan (NECP)** have set clear goals of ambitious hydrogen production. Due to its climate and geography, Spain is the European country with the most hours of sunshine and an extensive territory. Therefore, **it is an ideal area for the production of hydrogen (H2).** However, it also has **disadvantages due water shortage threats in the foreseeable future in Spain.** Also, huge costs and energy transportation losses reduce hopes of importing hydrogen as a viable alternative.

Although there is no production of synthetic fuels in Spain, there are currently several projects planned for the production of green hydrogen and synthetic fuels. Four companies plan to produce synthetic fuels in the coming years. Similarly, there are several companies planning to deploy green hydrogen, although most of it is expected to be used to decarbonise existing grey hydrogen used, for example, in refineries and fertiliser production.

The production of synthetic fuels and hydrogen and their use in the aviation sector, is one of the great hopes for the decarbonisation of the aviation sector. However, this will only happen if it is prioritised and policies are promoted to enable the deployment of synthetic fuels and green hydrogen for aviation, with a commensurate regulatory framework that provides legal certainty and allows the necessary investments to be made for this deployment.

One way may be to promote the production and use of synthetic fuels and use surplus renewable energy from the electricity mix and other sectors to produce hydrogen. **Priority should also be given to electrification wherever possible:** activities related to flight operations, such as auxiliary vehicles or ground crew operations, should be electrified, leaving hydrogen or e-fuels as alternatives for aircraft decarbonisation.

This report analyses the main aspects of synthetic fuels and green hydrogen as substitutes for kerosene for aviation and delves into their main challenges and opportunities in terms of costs, availability, production and some environmental issues to be taken into consideration. It also includes the main projects under development or planned in Spain, analysing the production estimates forecast and the scenario in which Spain finds itself in order to meet the targets set.

Context

Towards the decarbonisation in the aviation sector

The aviation industry accounts for 3.8% of total EU CO_2 emissions [4]. Spanish national aviation emissions increased by 5.5% annually from 2015 to 2019 -with the exception of a decrease in 2020 due to COVID-19 measures-[5]. In 2023, greenhouse gases emissions from domestic traffic recovered to 2019 levels[6] and **6.6 million tonnes of kerosene were consumed in Spanish airports, exceeding 2019 consumption[7].** Furthermore, aviation is the main transport for the different archipelagos in Spain, which makes it a key sector to decarbonise.

Planes also emit non-CO_2 emissions such as NOx, particulate matter, sulphur dioxide and water vapour[8], which also have warming potential and other health consequences. In order to deal with the environmental and climate crisis we currently undergo, **it is compulsory to tackle CO_2 and non-CO_2 emissions from the sector.**

Technology developments are being promoted and researched to decarbonise aviation, such as improvements in propulsion, aerodynamics and materials. However, new fuels stand out as a short-term feasible solution with enormous potential to reduce CO_2 and non-CO_2 aviation emissions.[9]

As electrification is barely possible for long flights and only foreseeable for less than 500 km flights, aviation is one of the sectors that will rely the most on alternative fuels[10],being the huge weight of the batteries the main issue[11].

Electrification is only considered likely for aircraft with less than 100 seats, **while SAF.[12] and hydrogen are the potential substitutes of current aviation fuels[13], as seen in Figure 1[14].** Long distance aeroplanes require a more energy-dense fuel[15], Moreover, aviation fuel has more stringent quality requirements and fuel specifications than fuels used in road transportation.[16]

This implies that aviation is currently one of the sectors most dependent on alternative fuels, and that **sustainable aviation fuels (SAF) and hydrogen are potential substitutes for current aviation fuel, as can be seen in Figure 1.**[17]

	2020	2025	2030	2035	2040	2045	2050
Commuter » 9-19 seats » < 60 minute flights » <1% of industry CO_2	SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF
Regional » 50-100 seats » 30-90 minute flights » ~3% of industry CO_2	SAF	SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF
Short haul » 100-150 seats » 45-120 minute flights » ~24% of industry CO_2	SAF	SAF	SAF	SAF potentially some Hydrogen	Hydrogen and/or SAF	Hydrogen and/or SAF	Hydrogen and/or SAF
Medium haul » 100-250 seats » 60-150 minute flights » ~43% of industry CO_2	SAF	SAF	SAF	SAF	SAF potentially some Hydrogen	SAF potentially some Hydrogen	SAF potentially some Hydrogen
Long haul » 250+ seats » 150 minute + flights » ~30% of industry CO_2	SAF	SAF	SAF	SAF	SAF	SAF	SAF

Figure 1. *Forecasted technology availability in the aviation sector. Source: Waypoint 2050. An Air Transport Action Group Project.* [17]

These sustainable aviation fuels (SAFs) are fuels that are not produced from fossil energy sources, and which, with proper use and attention to the challenges they present, can lead to significant reductions in aircraft emissions.

However, a distinction must be made in the origin of the raw material used to produce them, as bio-based fuel production is currently booming. **Biofuels, produced from waste or crops, have a worrying potential for fraud, feedstock shortages and external dependency.[18]**

In the face of this challenge, fuels of non-biological origin (RFNBOs) are emerging as the most sustainable alternative in aviation. **These are produced from renewable or non-fossil feedstocks that resemble the characteristics of fossil fuels. They can replace traditional fossil fuels in various applications, such as aviation and maritime transport.**

So-called Renewable Fuels of Non-Biological Origin (RFNBO) are fuels of non-biological origin. Hydrogen and synthetic fuels belong to this classification. They are produced from renewable or non-fossil raw materials that resemble the characteristics of fossil fuels. They can replace traditional fossil fuels in various applications, such as aviation and maritime transport.[19]**. Synthetic fuels are produced with hydrogen, so both zero-emission alternatives depend on the increasingly relevant production of green hydrogen.**

Hydrogen and synthetic fuels belong to this classification[20]. E-fuels are produced with hydrogen, so both zero-emission alternatives depend on the increasingly relevant production of green hydrogen.

Biofuels use for aviation is on the rise,[21] and Hydroprocessed Esters and Fatty Acids (HEFA) production and consumption is increasing as the only alternative fuel suited for aviation that is currently on the market and is able to blend with conventional kerosene[22]. In Spain in particular, HEFA production is rising. This increased the feedstock percentage coming from third countries. A third of the used cooking oil comes from Indonesia.[23]

Biofuels are touted as a ready-to-use and sustainable alternative to fossil fuels, but their high demand for multiple sectors and the way they are produced must be taken into consideration when addressing medium- and long-term transformations. **Different environmental criteria need to be considered to transition towards a more ecological transport, such as water consumption, GHG emissions and land use.**

However, **negative environmental impacts along with the various sectors to decarbonise and transparency issues of biofuels leave green hydrogen and e-fuels, the so-called RFNBOs, as the best-to-the-environment alternative to substitute fossil fuels in the aviation sector.**

The International Energy Agency (IEA) estimates that, in 2050, biofuels will account for 33% of the total share and synthetic hydrogen-based fuels for 37% (see Figure 2)[24].

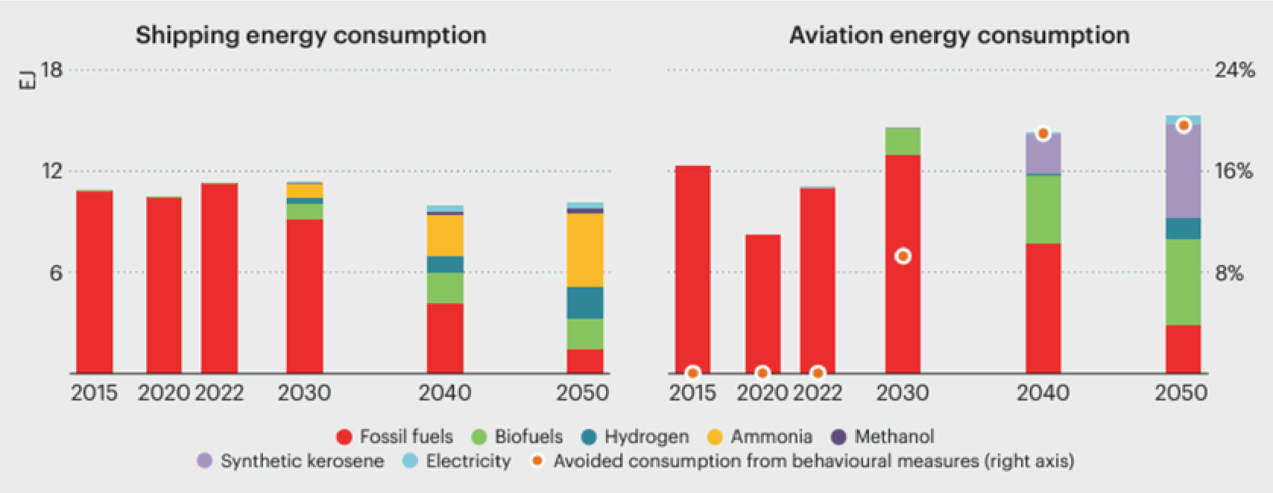


Figure 2. *Energy source share in shipping and aviation 2015-2050.*
Source: Net Zero Roadmap IEA 2023.

New fuels

Biofuels

Biofuels are fuels produced from biomass materials, such as crops or residues of different processes[25]. Biofuels can be used instead of fossil fuels in most of today's transport modes, such as cars, shipping, trucks and aviation, but they are not the preferred option for decarbonisation.

The International Energy Agency (IEA) estimates that for a net zero in 2050, biofuels have to increase their production from 4% per year today to 11% in the 2030 scenario.

They are divided into different types (see Figure 3).

- **First generation biofuels** are produced by crop feedstocks, such as sugarcane, palm, soy, corn and rapeseed.
- **Second generation biofuels (or advanced biofuels)** are derived from lignocellulosic biomass, nonfood crop feedstocks, agricultural and forest residues, and industrial wastes.[26]
- **Third generation biofuels** are produced from algae, sewage sludge, and municipal solid wastes.[27]
- **Fourth generation biofuels** aim to utilise genetically optimised feedstocks that are designed to enhance capture of carbon dioxide.[28]

Generation	Feedstocks	Key Characteristics
First Generation	Sugar cane, palm, soy, corn, rapeseed	Produced from food crops, associated to indirect land use change (ILUC) and biodiversity loss
Second Generation (Advanced Biofuels)	Ligno-cellulosic biomass, non-food feedstocks, agricultural and forestry waste, industrial waste, Used Cooking Oil (UCO)	Uses waste, most of which are imported. Fraud risk and lack of UCO which could lead to ILUC
Third Generation	Algae, sewage sludge, municipal solid wastes	High sustainability potential; can use non -arable land
Fourth Generation	Genetically optimized feedstocks	Seeks to uplift carbon capture; still at an early stage of development

Figure 3. *Categorisation of biofuels. Source: Own elaboration based on T&E and others.*

First and second generation biofuels are the most popular, but their environmental impact is not the same. Second-generation biofuels are currently a focus for investment, as first-generation biofuels are harmful to the environment due to land-use change. However, the risk of fraud, scarcity of feedstock and dependence on external sources make second generation biofuels a dangerous ally for the transition, which, if not taken into account, could delay the development of other cleaner technologies with lower risks, such as RFNBOs.

In Spain, there is a supply of biofuels in the form of various projects[29] by companies such as Repsol and Cepsa. Repsol, at its Cartagena plant, plans to produce 250,000 tonnes of biofuels per year from waste[30]. Cepsa, together with Bio-Oils, is building the largest second-generation biofuel factory in southern Europe[31] in Palos de la Frontera, with a forecast production of 2.5 million tonnes of biofuels, of which 800,000 tonnes will be SAF based on waste or crops.[32]

In Spain, HEFA, produced from Used Cooking Oil (UCO), is the only aviation biofuel currently produced, and its production, as well as its necessary importation, is increasing rapidly (see Figure 4).[33]

HEFA		
	2022	2023
Spain	97,83%	63,11%
Portugal	2,17%	-
Indonesia	-	36,83%

Figure 4. *HEFA aviation biofuel production in Spain. Source: Berna, L. Estado de los biocombustibles en España, ECODES, (2024, October) based on data from MITECO.*

ENVIRONMENTAL CONSEQUENCES

Biofuels derived from crops, especially palm and soy, can cause more carbon emissions than conventional fossil fuels,[34] due to their indirect land use change (ILUC). Massive palm and soy plantations have led to deforestation and the release of former carbon sinks that are very difficult to sequester again, increasing climate change. In addition, this landscape change also has impacts on the ecosystem, reducing biodiversity and all its positive effects.

According to the industry, biofuels used in aviation could reduce carbon emissions by up to 90%[35]. However, recent research suggests that, counting direct and indirect emissions, some feedstocks could increase emissions by up to 300% or up to 800% in the case of aviation (see Figure 19) compared to fossil fuels, and that less harmful ones, such as used cooking oil, could reduce emissions by 70%.[36]

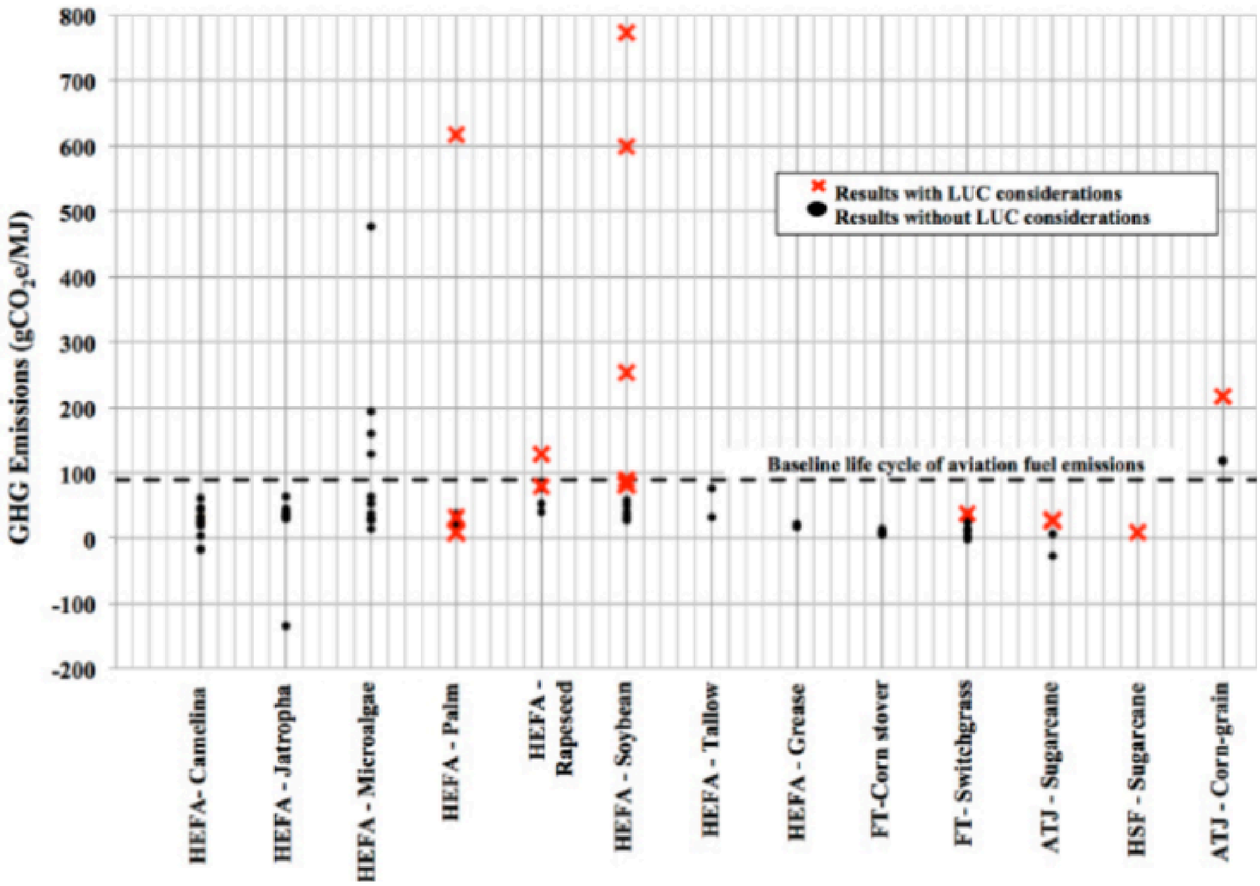


Figure 19. *GHG emissions associated with ILUC from different biofuels. Source: ICAO. Sustainable Aviation Fuels Guide. Version 2, December 2018.*

Other problems of biofuels are related to their supply and demand. Second-generation biofuels, such as used cooking oil (UCO) or animal fats, are supposed to promote a circular economy, reduce energy dependency and avoid numerous emissions. However, one of the associated problems lies in the sourcing of raw materials for production, their traceability and related transparency.

It has been shown that most of the waste for biofuels is imported. Although the production of biofuels from OUCO is increasing in Europe, 80% of the feedstock is imported, mainly from Asia, and in particular 60% comes from China.[37]

In addition, there is a risk of UCO import fraud, as the EU biofuel industry has detected palm oil sold as used, thus transforming the positive environmental effects of waste use into the terrible ILUC consequences of palm oil production. There is a major risk to the increased growth of biofuels from used cooking oil related to the actual supply of the feedstock, and how to deal with fraud or shortages.

On the other hand, the RED rankings raise serious questions. In the case of animal fats, their use has increased by 60% between 2021 and 2022, increasing dependence on other countries for this raw material[38]. Their classification[39] in the biofuels market is dubious, with possible fraud in the classification between categories 1 and 2, and category 3, - as categories 1 and 2 count double for the targets in the RED and category 3 could be intentionally downgraded to count double. This implies that CO2 emissions from animal fats can be up to 1.7 times higher than from conventional diesel. Animal fats are used in other industries such as the oleochemical and pet industries, threatening the supply of this material and its replacement by, most likely, palm oil.

Even though biofuels are increasingly produced in Europe and the EU Renewable Energy Directive[40] counts them as renewable energy in the targets, the problems related to the raw materials used, their supply and demand, traceability, as well as the dependence on imported raw materials, are clear arguments against their use as a medium-term option for decarbonisation of transport, including aviation.

Renewable Fuels of Non-Biological Origin: RFNBOs

So-called Renewable Fuels of Non-Biological Origin (RFNBOs) are produced from renewable or non-fossil feedstocks that resemble the characteristics of fossil fuels. Hydrogen and synthetic fuels are the RFNBOs used for aviation.[41]

- **E-fuels, synthetic fuels or Power-to-Liquid (PtL) are fuels produced by the combination of CO2 and H2**[42]**.** Synthetic fuels are a diverse group of compounds that can be used as replacements for traditional fuels, such as gasoline and diesel[43]. **Its emissions can reach zero when hydrogen is produced with renewable energy and carbon dioxide is captured from the atmosphere**[44]**.** However, this process requires a great amount of energy, which makes it only fitting for difficult to electrify sectors, such as aviation, but including a reduction of its demand. Its water consumption is also large, due to hydrolysis from hydrogen, but it is still way lower than water consumed by crop based biofuels.

- **Regarding hydrogen, it is not a source of energy, but rather an energy vector, the so-called “hydrogen vector”.** This means that hydrogen needs energy to be produced and that is able to accumulate energy to be later released[45]. Green hydrogen is generated from renewable energy, using water for the electrolysis process. There are other types, such as blue hydrogen (produced by carbon capture, utilisation and storage) and grey (produced from natural gas or other hydrocarbon fuels). It is usually transformed into ammonia for transport, as this liquefied resource is easier to move and already has an infrastructure in place, although it also carries associated risks such as toxicity or added energy consumption for its transformation. Its uses are mainly in industry, but it is also being directed towards transport with a special emphasis on its potential for the aviation sector.

E-FUELS, SYNTHETIC FUELS, E-KEROSENE, POWER-TO-LIQUID (PTL) AND GAS-TO-LIQUID (GTL).

These are fuels produced from the combination of CO2 and H2[46]. Synfuel production essentially consists of four steps: hydrogen production, carbon dioxide (CO2) capture, conversion of the feed gas into new molecules in a synthesis and final upgrading of the crude product[47]. **As mentioned above, their emissions can go to zero when the hydrogen is produced with renewable energy and the carbon dioxide is not of biological origin, i.e. it is captured from the atmosphere.** Due to the difficulty of capturing it directly from the atmosphere, the projects being carried out today capture biogenic CO2, for example from biomass or industrial emissions.

There are four main factors that primarily and currently affect the cost of synthetic fuels (see Figure 20):

- Fischer-Tropsch synthesis (around 22-28% of total cost)
- Renewable energy supply (28-49%)
- CO2 supply (13-17%)
- Electrolysis (14-27%)[48]

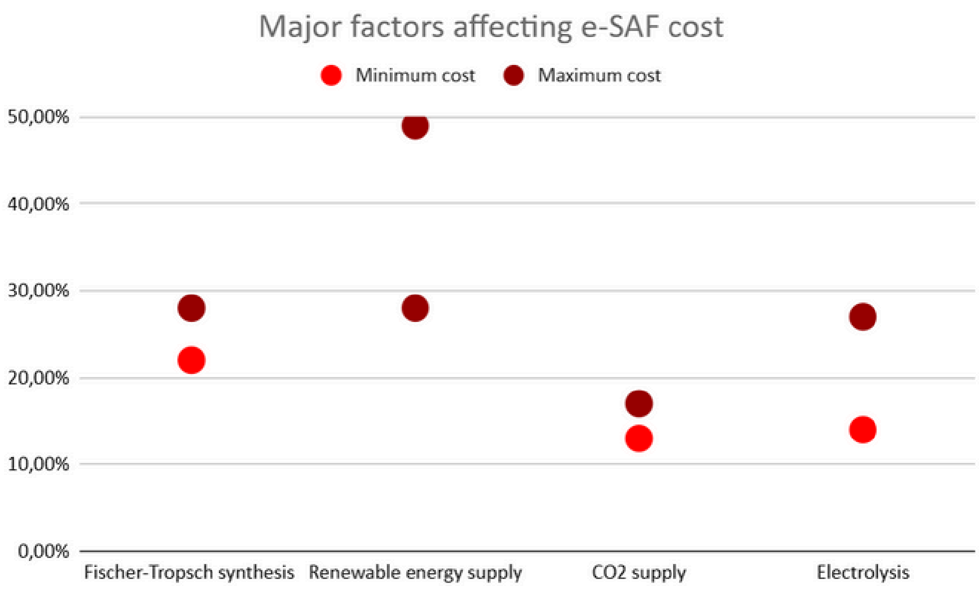


Figure 20. *Maximum (orange) and minimum (blue) cost sharing factor of e-fuel production. Source: Own elaboration based on data from PtX Hub and Agora Verkehrswende.*

E-fuels are seen as a viable tool for decarbonisation in certain sectors that are difficult to electrify, such as aviation,[49] but they are currently eight times more expensive than conventional fossil kerosene, which poses one of the main challenges to be addressed for the deployment of this type of fuel.[50]

According to the report 'Defossilising aviation with e-SAF' by International PtX Hub and Agora Verkehrswende,[51] a tonne of conventional jet fuel costs 650 euros on average in June 2024, compared to a tonne of synthetic fuels costing 4,000 euros on average.

By 2030, a homogenisation of costs and a halving of the price of synthetic fuel to EUR 2,000-2,500 per tonne is foreseen. By 2050, the price is expected to stabilise at around 1,800 euros per tonne.

Other reports such as the EASA report <<State of the EU SAF market in 2023>> of December 2024 indicate an **average price per tonne of conventional fuel of €816 in 2023 and estimate an average production price of around €7,500 per tonne for e-fuel from industrial or biogenic CO2 and €8,225 per tonne for synthetic fuel from CO2 captured from the atmosphere.**[52]

E-fuel prices and slow market growth risk causing a downturn in production and in final investment decisions. Recent examples such as the closure of the marine and aviation synthetic fuels plant in Örnsköldsvik, Sweden, illustrate the current uncertainty.[53]

This leads to great uncertainty about the role synthetic fuels will play in the decarbonisation of aviation: the International Civil Aviation Organisation (ICAO) estimates that they will account for 3-17% of aviation fuel in 2035 and 8-55% in 2050.[54]

The fact that, in some cases, the supply of renewable energy accounts for almost half of the total cost of synthetic fuel production represents a competitive advantage for Spain and its extensive network of renewable energy sources - 50.8% of the electricity supplied in Spain in 2023 came from renewable energy sources.[55]

According to the Spanish Comisión Nacional de los Mercados y la Competencia (CNMC), as renewables and energy storage increase, the cost of producing synthetic fuels or e-fuels is expected to decrease due to lower electricity prices.[56]

In aviation, synthetic fuels benefit from their ability to utilise existing transport, storage and distribution infrastructures as well as end-use equipment,[57] as their chemical and physical properties are similar to those of conventional aviation fuel[58]. They are mainly considered as an alternative for blending with sustainable biofuels[59]. In addition, when synthetic fuel is produced to complement sustainable biofuels in aviation, a certain amount of synthetic gasoline is produced as a by-product.

The private sector is increasing its interest in synthetic fuels, as evidenced by its growing investment in research and development, especially in Europe[60]. Most of the large synthetic fuel projects are located in the Nordic countries, such as 'Alpha, Beta, Gamma' and 'E-fuel 2' in Norway, 'Hy-X' in Sweden and 'Arcadia synthetic fuels' in Denmark. Central and Western European countries, such as Germany, France and the Netherlands, complete the first tier of aviation fuel production.[61]. **In Spain, no commercial production has yet taken place, but some projects are planned (see section 5).**

ENVIRONMENTAL CONSEQUENCES

WATER CONSUMPTION

Water consumption in the production of synthetic fuels, although lower than for biofuels, can be very high. A synfuel project using hydrogen derived from renewable electricity for energy requires as much water as a nuclear or coal-fired power plant[62].

In addition, many synthetic fuel plants are likely to be close to solar plants in normally arid regions, making it a factor to consider because of the scarcity of water in such areas[63]. The possibility of increasing desalination is attractive as an alternative, although estimates suggest that 5% of the entire current installation of desalination capacity would be needed to meet both aviation and marine synthetic fuel supply targets by 2030.

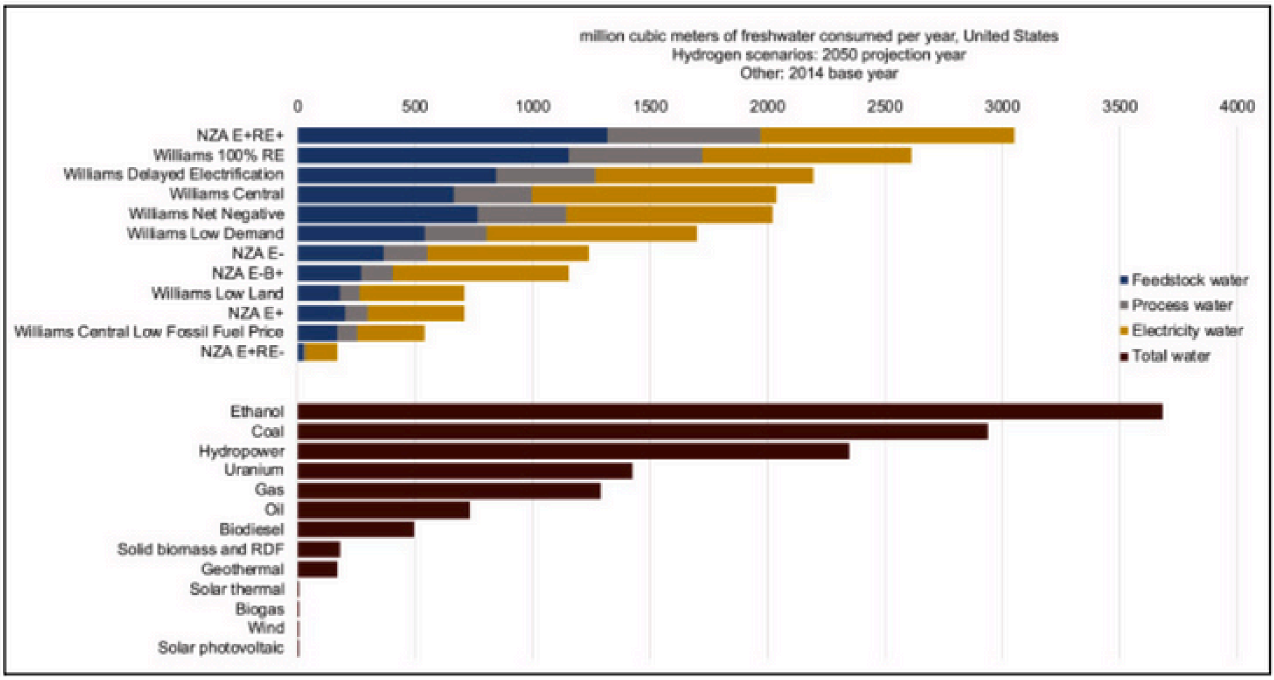


Figure 21. *Annual freshwater consumption for electrolytic hydrogen (centralised production) by US 2050 scenario, million cubic metres (106 m3)/year. Source: Grubert, E. (2023).*

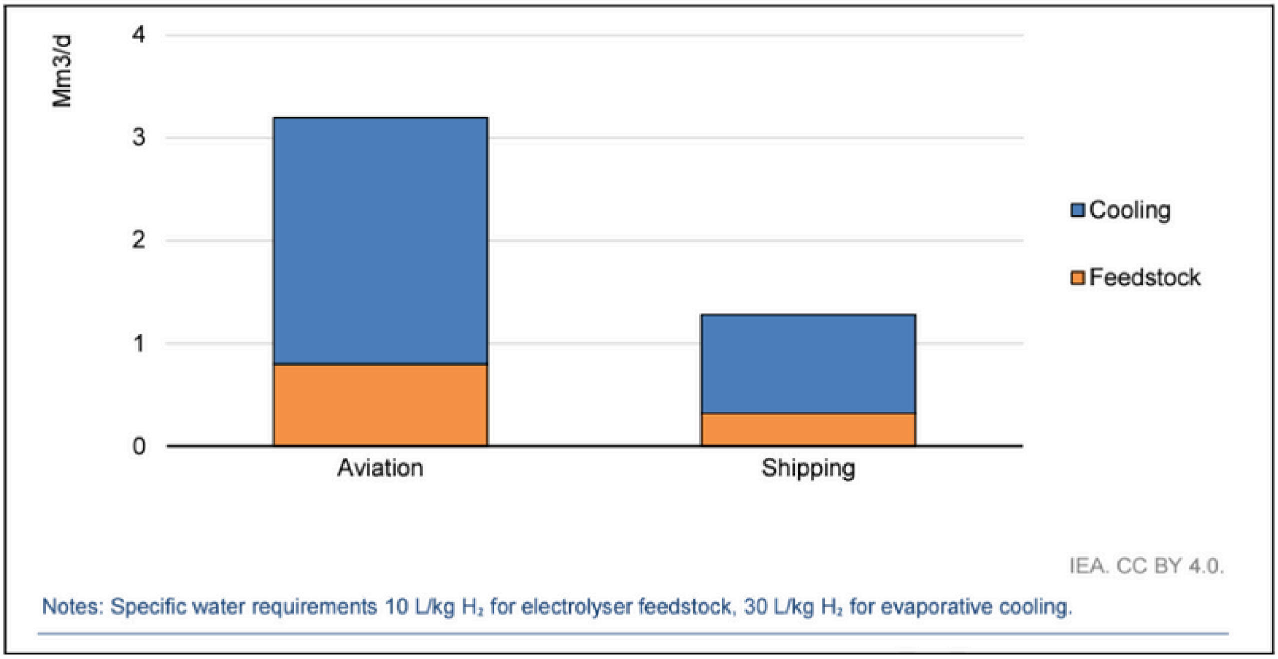


Figure 22. *Water needs for achieving a 10% share goal e-fuels in 2030 by the transport sector. Source: "The Role of E-fuels in Decarbonising Transport". IEA, 2024.*

LAND USE

The production of synthetic fuels, closely related to electricity generation, especially wind energy, requires land for its installation[64]. Estimates vary widely, but according to the International Energy Agency, an area between the size of Belgium and Greece would be required to produce 10% of the world's synthetic aviation fuel and 10% of the world's ammonia for shipping by 2030.[65].

Green hydrogen

As mentioned above, green hydrogen is an energy vector that needs energy to be produced and is capable of storing energy for later release[66]. Green hydrogen is generated from renewable energy, using water for electrolysis, and is also a way of using surplus renewable energy from the electricity mix to store that energy. In addition, there are other types of hydrogen, depending on the energy source, which are not ideal due to their low or zero emissions reduction, such as grey hydrogen (from fossil gas) or black and brown hydrogen (from coal).[67]

Hydrogen is mainly used in industry, especially in refineries and ammonia plants,[68] and some sectors, such as fertilisation, have no real alternative to hydrogen as can be seen in Figure 23, **but it can also be a source of energy for sectors such as aviation.** To be transported, it is usually transformed into ammonia, as this liquefied resource is easier to transport and the gas infrastructure is already in place.

Although aviation has other alternatives such as biofuels or synthetic fuels, its usefulness is clear at the top of the Hydrogen Ladder[69]. **As RFNBO, hydrogen is a feasible alternative that gives hope for transforming the aviation sector into a carbon neutral sector.**

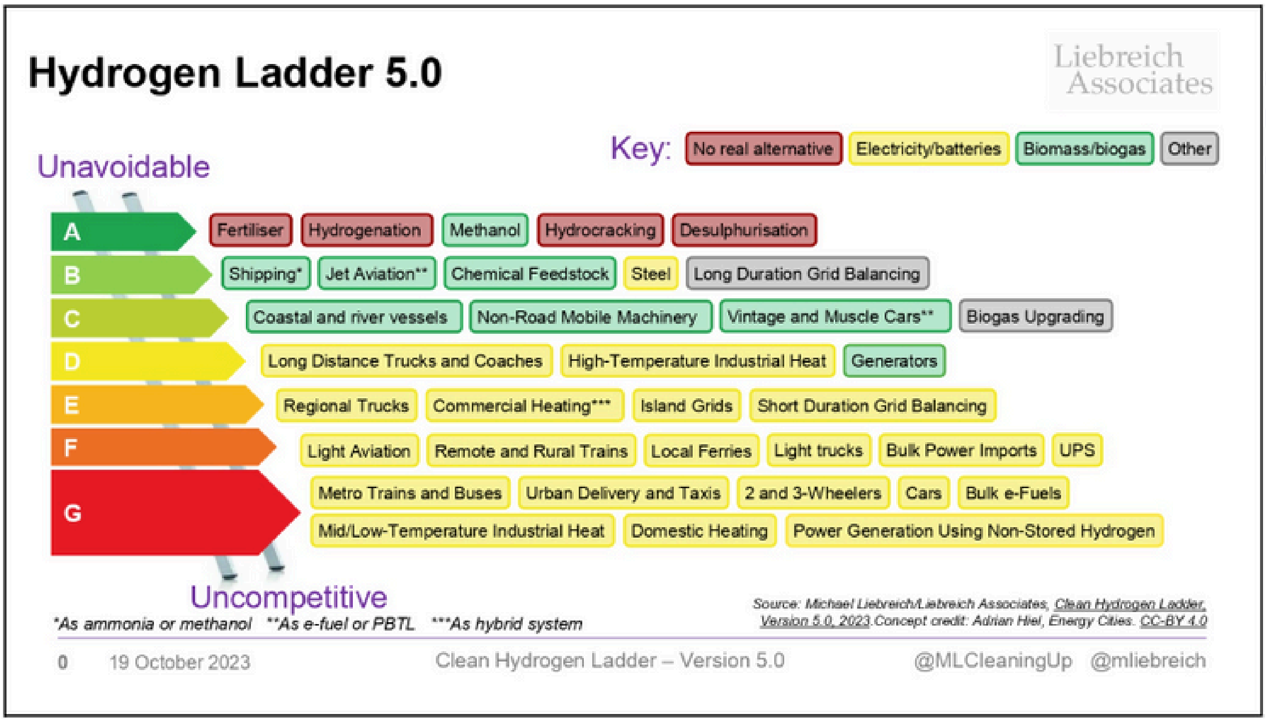


Figure 23. *Hydrogen Ladder Source: Michael Liebreich/Liebreich Associates, Clean Hydrogen Ladder, Version 5.0, 2023. Concept credit: Adrian Hiel, Energy Cities. CC-BY 4.0*

Despite its high position on the ladder, which makes green hydrogen an indispensable vector for the decarbonisation of aviation, hydrogen involves large energy losses in various parts of the transport value chain that need to be taken into account, such as 30-35% in electrolysis, 13-25% in ammonia conversion, 10-12% in transport and 40-50% in hydrogen fuel cells.[70]

There are two ways of using green hydrogen in aircraft:

1. Use of hydrogen to produce electrical energy through combustion cells that power electric engines.
2. Direct combustion of hydrogen in internal combustion engines, similar to today's aircraft engines.[71]

In 2020, total European hydrogen production - including non-renewable hydrogen - was 11.5 Mt per year. Germany was by far the largest hydrogen producer with 2.09 Mt, **while Spain produced 0.79 Mt. Most of the hydrogen produced in the EU comes from captive reforming, i.e. the production of hydrogen from fossil fuels.[72]**

Of the 8.7 Mt of hydrogen used in 2020, 50% went to refineries and 29% to the ammonia industry[73]. **Spain is the fourth European country with the highest demand for hydrogen, with around 500,000 tonnes.**

In 2022, a multi-sector hydrogen alliance called SHYNE (Spanish Hydrogen Network) was created which, led by Repsol, has the main objective of generating 2 GW of green hydrogen by 2030 (half of the Hydrogen Roadmap target) through ten projects.[74]

Green hydrogen also generates deep dependency in countries with a shortage of renewable energy and it is expected that the cost savings from producing green hydrogen in third countries, where renewable energy could be widely available, **do not offset the costs associated with distribution and transportation.** For example, importing liquefied hydrogen or hydrogen via ammonia from North Africa would be more expensive than locally produced hydrogen[75]. This factor is relevant when considering the actual environmental impact and potential of green hydrogen consumption in the EU, taking into account that the EU will import 10 Mt and produce 10 Mt in 2030, according to REPower EU.[76]

Moreover, **research by Transport & Environment found that only 1% of the planned green hydrogen production in the potential global exporting countries they assessed** (Chile, Egypt, Morocco, Namibia, Norway and Oman) **had final investment decisions, demonstrating the current lack of certainty about actual production.** There are also other social aspects to consider, such as the ecological transition itself in producer countries that still lack a sufficient share of renewables in the electricity mix, and the consequences of such high water consumption on the population of these countries.[77]

In Spain, several projects have been announced by companies in the energy or construction sector, such as Iberdrola, Endesa, Acciona, Repsol or Solarig (see section 5.2). Repsol or Solarig (see section 5.2). **Of these projects, only 29,100 tonnes of green hydrogen per year would be destined for the production of synthetic aviation fuel.**

It is necessary to take advantage of the potential of our territory for the production of green hydrogen associated with synthetic fuel production projects **to ensure the sustainability of air transport, as well as to prevent the potential fraud** of hydrogen production from non-renewable energy sources, and **to reduce energy dependence on other countries** through local production.

ENVIRONMENTAL CONSEQUENCES

WATER CONSUMPTION

The production of green hydrogen, like any other hydrogen generation, requires water for both the production and cooling processes[78]. The production of this feedstock consists of the electrolysis process that splits H2O molecules into hydrogen and oxygen, which requires 9 litres of H20 for every kilogram of H2[79]. **However, green hydrogen is the least water-intensive of all types of clean hydrogen production[80].** Post-treatment of the water to remove minerals uses another 15 litres per kilogram. The proportion of water for cooling green hydrogen is 52%, while it reaches 92% for blue hydrogen. Much of the water consumed is extracted, and by 2030 and 2050 it will account for 7.3 and 12.1 billion m3 respectively of blue and mainly green hydrogen.

It is of utmost importance to note that 35% of the green and blue hydrogen production plants planned and in operation are located in water-stressed areas, so it is of utmost importance to invest and research in the reduction of water consumption. In the case of Europe, 23% of green hydrogen projects are located in such ecosystems. According to IRENA, 46% of all hydrogen projects planned in Spain are likely to be located in water-stressed areas.[81].

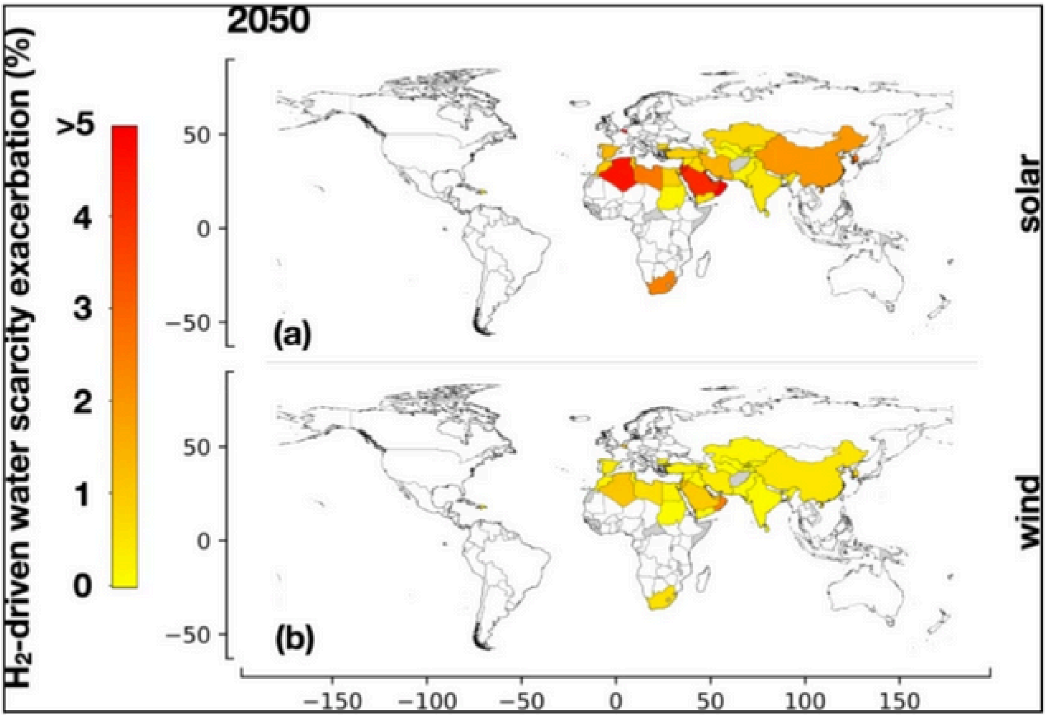


Figure 24. Exacerbation of water scarcity induced by hydrogen production in 2050. Source: Tonelli et al, 2023

To account for the actual total water consumption of green hydrogen production, production from solar and wind power plants is also considered, **but even then the scenario of 400 mt/year of green hydrogen consumption in 2050 would use 0.13% of the world's water supply if the energy came from wind and 0.56% if it came from solar.**[82]

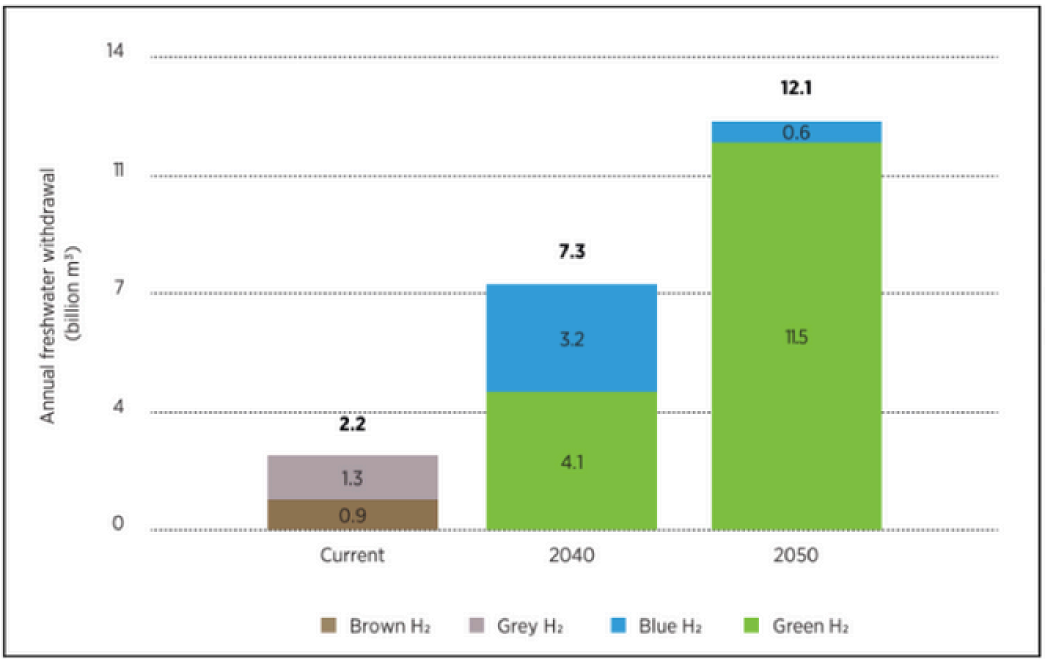


Figure 25. Annual freshwater withdrawal by hydrogen 2023-2050. Source: IRENA and Bluerisk (2023), Water for hydrogen production, International Renewable Energy Agency, Bluerisk, Abu Dhabi, United Arab Emirates.

LAND USE

Land use in green hydrogen production is intrinsically linked to renewable energy production, which requires land that competes with competing uses for agriculture, biodiversity and housing[83]. Changing some landscapes for green energy generation could destroy natural buffer zones that mitigate the impact of natural hazards such as floods, landslides and fires, which subsequently impacts the health of communities living adjacent to them.[84]

OTHER ENVIRONMENTAL ISSUES

The supply of materials for hydrogen fuel cells, electrolysers and added energy capacity to generate hydrogen also raises other environmental issues to consider and address[85]. Two of the critical materials, platinum and palladium, are used in both the fuel cells and electrolysers needed for the hydrogen economy.

Current legislative context

European Union

REFUELEU AVIATION

In line with the Fit for 55 package, the ReFuelEU Aviation Regulation works to increase the use of renewable and low carbon fuels to reduce greenhouse gas emissions from the aviation sector[86]. This is significant as aviation accounts for 14.4% of the EU transport greenhouse gas emissions.

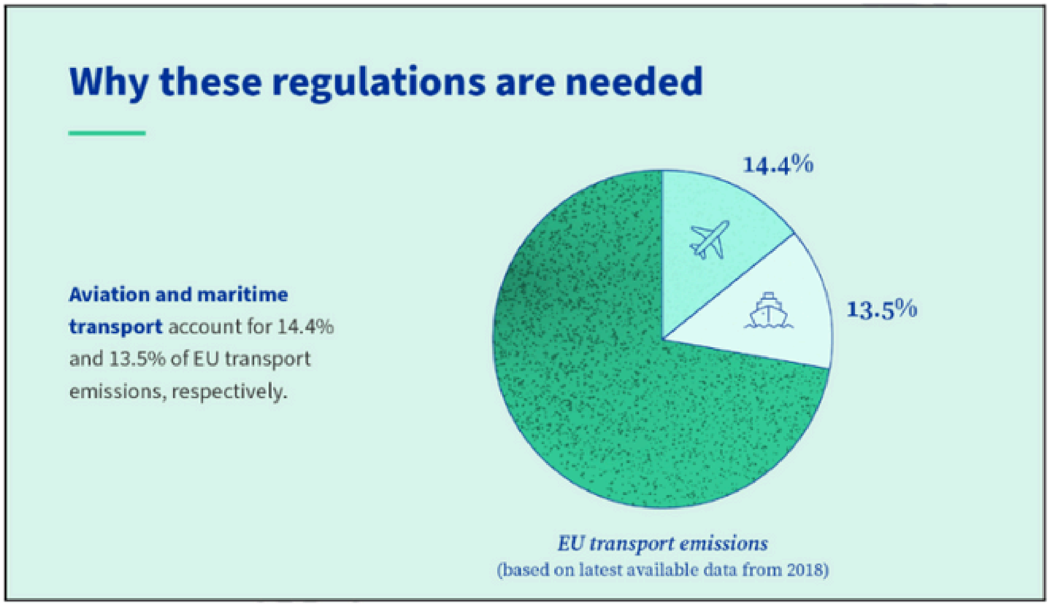
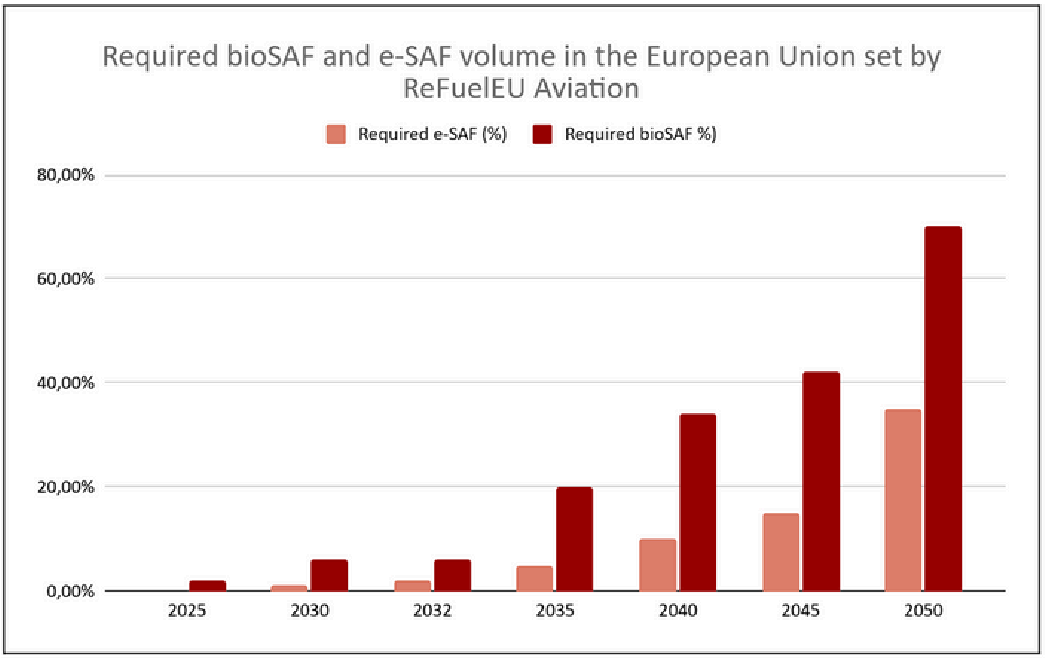


Figure 6. *EU transport emissions by contribution. Source: Council of the EU.* [87]

ReFuelEU Aviation, hereafter The Regulation, aims at increasing the supply of Sustainable Aviation Fuels (SAF), establishing targets for SAF share by deadlines from 2025[88]. It is relevant to mention that **the Regulation excludes the possibility of food and feed crops biofuels to be part of those SAF,** and allows other biofuels, renewable fuels of non-biological origin (RFNBOs) such as green hydrogen, recycled carbon aviation fuels and low-carbon aviation fuels to reach the minimum shares.[89].

Most regulations lack a 'use' obligation on sales, leaving the share of fuels used to the market rather than to the actual needs of each sector. However, the ReFuelEU Regulation is an exception and obliges companies supplying aviation fuel to airlines (Figure 7) to supply at least 2% of fuel of non-fossil origin by 2025, progressively increasing to 70% by 2050. **Similarly, a binding sub-target of at least 1.2% of synthetic fuel (e-fuel) in the period 2030-2031 is incorporated, with an annual minimum of 0.7% and 2% in 2032, reaching 35% in 2050.**[90]



*Assuming a scenario where all the airports are included in ReFuelEU Aviation.

Figure 7 . *Required SAF volume in the European Union by ReFuelEU Aviation Regulation in a scenario where all airports are included. Source: Own elaboration based on data from Council of the EU.*

This measure applies for jet fuel providers on an annual basis and prioritises closer airports to reduce transport costs and energy losses. **To avoid greater charges in non European airports, so-called 'tankering', planes will have to charge at least 90% of the fuel when taking off from EU airports.**

The Regulation also includes a voluntary labelling scheme about environmental performance to increase transparency and help consumers understand the real environmental impact of each airline and flight, that companies will be able to show by 2026 and that will have the same standards for all airlines, regulated by EASA.

Finally, ReFuelEU Aviation states the importance of collecting data and reporting the obligations by the fuel suppliers and aircraft operators. **As a general rule, by 31 December 2024, Member States must have established penalties for fuel suppliers that do not meet the targets set by ReFuelEU. It is of utmost importance that these penalties are sufficiently stringent to incentivise the uptake of sustainable fuel at EU airports.**

REPOWEREU

The REPowerEU Plan addresses two relevant issues: ending the EU's dependence on Russian fossil fuels and tackling the climate crisis[91]. Its objectives are to increase the Fit for 55 Energy Efficiency Target from 9 to 13%, the renewables target from 40 to 45% and establish the goal of 10 Mt of locally produced renewable hydrogen, while also increasing to 10 Mt of imports[92]. To incentivise hydrogen projects, €200 million is allocated for research.[93]

DELEGATED ACTS

There are two EU Delegated Acts related to renewable hydrogen. **The Commission Delegated Regulation (EU) 2023/1184,** defines when hydrogen, hydrogen-based fuels or other energy carriers can be considered as a renewable fuel of non-biological origin, or RFNBO[94]. Its goal is to ensure that these fuels can only be produced from “additional'' renewable electricity generated at the same time and in the same area as their own production.

The Commission Delegated Regulation (EU) 2023/1185, sets the methodology to calculate GHG emissions savings from RFNBOs and recycled carbon fuels[95]. It establishes that the greenhouse gas emissions savings from the use of recycled carbon fuels shall be at least 70% compared to the fuels they replace.

RENEWABLE ENERGY DIRECTIVE

The Renewable Energy Directive (RED) is the legal framework for the development of clean energy across all sectors of the EU economy[96]. Its goal is to increase the share of renewable energy that was first promoted in the European Green Deal, and therefore reduce the consumption of fossil fuels.

In its last revision that took place in 2023, the renewable energy target was increased to 42.5%. **This new Regulation has sector-specific targets among which is transport, with a 29% share of renewables or 14.5% of carbon intensity reduction.**

This ambitious goal is positive when thinking about Europe's energy transition but also incentivises biofuels, which are considered renewable energy in the RED. **Biofuels are not always the best solution for the environment and the Directive should be careful when increasing the targets,** also imposing bans or restrictions on the most environmentally harmful.

RED III divides biofuels into two different categories in Annex IX: Part A and Part B. In addition to the original 17 feedstocks included in Part A and the 2 feedstocks in Part B of Annex IX of the RED, 5 additional feedstocks have recently been classified in Part A and 4 in Part B. Most of the new feedstocks are related to agriculture, such as catch crops, damaged crops or crops on degraded land. The feedstocks in Annex IX have designated targets to be achieved by 2030, which incentivises fuel producers to generate biofuels from these feedstocks.

Part A biofuels have feedstocks that constitute what are considered advanced, waste-based biofuels, and have a specific sub target of 3.5% by 2030 and a combined target with RFNBO representing 5.5%[97] [98]**.** Part B biofuels have a subtarget of 1.7% and are exclusively UCO and animal fats.

RED III was the first one that set a binding target for RFNBOs[99]. This Directive sets a transport target that counts on a final 5.5% of green hydrogen and advanced biofuels, out of which RFNBOs must account for 1%. Because of double counting and the 1,2 multiplier to incentivise the use in the aviation and shipping sectors, **current volumes of RFNBOs delivered to transport will be much lower than implied by the 1% target, about ⅓ of that.[100]**

EMISSIONS TRADING SCHEME (EU ETS)

In order to reduce greenhouse gas emissions, the **Emissions Trading Scheme** has been established, whereby there is a limit on the emissions that can be emitted by an actor. In the event of exceeding this limit, and following the "polluter pays" principle, the participant in the system must purchase emission allowances equal to the limit exceeded[101]. The scheme also has an incentive system that allows the allocation of emission allowances to the actor that contributes to reduce emissions voluntarily from the allowances purchased by other participants.

In the aviation sector, **the approval of Directive 2023/958** amending Directive 2003/87/EC -still pending transposition in Spain and updating of Law 1/2005- establishes in Article 3 that **20 million allowance allocations will be distributed until 2030** to cover the price difference between other fuels and conventional fossil kerosene.

This translates into the following:

- **BioSAF and hydrogen price difference for Union Airports (a):** The ETS covers 70 % of the remaining price difference between the use of fossil kerosene and hydrogen from renewable energy sources, and advanced biofuels at all airports classified as Union Airports.
- **e-SAF price difference for Union Airports (b):** Covers 95% of the remaining price difference between the use of fossil kerosene and renewable fuels from non-biological sources at all airports classified as Union Airports.

- **Price differential for any fuel other than fossil kerosene at airports not large enough to be classified as Union Airports, airports located on islands smaller than 10 000 km2 and at airports located in Outermost Regions (c):** Covers 100% of the remaining price difference between the use of fossil kerosene and any eligible non-fossil fuel aviation fuel referred to in the first subparagraph of this paragraph, at airports located on islands smaller than 10 000 km2 and with no road or rail connection to the mainland, at airports which are not large enough to be defined as Union airports in accordance with a regulation on ensuring a level playing field for sustainable air transport, and at airports located in outermost regions. This article is particularly relevant in the Spanish case, as it covers 100% of the difference at airports located in the Canary Islands, Balearic Islands and all airports smaller than 100,000 tons of goods or 800,000 passengers.
- **Other cases (d):** In cases other than those referred to in letters a), b) and c), the ETS covers 50% of the remaining price difference between the use of fossil kerosene and any eligible aviation fuel not derived from fossil fuels.[102]

Spain

NATIONAL ENERGY AND CLIMATE PLAN (NECP)

The new draft for the **Spanish National Energy and Climate Plan (NECP)[103]** review launched in 2023 specifically mentioned the decarbonisation of aviation in measure 1.14 and specifically refers to biofuels in measure 1.12 and to green hydrogen in measure 1.16. The NECP does not have a binding nature but works as a guide and strategy for national policy to work for.

- **Measure 1.12** focuses on the development of advanced biofuels for transport, framing it with the importance of decarbonising the sector that emits the most greenhouse gas emissions in Spain (30,7% in 2022)[104].

- El objetivo es aumentar el uso de biocarburantes avanzados y RFNBO en el sector del transporte, planteando la posibilidad de establecer mecanismos para obligar a vender o consumir biocarburantes y RFNBO, promoviendo etiquetas para las gasolineras que fomenten el uso de biocarburantes, al tiempo que se limita el uso de biocarburantes producidos a partir de alimentos y piensos.

- **Measure 1.14** concerns the aviation industry and promotes renewable energies and the implementation of ReFuelEU Aviation obligations. In addition, it foresees as a mechanism for action a support scheme for SAF production facilities, the promotion of the consumption of labelled blends of renewable or sustainable fuels, the integration of SAF as a qualifying fuel for the purposes of the obligation to sell or consume biofuels and the deployment of alternative fuels at airports. In addition, it sets as a mechanism for action the transposition of the regime of sanctions applicable in case of non-compliance with ReFuelEU Aviation. The NECP prioritises hydrogen alongside other advanced biofuels for aviation, prioritising the implementation of aviation-related measures of the Hydrogen Roadmap.

- **Measure 1.16** deals with the hydrogen scenario in Spain, said to be more positive than in other countries because of our renewable energy expansion and the cheaper prices this entails. The brighter state of hydrogen development in 2023 led the Ministry to estimate an increase to 11 GW of green hydrogen electrolysers by 2030, more than twice greater than the Hydrogen Roadmap estimated in 2020[105].

Finally, on page 452 of the previous NECP, the phasing out of palm and soya for transport purposes from 2025 was mentioned, which the update of the NECP does not take up, and which only states that, in accordance with Order TED/728/2024, from 2025 onwards, biofuels whose raw material is palm cannot be counted towards the targets for the sale of biofuels for transport purposes.[106]

ORDER TED/728/2024 FOR THE DEVELOPMENT OF A MECHANISM PROMOTING BIOFUELS AND OTHER RENEWABLE FUELS FOR TRANSPORT PURPOSES

The Ministerial Order for biofuels and other renewable fuels for transport purposes, which entered into force in July 2024, de facto banned the use of palm oil in the transport sector in Spain[107].

However, palm is left out of the ban, and will continue to be a major issue due to the risk of palm substitution and deforestation. It also states that 'biofuels produced from crops associated with deforestation will not count as renewable fuels from 2025' and aims to unify existing legislation on obligations for the sale or consumption of biofuels and other renewable fuels.

It also includes a definition of 'sustainable aviation fuels', which refers to the definition in ReFuelEU 'aviation fuels that are synthetic aviation fuels **and aviation biofuels. Despite being included in the definition of the Regulation, the Order leaves out recycled carbon aviation fuels.**

In addition, Article 12.3 is particularly relevant for the aviation sector: from the adoption of the new Ministerial Order, sustainable fuels in the aviation and maritime sectors count towards the targets for the sale or consumption of renewable fuels. The share supplied in the two aforementioned sectors, with the exception of biofuels produced from food and feed crops, is equivalent to 1.2 times their energy content.

The Order establishes the specific procedure for the incorporation of any new feedstock for the purposes of compliance with the obligations to sell or consume biofuels and other renewable fuels for transport purposes, as well as the countries of origin and the emissions they generate. It also sets up a reduction pathway for biofuels produced from feedstocks considered to be at high risk of indirect land use change (ILUC) until 2030.[108]

WHITE BOOK ON R&D FOR AVIATION SUSTAINABILITY IN SPAIN

The White book on R&D for Aviation Sustainability in Spain is a document produced by the Spanish Aviation Safety Agency (AESA) whose goals are to limit noise, local air pollution and greenhouse gas emissions from aviation[109]. It is divided in three challenges; Climate change and ecological transition; Circular Economy; Local environment. Additionally, within the climate change challenge, there is a key part on sustainable aviation fuels.

This White Book is produced with the collaboration of experts from different institutions, public and private sector. It states the importance of promoting a market for these new, more sustainable fuels with national feedstocks, to reduce energy dependence, and the necessary support from the government to carry out this energy transition.

Therefore, public-private partnerships must be incentivised with research and innovation from research centres and industry to position the Spanish aviation industry as a pioneer. The document emphasises that new fuels are not widely adopted because of their price, even though their implementation can save up to 80% CO2 emissions from the sector. Neither e-fuels nor green hydrogen are mentioned in the whole document.

SPANISH ACTION PLAN FOR CO2 EMISSIONS REDUCTION IN THE INTERNATIONAL AVIATION SECTOR

AESA also launched the Spanish Action Plan for CO2 Emission Reduction in the International Aviation Sector[110]. Hydrogen is only mentioned a few times, mainly as a new technology that is being promoted through the Hydrogen Roadmap of the Ministry for the Ecological Transition[111]. The document points out several projects that are being developed currently with hydrogen as an alternative to fossil fuels. It emphasises the project of Boeing back in 2008 that carried out the first hydrogen cell propelled flight in the world.[112]

HYDROGEN ROADMAP

The Hydrogen Roadmap of the Spanish Ministry for the Ecological Transition looks at the challenges and opportunities of green hydrogen development in Spain[113]. The document shows the importance of hydrogen cells for both planes and airport infrastructure, in addition to its participation in the production of synthetic fuels such as biokerosene. This roadmap, created in 2020, sets a hydrogen target of 4 GW, and proposes several measures focused on the production of e-fuels for aviation, on proper infrastructure and design changes. Three measures must be highlighted:

- **Measure 24:** Encourage the development of production plants for synthetic kerosene produced from renewable hydrogen or new generation biofuels to decarbonise air transport.

- **Measure 25:** Analyse the necessary conditions for redesign and appropriate modifications to allow the use of aircraft that enable the use of aircraft using synthetic fuels from renewable hydrogen or biofuels to decarbonise air transport.

- **Measure 26:** Establish environmental requirements in the technical specifications that regulate contracts handling agents providing airside handling services at airports.

Projects in Spain

Decarbonising has become the main priority for the European Union and the Spanish government, shown in their ambitious targets in the European Fit for 55 and the Spanish NECP, that state 55% reduction of GHG emissions by 2030[114]. In these plans, renewable energy is incentivised to achieve those targets. They aim for 42.5 and 48% final consumption of renewables by 2030 in the European and Spanish plans, respectively.

Biofuels and RFNBOs count towards those renewable energy targets. However, not all of these fuels have the same environmental impact. **Biofuels have very diverse impacts, and it has been proven that some biofuels produce more greenhouse gas emissions than fossil fuels. That is the case for crop based biofuels[115].**

Others have fraud-related problems, such as the ones produced with used cooking oil (UCO)[116]. It also raises the question of energy independence and the impacts of production increases and their link to, for example, the import of raw materials.

RFNBOs have a clear advantage, as scaling them up will use far less land and water compared to biofuels (See Figure 5).[117] Charging electric vehicles directly with (renewable) electricity is far more efficient than converting the electricity into hydrogen and e-fuels. That is why RFNBOs need to target those sectors of the economy where direct electrification is not feasible, like aviation.

The planned projects are also expected to have a positive direct economic impact due to the creation of infrastructure and jobs. In this sense, it is important to take into consideration the socio-economic returns generated for the territories where the plants are located.

Fuel Type	Production Capacity	Environmental Impact	Projected Costs	Relevant Projects
Biofuels	Increasing production; significant projects in Spain (e.g., Repsol, Cepsa, BP)	Up to 90% carbon emissions reduction but crop based (especially palm and soy) can emit three or even eight times more than fossil fuels due to land use change	Competitive with fossil fuels but still higher; high external dependence, varies by feedstock, fraud risk	Repsol,Cepsa and BP biofuels from waste
E-fuels (RFNBO)	Not yet in production; plans by three companies in four different locations	Potential to reduce CO2 emissions by up to 100%. Energy and water consumption concerns	High initial costs; expected to decrease with scale-up and RES penetration	Repsol, Solarig, and Breogán
Green Hydrogen (RFNBO)	Significant potential due to Spain's climate; focus on decarbonising grey hydrogen	Low emissions; water and energy consumption concerns	Currently high; expected to decrease with technology advancements	Various projects aimed at hydrogen production, mainly for industrial use

Figure 5. *Main aspects of alternative fuels in aviation. Source: Own production.*

Forecasted production

Around 41.93% of the total biofuel production of the industrial complexes planned in Spain in 2030 will be destined to aviation (see Figure 16). Taking into account that the current demand for aviation kerosene in Spain in 2023 amounted to 6,642,869 tons, **to date, the expected 2030 production of non-biological and biological SAF in Spain could only cover 24.54% of the total annual kerosene demand** (see Figure 16).

However, although there are several SAF production plants planned in Spain, such as those of Repsol, Cepsa, Solarig, BP and Gunvor (see Section 5), only Repsol, Solarig and Greenalia plan to produce synthetic aviation fuels (see Figures 14 and 15).

Of the 1.63 million tons of annual SAF expected to be produced, only 7.98% will be synthetic fuels, equivalent to 130,000 tons per year, which would cover the 79,714 tons required by 2030, but not the 132,857 tons required in 2032 by ReFuelEU[118]. **This production would only cover a derisory 1.96% of the total demand for aviation kerosene in 2023 in Spain (see Figure 16).**

However, due to the characteristics of the production plants, it is estimated that the amount will be significantly lower than 130,000 tons per year. In addition, it is essential to assess the current state of construction of the production plants, since most of the data collected are based on company estimates and the final production could vary.

In particular, the difficulty of capturing CO2 from the atmosphere is an obstacle to neutral or even negative emissions in the production of synthetic fuels. Strictly defined, synthetic fuels do not rely on fossil fuels, and CO2 is extracted from the atmosphere. Due to the complications of direct carbon capture (DCC) from the air, the projects currently planned use biogenic CO2 from biomass and, in the case of Repsol, from the Bilbao refinery.

As mentioned above, **the demand for kerosene in Spain is increasing rapidly due to the increase in tourism[119] and more synthetic fuel plants will be needed to cover the demand for kerosene.** In this sense, due to the environmental and social concerns linked to the production of biofuels of biological origin, the development of synthetic fuel production and the reduction of flight demand must be a priority to reduce aviation emissions.

Year	Project	Total biofuel production (t/year)	SAF production (t/year)	
			Aviation Biofuels	Aviation E-fuels
Operating	Berantevilla (Gunvor)	40.000	0	**0**
2024	Cartagena (Repsol)	250.000	200.000	-
2025	Puertollano (Repsol)	240.000	Not specified but mentioned	-
2025	Bilbao (Repsol)****	2.000	-	2.000
2027	Breogán (Greenalia)	20.000	0	20.000
2027	Alperujo H2 (Avalon Renovables)	50.000	Not specified but mentioned	-
2028	Soria (Solarig)	60.000	0	48.000
2030 (2026)	Palos de la Frontera (Cepsa) ***	2.500.000	800.000	0
2030 (2027)	Castellón (BP)**	**650.000**	500.000	0
2030	Teruel (Solarig)	**75.000**	**0**	**60.000**
Totales (t)		**3.887.000**	**0**	**60.000**
			1.500.000	**130.000**

Figure 14. *Alternative fuel projects, biofuel and SAF production for aviation. SAF production includes biofuels and e-fuels (in red color) used for aviation. Source: Own elaboration based on data from Berna, L. State of biofuels in Spain, ECODES, (2024, October).*

**Around 16-24% of the total 60.000 tonnes (9.600-14.400 tonnes) will be nafta.*
*** The plant has been operating since 2016. In 2027, 400.000 tonnes of aviation biofuels are estimated to be produced, which will raise to 500.000 in 2030.*
**** In 2026 it will start producing SAF, with an estimated capacity of 500.000 tons, which will increase to 800.000 in 2030 .**** It is not clear that the fuel produced by Repsol-Petronor is a RFNBO as it is taken as a 'by-product' of the Petronor refinery and uses CO2 from the plant.*
****** The plant will valorise the alperujo, a waste product from the olive industry, and plans to produce green methanol, biogenic CO2, renewable electricity, compost and green hydrogen.*
******* Following the European Commission, hybrid plants count as the RFNBO percentage used in the process.*
Q&A implementation of hydrogen delegated acts
**Around 16-24% of the total 75.000 tonnes (12.000-18.000 tonnes) will be nafta.*

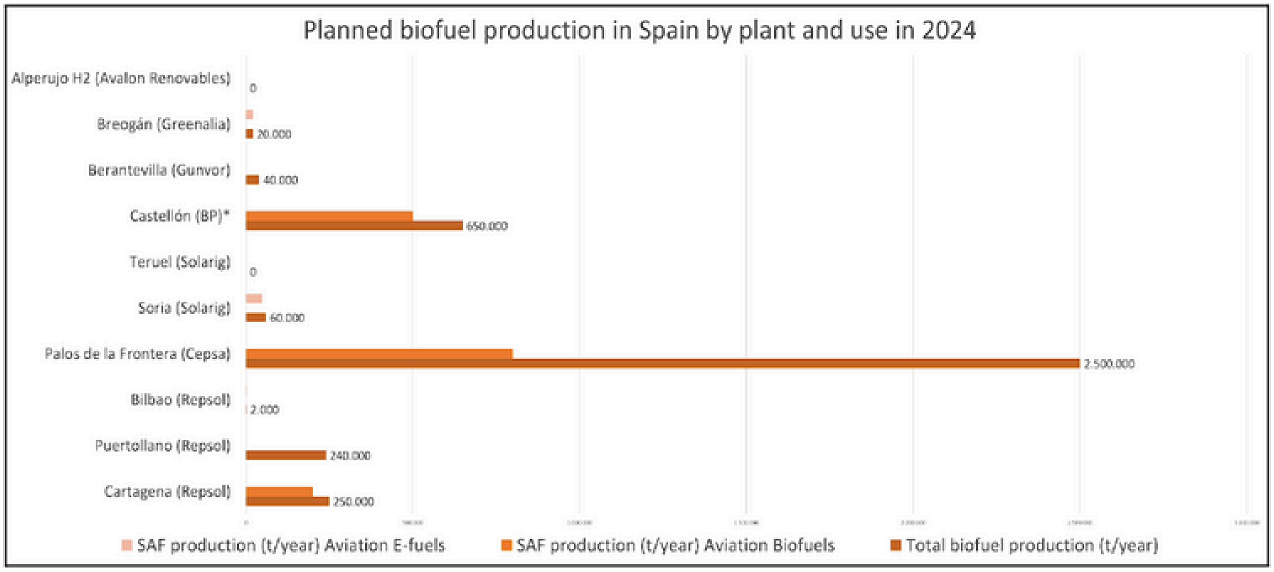


Figure 15. *Planned biofuel production in Spain by plant. SAF production includes biofuels and e-fuels (in green) used for aviation. Source: Own elaboration based on data from Berna, L. State of biofuels in Spain, ECODES, (2024, October).*

Production by feedstock	Compared to total biofuel production	Compared to total SAF production (%)	Compared to 2023 kerosene demand*
Biofuel production (%)	100,00%	-	-
SAF production (%)	41,93%	100,00%	24,54%
Biokerosene production (%)	38,59%	92,02%	22,58%
e-Fuel production	3,34%	7,98%	1,96%

**Based on 6.642.869 tonnes of kerosene consumed in Spain in 2023. Source: CORES.*

Figure 16. *Comparison between planned alternative fuel projects, biofuel, SAF production and kerosene demand in Spain in 2023. SAF production includes biofuels and e-fuels used for aviation. Source: Own elaboration based on data from Berna, L. State of biofuels in Spain, ECODES, (2024, October).*

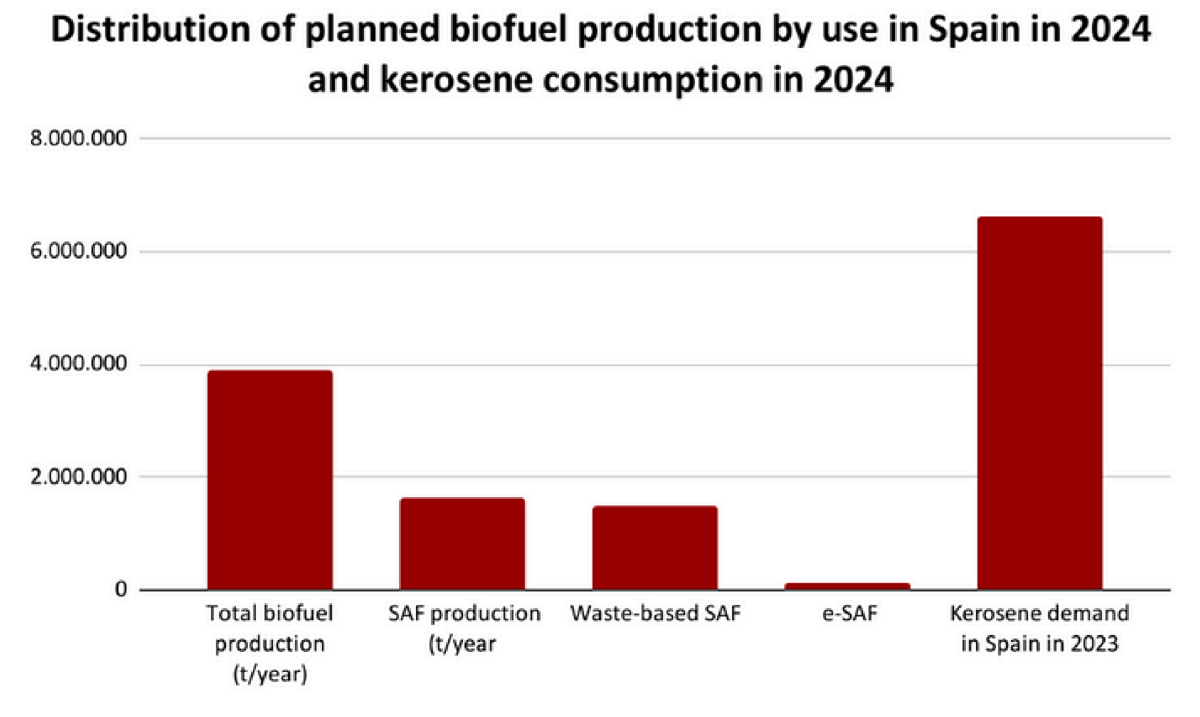


Figure 17. *Distribution of planned biofuel production by use in Spain. Source: Own elaboration based on data from Berna, L. State of biofuels in Spain, ECODES, (2024, October)*

In addition to those already mentioned, several hydrogen production projects are planned in Spain (see Figure 18), such as Catalina (Endesa), or Castellón (BP).

However, **the use of green hydrogen in aviation is not prioritised** due to the early technology development and several hurdles such as range, aircraft design and cost. **It is currently used for the production of synthetic fuels, and in the coming years, production of 29,100 tons of green hydrogen per year is expected from companies such as Greenalia and Solarig.**

The main hydrogen projects in Spain are the following[120]:

Project	Green hydrogen (t/year)	Used for SAF production (t/year)
Several projects (Endesa)	26.000	-
As Pontes (Endesa)	10.000	-
Catalina (Endesa)*	84.000	-
Mallorca (Acciona)	300	-
Barcelona (Iberdrola)	300	-
Bilbao (Repsol)	100	100
Castellón (BP)	31.200	Mentioned but not specified
Breogán (Greenalia)**	11.000	11.000
Soria (Solarig)	18.000	18.000
Teruel (Solarig)	Mentioned but not specified	Mentioned but not specified
Total	180.900	29.100

FFigure 28. *Relevant hydrogen projects in Spain, number of tonnes estimated to be produced and tonnes intended for aviation. Source: Own elaboration based on companies' data and the Spanish Hydrogen Association (AeH2).*

** 336.000 tonnes of hydrogen forecasted in 2030*
*** Aviation e-fuel will be produced by combining hydrogen, carbon capture and biomass.*
**** Currently, the project is on stand-by.*

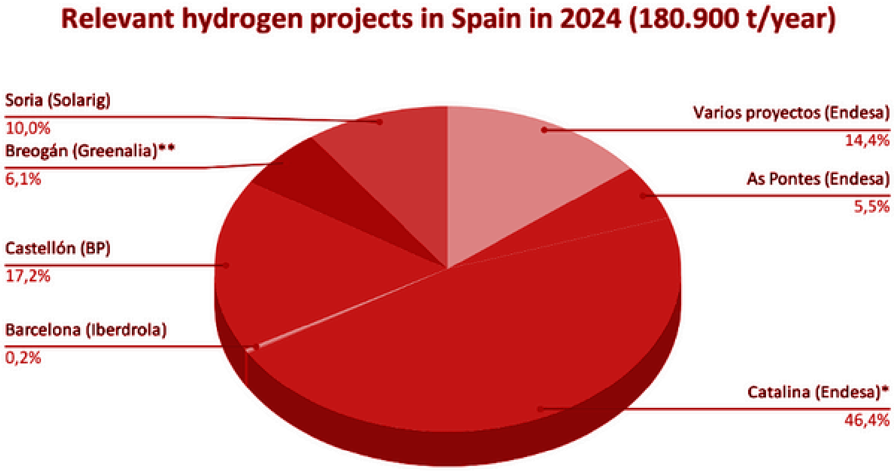


Figure 18. *Relevant hydrogen projects in Spain and number of tonnes estimated to be produced Source: Own elaboration based on data from Berna, L. State of biofuels in Spain, ECODES, (2024, October).*

E-fuel projects in Spain

Because of its climate and wide space for renewable energy, Spain has a great potential as a hydrogen and e-fuels producer[121]. Only Repsol, Solarig and Greenalia's projects are considering the production of e-fuels. The remaining SAF production projects, accounting for 92% of the estimated production, focused on biogenic aviation fuels (biokerosene).

Most aviation e-fuel plants will be located in the northeastern part of Spain, where also the main Spanish airports (by cargo and/or passengers) are located. Also, southern Spain will have three SAF plants (See Figure 26).

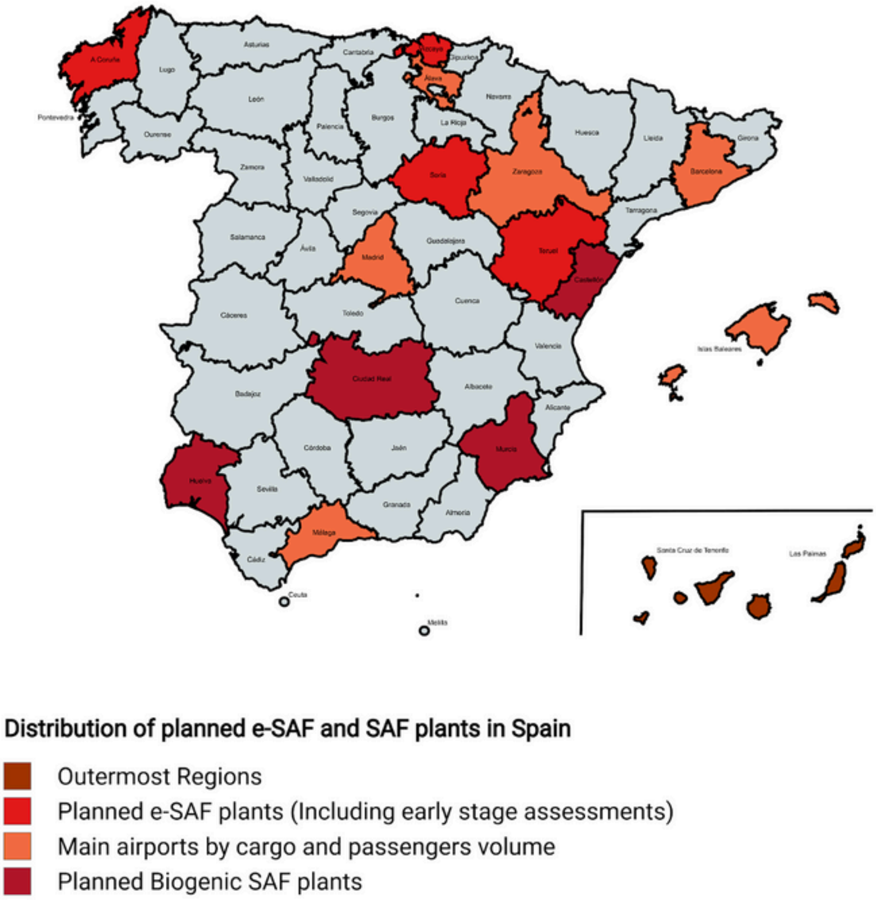


Figure 26. *Map of planned e-SAF and SAF plants, outermost regions and location of the main airports by cargo and passengers in Spain. Source: Own elaboration based on data from AENA, MapChart.*

Solarig is building a factory in **Soria** exclusively for e-SAF production[122] **48.000 tonnes of aviation fuel** are estimated to be generated, of both **biogas** from farm waste and **renewable hydrogen.** Another plant is planned in **Teruel, accounting for 60.000 tonnes of fuel.** Following the same rationale, it would produce e-fuels by two technologies: **biogas from farm waste and renewable hydrogen combined with carbon dioxide.**[123]

The project **Breogán by Greenalia** and P2X-Europe plans to generate e-fuels for aviation in Curtis-Teixeiro, **Galicia**[124]**.** The companies estimate that **11.000 tonnes of green hydrogen** will be produced per year, capturing 70.000 tonnes of CO2 generated from biomass annually and an additional **20.000 tonnes of synthetic crude to create e-fuels for aviation** or synthetic wax for the chemical and pharmaceutical industries.

Repsol is building a factory in **Bilbao for synthetic fuels with a 2.000 tonnes potential**[125]**.** This factory will have an initial investment of €60 million in a partnership with Petronor, which will supply the carbon captured, and the Basque Energy Entity (EVE)[126]. An electrolyser will be used for the plant, which will supply 350 tons of green hydrogen per year.

Relevant Hydrogen projects

The H2Med is a transnational initiative to interconnect the hydrogen networks of the Iberian Peninsula to Northwest Europe, enabling Europe to be supplied with affordable green hydrogen by 2030[127]. A hydrogen interconnection will be built between Portugal and Spain (Celorico da Beira – Zamora) as well as the development of a maritime pipeline connecting Spain and France (Barcelona – Marseille) in order to transport renewable hydrogen from the Iberian Peninsula to North and Central Europe. The H2Med was launched by France, Spain and Portugal, strongly supported by Germany, and is promoted by the TSOs of these countries: Enagás, GRTgaz, OGE, REN, and Teréga.

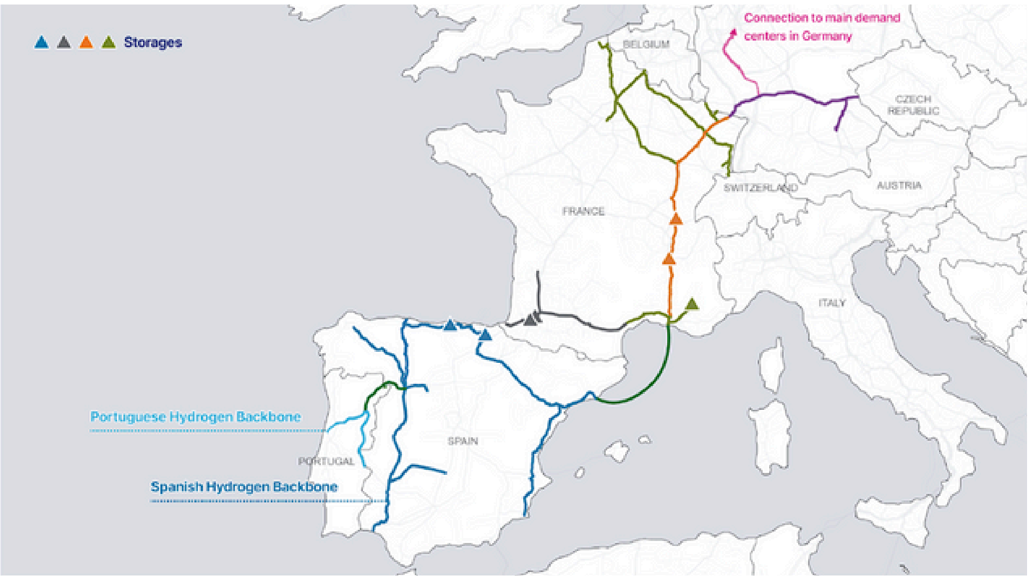


Figure 27. *Hydrogen pipelines' routes. Source: H2MedProject.com*

Endesa is planning to develop 23 projects to produce green hydrogen with an investment of €2.9 billion[128], but prefers to develop small projects rather than mega-projects[129]. Their main projects in the Iberian peninsula are **Andorra (Teruel), As Pontes (A Coruña), Huelva, Almería, Tarragona, Valle del Ebro, Compostilla (León) and Seseña (Toledo)[130]**. All together, with the Andorra plant, they have an investment of 2,900 million euros and a resulting generation of 315 MW and 26,000 tonnes of green hydrogen per year.

Power to Green Hydrogen Mallorca is a project led by Acciona and Enagás in alliance with Cemex, Redexis, IDAE and the Balearic Government that aims at producing 300 tonnes of green hydrogen annually[131]. The project includes two solar plants, an electrolyser plant and a hydrogen station all located in the Balearic island Mallorca. It is funded with the support of the European Commission through "Fuel Cell and Hydrogen Joint Undertaking".

Iberdrola has built what is called a "hidrogenera" or hydrogen station in Zona Franca in Barcelona to produce and distribute green hydrogen for heavy transport[132]. It supplies the public buses of the metropolitan area of Barcelona. The electrolyser of this hidrogenera can produce 300 tonnes of green hydrogen per year.

R&D projects

R&D projects aiming to help the hard-to-abate sectors and demonstrate the feasibility of large scale aviation and maritime biofuels are being put into practice in Spain.

The **ChemCon project of the University of Zaragoza,** led by Prof. María U. Alzueta, aims to reduce aviation emissions by using the compound p-cymene and to evaluate the chemical behaviour of the bio-based fuel when burned and its ability to produce fine particles. It is funded by Marie Skłodowska Curie Fellowship and will start in January 2025. [133].

BIOGREENFINERY is led by Celia Bueno from the **Canary Islands Technological Institute and the Government of the Canary Islands** and funded by REACT-EU. The project aims to analyse the economic viability of the production of green hydrogen and e-fuels in transport. The initial line of the project focuses on the production of green ammonia for maritime transport, fertilisers and cleaning products. In the future, they plan to produce e-kerosene using Power to Liquid (PtL)[134].

Fundación Ciudad de la Energía (CIUDEN) is a body under the Institute for Just Transition and the Ministry for Ecological Transition and the Demographic Challenge. It has launched a €1 million tender for a synthesis gas cleaning system, consolidating its role in sustainable fuels research. The project aims to synthesise methanol and sustainable aviation fuel using biomass, renewable electricity and green hydrogen.[135]

Airport Hub is a conglomerate of six key companies of the aviation sector's chain value that have agreed to analyse the establishment of an airport hub with the purpose of integrating hydrogen into the sector. These companies range from production to distribution and use (Airbus, Aena, Air Nostrum, Iberia, Exolum and Repsol).[136]

Other aviation biofuel projects

Cepsa built a plant, located in Palos de la Frontera, aims to produce 2.5 million tonnes of biofuel per year by 2030, and in particular, 800.000 of them of bioSAF[137]. The plant is in a partnership with Bio-Oils that will create biofuels from agrifood waste and UCO[136], It will also produce hydrogen for its own consumption. Cepsa is already providing **bioSAF** to five of the main Spanish airports: Madrid, Barcelona, Palma de Mallorca, Sevilla and Málaga. Moreover, Cepsa has alliances with Iberia, Binter, Vueling, Air Nostrum, TUI, Volotea, Wizz Air and Etihad to supply bioSAF[138].

Repsol is finishing the construction of a plant in **Cartagena** that will produce 250.000 tonnes of biofuels per year from waste[139]. It aims to supply Spain and Portugal producing 200.000 tonnes of biogenic SAF, a huge part of its total production. 300.000 tonnes of UCO will be used in this factory. They also aim at starting to produce biofuels not intended for transport in a second plant, in **Puertollano**, also from waste, with a 240.000 tonnes production.

The **cluster HyVal,** promoted by **BP** and located in the Valencian Community is focused on hydrogen, and will supply 31.200 tonnes of green hydrogen and 650.000 tonnes of biofuels per year in the factory of **Castellón[140]**. Both hydrogen and biofuels produced are used for relevant sectors in Castellón such as chemical and ceramic industries, and also for aviation, shipping and heavy transport. The plant has been in operation since 2016, and it **aims to produce 400,000 tonnes of biogenic SAF by 2027. By 2030, BP intends to increase this output to 500,000 tonnes of bioSAF.**

Gunvor opened in 2008, the plant is located between the **Basque Country and La Rioja.** It has the capacity to process 40,000 tonnes per year of various feedstocks, such as used cooking oil, fatty acids and other types of waste to produce biodiesel.

Compliance with REFuel EU Aviation

There are currently 49 airports of general interest in Spain, managed by AENA[141]. Due to ReFuelEU Aviation requirements, those Spanish airports carrying more than 800,000 passengers or more than 100,000 tonnes of cargo per year will have to incorporate a mandatory percentage of UAS from January 2025 (see Figure 7), as they fall under the definition of 'Union airports' and therefore the Regulation will apply.

Union Airports	Where passenger traffic was higher than 800 000 passengers or where the freight traffic was higher than 100 000 tonnes in the previous reporting period, and which is not located in an outermost region, as listed in Article 349 TFEU.

Figure 8. *Union airports' classification criteria. Own production based on ReFuelEU Aviation*

According to the requirements for cargo, passengers and location in outermost regions established by ReFuelEU Aviation, 23 airports out of the 49 existing ones, representing 82% of passengers and almost 97% of total cargo in Spain, including Madrid-Barajas, Barcelona-El Prat, Zaragoza and Vitoria, are obliged to comply with SAF obligations from 2% in 2025 (Figure 8, 9 and 10). The remaining airports, due to their characteristics, would not enter and would be left out, such as Burgos or Valladolid (see Annex 1).

Likewise, in Spain there are some airports that meet these requirements, such as Tenerife Sur or Gran Canaria, **but they will not have to include SAF in their operations due to the status of the Canary Islands as an Outermost Region of the European Union.** ReFuelEU Aviation establishes that those airports located in Outermost Regions of the European Union fall outside the definition of 'Union airports'.

Consequently, airports located in Outermost Regions (ORs), such as Gran Canaria, Tenerife South, Tenerife North, Lanzarote, Fuerteventura, La Palma, El Hierro and La Gomera are not obliged to apply the Regulation, causing some concern that there will be no limitations on tankering - the possibility to load more fuel from an airport that is not obliged to have UAS and is therefore cheaper and more efficient, Therefore, it is cheaper and more harmful to the environment - on a route between the Canary Islands and an airport that is not obliged to do so, such as León, which would set off alarm bells about deficiencies in EU environmental regulations.

TOTAL PASSENGERS 2023	283.195.399	TOTAL FREIGHT (t) 2023	1.079.676.272
At airports Not Obliged by ReFuelEU Aviation (OR and others)	50.942.625	At airports Not Obliged by ReFuelEU (OR and others)	30.726.529
At airports Obliged by ReFuelEU Aviation	232.252.774	At airports Obliged by ReFuelEU Aviation	1.048.949.743
At OR airports likely to be included in ReFuelEU	48.021.609	At OR airports likely to be included in ReFuelEU	30.629.858
At airports if OR were included	280.274.383	At airports if OR were included	1.079.579.601

**OR: Outermost Regions*

Figure 9. *Aviation figures in Spain in 2023. Source: Own elaboration based on data from AENA, Annual Report 2023. https://www.aena.es/es/estadisticas/inicio.html*

TOTAL PASSENGERS SHARE	100%	TOTAL FREIGHT (t) SHARE	100%
Passengers at Obliged airports	82%	Goods at Obliged airports	97%
Passengers at Non-Obliged airports (OR and others)	18%	Goods at Non-Obliged airports (OR and others)	3%
Passengers at OR airports	17%	Goods at OR airports	3%
Passengers at Obliged airports if OR airports meeting the requirements were included	99%	Goods at Obliged airports if OR airports meeting the requirements were included	99,99 %
Passengers at Non-OR airports if OR airports meeting the requirements were included	1%	Goods at Non-OR airports if OR airports meeting the requirements were included	0%

**OR: Outermost Regions*

Figure 10. *Aviation figures in Spain in 2023. Source: Own elaboration based on data from AENA, Annual Report 2023. https://www.aena.es/es/estadisticas/inicio.html*

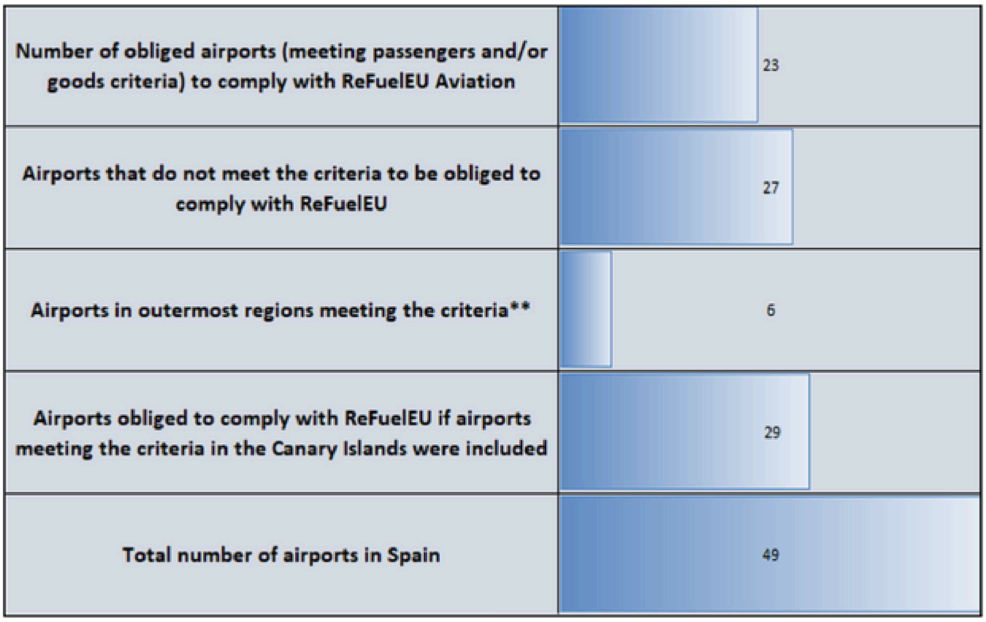


Figure 11. *Aviation figures in Spain in 2023. Source: Own elaboration based on data from AENA, Annual Report 2023. https://www.aena.es/es/estadisticas/inicio.html*

**Two airports meet the goods criteria: Zaragoza and Vitoria, and six airports meet the passengers criteria: A Coruña, Asturias, FGL Granada- Jaén, Seve Ballesteros-Santander, Jerez de la Frontera, Aeropuerto Intl. Región de Murcia and Reus.*

***Two airports located in outermost regions would not comply with the criteria even if outermost regions were included in ReFuelEU, namely El Hierro and La Gomera.*

In a theoretical scenario with a constant demand for aviation kerosene (2023) and in which 49 Spanish airports would be mandated by ReFuelEU (see figures 10 and 11), airlines operating in Spain will be able to comply with the SAF mandate in the next 5 years.

Year	Total SAF required by ReFuelEU (%)	SAF required (t/year)*	Synthetic fuel required (%)	Synthetic fuel required (t/year)*
2025	2%	132.857,38	-	-
2030	6%	398.572,14	1,2%	79.714
2032	6%	398.572,14	2%	132.857
2035	20%	1.328.573,80	5%	332.143
2040	34%	2.258.575,46	10%	664.287
2045	42%	2.790.004,98	15%	996.430
2050	70%	4.650.008,30	35%	2.325.004,15

**Based on 6.642.869 tonnes of kerosene consumed in Spain in 2023. Source: CORES.*

Figure 12. *Required SAF and synthetic fuel volume in Spain by ReFuelEU Aviation Regulation based on kerosene demand in Spain in 2023. Source: Own elaboration based on data from European Commission and Council of the EU.*

However, Spain needs to increase production, especially of synthetic fuels, to meet the mandate in the coming years. According to the data compiled in this report, it is estimated that only 130,000 tonnes of synthetic fuels will be produced (see Figure 14), which would reach the 79,714 tonnes required by 2030, but not the 132,857 tonnes required in 2032 by ReFuelEU.[143]

At the same time, demand is expected to increase by 10% and reach more than 300 million passengers this year[144]. Spanish airport operator AENA is already expanding 4 airports -three in the Canary Islands and one in Madrid- and has plans to expand another ten airports (See Figure 13).

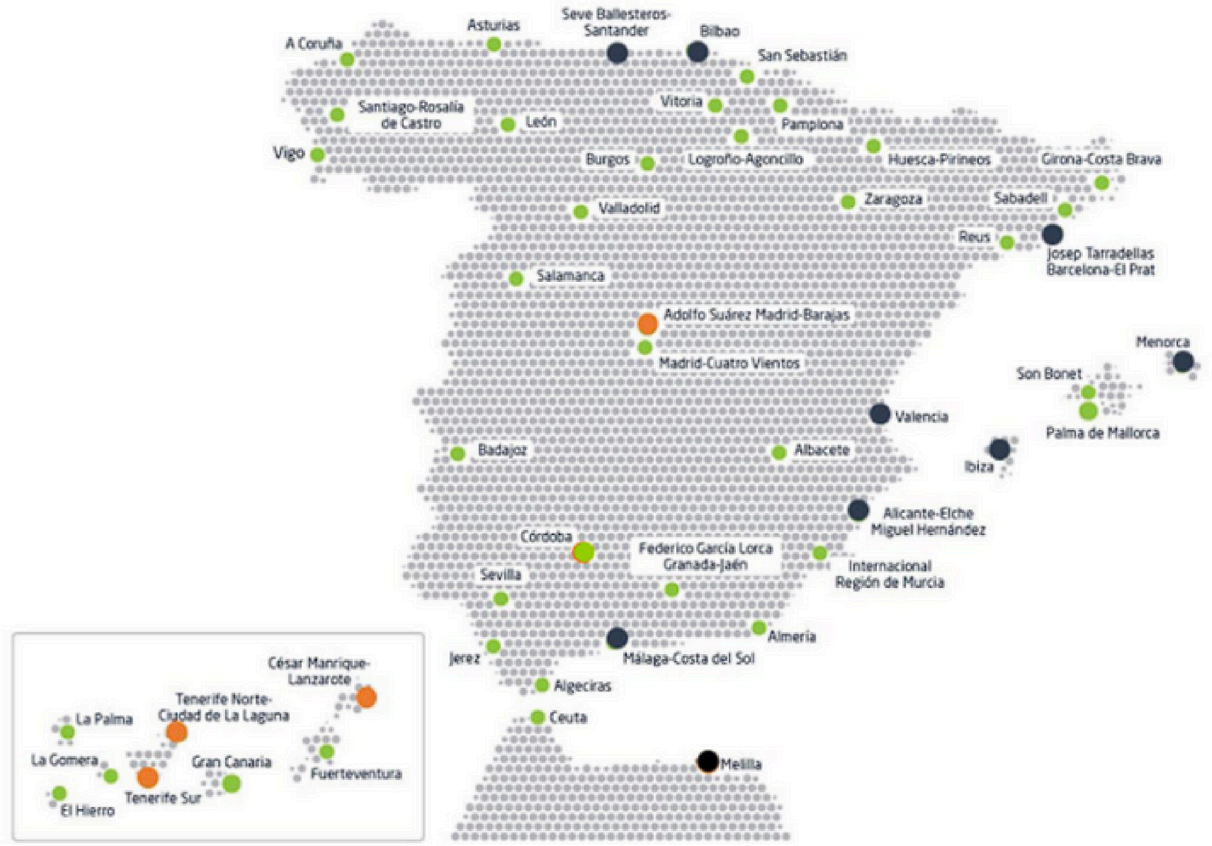


Figure 13. *Airports (green) and airport expansions in process (orange) and future (black) in Spain. Source: AENA.*

Conclusions

Decarbonising the aviation sector is a major challenge that requires a comprehensive approach, a combination of different measures and the collaboration of all actors involved in the sector.

Within these measures, opting for the use of fuels that are sustainable has impacts in the short and medium term, while developing new technologies and addressing the demand for flights. **Green hydrogen and synthetic fuels are two alternatives to fossil fuels that can have zero emissions, but their production is still very low and requires a multi-stakeholder drive to ensure their deployment.**

The state of development and use of synthetic fuels and green hydrogen for aviation in Spain is currently characterised by research and some planned small-scale projects, which have not yet materialised into deployment.

Although there are several green hydrogen projects underway, **hydrogen production is aimed at decarbonising sectors other than transport and to date, only four companies have announced plans to produce synthetic fuels in Spain.** It can also be seen that many of the planned projects are focused on the production of biological origin SAF. This circumstance highlights the current focus of companies' investment decisions and **the need for measures to be taken to support the deployment of synthetic fuels and green hydrogen specifically for the aviation sector.**

In this respect, the introduction of the ReFuelEU Aviation Regulation is key to the uptake of synthetic fuels in the European Union and Spain. It sets binding targets for biogenic and non-biogenic aviation fuel for EU airports. **By 2030, at least 1.2% of aviation fuel supplied at EU airports must be synthetic fuel, rising to 35% by 2050.**

In Spain, 23 of the 49 airports will be affected by the Regulation, currently accounting for 82% of passengers and 97% of total aviation cargo in Spain.

In particular, airports located in Outermost Regions of the European Union, such as the Canary Islands in the case of Spain, are excluded from the definition of EU airports, which indicates the characteristics that an airport must meet in order to be subject to ReFuelEU Aviation. However, some of the airports located on the islands are an important hub for passenger and freight traffic and the decarbonisation of their operations and air traffic is of paramount importance to advance the decarbonisation of the sector, especially as they are one of the main means of connection between the islands.

If the airports of the Canary Islands were to be included in the Regulation, 29 Spanish airports would be obliged in total, representing 99% of passengers and 99.99% of freight traffic in Spain in 2023.

However, taking into account the projected production of bio and synthetic aviation fuel, a scenario with a stable demand for kerosene and the inclusion in ReFuelEU Aviation of the airports located in the Canary Islands, **Spain could cover aviation fuel of biological origin production up to the 2035 target; however, it needs to increase the production of synthetic fuels.**

Currently, the four synthetic fuel plants in Spain would produce up to 130,000 tonnes per year, which implies that Spain is at the limit of meeting projected demands and would not allow the sector to advance one step beyond the targets set in ReFuelEU Aviation; this is without taking into consideration increases in flight demand that may occur and are expected.

With the estimated production of synthetic fuels, only 1.96% of the current demand for aviation kerosene in Spain in 2023 could be covered, which, in the same scenario, would not meet the synthetic fuels target for 2032.

One of the issues that have been identified as essential is the cost of producing these fuels and the legal certainty needed to secure investments to enable their deployment. Producers face a major obstacle in the form of the huge difference in cost of synthetic fuels - from €4000 to €8225 per tonne - compared to conventional aviation fuel - from €650 to €816 per tonne - i.e. at least 6 times more expensive.

The use of the 20 million voluntary European ETS allowances for the supply of SAF, and especially e-SAF, could make a difference by covering 95% of the price difference between fossil kerosene and synthetic fuel at all EU airports, or 100% between fossil kerosene and another sustainable fuel, in the case of the Canary Islands, Balearic Islands and small airports such as Burgos or León, for example.

Today's technologies can start the way towards a net-zero emission aviation sector. **While these two alternatives consume less water and use less land than biofuels, they still present some environmental issues, mainly related to the amount of renewable energy needed, CO2 capture and the critical raw materials they need to be produced, which also need to be addressed.**

Spain has great potential for green hydrogen production due to the low cost of renewable energy, its industrial capacity and existing infrastructure network. High transport costs, water use, electricity availability, land use and dependence on critical raw materials are some of the main obstacles to its development.

Similarly**, one of the main cost factors for the production of synthetic fuels is the availability of renewable energy. Spain's leading position in renewable energy sources will be essential to reduce the cost and increase competitiveness.** Similarly, CO2 capture remains another major obstacle to the production of synthetic fuels and how companies will address the shortage of CO2 capture is an important aspect to be addressed.

Currently most projects are privately funded, and the amount of synthetic fuels and hydrogen production for aviation is low. This contrasts with the **stronger commitment to synthetic fuel production in Nordic and Western European countries,** such as Norway, Sweden, Denmark or France. However, this situation is not set in stone: **an uncertain market and an unsustainable price scenario could change its direction.**

Collaborations between key industry players, a supportive legislative framework and decisive leadership by public authorities would place Spain in a privileged position to lead the way in sustainable aviation practices.

Only by increasing production and committing to the deployment of synthetic fuels and green hydrogen for aviation, while investing in research, innovation and partnership building, **will the cost gap with fossil fuels be narrowed** and Spain can continue to contribute to a more environmentally friendly and sustainable future for aviation.

Recommendations

PROMOTION MECHANISMS

- **Develop a national roadmap for synthetic fuels,** with the objective of coordinating efforts towards synthetic fuel production, research and development in the aviation sector.

- **Establish specific sub-targets for different sectors, including the aviation sector** within the mandatory minimum targets for the sale or consumption of biofuels and other renewable fuels for transport purposes. Nowadays, Royal Decree 376/2022 provides for general targets for transport until 2026, which will apply in subsequent years as long as no new targets are regulated.

- **The sub-target linked to the aviation sector should include renewable fuels of non-biological origin and synthetic fuels and also renewable electricity and green hydrogen for direct use in aircraft,** which will be used in novel propulsion technologies that will also enter the market, such as electric, fuel cell or hydrogen-powered aircraft. This will allow these energy sources to count towards the aviation sub-target, thus creating incentives for technological innovation.

- **Prioritise the use of renewable fuels of non-biological origin and synthetic fuels in sectors that are difficult to electrify, such as aviation;** This may be generated with differential calculations according to the sector in which they are used and not as currently provided for in Article 12 of Order TED/728/2024 of 15 July, which states that from and including 2025, renewable liquid and gaseous fuels of non-biological origin may be counted towards the target for the sale or consumption of biofuels and other renewable fuels for transport purposes, also when they are used as an intermediate product for the production of conventional fuels. These fuels shall be considered to be equivalent to 2 times their energy content irrespective of the sector in which they are supplied.

- In parallel to the inclusion of this specific sub-target for the aviation sector, **a regulatory framework should be pursued to incentivise an early supply of synthetic fuels by establishing incentives for their supply before 2030,** in order to ensure that only the minimum volumes are not provided to the aviation sector needed to meet the regulatory targets under ReFuelEU.

- **Include recycled carbon fuels in the definition of <<sustainable aviation fuels>>** of Order TED/728/2024 for the development of a mechanism for the promotion of biofuels and other renewable fuels for transport purposes, which are included in the definition of the RED III Directive.

FINANCING AND INVESTMENT

- **Establish funding mechanisms and/or support schemes combining public and private investments that prioritise non-biological renewable fuels for the aviation sector within the SAF.**

- **Encourage the development of synthetic fuel production plants produced from green hydrogen,** in line with the measures of the Hydrogen Roadmap related to the aviation sector, while incentivising the increase of available renewable energy.

- **Encourage a regulatory framework that allows companies to increase their own production targets, strengthening the inclusion of new operators in the sector,** enabling a diversification of companies currently producing fuels for the aviation sector.

- **Ensure fair and unrestricted access to existing and future aviation fuel infrastructures** in order to promote a competitive market for synthetic fuels and avoid the extension of existing fossil fuel monopolies, with the aim of allowing new players, in addition to companies already operating airport infrastructures, to make investments.

TECHNOLOGICAL DEVELOPMENT

- **Promote mechanisms to develop CO_2 capture from the atmosphere, replacing biogenic CO_2 capture,** e.g. from biomass or industry emissions, including future mandates for its use within fuel policies and policy support for supply, such as funding for research, development and demonstration and project development.

- **Encourage research into renewable hydrogen-powered aviation technology, as well as electric aircraft,** including aircraft redesign, and assessment of the potential of hydrogen turbines for use in air transport.

TAXATION

- **Earmark a percentage of EU ETS revenues or other expected revenues to support the production of synthetic fuels and green hydrogen for the aviation sector.**

LOCAL TERRITORIES

- **Ensure sustainable development by creating programmes to maintain the benefits of renewable energy and hydrogen production for local communities.**

TRANSPARENCY

- **Transparency and accountability should be a priority,** requiring stakeholders to provide full information on fuel supplied and consumed, with sectoral disaggregation, and what practices are being implemented to move towards a more environmentally friendly sector.

PENALTY REGIME

- **Establish a penalty scheme for suppliers who fail to meet the sustainable fuel targets set by the ReFuelEU Aviation Regulation,** which is included in the PNIEC as an enforcement mechanism, by 31 December 2024.

- **Penalties or sanctions** for fuel suppliers that fail to meet the ReFuelEU bio- and non-biological fuel targets **should be sufficiently stringent to incentivise the uptake of sustainable fuel at EU airports.**

MEASURES AT AIRPORTS

- **Promote the deployment of renewable energy sources at and near airports** as the cornerstone for the production of synthetic fuels and hydrogen and for the electrification of flight operations.

- **Prioritise electrification of flight operations, such as auxiliary vehicles and ground crew operations.**

Annexes

Airports in Spain in 2023			
Airport	Number of passengers	Airport	Number of goods (tonnes)
ADOLFO SUÁREZ MADRID-BARAJAS	60.220.984	ADOLFO SUÁREZ MADRID-BARAJAS	643.534.817
BARCELONA-EL PRAT J.T.	49.909.544	BARCELONA-EL PRAT J.T.	156.485.423
PALMA DE MALLORCA	31.105.987	ZARAGOZA	129.753.429
MÁLAGA-COSTA DEL SOL	22.344.373	VITORIA	71.689.094
ALICANTE-ELCHE MIGUEL HDEZ.	15.747.678	GRAN CANARIA (OR)	17.117.093
GRAN CANARIA (OR)	13.961.638	VALENCIA	13.665.158
TENERIFE-SUR (OR)	12.337.244	TENERIFE NORTE-C. LA LAGUNA (OR)	11.561.686
VALENCIA	9.948.141	SEVILLA	10.913.974
IBIZA	8.931.598	PALMA DE MALLORCA	7.184.352
LANZAROTE-CÉSAR MANRIQUE (OR)	8.212.943	SANTIAGO-ROSALÍA DE CASTRO	4.818.283
SEVILLA	8.071.524	ALICANTE-ELCHE MIGUEL HDEZ.	4.461.504
BILBAO	6.336.441	MÁLAGA-COSTA DEL SOL	2.806.338
TENERIFE NORTE-C. LA LAGUNA (OR)	6.120.550	IBIZA	993.160
FUERTEVENTURA (OR)	6.020.413	VIGO	807.235
MENORCA	4.045.215	TENERIFE-SUR (OR)	777.859
SANTIAGO-ROSALÍA DE CASTRO	3.537.445	BILBAO	750.817
ASTURIAS	1.974.850	MENORCA	687.993
GIRONA-COSTA BRAVA	1.586.463	LANZAROTE-CÉSAR MANRIQUE (OR)	521.603
LA PALMA (OR)	1.368.821	FUERTEVENTURA (OR)	371.395
A CORUÑA	1.252.022	GIRONA-COSTA BRAVA	308.020
SEVE BALLESTEROS-SANTANDER	1.242.089	LA PALMA (OR)	280.222
VIGO	1.136.157	ReFuelEU Aviation Requirement Limit (100,000 tonnes of goods)	
REUS	1.045.419	A CORUÑA (Complies by number of passengers)	76.963,00
FGL GRANADA-JAÉN	1.039.429	EL HIERRO (OR)	58.142,00

Figure 29. *Aviation figures in Spain in 2023. Source: AENA, Annual Report 2023.*
Estadísticas de tráfico aéreo

JEREZ DE LA FRONTERA	904.000	MELILLA	24.674,00
AEROPUERTO INTL. REGIÓN MURCIA (**)	877.796	ASTURIAS (Complies by number of passengers)	11.494,00
ReFuelEU Aviation Requirement Limit (800.000 passengers)		VALLADOLID	6.120,00
ALMERÍA	775.393	LA GOMERA (RUP)	4.891,00
ZARAGOZA (Complies by number of goods tonnes	685.690	SAN SEBASTIÁN	2.530,00
MELILLA	501.069	LA GOMERA (OR)	1.197,00
SAN SEBASTIÁN	482.662	SAN SEBASTIÁN	370,00
VITORIA (Complies by number of goods tonnes)	309.929	FGL GRANADA-JAÉN (Complies by number of passengers)	268,00
EL HIERRO (OR)	301.241	SEVE BALLESTEROS-SANTANDER (Complies by number of passengers)	122,00
VALLADOLID	208.923	PAMPLONA	46,00
PAMPLONA	197.509	JEREZ DE LA FRONTERA (Complies by number of passengers)	-
LA GOMERA (OR)	113.318	ALMERÍA	0
CEUTA-HELIPUERTO	87.024	AEROPUERTO INTL. REGIÓN MURCIA (Complies by number of passengers)	0
BADAJOZ	80.181	BADAJOZ	0
LEÓN	63.442	BURGOS	0
ALGECIRAS-HELIPUERTO	41.308	CEUTA-HELIPUERTO	0
SALAMANCA	21.083	CÓRDOBA	0
LOGROÑO	16.728	HUESCA-PIRINEOS	0
SON BONET	10.061	LEÓN	0
SABADELL	6.207	LOGROÑO	0
CÓRDOBA	5.938	MADRID-CUATRO VIENTOS	0
BURGOS	4.053	REUS (Complies by number of passengers)	0
ALBACETE	2.644	SABADELL	0
MADRID-CUATRO VIENTOS	1.956	SALAMANCA	0
HUESCA-PIRINEOS	276	SON BONET	0
MURCIA-SAN JAVIER (*)	0	MURCIA-SAN JAVIER (*)	0
T O T A L NUMBER OF PASSENGERS	283.195.399	TOTAL NUMBER OF GOODS (t)	1.079.676.272

**AS OF 15 JANUARY 2019 THIS AIRPORT HAS CEASED OPERATIONS.*

Note: Airports in green meet the criteria to be subject to ReFuelEU Aviation. Airports in red do not meet any of the three criteria to be subject to ReFuelEU Aviation. Airports in gold belong to the Canary Islands, which, as an outermost region (OR), is not subject to ReFuelEU Aviation. Airports in light green are close to meeting the requirements (Almeria for passengers) and given the expected increase in demand in 2024 could be subject to the Regulation.

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