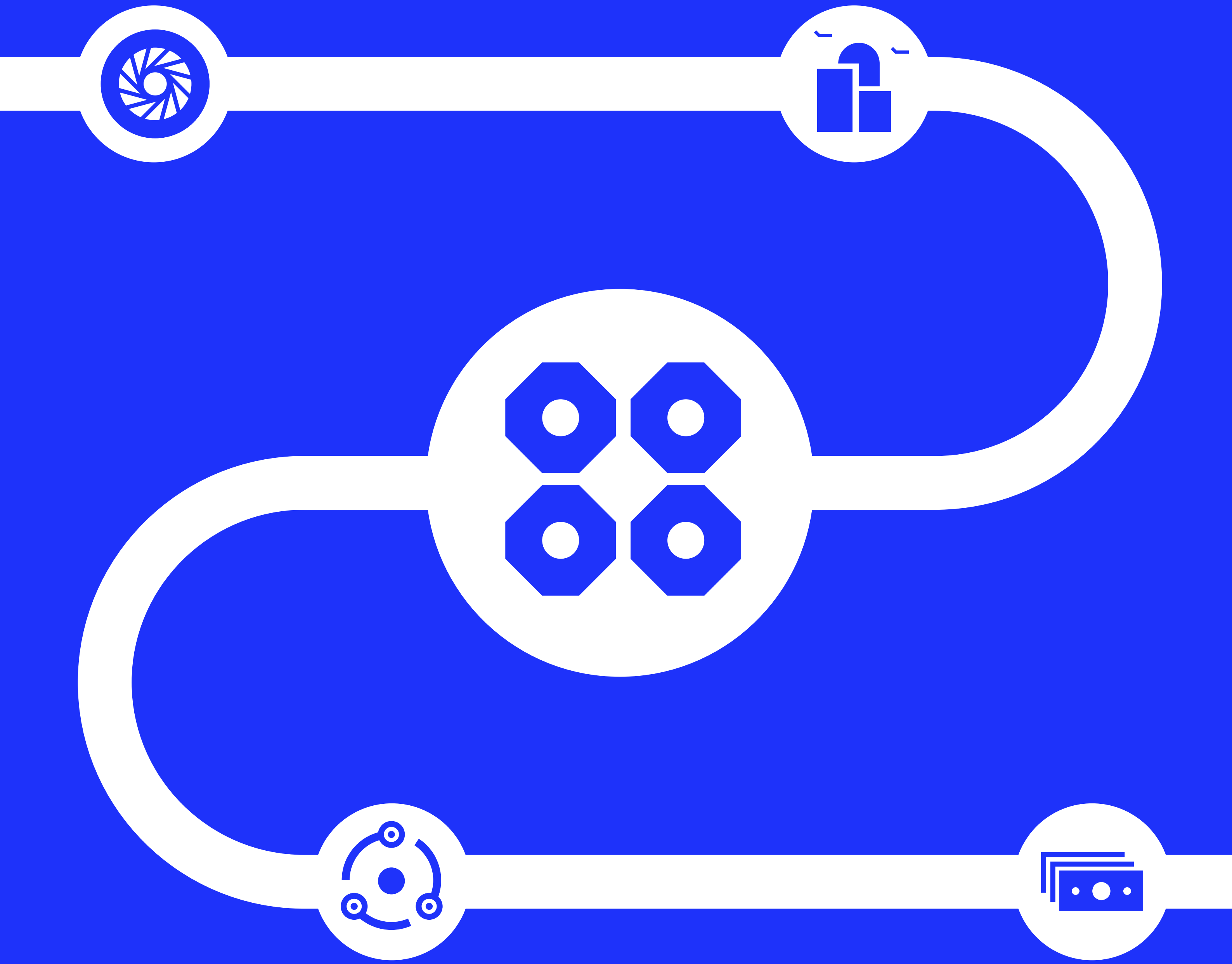
Policy
Net Zero Roadmap



Overview

IATA's Net Zero Roadmaps aim to provide greater clarity of the developments and actions needed for the airline industry to be able to deliver on its commitment to reaching net zero CO_2 emissions by 2050. The roadmaps cover aircraft technology, operations, infrastructure, policy, and finance. The first three roadmaps address the question "What do we need to reach net zero?", while the latter two tackle the question "How do we make that happen?". This Policy Roadmap discusses the key directions in which policy needs to develop to play its part in enabling the transition. As such, it presents:

1. The multilateral policy agenda and the role of policy as an enabler.
2. Foundational policies for creating new markets.
3. Policies for building capacity.

Once capacity has been built, the policy makers' role fades and their focus turns to addressing potential market failures. By such a time, private actors should be able to ensure that the system runs smoothly.

Detail regarding existing policies in major countries is presented in the Appendix.

1. The Role of Policy as an Enabler

The role of government policy is to enable and protect – enable the targeted activity and protect people and the planet from any harm that might come from that activity. Policies set the scene, provide certainty for industry and investors, and steer and facilitate economic development.

At the top of the policy-making hierarchy sits the United Nations (UN), which adopted the 2030 Agenda for Sustainable Development [1] in 2015. This agenda envisions a world in which every country enjoys sustained, inclusive, and sustainable economic growth. The need to facilitate sustainable aviation derives from the industry's direct contributions to 15 of the 17 Sustainable Development Goals (SDG) [2]. Moreover, 193 UN Member States have recognized the need to safeguard a global level playing field in the interest of fostering global civil aviation, by signing the Chicago Convention [3] of 7 December 1944 – the "birth certificate" of civil aviation. From this, the overarching policy thrust can be summarized as follows:

- Flying is a necessary and essential activity for economic development and for meeting the UN SDGs.
- Achieving net zero CO_2 emissions in air transport is equally necessary and essential for the same reasons.
- To optimize on the benefits that sustainable aviation can bring to the global economy, a level playing field needs to be preserved.

Especially relevant for the aviation environment policy, in 2022 the UN agency for civil aviation, ICAO (International Civil Aviation Organization) [4], adopted a long-term global aspirational goal (LTAG) [5] for international aviation of net zero carbon emissions by 2050 in support of the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement's [6] temperature goal. This global vision paves the way for the states to formulate their own vision and translate it into national regulatory frameworks, providing direction, stability, and predictability. This agreement followed the industry's commitment to the same objective, adopted by IATA in 2021.

The more clearly the goals are formulated, the more stakeholders that are involved, and the closer progress is being monitored, the more successful the outcome (Chart 1).

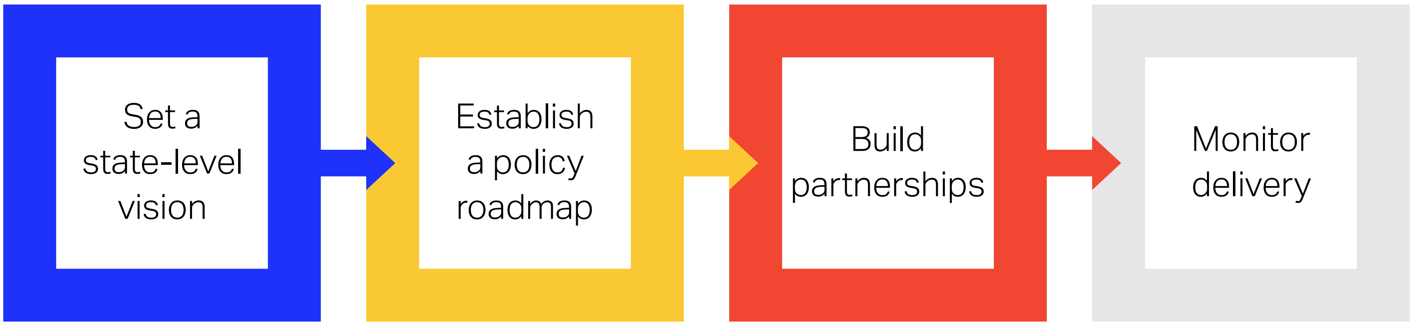
Multiple states have determined a national decarbonization vision and a strategy for their energy transition, including specific implementation plans for the aviation sector. Key examples are the United States of America (US) Aviation Climate Action Plan [7] and the European Union (EU) Green Deal [8].

The challenge of this transformation is daunting for airlines and the entire value chain. It is particularly challenging for airlines because most solutions lie out of their direct control. As shown in the Technology Roadmap, aircraft and propulsion system efficiency improvements, biofuels, hydrogen, and synthetic fuels which together will likely make the largest contributors to CO_2 emissions reductions, all have yet to be developed commercially. Investments will need to be mobilized to bring these solutions to fruition.

Regulators too are faced with a formidable task as completely new frameworks must be created to enable and protect all involved. The fact that we do not have all the frameworks necessary so far, and that current frameworks are not yet harmonized across jurisdictions, is only natural, given that we are only at the early stages of this transformation - just how early is evidenced by the fact that all sustainable aviation fuel (SAF) produced today globally represents less than 0.1% of global aviation's fuel consumption.

The role of policy in enabling an industry transition to support aviation's goal to reach net zero carbon emissions by 2050, is key. Only with a predictable policy framework, encompassing all aspects of regulation, can all industry stakeholders confidently invest the amounts required to bring revolutionary, carbon-saving technologies to market with the necessary speed [9].

Chart 1: Steps for creating a national policy framework



Source: IATA Sustainability and Economics

2. Policies for creating new markets

To create a new market, a whole host of new administrative infrastructure must be built. In the context of global aviation, a uniquely complex activity, and the goal to bring it to net zero CO_2 emissions by 2050, this type of infrastructure will be needed for multiple new technologies and systems, and all must ensure that strict technical and safety criteria are met.

Unblock institutional barriers

The approval process for airworthiness certification of new aircraft, hydrogen or electric, as well as for new energies currently take up to nine years to complete. Without these approvals, the product cannot be launched, and the related market remains hypothetical. Regulators must strive to accelerate approvals and certifications, though without compromising safety, as this is one of the early institutional barriers to creating new markets.

Regarding SAF, most is produced from oils and fats though the hydro-processing of esters and fatty acids pathway (HEFA) [10]. Other feedstocks and qualified pathways are not yet available at commercial scale, in part hindered by lengthy approval processes. While HEFA fuels are expected to dominate SAF production up to 2030, other feedstocks will be necessary beyond that date. ASTM [11] has taken a rather proactive stance and has approved nine conversion processes or pathways for SAF production, with five more under consideration. The United Kingdom (UK) is facilitating the certification of new fuels through the establishment of a SAF Clearing House [12] which will connect industrial capabilities with academic expertise, provide advice to fuel producers on testing, and signpost toward testing facilities. While these efforts are laudable, we need to accelerate the process, as well as ensure standards are available to all the solutions which will be necessary in aviation's net zero transition, notably to hydrogen and electric aviation. And procedural and equipment standards would greatly facilitate and likely accelerate the timeline for its use.

In order to take full advantage of the benefits of SAF, it must be used neat, unblended. Currently, SAF can only be used in aircraft mixed with conventional jet fuel, and this up to a maximum blend ratio of 50% [13]. The industry, through ASTM, is working on ensuring the required criteria for higher blend ratios, up to 100% use of SAF, but the process is slow. Policy can be directed towards accelerating the Research & Development (R&D), testing, and demonstrations necessary to enable 100% SAF which, in turn, can accelerate the pace of CO_2 emissions reductions in air transport.

For hydrogen, there are multiple standard initiatives being pursued at the global level (e.g., International Industry Working Group (IIWG) and ICAO), and regionally (e.g., EU Alliance for Zero Emissions Aviation (AZEA) [14] and European Organisation for Civil Aviation Equipment (EUROCAE) [15]. Regarding battery-electric aviation and hybrid models, the work on global standards is lagging, as are standards and recommended practices for aircraft refueling. In these domains, the support of the regulator is imperative, as the pace at which the industry can advance is determined by it.

Prior to approval though, standard sustainability criteria for doing so much be developed. The European Union's alternative definition for fuel criteria is prescribed in its Renewable Energy Directive (RED) [16]. In the US, the standards in use are California Low Carbon Fuel Standard (CA-LCFS) [17], and the US Renewable Fuel Standard [18].

The sustainability credentials of different types of SAF vary greatly, leading to different definitions of SAF-related sustainability criteria. Globally, CORSIA [19]'s Eligible Fuel Criteria [20] serve as a useful point of reference to identify viable feedstock, highlighting a range of carbon, environmental, and socio-economic factors across 13 identified themes which must be considered for a feedstock's aggregation and cultivation process.

In addition to standards, approvals, and certifications, the sustainable aviation of the future will also require new registries for energy purchases (for which the buyer needs to receive a standardized and eligible certificate), and for the ability to claim those purchases against systems which monitor such obligations, such as CORSIA and the EU Emissions Trading System (EU ETS) [21]. It goes without saying that a single certificate regarding a SAF purchase ought to be claimable against all and any such obligatory schemes, as long as no double counting takes place. This could be supported by a Book and Claim [22] chain of custody mechanism, (see Book and Claim box), which allows a fuel purchase to take place in a location different from that of the physical fuel uplift. This is crucial for SAF at the early stage of the commercial ramp-up. In addition, the policies should include a clear process for the secure and transparent transfer of sustainability documentation, ensuring that all stakeholders in the supply chain (producers, airlines, customers) will benefit from the sustainability credentials that SAF deliver.

Other foundational elements that will facilitate technical and commercial progress are setting best practices and guidelines for air and ground operations, and for the re-configuration of airport layouts and infrastructure, considering the different fuel systems' spatial and operational needs and requirements [23].

Book and Claim

A necessary step in building SAF infrastructure is the development of accounting mechanisms that can ascertain the chain of custody, such as “Book and Claim”. This type of chain of custody-system separates the fuel purchase from its physical location, which simplifies supply chains, increases market potential, and reduces cost.

A prerequisite for Book and Claim is that fuel suppliers provide aircraft operators with full and complete sustainability documentation associated with the SAF they have procured or produced. The system should allow stacking of environmental attributes for compliance with multiple or overlapping regulatory requirements under different greenhouse gas emissions (GHG) scopes, understanding that the necessary provisions to avoid double counting are in place.

Such mechanisms already exist in other sectors, e.g., green electricity.

Research and Development

Fundamental building blocks in terms of bringing new technologies to the market are of course research and development (R&D). Accelerating R&D processes, which are inherently lengthy, will in all probability allow new decarbonization solutions to be brought to market faster. This is crucially important at the current juncture when there is a lack of commercially viable decarbonization solutions for airlines to benefit from. However, R&D can be expected to be an important driver of developments over the whole transition to net zero, and the need for policy support in this domain is likely to remain high until 2050, and beyond.

Examples of R&D policy frameworks include national initiatives like the National Aeronautics and Space Administration (NASA) [24], the Japan Aerospace Exploration Agency (JAXA) [25], the Aerospace Technology Institute (ATI) or the German Aerospace Centre (DLR) [26] which are exploring new aircraft technologies, many of them listed in the technology roadmap. The EU offers funding opportunities through the Horizon 2020 [27], Clean Aviation [28] and Digital European Sky [29]. For the latter, and to deliver on the goals of the EU Green Deal, Single European Sky ATM Research (SESAR) [30] is an operative tool to fast-track innovative solutions and accelerate technological progress through exploratory and industrial research. Like SESAR, some of these programs also provide support for activities aimed at improving aviation’s operational environmental performance.

More research is required regarding all potential solutions for enabling aviation’s transition. This includes SAF, hydrogen, batteries, and their infrastructure solutions, knowing that the infrastructure for conventional jet fuel will not become obsolete this side of 2050. Solutions such as carbon dioxide capture, removal, and storage also merit both urgent and long-term research efforts and it is required in the medium term especially for Direct Air Capture (DAC)-based SAF deployment, and in the longer term for removing residual emissions [31].

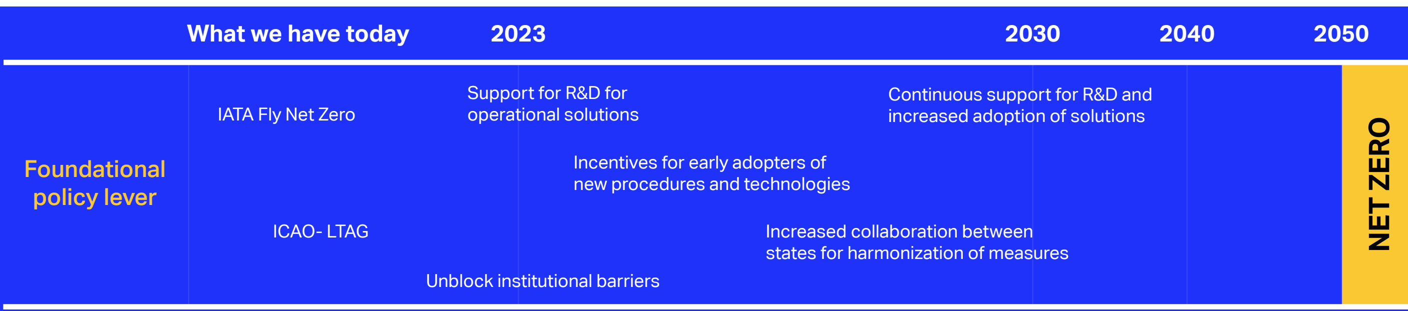
Harmonization

The harmonization of policies, regulations, and standards across aviation is of course another way to address the need for a level playing field. Aviation’s transition to net zero would best be addressed by facilitating a common sustainability framework, agreed globally. Nevertheless, we have to start somewhere. It can be difficult to harmonize policies prior to their existence, though harmonization efforts can be built into new regulations by anticipating areas in which various forms of regulations and regulators need to be able to function and work together. As per Chart 2, we would like to see harmonization efforts stepped up by the end of this decade in order to be ready notably for the ramp up in the production of SAF. It is also important that any new policies consider overlapping requirements and seek to simplify processes across frameworks dealing with the same or interconnected matters.

The lack of harmonization can:

- Lead to arbitrage behavior between policy regimes, with the associated inefficient allocation of capital
- Discourage entrepreneurship and investments, due to an uncertain and potentially volatile legal context
- Make it difficult for operators to claim the benefits of SAF purchased
- Shrink the market if operators fail to comply with disparate rules in various jurisdictions
- Distort competition

Chart 2: Roadmap for foundational policy levers



3. Policies for building market capacity

De-risk

The investments required to enable a net zero transition of aviation amount up to USD 5.3 trillion [5] [32] [33]. The Finance Roadmap examines the policy support that could enable the effort in greater detail. In general terms, the main policy objective in this context must be to de-risk the endeavor, i.e., provide more clarity and security for the parties involved.

The high capital expenditure involved in developing new energies such as SAF and hydrogen, and in developing new pathways for scaling up SAF production, frequently makes the related investment case unattractive, particularly in the early stages of development when the investor stands to lose the entire amount invested. This situation contributes to the lack of supply of SAF on the market, and with airline demand exceeding supply, and because of the lack of economies of scale, the price of SAF is up to four times higher than that of conventional jet fuel. Similar constraints also apply to the scaling up of green hydrogen, battery-electric aviation, and carbon removal solutions, all of which require policy efforts to de-risk their early investments.

Policy packages should aim to reduce the first-mover risk by offering grants for first-of-its-kind plants to scale up new technologies. Projects currently in the pipeline are insufficient and need to increase by a factor of 5-6 by 2030 to be in line with aviation's goals. In general, global investments of USD 40-50 billion are needed annually for SAF ramp-up, starting today. Incentives are thus required to facilitate the prioritization of SAF by lowering their opportunity cost, improving returns on investment for fuel producers, and managing the cost profile for the SAF buyers.

Governments can provide greater clarity regarding price evolutions through the use of contracts for difference [34], for instance (see Contracts for Difference box) – a form of derivative contract commonly used in financial markets and already in use in new energy markets. This can be done by creating a public agency for this specific purpose, for example. Co-investments through public-private partnerships, the provision of guarantees, tax credits, and many more are ways in which governments can reduce the risk burden on the private sector during the most high-risk phases of developing new technologies and bringing them to the market.

The need for de-risking wanes as projects mature. Once a commercial market has been established, public sector involvement can diminish, and market forces can determine the winners and the losers in terms of the most favored solutions. In this respect, it is important that all policy support remains technology agnostic as any early bets on specific solutions from the governments' side will only discourage competition and curtail the development of other potential solutions.

Contracts for Difference

Contracts for Difference (CfD) are private law contracts between a supplier and a government, aimed at incentivizing capital-intensive long-term projects by agreeing on a fixed price of a product during a given period. CfDs have been previously used successfully in other sectors like offshore wind farms. The concept of CfD for aviation consists in awarding fuel suppliers a contract for a specific period and a set of obligations to deliver the contracted capacity within this timeframe. The CfD scheme aims to reduce suppliers' and investors' risks by providing more confidence and certainty, guaranteeing a certain revenue stream during the contract lifetime. CfDs, that are currently considered as a SAF policy instrument in countries like the UK or in Canada, can indirectly assist to reduce the price gap of SAF by enabling increased supply. However, the scheme should make sure that all stakeholders of the supply chain will benefit from it - SAF suppliers, investors, and airlines, and this way enabling a fair level playing field.

Other key elements that need to be considered are the feedstock definition and the establishment of the strike price. SAF have major differences with other energy sources, due to the different feedstocks and pathways used, so preferably, there should be a classification – and prioritization - according to established criteria. Also, at current stage, the prices of SAF are up to 4 times higher than that of conventional fuel, due to scarce supply and high competition. There is therefore a need to carefully assess the strike price, considering the status quo and the initial high mark-up.

Finally, due consideration should be given as to where the funding for CfDs is sourced from. In Europe, to reduce government spending, one possible source for funding potential differences in the CfD could be through revenues from the Emissions Trading System. The EU ETS generates revenues from operators purchasing emissions allowances and thus, their yields are a natural source for funding sustainability projects. However, provided this a region specific initiative, IATA strongly advises against creating additional complexity or financial burden to the stakeholders of the supply chain by putting in place new systems of revenue collection to the detriment of the industry.

Incentivize and support

It helps to have national frameworks for promoting technological transitions, as the lack thereof can lead to a fragmented and uncoordinated assistance. Important policy packages in this domain include the US Inflation Reduction Act [35] and the EU Net Zero Industry Act [36], which provide funding for technologies that enable the net zero transition, including SAF and hydrogen. Other examples include the UK's Jet Zero Strategy [37], the US with the SAF Grand Challenge [38], and the EU with the Refuel EU regulation [39], all forerunners with respect to enabling SAF production. Some states have acknowledged that feedstock development needs to be included in their national plans, with the aim to increase strategic feedstock independency. Enabling economies of scale in SAF production through the diversification of feedstock can also directly improve the state of local environments across the world and the livelihoods within.

So far, over 50 states have announced national hydrogen strategies. Hydrogen Shot [40] was initiated by the US Department of Energy which seeks to reduce the cost of clean hydrogen by 80%. Several states have also addressed battery-electric aviation in their national plans, such as Norway [41], that aims to electrify all domestic flights by 2040.

There is a pronounced need for more comprehensive plans which embed carbon capture, removal, and storage technologies as part of the roadmap, and which support voluntary mechanisms for carbon offsets. Certification schemes under ICAO's CORSIA should also qualify carbon removal projects to generate carbon credits. At operational level, countries are expected to transpose the provisions of the Global Air Navigation Plan (GANP) [42] into national legislation and address the needs of the Long-Term Aspirational Goal (LTAG) through implemented operational measures. Regulators can also, for example, aim to render military airspace restrictions more flexibly, or implement the ICAO Aviation System Block Upgrades [32]. In Europe, the long awaited Single European Sky [43] reform that promises to bring important environmental gains is still pending approval by EU Member States.

A priority must be to encourage private sector participation in the earliest stages of development. Such policies can take the form of funding for research and development, grants, guarantees, tax relief, and creating incubator opportunities for technology start-ups working on new fuel and aircraft technologies.

Furthermore, providing incentives to feedstock producers as well as to SAF fuel producers will likely promote the diversification of sustainable feedstocks. Incentives could favor feedstock with high sustainability profiles and integrity, considering the likely associated higher upfront investment. This will enable economies of scale for producing fuels that rely on a variety of feedstock and conversion technology combinations.

The need for a level playing field applies also to how incentives are designed across industries. Aviation is already competing with other sectors for the same resources. Policies should be technology and energy agnostic and must safeguard equal access to scarce resources. Still, in some cases privileged access for specific industries can be warranted, if, for instance, the favored industry has no other viable decarbonization alternative. A case in point is that of the road sector which can more easily electrify, potentially motivating restricting that industry's access to biofuels [44]. In fact, we already see that road transport demand for ethanol, among others, is dropping as the sector electrifies. In the medium term, the importance of e-fuels, i.e., Power-to-Liquid (PtL) [10] fuels will grow as an energy carrier for aviation. E-fuels are produced using sequestered CO_2 and hydrogen from renewable sources, and they have the potential to achieve significant carbon reductions compared to conventional jet fuel. Nevertheless, we expect similar inter-industry competition for green electricity as for bio-feedstocks, and this will also need to be addressed at policy level.

A policy tool which acts more like the stick compared to the carrot of incentives is to impose a mandate on production. Mandates typically constitute an early bet on specific solutions from the governments' side. Given the high risk of perverse outcomes associated with such policies, mandates should only be used as part of an overall strategy that encourages research and development of alternative solutions and provides incentives to effectively promote the technology scale-up. The penalties associated with not fulfilling the obligations under the mandate, nor the outsized pricing power of the mandated producers, must not be allowed to increase the sales price of the product (see SAF Mandates box).

SAF Mandates

With respect to SAF policy, mandates are state-imposed obligations to use a minimum share of SAF. Such obligations can be imposed on suppliers or buyers. Imposing such obligations in excess of the current total production capacity can, in theory, stimulate producers to increase production, though this will depend on other factors as well, including feedstock availability, access to finance for new production facilities, and any potential penalties for non-compliance. The risk of perverse outcomes is high in this context. Mandates can present barriers to entry which can favor incumbents and discourage entrepreneurship. Mandates can also direct investment, research, and development in such a way that new feedstock and new solutions, are overlooked or discouraged as mandates create strong incentives for the use of available solutions.

If applied at the current time, mandates would benefit the well-established HEFA pathway, which today accounts for almost all SAF production, though this could come at the price of discouraging the development of new pathways. This is so because a mandate would favor the pathway, and the few existing producers, that are able to produce SAF today. The result can be an oligopolistic market structure, giving outsized pricing power to the small number of incumbent producers. Competition would be limited as new entrants would face important barriers to entering the market. Therefore, at the minimum, short-term mandates would have to be combined with policies that favor equally the ramp-up SAF production in the mid- to long-run, given the anticipated need to develop and leverage multiple technological pathways and feedstock avenues to meet net zero targets.

Charts 3 – 5 below outline the policies that will be the most needed per energy type over the 2023 – 2050 horizon.

What we have today | 2023 | 2030 | 2040 | 2050

NET ZERO

Chart 3:
Policies to build market capacity in SAF

SAF & CO_2 capture, utilization and storage

What we have today

- UK Jet Zero Strategy – SAF key measure
- Nine conversion pathways approved by ASTM
- UAE SAF roadmap
- US technology grant program and IRA
- EU RED and Critical Raw Materials Act
- UK Jet Zero Strategy includes investment in eight UK SAF plants
- US Clean Fuel Production Credit
- US provides loan guarentees, grants and tax support for CCUS projects
- EU facilitates R&D programs
- US SAF grand challenge
- Five new conversion processes to be approved
- SAF sustainability standards in the EU, US, ICAO

2023 onwards

- Vision documents and policy frameworks in all major states – send clear signals to industry
- Provide tax exemptions and production incentives to SAF producers/blenders in technology and feedstock agnostic manner
- Public-private partnership to develop and execute SAF transition pathway
- Acceptance of global SAF book and claim system and enshrine in lesgiation
- Facilitate access to public credit for sustainable feedstock production
- Global harmonization of SAF sustainability standards
- Incentives for renewable hydrogen production
- Prioritize CO_2 capture deployment for SAF production
- Accelerate R&D for 100% drop-in SAF and new processes and their approval
- Robust and clear process for transferring sustainability documentation – operationalize B&C
- Update vision statements policy frameworks according to status of SAF market
- Mechanisms to limit volatility of feedstock prices
- Facilitate understanding of policymakers for the need for CCUS
- Support R&D for third-generation feedstocks
- Incentives to bring novel feedstocks to commercial readiness
- Facilitate sequestration projects by mapping and assessing geological formations
- Update vision statements policy frameworks according to status of SAF market
- Facilitate low-interest loans and up-front capital grants for new facilities
- Continue increasing renewable electricity capacity and introduce incentives to augment renewable hydrogen capacity
- Assess whether mandates have led to higher production capacity and recalibrate

SAF visions and policy framework | SAF standards and definitions | SAF feedstock | SAF production and infrastructure | Carbon Capture, Utilization and Storage (CCUS)

Chart 4:
Policies to support hydrogen aircraft and hydrogen production

Hydrogen aircraft

What we have today

- ICAO, EU AZEA, EUROCAE, IIWG
- Government funding schemes like EU Clean aviation, UK ATI
- 50+ countries with H_2 strategies
- R&D funding to research centres and technology developers
- EU RLCFA
- National aerospace technology strategies
- US infrastructure law for hydrogen hubs

2023 onwards

- Global hydrogen sustainability criteria
- Scaled-up funding for technology de-risk
- Equipment and sensing standards
- Revision of fuel and sustainability standards
- Support for operators that transition to hydrogen
- Certification procedures for H_2 aircraft
- CfD for hydrogen
- Support for first commercial H_2 flight
- Continuous R&D support to extend range and payload of H_2 aircraft
- Support hydrogen trade as a commodity
- Include H_2 in EU Net Zero Industry Act & Industrial Strategy
- Quality criteria for hydrogen
- Incentives for H_2 production in regions with access to low-cost renewables
- Government support for liquid hydrogen infrastructure

Hydrogen fuel and aircraft standards | Hydrogen aircraft development | Hydrogen production, storage, and distribution

Chart 5:
Policies in favor of electric aircraft

Electric aircraft

What we have today

- National strategies to decarbonize aviation
- Government funding schemes for technology development
- National aerospace technology strategies
- National targets for renewable energy
- Government funded infrastructure feasibility studies like ZEFI

2023 onwards

- Include electric aircraft on net zero industry acts or equivalent
- Define life-cycle sustainability criteria for energy production for electric aircraft
- Incentivize operations of electric aircraft at airports
- CfD for electric aviation
- Harmonization of charging standards for electric aviation
- Accelerate airworthiness certification process
- Consider electric aviation in national industrial strategies
- Funding for infrastructure scale-up: energy generation and charging
- Continuous funding through government R&D programs
- Include aviation on national zero-emission vehicle programs

Electric aviation standards | Electric aircraft development | Electric infrastructure

Acronyms

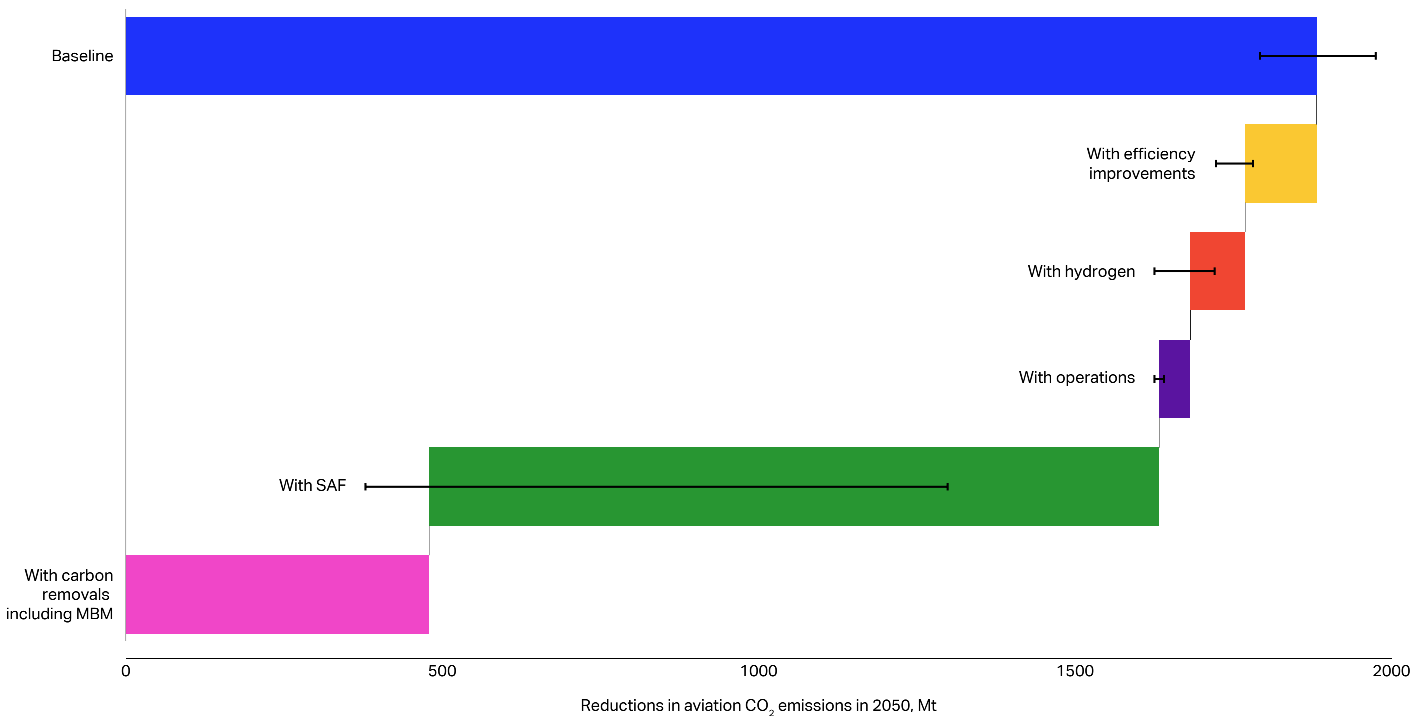
AZEA: Alliance for Zero Emissions Aviation
EUROCAE: European Organisation for Civil Aviation Equipment
CfD: Contracts for Difference
ICAO: International Civil Aviation Organization
IIWG: Internatinoal Industry Working Group
RLCFA: Renewable and Low-Carbon Fuels Value Chain Industrial Alliance
ZEFI: Zero Emission Flight Infrastructure Initiative

Conclusions

Net zero CO_2 emissions for aviation by 2050 is a major challenge and it requires a concerted and coordinated effort by all public and private stakeholders. The Aircraft Technology, Infrastructure, and Operations Roadmaps showed milestones that must be achieved in order for aviation to deliver the emissions reductions required on the course to 2050. Chart 6 below shows how aviation emissions by 2050 could reach net zero if all the levers are applied. The scenarios, however, are bounded by many variables. New more efficient or zero-carbon aircraft could come into service earlier or later than anticipated, shifting the expected reductions from them towards the right or the left of the chart. Operational improvements could also happen more or less aggressively, expanding or limiting their potential. SAF could be deployed at unprecedented scale and completely replace aviation fuels by 2050 or could scale up just enough to meet current obligations. Without the right policies and incentives mentioned on this roadmap, all these achievements will lag. They may happen later, or they may never happen. The key to determining the delivered timeline is very much in the hands of policy makers who, above all, must not delay their action.

Policy is about setting a regulatory framework within which the favorable circumstances are created for the technologies to mature rapidly and scale up successfully. This involves minimizing administrative hurdles, making private investment attractive, and accelerating all processes. All stakeholders of the aviation ecosystem can and must benefit from opting for these technological and operational solutions. Government policy at its best can fairly and efficiently steer the development of the selected economic activities to deliver on the objectives set at national level. The aviation industry cannot decarbonize alone, and the support of regulators and policy makers on this journey is absolutely essential.

Chart 6: Reduction in aviation CO_2 emissions in 2050 achieved through the different levers of action. The solid bar indicates the central case and the black lines indicate maximum and minimum reductions based on the scenarios modeled.



Source: IATA Sustainability and Economics, ICAO LTAG SAF availability scenarios

APPENDIX: Existing Aviation Environment Policies

The objective of aviation policy is to create the necessary conditions for maintaining safe, efficient, sustainable, and reliable air transport operations. Policies create a regulatory framework that enables and facilitates air travel, supporting connectivity. Given the complexity of the sector, there are multiple organizations that have developed regulations, standards, and procedures to cover the full spectrum of aviation. These may have a recommending, guiding, or enforcing character, and be in place nationally, regionally, or globally. This applies also to aviation environment policy. IATA supports the development of global policy and regulatory frameworks that are harmonized across the world and preserve a global level playing field.

Global: ICAO

The United Nations' body overseeing international aviation policies is **ICAO**, the **International Civil Aviation Organization**. Since 1944, ICAO develops policies and standards, undertakes compliance audits, performs studies and analyses, provides assistance, and builds aviation capacity through numerous activities, in cooperation with its Member States. The Chicago Convention, the constitution of air travel, has 19 annexes which must be maintained to reflect to current status of the aviation system. The Standards and Recommended Practices (SARPS), produced by ICAO, are all related to these annexes, and transposed into regulations in the national laws of ICAO's Member States. The SARPS are complemented by manuals that facilitate the implementation of those practices.

ICAO has become increasingly important in steering the aviation industry towards a more environmentally sustainable future (Annex 16 of the Chicago Convention). Key achievements in this area have been the establishment of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) in 2016, and in 2022, a **Long-Term Global Aspirational Goal** (**LTAG**) for international aviation of net zero carbon emissions by 2050 was adopted. This historic agreement reinforces the leadership of ICAO on issues relating to climate change and provides general direction for consistent and harmonized environmental policies. While being an important ambition, which endorses that of the aviation industry expressed in 2021, the LTAG does not attribute specific obligations in the form of emissions reduction goals to individual states. Instead, it recognizes that each state has its own particular circumstances and will advance towards the goal independently. ICAO does, however, provide guidance and assistance to Member States regarding how best to advance the decarbonization agenda.

The **Carbon Offsetting and Reduction Scheme for International Aviation** (**CORSIA**) was agreed upon by the UN Member States under ICAO in 2016 and is the first and only global market-based scheme for capping international aviation emissions. This landmark agreement was possible through the consensus among governments, industry, and international organizations, and it incarnates the global approach which is consistent with the needs of a global industry. Aviation is the only sector to have implemented a global scheme to address its carbon emissions.

CORSIA aims to stabilize the CO_2 emissions originating from international flights after 2019 through incentivizing more efficient operations and the use of SAF. Emissions exceeding an agreed baseline are subject to offsetting, i.e., obliging aircraft operators to purchase emissions units for any emissions exceeding the baseline established. Eligible emissions units can originate from different sources of emissions reductions achieved through mechanisms, programs, or projects. CORSIA is set up as a temporary measure, designed to end in 2035, when global emissions from international aviation should be below the 2019 baseline thanks to technological progress, more efficient operations, and the use of sustainable fuels. After its inception in 2016, the voluntary compliance phase commenced in 2021. CORSIA will be mandatory starting 2024, and obligations will be imposed on a broader set of states from 2027, when it shall cover over 80% of emissions from international flights. CORSIA will then offset around one-fourth of total emissions from international aviation.

European Union

Around 15% of the world's aircraft movements took place within the European Union (EU) in 2019. The EU is one of the world's most significant aerospace hubs, being the home of major aircraft and engine manufacturers, as well as universities and research centers. In addition, EU regulations and directives have an impact on the regulations of all of its members, as they are enforceable directly at state level and often need to be transposed into national law. Developments at the EU legislative level are also closely watched by other parts of the world, and often lead the way in areas such as environmental protection.

The key regulations which affect aviation's decarbonization journey in the European network at the current stage are those being considered within the Fit for 55 regulatory package [45], which is embedded into the overall EU Green Deal. The Green Deal highlights the need for aviation, together with road, rail, and waterborne transport, to jointly reduce emissions in the transportation sector by 90% by 2050, in order to achieve climate neutrality. Fit for 55 refers to the EU's intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. The proposed package aims to bring EU legislation in line with the 2030 goal on the way to net zero in 2050. The key initiatives in the package affecting aviation are the reform of the EU Emissions Trading System (EU ETS), the revision of the Energy Taxation Directive (ETD) and the RefuelEU regulation. Many other regulatory initiatives, such as the Alternative Fuel Infrastructure Regulation (AFIR – also within Fit for 55), the Renewable Energy Directive (RED III), REPowerEU, and Count Emissions EU, also have touching points with aviation and can potentially impact the decarbonization roadmap of the sector.

United States of America

United States of America (US) is currently the world's largest air transport market. In 2019, there were around 852 million air passenger journeys undertaken to, from, and within the US representing 25% of global aircraft movements. In addition, the country is a net exporter of aviation technology, housing some of the largest aircraft and engine manufacturers in the world, notably Boeing and GE Aerospace.

- In 2021, the US government adopted the United States Aviation Climate Action Plan, which describes the country's approach to steering the aviation sector to net zero emissions by 2050. The plan includes the development of new, more efficient aircraft and engine technologies, improvements in aircraft operations throughout the national airspace system, promoting the production and use of SAF, electrification and potentially hydrogen, participation in the voluntary stage of CORSIA, as well as directing support to climate science research.

- In 2022, the US announced the SAF Grand Challenge, a government-wide ambition to reduce the cost, enhance the sustainability, and expand the production and use of SAF, which includes a goal of at least 3 billion gallons per year by 2030 and reaching 100% of aviation fuel uplift by 2050.

- To enable the delivery of the SAF Grand Challenge, the US announced several support instruments in the Inflation Reduction Act (IRA) of 2022. The agreement includes funding for both SAF and hydrogen. For SAF, the plan includes a new Alternative Fuel and Low-Emission Aviation Technology competitive grant program of USD 297 million. It also provides two separate tax credits: a two-year SAF blender's tax credit (BTC) until 2024, and the Clean Fuel Production Credit until end of 2027, in addition to the clean hydrogen production tax credit. It also extends the existing investment tax credit to hydrogen projects and standalone hydrogen storage technology.

China

In 2019, aircraft movements in China represented about 12% of global air transport operations. It has one of the largest domestic aviation markets in the world. Furthermore, China will likely become an important aircraft technology player having recently received a type certificate from the Civil Aviation Administration of China (CAAC) of the COMAC C919 aircraft.

- In 2020, China announced its ambition to peak CO_2 emissions before 2030 and to deliver carbon neutrality before 2060 [46]. In the plan, China aims to expedite the construction of a green and low-carbon transportation system, acknowledging the challenging task to decarbonize aviation. The development of aircraft and engine technology, the use of sustainable aviation fuels, as well as efficiency in air traffic management are mentioned as measures to explore.

- In March 2023, in line with the above ambition, CAAC indicated that a feasibility study is being taken on the plan for the adoption of SAF, consisting of a target of 10% aviation's fuel consumption by 2035 and 50% by 2050 [47]. The feasibility of the target and its enabling policy requirements will be assessed and decided through a new Leaders Group of CAAC which is a restructuration of the CAAC Group on Energy Conservation and Emission Control.

United Kingdom

In 2019, aircraft movements in the UK represented 3% of global operations. While being a key aviation market, the UK also has a prominent aerospace industry, hosting some of Airbus' production facilities as well as one of the largest aircraft engine manufacturers in the world, Rolls Royce.

- In 2022, the UK published the UK Jet Zero Strategy, outlining the state's ambition to reach net zero emissions in aviation by 2050. The key goals within the plan are to enable net zero domestic flights by 2040, a SAF mandate with 10% SAF in the UK fuel mix by 2030, net zero airport operations in England by 2040, an emissions reduction trajectory from 2025, and implementing CORSIA by 2024.

- SAF plays a significant role in the Jet Zero Strategy as the UK envisions to be a global leader in the development, production, and use of SAF and the Strategy ensures there will be at least 5 commercial-scale UK SAF plants in construction by 2025. The key financial instruments are GBP 180 million of new funding, distributed through the Advanced Fuels Fund, and targeted to support the commercialisation of SAF plants and fuel testing. This is in addition to GBP 400 million of funding through a government partnership with Breakthrough Energy Catalyst. Moreover, the UK plans to establish a SAF clearing house to enable early state aviation fuel testing.

- Other ambitions are the delivery of the first net zero transatlantic flight running on 100% SAF – providing up to GBP 1 million of funding, and GBP 100 million for R&D and GBP 1 billion investment for the development of carbon capture, usage, and storage clusters. The UK also aims to double their hydrogen production to up to 10 GW by 2030. To support the development of new aircraft technology, including hydrogen aircraft, GBP 685 million government R&D funding has been granted to the Aerospace Technology Institute (ATI) [48] Programme over 2022-2025. This is one part of the GBP 3.9 billion joint government and industry investment fund for aerospace research and technology development in the UK. Prior to these ambitions, the UK had already established their Hydrogen Strategy.

Brazil

In 2019, aircraft movements in Brazil represented just under 3% of global air transport operations, making Brazil the largest aviation market in Latin America. Brazil is also an exporter of aviation technology, being the home of Embraer, one of the world's leading suppliers of regional jets.

- The Brazilian National Council for Energy Policy (CNPE) published a Resolution in 2021 giving instructions to the Ministry of Mines and Energy (MME) to lead a working group aimed to propose measures to increase the use of sustainable and low-carbon fuels and to decarbonize the transport sector, including aviation. In 2022, the MME established a program called ProBioQAV [49], which sets an emission reduction target for domestic aviation with the use of SAF, starting at 1% in 2027. The program is expected to be introduced in Congress in 2023.

United Arab Emirates

In 2019, aircraft movements in United Arab Emirates (UAE) represented about 1.3% of the global movements, mostly operated by widebody aircraft on medium and long-range routes. It is considered an aviation hub in the Middle East region.

- In January 2023, United Arab Emirates launched a National Sustainable Aviation Fuel Roadmap [53] aiming to accelerate the decarbonization of the aviation sector in UAE. The roadmap contributes to achieving the country's goals in climate neutrality, enhancing fuel efficiency, and maintaining it in one of the vital sectors that support national economies, thus making the UAE a regional hub for sustainable aviation fuel.

- In 2022, UAE also launched a "Power-to-Liquids" Roadmap: Fuelling the Aviation Energy Transition in the UAE" [54], which was drafted jointly by the Ministry of Energy and Infrastructure, and the World Economic Forum (WEF). The roadmap outlines the financial, economic, and environmental benefits of Power-to-Liquid (PtL) in decarbonizing the country's aviation industry.

Japan

In 2019, aircraft movements in Japan represented about 3.5% of air transport operations. Japan also provides components to large aircraft Original Equipment Manufacturers (OEM) and has a tradition of aerospace technology development as well as being a leader in hydrogen development.

- In its Intended Nationally Determined Contribution (INDC) plan in 2021, Japan adopted the goal of achieving at least a 50% reduction in global greenhouse gas (GHG) emissions by 2050 and identified measures which should deliver this ambition. For air transport, the goal mentioned is the improvement in the fuel efficiency of aviation. In 2022, the country published the "Basic Policy for the Realization of Green Transformation (GX)" [50], which sets out its response to the climate and energy crises.

- Japan has set a soft target of replacing 10% of the fuel consumption of Japanese airlines with SAF by 2030 while looking at developing SAF domestically [51]. To accelerate this work, the government has set up a SAF Working Group, which will consider specific measures to encourage Japanese companies to make and use SAF. Furthermore, the Japanese government released a draft Basic Policy for promoting Decarbonization of Aviation, proposing three decarbonization targets and identifying SAF's importance in achieving them.

- In 2017, Japan was the first country in the world to adopt a Hydrogen strategy [52], which aims to increase the country's hydrogen supply to 3 million tonnes by 2030.

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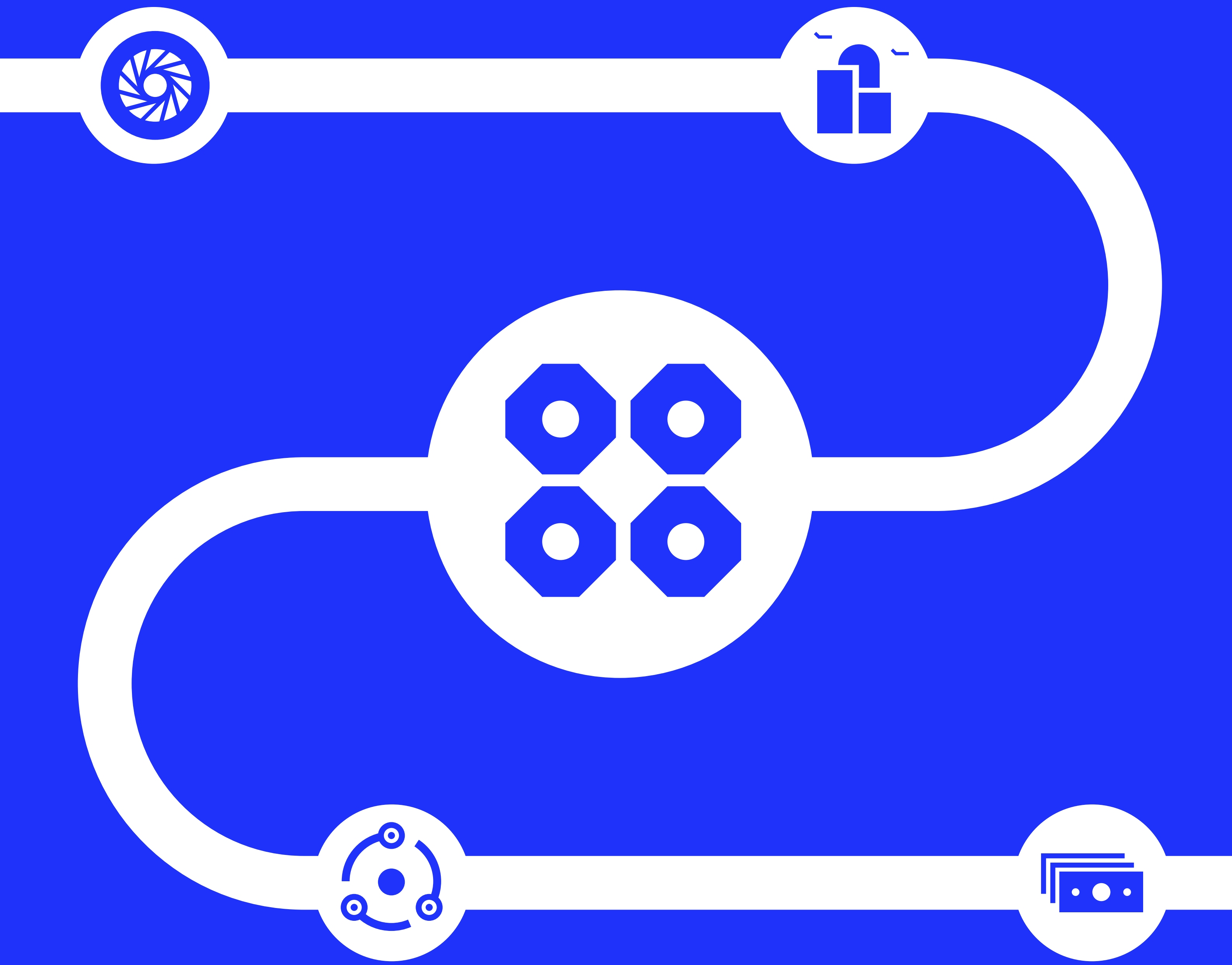

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