FLORENCE SCHOOL OF REGULATION

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POLICY BRIEF

EUROPEAN TRANSPORT REGULATION OBSERVER

Navigating Towards the Decarbonisation of European Aviation

Highlights

Prior to the COVID-19 pandemic, aviation was one of the fastest-growing sources of greenhouse gas emissions, directly accounting for about 3% of the EU's total emissions and more than 2% of global emissions. Even though the crisis has caused a visible drop in air traffic and aviation emissions, the upward trend in emissions will likely resume unless further measures are taken to ensure that the sector's growth is compatible with the European Green Deal objectives.

Following the release of the Fit for 55 Package, a number of legislative processes are underway at the EU level to support the aviation sector's decarbonisation. A key measure in the "Basket of Measures" is increasing the use of Sustainable Aviation Fuels (SAFs), which hold significant potential to reduce aircraft emissions. To this end, the European Commission's recently published ReFuelEU Aviation Initiative seeks to boost the production and uptake of SAFs in the EU, which today account for a mere 0.05% of total jet fuel consumption. Significant efforts will also be needed to develop disruptive technologies to bring zero-emission aircraft to the market. For this to happen, an enabling EU policy framework will need to be put into place, including through the enactment of adequate carbon pricing policies and research and innovation (R&I). The reduction of the EU Emissions Trading System allowances allocated for free to airlines is another avenue the Commission is pursuing whilst closely coordinating with actions at the global level, notably with the International Civil Aviation Organisation (ICAO).

This policy brief draws inspiration from the 16th Florence Air Forum, which took the 2030 and 2050 perspectives on the progressive decarbonisation of civil aviation in the EU and globally. In particular, this involved the examination of the industry's Destination 2050 roadmap, the recently tabled EU legislative proposals and the ongoing work in the ICAO on establishing a long-term aspirational CO_2 goal.

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Decarbonising aviation … but how?

A comment by Matthias Finger, Juan Montero and Teodora Serafimova, Florence School of Regulation – Transport Area

The debate about the decarbonisation of aviation has considerably evolved as of recently: indeed, today we no longer question the urgency or even the necessity to decarbonise, as this has been broadly accepted and recognised by the industry (i.e., manufacturers, airlines, airports and air traffic control). We have now moved on to the next stage, i.e., to the discussion about the best strategy to reach the goal: how to minimise the adverse effects along a transition path? How to orchestrate the necessary actions by the different actors involved in the most effective manner? What should be the role of the public authorities? As reaffirmed by the discussions of the 16th Florence Air Forum, consensus on these questions is yet to be reached.

The European Union has embarked on an ambitious transition plan to meet the goals set in its European Green Deal, i.e., to transform Europe into the first climate-neutral continent by 2050. Decarbonising transport is one of the cornerstones of the Green Deal, it is laid down in its subsequent Sustainable and Smart Mobility Strategy, and followed by concrete legislative proposals as part of the recent Fit for 55 Package.

Within the transport sector, aviation poses a challenge, as it is particularly difficult to decarbonise for technical reasons. In view of this, our 16th Florence Air Forum also debated whether aviation can substantially reduce its emissions without embarking on a significant curtailment of output. And if output were to be negatively affected, should this be promoted, considering Europe's strong commitment to the free movement of persons and goods, among others?

Still, it appears clearly that a smart combination of different measures can steer aviation to net-zero CO_2-emissions by 2050. Reaching this goal is seen as both necessary and doable. The commitment of the European industry has been made forcefully by the airlines, airports, manufacturers and air navigation service providers and is convincingly laid out in its report *"Destination 2050 – A Route to net-zero European aviation"*. This report is only one of many publications from the industry signalling their commitment.

Destination 2050 clearly shows that aviation can continue to grow despite a basket of necessary measures. Already by 2030, net CO_2 emissions from intra-European flights could be reduced by 55% compared to 1990 levels through a combination of four types of measures, namely technological improvements of airplanes (e.g., aircraft design, engine efficiency, electric propulsion) and subsequent fleet renewal, sustainable aviation fuel (SAF), operational improvements, and market-based mechanisms such as the EU Emissions Trading System (ETS). Policies favouring modal shift (e.g., high-speed trains replacing some short-haul routes) can further contribute. The collective implementation of these measures, the industry report claims, could result in a peaking of absolute emissions from European aviation in 2019.

But all this costs and the bill is likely going to be hefty. It is widely understood that the industry cannot make the transition without solid support from the public authorities, both at the EU and Member State levels. And it is not only that the transition will be expensive; in addition, uncertainty, especially when it comes to disruptive technological developments, such as electric- or hydrogen-powered aircraft, poses a level of risk which cannot be borne by the private sector alone. A conducive regulatory framework along with public financial support will therefore be necessary. And the EU has already established a Partnership for Clean Aviation as part of the EU Horizon Europe framework programme for research and innovation; Member States are also active in providing research and development funds. But, such funds should only reinforce private investment, which is already present and growing.

Most other measures, including SAFs, which are technologically already mature, will require "smart regulation", to ensure that these fuels are truly sustainable and that the entire ecosystem evolves in a coordinated manner. Indeed, investment risks can be considerably reduced if the introduction of new aircraft technologies, new fuels, ATM measures, taxes and incentives is well coordinated. No private actor alone can take the lead, as the challenge is too massive for any company to carry on its own. For example, airlines would only be able to commit to sustainable fuels if these are supplied in a minimum number of airports. Conversely, airports and other players will only invest in making these new fuels available if airlines end up making

use of them. Here, the Commission's ReFuelEU Aviation proposal, which seeks to oblige fuel suppliers to blend increasing levels of SAFs in jet fuel taken onboard at EU airports, could be a step in the right direction. Different regulatory tools can and must be used to foster and even impose a coordinated transition.

Such smart regulation will also have to make sure that the competitiveness of the European industry globally is not damaged but, quite to the contrary, is strengthened in the long run. This means that Europe is well positioned as the continent where the most efficient aviation technologies are developed, prototyped, and adopted first. Alliances, both public and private, must be built to convince, and perhaps even help, the rest of the world to embark on the same decarbonisation journey.

All this must be done in a way that ensures a level playing field inside the EU but also globally. The transition should not provide unfair advantages to certain companies against others, nor to certain transport modes against others. A coordinated transition is necessary, but coordination does not mean the preservation of the *status quo*. On the contrary, market mechanisms should reward the players that make the right investments and adopt the best business models. Regulation, including State aid rules and the EU taxonomy for sustainable activities, should ensure that incentives are correct and the transition is fair. There will inevitably be winners and losers, but the role of smart regulation is not to pick the winners but to let them emerge from competing on a level playing field.

Still, it is probably illusionary to think that such an ambitious decarbonisation path can be achieved without reducing demand compared to business as usual. And some form of modal shift is not only desirable but in any case going to take place. Also, the higher costs of new fuels and new technologies capable of substantially reducing emissions will inevitably shift some demand to transport modes which are less challenged, such as railways (which already enjoy the lowest emissions per kilometer and unit transported in Europe[1]). Still, reducing overall demand for air transport should not be a policy objective per se. Air connectivity has always been an important element of European aviation policy, inside some Member States, but more importantly for the EU as a whole. Air is often the main (and sometimes in practice even the only) available transport mode (e.g., islands, remote areas, long-haul trips). As such, the overarching policy objective in this regard remains the mobility of European citizens, albeit now from a more systemic view by the always most environmentally efficient mode of transport.

A decarbonised aviation sector will be a different sector. There will be winners and losers as different technologies will be deployed, new companies will grow, and new business models will emerge. The role of the public authorities is to accelerate the reduction of emissions while ensuring a fair transition, both for industry players and for passengers.

1 European Environment Agency, (2021), *Rail and waterborne – best for low-carbon motorised transport,* https://www.eea.europa.eu/publications/rail-and-waterborne-transport

Main Takeaways from the Discussion

By Teodora Serafimova, Florence School of Regulation – Transport Area

At the start of the past decade, "techno-pessimism" dominated the aviation decarbonisation debate in Europe, leading some to conclude that the only means to curb the sector's emissions is by offsetting or curtailing them (i.e., "demand management"). The debate today has evolved considerably with the emergence of "techno-optimism", whereby policymakers are hoping that the aviation industry can be decarbonised without curtailing its growth. Not astonishingly, this approach also has the support of the industry. Indeed, a broad consensus has emerged over the need for European aviation to decarbonise. This consensus can, at least in part, be attributed to the European Green Deal, which is at the heart of the von der Leyen Commission. Simple market forces and passenger expectations are also playing a role in inducing actors towards decarbonisation, which is increasingly seen as a means for European aviation to gain a competitive advantage. This consensus has been instrumental in the delivery of the Round Table Report on the Recovery of European Aviation at the end of 2020, which highlighted the need to "build back better" post-COVID-19, both in terms of resilience as well as in terms of sustainability.

The Fit for 55 Package, which was released in mid-July 2021, aims to achieve at least 55% reductions in greenhouse gas (GHG) emissions by 2030 compared to 1990 levels. The Package seeks to stimulate innovation, foster investment and create new jobs across the European economy while being fair and socially just for citizens. The European Commission has conducted various impact assessments, which show that the proposals are both ambitious and achievable. The Package constitutes a mix of upgrades of existing legislation, as well as new initiatives, and covers almost all sectors of the economy (i.e., energy, transport, buildings, land use, agriculture, and forestry, among others). When examining the transport sector it is important to also consider the Sustainable and Smart Mobility Strategy, which, besides focusing on decarbonisation, explores ways of improving competitiveness, reinforcing the internal market and creating new business opportunities in the EU.

When it comes to the aviation sector, the Fit for 55 Package remains true to the "basket of measures" approach, which is followed in the International Civil Aviation Organisation (ICAO) context. As part of this basket of measures, the Commission is 1) supporting the development of improved aircraft technologies; 2) promoting further operational improvements through the completion of the Single European Sky (SES); 3) proposing new legislation on sustainable aviation fuels (SAFs) (which gradually increases the blending obligation for fuel suppliers, coupled with a mandatory uplift obligation for all airlines departing from European airports); and 4) pursuing market-based measures, whereby the EU Emission Trading System (ETS) is undergoing revision in respect to aviation, and ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) will be implemented in the EU Member States.

The discussions of the 16th Florence Air Forum explored the industry's and stakeholders' visions for decarbonisation in the context of the recently tabled proposals and EU discussions, but also in light of the UN Climate Conference COP 26, and next year's Environmental High-Level Conference at the 41st ICAO Assembly. The discussions were structured into three sessions, each answering a set of questions.

How aligned are the EU Sustainable and Smart Mobility Strategy, the Aviation Roundtable Report, Destination 2050 Report and (upcoming revised) ACARE Flightpath 2050 in terms of aviation decarbonisation? Where are the interconnections and possible gaps?

The Round Table Report on the Recovery of European Aviation, published at the end of 2020, outlines key policies and asks for the industry to remain viable and recover from the pandemic while also demonstrating its commitment to achieving net-zero CO_2 emissions by 2050. Notably, the report reflects the newly established consensus between the aviation industry, NGOs, consumer organisations and worker representatives on the need to decarbonise aviation. This broad agreement between key stakeholders in society offers a fertile environment for the development of EU policies and legislations.

Similarly, the more recent Destination 2050 Roadmap commits to reducing net-CO_2

emissions from all flights within and departing from the EU by 45% by 2030 compared to the 1990 baseline. In 2030, net-CO_2 emissions from intra-EU flights would be reduced by 55% compared to 1990 levels. The roadmap commits to assessing the feasibility of making 2019 the peak year for absolute CO_2 emissions from flights within and departing from the EU. It also highlights that collaboration is key within and between industries, namely between the aviation and energy sectors, but also between industry and regulators.

Destination 2050 illustrates the extent to which each of the identified solutions in the basket of measures stands to contribute to reducing CO_2 emissions by 2030 and 2050. By 2030, for instance, market-based mechanisms hold the largest mitigation potential, offering to reduce CO_2 emissions by 27% compared to a business-as-usual scenario. Subsequently, after 2030, the reliance on market-based mechanisms diminishes as SAFs and disruptive technologies become more widely available and enter the market. This, in turn, allows for in-sector emission reduction efforts to intensify. By 2050 there is a growing role for hydrogen-powered and hybrid electric aircraft, along with more fuel-efficient propulsion systems, whereas SAFs offer the highest potential. All in all, participants were aligned over the importance of retaining a degree of technology openness and competition when it comes to decarbonising aviation in view of the still uncertain development paths of the various technologies.

Fleet improvement (e.g., putting so-called shark skin onto aircraft) stands to deliver an additional 1.5-3% of extra fuel efficiency, whereas aircraft fleet renewal can achieve up to 15-20% of extra fuel efficiency, participants noted. Keeping in mind the long average life cycle of aircraft, participants stressed the need to ensure that 75% of existing fleets are replaced by 2050, which places significant pressure on the industry. What is more, the COVID-19 crisis has opened the door for valuable experimentation with various operational improvements such as fewer detours, optimal flight level during full flight, and situative steering of air spaces, which in turn, stand to generate up to 10% of industry savings. In a hard-to-decarbonise industry, such as aviation, stakeholders agreed that compensation mechanisms would continue to play a role in the coming decades, though cautioned the need to ensure their careful design and implementation.

While technological measures are set to play a central role, their successful deployment relies on an enabling EU regulatory framework coupled with a robust industrial policy. Though the overall direction taken by the Fit for 55 Package was broadly welcomed, some proposals were viewed as more controversial than others. The Commission's ReFuelEU Aviation initiative, for instance, was commended as an important instrument to stimulate supply and demand of SAFs, though opinions were nuanced as regards its ambition level and future implementation (discussed in further depth in the following section).

While airline stakeholders generally support the introduction of a SAF mandate and a revision of the EU ETS, some hesitations were expressed regarding the enactment of a kerosene tax on the grounds that it would make aviation more expensive without supporting its transformation. Building on this, discussions touched upon the eventual implications of the Commission's new policy package on the industry's external competitiveness and the related question of carbon leakage. In particular, concerns were raised with regards to the possibly heightened risk of carbon leakage and loss of competitiveness on routes covered by the new SAF mandate. Others reassured that the risk of carbon leakage would remain minor, though highlighting that this will largely depend upon the willingness of other States (e.g., Turkey, the Gulf States) to move in the same direction.

Another question participants explored during this session was the extent to which recent decarbonisation roadmaps are aligned with the Paris Agreement's objectives as well as with the latest climate science research, namely the recommendations of the IPCC's 6th Assessment Report. It was pointed out that current policies fall short on two main fronts, in particular. The first one is the failure to address the non-CO_2 effects of aviation. Last year EASA published a comprehensive study, which outlines the non-CO_2 climate effects of aviation while also underlining various policy measures to address these. Some participants urged the need to incorporate the proposed measures into EU policies and legislation.

Despite significant improvements in our understanding of the atmospheric conditions, which lead to the creation of contrails, participants called for further research on the non-CO_2 impacts of aviation in relation to contrails. This,

in turn, would be instrumental in enabling the implementation of operational procedures to prevent contrail creation and presents a great co-benefit from the deployment of SAFs, which are found to reduce the formation of contrails.

Secondly, some participants highlighted the lack of policies targeting an immediate reduction of both the CO_2 and non-CO_2 effects of aviation. Given that the current EU policy framework does not foresee the deployment of large quantities of SAFs in the next decade, the most effective way to reduce the CO_2 impact of aviation, some argued, would be through demand management (i.e., a reduction of flying). To put things into perspective, the International Energy Agency (IEA), in its 1.5 Degrees Report, concludes that a 12% reduction in flights – targeting long-haul flights - could reduce aviation emissions by 50%. In view of this, some participants highlighted the need for demand management to be increasingly considered as part of the broader basket of decarbonisation measures.

Even though modal shift has featured prominently in the political debates in Europe, we have not observed the adoption of aggressive demand management policies across the industry. The question of demand management was studied at length in the production of the Destination 2050 roadmap. It was found that the various measures foreseen in the roadmap would bring the price of flying upwards, which in turn would reduce demand. The collective impact of the proposed basket of measures on demand was estimated to represent roughly 12-13% of all reductions by 2050. The Impact Assessment of ReFuelEU Aviation initiative, too, was found to have an impact on demand. The management of demand is clearly linked to the policy options that have been proposed, specifically the taxation of the fuel, where we would see a major price hike. By 2030 fuel costs could increase by 90%, which is significant, especially bearing in mind that roughly a third of airline costs are linked to fuel consumption.

The impact on demand could be especially powerful across the smaller and regional routes within Europe, which are not served by rail. Some participants warned against the imposition of additional taxes on short-haul flights or their banning altogether, given that the regional segment offers a particularly important testing ground for disruptive zero-emission technologies. Furthermore, since most aviation emissions stem from long-haul flights, where modal shift has a very limited role, stakeholders noted that it cannot be considered a prime lever to greening the industry.

On a more practical note, other participants pointed out that the EU's competencies in the field of demand management are limited, given that airport capacity expansions and corporate travel policies fall outside of its remit. While demand management is not an objective of the European Commission per se, it could be a side effect of its policies if these increase the cost of flying (e.g., more expensive fuels and higher ETS bills). High energy prices are likely to lead to a rise in the price of all goods and services, impacting European households' capacity to travel as a whole. Drawing on this, participants noted that demand management needs to be approached from a broader perspective, taking the entire economy, not only aviation, into consideration.

In sum, the discussions of the first session reflected a broad alignment of views on the overall objectives and level of ambition set for the decarbonisation of European aviation. Similarly, participants agreed on the importance of pursuing the full "basket of measures" due to the absence of a silver bullet for aviation. Divergent views, however, emerged about some of the concrete instruments, with taxation and demand management, in particular, being the most controversial. Another particularly disputed question pertained to the external competitiveness' implications of the enacted greening measures and how best to address the risk of carbon leakage. Drawing on this, participants favoured a gradual phase-in and careful monitoring of the various measures so as to allow for their subsequent adaptation if and where needed.

What EU policy framework support is needed for the two major avenues, i.e. Sustainable Aviation Fuels and "zero-emission" aircraft?

Fuel use and efficiency in aviation have improved by 80% from the dawn of mass travel (i.e., with the appearance of the Boeing 747 during the 1970s). However, these efficiency gains have been largely outpaced by the rebound effect, i.e., the exponential growth in air traffic and emissions. With roughly two-thirds of global emissions stemming from flights under 4000 km, there is clear scope for technological disrup-

tion in this segment (ICCT, 2019). Regional and short-haul flights have been the prime focus of greening measures, where there is an industrial opportunity for a new breed of aircraft to enter the market as of the 2030s.

As highlighted in the Forum's first session, some decarbonisation pathways, such as SAFs, for instance, are already technologically mature and ready to be scaled. The debate here mainly concerns the additional costs and the level of ambition, especially in the short run. Drawing on the fact that a blending mandate of 5% in 2030, as per the Commission's proposal, would translate into 95% of fossil jet fuel by 2030, some participants argued that SAF production levels can realistically increase to 10% of total EU jet fuel demand by 2030. In fact, 60 companies across the value chain, including 20 airlines, have already committed to achieving a 10% SAFs blend by 2030. Indeed, if industrial capacity increases faster than anticipated, the EU SAF mandates should be reviewed and tightened accordingly. This underlines the need for constant monitoring and adaptation of the regulatory framework.

Proponents of a 10% SAF blending mandate by 2030 argued that this level is feasible, but requires a number of supporting components, such as preferential feedstock access for the aviation sector and a solid and long-term policy framework to support both airlines and SAF production itself. A SAF blending mandate can efficiently be implemented via an obligation on fuel suppliers, which is seen as the easiest method to operationalise a mandate and limit market distortions. Blending targets, it was argued, should also include clear sub-targets for advanced production pathways, such as Power-to-X (PtX), that offer higher decarbonisation potential but are not yet as technologically advanced and thus require continued support. An effective mandate could be implemented via a volumetric target or a GHG intensity reduction target. A harmonised global approach (i.e., at the ICAO level) to scaling up SAF production was the preferred approach to ensure a level playing field. Thus the ReFuelEU Aviation initiative was well received as a first regional initiative.

Other particpants stressed the need to ensure adequate financing support for the production and uptake of SAFs, especially in the case of raised ambition. Indeed, increasing SAF production will require significant public financial support in the range of €120 billion over 15 years. The majority of this sum would go to advancing the development of PtX and other cutting-edge technologies. This support is required to both reduce the risks for private investors and decrease the cost gap between SAF and conventional fossil jet fuel.

Stakeholders cautioned that in order to be considered a genuinely net-zero fuel, SAFs need to be produced by means of direct air capture (DAC) in terms of a synfuel approach, as opposed to using a point source from a steel or cement factory, for instance. In fact, synfuel production was found to require roughly three times the amount of energy needed to produce, distribute and store hydrogen at airports. This, in other words, means that putting hydrogen onboard aircraft could enable two-thirds of energy savings. In view of this, it was argued that drop-in SAFs are to be seen as a mere transitional technology, which will eventually give way to zero-emissions aircraft, namely battery-electric, liquid hydrogen and fuel cells. Drawing on these takeaways, some stakeholders questioned the interplay between hydrogen as feedstock for power-to-liquid (PtL) or fuel cells, and more generally, whether EU policy is going in the right direction by channelling scarce financial resources into PtX if the future of aviation appears to be hydrogen-driven.

Some participants noted that we might be observing the start of the fourth revolution in aviation and called for the need to demystify and prove that zero-emission flight for larger aircraft (ca. 50-100 seats) based on fuel cell propulsion is feasible. In fact, many of the technologies necessary to build zero-emission aircraft exist today. Still, work remains to be done on long-distance hydrogen-powered flights, either related to hydrogen burning or hydrogen fuel cell type powertrains.

Venice International Airport, in particular, was presented as an interesting testing ground for zero-emission aircraft carrying passengers from small airports to hubs to enable onwards travel and vice-versa. There are currently roughly 3700 airfields around Europe, where air and noise pollution regulations restrict air travel. Zero-emission aircraft, which are approximately 10 decibels quieter than conventional jet engines, could offer an opportunity to revive these airfields, thereby easing congestion issues at major hubs. Though zero-emission aircraft can be built, an eco-systemic approach and regulatory changes will be

needed to enable the utilisation of airfields and airports that today are not considered transportation hubs.

Whereas there is a clear case for battery-electric propulsion over shorter distances, battery density continues to hinder the development of long-haul aircraft. On the other hand, hydrogen enables longer range flights, given that it enjoys a higher degree of infrastructural independence than battery-electric aircraft. In other words, charging could be limited to only once per day or per night, thereby allowing for uninterrupted operation throughout the day at airports that do not necessarily dispose of hydrogen refuelling infrastructure. Therefore, hydrogen was viewed as a viable solution for regional commuter aircraft (up to 4000 km and probably up to 8000 km). Liquid hydrogen for long-range aviation is likely to happen in the second half of this century. Participants urged the need to ramp up the production of green hydrogen, regardless of whether it would be used onboard aircraft or for synfuel production.

Getting the short- and medium-range segments of the market to run on hydrogen, however, requires massive infrastructural and system-level changes. The amount of public and private funding that will have to be channelled into research on clean aviation is estimated to exceed €12 billion over the next decade. Product development, on the other hand, will necessitate at least four times that amount of funding if we look at three new aircraft types. But the market opportunity is also tremendous, surpassing €5 trillion by 2050. And these figures only take into account the fleet, but the infrastructure needs to be factored in too.

In sum, participants were united in supporting the need to pursue all the different avenues to decarbonisation. Whereas drop-in fuels such as PtL will be key in the long run, in parallel, investments will be necessary to develop new aircraft concepts and a whole new energy system. The full "basket of measures" will be paramount to cater to various segments of the market. The real costs linked to building and operating new technologies are yet to be fully understood, based on which policies would have to be adapted accordingly. Going forward, incentives will have to be created through, among others, the EU ETS (e.g., scaling up revenue generation to support the development and deployment of new technologies). The green taxonomy on sustainable activities will be instrumental in guiding both public and private investment. The ongoing review of the State aid guidelines for aviation, which, in their current form, are restrictive in terms of environmental State aid, would have to be opened up to foster the green transformation of the sector. Last but not least, the zero-emissions and SAFs alliances, which will bring together stakeholders along the value chain starting from next year onwards, will play a key role in advancing the sector's greening.

How to extend the EU framework and approach to the global level? How to drive ICAO towards decarbonisation?

As it emerges from the COVID-19 crisis, the aviation sector needs to confront two main challenges: boosting its resilience to demand shocks in the long term and decarbonising in line with the net-zero carbon vision by 2050. Meeting these challenges will require unprecedented efforts in terms of technological innovation, energy transition, aircraft design, airport infrastructure and not the least, investments. All of these will necessitate an adequate level of regulation and policy support.

The EU's decarbonisation objectives are clearly laid down in its European Green Deal. The Commission's recent Fit for 55 Package puts forward 13 legislative proposals with a view to achieving the additional GHG emission reductions by 2030 in line with the tighter at least 55% emission reduction target. Among the initiatives of the recent Fit for 55 Package is the revision of the EU ETS Directive, where the Commission has proposed the phasing out of free emission allowances to airlines and the alignment with ICAO's CORSIA for traffic with third countries. Another proposal is the revision of the Alternative Fuels Infrastructure Directive, which requires securing clean electricity supply in the core airports. The ReFuelEU Aviation initiative, on the other hand, seeks to oblige fuel suppliers to blend increasing levels of SAFs in jet fuel taken onboard at EU airports.

All of the legislative proposals comprised in the Package will have to be implemented in coherence with international obligations through the ICAO process. Europe is a strategic player within the ICAO framework and assumes a leadership role in formulating policies and adopting standards and recommended practices (SARPs) related to aviation's environmental impact. The

Monitoring, Reporting and Verification (MRV) process within CORSIA, for instance, has been largely built upon the experiences and architecture of the EU ETS' MRV system. In this regard, the EU has a collective role to contribute its expertise and experiences to the global process and to drive the rest of the world in the same direction. The US has, in fact, recently demonstrated its willingness to show stronger environmental leadership at the ICAO level by implementing CORSIA and by supporting the adoption of a Long Term Aspirational Goal (LTAG). Illustrative of this change, the US administration plans to release a comprehensive aviation climate plan in the coming months[2]. Moreover, the US has implemented a tax credit for aviation fuel that reaches a reduction of at least 50% of CO_2 emissions over the lifecycle of the fuel, and has put into place incentives to ramp up SAFs production along with announced investments totalling $3.4 billion to support SAFs within the US. Whereas the EU and US ambitions on the aviation decarbonisation front may be somewhat similar, the foreseen means and pathways to achieving these ambitions vary.

ICAO has a crucial role to play in acting as a driving force for convergence among countries. It was argued that a growing link between the EU and US might help to mobilise ambition in the lead up to the 41st Assembly in October 2022. In addition to public alliances, the support of the industry will be paramount for securing a consensus. Globally increasing numbers of airlines have announced commitments to achieving net-zero emissions. Forty-nine airlines representing approx. 41% of global passenger traffic have made individual commitments to net-zero carbon emissions by 2050 or even before that date. More recently, the global air transport industry (IATA) announced its commitment to achieving net-zero carbon emission by 2050, thereby also aligning with the Paris Agreement objectives. This sends a strong signal ahead of the UN Climate Conference, COP 26, and next year's ICAO Assembly.

Notwithstanding, ambitions on their own do not suffice, and these need to be backed by the ICAO level, to ensure these are achieved while safeguarding a level playing field. In particular, participants underlined the need for an ICAO roadmap, which addresses the specifications required for the new technologies and new fuels, such as hydrogen and SAFs.

Participants drew attention to the operative paragraph 9 of the 40th Assembly resolution on the Long Term Aspirational Goal (LTAG), given its strong interrelation to the forthcoming Assembly discussions. Using particularly non-committing and unambitious wording, the resolution requests the Council to continue to explore the feasibility of the LTAG for international aviation, by conducting detailed studies assessing the attainability and impacts of any goals proposed, including the impact on growth as well as costs in all countries, especially developing countries, for the progress of this work to be presented to the 41st Session of the ICAO Assembly. Assessment of options for a long-term goal should include information from Member States about their experiences working towards the medium-term goal of carbon neutral growth from 2020.

The need for GHG emissions reductions was explicitly mentioned for the first time in an assembly resolution back in 2005, at which point it formed a highly disputed issue, preceded by intense political discussions. A secret ballot has revealed that 25 States opposed the latest assembly resolution, ten states did not indicate their positioning, and six abstained from voting altogether. Therefore, a significant number of States have not made public their position in terms of acceptability and ambition of a potential long-term goal.

However, discussions on the LTAG transcend beyond political decisions to the technological pathways and their acceptability. In particular, divergences in positions have been observed during the LTAG process regarding liquid hydrogen, the inclusion of new fuels, and the associated new aircraft technology. A common understanding is yet to be secured on the emissions reduction potential of advanced aircraft concepts. Failure to ensure that breakthrough aircraft technologies are widely accepted and supported globally could create technological challenges for a global sector such as aviation, where airport infrastructure around the world would have to be adapted accordingly.

Regional and State analyses of the impact and costs have been another critical topic. A number of States, having shown interest in an LTAG, do not necessarily have a clear understanding of the related impacts and costs on their economies and aviation sectors. Furthermore, participants noted that the linking of various climate change-related topics during the last assembly meeting has

2 Published on 9 November 2021: https://www.faa.gov/sites/faa.gov/files/2021-11/Aviation_Climate_Action_Plan.pdf

led to compromises being made about one topic to achieve progress on another, e.g., the role of CORSIA in relation to the technical in-sector reduction.

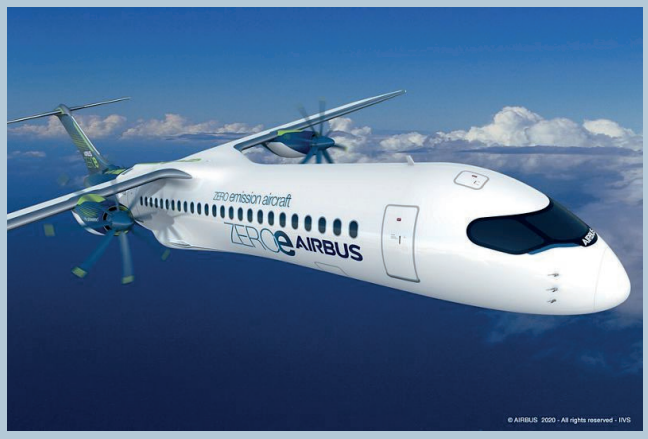
While participants echoed the need to embrace the sustainability objective worldwide, concerns were expressed as regards ICAO's ability to keep up with the EU's pace and binding level of ambition. Some participants, moreover, questioned whether ICAO provides a useful forum to advance discussions on the decarbonisation of aviation altogether. To illustrate this argument, it was argued that ICAO has no capacity to adopt sufficiently ambitious measures (e.g., to develop electro-fuels or new aircraft technologies) needed to achieve a long-term goal. Similarly, concerns were expressed with regards to CORSIA's added value, in case its offsetting rules fail to prevent double-counting of emission reductions. Others, however, reminded that CORSIA is the only global scheme in place, and as such it deserves further efforts to render it an effective instrument.

Some also argued that despite the largely international nature of aviation a more effective path to decarbonising aviation could come from a bottom-up approach, whereby national governments take responsibility for aviation emissions by including them into their intended nationally determined contributions (INDCs) committed through the Paris Agreement. It is precisely through such a bottom-up approach that China has committed to achieving net-zero emissions by 2060, whereby aviation is included in its national net-zero target. All in all, there was no consensus among participants as to whether a top-down or a bottom-up approach is to be preferred in climate policy whereas the largely international nature of aviation cannot be ignored.

Getting to zero-emission aviation is a system-level challenge

A comment by Ron van Manen, Head of Strategic Development, Clean Sky 2 Joint Undertaking

The journey towards climate-neutral aviation must be approached from 360 degrees.



Aviation has an impressive track record when it comes to efficiency – it has reduced the amount of fuel burned per revenue passenger kilometre (RPK) by no less than 97.5% since the dawn of post-war international aviation.

However, the aviation sector quadrupled in size in the thirty years up to 2019. That meant that even though each new generation of aircraft was more energy-efficient than ever before, net emissions continued to rise, “only doubling” within the same timeframe.

But this is no longer acceptable. If we want to prevent the worst of the IPCC’s climate scenarios, then driving emissions down to absolute zero is the only acceptable route to take.

That’s no easy challenge, especially as aviation is one of the hardest sectors to decarbonise. The energy needed to take off and fly, and distances flown are of a completely different order of magnitude compared to most ground transport. Hence solutions on the ground such as ‘battery electric vehicles’ will play only a very modest role in aviation.

Clean Sky Joint Undertaking has been at the forefront of aviation research in Europe for the past 14 years, bringing together industry, academia, SMEs and research centres to deliver cutting-edge innovations. We’ve investigated a wide range of technologies, from new propulsion options, including electrification, to novel aircraft shapes and innovative systems. The Clean Sky programmes are on their way to enabling a 20 to 30% efficiency improvement over the best aircraft commercially available today. But ultimately, that alone will not be enough either. We need to look beyond the fuel or energy efficiency and re-imagine the full system, including the energy onboard, and develop approaches that are carbon-neutral.

Sustainable aviation fuels, or SAFs as they are known, are one stepping stone along the road to low-carbon flight. Essentially, SAFs are still kerosene, though produced in a different way. They are referred to as a ‘drop-in’ fuel because they can essentially be mixed in with or swapped for kerosene, with only very modest revisions in aircraft fuel systems. There is no need to alter the aircraft design or the refuelling systems at the airports. Proponents of SAFs claim that they are low ‘net carbon’ because fossil fuels are not burnt. Instead, the fuel is created by combining CO_2 from plants or other sources with hydrogen to make kerosene. At the end of the day, there is still a release of carbon into the atmosphere, so this method is not emission-free. In fact, its ‘net emissions’ reduction only occurs when the CO_2 released is recaptured from the atmosphere.

In industrial-scale refineries, the CO_2 used for the production of these SAF often comes from point sources – bio-waste, steel mills, refineries, cement factories. What is often forgotten is that these emissions could have been captured and sequestered. So re-using the CO_2 does not really provide a full net reduction of emissions: at best, these net reductions are ‘shared’ between the source and the user of the fuels, i.e. aviation.

The only way to make SAFs truly ‘net zero’ is if we can perfect Direct Air Capture. This involves capturing the CO_2 directly from the atmosphere, which is later released back into the air when the SAFs are burned as fuel. But this methodology will take decades to mature and become cost-effective. And the energy required to produce SAF in this manner is almost threefold what would be needed to produce, liquefy and distribute hydrogen and an energy source.

As a consequence, in the new Clean Aviation Partnership, developing hydrogen as on-board energy source or ‘fuel’ is going to be a key area of focus. The new Partnership is going to focus on three main thrusts as priority areas moving forwards. They are:

- Hybrid electric and full electric regional aircraft concepts
- Ultra-efficient short and medium-range aircraft architectures
- Disruptive technologies to enable hydrogen-powered aircraft.

A massive 2/3 of all emissions come from flights that are less than 4000 km in length, and more than 80% of the aircraft that travel those routes are single-aisle or regional aircraft. Notwithstanding regular updates, the basic designs are from the 1960s and 1980s, meaning now is the time to re-imagine short- to medium-range aircraft and bring 'clean sheet' solutions to the market.

Clean Aviation will aim for a revolutionary leap in these technologies. Rather than continuing a step-by-step process, we need to make drastic, disruptive breakthroughs. We must take a skip-a-generation leap in technology before 2030 – and we see that energy efficiency gains of 30-50% are possible.

Massive change is required in the aviation sector to make climate neutrality a reality. The complexity of the aviation system and of flight itself means that we will need system-wide transformation, encompassing everything from fuels and aircraft to airport infrastructure, down to the routes and networks that we fly.

Europe now has a unique opportunity to lead the global transformation towards climate-neutral aviation. Rapid, ambitious investment in innovative and disruptive research across a broad range of technology streams will be needed.

With the support of all aviation sector players – industry, universities, SMEs and research centres – as well as public policy and financial instruments to fuel this journey, decarbonisation by 2050 can be a reality. There is no time to lose – the time to start was yesterday.

Regional flights: an important testing ground for disruptive greening technologies

A comment by Martina Di Palma, Sustainability Manager at European Regions Airline Association (ERA)

In recent years, climate change has become increasingly important at a global level, with the aviation sector receiving growing pressure and scrutiny to reduce its environmental impact. The COVID-19 crisis has only increased the pressure on the industry to act. In November 2020, the European aviation ecosystem published the Aviation Roundtable (ART) report on the recovery of European aviation from the COVID-19 crisis, underlining the need for the recovery to be compatible with CO_2 emission reductions.

As a result, five European Aviation associations, A4E, ACI Europe, ASD, CANSO and ERA, published in February 2021 *Destination 2050 – A route to net zero aviation* report. The report presents a concrete vision and a series of commitments from the industry to achieve -45 per cent CO_2 emission reductions by 2050 and to achieve net-zero CO_2 emissions by 2050 by addressing technological improvements, sustainable aviation fuels, ATM and operational improvements and market-based measures. The two commitments are in line with the EU's own targets of CO_2 emissions reductions by 2030 and carbon neutrality by 2050.

This is only possible via collaboration, which is key. We not only need collaboration within the aviation industry but also between the industry and energy industries. Most importantly, we need policymakers and regulators to align with our industry, and in particular, the sector asks for, among other things:

- funding for research programmes to enable development and deployment for breakthrough technologies;
- support industry investments via incentives;
- realisation of the Single European Sky (SES);
- a coherent long term policy framework for SAF; and
- strengthening of the EU ETS and high standards for CORSIA offset credits.

We need national governments and the European Union (EU) to establish a policy framework that enables the industry to decarbonise that provides clarity and the necessary stability. The European Commission (EC) published in July 2021 the Fit for 55 Package, with relevant proposals for the aviation sector: the EU ETS, ReFuel EU Aviation and the energy taxation. Now it is time for the European Parliament (EP) and European Council to play their role and make sure that these proposals are aligned with the industry targets and allow for the greening of the sector. Member States must, in particular, avoid unilateral approaches that we are currently witnessed when it comes to short-haul flight bans and taxation.

For the past year, regional aviation has been finding itself at a crossroads between innovation and the political and public pressure to reduce passenger volumes. Recently there have been various announcements throughout Europe on the banning of short-haul routes in order to reduce the environmental impact of aviation. However, banning short-haul routes and shifting to rail is only a 'cosmetic' measure as most of the CO_2 emissions from the sector, circa half of the emissions, come from long-haul routes, while short-haul is responsible for 4.3 per cent in Europe[3]. Therefore, the regional sector is finding itself justifying its very purpose of existence: providing connectivity. ERA airline members connect parts of Europe where air transport is both vital and often the only mode of transportation available to inhabitants in remote regions, islands and dispersed areas.

In addition to this, the short-haul segment can offer the necessary push for the decarbonisation of the sector as it provides the testing ground for the new technologies that will enable the transition to a more sustainable industry. Electric and hydrogen-powered aircraft, for example, will be made first available on short-haul routes by 2035 and then on longer routes beyond 2050.

It is therefore important that the EU and Member States focus on solutions that can actually provide CO_2 reductions, such as the ones listed above, and not hinder the progress and potential with initiatives like banning short-haul routes.

3 Eurocontrol Data Snapshot 4 on CO2 emissions by flight distance (link)

How the 41st ICAO Assembly in 2022 could become a game changer

A comment by Michael Lunter, Senior Policy Advisor Sustainable Aviation, Dutch Ministry of Infrastructure and Water Management

Against the background of extreme summers and natural disasters and an alarming report of the IPCC, there is no time to waste, and there is a clear need to take action to limit temperature rise to a maximum average of 1.5°C above pre-industrial levels. The associated reduction in CO_2 emissions will have to come from every anthropological source, including the aviation sector. The aviation sector has consistently increased its fuel efficiency resulting in a step-wise reduction path of more than 80% lower emissions since the early sixties. However, times have changed, and the outlook is entirely different as compared to 40 years ago. World air travel has exponentially increased with annual growth rates of 5-6%, or even more in some regions, and typically outweighed the fuel efficiency gains in terms of CO_2 emissions reduced with an annual average of 1.5 to 2%. The 'traditional' approach of further improvements in engine performance and aircraft technology will however not be enough to meet the climate goals. Despite the effects of Covid-19 restrictions on international aviation, many still hold the expectation that the aviation sector will recover and that air travel demand will grow to a level that merits radical changes in the aviation sector. Changes that will have to start now to be effective in 15-20 years' time considering the period needed to bring new technology at a level of technical and economic application.

Over the past decade, industry has shown to be well aware of the challenges involved in a transition to sustainable aviation. Industry was, in fact, a driving factor behind the political will to reach a consensus on the development of a CO_2 technology standard for airplanes and the carbon offsetting and reduction scheme for international aviation (CORSIA) by the International Civil Aviation Organisation (ICAO). And now again, with its continued responsibility to meet the goals of the Paris Agreement, the ICAO seem to need a push from the industry such as with recent roadmaps by IATA (Waypoint 2050 (2020)) and by the European industry (Destination 2050 (February 2021)), while at the same time it is developing the input for a decision on a long-term aspirational goal for international aviation at the 41st ICAO Assembly in 2022.

The question at the Florence Air Forum addressed the possible influence of ambitious policies on that decision, such as the European Green Deal and the development of the Fit for 55 package that includes legislative proposals relating to aviation amending the EU ETS. But how to take that ambition to the global level, given that the atmosphere at the negotiating table does not seem to be as constructive as it was around the undersigning of the Paris Agreement? Instead, some players closely involved in the ICAO process observe that there is now a more intoxicated atmosphere and foresee complicated and tough negotiations.

Still, similar to the CoP in Paris, the climate talks at the CoP26 in Glasgow may affect the discussions in ICAO by pushing the willingness to take a decision on a long-term reduction goal. Traditionally, such a decision depends on a number of interrelated topics, with the first periodic review of CORSIA being one of them. Clear support from Europe for CORSIA as an important element in the package of CO_2 reduction measures will be necessary. At the same time, non-EU states will follow closely what a revision of the EU ETS entails for their airlines and how this may affect the working of CORSIA. Ultimately, the long-term goal itself will be at the centre of the debate whilst bearing in mind that the decision to task the ICAO Council to execute the work, as laid down in the Assembly resolution 40-18, was a hard-fought compromise. That compromise was further weakened by the result of the voting. The support for the resolution text was a seemingly big win, but with 92 states in favour out of 127 states voting, there are still more than 60 members of ICAO whose opinion remains unclear. With some states reconsidering their position and if it would come to a vote at the 41st ICAO Assembly, it may get very close, and a decision may be postponed until the next assembly. This is an option that has been advocated by some states already. Therefore, building a solid basis with like-minded states is crucial now at the CoP26 and afterwards. Using the momentum created by the recent announcements of industry and their roadmaps and mobilising their influence could be helpful. Finally, there is a lot of wisdom in getting a better understanding of the concerns and objections states may have with agreeing to a long-term emissions reduction goal for in-

ternational aviation. What can make states feel more comfortable, and how can a situation be avoided where advanced concepts and a fundamental energy transition will primarily benefit the North-American and European states and their aviation sector?

FSR Transport

The Florence School of Regulation (FSR) is a project within the European University Institute (EUI) focusing on regulatory topics. It works closely with the European Commission, and is a growing point of reference for regulatory theory and practice. It covers four areas: Communications and Media, Energy (Electricity and Gas), Transport, and Water.
The FSR-Transport Area's main activities are the European Transport Regulation Forums, which address policy and regulatory topics in different transport sectors. They bring relevant stakeholders together to analyse and reflect upon the latest developments and important regulatory issues in the European transport sector. These Forums inspire the comments gathered in this European Transport Regulation Observer. Complete information on our activities can be found online at: fsr.eui.eu

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