OECD Taxation Working Papers

Greening International Aviation Post COVID-19

What Role for Kerosene Taxes?

Abstract

This paper discusses the contribution that kerosene taxes could make to decarbonising international air travel post COVID-19. Reaching climate neutrality by mid-century requires that all sectors, including aviation, cut emissions strongly. The paper argues that clarity on decarbonisation targets, including through carbon price signals in the form of kerosene taxes, will support an orderly transition in aviation. A gradually increasing tax on kerosene can strengthen the incentives for investment and innovation in clean aviation technologies. Taxing kerosene would also provide implementing countries with tax revenues that could be used to support clean investment and innovation, while addressing competitiveness and equity issues. Where legal obstacles to taxing kerosene exist, these can be overcome by renegotiating the relevant air service agreements.

Résumé

Ce document s'intéresse au rôle que les taxes sur le kérosène pourraient jouer dans la décarbonation du secteur du transport aérien international dans le contexte de l'après-COVID-19. Pour atteindre l'objectif de neutralité climatique d'ici au milieu du siècle, tous les secteurs, y compris celui de l'aviation, devront fortement réduire leurs émissions. Les auteurs estiment que définir des objectifs clairs en matière de décarbonation, notamment au moyen de signaux de prix du carbone prenant la forme de taxes sur le kérosène, permettrait d'assurer une transition ordonnée dans le secteur du transport aérien. Une augmentation progressive des taxes sur le kérosène peut renforcer les incitations à l'investissement et à l'innovation dans des technologies aéronautiques propres. La taxation du kérosène générerait également, pour les pays qui mettraient en œuvre une telle mesure, des recettes fiscales qu'ils pourraient utiliser pour soutenir l'investissement et l'innovation, tout en remédiant aux problèmes de compétitivité et d'équité. Les obstacles légaux à la taxation du kérosène pourraient être levés par une renégociation des accords de services aériens concernés.

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Executive summary

International aviation's emissions are significant and remain largely untaxed. If international aviation were a country, it would be among the world's ten largest emitters of CO_2. The aviation sector as a whole accounts for approximately 11% of CO_2 emissions from transport. Given that emissions from other modes of transport are typically more heavily taxed, this creates an uneven playing field, which also has equity implications, as richer households tend to fly substantially more than poorer ones.

Reaching climate neutrality by mid-century requires that all sectors, including aviation, decarbonise. One of the challenges in aviation is the current lack of inexpensive low- and zero-carbon technologies, which means that substantial progress is needed to develop cleaner alternatives.

While urgent action to reduce emissions in the aviation sector is required, the sector is also trying to recover from the massive impact of the COVID-19 pandemic. With many airlines and related industries receiving considerable government support, now is the time for policymakers to be setting the ground rules for the industry in a decarbonising world.

In this context, a strong commitment to a meaningful and predictable long-term carbon price trajectory is needed. This can be achieved through kerosene taxation as long as countries credibly commit to gradually increasing tax rates over time. Where legal obstacles to taxing kerosene exist, these can be overcome by renegotiating the relevant air service agreements. The Chicago Convention is not an obstacle to taxing kerosene that is taken on board at the point of departure. The European Union's Energy Tax Directive, which is currently under revision, already contains a procedure that would allow European countries to enter into bilateral agreements to start taxing kerosene for flights between themselves.

A predictable carbon price can support the process of 'building back better' and create the incentives needed to accelerate investment and innovation in clean aviation technologies. Taxing kerosene would also provide implementing countries with tax revenues that could be used to support clean investment and innovation, while addressing competitiveness and equity issues.

Failure to create the conditions today for the decarbonisation of the aviation sector will leave the industry and its workers more vulnerable in the future. Clarity on decarbonisation targets including through carbon price signals will support an orderly transition in aviation, avoiding elevated mitigation costs associated with sudden decarbonisation at a late stage. Flying blind can only get the sector so far; better incentives are needed to reach climate goals fairly and cost-effectively.

1 Introduction

The airline industry is facing unprecedented challenges. The International Civil Aviation Organization (ICAO), a UN specialised agency, estimates the number of passengers to have fallen by 60% in 2020.[1] And while the industry is expected to return to strong growth eventually,[2] it could take some time for demand to recover from the impacts of the COVID-19 pandemic (OECD, 2020[1]). While the air transport sector only accounts for a small share of OECD countries' value-added (around 0.3% on average before COVID-19), it is an important part of the economy due to strong inter-industry linkages (OECD, 2020[1]). Against this background, the airline industry has asked governments to take extra measures to replace or extend existing programmes beyond the self-reported USD 160 billion in government support it has already received (Abate, Christidis and Purwanto, 2020[2]).[3]

Airlines are not merely facing a liquidity crisis, and potentially a solvency risk, resulting from COVID-19, they also need to address climate change.[4] Accordingly, in a survey carried out in April 2020 among 231 finance ministry officials and other experts representing 53 countries, including all G20 nations, unconditional airline bailouts were found to be the least desirable stimulus policy from both an economic and a climate perspective (Hepburn et al., 2020[3]). Nevertheless, most bailouts have been unconditional. IEA data suggest that only 4 out of 30 bailouts (Air France-KLM, Austrian Airlines and Swiss Air) set green conditions (IEA, 2020[4]).

In any case, making airline bailouts conditional on reaching climate targets cannot substitute for providing broad-based incentives for decarbonising aviation. Making bailouts conditional, e.g. on achieving net-zero emissions by 2050 and taking equity stakes if targets are not met, has been suggested as a solution for making bailouts sustainable.[5] However, in liberalised aviation markets such conditionality has its limits.[6] If onerous and legally binding constraints are imposed on domestic carriers in exchange for public support, competitors receiving unconditional government support as well as new entrants could step in and take market share, with little if any positive climate effects. It is not clear how state ownership would help unless governments are willing to subsidise their state-owned companies to remain competitive with competitors not bound by similar constraints.

Greening a liberalised aviation sector post COVID-19 requires broad-based climate incentives that create a level playing field for all airlines active on a given route. Kerosene taxes for international flights could be

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[1] https://www.icao.int/sustainability/Documents/COVID-19/ICAO_Coronavirus_Econ_Impact.pdf.

[2] https://www.ft.com/content/3190522f-ad61-432a-b62d-270a068c90fa.

[3] https://www.iata.org/en/pressroom/speeches/2020-10-06-01/.

[4] https://theicct.org/blog/staff/towards-climate-solvency-airlines.

[5] https://theconversation.com/why-airline-bailouts-are-so-unpopular-with-economists-137372. Another possibility would be to link bailouts to blending requirements for more sustainable aviation fuels.

[6] France attached environmental conditions to its EUR 7 billion euro bailout of Air France, but these are not legally binding (https://www.transportenvironment.org/publications/air-frances-bailout-climate-conditions-explained).

a promising addition to the instrument mix for decarbonising air transport in the future.[7] To the extent that they provide stable and predictable long-term carbon price trajectory for fuels they apply to, kerosene taxes could help to ensure that aviation takes off again on a greener trajectory. In contrast to what is often suggested, taxing kerosene for international flights is not as such ruled out by the Chicago convention,[8] but it will in many cases require renegotiating bilateral air service agreements.

It can be expected that in the near to mid-term, only a subset of countries will consider taxing kerosene for international flights, considering the difficulties of agreeing on stringent carbon prices globally – an issue that is not limited to the aviation sector. Raising carbon prices for international flights was controversial before the pandemic. In the current context, where the number of flights operating is down sharply, a number of governments are focusing on options to avoid airline bankruptcies. Against this background, raising the operating costs for the industry through carbon prices may seem counterintuitive. However, the basic rationale for kerosene taxation and the long term need to address aviation related emissions remain valid.

Leveraging the power of taxes for greening the aviation sector does not require hiking rates in the middle of the COVID-19 pandemic, but initiating their gradual introduction over time. The economic case for kerosene taxes remains valid in principle, in the sense that there are better ways to provide stimulus than continuing to underprice carbon emissions for aviation. What is key in practice is to credibly commit to gradually increasing tax levels in the years and decades to come (Teusch and Van Dender, 2020[5]), such that investments are steered into cleaner fuels, novel aircraft designs and other decarbonisation options.

This paper, which is targeted towards tax policy makers, proceeds as follows. Section 2 explains why aligning international aviation with climate neutrality targets remains challenging and demonstrates the need to improve decarbonisation incentives for the aviation sector. Section 3 discusses how interested governments could make progress with kerosene taxes by first introducing their economic merits, before turning to the legal requirements for their implementation, and finally discussing carbon leakage and other side-effects that can occur in the likely event that only a select number of countries implement kerosene taxes or other forms of carbon pricing. Conclusions include suggestions on how OECD analysis could inform reform efforts.

[7] Taxing kerosene on domestic flights is already possible and such taxes exist in some countries (OECD, 2019[17]). This paper focuses on kerosene taxes for international travel where legal and political economy constraints make reform (even) more challenging.

[8] Article 24 prohibits the imposition of customs duty, inspection fees or similar national or local duties and charges (which is assumed to include taxation) of fuel on board an aircraft on arrival in the territory of another contracting state and retained on board on leaving the territory of that state.

2 Aligning international aviation with climate neutrality targets remains challenging

The climate challenge

Reaching climate neutrality by mid-century or not long thereafter is key to curbing climate change in line with the objectives of the Paris Agreement. Given that carbon dioxide removal options that could achieve negative emissions, such as direct air carbon capture and storage, "remain largely unproven to date and raise substantial concerns about adverse side effects on environmental and social sustainability" (IPCC, 2018[6]), the reality is that all sectors need to decarbonise by 2050 or not too long thereafter.

As a result of the COVID-19 crisis, emissions have declined sharply (see Figure 2.1), but are expected to bounce back in the absence of structural changes, as was the case after the 2008 global financial crisis.[9] Emissions from global aviation decreased by 47% during the first seven months of 2020; 70% of the reductions was due to international flights (Liu et al., 2020[7]).

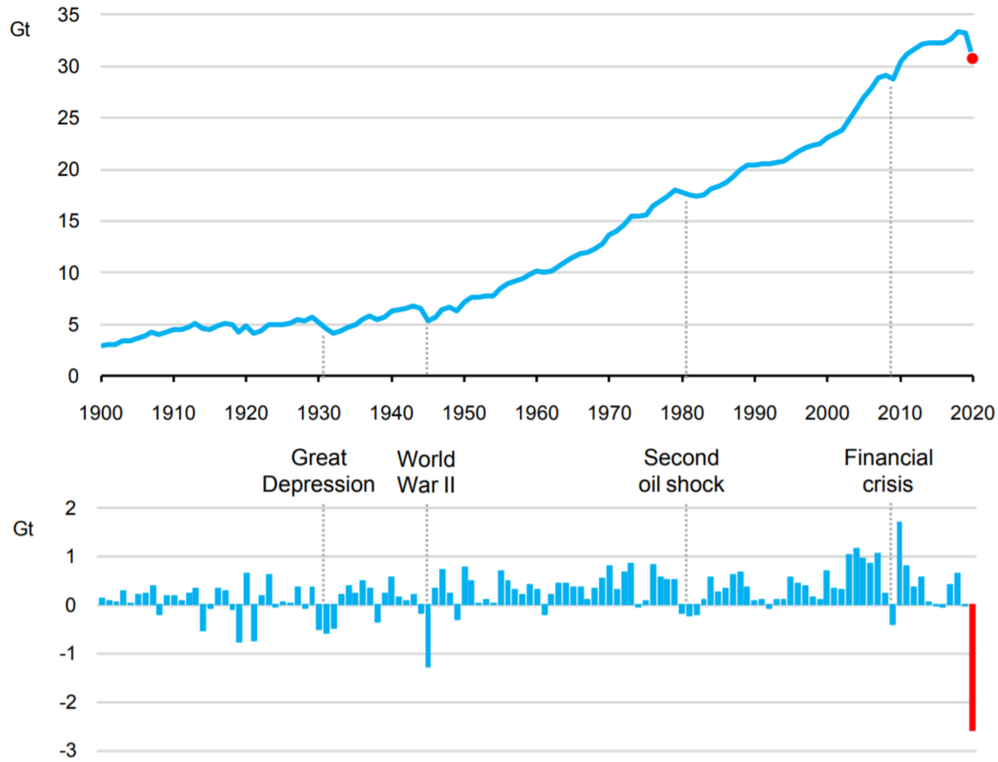
While it is too early to predict the extent of any long term behavioural changes resulting from the COVID-19 pandemic, on their own, any such changes will almost certainly be insufficient to drive the deep and sustained emissions reductions that are required for carbon-neutrality (Le Quéré et al., 2020[8]). There has been, however, a temporary reduction in GHG emissions due to the slowdown in aviation operations related to the COVID-19 pandemic (Le Quéré et al., 2020[8]).[10] As recent OECD analysis notes (OECD, 2020[1]):

> *In the longer run, changes in consumer behaviour may result in structural changes in air transport demand. Even though the rebound of domestic flights in China suggests that traffic may revert to pre-crisis levels, a permanent drop in demand from pre-crisis levels cannot be excluded, either through modal shifts in services trade (e.g. video-conferencing instead of business travel) or, to a lesser extent, through substitution with other modes of transport (e.g. high-speed trains).*

[9] In fact, in December 2020, global emissions were 2% higher than they were in the same month a year earlier (IEA, 2021[74]).

[10] It took certain types of travel (e.g. international business travel) more than 5 years to recover after the Great Recession (vs 2 years for leisure travel).

Figure 2.1. Global energy-related CO_2 emissions and annual change, 1900-2020



Source: IEA (2020[9]).

The aviation sector is a major contributor to CO_2 emissions from fossil fuel combustion, the largest source of Greenhouse Gas Emissions (GHG) from human activities. With emissions of approximately 0.9 gigatonnes of CO_2, the aviation sector as a whole (domestic and international) accounted for around 2.5% of CO_2 emissions from fossil fuel use before COVID-19. Aviation accounts for approximately 11% of CO_2 emissions from transport.[11]

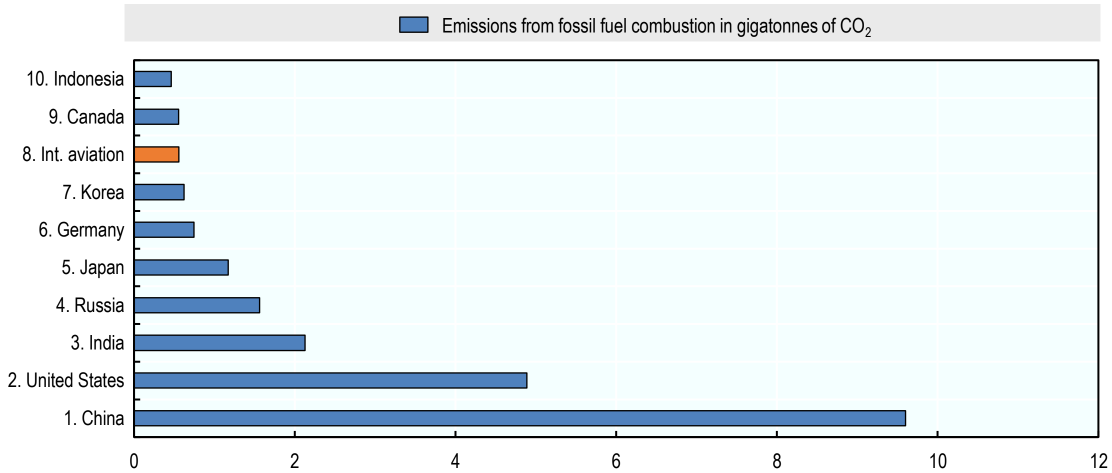
If international aviation were a country, it would have ranked among the world's top 10 emitters before the COVID-19 pandemic. Specifically, Figure 2.2 shows that only seven countries accounted for more fossil-fuel related CO_2 emissions than international aviation in 2018. In 2020, its impact was smaller as aviation activity has contracted more sharply than other sectors (IEA, 2020[10]). In addition to CO_2 effects, there are non-CO_2 effects, including the emissions of water vapour, particles and nitrogen oxides, which could amplify the negative climate impacts of aviation by two to four times (Lee et al., 2020[11]; European Commission, 2020[12]), even though the precise magnitude of these impacts is more uncertain (ICAO, 2019[13]).[12] Estimates that also account for non-CO_2 effects, including cirrus cloud enhancement, put aviation at approximately 3.5-5% of overall negative climate impacts (anthropogenic radiative forcing) (Lee

[11] https://www.iea.org/subscribe-to-dataservices/co2-emissions-statistics.

[12] Given that "non-CO_2 climate agents have a much shorter lifetime, […] the location (longitude, latitude, and altitude) and time, and also the meteorology at the time of emission determines the lifetime of the perturbation (Grewe, 2020[72]) Diverting flights can therefore be an effective means to reduce non-CO_2 climate impacts from air travel (Teoh et al., 2020[71]).

et al., 2009[14]; Kärcher, 2018[15]; Lee et al., 2020[11]). Aviation emissions also come with substantial air quality impacts, whose social costs may exceed climate impacts (Grobler et al., 2019[16]).[13]

Figure 2.2. In 2018, international aviation accounted for more fossil fuel-related CO_2 emissions than most countries



Note: This figure is based on the principle of territorial-based emissions accounting, also followed by the UNFCCC, the IEA and related OECD work (Taxing Energy Use, Effective Carbon Rates). Emissions from rail and road transport are allocated to the country where the fuel is sold. Emissions from domestic aviation and domestic navigation are included in the country total.
Source: Taxing Energy Use (2019[17]) based on IEA data.

The distribution of aviation emissions is highly unequal. Only 2-4% of the global population flew internationally in 2018, and approximately 1% of the world population accounts for half of aviation's climate impacts (Gössling and Humpe, 2020[18]).

Passenger transport dominates aviation activity. Specifically, in pre-COVID times, passenger transport was responsible for 90% of total aviation emissions (Table 2.1). The main source of aviation emissions remain passenger transport – not freight.

International aviation is the main contributor to total CO_2 emissions from the aviation sector, representing roughly 62% of total CO_2 emissions from aviation in normal times (Table 2.1). With 38% of total emissions, domestic aviation is thus also a major source overall, and is especially pertinent for large countries.

[13] The study finds that air quality impacts are between 1.7 times (full flight) and 4.4 times (landing and take-off) higher than the climate impact per unit of fuel burn.

Table 2.1. Aviation emissions by sector

Sector	% of total emissions
Domestic	38
Scheduled passenger transport	37
Dedicated freighters	1
International	62
Scheduled passenger transport	53
Charters	5
Dedicated freighters	4

Note: Passenger transport includes bellyhold freight.
Source: ITF (2017, p. 115[19]).

The demand for passenger air transport was projected to double between 2015 and 2030 and would continue to grow, at a somewhat reduced pace, through 2050; between 2010 and 2017, international flights, measured in passenger-kilometres, have increased by 61% (ITF, 2019[20]).[14] Improvements in the fuel efficiency of jet aircraft[15] and increasing passenger load factors will continue to allow the growth rate of CO_2 emissions to remain lower than the growth rate of air passenger traffic. The doubling of air traffic is nevertheless expected to be accompanied by a substantial increase in overall aviation emissions. In the absence of technology and air traffic management improvements, emissions could more than triple compared to 2015 (ICAO, 2019[13]). Non-CO_2 effects have been projected to increase as well (Lee et al., 2009[14]; Lee et al., 2020[11]).

If the aviation sector goes back to business-as-usual after the pandemic, aviation could become one of the biggest sources of CO_2 emissions from fossil fuel use. In addition to strong demand growth, abatement costs for international aviation are relatively high, and decarbonisation incentives weak, as further discussed below. CO_2 emissions from international aviation are therefore projected to be somewhere between 3.0% and 10.1% of the total cumulative CO_2 budget (2016 – 2100) that is available to keep global warming to less than 2°C above preindustrial levels (Lee, 2018[21]). This share increases further if non-CO_2 impacts are taken into account, and for scenarios that are consistent with keeping global warming to 1.5°C (ibid). Notably, the Paris Agreement sets out a goal to hold increases in temperature to well below 2°C by 2100 and to pursue efforts to limit this increase to 1.5°C. Efforts to reduce the climate impact from international aviation will be crucial.

While decarbonising aviation is critical for achieving the goals of the Paris Agreement, international aviation is not explicitly mentioned in the agreement. The parties to the Paris Agreement can thus choose to include measures to reduce emissions from international aviation in their nationally determined contributions (NDC). No such measures were originally recorded (Martinez Romera, 2016[22]). Including such emissions would strengthen government incentives to address emissions from international aviation (Murphy, 2020[23]). In 2019, the United Kingdom's Committee on Climate Change, an independent, statutory body established under the Climate Change Act of 2008, has recommended the inclusion of international aviation (and shipping) emissions in the United Kingdom's net-zero target, as this would complement

[14] The income elasticity of air travel is considerable. An indicative value from meta-analyses is 1.2 (Gallet and Doucouliagos, 2014[75]).

[15] The 2019 ICAO Environmental Report notes that ICAO aspirational goal of improving fuel efficiency by 2% per year is unlikely to be met (ICAO, 2019[13]).

agreed international policies.[16] Such emissions are, however, not included in the UK's First Nationally Determined Contribution under the Paris Agreement.[17]

The technology challenge

Assuming a return to pre-pandemic aviation demand, the relative share of emissions from international aviation in total emissions is set to rise in the absence of policy changes post pandemic. For now, the bulk of CO_2 emissions come from sectors with relatively low-abatement costs, namely light-duty road transport, rail, pulp and paper, aluminium and other industries, as well as buildings (Energy Transitions Commission, 2018[24]). The high cost and lack of availability of low- and zero-carbon technologies in the aviation sector implies that it is a "harder-to-abate" sector, with progress requiring substantial policy support.

Reducing the negative climate impacts from long-distance air transport is technologically challenging. In the absence of technological breakthroughs in battery density or other storage options, the main route to decarbonising long-distance aviation, especially intercontinental flights, would appear to be bio jet fuel or synthetic jet fuel.

Alternative fuels, also referred to as sustainable aviation fuels (SAF),[18] are likely to remain substantially more expensive than fossil fuels in the foreseeable future. SAF are generally more than double the cost of conventional fuel (World Economic Forum, 2020[25]; IEA, 2020[4]).[19] As of 26 March 2021, the global average price of conventional jet fuel was EUR 447 per tonne of fuel,[20] which corresponds to approximately EUR 140 per tonne of CO_2 (OECD, 2019[17]). Enabling conditions for fuel switching include higher crude oil prices, lower feedstock prices, clean fuel subsidies and a carbon tax on fossil fuels (International Energy

[16] https://www.theccc.org.uk/publication/letter-international-aviation-and-shipping/letter-from-lord-deben-to-grant-shapps-ias/.

[17] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/United%20Kingdom%20of%20Great%20Britain%20and%20Northern%20Ireland%20First/UK%20Nationally%20Determined%20Contribution.pdf.

[18] Burning SAF releases a similar amount of CO_2 as burning fossil fuels. However, SAF can in principle reduce life-cycle CO_2 emissions substantially. The extent to which this happens will depend on the technology and the feedstock used, among other factors. In the case of power-to-liquid fuels made only from CO_2 and green electricity, SAF could largely eliminate lifecycle CO_2 emissions. SAF still come with non-CO_2 effects, however. The overall reduction in aviation's climate impact (also including non-CO_2 effects) that SAF could deliver relative to fossil jet fuel has been estimated at 30-60% (World Economic Forum, 2020[25]).

[19] Similarly, earlier research commissioned by the Energy Transition Commission (Energy Transitions Commission, 2018[24]) found that decarbonisation costs, i.e. the abatement cost per tonne of CO_2 saved by using bio jet fuel or synthetic jet fuel, could be USD 115-230 per tonne of CO_2. Recent analysis published by the World Economic Forum suggests that hydroprocessed esters and fatty acids (HEFA)-produced SAF will remain the most cost-competitive option in the near term (approximately EUR 1 000-1 500 production costs per tonne of fuel.). According to the same analysis, power-to-liquid fuels are expected to remain substantially more expensive in the near term, but could reach a similar cost range as current HETA-based fuel by 2040. The cost reduction potential is related to declining costs for electrolysers and scale effects, and also depend on the transition to sustainable energy production, such as green electricity and hydrogen (World Economic Forum, 2020[25]).

[20] Current jet fuel prices in USD are available here: https://www.iata.org/en/publications/economics/fuel-monitor/.

Agency, 2018[26]).[21] Bio jet fuel would be difficult to produce sustainably at the scale required to meet the demand for international air travel (Larsson et al., 2019[27]). Constraints include the limited availability of waste and residues and competition with other uses.

Electric engines that rely on battery or hydrogen energy storage could become viable alternatives for short-range air travel in the not-too-distant future (Schäfer et al., 2018[28]). Provided that batteries are charged using low-carbon electricity, electrifying aviation would largely avoid CO_2 impacts, even though battery production will also come with environmental externalities. Non-CO_2 climate impacts and local pollution would be reduced as well (ICAO, 2019[13]). Avinor, a wholly-owned state limited company under the Norwegian Ministry of Transport and Communications, and responsible for 44 state-owned airports, aims to electrify all domestic flights by 2040.[22] Airbus has the ambition to deliver the world's first hydrogen-powered commercial plane by 2035.[23]

Less radical technological and operational options could contribute to the mitigation challenge as well, but are not in themselves sufficient to align emissions from international aviation with climate-neutrality goals. It is, for instance, possible to increase fuel efficiency further and to save emissions through improved air traffic management and operations (ICAO, 2019[13]). Deploying hybrid-electric aircraft that allow for electric taxiing and using electric motors to supplement jet engines at take-off could equally contribute to reducing the climate impact of flights (ICAO, 2019[13]). Hybrid-electric aircraft can also provide a waypoint between today's aircraft and full battery-electric aircraft by helping advance R&D and scale up the technology.

Alternative modes of transport, such as high-speed rail or electric vehicles powered by clean electricity, could reduce emissions from travel on certain routes as well. However, only about one third of total emissions from aviation are from short-haul flights (Graver, Zhang and Rutherford, 2018[29]), and the share of short-haul flights where high-speed rail or electric vehicles are economically viable alternatives would remain limited unless carbon prices were to rise substantially.

The incentive challenge

Putting a price on CO_2 emissions is an effective and efficient tool to reduce CO_2 emissions and encourage investment and innovation in cleaner alternatives.[24] Governments can price carbon directly in two main ways: through taxes or emissions trading (OECD, 2018[30]). Taxes are typically levied on the fuels that cause CO_2 emissions when combusted (fuel-based approach), but it is also possible to tax CO_2 emissions directly, as is the case for emissions-based carbon taxes (OECD, 2019[17]).

At present, most CO_2 emissions from international aviation are not priced. Fuel or carbon taxes generally do not apply to international aviation (OECD, 2020[31]), as shown in Figure 2.3. The figure also shows that a similar situation prevails in international maritime transport. Domestic use of aviation and maritime fuels is sometimes taxed, as is rail transport, but there are tax exemptions and reduced rates are widely

[21] With respect to hydroprocessed esters and fatty acids synthetic paraffinic kerosene (HEFA-SPK) fuel, currently the only technically mature and commercialised biofuel, the IEA (International Energy Agency, 2018[26]) estimates that a carbon price of USD 150 per tonne of CO_2 would be necessary to make it cost competitive, assuming oil prices of USD 70/bbl – at the time of writing, oil prices were around USD 40/bbl. Alternatively, if crude oil prices rose to USD 110/bbl, feedstock prices declined to EUR 350/tonne (from USD 500-800), or a biofuel subsidy of USD 0.35/l was introduced, a similar result could be obtained.

[22] https://avinor.no/en/corporate/klima/electric-aviation/electric-aviation.

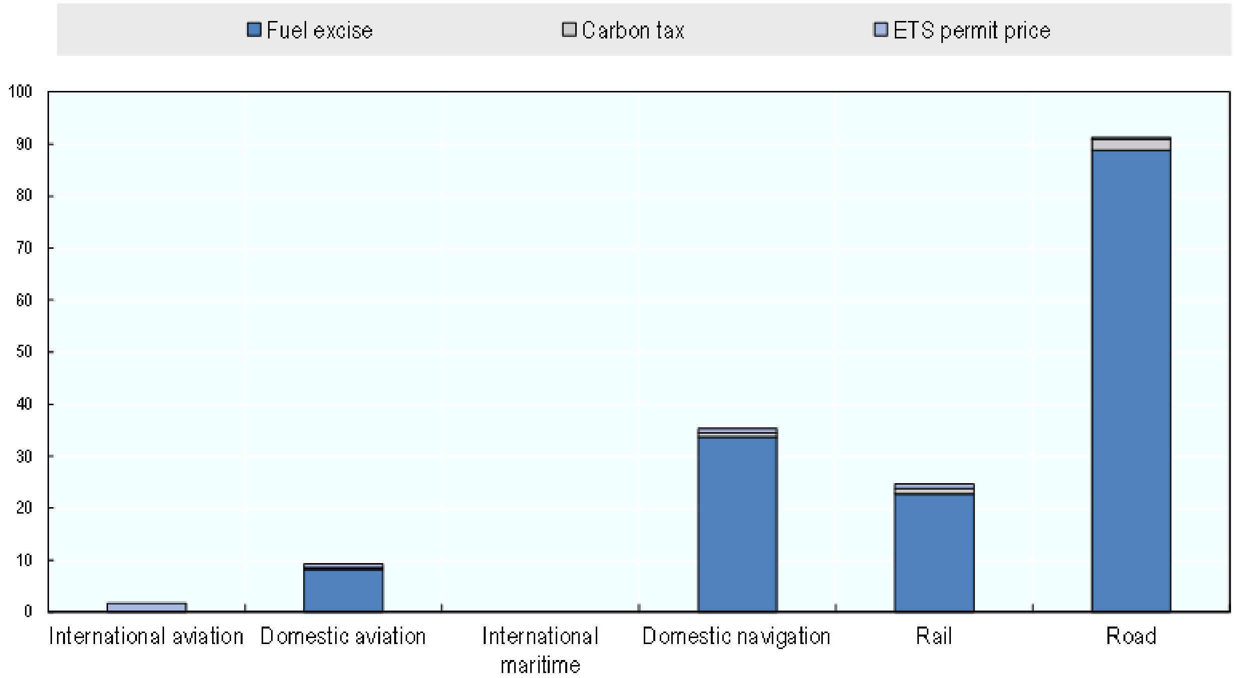
[23] https://www.airbus.com/newsroom/press-releases/en/2020/09/airbus-reveals-new-zeroemission-concept-aircraft.html.

[24] For a general discussion, see e.g. Van Dender and Teusch (2020[49]).

applied.[25] In road transport, by contrast, effective carbon taxes sometimes reach EUR 300 per tonne of CO_2, and where reduced rates exist (e.g. Belgium, France, Portugal), these are largely limited to heavy-duty road transport (OECD, 2019[17]). As a result, effective carbon taxes differ strongly between different modes of transport, and fuel taxes continue to mainly fall on road users.

Figure 2.3. Effective carbon rates differ strongly across transport fuels

Emissions-weighted averages rates for OECD and G20 countries in EUR per tonne of CO_2



Note: Estimate based on Taxing Energy Use 2019 (OECD, 2019[17]), Effective Carbon Rates 2021, and desk research. The figure only shows effective carbon rates for primary energy use by transport mode, which excludes electricity use which may also be subject to carbon prices. Not visible in the figure is that Slovenia applies a surcharge to all aviation fuels (including for international flights) in addition to excise duties (for non-commercial and pleasure flights) (OECD, 2020[31]). In Canada and the United States, certain provinces and states, such as Florida and California, tax aircraft fuel consumed even for international flights (Faber and O'Leary, 2018[32]), this is not shown in the figure. Aviation fuel used for non-commercial and pleasure flights is taxed in 14 OECD countries for international flights (Belgium, Finland, Germany, Greece, Hungary, Ireland, Latvia, Lithuania, Luxembourg, Poland, Portugal, Slovenia, Spain and Sweden), but this is not included in the calculations as the associated emissions are very small.

The implementation of a global market-based instrument, the Carbon Offsetting and Reduction Scheme for International Aviation, CORSIA, has begun under the auspices of the International Civil Aviation Organization (ICAO) in 2016. CORSIA is part of a basket of ICAO measures to tackle climate change in the air transport sector ICAO that also include other measures that directly target aircraft technology improvements, operational improvements and sustainable aviation fuels (ICAO, 2019[13]). ICAO also continues to explore long-term global aspirational goals for emissions from international aviation, as reiterated by the 40th Session of the ICAO Assembly. CORSIA's current level of ambition is limited to

25 Fuel tax reform for other modes of transport, including maritime transport and rail transport is beyond the scope of this paper, but for instance discussed in Taxing Energy Use (OECD, 2019[17]).

offsetting the growth in CO_2 emissions from international aviation after 2020,[26] and does not address the non-CO_2 climate impacts from international aviation. Airlines will have to buy carbon offsets from other sectors to compensate for increases in emissions from international aviation. The implementation of CORSIA is scheduled to take place along three phases – the pilot phase (2021-2023), the voluntary first phase (2024-2026) and the mandatory second phase (2027-2035). The extension, revision or termination of the CORSIA beyond 2035 will be decided by a special review to be conducted by the end of 2032.

In its present form, CORSIA's potential for mitigating the climate impacts from international aviation is weakened by a number of factors. First, even before the COVID-19 crisis, estimates suggested that only around 22% of cumulative 2021-2035 CO_2 emissions from international aviation would have been subject to a carbon price (CE Delft, 2016[33]). The reasons are that CORSIA requires airlines to only buy offsets for emissions in excess of 2019/2020 levels,[27] and that not all routes are covered.[28] Carbon pricing will be particularly limited in the early years of the scheme, where a recent change of the baseline to 2019 levels (i.e. pre-COVID-19) implies that no emissions may need to be offset during the voluntary phase.[29]

Second, offset prices for those emissions that will be subject to a carbon price are likely to remain below even a low-end estimate of the climate damage from CO_2 emissions. Offsets from a wide range of programmes will be eligible,[30] which is expected to lead to an abundant supply of carbon offset credits (German Emissions Trading Authority, 2019[34]). Low or zero carbon prices imply that the resulting emissions reductions in the aviation sector will be limited and prices fail to provide incentives for long-term decarbonisation efforts for the sector (investing in sustainable aviation fuels, electrification).

Third, given the continued uncertainty of offset prices, and the fact that the scheme is currently only scheduled to run until 2035, it does not provide price stability to investors despite the long life time of assets in the sector.[31] More generally, the use of offsetting as a mitigation instrument is hindered by the fact that negotiations on the rulebook that would guide countries in make use of 'Internationally Transferred Mitigation Outcomes' and pursuing mitigation projects under Article 6 of the Paris Agreement remains to be concluded.

Proxy carbon pricing instruments, such as ticket taxes, are somewhat more common than direct forms of carbon pricing. In particular, a number of countries have implemented ticket taxes (CE Delft, 2019[35]).

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[26] The 2019 ICAO Environmental Report, published before the Covid-19 pandemic, notes that the aspirational goal of carbon-neutral growth post 2020 is unlikely to be met (ICAO, 2019[13]).

[27] According to ICAO Resolution A39-3, the baseline is the average of total emissions covered by CORSIA between 2019 and 2020. Covid-19 would thus have resulted in a tighter the baseline, compared to what was originally envisaged. However, the ICAO Council has decided that 2019 emissions shall be used for 2020 emissions at least during the pilot phase from 2021 to 2023 (https://www.icao.int/Newsroom/Pages/ICAO-Council-agrees-to-the-safeguard-adjustment-for-CORSIA-in-light-of-COVID19-pandemic.aspx). Generally, from 2021 through 2029, the growth factor will be based on the growth of the international aviation sector. From 2030 onwards, the growth factor will take into account both the sectoral and the individual operator's emissions growth. The growth factor is calculated by ICAO and is the percent increase in the amount of emissions from the baseline to a given future year (ICAO, 2019[13]).

[28] As of 16 July 2019, 81 States representing 76.63% of international aviation activity will take part in the pilot phase commencing in 2021. Notably, Chile, Colombia, Brazil, Russia and China are not listed as participants to the pilot phase of CORSIA (https://www.icao.int/environmental-protection/CORSIA/Pages/state-pairs.aspx).

[29] https://theicct.org/blog/staff/covid-19-impact-icao-corsia-baseline.

[30] https://www.icao.int/Newsroom/Pages/ICAO-Council-adopts-CORSIA-emissions-units.aspx.

[31] United Airlines, a leading airlines, recently announced that it does not want to rely on offsetting, but intends to reduce emissions by investing in direct air capture technology and SAF (https://hub.united.com/united-pledges-100-green-2050-2649438060.html).

Ticket or departure taxes increase the cost of air travel. Given that these costs are typically passed on to consumers, this has the effect of discouraging air travel. However, ticket taxes not a perfect substitute for direct forms of carbon pricing, as ticket taxes do not encourage airlines to exploit the full set of emission reduction opportunities. Specifically, ticket taxes typically do not provide the same incentives as direct carbon prices to increase fuel efficiency and passenger load factors (capacity utilisation), optimise flight routes or switch to fuels with a lower carbon content.[32] Transit and transfer passengers are typically exempt from ticket taxes. Cargo flights are sometimes subject to departure taxes, but this is rare – France, for instance, is at present the only EU member to tax freight flights (ibid). Related tools that have been suggested include frequent flyer and air miles levies (Carmichael, 2019[36]).

Pricing carbon or taxing tickets are not the only ways to strengthen incentives for reducing CO_2 emissions from international aviation. Other instruments include efficiency standards for aircraft, quota obligations or blending requirements for cleaner fuels,[33] improvements in air traffic management,[34] and making the disclosure of the emissions associated with a given flight mandatory at the time of booking.[35] Green recovery packages may additionally give the opportunity to provide direct public support to clean aviation technologies. Progress could also be made by avoiding disincentives for decarbonisation, for example phasing out the favourable tax treatment of fuels and tickets for international flights that are typically subject to a zero rate of VAT (Keen, Parry and Strand, 2013[37]),[36] as well as terminating subsidies for airports and related infrastructures, airline companies and aircraft manufacturers (Gössling, Fichert and Forsyth, 2017[38]). While all of these measures have a role to play in the instrument mix, they cannot be a substitute for carbon prices, given the scale of the mitigation challenge in international aviation.

The sizable non-CO_2 impacts of international aviation equally require policy makers' attention. As these impacts vary in space and time in ways that are not directly correlated with fuel consumption, they may benefit from additional policy instruments that are targeted specifically at these emissions. One policy option to reduce these impacts would be, for instance, re-routing "to avoid meteorological conditions that cause the potentially largest climate impact" (Kärcher, 2018[15]). A detailed discussion of measures to address non-CO_2 impacts is beyond the scope of this paper.

[32] However, ticket taxes, unlike kerosene taxes, typically do not discourage rerouting flights to reduce non-CO_2 impacts. The reason is that rerouting would sometimes increase fuel consumption (Teoh et al., 2020[71]), which would in turn increase the carbon tax liability, but typically not impact ticket tax liabilities.

[33] Norway requires that 0.5% of all aviation fuel sold must be advanced biofuels, and aims to reach 30% in 2030 (Larsson et al., 2019[27]). Similar measures have been or are planned to be put in place in other European countries including the Finland, France and the Netherlands (https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/659361/EPRS_BRI(2020)659361_EN.pdf).

[34] Colombia's 2020 NDC Update includes a proposal to improve air traffic management and operations through performance-based navigational objectives.

[35] https://theicct.org/blog/staff/towards-climate-solvency-airlines.

[36] "The provision of aviation fuels to enterprises operating aircrafts for international commercial flights (i.e. passenger transport or cargo) is subject to a zero rate of VAT in all OECD countries or subject to a full refund of input VAT (Chile), except Colombia, where it is subject to the reduced VAT rate of 5% and the United States where there is no federal VAT. […] Since aviation fuel will typically be a business input of an enterprise large enough to be registered for VAT, this component of tax will generally be fully deductible and thus ultimately have no economic impact" (OECD, 2020[31]). In Chile, any service that can be considered an "export service" has the possibility to recover the input VAT involved in the acquisition of products (e.g. provision of aviation fuel) and services hired, which are part of the service offered. The tax benefit is therefore not limited to enterprise operating international commercial flights.

3 Making progress with kerosene taxes

The economic case for kerosene taxes in international aviation

Taxing kerosene used for international flights would be an effective and efficient tool to reduce emissions and encourage investment and innovation in cleaner mobility choices. Taxing fossil kerosene would effectively put a price on carbon emissions – given that CO_2 emissions are directly proportional to fossil fuel consumption.[37] This leaves the decision on how much and where to cut pollution to emitters. Airlines would be encouraged to supply less carbon-intensive air services to reduce the tax burden, while higher fuel costs would increase ticket prices, which reduces demand for air travel. The effectiveness of kerosene taxes at reducing emissions has been confirmed in a study on the domestic aviation fuel tax in Japan, which estimated that the 30% *reduction* of the Japanese fuel tax in April 2011 (a decrease of approximately EUR 25/tCO_2) increased cumulative CO_2 emissions from domestic air travel between 2011 and 2013 by some 9% (González and Hosoda, 2016[39]).

On the supply side, the main short-term options available to airlines is to optimise flight routes and operations of existing aircraft, including by maximising capacity utilisation. This may also involve flying at lower cruising speed to decrease fuel cost.[38] Using data from 16 US carriers over the 1995–2015 period, regression analysis by Brueckner and Abreu suggests that the short-run effect of such operational measures (excluding improvements to aircraft fuel efficiency and size) in response to a carbon tax of USD 40 per tonne of CO_2 (USD 0.39 per gallon) would lead to fuel savings of 2.2% (Brueckner and Abreu, 2017[40]; Brueckner and Abreu, 2020[41]).

In the medium to long-term, a kerosene tax provides airlines with incentives to deploy more efficient engines and aircraft, and potentially use biofuels blends if the joint impact of the oil price and the kerosene tax is sufficiently high. Finding new and cheaper ways to reduce emissions, such as using alternative fuels or (hybrid) electric planes, would lead to a further reduction of the tax burden. A kerosene tax, therefore, would stimulate the pursuit of still cheaper abatement options, even after significant abatement has already occurred, because the tax will still be due on remaining emissions (OECD, 2010[42]) (OECD, 2021[43]).[39] This does, for instance, strengthen incentives for aircraft and engine manufacturers, as well as biofuel manufacturers, to develop and commercialise cleaner options.

[37] All references to taxing kerosene in this paper refer to the taxation of fossil kerosene. If fossil kerosene is blended with alternative fuels with a lower carbon content, the tax rate could be adjusted accordingly.

[38] Other fuel conservation options include "taxiing on one engine, installation of winglets, and carrying less reserve fuel to reduce weight" (Brueckner and Abreu, 2020[41]).

[39] Empirical evidence from the automotive sector suggests that "higher, tax-inclusive fuel prices are effective at redirecting patenting activity from non-green to green technology fields" (Barbieri, 2016[76]).

A kerosene tax reduces demand for air travel in a variety of ways. Tourists do not always have a strong preference for remote holiday destinations over closer ones, and could react to relatively small changes in ticket prices resulting from the kerosene tax by adjusting their travel plans in favour of closer destinations.[40] Business travellers may be able to replace some trips with video conferencing solutions, as has become increasingly common during the COVID-19 pandemic, but will often be less flexible with destinations. Foreign workers wishing to visit family will not be able to change their home town but may reduce the frequency of their trips while increasing the duration of each stay. Where those options cannot be taken, the customer is left to pay the tax.

Table 3.1. How much would a carbon tax on kerosene change air fares on selected routes?

Round-trip	Cabin class	Assumed ticket price before carbon tax	Tonne of CO_2 emitted	Carbon tax assumption per tonne of CO_2	Absolute price change	Relative price change
Paris - New York	Premium	EUR 2 000	1.309	EUR 30	EUR 39	2%
Paris - New York	Premium	EUR 2 000	1.309	EUR 120	EUR 156	8%
London – Palma de Mallorca	Economy	EUR 100	0.256	EUR 30	EUR 8	8%
London – Palma de Mallorca	Economy	EUR 100	0.256	EUR 120	EUR 32	31%

Note: Results for 1 passenger round-trip; emissions based on https://www.icao.int/environmental-protection/Carbonoffset/Pages/default.aspx; assumes full cost pass-through of carbon tax. Results are rounded to the nearest euro or percent. Carbon tax assumptions are based on carbon price benchmarks discussed in Effective Carbon Rates (OECD, 2021[44]).

How much would a carbon tax on kerosene change air fares? A passenger's business-class roundtrip Paris - New York emits around 1.309 t of CO_2. Assuming full cost pass-through, a kerosene tax of EUR 30 per tonne of CO_2 (a commonly used low-end carbon benchmark) would increase the ticket price by around EUR 39, a roughly 2% increase in ticket prices. With kerosene taxes of EUR 120 per tonne of CO_2 – still less than half of effective carbon rates on gasoline in many European countries (OECD, 2019[17]) – the ticket price would increase by EUR 156, or 8%. While emissions on an economy class round-trip London – Palma de Mallorca are much lower, the relative price change is larger than for the considerably more expensive business-class trip and accounts for 8% of the ticket price. With kerosene taxes of EUR 120 per tonne of CO_2, this the round-trip would become 31% more expensive.

Kerosene taxes could be designed in such a way as to provide assurance about emissions reductions. Specifically, implementing countries could agree on a tax adjustment mechanism that gauges emissions in each year against an emissions pathway, as discussed in the context of potential US carbon tax legislation (Metcalf, 2019[45]; Hafstead and Williams, 2019[46]). If emissions exceed pre-established levels, then the tax rate would increase automatically. A similar mechanism already exists with respect to the Swiss carbon tax. By enshrining emissions reductions in the relevant legislation, a tax adjustment mechanism can contribute to addressing stakeholder concerns about the effectiveness of carbon taxes at reducing emissions.

A kerosene tax helps to avoid rebound effects. Notably, improvements in energy-efficiency can lead to increased demand that offsets part of the reduction in energy use from deploying more fuel-efficient technology. This is problematic if travel is priced below social cost or at levels that are not consistent with the policy objectives, e.g. of the Paris Agreement. For example, a fuel-efficiency standard for planes will decrease fuel consumption of new planes, which may result in lower ticket prices and increased air travel, an effect that has received considerable attention in road transport (Dimitropoulos, Oueslati and Sintek,

[40] Recent research based on a quantitative analysis of travel patterns of a sample of 587 flights by 29 international students in Sweden concluded that almost half of the leisure flights 'lacked importance' (Gössling et al., 2019[73]).

2018[47]). Model results for an air traffic network of the 22 busiest US airports suggest that the average (direct) rebound effect in response to the introduction of a more fuel efficient technology is around 19% (Evans and Schäfer, 2013[48]). Unlike target-based or technology-based regulation, kerosene taxes provide ongoing incentives to reduce emissions. As a result, kerosene taxes and other forms of carbon pricing avoid such direct rebound effects (Van Dender and Teusch, 2020[49]). In addition, a fuel tax provides a greater range of abatement options than alternative instruments, such as distance-based air passenger taxes ("ticket taxes") or quota obligations for biofuels (Larsson et al., 2019[27]). Not favouring a particular form of abatement generally minimises abatement costs.

Taxing kerosene would be a means to establish a carbon price floor for international flights between countries that choose to enact them. Even at modest carbon price levels, such as EUR 30 per tonne of CO_2, kerosene taxes would imply a substantial step forward, given the lack of carbon price signals today, and the high uncertainty about future price signals through emissions trading and offsetting schemes. Kerosene tax levels would, however, need to increase substantially over time in a predictable way if they were to play a leading role in the decarbonisation of aviation. For the reasons discussed in the previous section, the costs of cleaner alternatives to fossil fuels in aviation remains high, and marginal abatement cost estimates are well above EUR 100 per tonne of CO_2 (Energy Transitions Commission, 2018[24]).

The high cost of cleaner alternatives does not mean that modest carbon prices will be ineffective. Even at relatively low initial kerosene tax levels, such carbon pricing would reduce decarbonisation costs relative to alternative policies that rely on standards and blending mandates. Dimanchev and Knittel (2020[50]) show that *"the cost-saving benefit of incorporating carbon pricing is large at first and diminishes the more a policy relies on carbon pricing as opposed to a standard […which…] underscores that even a modest carbon price can have large efficiency benefits."* The intuition behind their theoretical result is that carbon pricing triggers the uptake of more cost-effective abatement options that are outside of the limited scope of the standard. Carbon pricing will also limit the need for other support measures, such as subsidies for zero-carbon mobility technologies. The reason is that the cost reductions required for cleaner alternatives to compete commercially with fossil fuels will be lower once carbon prices are in place.

Taxing kerosene would also raise revenues that could, among other purposes, be used to further stimulate the development of cleaner mobility options or to address distributional issues.[41] It should be noted that richer households tend to fly substantially more than poorer households, many of which do not fly at all (Gössling and Humpe, 2020[18]; Ivanova and Wood, 2020[51]). Evidence from a large representative survey in France suggests that a kerosene tax might be relatively popular with the electorate (Douenne and Fabre, 2020[52]).

Kerosene taxes would have the potential to provide a stable and predictable carbon price floor. Carbon price stability would be particularly important for the aviation sector because aviation assets tend to have a very long life time – commercial planes are typically in operation for 20-30 years, which is longer than the typical lifetime of road vehicles. To accelerate investments in more fuel-efficient planes and clean aviation technologies, a commitment to meaningful and predictable carbon prices up to the 2050s and beyond would be key. As discussed in the previous section, CORSIA does not deliver such price signals in its current form. Kerosene taxes could therefore be an important complementary tool to strengthen incentives for decarbonising aviation on routes between countries that choose to enact them. The potential for technological spill-overs and the global nature of the climate challenge imply that the benefits would not be limited to the participating countries.

Taxing kerosene for international flights between some countries would create instances where a carbon tax applies in parallel to a quantity-based instrument, in particular the EU ETS and CORSIA (see Section

[41] It is up to governments to decide how to use these revenues, and countries may face constitutional constraints in these choices. Marten and Van Dender (2019[77]) provide an overview of the revenue use practices in the carbon pricing space in OECD and G20 countries.

2). This situation already exists in the domestic context. For instance, the Norwegian carbon tax applies to domestic flights, in addition to their inclusion in the EU ETS. Furthermore, other transport sectors are subject to both price- and quantity-based mitigation instruments, such as road transport in California and Québec that are subject to both fuel excise and emissions trading. In the United Kingdom, the carbon price support is a tax which sits alongside the ETS and has the effect of setting a floor price for carbon used in electricity generation (OECD, 2019[17]).

In real-world settings, kerosene taxes will strengthen overall mitigation incentives, even if they overlap in full or in part with emissions trading systems or related policy instruments. In instances where a kerosene tax would apply in addition to emissions trading systems, the tax may weaken the price signals provided by the emissions trading system. In the textbook case of a fixed emissions cap that is binding, the so-called waterbed effect could then prevent the kerosene tax from causing additional emission reductions (Forsyth, 2020[53]). However, in the real world, emissions caps are not set in stone, *inter alia,* because:

- The stringency of emissions caps may be increased in the political process.
- Surplus allowances (permits) may be cancelled or removed from circulation through non-discretionary mechanisms, such as the market stability reserve under the EU ETS, which effectively transformed the EU ETS into a "punctured waterbed." (Perino, Ritz and van Benthem, 2019[54]).
- Even if emission caps were strictly exogenous, the additional price stability provided by a kerosene tax could still improve investment incentives (Flues and van Dender, 2020[55]).

The waterbed effect is therefore of limited relevance in the current debate on kerosene taxes, also considering the low levels of current and expected quantity-based carbon price signals, which implies that kerosene taxes would complement rather than replace other policy instruments.

Legal requirements

The Chicago Convention, which lays down the basic standards and principles governing international aviation (see Annex A), does not prevent countries from taxing aviation fuels destined for international flights. Article 24 of the Convention states that taxing fuel on board an aircraft *arriving* in the territory of a Contracting Party is forbidden. However, Article 24 does not forbid imposing any duties, charges, fees, levies, or taxes on fuel *supplied* to an aircraft on the point of *departure* (Faber and O'Leary, 2018[32]; Keen, Parry and Strand, 2013[37]; Faber and Huigen, 2018[56]).[42]

ICAO recommends that countries exempt aviation fuels from tax, but several countries have stated that they do not wish to rule out taxing such fuels in the future. While an ICAO resolution "resolves" that Contracting States *inter alia* exempt fuel supplied to aircraft at the point of departure on the basis of reciprocity, and encourages Contracting States to extend the exemption on a general basis (ICAO, 2000[57]), this does not prevent taxing fuels supplied on the point of departure, because legal analysis suggests that countries have a unilateral right to opt out from the relevant provisions (Hemmings, 2020[58]). In fact, a number of countries, including Germany, Norway and Sweden formally filed reservations to the resolution, clarifying that they do not want to rule out taxing aviation fuels in the future (ICAO, 2016[59]; CE Delft, 2019[35]).

The present non-taxation of kerosene used for international flights is typically enshrined in air services agreements (ASAs). Bilateral and multilateral ASAs and Single Skies arrangements derive from the Chicago Convention and contain additional provisions for taxing fuel used in international air transport.

[42] Article 15 nevertheless warrants that Contracting Parties would need to impose customs or duties (including on kerosene *supplied* to an aircraft) in a non-discriminatory manner.

Some of these ASAs, including several ASAs concluded by Australia,[43] explicitly exempt fuel taken on board an aircraft of the other contracting party from any taxes, charges, duties, fees and levies without qualification (see Table 3.2). Other ASAs, e.g. many ASAs concluded by the United States, including the EU-US Open Skies Agreement, render this exemption subject to reciprocity among the Contracting Parties. The latter is also the wording used in ICAO's bilateral template air services agreement which states that "[e]ach Party shall on the basis of reciprocity exempt a designated airline of the other Party to the fullest extent possible under its national law from … excise taxes" (ICAO, 2016[60]). A special case is the taxation of flights between European countries that are subject to the provisions of the EU Energy Tax Directive that contains a procedure by which jet fuel could be taxed (see Box 3.1).

Table 3.2. Provisions on the taxation of fuels on departure in ASAs between OECD and G20

Provision on the taxation of fuel supplied to an aircraft of the other Contracting Party on the point of departure

	Exempt	Exempt, subject to reciprocity	Exempt, reciprocity ambiguous	No provision	EU
Number of ASAs	197	116	38	1	2
Number of Country pairs	197	188	38	1	325

Note: Treaties that were not retrieved, country pairs without treaties, and treaties undergoing treaty process are not included in the table (24% of country pairs, meaning 76% are covered). The 38 ASAs for which the reciprocity provision is categorised as ambiguous all contain a clause warranting a reciprocity-based exemption pertaining to the taxation of fuel and supplies on the point of arrival; the paragraph pertaining to the taxation of fuel and supplies supplied to the aircraft notes then simply states that an equivalent treatment shall apply to fuels on the point of departure 2, but does not reiterate the reciprocity principle (see e.g. Canada-New Zealand ASA). No provision refers to the Agreement between Portugal and South Africa that does not contain a provision for taxing fuels (https://treaties.dirco.gov.za/dbtw-wpd/images/19630507Portugalair.pdf). EU refers to flights between countries that are subject to the provisions of the Energy Tax Directive as of 2020, and where the possibility exists for two Member States to enter into a bilateral agreement to waive the exemption for the taxation of jet fuel (see Box 3.1).
Source: Authors.

Countries that wish to tax aviation fuels for all international flights may need to renegotiate existing bilateral air transport agreements (Michaelis, 1997[61]). The need for renegotiation is clear cut if ASAs explicitly exempt fuels from any taxes.[44] In the (common) case where non-taxation is qualified by the reciprocity condition, renegotiation may not be necessary if the condition is interpreted as allowing either party to terminate the fuel tax exemption unilaterally. This interpretation has not yet been tested in the courts (Faber and O'Leary, 2018[32]). ASAs may also contain a provision for a joint committee that would be charged to examine certain issues (see also, Box 3.1);

[43] See for instance Article 13 in the agreement between Australia and China (http://www.austlii.edu.au/au/other/dfat/treaties/2006/19.html).

[44] In the special case of the European Union, legal analysis suggests that the EU can tax aviation fuels across the European Common Aviation Area subject only to any exemptions in Air Service Agreements (ASAs) the EU itself has concluded with foreign governments (Hemmings, 2020[58]).

Box 3.1. Kerosene taxation for flights within the European Union

The taxation of fuel used on intra-EU flights is governed by the 2003 Energy Tax Directive (ETD), which is presently being revised. Article 14(1)(b) of the ETD states that Member States (including, in the case of aviation, non-EU members of the European Common Aviation Area) shall apply a waiver on the minimum tax rate applicable to jet fuel for international and intra-community flights. However, Article 14(2) also states that should two Member States enter a bilateral agreement, they can waive the exemption for the taxation of jet fuel. Furthermore, such arrangements allow the Member States to apply a tax rate lower than the minimum tax rate mandated by the ETD.

The applicability of the legal provisions under the ETD is complex with respect to the governance of civil aviation relations between individual EU Member States and third countries (who do not all have a comprehensive ASA with the EU as a single block). This is so because of the so-called "Freedoms of the air" provisions contained in the individual ASAs. Under ASAs, Contracting Parties designate air service providers (airlines) that are allowed to provide air services under the terms and conditions specified in a given ASA. To provide an example, most Open Skies ASAs (ASAs concluded after 1978, representing the latest era of liberalised ASAs) offer the other Contracting State's designated airlines the right to cabotage traffic. This right allows the airline of Contracting State A to carry passengers between two points in the other Contracting State (B).

For Contracting States that have concluded bilateral ASAs with individual EU member states or with the EU, this implies that the taxation of fuel on flights between A and B are governed by the ASA. However, the taxation of fuel on flights within either A or B by either A's or B's airlines should be governed by either A's or B's domestic laws. The Euro-Mediterranean Agreement between EU, Iceland, Norway and Israel explicitly permits the taxation of fuel supplied to an aircraft of the designated airline of the other Contracting Party for use on cabotage routes.

Due to certain provisions in bilateral ASAs, taxing fuels used on cabotage flights is not always legally permissible. For example, the decision to tax the fuel supplied to the aircraft of a US-designated airline in the territory of an EU member state for use on an intra-EU (cabotage) flight would have to be examined by a joint US-EU committee. However, US (and non-European) carriers have largely stopped operating intra-European flights and legal analysis suggests that a fuel tax de minimis that would exempt carriers from such countries and all cargo flights could provide a potential solution for such constraints (Hemmings, 2020[58]).

Source: Authors.

Carbon leakage and other side effects of kerosene tax leadership

Differences in carbon prices across countries can lead to carbon leakage, whereby foreign emissions (kerosene consumption) increase because of more stringent domestic climate policies in those countries that decide to tax kerosene for international flights. A recent study that estimated the leakage effects of UK-specific policies, including a hypothetical scenario where the UK would unilaterally introduce a carbon price on UK departing flights set at levels between USD15–300/tCO_2, found that leakage can be substantive, but global emissions would typically still decline (Dray and Doyme, 2019[62]). Two prominent channels for carbon leakage are fuel tankering and hub effects, as discussed in earlier OECD work (Michaelis, 1997[61]):

> *If a CO_2 charge [e.g. in the form of a kerosene tax] were applied at a non-uniform level, it would be less effective than a uniform, globally applied charge. "Tankering", where aircraft take on more fuel than is needed for a flight to avoid taking on more expensive or lower quality fuel at the next port of call, already occurs to some extent — indeed airlines have developed software to plan their refuelling patterns taking account of relative fuel prices. A non-uniform CO_2 charge would give airlines an incentive to buy more of their fuel in countries that imposed a lower charge, or did not impose a charge at all. This might simply mean that, when operating flights with ports in both participating and non-participating countries, airlines would tend to buy more of their fuel in the non-participating countries than they would otherwise have done. Carrying extra fuel involves costs: it reduces the amount of cargo that can be carried, and increases the fuel consumption of the aircraft. Tankering is likely to be confined to short-haul flights, where these costs are least significant…*
>
> *The effects of unilateral imposition of a charge on passenger markets would probably be most noticeable in long-haul flights. Passengers would be more likely to fly via neighbouring countries not imposing the charge, leading to some concentration of long-haul hubs in these countries.*

Tankering would not only result in decreased tax revenue but may also compromise the environmental purpose of the tax, as tankering increases fuel burn and hence CO_2 emissions. A recent Eurocontrol study provides evidence on fuel tankering in Europe. Their simulation analysis revealed that 16.5% of flights were able to perform full tankering (i.e. avoiding the need to refill at the higher-cost airport) and an additional 4.5% partial tankering (some refuelling at the high-cost airport is necessary), causing 901 000 tonnes of additional CO_2 emissions per year (Eurocontrol, 2019[63]). The Swedish transport agency also commissioned a study to assess the risk of increased fuel tankering in a situation where the cost of fossil kerosene would be higher in Sweden than in other countries, as a result of the introduction of a national tax. The report estimated that a fuel price increase of up to 4% would lead to no increased tankering; increases of 4-9% would lead to increased tankering, mostly with respect to short-haul flights; for price increases between 11% and 20%, fuel tankering would increase for longer flights, but not for shorter ones for which maximum take-off and landing weights represent a constraint; at fuel tax rates between 21% and 32% of fuel prices, approximately 50% of the fuel required for the return flights would be tanked abroad (Swedish Transport Agency, 2020[64]).

Hub effects raise similar issues to tankering, and create additional political economy obstacles as domestic hubs potentially lose out to foreign competitors. Faber and Nellisen (2007[65]) evaluated hub effects for the original design of the EU ETS that included emissions from international aviation. The study concluded that hub relocation was unlikely at the price levels that were envisaged for the EU ETS at the time. However, their results also showed that:

> *The pattern for the separate groups of cities varies. On routeings to/from North America, the effect on direct traffic is almost the same for EU and non-EU carriers, but the impact on EU carriers' transfer traffic is particularly severe. Non-EU (effectively North American) carriers' transfer traffic is less seriously affected, because of the presence of US East Coast hubs.*
>
> *To/from the Asia-Pacific region, the effects on EU and non-EU carriers are more similar. Non-EU hubs are (mostly) so far from the EU that non-EU carriers could not gain the same advantage in attracting passengers as is provided by US East Coast hubs to North American carriers.*

Another leakage channel is fleet swapping. Airlines could redeploy less efficient aircraft to routes where carbon prices are lower sell or lease out older aircraft in their fleet (Dray and Doyme, 2019[62]).

Incentives for carbon leakage decrease with broad carbon tax coverage, as pre-tax price differences become less relevant and the additional fuel consumption resulting from tankering are relatively more costly. However, with limited coverage, carbon taxes may further increase tankering by increasing price differences. Both tankering and hub effects will vary by region and with the number of countries that decide to tax kerosene. Quantitative analysis would therefore appear most useful if it is conducted for a variety of plausible coalitions for introducing kerosene taxes, and different kerosene tax levels. Recent evidence is already available for the Nordic countries (Nordic Council of Ministers, 2020[66]).

Quantitative assessments of kerosene tax reform options could usefully identify distributional effects that will vary with countries' geographical situation and economic structure.[45] As discussed, taxing kerosene would have distributional effects across countries and within countries, which would also depend on how the revenue of such taxes is used. Developing a thorough understanding of the potential revenues raised from kerosene tax reform as well its distributional effects within and across countries would therefore also be important from a political economy perspective. A kerosene tax might on the one hand mainly fall on the richest households who fly the most, but may also have negative side effects for remote countries that heavily rely on flight-based tourism.

[45] In Chile, for instance the geographic factor is particularly relevant, which will affect the effectiveness of kerosene taxes at reducing emissions from international aviation.

4 Conclusions

Despite the significant decrease in aviation emissions triggered by the COVID-19 crisis, reducing the negative climate impacts from international aviation in the long run remains challenging. In the absence of policy changes, the sector can be expected to return gradually to strong growth once the pandemic subsides, even though the precise impact of the behavioural and structural changes resulting from the pandemic is difficult to predict. Abatement costs for cleaner air travel are high, and will remain high in the foreseeable future. Despite progress at the international level, the current incentives to reduce emissions from international aviation are not sufficient to meet the objectives of the Paris Agreement.

Considering the urgency of climate change mitigation, there is a case to be made for additional policy measures that could help countries better align emission trajectories from international flights with carbon-neutrality ambitions. Recovery packages and related policy measures could provide a window of opportunity to introduce such measures as part of a policy package, in exchange for liquidity support to airlines, where such support is deemed appropriate and necessary.

Kerosene used for international flights is generally not taxed. While rarely introduced with climate ambitions in mind, fuel taxes continue to be the most widespread price-based climate policy instrument across economies, with a track record of reducing emissions cost effectively. The highest rates tend to apply to gasoline and diesel used in the road sector. At present, the aviation sector benefits from favourable tax treatment compared to other sectors of the economy, in particular road transport.

Countries that wish to do so, could start taxing kerosene used for international flights, but this will at least in some cases require the renegotiation of air service agreements. This could be done either through bilateral treaty renegotiations or through the use of a multilateral treaty instrument (MLTI), where participating countries would agree to implement a harmonised legal clause permitting the aforementioned type of taxation. The Chicago Convention is not an obstacle to kerosene taxation supplied to airlines on the point of departure, as it merely rules out taxing fuel on board an aircraft arriving in the territory of a Contracting Party. The European Union's Energy Tax Directive, which is currently under revision, already contains a procedure that would allow EU countries to enter into bilateral agreements to start taxing kerosene for flights between themselves.

The interest in kerosene taxation varies across countries, and initial implementation will likely be confined to a limited number of frontrunner countries. While such a nationally determined approach arguably reflects the spirit of the Paris Agreement, partial implementation will raise concerns over carbon leakage and competiveness. In particular, this might incentivise airlines to tanker or move hub functions to low-tax jurisdictions, which could ultimately increase overall emissions and have a negative effect on the environment relative to the status quo. However, fuel tankering only makes sense on a limited range of flights (i.e. upper-range short-haul and mid-haul flights), limiting the number of routes on which airlines can tanker.

Fuel tankering and hub effects could be mitigated by agreeing on kerosene price floors at the regional level. The extent to which such mitigation strategies will be successful will depend on the coalition of taxing countries. Quantitative analysis, e.g. drawing on detailed air traffic and emissions data collected as part of the OECD estimations of SEEA Air Emission Accounts (Flachenecker, Guidetti and Pionnier, 2018[67]), could be helpful in this regard.

Countries could also move ahead with imposing or reforming passenger ticket taxes or related instruments, while working towards introducing kerosene taxes. Ticket taxes are already applied by a substantial number of OECD and G20 countries (e.g. France, the United Kingdom, Germany). They could be an alternative to taxing kerosene that does not raise the legal issues relating to kerosene taxes and would avoid tankering. Ticket taxes may still come with hub effects and raise other issues. Such taxes could often also be reformed so that the underlying tax base and rate better reflects the climate effects of the flights that are being taxed. Taxes on air traffic movements (per-flight taxes), air miles and frequent flyer levies are related instruments that could generally be adapted without the need to renegotiate air services agreements.

As with kerosene taxes, the effectiveness of ticket taxes in reducing emissions could be increased by international co-operation. This is especially relevant in smaller countries and border regions where some passengers may otherwise choose to fly from an airport in a different country (Faber and Huigen, 2018[56]; Borbely, 2019[68]). Co-ordination could target establishing minimum ticket tax levels. An important enabler of such co-ordination would be to develop a robust methodology to be able to compare ticket taxes across countries, which is not straightforward considering design differences and heterogeneous flight patterns. Considering its experience with calculating effective carbon rates and air emission accounts (OECD, 2018[30]; Flachenecker, Guidetti and Pionnier, 2018[67]), the OECD would be uniquely placed to facilitate comparisons of ticket taxes across countries and airports.

The role of ticket taxes need not be limited to providing a proxy carbon price. They could equally be implemented or reformed to meet fiscal or equity objectives or better align the tax burden across transport modes. Considering that tickets for international flights frequently benefit from a VAT rate of zero, they could also be a proxy for VAT. It should be noted that the incidence of ticket taxes does not only fall on passengers from the taxing country, but will equally fall on passengers from the destination country in the common case where these book return tickets. The unilateral introduction of ticket taxes may then create incentives for destination countries to enter bilateral or multilateral agreements to participate in the tax revenue e.g. coordinate on aviation taxes more broadly (Nordic Council of Ministers, 2020[66]).

Using taxes to complement existing measures to decarbonise international aviation provides implementing countries with revenues that could be used to address competitiveness and equity issues, and encourage broad participation in a potential coalition of countries around minimum tax levels for air transport CO_2 emissions. Revenue recycling strategies could, for one, ensure that the mobility of vulnerable groups is not compromised as a result of aviation taxes. Revenues could also usefully be employed to fund research, development, demonstration, deployment and diffusion of cleaner aircraft and fuel technologies.

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Annex A. Governance of international aviation

Chicago Convention of 1944

The Chicago Convention is a multilateral legal instrument with treaty status that binds its signatories to a set of basic standards and principles governing international aviation. The Chicago Convention is the document establishing the ICAO, of which 193 countries are signatories, including all OECD and G20 countries. The Chicago Convention is the main reference document for laws governing international civil aviation, containing the general principles of civil aviation between ICAO member countries.

The ICAO Assembly is comprised of all ICAO Member States and meets triennially to decide on the matters proposed by the ICAO Council. The Assembly adopts technical guidelines and non-binding policy documents by a simple majority of votes. Amendments to the Chicago Convention require a two-thirds majority of voting States. Entry into force requires the ratification of the amendment by no less than two-thirds of all ICAO Member States.

Air service agreements

Air service agreements (ASAs) (also known as air *transport* agreements) are legal instruments with treaty status that govern civil aviation relations between two or more Contracting States of ICAO. ASAs further build on the principles contained in the Chicago Convention and *ICAO's Policies on Taxation in the Field of International Air Transport* (Doc.8632) (ICAO, 2000[57]), adapting the principles to the specificities of the flight-routes between different country pairs. This process includes individualised provisions for the taxation of fuel on departure. Consequently, ASAs are key for understanding the institutional context of carbon pricing in international aviation. ASAs are generally modelled after a template ASA found in *Policy and Guidance Material on the Economic Regulation of International Air Transport* (DOC 9587) (ICAO, 2017[69]).

Bilateral ASAs govern civil air transport between two ICAO member countries. ICAO membership awards the members the legal status of a "Contracting Party". Multilateral ASAs govern civil air transport between multiple countries (e.g.. Multilateral Agreement on the Liberalization of International Air Transport (MALIAT) between the United States, New Zealand, Chile, and others). Another example of a multilateral ASA is a Single Aviation Market (i.e. Single European Sky).

Single Aviation Market

A single aviation market (SAM) refers to an airspace shared by two or more Member States, which operate under unified rules. The primary difference between a SAM and an ASA is the navigation freedoms awarded to the contracting parties (Brooker, 2003[70]).[46] ASAs are more limited in scope than SAMs.[47] Among OECD/G20 countries, the two SAMs are the EU SAM and the Australia-New Zealand SAM.

In the EU, the Single Sky initiative aims to facilitate a common civil aviation airspace shared and governed by a unified set of rules for all airlines of all member countries of the Single Sky and their respective

[46] SAMs permit for all nine freedoms of navigation, which is not always the case for ASAs. Furthermore, the legal framework governing the EU SAM does not recognise national but rather "Community Carriers". This distinction liberalises the routes a Community Carrier can operate, while harmonising state aid and safety, as well as environmental standards.

[47] https://www.itf-oecd.org/sites/default/files/docs/dp201504.pdf.

aircrafts. This includes harmonised rules for Air Traffic Control (ATC), common upper aviation airspace, and division of airspace zones controlled by different ATC centres by efficiency rather than by national borders. The EU SAM is not directly subject to the legal provisions contained in the Chicago Convention as the EU is not a party to the Convention.[48]

Dispute resolution mechanisms

Dispute resolution mechanisms are specified in individual bilateral ASAs and SAM agreements. Bilateral ASAs generally follow a three-step process of dispute resolution, as recommended by ICAO. First, in case of a dispute, Contracting Parties' Civil Aviation Authorities are encouraged to resolve the dispute through negotiation and consultation.

Second, if Contracting Parties' Civil Aviation Authorities fail to resolve the dispute, the matter should be referred to Contracting Parties' for further negotiation and consultation, including on a high-level platform.

Third, should the Contracting Parties be unable to resolve the dispute through negotiation or consultation, a three-member arbitration panel is appointed. The Contracting Parties appoint one member of the panel each. The President of the panel is jointly appointed by the two arbitrators. If the two arbitrators cannot come to an agreement, the President of the panel shall be appointed by the ICAO President, or the highest ranking Vice-President of ICAO.[49]

The ruling of the arbitration panel is binding on the Contracting Parties in dispute. In the event that the violating Contracting Party does not comply with the ruling of the panel, the other Contracting Party can retaliate in kind. Disputes arising within the EU SAM are referred to the court of justice of the European Union.

48 http://curia.europa.eu/juris/document/document.jsf?text=&docid=110742&pageIndex=0&doclang=en&mode=req&dir=&occ=first&part=1&cid=10226491.

49 The ICAO official making the appointment cannot be a national of either of the Contracting Parties in dispute. For the EU-third country ASAs, this constraint encompasses a nationality of any EU Member State.