Tankering in aviation

Assessing the impact of the ReFuelEU SAF mandate

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Executive Summary

This study is a deep dive into intra-European tankering, a practice whereby an aircraft uplifts excess fuel in one airport to cover its return trip in addition to its outward journey. Airlines tanker to save fuel cost when fuel is cheaper at the departing airport than at the destination airport. **Tankering is a real climate issue,** as the extra weight from the excess fuel leads to extra fuel consumption, **but there are solutions to mitigate it,** most notably in the context of ReFuelEU, the upcoming EU's sustainable aviation fuel (SAF) mandate.

- Because of the inhomogeneity in fuel price across the EU, this study finds that 37% of intra-European flights would find it profitable to carry extra fuel for economic benefit at present. This corresponds to the emission of **457,000 additional tonnes of CO_2 per year, which exceeds the yearly emissions of the three busiest German domestic routes**, namely Berlin-Frankfurt, Berlin-Munich and Munich-Hamburg.

- Under the ReFuelEU proposal from the European Commission (EC), the introduction of SAF mandates in large and medium airports, called "Union airports" in the Regulation (over one million passengers) is good news regarding intra-European tankering, **as it leads to an homogenisation of airport fuel prices. Combined with fair carbon pricing**, which penalises the additional CO_2 released by the consumption of the tankering fuel penalty, **extra fuel consumption from intra-European tankering could decrease by 30% and 42% in 2030 and 2035 respectively.**

- However, we find that in the absence of a fair kerosene tax, intra-European tankering would still be responsible for 280,000 and 300,000 avoidable tonnes of CO_2 per year in 2030 and 2035, or about the **yearly emissions of flights between Paris and Nice as well as Paris and Toulouse. This undermines the full climate benefit of the SAF mandates**.

- We therefore welcome the EC's proposal of an "anti-tankering" provision (Art. 5 of ReFuelEU) which ensures that at a given Union airport, an airline uplifts at least 90% of the fuel needed to operate flights from that given airport, limiting the amount of tankering allowed. Unfortunately, **this policy instrument still leaves a buffer to airlines, allowing them to practise tankering** on a selection of routes amounting to 10% of total fuel required at a departing airport. **This opens the door to SAF avoidance tankering if this buffer were to be used on non-mandated airports outside of EU27+NO**.

- **An anti-tankering provision applied at route level** (rather than at airport level) **would limit the risk of SAF avoidance outside of EU27+NO while significantly reducing tankering**

within EU27+NO. We find that in all scenarios, the amount of extra fuel burnt via tankering is cut by at least 80% and the emission cuts intended by ReFuelEU are entirely secured.

- We find that most intra-European tankering occurs on short-haul flights, 9 out of 10 flights practising tankering being shorter than 1500 km. **An “anti-tankering exemption” for short-haul flights will therefore fail to address the bulk of extra emissions from intra-European tankering**. In addition, flights to neighbouring EU27 countries like Turkey could fall under the exemption. **Exempting flights under 1500 km** could mean, for example, that **up to a fifth of the fuel required by Turkish Airlines to operate its flights from Europe to Turkey could be tankered in a non-mandated Turkish airport instead**. This leads both to extra emissions and to SAF avoidance.

In the context of the ReFuelEU trilogues, T&E highlights the absolute necessity of an anti-tankering provision, without distance-based exemptions, and urges policymakers to consider applying this at route level, instead of airport level (as shown below), in order to close a potentially damaging loophole in the legislation.

Article 5:

”the yearly quantity of aviation fuel uplifted by a given aircraft operator ~~at a given Union airport~~ ***for a given route*** shall be at least 90% of the yearly aviation fuel required ***for this route***”.

Table of contents

1 Introduction

The European Commission (EC) published on the 14th of July 2021 a set of proposals aiming at reaching a decrease in net emissions of -55% in 2030, compared to 1990 levels. As part of this "Fit for 55" package, RefuelEU, the revision of the EU Emission Trading System (ETS) and the Energy Taxation Directive (ETD) aim at addressing aviation emissions. ReFuelEU will mandate an increasing use of Sustainable Aviation Fuels (SAF) at Union airports, which are defined by the EC as European airports with more than 1 million departing passengers per year[1]. The EU ETS and the ETD will directly or indirectly put an effective price on CO_2 emissions for flights covered, respectively by making airlines purchase permits to emit CO_2 and through a tax on kerosene.

1.1 Risk of carbon leakage via tankering

As the EU climate measures will make flying more expensive in the EU, concerns were raised about the risk of carbon leakage. Tankering is one of the five types of carbon leakage identified [1]. This practice occurs when airlines uplift excess fuel in one airport to cover the full or partial return for economic benefit. As SAF will be more expensive than fossil kerosene in the years to come, a concern is that tankering would occur in non-mandated airports to avoid uplifting more costly SAF blended fuels. This practice would reduce the uptake of SAFs European aviation. In addition, tankering has a CO_2 penalty owing to the extra weight carried in the first leg as shown in Fig. 1. The combination of the SAF avoidance as well as the extra CO_2 emissions due to the fuel penalty could undermine ReFuelEU's ambition.

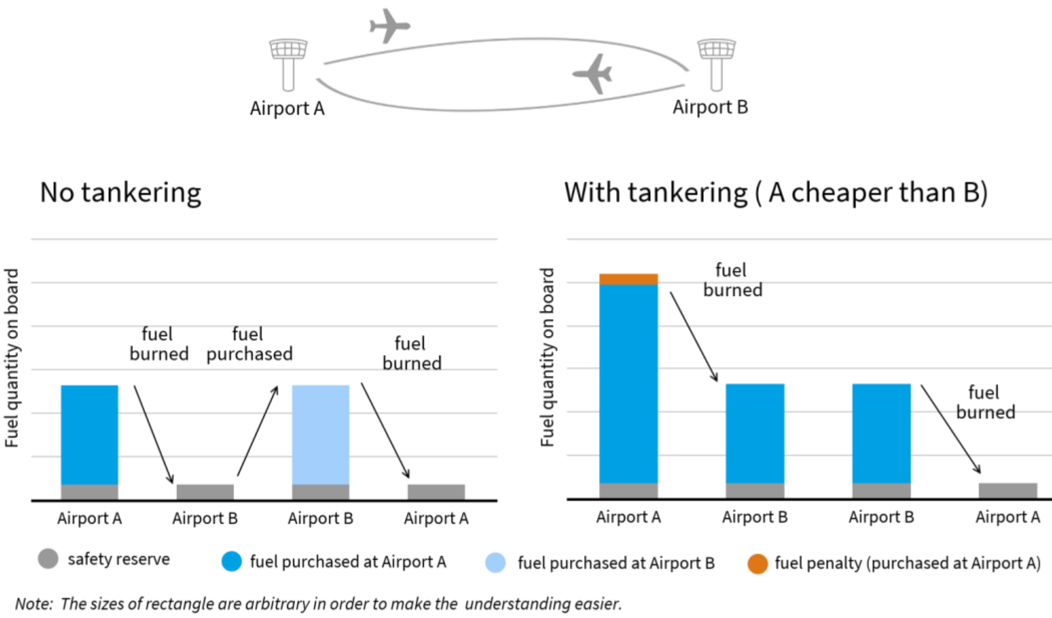


Figure 1: Simple visualisation of the practice of tankering

[1] At the time of the modelling, the ReFuelEU trilogues are still ongoing, which means that the definition of "Union airports" is the one defined in the European Commission proposal.

The ICCT has assessed the risk of tankering and SAF mandate avoidance for flights between the EU and non-EU territories [2]. It has been found that in 2030 (and without any anti-tankering measures), actual emission reductions achieved by the SAF mandate would fall by about a quarter. In particular, flights originating from the UK are found to be responsible for half of tankered flights[2]. These results could however be revised downwards for two reasons. Firstly, in the light of the UK drafting a similar SAF mandate to the EU[3], one could expect a considerable reduction of the amount of tankering occurring between the two territories. Secondly, ReFuelEU includes an obligation for airlines to refuel a certain amount of the fuel needed in departing mandated airports, a so-called anti-tankering provision. However the actual efficiency of the refuelling obligation regarding the flights between EU and non-EU airports is made uncertain by its design. This will be discussed in section 3.4 of this study.

1.2 Aim of the study

While the ICCT assessment covers the round trips between airports in the EU and Norway (NO)[3] (EU27+NO) and other airports, **this study focuses on the flights within EU27+NO, also called intra-European flights in this study**. We look at the following points:

- We estimate the **extent of the practice of tankering due to the fuel price differentials already existing** between EU27+NO airports.
- We estimate how the practice is likely to **evolve with the introduction of mandates for cleaner fuels and higher carbon prices**. The quantitative analysis is based on the ReFuelEU text published by the EC in July 2021. In this version of the text, only airports with more than 1 million passengers a year are mandated to blend a certain percentage of SAF in their fuel.
- We look at the **effect of the anti-tankering provision and discuss its design**. In that section, and because of the current design of the anti-tankering provision, the scope of the analysis is extended to all flights departing from EU27+NO airports.
- We analyse qualitatively the **impact of a potential refuelling obligation** (so-called anti-tankering provision) **exemption for short-haul flight**.

The quantitative analysis includes an estimate of the climate impact of tankering. To do so, the following aspects are considered:

- **Additional fuel burnt from the tankering fuel penalty**: as explained above, the practice of tankering results in extra fuel consumption per flight, and therefore extra CO_2 emissions.
- **The type of fuel that is tankered**: In the EC proposal, only airports with more than 1 million departing passengers per year - so called Union airports, would be mandated to blend SAF. If tankering happens at a non-Union airport to avoid refuelling at a Union airport, it will affect

[2] This assumes that the UK does not adopt parallel SAF mandates, which is unlikely as the UK government plans to align or mandate even higher SAF shares.

[3] Norway is likely to align its SAF mandates with EU ones.

the uptake of SAF compared to a theoretical “no tankering scenario”. This will be called “**tankering SAF avoidance**” in this study. If tankering happens at a mandated airport to the detriment of a non-mandated airport, the uptake of SAF will be bigger than in the “no tankering scenario” - this will be called “**tankering SAF boost**”.

- **Cut in emissions**: combining points 1 and 2 above, we investigate how tankering might affect the expected climate outcome of ReFuelEU.

2 Methodology to estimate intra-European tankering

2.1 Intra-European round trips

We use a round trip based approach to investigate the practice of tankering. Automatic Identification System data for 8 weeks in 2019 were analysed and emissions were calculated using the EMEP/EEA emissions calculator [4]. 2019 was chosen as the last year prior to the Covid-19 crisis. It should be noted that **no projections were undertaken for the year 2030 and 2035, ignoring any growth in traffic or decrease in demand due to higher ticket prices induced by the increase of fuel expenses**. As most European flights are found to be involved in simple return flights patterns [5], round trips were identified by aggregating flights operating on a same route by the same airline and aircraft type[4].

As explained above, the SAF mandates are only applicable to “Union” airports. The categories “large”, “medium”, “small” and “very small” are used in this study to give more granular results, with the following correspondence (Table 1).

Size Label	Passenger threshold (departing pax/yr)	Status in the EC proposal
Very small	< 500,000	Not mandated
Small	≥ 500,000 ; < 1,000,000	Not mandated
Medium	≥ 1,000,000 ; < 3,000,000	Union airports - mandated
Large	≥ 3,000,000	Union airports - mandated

Table 1: Airports size and corresponding status in the European Commission ReFuelEU proposal

[4] We find that intra-EU27+NO roundtrips emissions amount to 43Mt. Comparison with ETS data shows that this methodology might be underestimating emissions by 9%.

Fig. 2 shows that most round trips identified, as well as CO_2 emissions come from flights between two Union airports - between medium and large airports.

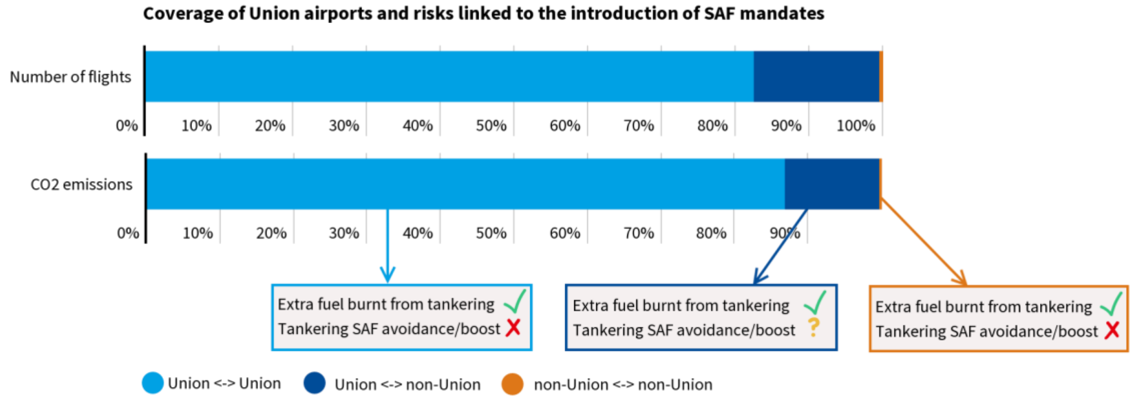


Figure 2: Share of number of intra-European round trips and CO_2 emissions per route type, as defined in the EC proposal, and qualitative assessment of risks

Two points must be noted:

- For **roundtrips between two airports of the same status** (e.g. two Union airports or two non-Union airports), **the practice of tankering cannot lead to any SAF avoidance or boost**, because the same type of fuel is sold in both the departing and the arriving airports. For these segments and in a climate perspective, it is desirable to reduce tankering, to avoid any extra fuel consumption.
- For roundtrips between a Union airport and a non-Union airport, the desirable outcome can be more ambiguous. In some very particular cases, the emission savings[5] due to *tankering SAF boost* might overcome the extra emissions due to the fuel penalty.

2.2 Intra-European jet fuel prices

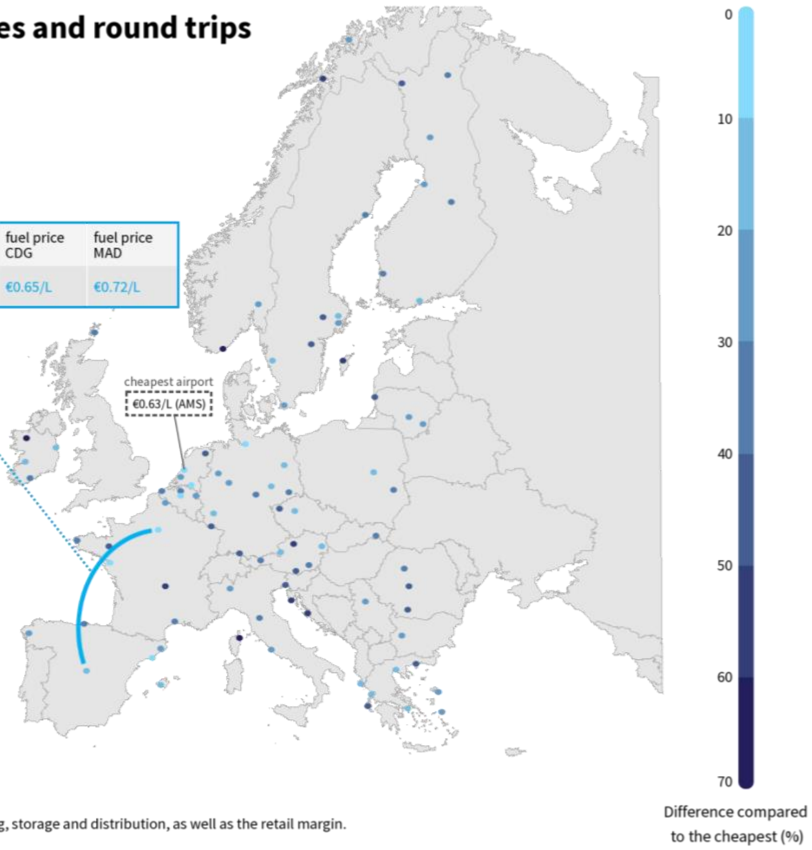
The practice of tankering results from the differentials between jet fuel prices across airports. In order to estimate the extent of the practice, consumer point jet fuel prices in European airports were purchased from Stratas Advisors. They include production cost, cost of handling, storage and distribution, and retail margin. Fig. 3 shows the inhomogeneity of fuel price across Europe. It can be explained by both the lack of competition at smaller airports and the difference in cost of transport which is highly dependent on the infrastructure in place. For example, pipelines are cheaper than transport by truck. It should also be noted that airlines have different negotiation powers within the same airport. As those data are highly confidential and difficult to access, it is assumed in this study that for a given airport, all airlines are paying the same jet fuel price.

[5] Both in 2030 and 2035, assuming an 80% reduction in lifecycle CO_2 emissions from SAFs, aligned with ICCT's assumption [2].

European aviation jet fuel prices and round trips database

Extract from the database

IATA airports	aircraft type	airline	no roundtrips per year	CO2 per year (t)	fuel price CDG	fuel price MAD
CDG-MAD	A320	Iberia Express	539	12,270	€0.65/L	€0.72/L



Sources: Airport prices (STRATAS, 2019)
2019 European emissions (PlaneFinder, Eurocontrol)
Note: Consumer point fuel prices include the cost of production, handling, storage and distribution, as well as the retail margin.

Figure 3: Jet fuel prices in airports across Europe and sample of the round trip database

Missing airport prices were allocated the average jet fuel price per size and corresponding country. Fig. 4 shows the distribution of CO_2 emitted by flights departing from airports with different jet fuel prices. 93% of emissions result from flights departing from large and medium airports, where the fuel is typically cheaper (average of respectively €0.72/L and €0.84/L) than in small and very small airports (average of respectively €0.87/L and €0.92/L).

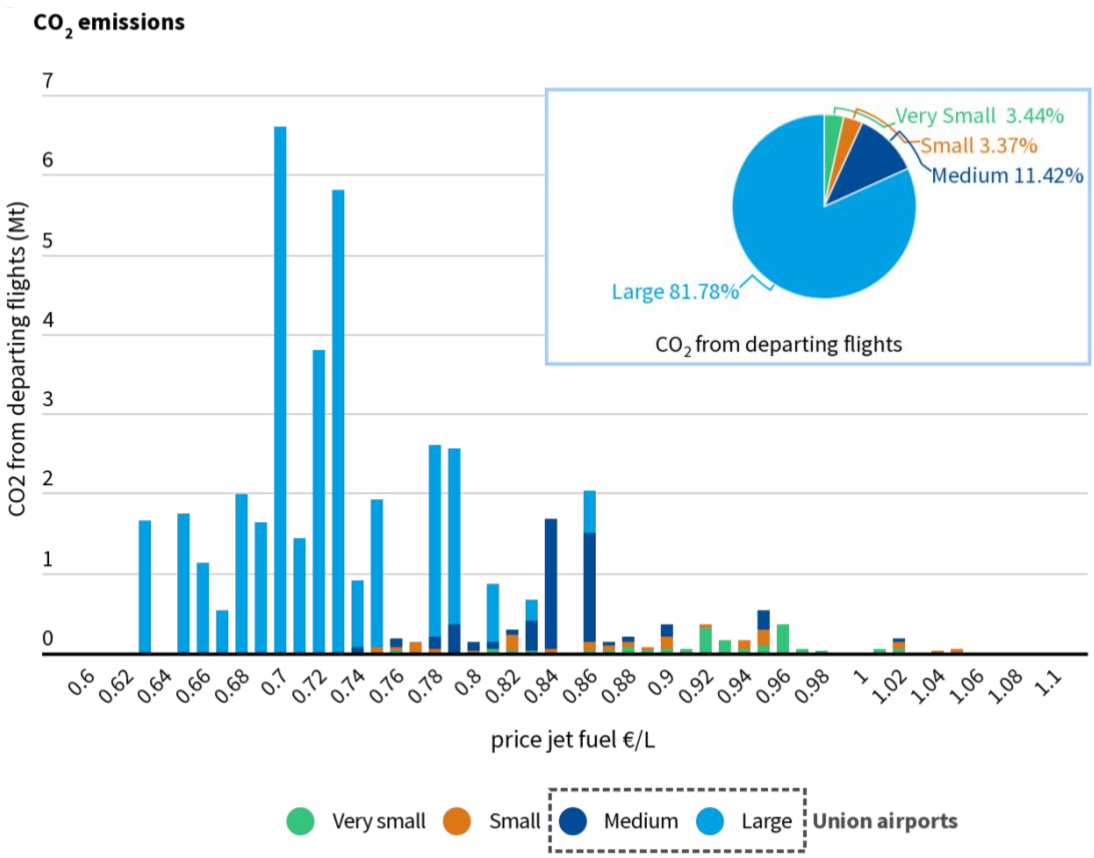


Figure 4: Jet fuel price distribution across EU27&NO per airport size. CO2 associated with the price range

2.3 Cost-effectiveness of tankering and weight limitations

This section explains how we assess if an airline is likely to practise tankering or not for a given round trip. The main assumption is that an airline practises tankering as soon as it generates savings above 15 euros, which was found to be a minimum pivotal point in the decision to go into fuel tankering according to a survey carried out by Eurocontrol [5]. The expenses considered are:

- Fuel purchased (affected by the introduction of SAF in 2030 and 2035)
- Tax on fossil kerosene (only in 2030 and 2035)
- Allowances purchased under the ETS

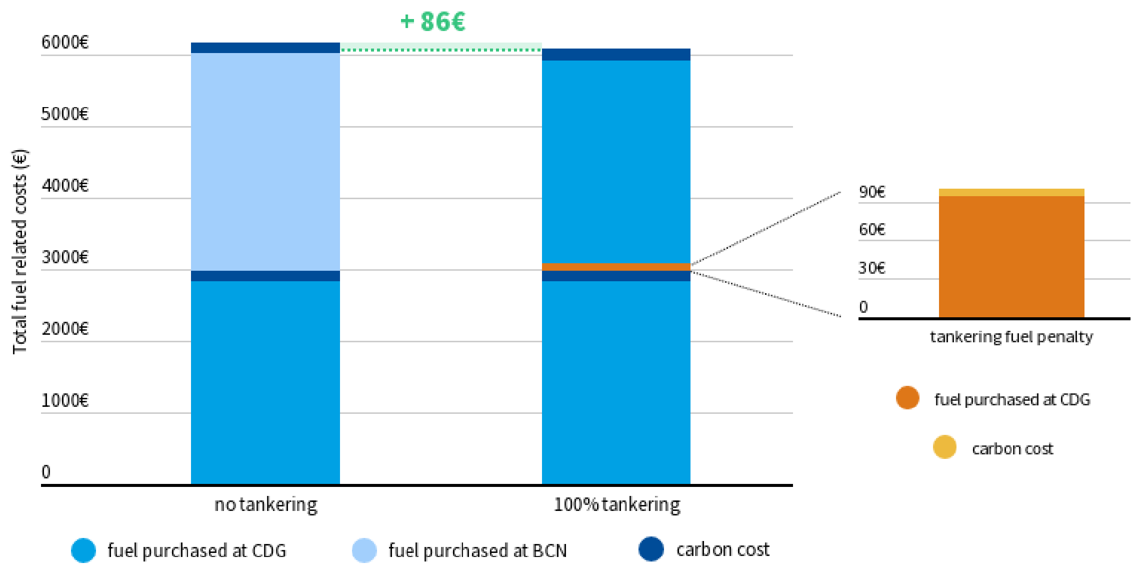
As explained above, if an aircraft tankers, it incurs a fuel penalty due to the extra weight of fuel carried. We use a fuel penalty factor of 0.388% per 100 km flown[6], as calculated by the ICCT for a narrow-body aircraft [2]. It adds the following expenses:

[6] In a 100km leg, if the aircraft performs full tankering, it will burn 0.388% more fuel than normally needed when flying without carrying extra fuel. For a 200km leg, it will burn 0.776% more fuel.

- Additional fuel purchased (affected by the introduction of SAF only in 2030 and 2035)
- Tax applied on additional fossil kerosene (only in 2030 and 2035)
- ETS allowances purchased to cover the additional emissions

Therefore, tankering is cost-effective as long as the cost penalties due to the extra fuel burnt do not offset the cost benefits of purchasing cheaper fuel. In the example below of a round trip between Charles de Gaulle airport (CDG) and Adolfo Suárez Madrid-Barajas airport (MAD), a 7% difference in fuel price between the airports is sufficient so that the additional costs generated by the fuel penalty do not exceed the benefit of purchasing all the required fuel in the cheaper airport (CDG).

Round trip	Distance (km)	Aircraft	Fuel price difference (%)	Carbon price (€/tCO2)	Net savings from tankering (€)
CDG-BCN	860	A320	7%	13*	+86
					Cost effective



Note: This example assumes that the final text does not include an antitankering provision.
*Assumes an ETS allowance price of 24.72€, and 47% of allowances given for free.

Figure 5: Example of a round trip where the practice of tankering is cost-effective

In reality, aircraft are subject to weight limitations defined in the certification of the plane, both at takeoff by the Maximum take-off Weight (MTOW) and at landing by the Maximum Landing Weight (MLW). Therefore, an aircraft cannot necessarily carry the amount of fuel required to fly the whole round trip. In that case, if tankering is cost-effective, the aircraft will uplift fuel up to a certain limit defined by MTOW and

For partial tankering, we assume a linear decrease in the fuel penalty factor. If an aircraft performs partial tankering, by carrying for example an additional quantity of fuel to perform one tenth of the return trip, it will burn 0.0388% more fuel than normally needed.

MLW, which will only cover a part of the return leg. This practice is known as partial tankering. In this study, MTOW and MLW for the five most common aircraft types were considered, covering 84% of emissions. The amount of fuel possibly tankered was calculated considering taxi fuel, fuel to destination and the safety reserve. These assumptions are detailed in the annex.

3 Results

3.1 Scenario assumptions overview

The result section assesses the extent of the practice of tankering for different scenarios and the resulting CO_2 emissions. To single out the climate impact of tankering, **the demand is considered constant in all scenarios**.

- The *baseline scenario* refers to a typical year (air traffic from 2019 was chosen as the last year prior to the Covid-19 crisis), without SAF mandate and with only a share of ETS allowances that have to be purchased. It allows us to appreciate **how the practice of tankering will evolve with the introduction of the new regulations, compared to the current situation**.
- The *theoretical zero tankering scenarios* refer to scenarios in 2030 and 2035 where no tankering is occurring. It is used for appreciating **how the practice of tankering could curb the expected outcome of RefuelEU**.

Initially, calculations are run in the absence of any anti-tankering provision to cover the eventuality of its repeal. The effect of an anti-tankering provision as well as its design are the objects of section 3.4.

The *2030 and 2035 scenarios* investigated take into account three pieces of legislation. The ReFuelEU initiative [6] aims at implementing increasing shares of SAF as well as refuelling obligations (so-called anti-tankering provision) at Union airports. The Energy Taxation Directive [7] sets an incremental tax on fossil fuels, starting from 2023 and reaching its maximum in 2033, at 0.38 euros per litre of kerosene[7]. The review of the ETS includes the phase out of free allowances by 2027 [8]. Further assumptions are presented in Table 2.

Metric	Baseline	2030	2035
SAF mandate (from biological origin)	-	4.3%	15%
SAF mandate (synthetic fuels)	-	0.7%	5%
Jet A fuel production cost (€/t)	557 [8]		
SAF (from biological origin) production cost (€/t)	-	2000[9]	

[7] The ETD proposal set an incremental tax on kerosene, reaching a value of €10.75/GJ in 2033.

[8] Production costs in 2020 (pre-covid times)[9]. In this study, the cost is kept constant over the years. In reality, fossil jet fuel production cost is foreseen to increase up to €690/t in 2050 [10].

[9] Central value of the range of levelised cost of production for SAF from Gasification-FT pathways [11].

SAF (synthetic fuels) production cost (€/t)	-	2200[10]	
ETS allowance price (€/tCO_2)	24.7[11]	100[12]	
Share of free ETS allowances	47%[13]	-	
Kerosene tax (€/tCO_2)	-	103	147
Refuelling obligation in Union airports	-	90% (only in Section 2.2.4)	

Table 2: Main scenarios assumptions

3.2 Baseline scenario: already existing tankering

We find that 24.2% of flights (i.e 48.3% of roundtrips[14]) within EU27+NO would already practise full tankering according to our assumptions. An additional 12.7% would practise partial tankering. The practice would be responsible for the yearly emissions of 457,000 additional tonnes of CO_2, adding 1.1% of avoidable emissions to the sector. This compares with the CO_2 emissions of 2 700 flights from Paris to New York and represents more than the emissions from the three biggest domestic German routes, namely Berlin-Frankfurt, Berlin-Munich and Munich-Hamburg. Fig. 6 shows how the practice is distributed across distance bands.

[10] Central value of the range of levelised cost of production in 2030 [12].

[11] Average price of an ETS allowance in 2019 [13].

[12] In line with recent projections [14]. On the 27th of January 2021, ETS prices reached €89.8/allowance

[13] In 2018, 53% of verified emissions were covered by allowances acquired from auctions or from other sectors [15].

[14] Tankering is defined as "a practice that consists in uplifting excess fuel at one airport to avoid purchasing more expensive fuel at another". Therefore, for a given roundtrip where tankering is practised, the aircraft is carrying excess fuel in only one leg out of the two. The share of tankered flights has therefore to be doubled to account for the share of roundtrips concerned by the practice.

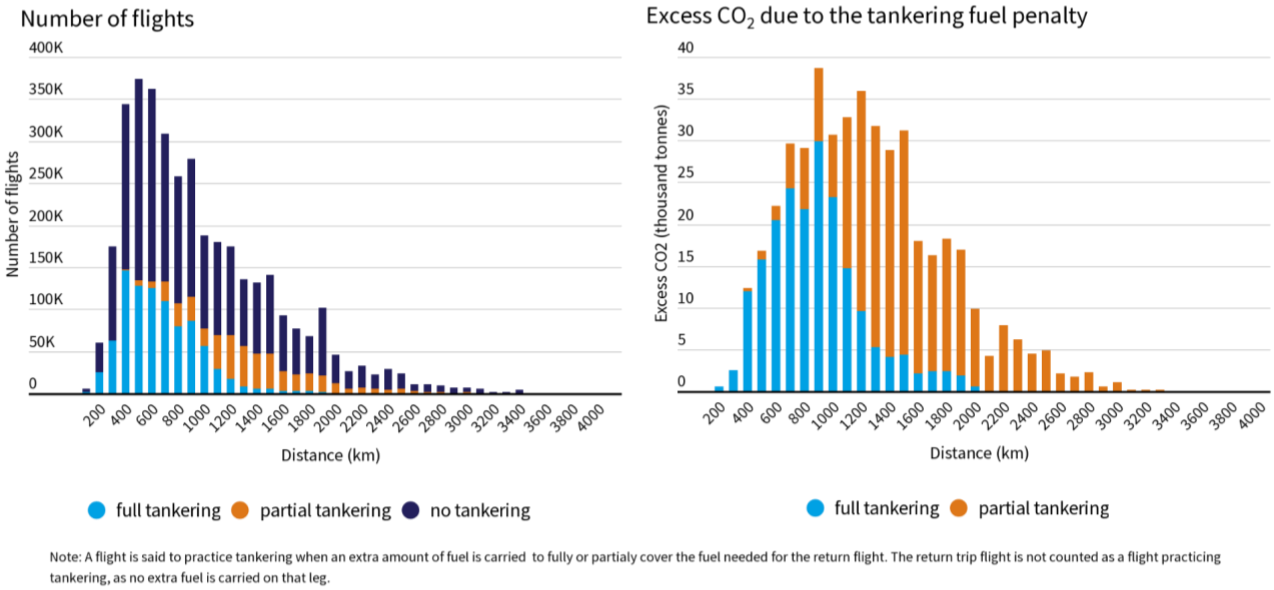
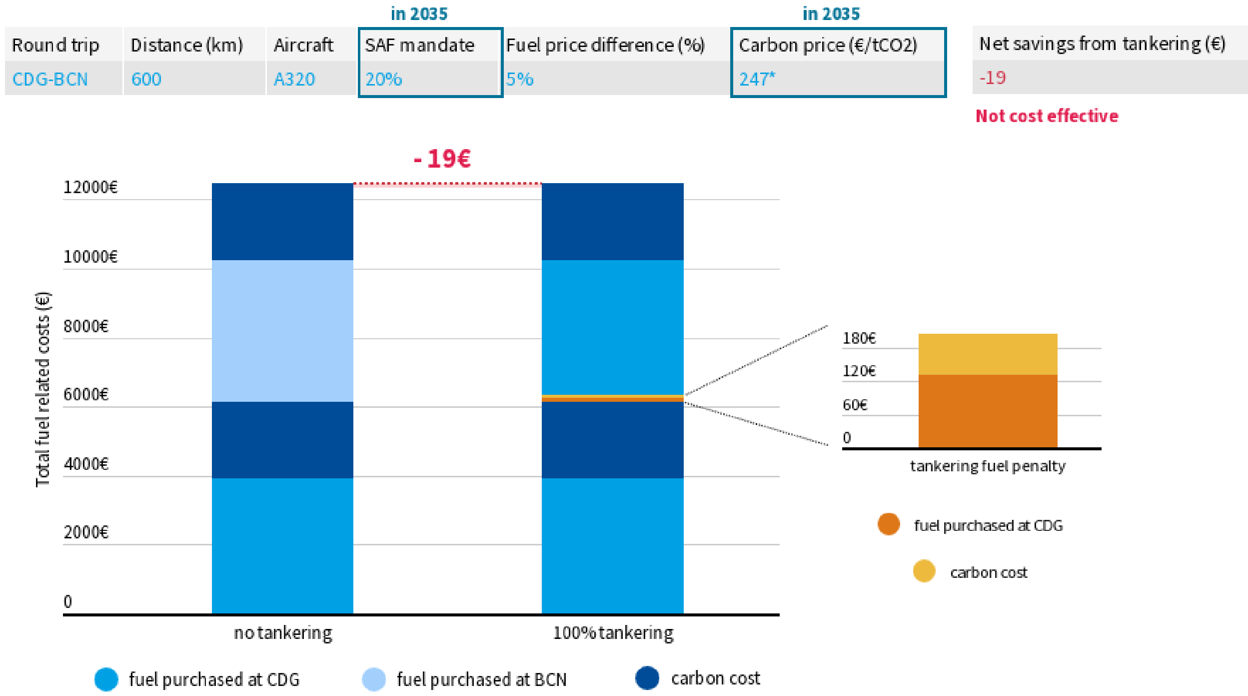


Figure 6: Extent of the practice of tankering in the Baseline scenario; number of flights and additional CO_2 emissions

It should be noted that for flights between Union airports (Large and Medium) and non-Union airports (Small and Very small), in over 98% of the cases of tankering, the additional fuel is uplifted in the Union airport to avoid buying fuel in the smaller airport. That is because larger airports typically offer cheaper jet fuel than smaller airports (Fig. 4).

3.3 Effect of a SAF mandate and carbon pricing on tankering

In 2030 and 2035, it is assumed that fuel suppliers are mandated to blend a certain share of SAF in their fuel, which slightly increases the fuel price at Union airports (see assumptions in Table 2). New prices due to the introduction of SAF are calculated by assuming that in a given airport, the retail margin and the expenses related to handling, storage and distribution are the same for fossil jet fuel and SAF. It implies that a fuel purchaser that benefits from an important negotiation power for fossil fuel will have a similar one for SAF-blended fuel, and that a low jet fuel price due to the infrastructures in place will similarly benefit SAF. Therefore, the introduction of the SAF mandate (5% in 2030 and 20% in 2035) has two consequences. First, it **narrows the gap in jet fuel price between large and small airports**. Second, it **decreases the relative price difference between Union airports themselves**. As a result, for some routes, the difference in fuel price between airports is not high enough anymore to overcome the costs incurred due to the fuel penalty (Fig. 7).



Note: This example assumes that the final text does not include an antitankering provision.

*Assumes an ETS allowance price of 100€, no free allowances and a kerosene tax of 0.38 euros per litre of JetA.

Figure 7: Example where tankering is no more cost effective

Table 3 and Table 4 summarise the results of the evolution of tankering in 2030 and 2035 with the introduction of SAF mandates and carbon pricing (ETS and kerosene tax), in the absence of any anti-tankering provision, that will be analysed in section 3.4.

Metric	Baseline	2030		2030 Theoretical zero tankering
		SAF (5%)	SAF + kerosene tax	
Full tankering (% flights)	24.2%	21.9%	20.4%	-
Partial tankering (% flights)	12.7%	10.1%	8.6%	-
Total fuel consumed (Mt) (of which fuel penalty)	13.73 (1.1%)	13.70 (0.9%)	13.68 (0.7%)	13.58 (-)
Total SAF uplifted (Mt)	-	0.67	0.67	0.63
Share of SAF in the fuel system	-	4.9%	4.9%	4.7%
Total CO_2 emissions (Mt) (of which emissions from fuel penalty)	43.49 (0.46)	41.71 (0.36)	41.66 (0.31)	41.43 (-)

Reduction in CO_2 emissions thanks to SAF blending (with constant demand)	-	4.1%	4.2%	4.7%

Table 3: Results in 2030. Introduction of SAF and direct and indirect carbon pricing

Metric	**Baseline**	**2035**		**2035 Theoretical zero tankering**
		SAF (20%)	**SAF + kerosene tax**	
Full tankering (% flights)	24.2%	19.7%	17.8%	-
Partial tankering (% flights)	12.7%	9.2%	7%	-
Total fuel consumed (Mt) (of which fuel penalty)	13.73 (1.1%)	13.69 (0.8%)	13.67 (0.6%)	13.58 (-)
Total SAF uplifted (Mt)	-	2.55	2.61	2.53
Share of SAF in the fuel system	-	18.6%	19.1%	18.6%
Total CO_2 emissions (Mt) (of which emissions from fuel penalty)	43.49 (0.46)	36.91 (0.29)	36.67 (0.23)	36.61 (-)
Reduction in CO_2 emissions thanks to SAF blending (with constant demand)	-	15.1%	15.7%	15.8%

Table 4: Results in 2035. Introduction of SAF and direct and indirect carbon pricing

Three conclusions can be made:

1. **In every scenarios, and in the absence of any anti-tankering provision, the practice of tankering decreases compared to the baseline**, thanks to the (combined) effects of:
    - The homogenisation of fuel prices across Europe, as big airports where the fuels tend to be less expensive are mandated to use more expensive SAF
    - Carbon prices penalising the additional CO_2 released by the consumption of the tankering fuel penalty

    Our analysis finds that the introduction of a SAF mandate would decrease the share of flights practising tankering from 36.8% in the baseline to respectively 32.0% and 28.9% in 2030 and 2035. This translates into a reduction in the total amount of fuel consumed, by respectively 30,000 tonnes and 40,000 tonnes in 2030 and 2035. We find that the introduction of a kerosene tax cuts the practice of tankering even further, resulting in a cut in fuel consumption of 50,000 tonnes and 60,000 tonnes in 2030 and 2035 respectively. In relative terms, it translates into a cut in extra fuel consumption due to tankering of 30% and 42% respectively in 2030 and 2035.

However, the fuel penalty incurred by tankering remains significant, especially in the absence of a kerosene tax, and would still add up to 0.9% to the total amount of fuel consumed in intra-European aviation.

2. As presented in section 1.2, another important parameter to measure the climate impact of tankering is the type of fuel tankered for the 16% of roundtrips between a Union airport and a non-Union airport. **Our analysis finds that in almost all scenarios, tankering occurring between Union and non-Union airports originates from a Union airport, called SAF boost tankering.** This is the reason why the share of SAF among total fuel consumed is higher than in a theoretical no tankering scenario. One exception is with the scenario where a 20% SAF blend is introduced, not accompanied by a tax on fossil jet fuel. In that case, close to half of the tankering between Union and non-Union can be qualified as SAF avoidance tankering and the share of SAF in the overall fuel system is similar to the one in a zero tankering scenario.
The predominance of SAF boost tankering over SAF avoidance tankering in roundtrips between a Union airport and a non-Union airport results from the cost-competitiveness of fuel purchased in Union airports. Indeed, the increase in price in Union airports due to the introduction of SAF is actually counterbalanced by the exemption of SAF from carbon pricing (ETS and kerosene tax). Fig. 8 shows the effect of carbon pricing (ETS and kerosene tax) on the actual cost-competitiveness of blended fuel.

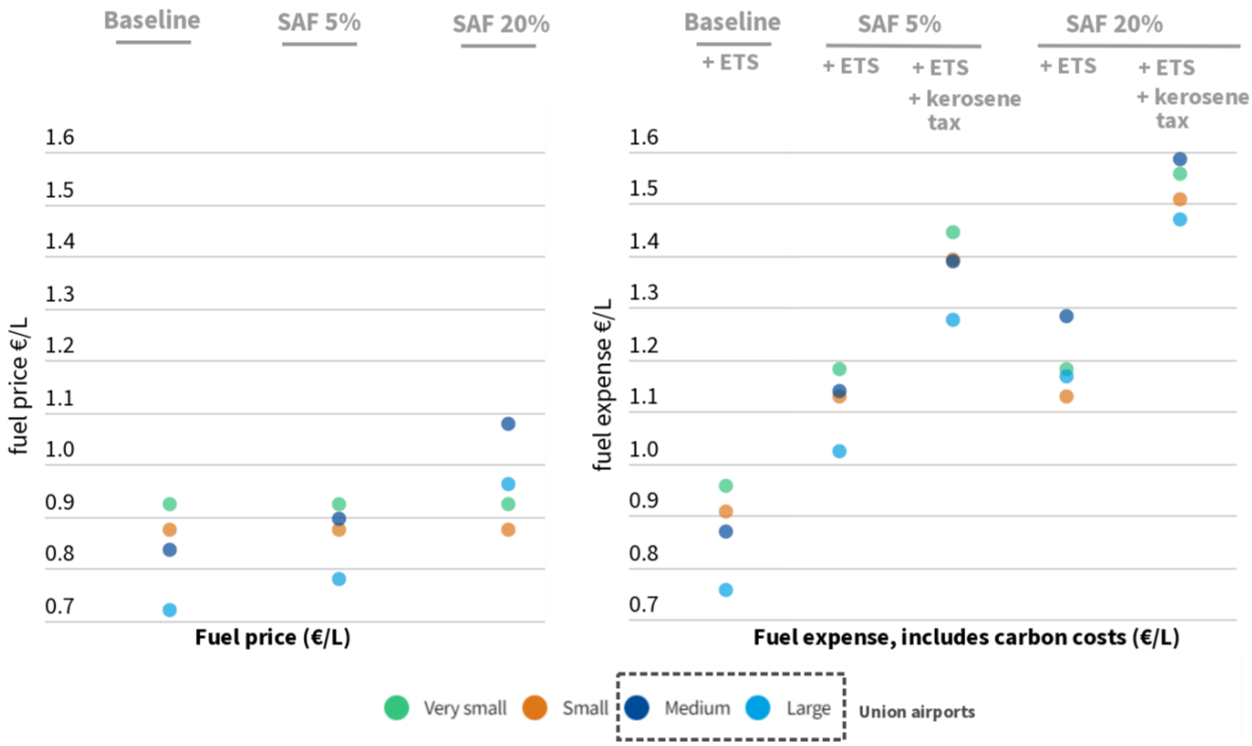


Figure 8: Fuel price vs. fuel expense: competitiveness of blended SAF fuel

With the introduction of a 20% SAF mandate in 2035, average prices for large and medium increase up to an average of €0.96/L for large airports and €1.08/L for medium airports, while fuel prices in non-mandated airports remain the same (average €0.87/L and €0.92/L for small and very small airports). However, when adding the cost of carbon pricing (ETS and kerosene tax, both exempting SAF), purchasing fuel in large airports gets on average cheaper. The fuel expenses are on average €1.47/L, €1.59/L, €1.51/L and €1.56/L in large, medium, small and very small airports respectively. The only case where large airports do not have the smallest expenses related to fuel is in a scenario with a 20% SAF blending and no kerosene tax. This explains why it is the only situation where SAF avoidance tankering is slightly predominant among roundtrips between Union and non-Union airports. **Carbon pricing helps SAF-blended fuel in Union airports to stay cost-competitive.**

3. In all scenarios but one, the share of SAF used is bigger than what could be expected from ReFuelEU SAF mandates in a zero-tankering scenario. However, results show that **in all scenarios, the higher share of SAF in the fuel system does not overcome the increase in emissions from the extra fuel burnt owing to the extra weight carried**. We find that, in the absence of a fair kerosene tax, the practice of tankering would be responsible for respectively 280,000 and 300,000 additional tonnes of CO_2 in 2030 and 2035 compared to a scenario where

no tankering is occurring, or about the **yearly emissions of flights between Paris and Nice as well as Paris and Toulouse.**

3.4 Analysis of the anti-tankering provision

In this section, we assess the effect of an anti-tankering provision depending on its design. As the anti-tankering provision proposed by the Commissions applies on aggregated fuel volumes at an airport level, all departing flights need to be considered: in this section, we look at flights inside EU27+NO as well as those outside of it.

3.4.1 Effect of an anti-tankering provision applied at airport level

Article 5 of the Commission proposal of RefuelEU imposes that ”the yearly quantity of aviation fuel uplifted by a given aircraft operator at a given Union airport shall be at least 90% of the yearly aviation fuel required” [6]. The ‘yearly aviation fuel required’ is defined as “the amount of aviation fuel necessary to operate the totality of commercial air transport flights operated by an aircraft operator, departing from a given Union airport, over the course of a reporting period”[4]. In this study, and consistently with the amendment proposed by the Council of the European Union and the Parliament, the ‘yearly fuel required’ is defined as the sum of the taxi fuel and the trip fuel, as defined by the European Commission [16].

Article 7 requires any aircraft operators to report this quantity after each reporting period, as well as the total amount of aviation fuel actually uplifted in each Union airport.

There is compliance when the quantity of fuel actually uplifted in a year by a given aircraft operator amounts to at least 90% of the quantity of fuel required. It implies that at an airport level, an airline could keep practising tankering on a selection of routes accounting for 10% of the total fuel required at the airport in a year.

The present study finds that even with the introduction of a 20% SAF mandate in Union airports - the risk of SAF avoidance via tankering in non-mandated EU airports is very low to non-existent. However **if the 10% buffer is used to take advantage of cheaper non-blended fuel in extra-EU airports, it could result in SAF avoidance**. The ICCT has determined a list of extra-EU countries where tankering could occur in 2030 with the introduction of SAF mandates in EU airports. Those countries are typically at a close neighbourhood of EU27+NO because for long-haul flights, the large fuel penalty can only be overcome by an important price differential between the departing airport and the non-EU destination airport. At a EU level, flights departing from EU27+NO airports to this list of countries[15] account for 7.4% of the total amount of fuel theoretically uplifted in EU27+NO airports. The ICCT finds

[15] ICCT has identified flights to the following countries to be at risk for tankering in 2030: Russia, Turkey, Switzerland, Morocco, Ukraine, Israel, Algeria, Tunisia and Serbia [2]. We didn’t not consider flights to the UK to lead to any SAF avoidance as the UK is expected to adopt its own mandates that are even more ambitious. Longer flights could be affected by tankering in 2035 with the introduction of higher SAF mandates.

that longer flights could be affected by tankering in 2035 with the introduction of higher SAF mandates.

Fig. 9 shows how the anti-tankering provision applied at airport level could still leave space for SAF avoidance tankering for flights between EU27+NO and other territories. Among all the fuel theoretically required by an airline to operate flight from a given airport in a year, **up to 10% could still be uplifted in the destination airport instead via tankering**.

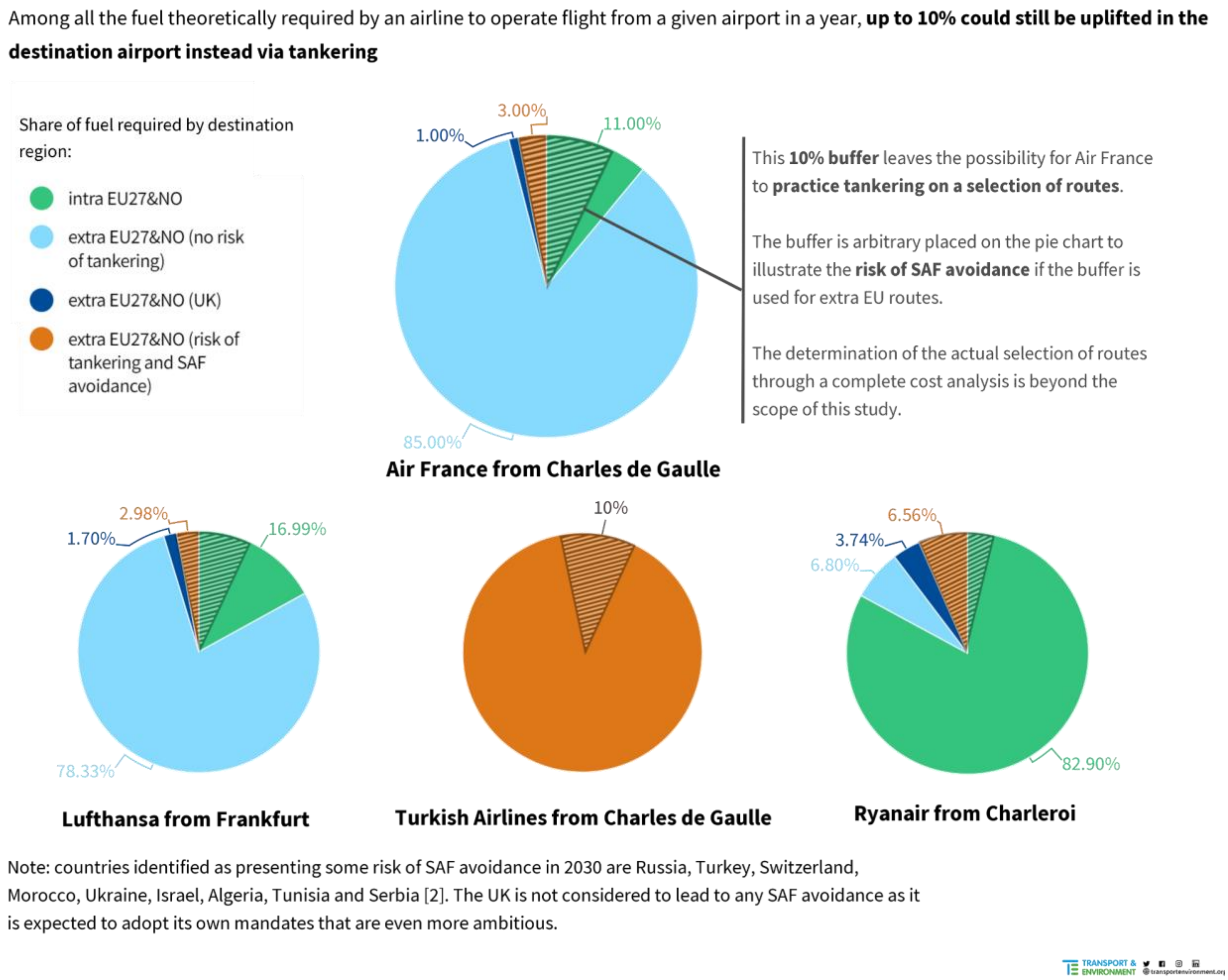


Figure 9: Simple visualisation of the risk of applying the anti-tankering provision at the airport level

A complete analysis of the efficiency of the anti-tankering provision applied at airport level is beyond the scope of this study. However, we point out through this what-if analysis that **applying the anti-tankering at airport level still leaves airlines a buffer that could be used for extra-EU+NO flights at risk of SAF avoidance tankering**. The next section analyses how applying the anti-tankering provision at route level would increase its efficiency.

3.4.2 Effect of an anti-tankering provision applied at route level

Applying the refuel obligation at a route level corresponds with amending Article 5 to ”the yearly quantity of aviation fuel uplifted by a given aircraft operator at a given Union airport *for a given route* shall be at least 90% of the yearly aviation fuel required for this route”. Such level of reporting is already required in the text adopted by the Parliament on the aviation ETS[16]. Applying the anti-tankering measure at a route level would decrease the amount of tankering and ensure that at least 90% of the blended fuel required for extra-EU+NO routes at risk of SAF avoidance tankering would be actually uplifted in EU27+NO airports. As explained before, this would not necessarily be the case with an anti-tankering provision at airport level, where the entire buffer could be used to cover those routes at risk of SAF avoidance. Fig. 10 illustrates the difference in the example of Air France departing from Charles de Gaulle airport. In that particular example, the anti-tankering provision applied at route level could reduce the amount of blended fuel at risk of SAF avoidance by 10. This figure should be regarded as a maximum and is not representative of all the airports in the EU27+NO. For example, with the case of Turkish Airlines from Charles de Gaulle airlines (Fig. 9), applying the anti-tankering provision at airport level or route level would have similar effects.

[16] Amendment 52, Article 14 [17].

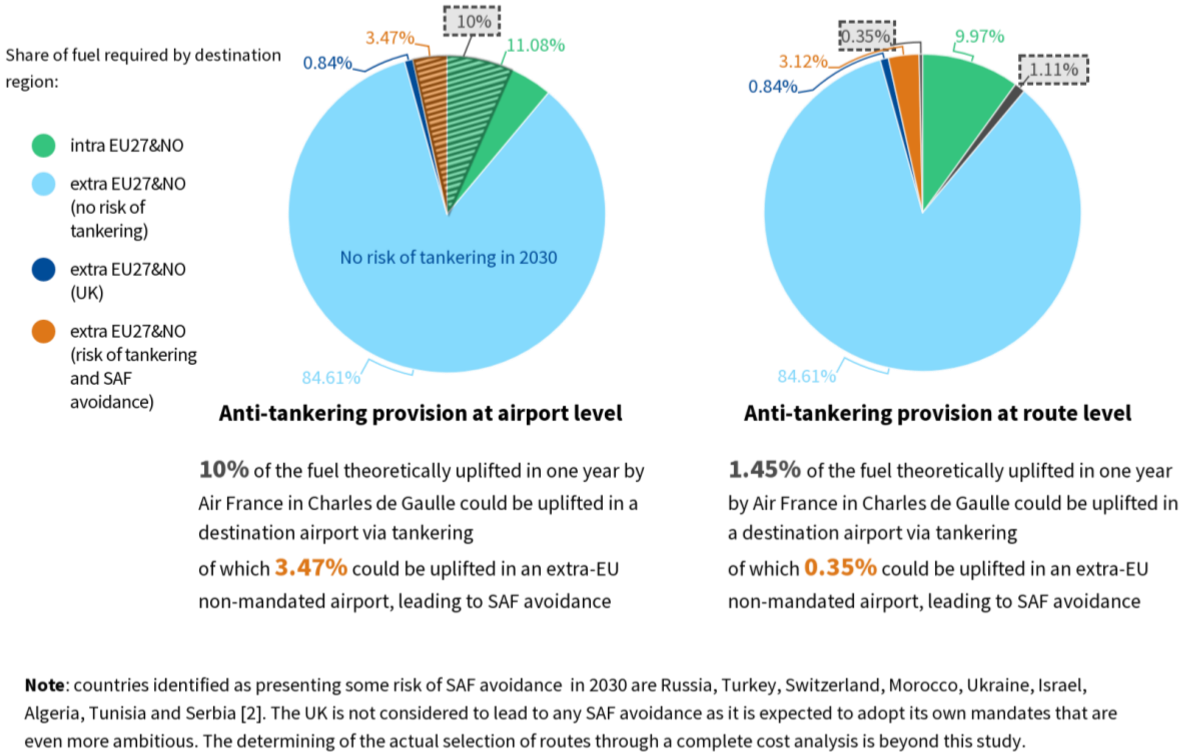


Figure 10: Impact of applying the anti-tankering provision at the route level. Example of flights operated by Air France and departing from Charles de Gaulle airport

The following paragraph estimates the **impact of an anti-tankering provision applied at route levels for flights within EU27+NO**. Table 5 and Table 6 show how the anti-tankering provision applied at route level would improve the emissions savings from the introduction of SAF.

Metric	**Baseline**	**Anti-tankering provision applied at route level**		**2030 Theoretical zero tankering**
		2030		
		SAF (5%)	**SAF + kerosene tax**	
Full tankering (% flights)	24.2%	6.1%	6.2%	-
Partial tankering (% flights)	12.7%	15.9%	13.5%	-
Total fuel consumed (Mt) (of which fuel penalty)	13.73 (1.1%)	13.61 (0.2%)	13.61 (0.2%)	13.58 (-)

Total SAF uplifted (Mt)	-	0.66	0.66	0.63
Share of SAF in the fuel system	-	4.9%	4.9%	4.7%
Total CO_2 emissions (Mt) (of which emissions from fuel penalty)	43.49 (0.46)	41.43 (0.09)	41.43 (0.08)	41.43 (-)
Reduction in CO_2 emissions thanks to SAF blending (with constant demand)	-	4.7%	4.7%	4.7%

Table 5: Results of applying an anti-tankering provision at route level in 2030

Metric	Baseline	Anti-tankering provision applied at route level		2035 Theoretical zero tankering
		2035		
		SAF (20%)	SAF + kerosene tax	
Full tankering (% flights)	24.2%	2.7%	4.7%	-
Partial tankering (% flights)	12.7%	15.0%	11.9%	-
Total fuel consumed (Mt) (of which fuel penalty)	13.73 (1.1%)	13.60 (0.1%)	13.60 (0.1%)	13.58 (-)
Total SAF uplifted (Mt)	-	2.58	2.62	2.53
Share of SAF in the fuel system	-	19.0%	19.3%	18.6%
Total CO_2 emissions (Mt) (of which emissions from fuel penalty)	43.49 (0.46)	36.54 (0.04)	36.45 (0.05)	36.61 (-)
Reduction in CO_2 emissions thanks to SAF blending (with constant demand)	-	16.0%	16.2%	15.8%

Table 6: Results of applying an anti-tankering provision at route level in 2035

Three points can be noted:

1. **An anti-tankering provision applied on routes significantly reduces the share of flights practising tankering - and consequently the amount of extra fuel burnt.** In all scenarios, the extra fuel burnt due to tankering is reduced by at least 80%.
2. Due to the design of the anti-tankering provision as proposed by the EC, the minimum of fuel uplifted only applies on Union airport (and thus mandated airport). While it is still possible to avoid uplifting fuel at a non-Union airport, at least 90% of the fuel required has to be actually uplifted in a year departing from a Union airport. This means that it is still possible to uplift extra fuel in a Union airport to avoid uplifting fuel in a non-Union airport. However, in a case where fuel in a non-

Union airport would be cheaper, only 10% of extra fuel could be uplifted in a non-Union airport to limit the quantity of fuel uplifted in the Union airport. Therefore, **SAF boost tankering is largely predominant**.

3. As a consequence, **in all scenarios involving an anti-tankering provision at route level, the higher share of SAF in the fuel system due to the predominant SAF boost tankering offset the emissions due to the fuel penalty**. This explains why the cuts in emissions are higher in 2035 compared to a zero tankering scenario. However, this last finding relies on the assumption that SAF truly delivers a 80% reduction in emissions. As stated by the ICCT, this assumption is not based upon a complete life cycle analysis of SAF and should be used cautiously.

3.5 Limitations of the analysis

This analysis disregards any change in future demand in order to single out the effect of the practice of tankering on the outcome of ReFuelEU. A comprehensive assessment of the climate impact of upcoming EU regulation should include projected growth in traffic, as well as demand reduction due to an increase in ticket prices. The reduction in demand resulting from the increase in ticket price due to fair carbon pricing and more expensive blended fuel is a desirable outcome from a climate perspective. However, it was not estimated in this study.

The production cost of SAF is an uncertain parameter and plays an important role in estimating the extent and the type of tankering that could occur, as it will have a major influence on the cost-competitiveness of blended fuel sold in Union airports compared to non-blended fuel sold in non-Union airports. We calculated how an increase in SAF production cost would affect the practice of tankering, in the situation where Union airports are the least cost-competitive, i.e. in 2035 without the introduction of any kerosene tax and anti-tankering provision. For that calculation, we assume a 20% higher SAF production cost, aligned with the upper bound costs given in [11] and [12]. We find that extra fuel consumption is reduced by 30%. However, for that particular case, 90% of tankering occurring between Union and non-Union airports is SAF avoidance tankering. The remaining tankering and the predominance of SAF avoidance tankering between Union airports and non-Union airports lead to a cut in CO_2 of 14.7%, where a scenario without any tankering leads to a cut in CO_2 of 15.8%. We find that an anti-tankering provision applied at route level secures the CO_2 savings, by increasing the cut to 15.7%. The results of that case are detailed in Annex II.

4 Qualitative assessment of the possibility for flights below 1200 km to be exempted from the refuelling obligation

The Council proposes to allow flights below 1200 km to be exempted from the refuelling obligation for aircraft operators, provided that a request is made three months before the date of application and that it is justified by operational refuelling difficulties, or by "significantly higher prices of fuels compared to prices applied on average to similar types of fuels in other Union airports due in particular to specific fuel transport constraints or to limited availability of fuels at that airport"[18].

In the worst case scenario where any higher prices in an airport can justify an exemption, the antitankering provision could fail to address the big bulk of emissions incurred by tankering. Fig. 6 indeed shows that a large bulk of extra emissions due to tankering occurs on short-haul flights, since the extra cost due to the fuel penalty in longer-haul flights can overcome the savings from purchasing cheaper fuel at one airport.

This study finds that among flights practising tankering, 90% are flights below 1500 km, emitting 75% of the extra CO2 due to tankering. Flights below 1000 km account for 69% of flights practising tankering, emitting 40% of extra CO2 emissions. In addition to failing to address the issue of the additional fuel consumption due to tankering, this exemption could also lead to SAF avoidance, i.e the practice of tankering to the detriment of the uplifting of SAF (tankering between a mandated airport, and a non-mandated airport). Some flights departing from neighbouring countries at risk of SAF avoidance tankering identified by the ICCT[2] could fall within this distance threshold (for example, Morocco to Spain, Turkey to Hungary, Croatia, Romania, Bulgaria and Greece).

To give a concrete example, 35% of Turkish Airlines flights from the EU27 to Turkey are below 1500 km. Those short flights account for 22% of the fuel required by Turkish airlines departing from EU27 airports. Exempting flights under 1500 km (and to a lesser extent, under 1200 km) could mean that a fifth of the fuel required by Turkish airlines to operate flights from EU27 to Turkey could be uplifted in a non-mandated Turkish airport when tankering condition are met, leading to the so-called SAF avoidance.

3 Conclusion and policy recommendations

Because of the inhomogeneity in fuel price across the EU, this study finds that 37% of intra-European flights would find it profitable to carry extra fuel for economic benefit at present, leading to extra fuel consumption, which currently emits **457,000 additional tonnes of CO_2 per year, which exceeds the yearly emissions of the three busiest German domestic routes**, namely Berlin-Frankfurt, Berlin-Munich and Munich-Hamburg.

Under the ReFuelEU proposal from the European Commission (EC), the introduction of SAF mandates in large and medium airports, called "Union airports" in the Regulation (over one million passengers) is good news regarding intra-European tankering, **as it leads to an homogenisation of airport fuel prices. Combined with fair carbon pricing**, which penalises the additional CO_2 released by the consumption of the tankering fuel penalty, **extra fuel consumption from intra-European tankering could decrease by 30% and 42% in 2030 and 2035 respectively.**

However, we find that in the absence of a fair kerosene tax, intra-European tankering would still be responsible for respectively 280,000 and 300,000 avoidable tonnes of CO_2 per year in 2030 and 2035, or about the **yearly emissions of flights between Paris and Nice as well as Paris and Toulouse. This undermines the full climate benefit of the SAF mandates**.

We therefore welcome the EC's proposal of an "anti-tankering" provision (Art. 5 of ReFuelEU) which ensures that at a given Union airport, an airline uplifts at least 90% of the fuel needed to operate flights from that given airport, limiting the amount of tankering allowed. Unfortunately, **this policy instrument still leaves a buffer to airlines, allowing them to practise tankering** on a selection of routes amounting to 10% of total fuel required at a departing airport. **This opens the door to SAF avoidance tankering if this buffer were to be used on non-mandated airports outside of EU27+NO**.

An anti-tankering provision applied at route level (rather than at airport level) **would limit the risk of SAF avoidance outside of EU27+NO while significantly reducing tankering within EU27+NO**. We find that in all scenarios, the amount of extra fuel burnt via tankering is cut by at least 80% and the emission cuts intended by ReFuelEU are entirely secured.

We find that most intra-European tankering occurs on short-haul flights, 9 out of 10 flights practising tankering being shorter than 1500 km. **An "anti-tankering exemption" for short-haul flights will therefore fail to address the bulk of extra emissions from intra-European tankering**. In addition, flights to neighbouring EU27 countries like Turkey could fall under the exemption. **Exempting flights under 1500 km** could mean, for example, that **up to a fifth of the fuel required by Turkish Airlines to operate its flights from Europe to Turkey could be tankered in a non-mandated Turkish airport instead**. This leads both to extra emissions and to SAF avoidance.

In the context of the ReFuelEU trilogues, T&E highlights the absolute necessity of an anti-tankering provision, without distance-based exemptions, and urges policymakers to consider applying this at route level, instead of airport level (as shown below), in order to close a potentially damaging loophole in the legislation.

Article 5:

"the yearly quantity of aviation fuel uplifted by a given aircraft operator ~~at a given Union airport~~ ***for a given route*** shall be at least 90% of the yearly aviation fuel required ***for this route***".

Annex I: Aircraft characteristics

This section shows a detailed methodology of how the remaining capacity to carry extra fuel was calculated. Table 7 shows how regulatory fuel quantities were calculated and Table 8 lists the aircraft characteristics used to calculate the remaining capacity for extra fuel.

Category of fuel	Definition	Calculation	Note
Taxi fuel	Fuel used prior to take-off	[4]	-
Trip fuel	Fuel required from brake release on take-off at the departure airport to the landing touchdown at the destination airport		
Contingency fuel	Maximum of the two following fuel quantities: 5% of the trip fuel or 5 minutes holding consumption at 1500 feet above destination airfield elevation	Max (C1 , C2) With: C1 = 0.05 * (Trip fuel + Taxi fuel) C2 = 60 * 5 * cruise_consumption	See Table 8.
Alternate fuel	Fuel required from the missed approach point at the destination aerodrome until landing at the alternate aerodrome.	60*10*cruise_consumption	
Final reserve	Minimum fuel required to fly for 45 minutes at 1500 feet above the alternate aerodrome.	60*45* cruise_consumption	
Additional fuel	Additional fuel is fuel which is added to comply with a specific regulatory or company requirement.	-	
Extra fuel	Extra fuel is fuel added at the discretion of the Commander. The amount of extra fuel taken on board for tankering is included in that category.	This quantity is limited by the MTOW, the MLW and the fuel tank capacity.	

Table 7: Fuel quantities calculation

The quantity of fuel that can be tankered is calculated after considering the Operating empty weight and applying a weight of 124 kg per passenger, aligned with Eurocontrol assumption [5]. A load factor of

80.3% is applied to the typical number of seats to calculate the number of passengers [5].

	OEW* (t)	MTOW* (t)	MLW* (t)	Fuel tank capacity (t)	Typical number of seats	Cruise consumption (kg/s)
A320	42.6	78	66	19.61	164	1.132
B738	41.14	79	63.3	21.06	160	1.221
A319	40.8	75.5	62.5	19.61	134	0.891
A321	48.5	93.5	77.8	19.61	199	1.426
A20N	44.3	79	66	19.61	164	1.132
E190	28	48	43	12.97	94	0.87
Average	40.89	75.5	63.1	18.75	152.5	1.112

*OEW: Operating empty weight, MTOW: maximum take-off weight, MLW: Maximum landing weight.

Table 8: Aircraft characteristics

Annex II: Sensitivity analysis: case study of a SAF production cost increase

Table 8 shows results in the hypothesis where SAF production costs 20% more than what is assumed in the study. The particular case of a 20% blending mandate, as proposed in ReFuelEU for 2035, and without the introduction of a kerosene tax was chosen as it is the case where Union airports are the least competitive, as shown in Fig. 8.

Metric	Baseline	Example where SAF are 20% more expensive	2035 Theoretical zero
		2035	

		SAF (20%)	SAF (20%)+ anti-tankering provision	tankering
Full tankering (% flights)	24.2%	19.0%	0.6%	-
Partial tankering (% flights)	12.7%	8.9%	15.7%	-
Total fuel consumed (Mt) (of which fuel penalty)	13.73 (1.1%)	13.68 (0.7%)	13.59 (0.1%)	13.58 (-)
Total SAF uplifted (Mt)	-	2.47	2.53	2.53
Share of SAF in the fuel system	-	18.1%	18.6%	18.6%
Total CO_2 emissions (Mt) (of which emissions from fuel penalty)	43.49 (0.46)	37.09 (0.28)	36.64 (0.03)	36.61 (-)
Reduction in CO_2 emissions thanks to SAF blending (with constant demand)	-	14.7%	15.7%	15.8%

Table 9: Results of a case where SAF production cost is 20% more expensive. No kerosene tax.

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