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Private Jets and Environmental Sustainability: Evaluating Emissions and Efficiency Indicators

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Abstract

This study evaluates the environmental impact of private and business aviation, with a focus on emissions generated by specific aircraft operating in Poland in 2024. Three aircraft models—Pilatus PC-12, Bombardier Challenger 350, and Dassault Falcon 900EX—were analyzed in terms of flight frequency, fuel consumption, and emissions of CO_2, CO, NO_x, CH_x, and soot. Data were collected daily over one year, covering 419 flights, allowing for precise mapping of route networks and operational profiles. Results indicate that private jets produce disproportionately high emissions per passenger-kilometer, exceeding commercial aviation by up to fivefold and rail transport by over tenfold. The environmental inefficiency is especially pronounced on short-haul flights due to energy-intensive takeoff and climb phases. Comparative analysis with cars, commercial aircraft, and rail highlights substantial mitigation potential through alternative transport modes, sustainable aviation fuels (SAF), electric aircraft for short-haul operations, flight simulation training, and optimized airport operations such as single-engine taxiing and electric tow vehicles. Despite these strategies, private aviation remains a high-emission sector, emphasizing the need for regulatory interventions and systemic solutions to align elite mobility with global climate objectives.

Keywords: Private Jets; Business Aviation; Sustainable Aviation; Emissions; Environmental Efficiency; Climate Justice

Introduction

In contemporary society, personal identity and representation are increasingly valued over material possessions. The ownership of a private jet no longer generates the same degree of interest as it did a decade ago. The issue arises, however, when individuals choose to undertake short business jet flights that could easily be substituted with a brief car journey. Private jet ownership is gradually ceasing to serve solely as a marker of luxury; it has also become a symbol of climate irresponsibility.

Public criticism is most frequently directed toward highly visible figures from the domains of entertainment, business, and politics. These individuals, through decisions that impose a disproportionate burden on the environment, have come to embody the notion of climate inequality. The perceived injustice is evident: while "ordinary citizens" make sacrifices such as abandoning plastic straws, pop stars and celebrities are reported to use private aircraft for journeys spanning only a few dozen kilometers. Such instances increasingly stimulate debate across social media platforms, reinforcing societal pressure and serving as catalysts for discussions on climate justice [1, 2].

The dynamics of this discourse have shifted in recent years. Social media now enables the tracking of virtually every flight, with accounts dedicated to documenting the travels of billionaires drawing public attention to short-haul cases in particular. Despite intensifying societal scrutiny, the Federal Aviation Administration has sought to safeguard the privacy of business jet passengers. The Limiting Aircraft Data Displayed program, operational for several years, allows restrictions on flight visibility and limits public access to air traffic data on platforms such as FlightRadar. This has contributed to an erosion of public trust in private jet users. Consequently, demands for greater climate accountability and decision-making transparency among business jet operators have become increasingly pronounced [3].

Criticism now extends beyond the act of flying itself to questions of necessity and legitimacy: are such flights essential, or do they represent mere indulgence, arrogance, and selfishness? At their extreme, they may be interpreted as manifestations of excessive consumerism.

Within the broader context of general aviation, research indicates that both operational efficiency and environmental impact are strongly dependent on operating conditions and the degree of resource utilization. Variations in utilization levels significantly affect fuel consumption and per-unit emissions [4]. Moreover, the World Health Organization (WHO), in its latest revision of the Global Air Quality Guidelines, underscored that aviation-related emissions pose significant risks to human health and life [5].

In response to these societal and environmental challenges, the aviation sector could pursue several strategies: investment in sustainable aviation fuels (SAF), adoption of innovative technologies, route optimization, and restrictions on the most contentious short-haul flights. Yet the central question remains: can these measures meaningfully alleviate social pressure while simultaneously reducing the substantial emissions of harmful substances generated by private aviation?

Accordingly, this article seeks to address the following research questions: What is the emissions structure within a given private jet network? How does the environmental efficiency of private aviation compare with commercial air transport and rail travel? Which scenarios—such as SAF adoption, route optimization, or increased passenger load factors—offer the greatest potential for improvement?

Expanding Accessibility of General and Business Aviation: Emission Profiles and Research Gaps

In recent years, general aviation (GA) and business aviation (BA) have become increasingly accessible, driven both by the growth in the number of aircraft classified as BA/GA and by the expansion of supporting infrastructure, including airports, handling services, charter providers, and fleet management systems. For instance, the European Union Aviation Safety Agency (EASA) reports that in 2023, business jet operations in Europe exceeded 2019 levels by 10%, after nearly matching the 2007 record of 700,000 annual flights in 2022 [6]. This expansion is occurring in the broader context of intensifying climate pressures: aviation is a significant contributor to greenhouse gas emissions, and the European Union, through frameworks such as the Green Deal, Fit for 55, and ReFuelEU Aviation, has introduced binding reduction targets alongside incentives for the development of sustainable aviation fuels (SAF) [7].

Further studies on the electrification potential of BA indicate that replacing conventional jets with electric aircraft could reduce emissions by as much as 80–90% [8]. Similar findings are confirmed in other work [9], where energy consumption per kilometer was compared across different categories of business aircraft: single piston engine (SEP) at 1.22 kWh/km, very light jet (VLJ) at 4.96 kWh/km, and electric aircraft (EA) at only 0.6 kWh/km. In summary, while the number of operations and aircraft available in BA/GA continues to grow, regulatory frameworks and societal expectations increasingly require consideration of their climate implications.

Although there is a growing body of literature estimating private and business jet emissions using ADS-B and OpenSky data, relatively few studies analyze emissions from specific jet engine types in the context of actual route networks. Such analyses should account for route structure, the share of short- versus long-haul flights, flight frequency, and geographical distribution. For example, the study *Environmental Footprint of Private and Business Jets* (MDPI, analysis of 250 private jets) provides aggregate emissions estimates but does not examine which routes contribute most significantly to the overall emissions within a network [10]. Similarly, the International Council on Clean Transportation (ICCT) 2025 report highlights emissions associated with private jet routes and shows that nearly half of private flights cover distances shorter than 500 km, a critical finding since short-haul operations are significantly less efficient in terms of per-passenger-kilometer emissions [11]. However, even these studies often lack detailed assessments of emission distributions across route networks, hubs, and regions. Another research gap concerns variation across engine types and aircraft models: how emission profiles change with aircraft mass, performance, altitude, and speed along the actual routes flown by BA/GA users. To fully capture the sector's environmental footprint and identify mitigation pathways, studies integrating route-level data (trajectories), aircraft and engine typologies, and route characteristics (length, seasonality, regional vs. international) are required.

The European business aviation sector illustrates this growth trajectory. Data from AEROAFFAIRES show that in 2022, approximately 1,589,611 movements (takeoffs and landings) related to business aviation were recorded, representing an increase of nearly 13% compared to the previous year [12]. Fleet size is also expanding: according to AvBuyer, by February 2024 there were nearly 4,900 jets and turboprops in business ownership across the EU and Turkey [13]. Short-haul flights represent a particularly pressing concern. Studies, including ICCT (2024), indicate that nearly half (≈47–50%) of private flights are under 500 km [11]. This finding is especially relevant because short-haul operations generate disproportionately higher emissions per passenger-kilometer, as takeoff, climb, and landing phases account for a larger share of total fuel consumption.

Seasonality is another factor influencing emissions. Air traffic in Europe exhibits strong monthly fluctuations, with peaks in July and August significantly exceeding winter levels. Research on the "monthly rhythms of aviation" shows that approximately 36% of airports worldwide experience pronounced seasonality in flight volumes [14].

Research Methodology

To assess the environmental impact of private jets, it was necessary to define a representative set of aircraft. The initial research design envisioned the inclusion of three aircraft owned by individuals representing the cultural, sports, and business sectors. Such an approach would have enabled the analysis of highly recognizable users, who constitute only a small fraction of society. However, the implementation of this plan was constrained by the Limiting Aircraft Data Displayed program, which restricts access to flight data for aircraft registered in the United States.

Consequently, the analysis was conducted using data provided by Polish Airports (Polskie Porty Lotnicze), covering two of the most frequently operated business jets in Poland (Figure1): the Bombardier Challenger 350 (CL35) and the Pilatus PC-12 (PC-12).

Although the PC-12 is a turboprop rather than a jet, it was intentionally selected to illustrate performance differences between propulsion systems. In addition, the study incorporated the aircraft of a well-known professional athlete, registered in the Netherlands, which is employed for high-frequency annual business travel.

Data collection included systematic tracking of flights, distance calculations, and the construction of route networks. Each flight was individually monitored, and detailed records of routes, flight frequencies, and operational parameters were maintained. The

Table 1: Aircraft data selection [15].

	PC-12	CL35	Falcon 900EX
			
Max. Passenger number [-]	10	10	16
Range [km]	2482	5926	8334
Max cruise speed[km/h]	527	870	893
Fuel consumption [kg/h]	230,2	899,4	869,1
Engine number [-]	1	2	3
Propulsion type	Turboprop	Turbojet	Turboojet

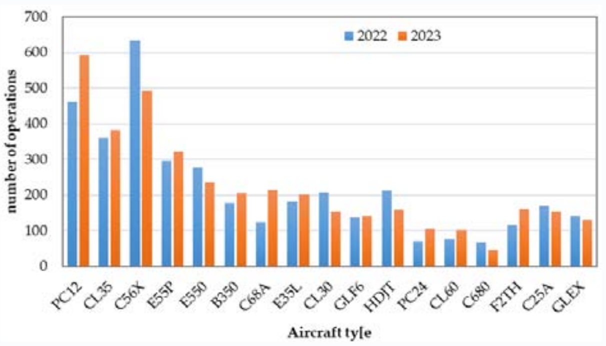

Figure 1: The most popular private planes in 2022 and 2023 at Warsaw Chopin Airport.

dataset was compiled and verified over the course of one year, resulting in a total of 419 verified connections across three aircraft, thereby ensuring both completeness and reliability.

The aircraft selected for analysis are among the most commonly used within Polish airspace and are noted for their operational popularity, comfort, and range (Table 1).

- Pilatus PC-12 — A single-engine turboprop valued for its robust design and fuel efficiency. It offers a maximum range of 1,340 NM, a cruise speed of 285 kt, and fuel consumption of 76 gal/h, making it well suited for short-haul operations. Its maximum passenger capacity is 10.
- Bombardier Challenger 350 (CL35) — A long-range business jet offering superior comfort and cabin space compared to the PC-12. It has a range of 3,200 NM, cruise speed of 448 kt, and significantly higher fuel consumption of 297 gal/h, resulting in elevated CO_2 emissions on long-haul routes. It also accommodates up to 10 passengers.
- Dassault Falcon 900EX — A large business jet included for comparative purposes. It provides more than three times the range of the PC-12 and a higher maximum cruise speed of 482 kt, while maintaining fuel consumption of 287 gal/h, slightly lower than that of the CL35. It also supports a larger passenger capacity, highlighting its relative efficiency in terms of fuel use per passenger.

These aircraft collectively represent a spectrum of propulsion technologies, operational capacities, and environmental impacts, thereby providing a meaningful basis for comparative analysis of emissions across short-, medium-, and long-haul private aviation operations.

The data for the analysis were collected from the following sources:

- Polish Air Navigation Services Agency and Polish Airports State Enterprise – these datasets enabled the analysis of general aviation traffic across individual FIS sectors in Poland, as well as the assessment of General Aviation activity at Warsaw Chopin Airport. This facilitated the identification of the most frequently operated private jets at Chopin Airport in 2023. Moreover, the data included information on the number of passengers and General Aviation flight operations over a 13-year period at Poland's largest airport, characterized by the highest frequency of air operations nationwide.
- PlaneFinder and FlightRadar – these online platforms provided data on flight routes and parameters such as distance and flight duration, and supported the analysis of the route networks of three selected aircraft. All flight times were recorded in the UTC time zone.
- GuardianJet – this website provided technical specifications of the three selected aircraft, which were subsequently compared and analyzed.
- Polish Economic Institute and works of individual authors – emission reports concerning other modes of transport enabled a comparative analysis of the emissions generated by these means against those of the three studied aircraft. The comparison encompassed rail transport, passenger cars, and the Boeing 737 passenger aircraft.
- Google Maps – online mapping tools were employed to determine flight routes and calculate distances. The covered distances were represented as the shortest paths between the point of departure and arrival, since a more detailed analysis would require accounting for factors such as airspace zones and their associated restrictions, departure and arrival procedures, weather avoidance, and other circumstances potentially affecting route selection.

All stages of the analysis, including data collection, distance calculations, and route network analysis, were conducted manually. Data were systematically collected and verified. Each flight was tracked individually, and detailed information on routes, frequency, and other parameters was meticulously recorded and analyzed. This process demanded precision and accuracy, as a total of 419 connections of three different aircraft were verified, ensuring the

Table 2: Jet A-1 fuel combustion products [16].

Pollutant	Unit	Value
CO_2	kg	3.16
H_2O	kg	1.29
CO	g	<0.6
NO_x	g	<15
SO_2	g	0.8
CH_x	g	0.01
Soot C	g	0.01-0.03

completeness and reliability of the compiled dataset.The assessment of the environmental impact of private jets was based on detailed calculations of the emissions of individual combustion products for each day of flight operations in 2024. The results presented derive directly from accounting principles and unit operations, and therefore did not require additional data sources. The methodology of emission calculations for individual combustion products is outlined below. The quantitative composition coefficients of combustion products were drawn directly from the Civil Aviation Authority report (Table 2).

Worked example — Bombardier Challenger 350.

Fuel consumption on a given segment is computed by multiplying the flight time (in decimal hours) by the aircraft's fuel burn rate (1):

$$Flight\ time \times Fuel\ burn\ rate = Fuel\ consumed \quad (1)$$

$$3.28h * 899.41\frac{kg}{h} = 2953.07kg$$

Table 3 presents the results of emission calculations for a representative flight segment performed by the Bombardier Challenger 350. The analysis is based on the aircraft's specific hourly fuel consumption and standard emission factors for individual combustion products. The calculated values include total fuel consumed, carbon dioxide, carbon monoxide, nitrogen oxides, unburned hydrocarbons, and soot. These results provide a quantitative basis for assessing the environmental impact of business jet operations on a per-flight basis.

Analogous calculations were performed for the Pilatus PC-12 and the Falcon 900EX, applying the same methodology based on aircraft-specific fuel consumption rates and standardized emission factors for individual combustion products. This approach enabled a comprehensive assessment of the environmental impact of private jet operations, with particular emphasis on CO_2 emissions and their comparison with alternative modes of transport. The results of these calculations provided the basis for drawing conclusions on the emission profiles of the studied aircraft, as well as identifying potential strategies to reduce their negative environmental effects.

In order to conduct an analysis of pollutant emissions generated by private aircraft, it is necessary to convert fuel consumption values from gallons per hour into kilograms per hour, followed by the relevant emission calculations. The density of aviation kerosene (Jet A-1) is defined by regulatory standards (2):

$$\rho Jet\ A-1 = 800\ \frac{kg}{m^3} \ \Rightarrow\ \rho Jet\ A-1 = 0.8\ \frac{kg}{m^3} \quad (2)$$

To convert the PC-12's fuel consumption into kilograms per hour, it is necessary to account for the conversion factor between gallons and liters, where 1 gallon corresponds to 3.7854 liters (3). Given that the PC-12 consumes 76 gallons per hour, the calculation proceeds as follows (4):

$$76\ gph \times 3.79\ \frac{L}{gal} = 287.69\ \frac{L}{h} \quad (3)$$

$$287.69\ \frac{L}{h} \times 0.8\ \frac{kg}{m^3} = 230.2\ \frac{kg}{h} \quad (4)$$

Analogous calculations were carried out for the Bombardier Challenger 350, assuming a fuel consumption rate of 297 gallons per hour and Falcon 900EX. The results for aircrafts are summarized in Table 4.

To estimate annual emissions for each aircraft, the quantitative composition of exhaust gases produced during combustion was applied, as published by the Civil Aviation Authority (Table 2). The analysis was based on operational data covering each day of flight activity for the respective aircraft.

Table 5 presents a comparative overview of fuel consumption and emissions for the first representative flights of the Bombardier CL35 and the Pilatus PC-12 in 2024. The data allow for direct comparison of both aircraft in terms of fuel use, CO_2 output, and other major pollutants. The table shows that the CL35, a midsize business jet, consumes significantly more fuel than the PC-12 turboprop for a

Table 4: Fuel consumption of the aircrafts expressed in kilograms per hour.

Aircraft	Fuel consumption [kg/h]
PC-12	230.2
CL35	899.4
Falcon 900EX	869.1

Table 3: Emission calculation for the Bombardier Challenger 350 on a representative flight segment.

Pollutant	Formula	Result
Fuel consumption	$2.953.07 \times 899.41\ \frac{kg}{h}$	$2953.07\ kg$
CO_2	$2953.07\ \times 3.16\ \frac{kg\ CO_2}{kg fuel}$	$9.3\ t\ CO_2$
CO	$2953.07 \times 0.0006\ \frac{kg\ CO}{kg fuel}$	$1.8\ kg\ CO$
NO_x	$2953.07 \times 0.015\ \frac{kg\ NO_x}{kg\ fuel}$	$44.3\ kg\ NO_x$
CH_x	$2953.07 \times 0.0001\ \frac{kg\ CH_x}{kg\ fuel}$	$0.3\ kg\ CHx$
Soot C	$2953.07 \times\ 0.00002\ \frac{kg\ C}{kg\ fuel}$	$0.3\ kg\ CHx$

Table 5: Comparative emissions for the first flights of the Bombardier CL35 and Pilatus PC-12 in 2024 (with CO_2 per hour).

Aircraft	Flight no.	Flight time [h:min]	Flight time [h]	Fuel consumed [kg]	CO_2 [t]	CO_2 [t/h]	CO [kg]	NO_x [kg]	CH_x [kg]	Soot C [kg]
CL35	1	03:17	3.28	2,953.07	9.3	2.84	1.8	44.3	0.3	0.06
PC-12	1	02:07	2.12	423.06	1.3	0.61	0.25	6.4	0.004	0.008

single flight segment (2,953.07 kg *vs*. 423.06 kg). This difference is reflected in the corresponding CO_2 emissions, with the CL35 producing 9.3 t per flight compared to only 1.3 t for the PC-12. When normalized per hour of flight, the CL35 emits approximately 2.84 t CO_2/h, whereas the PC-12 emits 0.61 t CO_2/h — almost five times less. Other pollutants, such as CO, NO_x, CH_x, and soot, also follow the same trend, indicating that the environmental impact of the CL35 is substantially higher across all combustion products. For example, NO_x emissions from the CL35 (44.3 kg per flight) exceed those of the PC-12 (6.4 kg per flight) by nearly a factor of seven.

Research Result

Route Network Analysis and Environmental Performance of Pilatus PC-12, Falcon 900EX, and Bombardier Challenger 350 in 2024

The annual emissions of the analyzed aircraft were calculated using the quantitative composition of exhaust gases generated in the combustion process. These data were obtained from the Civil Aviation Authority. The analysis was based on daily operational data for each aircraft, covering the entire year 2024. For every single flight, the following parameters were calculated: flight time, fuel consumption, and emissions of CO_2, CO, NOx, CHx, and soot (C).

In 2024, the Challenger 350 (CL35) completed 151 flights, the Pilatus PC-12 (PC-12) performed 147 flights, and the Falcon 900EX operated 121 flights. The cumulative results are presented in Table 6.

Comparative Analysis with Other Modes of Transport

To assess the relative efficiency of the selected business aircraft, their emissions were compared with those generated by other common modes of transportation, namely private cars, commercial aviation (Boeing 737 in business and economy configurations), and rail. The comparison was performed by calculating CO_2 emissions per passenger, assuming standard load factors. For private aircraft, an average passenger load of six was assumed; for cars, two passengers.

The analysis clearly demonstrates that alternative transport modes offer significantly lower emissions per passenger compared to private aircraft (Figure 2). While private jets provide speed and convenience, their environmental costs are substantially higher. In contrast, trains, cars, and commercial aviation present far less damaging options. The persistence of private jet use, despite available alternatives, highlights both limited public awareness of aviation's contribution to greenhouse gas emissions and the enduring perception of private air travel as the most convenient solution.

Table 6: Exhaust Emissions from Selected Aircraft in 2024.

Pollutant (unit)	PC-12	CL35	Falcon 900EX
Carbon dioxide CO_2 [t]	173.1	620.9	937
Carbon monoxide CO [kg]	32.9	117.9	177.8
Nitrogen oxides NOx [kg]	821.5	2947.4	4445.8
Hydrocarbons CHx [kg]	0.548	1.965	2.96
Soot C [kg]	1.095	3.93	5.93

Economic Costs of CO_2 Emissions

Reducing CO_2 emissions remains a central priority of European Union climate policy, with the European Union Emissions Trading System (EU ETS) serving as one of its primary instruments. In this study, the financial implications of CO_2 emissions were evaluated using an assumed carbon price of €100 per ton of CO_2, in line with 2025 market projections.

The results show substantial variation across the analyzed aircraft. The Falcon 900EX incurred the highest annual emission costs, amounting to approximately €94,000, reflecting its relatively poor fuel efficiency. The Challenger 350 followed with costs of about €62,000, while the PC-12 exhibited the lowest emission costs, slightly exceeding €17,000.

These differences underscore the economic significance of fuel efficiency in business aviation. High emission-related costs not only highlight the environmental burden of certain aircraft but also strengthen the economic rationale for promoting more sustainable technologies, including the adoption of alternative fuels and electrification.

On figure 3 showed Estimated annual CO_2 emission costs for selected business aircraft in 2024, calculated at a carbon price of €100 per ton of CO_2. The Falcon 900EX exhibits the highest costs due to its lower fuel efficiency, followed by the Bombardier Challenger 350

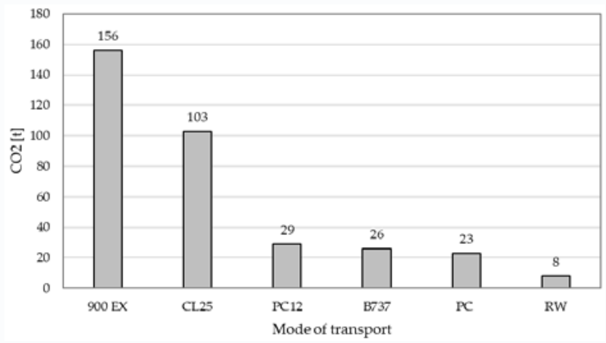

Figure 2: Comparision of CO_2 emissions per passenger for different modes of transport; B737 – Boeing 737, PC – passenger car, RW - railway.

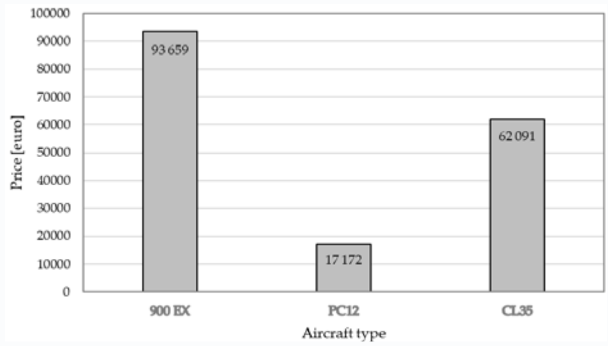

Figure 3: Annual CO_2 emission costs for selected business aircraft in 2024.

and the Pilatus PC-12, which incurs the lowest emissions-related expenses. These results highlight the direct link between aircraft fuel consumption and the economic impact of CO_2 emissions.

Discussion

The environmental impact of carbon mitigation technologies must be assessed holistically, considering not only operational emissions but also emissions associated with the production, installation, and disposal of these technologies [17]. Life cycle assessment (LCA) of private jets clearly indicates that the largest source of emissions is the operational phase—fuel consumption and combustion during flights. Emissions from production, maintenance, or end-of-life disposal are negligible compared to in-flight fuel use [18]. For private aircraft, this issue is exacerbated by short-haul flights, where energy-intensive takeoff and climb phases constitute a proportionally larger share of fuel use [1].

Environmental efficiency indicators, most commonly expressed as grams of CO_2 per passenger-kilometer (g CO_2/pkm), are particularly unfavorable for private jets. For domestic commercial flights, average emissions range from 246–285 g CO_2/pkm, while electric rail transport in Europe emits approximately 35 g CO_2/pkm [19]. In contrast, private jets can exceed 1,200 g CO_2/pkm, representing 5–14 times higher emissions than commercial aviation and several tens of times higher than rail transport [2, 20]. The present study confirms these findings: annual CO_2 emissions per passenger for the analyzed aircraft were 156 t for the Falcon 900EX, 103 t for the Bombardier Challenger 350, and 29 t for the Pilatus PC-12. When compared to commercial aviation and automotive travel, these values are fivefold higher, and thirteenfold higher relative to rail transport (Figure 1).

The characteristics of private jets—low passenger occupancy, short flight distances, and exclusivity—result in a disproportionately high per-passenger environmental footprint. The recent increase in private aviation activity (in terms of flights and emissions post-2019) further amplifies the significance of this issue from a climate policy perspective (ICCT) [2].

The literature increasingly emphasizes the need to mitigate emissions in private aviation through both technological and regulatory measures. A key strategy involves replacing conventional jet fuel with sustainable aviation fuels (SAF), which, depending on production technology, can reduce lifecycle CO_2 emissions by 27–87% [21, 22]. Another potential mitigation measure is the greater use of flight simulators, including for training components currently conducted in-flight. Studies show that simulator-based training can reduce emissions in private/general aviation by up to 97% [9]. Research on hydrogen and hybrid propulsion systems also indicates potential reductions in local air pollutants [23]. Short-haul electric aircraft are projected to reduce per-passenger-kilometer emissions by up to 90%, albeit at the cost of increased travel time [24].

Operational measures at airports also play a role. Studies on taxiing strategies demonstrate that using electric tow vehicles (ETVs), single-engine taxiing, or hybrid taxiing methods can substantially reduce CO_2 and NOx emissions compared to conventional engine taxiing or fossil-fueled tow vehicles [25]. Accurate emission estimation requires careful methodology; employing actual taxi times rather than standard LTO (Landing and Takeoff) cycles can reduce estimated CO and HC emissions by more than 50% [26, 27]. Market-based regulations, such as blending SAF with conventional fuels or implementing aviation fuel taxation, may further accelerate adoption of low-emission solutions [28]. The literature consistently highlights that a significant portion of private flights are short-haul (<500 km), where alternatives like high-speed rail are feasible [24].

Conclusions

The conducted analysis clearly demonstrates that private jets are among the least environmentally efficient modes of transport. Both total emissions and per-passenger-kilometer emissions are markedly higher than those of commercial aviation, road transport, and especially rail. CO_2 emissions per passenger in the studied aircraft exceed commercial aviation by multiple factors and rail transport by an order of magnitude. The operational profile—frequent short-haul flights (<500 km) with high fuel consumption during takeoff and climb—further exacerbates inefficiency.

Comparative analysis among aircraft types reveals substantial differences. The turboprop Pilatus PC-12 exhibits lower fuel consumption and a smaller carbon footprint, resulting in lower EU ETS-related costs. Conversely, the Bombardier Challenger 350 and Dassault Falcon 900EX, despite higher performance and comfort, emit several hundred tons of CO_2 annually, translating into significant economic costs (ranging from tens of thousands to nearly €100,000 per year in emission fees). These findings highlight the critical importance of operational decisions and technology choice for both environmental and economic outcomes in business aviation.

The study aligns with broader literature: the operational phase dominates lifecycle emissions, while production and end-of-life processes are minor contributors. Private jets, due to low occupancy, exclusivity, and short-haul operations, represent a particularly high environmental burden. This poses a significant challenge for climate policy, particularly in light of EU reduction targets under *Fit for 55* and *ReFuelEU Aviation*.

Promising mitigation pathways exist but require comprehensive strategies. Key approaches include implementing sustainable aviation fuels (SAF), which can reduce lifecycle emissions by up to 80%, and advancing hydrogen and electric technologies for short-haul flights. Operational measures—such as route optimization, single-engine taxiing, and electric tow vehicles—can further reduce local emissions and improve overall efficiency. Even under SAF or hybrid scenarios, private jets remain substantially less sustainable than ground-based alternatives.

In summary, private jets occupy a unique position in the climate justice debate. They symbolize both luxury and disproportionate environmental impact, contrasting sharply with the efforts of broader society. This study confirms the necessity of regulatory measures to limit the most environmentally contentious aspects of this sector, particularly short-haul flights that could be replaced with more sustainable transportation. Achieving sustainable transformation in business aviation thus requires not only technological innovation but also systemic solutions reconciling elite mobility with global climate objectives.

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