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# How much carbon does flight school produce? Case study on Api Banyuwangi

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***Abstract - Aviation in the world has contributed 2.5% of total carbon emissions. The aviation industry is not only dominated by commercial flights with large aircraft (wide body) but there are also many small piston engine aircraft that use 100 low lead Aviation Gasoline (Avgas) fuel. A total of almost 230 thousand piston-engine aircraft are in operation in the world, some of which are operated by flying schools. There are more than 20 pilot schools in Indonesia that operate nearly 250 piston-engine aircraft. This research aims to find out how much carbon emissions are produced by pilot schools in Indonesia. This research uses a qualitative method using secondary data in the form of aircraft production hours. Literature data also calculates the amount of carbon released into the air. This research was carried out at the Indonesian Civil Pilot Academy of Banyuwangi in September 2023. The results of the research show that the Indonesian Pilot Academy Banyuwangi produces more than 450 tonnes of carbon every year and all pilot schools in Indonesia are estimated to contribute 8000 tonnes of $CO_2$ to the air. Several solutions can be used to reduce the increase in carbon in the free air, including carbon taxes, the use of sustainable fuels, and most importantly planting trees.***

***Keywords: Carbon Emission, Flying Schools, and Sustainable Environment***

## I. INTRODUCTION

Technological developments including transportation technology threaten world climate change [1], [2]. The world climate has changed as indicated by the large amount of exposure to $CO_2$ looking at the condition of Serum Bicarbonate in the human body which can be life-threatening [3]. CO growth$_2$ Excessive amounts will also grow pathogenic cells in the human body [4]. The growth of carbines is also indicated by the presence of black carbon and brown carbon which are responsible for increasing world heat (global warming) [5].

Based on world market estimates from 2016 to 2035, there will be a demand for 39,260 new aircraft [6]. The development of aviation will increase the amount of carbon which will become greenhouse emissions which are difficult to reduce, in other words, the increasing development of aviation at this time will increase the amount of carbon and the greenhouse effect in the world [7]. Currently, aviation is responsible for 2.5% of greenhouse gas emissions and uses 3% of the world's total oil [8], [9]. Studies from China show that carbon growth from 1990 to 2014 increased by 468%, and in 2017 aviation contributed 160 million tonnes of carbon worldwide [10], [11].

The aviation industry is not only concerned with the movement of passengers, cargo, or mail but is also concerned with the training and education of pilots (*flying school*). Pilot training is the foundation for commercial aviation in providing professional pilots [12]. Pilot training is also growing along with the growth of global aviation [13].

Currently, there are at least 20 pilot schools in Indonesia with a total of approximately 250 aircraft operated [14]. Pilot training in operations also flies training aircraft which generally use fossil fuels, so pilot schools also contribute to the amount of carbon in the air. One of the pilot schools in Indonesia that continues to operate today is the Indonesian Pilot Academy Banyuwangi which has 33 Cessna 172 SP Land aircraft, 2 Cessna 172 SP Amphibious (Seaplane) aircraft, and 2 multi-engine Piper Seneca V aircraft.

Every month, API Banyuwangi operates 12 active aircraft consisting of 10 Cessna 172 SP Land, 1 Cessna 172 Amphibious (Seaplane), and 1 multi-engine Piper Seneca aircraft, while the remaining aircraft are on standby for operational reserves and other contingency plans. The fuel used is Avgas with a usage ratio for 1 hour of flight requiring 10.5 gallons (40 liters) (Airborne Aviation, 2016).

The Indonesian state has begun to pay attention to carbon emissions from vehicles with the issue and design of a carbon tax (*Carbon Tax*) [15], [16]. Even though implementing the carbon tax still faces challenges, the Indonesian Government remains committed to implementing carbon emission reduction in Indonesia [17], [18]. Meanwhile, the Government itself, through the Ministry of Transportation, has committed to reducing carbon emissions with plans to use Sustainable Aviation Fuel (SAF)[19], [20].

This research was conducted to find out how much carbon emissions are produced by pilot schools in Indonesia by taking a sample of pilot schools that still exist today and to find out what steps must be taken to offset the amount of carbon produced and had been discarded due to flight training being carried out. It is hoped that this research can provide consideration for the formulation of steps to maintain a sustainable environment so that human activities can continue to run well, supported by a healthy atmosphere.

## II. METHOD

This research was carried out at the Indonesian Aviation Academy Banyuwangi as well as a sample from pilot schools to calculate the amount of carbon released over the past 2 years. This research uses a descriptive qualitative method by describing secondary data that already exists and was recorded at the Indonesian Aviation Academy Banyuwangi [21], [22]. The secondary data is processed, displayed in graphs, and then narrated for discussion [23]. In this research, the data used is flight hour data and fuel usage calculation data which then calculates the amount of carbon released during flight training operations based on literature and previous research. To simplify the calculation process, this research uses several criteria and assumptions, including:

Fuel consumption per hour for Cessna 172 SP = 10.5 US Gallon / 40 Liters (Airborne Aviation, 2016).

Carbon Production ($CO_2$) from a Cessna 172 aircraft with avgas fuel.
≈ 1 Us Gallon Exhaust = 18.3 Lbs $CO_2$
≈ 3,78 Liter = 8,3 Kg $CO_2$
≈ 1 Liter = 2,2 kg $CO_2$
Source: Smoot (2023) [24]
The formula to find total carbon is:
TCP = TFH X FC X CPH
With description:
TCP: *Total Carbon Production*
TFH: *Total Flight Hours (Monthly/Annual)*
FC: *Fuel Consumption (in Hours)*
CPH: *Carbon Production per Hour*
CPH: 40 Liters Exhaust /*Hour* X 2.2 kg $CO_2$
: 88 Kg $CO_2$ / *hour*

The research was carried out within 1 month in September 2023. The data collection process was in the form of flight hour data from each aircraft for the last 3 years on the AIMPRO application (*Aircraft Maintenance Program*) belonging to API Banyuwangi. The flight hour data is processed and grouped every month to be graphed and narrated.

From the results of these calculations, balancing calculations will be carried out regarding what programs API Banyuwangi must carry out to reduce and absorb carbon released in the air by training aircraft flight activities to support environmental sustainability (*Environment Sustainability Governance*).

## III. RESULT AND DISCUSSION

Flight hour data was collected after obtaining permission from API Banyuwangi Engineering via the Aimpro application. Flight hour data that can be collected in this research is flight hour data from January 2021 to August 2023. This data is deemed sufficient to provide an overview of the amount of carbon produced by API Banyuwangi as a pilot school (*flying school*) annually. The following is a record of flying hours for API Banyuwangi aircraft.

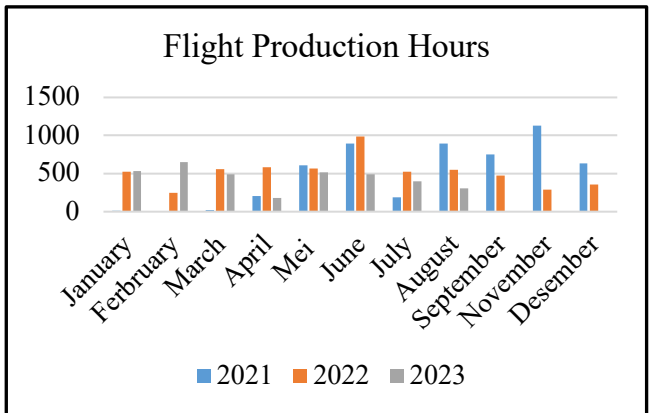


Fig 1. Flight Production Hours of API Banyuwangi

The number of flying hours in early 2021 is still very minimal due to lockdown/Quarantine due to Covid-19, several Banyuwangi API cadets and employees also tested positive so teaching and learning activities, one of which was flying, were stopped. With the cessation of human activities, nature repairs itself so that the air is fresher and healthier [25], [26].

The increase in the number of flying hours began in April with a total production of 204 flying hours and peaked in November 2021 with a total of 1128 flying hours. Meanwhile, in 2022, the number of API Banyuwangi flight hours production looks to be flat with an average monthly achievement of 513 flying hours with the lowest production point being 243 and the highest at 986 hours.

The total production hours in 2021 will be 5339 flying hours and in 2022 it will be 5653 flying hours, while for the total from 2023 to the end of August, the production of flying hours will reach 3577 flying hours. From the total watch production, we can enter it to find the amount of carbon produced by API Banyuwangi as a side/other result of watch production activities to produce competent pilots. The results of calculating the amount of carbon can be seen in Figure 2 below.

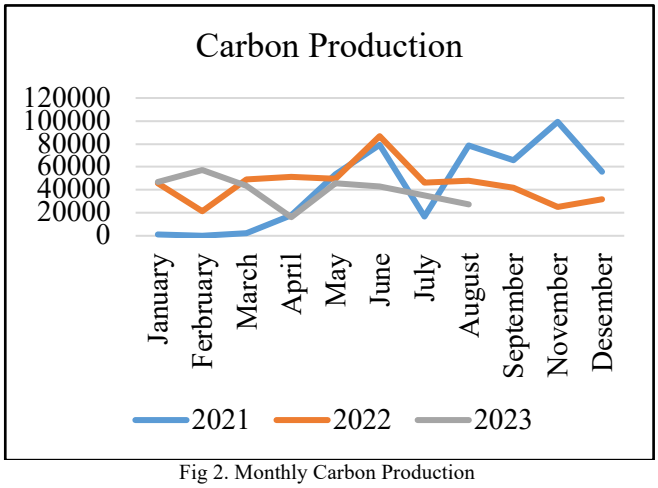


Fig 2. Monthly Carbon Production

Looking at Figure 2, there is consistency with Figure 1 (hour production) that the highest carbon production in 2021 was in November 2021 with a total production of 99,264 Kg $CO_2$. Total carbon production from API Banyuwangi in 2021 is 496 tons of $CO_2$ (more precisely 469,876 Kg $CO_2$), while in 2022 API Banyuwangi produced 497 tons of $CO_2$ (497,464

Kg $CO_2$). If in Indonesia there are 20 pilot schools with an average carbon production of 400 tons of $CO_2$ per year, the total carbon production produced by pilot schools can reach 8000 tons of $CO_2$.

There are several concepts to tackle carbon emissions from vehicles including the aviation industry, one of which is the implementation of a carbon tax [18], [20]. However, in its implementation, the carbon tax faces many challenges, one of which is economic distortion, because almost all aspects of economic and human mobility in Indonesia use energy and fossil fuels [17].

The principle of paying carbon tax is divided into 4 principles, namely polluters paying tax, the principle of prevention, state action and attention, and the principle of different responsibilities [16]. It is hoped that these 4 principles can reduce the use of fossil fuels thereby reducing the amount of carbon released into the air. However, even though taxation can reduce the amount of carbon released into the air, it still does not eliminate the carbon that has been released, so other measures are needed in the form of providing offsets to reduce the impact of carbon in the air. One of the best balances to deal with carbon is to plant more trees so that the trees can absorb the carbon released into the air (forestization) [27].

The aviation industry currently still uses fossil fuels as the main fuel and has contributed 2.5% of world carbon [8], [9]. Therefore, there is a need for alternative fuels that are more environmentally friendly, such as sustainable *Aviation Fuel* (SAF) [9]. Until now, the use of SAF has only been based on the concept of aircraft types*wide body* which uses a gas turbine engine that previously used aviation fuel (Jet 1A) [9], [10].

Meanwhile, pilot schools still use power piston engine aircraft which must use 100 low lead (100LL) Aviation Gasoline (AVGAS), and there are approximately 230,000 aircraft that rely on the same fuel [28], [30]. Until now there are several substitute fuels for 100LL Avgas including MOGAS (Motor Gasoline), Swift Fuels 100, and several other fuels which are formulated to reduce the impact of TEL (Tetraethyl Lead) which is dangerous for health and even reduces the IQ of children [28], [30].

A replacement fuel formulation to reduce carbon production from training flying operations using piston engines has not yet been discovered [31], [32]. Carbon reduction can also be done by replacing or modifying the engine so that it uses sustainable fuel or even by methods hybrid [29], [33]. However, this solution is still in the development process and cannot be used shortly, even though it could be a decisive point in reducing carbon from the aviation industry around the world [33].

Currently, the real solution that must be implemented by pilot schools in Indonesia, including the Indonesian Pilot Academy Banyuwangi, is the movement to plant trees to reduce carbon emissions now and in the future. This movement must be a sustainable goal (*sustainability goals*) as a balance to the activities carried out by API Banyuwangi and other pilot schools and must be included in the Key Performance Indicators of every aviation organization in Indonesia.

## IV. CONCLUSION

Carbon production produced by flight schools in Indonesia can reach 8000 tons of $CO_2$ every year. This carbon production is a by-product of watch production which must be achieved by each school to produce quality pilots/aviators to supply the needs of pilots in the country. Several steps have been planned, one of which is the plan to implement a carbon tax (*Carbon Tax*), use of sustainable fuels /*Sustainable Aviation Fuel* (SAF), or other substitute fuels to reduce the use of 100LL AVGAS which has Tetraethyl Lead emissions which are very dangerous for health.

The main solution to reducing carbon emissions apart from implementing a carbon tax (*carbon tax*) is by implementing a sustainable environmental program (*Environmental Sustainability Governance*) by planting trees around airports or flight schools to absorb carbon that has been released from aircraft emissions. This solution can provide new hope for a better environment in the future.

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