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Analysis of CO_2 Emission Reduction in Aviation Using Mix of 2,4% Biofuel

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***Abstract*— The activities of flight have an impact on the environment. Combustion from aircraft fuel produces chemical products that have been emitted from the high-speed aircraft engine. Aircraft engines produce emissions that are similar to other emissions resulting from fossil fuel combustion. The transportation sector include land and air transportation produced 22,4 % from all energy sector. To reduce aircraft emissions while maintaining healthy economic growth, the aviation sector needs to reduce the use of fossil jet fuel by using sustainable aviation fuel. The use of biofuel in airplanes does not completely replace the fuel we use today, but gradually starting with a mixture of 10 % or 20 %. Several European countries and China have used biofuels made from waste in each country. Likewise in Indonesia, Pertamina collaborates with ITB, producing aircraft fuel from palm oil. The flight test using a Garuda Boeing 737 aircraft was successful using a mixture of 2.4% biofuel in October 2023. The CO_2 emission estimation calculations at three large airports in Indonesia, Soekarno-Hatta International Airport Jakarta, Juanda International Airport Surabaya and Sultan Hasanuddin International Airport Makassar that using aviation fuel and a mix of aviation fuel with 2.4 % biofuel, reduce by 2.83 % - 2.95 %.**

Keywords*— CO_2 *emission, aircraft, biofuel, sustainable aviation fuel, palm oil

I. INTRODUCTION

According to a report from the International Energy Agency (EIA), which published the 2020 Flight Tracking Report, data collection was carried out during 2000-2019 and the result was that commercial aviation activity increased by 5% per year and increased CO_2 emissions by 2% per year [1]. However, the COVID-19 pandemic that began in early 2020 led to a near halt in activities worldwide, particularly in transportation. This situation has had a significant impact on the aviation industry, including in Indonesia. According to OAG data, the airline industry's revenue in 2020 was only 40% of the previous year, and this value was the same as revenue in 2000 [2].

The activities of flight have an impact on the environment. Combustion from aircraft fuel produces chemical products that have been emitted from the high-speed aircraft engine. This gas and particle flow processes chemically and dynamically then affects the initial composition and mixes with ambient air. Furthermore, the amount of ozone in the atmospheric layer will change if there are chemicals and anthropogenic that enters the atmospheric layer [3]. Aircraft engines produce emissions that are similar to other emissions resulting from fossil fuel combustion. However, aircraft emissions are unusual in that a significant proportion is emitted at altitude. These emissions give rise to important environmental concerns regarding their global impact [4].

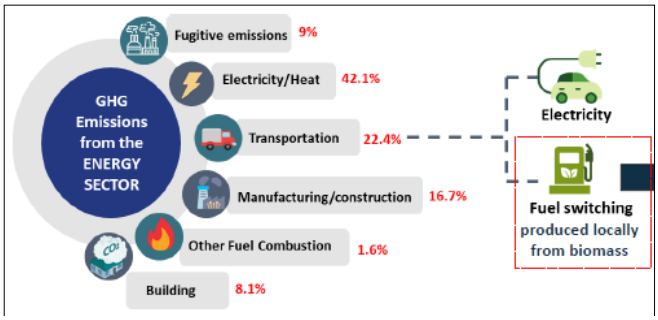

Figure 1. Greenhouse Gas Emissions from The Transportation Sector 22,4% [5]

Greenhouse gas emissions from all sectors can be seen in Figure 1 below. The transportation sector produced 22.4% of all energy sectors [5]. This sector contains all modes of transportation including air transportation. To be able to reduce aircraft emissions while maintaining healthy

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economic growth, the aviation sector needs to reduce the use of fossil jet fuel by using sustainable aviation fuel [1].

II. Sustainable Aviation Fuel

The European Commission in July 2021, proposed the establishment of a European-level mandate on the supply and use of Sustainable Aviation Fuels at all major EU airports. It specifically contains an obligation for airlines to increase the SAF flight fuel mix when departing from EU airports. And at the same time, introducing an obligation for fuel suppliers to incorporate an increasing share of SAF into jet fuel from 2025 to 2050 [1].

The first time biofuel was used in aviation was in 2008 [1]. At that time Virgin Atlantic airline mixed 20% biofuel with conventional fuel. Several airlines, Air New Zealand and KLM, are also experimenting with biofuel flights. In 2017, China's Hainan Airlines used used cooking oil-derived biofuel mixed with conventional jet fuel and then flew from Beijing to the US. Dr Chong Cheng Tung, first winner in the 2018 EURAXESS Science Slam China competition for science communication, and associate professor at China-UK Low Carbon College of Shanghai Jiao Tong University in China stated that used cooking oil waste and biomass are the most promising sources for fuel jet (green jet fuel) [1].

The quality of biofuel varies depending on the production process as well as the raw materials or the source. From many studies the biofuel produced contains oxygen so the calorific value or energy density is slightly lower than conventional jet fuel. So technology is used to further process such biofuel into aviation grade. The use of biofuel in airplanes does not require replacing fuel completely as is currently used, but gradually starting with a mixture of 10% or 20%. In this biofuel test the engine was not modified because it would be expensive and impractical. Testing is rigorous, especially combustion testing, to ensure that the desired emissions reductions and efficiency are achieved. However, the use of biofuel as jet fuel still requires more research to ensure that biofuel burns cleanly and can be produced on a large scale at low cost [1].

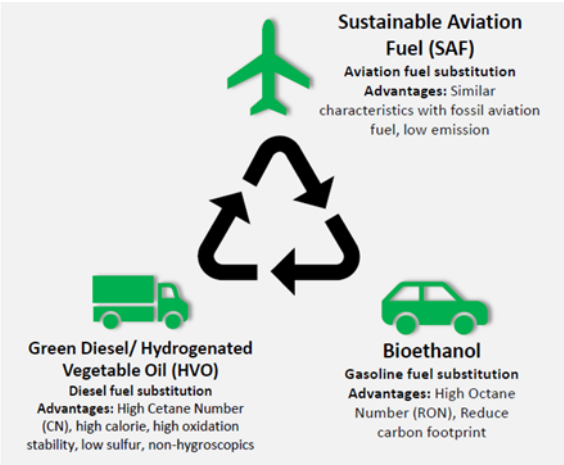

Figure 2. Alternatives Fuel Options from Biofuel [1]

In Indonesia, PT Pertamina has developed biofuel by releasing several biofuel products as presented in Figure 2. Biosolar is the first biofuel product for diesel engine vehicles produced by PT Pertamina in 1996. The development of biosolar was started by Lemigas and PT. Pertamina, both parties are trying to mix biodiesel and diesel in a ratio of 30:70. This mixture consists of 30% oil from plants or vegetables and 70% diesel fuel made from fossil fuels. A mixture of vegetable oils obtained from palm oil has been used as a mixture in biodiesel in Indonesia. Where palm oil is preferred because of its high energy value. Therefore, vegetable oil derived from palm oil is considered a very economical biofuel for fossil-based diesel oil [6].

Second is bioethanol, which is a mixture of Pertamax and vegetable ethanol. Bioethanol is a type of renewable fuel produced through the fermentation process of organic materials, especially plants with high carbohydrate content such as corn, cassava and sugar cane. However, the challenge that exists is that the raw material is a food product, so the use of bioethanol as an alternative energy source will result in competition for the availability of food raw materials [7]. Currently bioethanol fuel, which consists of a mixture of Pertamax RON 92 and 5% ethanol, has been used as an alternative biofuel for gasoline engine vehicles [5].

The latest biofuel produced by Pertamina is bioavtur, which is a mixture of palm oil in aviation fuel which is used as aircraft fuel. Pertamina is developing avtur with a mixture of Refined Bleached Deodorized Palm Oil (RBDPO) into the avtur. PT Pertamina (Persero) together with the Bandung Institute of Technology (ITB) have succeeded in producing bioavtur mixed fuel, namely mixing 2.4% palm kernel oil using a "red and white" catalyst made by ITB and a successful flight test has been carried out on the CN 235-220 FTB aircraft. belonging to PT Dirgantara Indonesia at Hangar 2 of PT Garuda Maintenance Facility Aero Asia Tbk (GMF), Tanggerang on September 10 2021 and on October 27 2023, it was tested with a commercial aircraft type Boeing 737-800 on the route from Jakarta Soekarno-Hatta Airport to Bandar Air Adi Sumarmo Surakarta [5]. Figure 3 illustrated the history of the development of biofuels for aircraft.

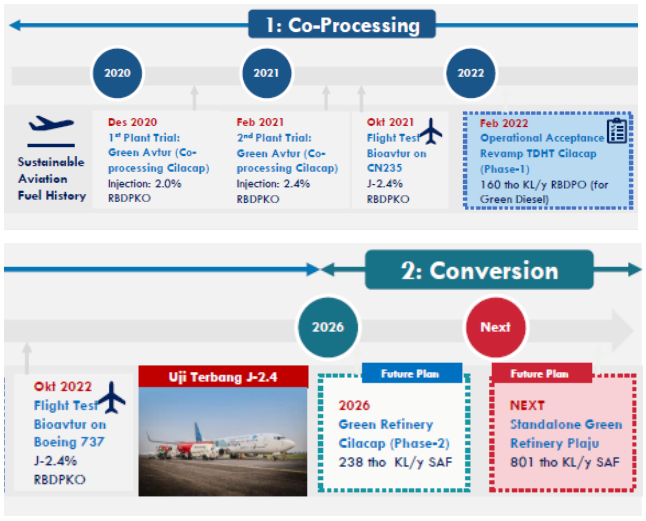

Figure 3. Sustainable Aviation Fuel History [5]

III. Air Traffics

The aviation industry in Indonesia was developing quite rapidly before the COVID-19 pandemic. In 2018 before the pandemic, Soekarno-Hatta International Airport (CGK) and Halim Perdanakusuma Airport (HLP) Jakarta experienced

substantial growth in 2018 according to ACI, with CGK increasing by 11.6% and HLP by 25.4% year-on-year [8]. The Soekarno Hatta Jakarta – Juanda Surabaya route was ranked the 8th busiest domestic route in the world according to the 2019 OAG Annual Report, while the Soekarno Hatta Jakarta – Changi Singapore route was ranked the third most dynamic international route [9]. After the pandemic, when the aviation industry began to operate normally, according to AOG's interim report as of September 2022, this route only ranked sixth in the Asia-Pacific region [10]. The COVID-19 pandemic which began in early 2020 caused activities to almost stop throughout the world, especially in the transportation sector. This situation has had a significant impact on the aviation industry, including in Indonesia. According to OAG data, aviation industry revenue in 2020 was only 40% of the previous year, and this value was the same as revenue in 2000. It is estimated that airline traffic will remain lower than in 2019 for several years [2].

This study focuses on estimating the reduction in aircraft emissions during the cruise phase following the reduction in flights due to the pandemic and predicting the estimated emissions of aircraft if they use biofuels. The flight routes in this study were domestic routes between provincial capitals in Indonesia and the three largest were taken. From the calculation of estimated aircraft emissions at airports in 34 provinces in Indonesia, the largest are flights from Soekarno-Hatta International Airport in Tangerang, Juanda International Airport in Surabaya and Sultan Hasanuddin International Airport in Makassar.

IV. METHODOLOGY

For CO_2 calculation methodology using the ICAO Carbon Emissions Calculator, it is necessary to first know the flight route, namely the origin airport and destination airport. From this route, a published flight schedule will appear, complete with aircraft type and flight distance. Each aircraft will be mapped to one of 312 similar types of aircraft so that fuel requirements on that route can be calculated. ICAO has collected data on aviation traffic and operations. Then the existing data will be used to calculate the average fuel requirements for that flight. To get the amount of CO_2 produced from these flights, the fuel requirements are multiplied by 3.16 for each flight from the two airports. The estimated CO_2 emissions due to aviation can be calculated using equation 1 [11].

CO_2 per person = 3.16 x (total fuel x people to transport factor)/ (number of seats x person load factor) (1)

Where:

Total fuel = average weight of fuel used for each equivalent type of aircraft,

Pax to freight factor = ratio calculated from the ICAO statistical database regarding the number of passengers and tonnage of mail and goods,

Number of Y-seats = total number of equivalent seats economy available on all flights serving a particular city pair,

Load factor Pax = ratio calculated from the ICAO statistical database based on the number of passengers carried and the number of seats available,

3.16 = constant representing the number of tonnes of CO_2 produced from burning one tonne aviation fuel.

From equation 1, the estimated calculation of CO_2 emissions from flights for departures from airports in 34 provincial capitals is presented in Figure 4.

The selection of airports in the provincial capitals was chosen from flight routes that used aircraft types whose flight level was more than 10,000 km and were routes between provincial capitals [12].

Figure 4. Estimated Aircraft CO_2 Emissions in 34 Provinces Capital in Indonesia

Figure 5. Estimated Aircraft CO_2 Emissions from 10 Largest of Provinces Capital in Indonesia (kg CO_2)

From the calculation results of estimated CO_2 emissions due to aviation in Fig. 4, and the ten largest airports in Fig.5. Then it can be seen that the three largest airports producing emissions are Soekarno-Hatta International Airport Tangerang, Juanda International Airport Surabaya and Sultan Hasanuddin International Airport Makassar.

V. RESULTS

The results of the estimated CO_2 emissions calculations from three large airports in Indonesia: Soekarno-Hatta Tangerang, Juanda Surabaya and Sultan Hasanuddin Makassar, both using aviation fuel and with a mixture of aviation fuel and 2.4% biofuel in kg CO_2 can be seen at Table 1.

TABLE I. ESTIMATION AIRCRAFT EMISSION CO_2 WITH AVTUR AND MIXTURE OF 2,4% BIOAVTUR (KG)

Airport	IATA	CO_2 Emissions with Fossil Fuel (kg CO2)	CO_2 Emissions with BioFuel (kg CO2)
Soekarno-Hatta Tangerang	CGK	44.286.681	43.020.256
Juanda Surabaya	SUB	14.293.582	13.871.524
Sultan Hasanuddin Makassar	UPG	13.462.195	13.081.801

From Table 1, comparing the estimated CO_2 emissions with fossil fuel and biofuel, it can be calculated that the reduction in the estimated CO_2 emissions with the aviation fuel-biofuel mixture of 2.4% is only 2.8-2.95% of the estimated CO_2 emissions using fossil fuels.

VI. CONCLUSION

From this study it can be seen that the use of biofuel mixtures will reduce aviation CO_2 emissions significantly. Fossil fuels mixed with 2.4% biofuel reduce CO_2 emissions by 2.8-2.95%. If the biofuel mixture can be increased further, it will increase the reduction in CO_2 emissions due to aviation. Based on the study by Wise et al. that the use of biofuel will reduce CO_2 emissions produced by aviation [13].

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