#CO2EMISSION #AVIATION #ALTERNATIVEFUELS

FEV CONSULTING

ALTERNATIVE PROPULSION SOLUTIONS FOR TRADITIONAL AIRCRAFTS

ELECTRIFICATION NOT EVERYWHERE A GOOD SOLUTION FOR CO_2 REDUCTION

THE AVIATION SECTOR CONTRIBUTES TO ALMOST 3% OF GLOBAL CO_2 EMISSIONS

195 countries signed the Paris climate agreement in 2015. The aim is to limit global warming to 1.5°C. This requires an overall strong reduction of CO_2 emissions in different sectors.

Today, the mobility and transportation sectors contribute 25% to the global CO_2 emissions. Within this sector, aviation accounts for 12% which makes it a total of 3%. Due to globally increasing flight activities and aircraft sales, the aviation sector will also have to contribute to reduction of CO_2 in the long run.

AVIATION CO_2 EMISSIONS ARE MAINLY DRIVEN BY COMMERCIAL AIRCRAFTS

24,400 aircrafts belong to the commercial aviation fleet. This fleet is mainly characterized by high utilization rates and large aircrafts such as the Airbus A320 or Airbus A350. 446,000 aircrafts are part of the general aviation fleet, characterized by lower utilization rates, often private usage and small aircrafts. Another 53,000 aircrafts are used for military purpose.

In 2018, approximately 4,670 aircrafts were sold for commercial and general aviation. FEV has analyzed various propulsion types and has developed market forecasts until 2040 for six segments. The six segments are clustered by maximum takeoff weight (MTOW) as shown in the diagram below. Commercial aviation is the largest contributor to CO_2 emissions in the aviation sector.

BATTERY ELECTRIC PROPULSION IS AN ATTRACTIVE SOLUTION FOR SMALL AIRCRAFTS AND DEDICATED USE CASES ONLY

For aircrafts, similar propulsion types as for on- & off-road vehicles are available. Next to conventional propulsion systems such as piston engines, turboprops, and turbofans also hybrid, battery electric or fuel cell systems exist. Due to the additional weight, hybrids can reduce CO_2 emissions only in some use cases (e.g. frequent takeoff and landing between islands) and will therefore just show very low market potential. Pure battery electric propulsion systems are mainly suitable for short distances and aircrafts with a maximum takeoff weight less than 12,000 lbs. due to a comparatively low energy demand. Nevertheless, improvements in battery energy density are required for range increase. For pure battery electric propulsion of larger aircraft (A05 & A06 segment), battery pack energy densities beyond 500 Wh/kg would be required to operate national short distances. Beyond that, new aircraft designs must be developed to realize the full potential. For these reasons, FEV does not expect any pure electric aircraft in the A05 & A06 segments, which are the main contributors for CO_2 emissions in the aviation sector, by 2040.

ALTERNATIVE FUELS (E.G. E-FUELS) AS MOST SUITABLE SOLUTION FOR CO_2 REDUCTION IN THE COMMERCIAL AVIATION

For the CO_2 emission reduction in the commercial aviation sector, other technologies must be considered. A feasible solution are alternative fuels such e-fuels from renewables. Alternative fuels can be used in both the existing fleets as well as in new aircrafts. Higher fuel prices result in higher operating costs. Therefore, larger shares of alternative fuels can only be expected assuming a CO_2 legislation for the aviation sector.

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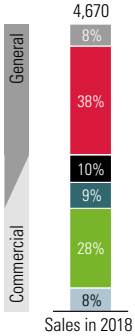

EXPECTED SALES SHARES IN 2040

MTOW segment	Example	Battery electric	Hybrid
A1: MTOW: 0 - 2,5k lbs	TECNAM Astore	~60%	0%
A2: MTOW: 2,5k - 12k lbs	Cessna Skyhawk	~20%	~5%
A3: MTOW: 12k - 40k lbs	Embraer Phenom 300	~5%	~10%
A4: MTOW: 40k - 100k lbs	Bombardier Q400	0%	~5%
A5: MTOW: 100k - 250k lbs	Airbus A320	0%	0%
A6: MTOW: > 450k lbs	Airbus A350	0%	0%

MTOW = Maximal Takeoff Weight