Comparative Life Cycle Analysis of hydrogen and battery-based aircraft

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Abstract - *Recent aeronautical research reveals that a variety of potential aircraft designs, including those powered by hydrogen, alternative energy sources, and electricity, are currently being explored. The reduction in harmful pollutants while flying is what distinguishes them from conventional airplanes with regard to the potential improvement in environmental effects. only after taking into consideration and analyzing the whole environmental impact over the course of a life.[1] To calculate the overall electrical environmental impact, of hydrogen, and alternatively fueled aircraft, the paradigm for modeling and assessing air-handling technology is presented in this paper, which also gives a summary of the issues and strategies being used in this field right now. The initial step involves conceptually designing future concepts using the fundamental requirements of conventional aircraft. The concepts' environmental impact is then evaluated using such a life cycle assessment. Future designers' utilization of ecologically friendly materials is significantly influenced by electricity. To determine which parts of the proposed strategy have been covered in the studies published and which still need additional research, a rigorous search and screening methodology is used. Future designs may only greatly lessen their impact on the environment if a substantial part of renewable energy sources is used in the electric generation process.[2][3]*

Key Words: **Electric airplane, Hybrid airplane, environment, climate change, sustainable, aviation**

1. INTRODUCTION

The aviation industry's relatively large impact on climate change has drawn more attention in recent years because of the continued rise in passenger air freight and cargo transportation. About 2.5% of the world's CO2 emissions and non-carbon emissions are related to energy that affects the climatic system's radiative forcing and are produced by the aviation industry alone (RF). The study of electric propulsion, the electrification of flight systems, and investment management in electric and hybrid aircraft designs have all increased steadily in the aviation industry. [4]Research on liquid hydrogen is being done for industries like aviation safety, where electric, hydrogen, and hybrid planes could help the International Civil Aviation Organization achieve its motto. This paper highlights the potential environmental advantages of these novel techniques and provides a researcher focus on their scientific literature and implementation in airplanes since environmental preservation is becoming more crucial in civil aviation. Although today's airplanes are largely intended to achieve the lowest Direct Operating Costs (DOC), it is pretty evident that good environmental preservation may be accomplished if Environmental Impact (EI) is minimized and used as the primary goal in plane design optimization. EI can be calculated using an ISO 14040 Life Cycle Assessment (LCA) covering the complete life cycle. LCA is characterized as the gathering and examination of data on inputs, outputs, potential, and product systems during the duration of a system's life cycle.

As usually said, many aspects of a plane are computed begin early in the design phase, and don't change. The same is true for an airplane's EI, which is established by choices made during the conceptual design phase. As a result, the conceptual design must contain an LCA rather than just studying the contaminants that are released during aircraft operation. To summarize: An important design criterion that incorporates an LCA (calculating EI) into the target function for optimizing aircraft at the conceptual design stage is environmental preservation and protection. Despite continual improvements in air travel, fuel economy, and more efficient operational processes, the global demand for airline travel is rapidly driving up overall aircraft emissions.[5] Air traffic demand is forecast to increase on average by 4.5% yearly, while efficiency improvements are anticipated to happen at up to 1.5% yearly rates. Despite continual improvements in air travel, fuel economy, and more efficient operational processes, the global demand for airline travel is rapidly driving up overall aircraft emissions. Air traffic demand is forecast to increase on average by 4.5% yearly, while efficiency improvements are anticipated to happen at up to 1.5% yearly rates. If no significant improvements are made in comparison to road traffic, aviation-related CO2 emissions would likely dual or triple until 2050 due to the lengthy lifespan of aircraft (20–30 years). The aircraft sector is also criticized for a number of additional consequences, such as noise pollution, especially in areas close to airports. Traditional aircraft technological efficiency advancements are not enough to significantly reduce aviation's environmental impacts while also meeting the Paris Agreement's CO2 goals and Flightpath 2050's emission-reduction targets. On the other hand, airplane operation that is both sustainable and energy-efficient can be facilitated by hybrid-electric and other electric-only propulsion systems. Here, fuel-cell-based, battery-powered, and possibly even hybrid-electric concepts of propulsion are used in place of conventional kerosene-powered jet engines to significantly reduce in-flight Greenhouse Gas (GHG) production. Bio-feedstocks are used to find separate fuels for jet engines, and therefore electro fuels (e-fuels), that are produced using RES, have also been recognised as potential replacements for gasoline as a fuel and energy source. Indeed, research and development into reduced weight techniques has decreased aircraft weight and, like a result, fuel usage. Although cutting-edge technology can reduce in-flight emissions, other life cycle stages, such as raw material acquisition, production, and end-of-life, may have a greater impact on the environment (EoL). [6] As a result, there may be significant changes to the global flow of material and energy associated to the aviation sector. Bio-feedstocks are used to find separate fuels for jet engines, and therefore electro fuels (e-fuels), that are produced using RES, have also been recognised as potential replacements for gasoline as a fuel and energy source. Indeed, research and development into reduced weight techniques has decreased aircraft weight and, like a result, fuel usage. Although cutting-edge technology can reduce in-flight emissions, other life cycle stages, such as raw material acquisition, production, and end-of-life, may have a greater impact on the environment (EoL). As a result, there may be significant changes to the global flow of material and energy associated to the aviation sector. The supply of rechargeable batteries is linked to energy-consuming activities carried out in the automobile industry, which have an impact on more than only greenhouse gas emissions.[7] Furthermore, it is necessary to factor in the cost planning for new aircraft techniques. Because they require extremely little maintenance and repair and because electricity is a less expensive energy source than kerosene, electric airplanes, for example, may be less expensive to operate. However, costs associated with production and recycling may be greater than they are for planes with kerosene-based engines. Social problems are also more likely to arise at the beginning of a life cycle. For instance, the resources required to build the cells used in electric airplanes are rare and vital, and they must be mined in underdeveloped nations where child labour, corruption, and unsafe working conditions are common. Similar to this, producing the ideal feedstocks for the production of biofuels competes with food production and might not be well received by the locals. Evaluation of the product's life cycle viability of developing airplane methods is required within this framework. A framework for modelling and assessing the assessment methods of proposed aircraft technology has in fact been built in order to appropriately conduct a literature assessment. Planes with kerosene-based engines. Social problems are also more likely to arise in the beginning of a life cycle. For instance, the resources required to build the cells used in electric airplanes are rare and vital, and they must be mined in underdeveloped nations where child labour, corruption, and unsafe working conditions are common. Similar to this, producing the ideal feedstocks for the production of biofuels competes with food production and might not be well received by the locals. Evaluation of the product's life cycle viability of developing airplane methods is required within this framework. A framework for modelling and assessing the assessment methods of proposed aircraft technology has in fact been built in order to appropriately conduct a literature assessment. Technology advancements in aircraft, sustainability considerations, indicators, evaluation procedures, life cycle phases, strategy and tactics of multi-disciplinary (research) data are all taken into account. This enables a thorough assessment of sustainability that considers the particulars of upcoming technical developments in aviation. In the literature now available, this paradigm has not yet been introduced, and the majority of studies that are currently available concentrate on certain sustainability factors or particular technologies. These studies have still not been thoroughly analysed. This paper's goal is to close a gap in research by thoroughly analysing the tools and techniques for evaluating and creating potential sustainable aviation technology. The components of the framework that have been thoroughly studied and those that still need more research are outlined in the overview that follows.

2. EVALUATION OF NEW AIRCRAFT DESIGNS AND PROPULSION SYSTEMS AND FRAMEWORK FOR SUSTAINABILITY MODELING

According to the "Our Shared Future", Brundtland Commission's Report, the present generation should live sustainably in order to protect generations' possibility of living comfortably. The "triple bottom line," or the three components of sustainable development, are often addressed (environmental, economic as well as social). In contrast to the idea of relative sustainability, which is anchored in environmental and social dimensions, the concept of absolute sustainability has recently gained recognition. [8] The term "sustainable-oriented development inside the spectrum of one to multiple product life cycles'' has been used to define a Life Cycle Engineer (LCE) idea, which broadens the focus to include all three sustainability pillars. The LCE idea seeks to steer engineering procedures in a sustainable path from conception through disposal. Given the current shift in the aviation sector toward new aircraft technology, the sustainability of evolving flight systems and their potential to reduce their environmental effect will depend on environmental components at each stage of their life cycles. An adaptive management modeling paradigm, shown in Figure 1, makes it possible to assess and enhance the production process as well as its interactions with relevant organizational components and the outside environment. This section introduces the sustainability components and modeling methodologies for integrating multiscale physiologic, environment, or social and economic models in order to forecast the future of aviation. The requirement for a unified LCE modeling technique that permits the production of a sizable number of profiles on the basis of changes in technology, geography, and also temporal characteristics makes it possible to conduct a meaningful sustainability review of the future expansion of aviation. The framework incorporates three modeling and function-building systems into an individual data modeling platform, as shown in Figure 1. [9] It contains model libraries that display possible systems in high contrast (cf. statistical models), models that illustrate how the background of the system interacts with the foreground of the system, and models that depict the simulation used in engineering and life cycle modeling. The integrated model is also connected to data analytics techniques that enable the incorporation of key metrics as technological limitations in the advancement of these nanotechnology product chains, algorithms for assessing item chains with respect to their impacts on society and society, and System analysis. The relationship between each area of the framework and the engineering and assessment of emerging aviation technology is clarified and reinforced in the sections that follow. The necessary research problems are derived using the framework that was previously described.

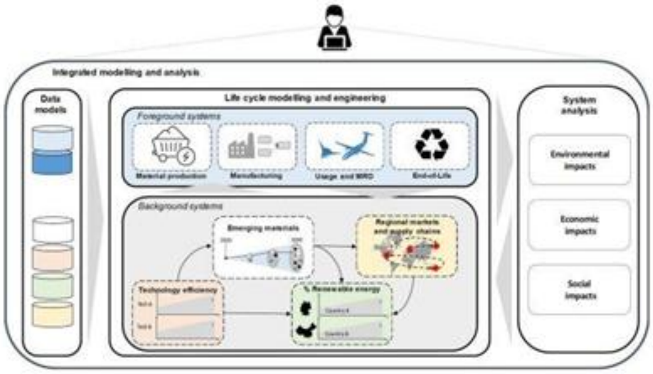


Figure 1 : A modeling approach for the sustainability assessment and engineering of future aircraft systems

3. REVIEW METHODOLOGY

Now, in the framework of the particular frame and the proposed research questions, a rigorous technical review is being applied to the study's objective. To ensure completeness and lessen the possibility of bias when selecting the linked articles, a thorough search method was applied. Based on the research objectives of this study, which are listed in upcoming sections, precise keywords were chosen and a set of multilayered search strings that describe the surroundings and the subject were created. The architecture of the search phrases is shown in Figure 2. Life-cycle sustainability-related terms and phrases are contained in the search query "A".[10]

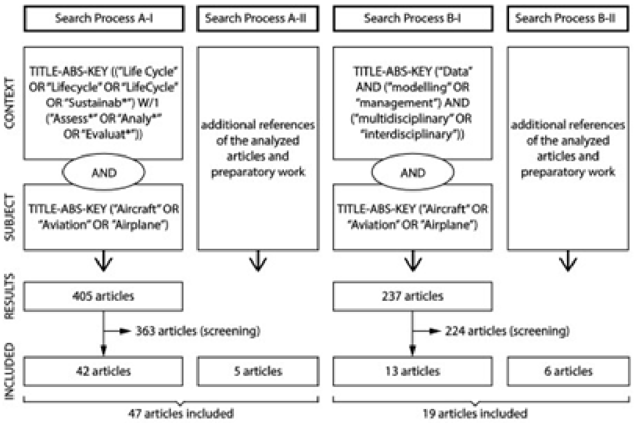


Figure 2 : Search strategy and results

To emphasize the growing significance of interdisciplinary data information in sustainability assessment and evaluation, query string "B" with the situation-specific (Multidisciplinary/Interdisciplinary Data Modeling/Management) is added to Assessment, Analysis, and Assessment (Aircraft, Airplane, and Aviation) for the same subjects. The Scopus database from Elsevier provides in-depth analysis and thorough coverage of major scientific literature. Utilizing data export, these searches were conducted in November 2019. [11] The outcomes of the information retrieval method were thoroughly screened. First, using technical criteria, only English-language publications which would be thoroughly examined were selected. Extra symposium papers are being utilized for the study of the climate consequences of aviation and for building the methodology discussed in this paper, as opposed to publications from peer-reviewed scientific journals. Second, the content criteria for the descriptions of the reviewed papers were examined. The search process only includes papers that analyze the existing assessment of both conventional and new aviation propulsion systems. A. During the search process, only papers that address the use of interdisciplinary models and/or product portfolio planning or maintenance are taken into consideration. B. The search process only includes papers that analyze the existing assessment of both conventional and new aviation propulsion systems. A. [12] During the search process, only papers that address the use of interdisciplinary models and/or product portfolio planning or maintenance are taken into consideration. B. The entire contents of the objects that were still in the system have been gathered in order to find the pertinent information. The assessment database (search operations A-II and B-II), which consists of forty-seven papers for scanning process A with nineteen papers for research phase B, has been updated to include many references found during this phase. This contribution analyses roughly 66 items in total.

Several LCE analysis rating systems were used to evaluate these papers. Despite the 1990s LCA techniques' success, since 2010 there has been a concern about the sustainability of aviation combust systems and solutions. Notably, in 2017 and 2018, more study in this field was finished.

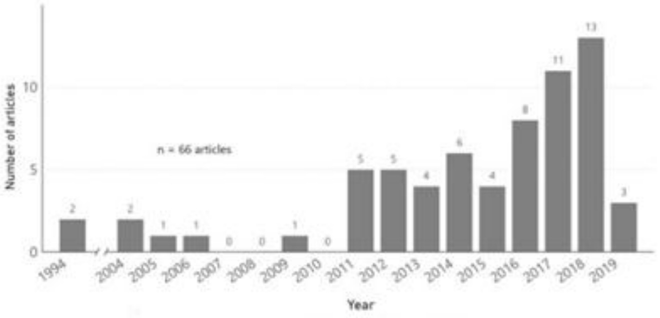


Figure 3 : Distribution of articles by publishing year

The goals of the Paris Agreement, an increase in the price of kerosene, and modifications to the legislative provisions of the framework, which include the European Union Emissions Trading System (EU ETS) and the Carbon Offsetting and Reduction Scheme, may all be significant contributing factors. (CORSIA)[13][14]

The next part focuses on categorizing the reviewed articles discovered using search technique A before going through a thorough analysis of the evaluation results in the previous section for just a better comprehension of the works of literature under investigation.

Depending on the innovations suggested to create a more self-sustaining airplane launch process, the identical dimensions and markers examined, and the assessment methodologies used, the descriptive research design of publications is carried out.

3.1 Descriptive Examination of the Selected Literature

The search strategy A-selected articles are initially discussed in this section in terms of the innovations taken into consideration, the sustainable development features and markers applied, as well as the evaluation techniques used. This provides a preliminary framework and classification of the data and serves as the prelude to the upcoming section’s in-depth analysis.[15]

3.2 Comprehensive examination of the papers and key Insights

This part examines the chosen study in light of the fundamental components of the created framework. Accurate as well as complete multi-disciplinary structures play a key role in ensuring effective LCA results by meeting the necessity for databases of LCI to assess the climate consequences of new aviation tactics, as detailed in earlier section.[16] Thus, methods that help organize multidisciplinary statistics have gained importance in the field of environmentally friendly flying.

3.3 Research Needs and Directions for the Future

Numerous framework components have already been discussed in scientific literature evaluations, according to the study's analysis. There are still significant research gaps, nevertheless. The key findings of this study have been outlined in the following part in order to address the research questions indicated in earlier section.

4. ELECTRIC, HYBRID, AND HYDROGEN AIRCRAFT: POSSIBLE ENVIRONMENTAL BENEFITS

4.1 Changing weather

The environmental impact of the aviation industry could be significantly reduced by using electricity or hydrogen in place of jet fuel since the procedure of battery-powered and hydrogen planes seems to be unconnected to emissions of carbon dioxide from fuel combustion. However, these CO2 benefits must be taken into account over the course of a specific life span and can only be attained if electric power or other hydrogen sources are derived from low-carbon sources. As an illustration, 98 airports globally had solar energy projects built as of 20151, and the number increased over time. Thanks to the quick growth of renewable energy production and the ease of access at airports, electric and hybrid aircraft will be able to charge up in a way that reduces CO2 emissions. Accordingly, using such sources of renewable energy to manufacture hydrogen would have a negligible overall CO2 impact. In addition to cutting Emissions of co2, electric aircraft may boost the environment by doing away with chemtrails, which really are long, thin particles that occur largely in the aftermath of jet engines. Science does not support scenarios involving contrail emissions, although a few studies indicate they might be able to contribute to additional global warming. It is crucial to keep in mind that, in regard to electrical and hydrogen propulsion, energy and hydrogen may both be used in a variety of ways inside the aviation industry. According to the ICAO's Thumb Rules, electrical taxiing (E-taxi) may cut CO2 by around 33 kg for every single minute of use. By using electric engines as an extra source of thrust after takeoff, mixed aircraft can help lower fuel usage and contrail production. This makes it possible for the airplane's sailing phase to be powered by smaller, more fuel-efficient engines. Additionally, hydrogen can be utilized for ground-handling vehicles, as demonstrated by runways all over the world. Examples include projects that installed hydrogen fueling stations that manufacture hydrogen locally using the electrolysis method while employing renewable energy sources in Heathrow, Berlin, and Los Angeles.[17]

Fully electric aircraft hold great promise for improved air quality because they don't generate pollutants during fuel combustion. Hybrid-electric planes' reduced fuel consumption may help significantly raise regional air quality standards. In addition, because these components contribute to the emissions of fine particles, they should all be taken into consideration when examining the air pollution effects of all types of aircraft, including those powered by electric motors, brakes, tires, and road surface erosion.

4.2 Local air quality

Such as with CO2 emissions, it is important to consider the electricity supply while evaluating the native environmental value components of electrification because different energy production techniques may still contribute to air pollution. In addition to broad trends, there are additional factors that must be considered. As aircraft become more fuel-efficient, their size and weight increase, allowing them to carry more people and fuel. The gas savings provided by higher hybrid model power efficiency could be offset by an increase in gasoline consumption. Therefore, it is clear that hybrid-electric aircraft contribute to a reduction in air pollution emissions when assessed per person, but not necessarily when considered globally. Additionally, battery packs are installed in the majority of hybrid-electric aircraft for power supply and storage. Because of the power density and also the necessary power supply of the battery, batteries as of now are quite heavy and can significantly add up to the aircraft’s weight. A long-term approach for electric planes could turn out to be helpful in assessing the all-around environmental influence and sustainability benefits of electric planes.[18] This approach encompasses the entire life span of an aircraft, assisting in the avoidance of social and environmental risks. The batteries being used in such aircraft are presently lithium-ion batteries. This battery's production procedures may produce pollutants that are detrimental to both air quality and human health. Additionally, because batteries have a finite lifespan, they produce waste that contains dangerous and corrosive elements like lithium. However, as their use increases, there is room for battery life improvements that will lessen the negative effects on the environment and human health. Alternatives to lithium batteries that are sustainable are also being developed.

4.2 Noise

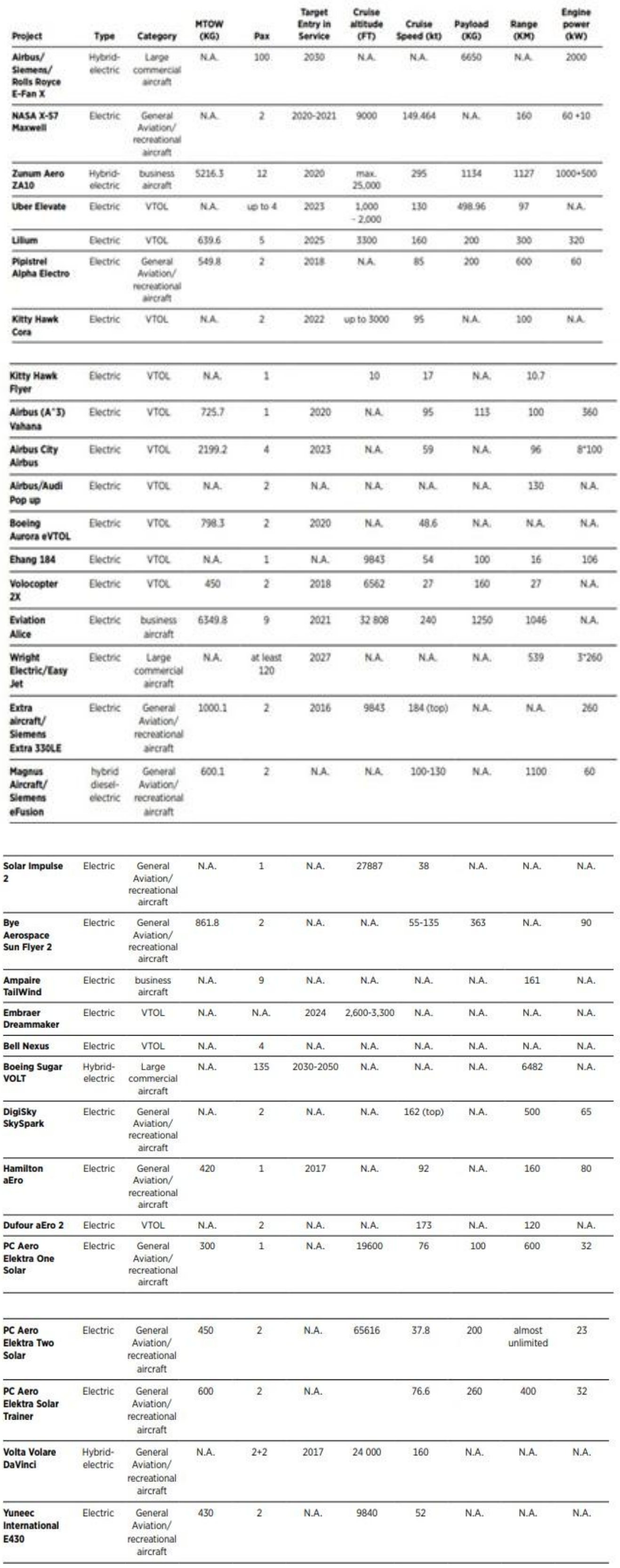
This battery's production procedures may produce pollutants that are detrimental to both air quality and human health. Additionally, because batteries have a finite lifespan, they produce waste that contains dangerous and corrosive elements like lithium. However, as their use increases, there is room for battery life improvements that will lessen the negative effects on the environment and human health. There are also sustainable lithium battery substitutes being developed.

Since electric trains do contain the noise sources connected to both jet and cylinder engines, like compression, turbine noise, and more, the propulsion system may result in reduced aviation noise levels. The reduced jet velocities necessary for airplane operation may provide a major decrease in jet noise, depending on the layout of the aircraft. Because electric airplanes produce less noise, they might be more appropriate for usage in densely populated areas. This is supported by the Uber Uplift project, which aims for a 15 dB decrease in sound compared to a regular helicopter of equal weight, and the quiet Pipistrel Alpha Electric, which will be utilized by modern flight schools.

5. CURRENT PROJECTS FOR ELECTRIC AND HYBRID AIRCRAFT

By using the Electric and Hybrid Aviation Platform for Innovation, the ICAO Secretariat is presently concentrating on industry advancements in hybrid and electric aircraft configurations (E-HAPI). This paper keeps a non-exhaustive list of innovations that have been widely acknowledged, from small regional and business aircraft to large commercial planes and vertical takeoff and landing (VTOL) airplanes (also known as electric urban air taxis). The majority are anticipated to enter service around 2020 and 2030, however, several are currently available. Four such projects made their first flights in 2019. (City Airbus, Lilium, Sun Flier 2, Bye Aerospace, and Boeing Aurora eVTOL) Such aircraft types are not currently covered by any ICAO environmental regulations in Annex 16. By using the Electric and Hybrid Aviation Platform for Innovation, the ICAO Secretariat is presently concentrating on industry advancements in hybrid and electric aircraft configurations (E-HAPI). [19] This keeps a non-exhaustive list of innovations that have been widely acknowledged, from small regional and business aircraft to large commercial planes and vertical takeoff and landing (VTOL) airplanes (also known as electric urban air taxis). The majority are anticipated to enter service around 2020 and 2030, however, several are currently available. Four such projects made their first flights in 2019. (City Airbus, Lilium, Sun Flier 2, Bye Aerospace, and Boeing Aurora eVTOL) Such aircraft types are not currently covered by any ICAO environmental regulations in Annex 16.

Table 1 : ICAO Electric and Hybrid aircraft platform for innovation



Project	Type	Category	MTOW (KG)	Pax	Target Entry in Service	Cruise altitude (FT)	Cruise Speed (kt)	Payload (KG)	Range (KM)	Engine power (kW)
Airbus/ Siemens/ Rolls Royce E-Fan X	Hybrid-electric	Large commercial aircraft	N.A.	100	2030	N.A.	N.A.	6650	N.A.	2000
NASA X-57 Maxwell	Electric	General Aviation/ recreational aircraft	N.A.	2	2020-2021	9000	149.464	N.A.	160	60 +10
Zunum Aero ZA10	Hybrid-electric	business aircraft	5216.3	12	2020	max. 25,000	295	1134	1127	1000+500
Uber Elevate	Electric	VTOL	N.A.	up to 4	2023	1,000 - 2,000	130	498.96	97	N.A.
Lilium	Electric	VTOL	639.6	5	2025	3300	160	200	300	320
Pipistrel Alpha Electro	Electric	General Aviation/ recreational aircraft	549.8	2	2018	N.A.	85	200	600	60
Kitty Hawk Cora	Electric	VTOL	N.A.	2	2022	up to 3000	95	N.A.	100	N.A.
Kitty Hawk Flyer	Electric	VTOL	N.A.	1		10	17	N.A.	10.7	
Airbus (A^3) Vahana	Electric	VTOL	725.7	1	2020	N.A.	95	113	100	360
Airbus City Airbus	Electric	VTOL	2199.2	4	2023	N.A.	59	N.A.	96	8*100
Airbus/Audi Pop up	Electric	VTOL	N.A.	2	N.A.	N.A.	N.A.	N.A.	130	N.A.
Boeing Aurora eVTOL	Electric	VTOL	798.3	2	2020	N.A.	48.6	N.A.	N.A.	N.A.
Ehang 184	Electric	VTOL	N.A.	1	N.A.	9843	54	100	16	106
Volocopter 2X	Electric	VTOL	450	2	2018	6562	27	160	27	N.A.
Eviation Alice	Electric	business aircraft	6349.8	9	2021	32 808	240	1250	1046	N.A.
Wright Electric/Easy Jet	Electric	Large commercial aircraft	N.A.	at least 120	2027	N.A.	N.A.	N.A.	539	3*260
Extra aircraft/ Siemens Extra 330LE	Electric	General Aviation/ recreational aircraft	1000.1	2	2016	9843	184 (top)	N.A.	N.A.	260
Magnus Aircraft/ Siemens eFusion	hybrid diesel-electric	General Aviation/ recreational aircraft	600.1	2	N.A.	N.A.	100-130	N.A.	1100	60
Solar Impulse 2	Electric	General Aviation/ recreational aircraft	N.A.	1	N.A.	27887	38	N.A.	N.A.	N.A.
Bye Aerospace Sun Flyer 2	Electric	General Aviation/ recreational aircraft	861.8	2	N.A.	N.A.	55-135	363	N.A.	90
Ampaire TailWind	Electric	business aircraft	N.A.	9	N.A.	N.A.	N.A.	N.A.	161	N.A.
Embraer Dreammaker	Electric	VTOL	N.A.	N.A.	2024	2,600-3,300	N.A.	N.A.	N.A.	N.A.
Bell Nexus	Electric	VTOL	N.A.	4	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Boeing Sugar VOLT	Hybrid-electric	Large commercial aircraft	N.A.	135	2030-2050	N.A.	N.A.	N.A.	6482	N.A.
DigiSky SkySpark	Electric	General Aviation/ recreational aircraft	N.A.	2	N.A.	N.A.	162 (top)	N.A.	500	65
Hamilton aEro	Electric	General Aviation/ recreational aircraft	420	1	2017	N.A.	92	N.A.	160	80
Dufour aEro 2	Electric	VTOL	N.A.	2	N.A.	N.A.	173	N.A.	120	N.A.
PC Aero Elektra One Solar	Electric	General Aviation/ recreational aircraft	300	1	N.A.	19600	76	100	600	32
PC Aero Elektra Two Solar	Electric	General Aviation/ recreational aircraft	450	2	N.A.	65616	37.8	200	almost unlimited	23
PC Aero Elektra Solar Trainer	Electric	General Aviation/ recreational aircraft	600	2	N.A.		76.6	260	400	32
Volta Volare DaVinci	Hybrid-electric	General Aviation/ recreational aircraft	N.A.	2+2	2017	24 000	160	N.A.	N.A.	N.A.
Yuneec International E430	Electric	General Aviation/ recreational aircraft	430	2	N.A.	9840	52	N.A.	N.A.	N.A.

5.1 Pipistrel Alpha Electro

The Pipistrel Alpha Electric is currently a 2-seat instructor with a 1.5-hour reserve endurance, it is true. With over 60 operational aircraft globally, it is the first certified all-electric aircraft. It is more appropriate for use by flight schools because its running costs average 1 Euro per hour. [20]

Aircraft with MTOW between 300 and 1000kg fall into the general aviation/recreational airliner category. Typically, they are two-seat electric aircraft. This category consists of certified and built aircraft like the Pipistrel Alpha Electro.

Both the business and regional aircraft categories boast of improved seat capacities and a nearly 1000 km longer claimed range of travel (nearly ten). A full-scale reproduction of the Variant Alice was only on display just at Paris Air Show. With seating capacities ranging between one and five, MTOWs between 450 and 2200 kg, and flying lengths between 16 and 300 km, the VTOL sector has advanced significantly recently. [21] These designs for electric-only airplanes will go into service between 2020 and 2025. Single-aisle, hybrid electric airplanes from Airbus and Boeing with seat capacities ranging from 100 to 135 people are part of the massive commercial aircraft program and are expected to enter service around 2030.

Figure 4 : Pipistrel Alpha Electro

5.2 Eviation Alice

The Eviation Alice is built to go over 650 kilometers at an airspeed of 240 knots with 9 passengers and 2 captains on board. Three 260 kW (350 hp) turbochargers produced by Siemens eAircraft company, who Rolls-Royce just acquired, provide its power. The battery makes up much to 60% of the aircraft's total takeoff weight with a mass of 3,700 kg. According to a statement from Eviation, Cape Air, a local aircraft company in the United States, will buy the Eviation Alice for an estimated $4 million per aircraft. Eviation anticipates certification by the end of 2021, and shipments will start in 2022. [22][23]

Figure 5 : Eviation Alice

5.3 Airbus E-Fan X

In order to aid LH2 integration and acceptance, Enable H2 will also offer a strong safety audit that will describe and reduce risks. The plan will offer a road map for creating inclusive aviation and propulsion systems, as well as essential enabling technologies, to TRL 6 by 2030–2035.

To evaluate a 2MW hybrid-electric rocket engine, Airbus developed the E-Fan X in partnership with Siemens and Rolls-Royce. One of the British Aerospace RJ100's four gas turbines will be replaced with a 2 MW electric motor.

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In 2020, flight testing is expected to start. The E-Fan X will be used by Airbus to set requirements for electric-operated aircraft as well as conduct research into thermal stresses, electrical thrust control, height and its impact on electric systems, and electromagnetic compatibility difficulties. In 2020, flight testing is expected to start. [25] The E-Fan X will be used by Airbus to set requirements for electric-operated aircraft as well as conduct research into thermal stresses, electrical thrust control, height and its impact on electric systems, and electromagnetic compatibility difficulties.

Figure 6 : Airbus E-Fan X

5.4 Lilium Jet

The tilt-jet Lithium Jet comprises 36 motors mounted on its wings. It will be capable of carrying a pilot plus four passengers and reach a top speed of 300 kilometers per hour. When compared to traditional helicopter designs, the ducted engine architecture is anticipated to reduce noise. In May 2019, the Lilium Jet completed its first flight; before 2025, it is anticipated to really be fully functional in all major cities. [26][27]

Figure 7 : Lilium Jet

6.CONCLUSION AND OUTLOOK

The shift to more environmentally friendly and energy-efficient aircraft is unmistakably linked to an increase of technological solutions capable of resolving the environmental issues that the aviation industry is now facing. There are technological developments, especially in the area of alternative powertrains. Jet engines that run on fossil kerosene are being proposed as a replacement, while alternatives include battery and hydrogen fuel jet engines, e-fuels, and biofuels. These technologies may lower aviation emissions, but they could also create new environmental and social problems. The framework for estimating and evaluating the sustainability of potential future advances for even more environmentally friendly but also powerful aviation is introduced in this paper. The components of the framework that have already been extensively discussed in the research journals as well as the requirement for more research were determined by a comprehensive literature review. Studies on data types for creating foreground and background systems are widely available.

An excellent basis for the simulation of product design is provided by models like CPACS. However, there is currently a lack of a direct connection to sustainability evaluation, especially to well-known sustainable assessment techniques like LCA, LCC, SLCA, or LCSA. For system analysis as well as product lifecycle modeling, there has already been a significant amount of study, with alternative fuels predominating.

It has been emphasized that additional study is necessary to evaluate batteries and hydrogen fuel in terms of socioeconomic and environmental concerns. To comprehend the consequences of prospective aviation technology further than the use stage, models are required. We still don't know how the extraction of necessary raw materials and challenges in the EoL stages will be affected. It is advised to carry out more studies that go beyond employing new technologies to reduce GHG emissions, like examining how altering flight height influences the amount of impact aircraft contrails are having on the environment. Furthermore, not only socio-economic studies must be incorporated into the LCA, as well as the relevant signals must be cautiously identified in the given environment in order to provide a coherent and thorough assessment of sustainability for future aviation development. Further research is needed to determine the conditions under which battery-powered aircraft were significantly more environmentally benign than hydrogen-powered aircraft. The approach described here, which would be based on the idea of enhancing learning LCE, makes it simpler to model a wide range of technologies or mechanisms while dealing with high data ambiguity and variable fluctuation. Future aviation techniques can be made more environmentally and power-efficient by merging multi-scale physical, environmental, and socio-economic models and looking at the circumstances in which a particular technology might be more so as a result, this strategy can help engineers create and run more environmentally friendly aircraft and increase the functionality of the suggested tools and procedures in aviation. The development of new and inventive technologies and airplane energy sources is accelerating. The possible effects of these changes on the ICAO Sustainability Goals are being attentively watched by ICAO. To maintain pace with timely environmental approval of these technical advancements, if necessary, ICAO will need to put in a significant amount of work.

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