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The Advantages of Life Cycle Assessment in Policy Development

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Description

Aviation, this study tackles these issues and identifies the technologies and practical steps needed to create an aviation industry that is more environmentally sustainable. Using prospective life cycle assessment, the environmental effects of new hybrid-electric aircraft configurations that are expected to be deployed in 2030, 2040, and 2050 have been thoroughly measured. Batteries, fuel cells, hydrogen, and certain Alternative Aviation Fuel (AAF) systems were among the technologies and systems that were covered throughout the whole life cycle of the conventional and hybrid-electric aircraft configurations. Comprehensive life cycle inventories derived from primary data, literature, and potential environmental databases were utilized for these components, and the degree of uncertainty was assessed. The findings indicated that while aircraft powered by fuel cells that use hydrogen produced through electrolysis offer significant environmental benefits over longer time horizons than conventional aircraft, hybrid-electric aircraft with batteries look to be a promising transition technology in the short term. However, when taking into account environmental impacts holistically, the analyzed AAFs show little to no environmental benefit, indicating the need for a global revision of the current AAF structures and incentives. The findings also show that the environmental burden is shifting from flight emissions in conventional aircraft systems to airport operations and aircraft manufacturing in hybrid-electric aircraft. This emphasizes the need for enhanced support for airports in managing their sustainability and for a greater integration of Eco design principles into the design and development of new and future aircraft.

Energy requirements

A crucial supplementary tool in the formulation of policies and decisions is life cycle thinking. The Life Cycle Assessment (LCA) approach is ISO-standardized and consists of four necessary, and interdependent steps: Defining the purpose and scope, analyzing the Life Cycle Inventory (LCI), evaluating the Life Cycle Impact (LCIA), and interpreting the life cycle. LCA's ability to quantify various environmental impacts and to do so from a life cycle perspective that is, to take into account all activities from the extraction of necessary raw materials through the production and operation of technological systems to their recycling and eventual end-of-life are two of its main advantages. Thus far, LCA has been used in scientific literature and other contexts to analyze aircraft systems. Nevertheless, the majorities of airplane Life Cycle Assessments (LCAs) only addresses the effects of climate change and provide scant information. Because of this, the carbon footprint of hybrid-electric aircraft is frequently calculated in literature using initial design outputs including weight, fuel consumption, energy requirements, and degree of hybridization. This made it difficult to interpret these rough carbon footprints, which suggested that hybridization would outperform conventional aircraft for a particular mission. However, because of the impact assessment's coarse granularity and lack of technical specifications for the power train, hotspot analysis was not possible. Thus, there haven't been many opportunities to enhance the design and Furthermore, airport systems are one area of the aircraft system life cycle that is frequently left out or only partially discussed in the literature on hybrid-electric aircraft life cycle assessments. Despite this, airport systems may be relevant in light of the infrastructure changes associated with electricity and hydrogen supply systems. In order to identify trade-offs between environmental issues and prevent burden shifting from one impact to another in subsequent decision-making, a variety of environmental impact indicators beyond just carbon footprints should be taken into account when evaluating the environmental sustainability of aircraft systems. Overall, these shortcomings and gaps in previous Life Cycle Assessment (LCA) research in the field mean that current LCA results are insufficient to fully address, from a future-focused perspective, comparisons between hybrid-electric and conventional aircraft systems and to offer significant recommendations to aviation sector stakeholders.

Life cycle assessment

Furthermore, the LCA technique is traditionally static and depends on data that is already available about current efficiency and processing practices. In order to make recommendations to policymakers about the sustainability of future aircraft solutions, it is imperative that the so-called prospective Life Cycle Assessment (LCA) be carried out in order to address the data limitations associated with the novelty of the technologies and the problem of dynamic modeling of future environmental impacts. Using up scaling technology and updated LCI background databases, prospective LCAs are used to evaluate the environmental effects of both mature and immature technologies at a later period. Previous research has only examined potential changes *via* the narrow lens of the fuel system. For instance, it has looked at differentiating the power Grid's Greenhouse Gas (GHG) emission intensity in accordance with government commitments and examining different routes for producing hydrogen. Therefore, these studies have not modeled future changes in industrial backdrop systems, such as electrification, efficiency increases, and technological maturation. Consequently, there are still unsolved questions about the availability of hybrid-electric aircraft technologies, their technical requirements, and any associated environmental implications.

Through the use of a prospective Life Cycle Assessment (LCA), this study fills in these gaps in the environmental sustainability evaluation of hybrid-electric aircraft systems and provides policy- and decision-makers in the aviation industry with a roadmap for environmental sustainability. The study's specific objectives are to compare the environmental performance of hybrid-electric aircraft configurations with conventional aircraft using either kerosene or AAF, quantify the environmental impacts of emerging hybrid-electric aircraft technologies, and provide recommendations to policy-makers and aviation stakeholders for a more sustainable transition in the context of regional aviation.

Based on battery and/or fuel cell technology, five hybrid-electric aircraft designs were assessed, and alternative aviation fuels were determined to be theoretically feasible by 2050. The prospective LCI, which is a compilation of all inputs, outputs, and emissions for each time horizon, was developed in collaboration with industry professionals using primary data and information from scientific literature.