ARIV
International Journal of Technology
Paper ID: AIJT12072020 Vol1 Issue 2 2020

A Comprehensive Analysis of Solar Powered Aircrafts

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Abstract

The use of aircrafts has been on the incline in the last few decades. The source of power these aircrafts have been petroleum. Petroleum is known to be a depleting resource and it releases harmful emissions to the environment. Finding alternative renewable energy that is clean and environmentally friendly is required in the near future. Harnessing the light from the sun using solar panels to power aircrafts is a possible solution. Further research into the types of planes available, solar panels used, customization and modification of panels for aircrafts to achieve the required results will be discussed in this article.

Keywords: Aircrafts, Pro-environmental behavior, Solar Power, Renewable Energy, Sustainable Future

Introduction

Air travel has become more frequent and accessible today. Air travel has been used for moving people, goods, and military applications and so on. Today the main source for fuelling these airplanes is petroleum. Petroleum is being used extensively. We are eventually going to have to find alternatives. We have to find an energy source that is renewable and environmentally friendly, so that we don't fall back to this position again. Hybrid alone is an option but it has the disadvantage of weight therefore reducing efficiency. Introduction of solar power as an energy source could help provide a solution to this. If not for the whole journey at least used during some parts of travel. Solar panels are being used widely now and research and development over the years have made Solar panels quite efficient. People are using it from powering buildings, vehicles, equipment, etc. Using Solar panels for airplanes could significantly increase efficiency, decrease carbon emission and also significantly reduce cost as there is no fuel used and has very little usage cost. Solar energy requires sunlight and sunlight is not available at all times hence the solar panels will have to be customized to accommodate to it and also provide the same amount of energy as petroleum to power these aircrafts. The aircraft will have to be modified to install solar panels; they will need to change the design to have more area to accommodate solar panels yet keeping it light and aerodynamic. In recent times the consumption of jet fuel has been increasing, we are consuming more than 5000 barrels of jet fuel per day worldwide (Index Mundi 2010). There are a number of factors that lead to this strong demand, For Example: Increase in passenger travel, increased use of airplanes in the military, helping transport patients between hospitals, delivers supplies, surveillance purposes, etc. The main reason is that there are more aircrafts taking off than ever before and there is no sign of it decreasing.

Aircrafts do serve a very big purpose in today's world, but this also means heavy environmental impacts. Flights worldwide have released 705 million tons of Carbon dioxide emissions in the year 2013, while carrying over 3 billion people worldwide (Air Transport Action Group 2014). Carbon dioxide emissions from air travel are predicted to increase significantly by 2050 therefore impacting climate change (Davidson et al. 2014). We currently rely heavily on aircrafts and will be relying on them for time to come. Due to this we are exhausting our jet fuel sources (Gregory 2014). Chowdhury et al., (2018), and Ahmed et al., (2017) stated that this in turn increases price of jet fuel, making flying more expensive. Nowadays aircrafts are more fuel efficient than ever before and some studies show that travelling by air is more fuel efficient that travelling via vehicles (McCartney 2010). But what will happen when we run out of jet fuel. We are going to run out of jet fuel some day and when the jet fuel reserves eventually run out, the world will be facing a very big setback.

Solar-Power a possible alternative source

Solar power is the result of converting the power of the sun to usable power through solar panels. This energy is clean and environmental friendly. Power from the sun is not a depleting source, it could be relied upon for the future and this could be harnessed as much as required (Tay et al., (2017)). On average in Kuching, Sarawak Malaysia we can receive over 120 kwh/m^2 per month using a 1kw photovoltaic system on 0^o inclination according to the Photovoltaic Geographical Information System provided by the European commission (European Commission 2015). This is free energy that could be harnessed.

Solar-Powered Aircrafts

Sunrise Project

Solar powered planes have been tried and tested for a long time and they are still breaking new ground today. The first project was the Sunrise I project which started in 1974. This plane was unmanned had a wingspan of 9.8m and a total weight of 12.3 kilograms (Boucher 1985). This was the first ever solar powered plane. They saw room for improvement and went on to make Sunrise II making it lighter and more powerful. These planes were very small and they did not have required resources to carry on with development. Sunrise project I & II both failed during test runs, Sunrise II travelled a distance of 5.2 kilometers taking it a big step towards the future. This project was eventually terminated making this ambitious project an unfortunate failure (Boucher 1979).

Solar Impulse

Solar Impulse I with Swiss aircraft registration code HB-SIA was a project that began in 2004 (Diaz 2007). The project started in the idea of circumnavigating the earth solely on a solar powered aircraft. They built a one-man long-range, light weight plane that had a wingspan of 63.4m similar to that of a Boeing 747-400. HB-SIA weighs close to 1600 kilograms and has an average flight speed of 70km/h (Solar Impulse 2015). There were a total of 11.628 monocrystalline silicon solar cells used, 10748 in the wing and 880 on the horizontal stabilizer. These solar cells provided the engines a maximum power output of 10 horse power per engine. The cockpit was very limited, it was made for a single pilot and no passengers with an interface providing traditional flying data to help with navigation and control (Solar Impulse 2015). Pilots had to be specially trained to fly this aircraft. To make the flight light yet sturdy they used materials that were very thin and with low densities. Carbon fiber was the main material used for this flight. The power generated by the solar panels is stored in 400Kg lithium batteries with 200Wh/kg capacities.

In July 2010, HB SIA flew day and night making it the first flight to ever complete this without using any fuel. It flew for 26 hours a total distance of 1116km at a maximum altitude of 39,000 feet (Solar Impulse 2015). Solar Impulse II took off where HB SIA left off; they saw room for improvement and have made tremendous leaps towards the future of air travel. The new design had a wing span of 72 meter wingspan and weighed 2300 kilograms (Solar Impulse (2015), Kashem et al., (2018), Touti et al., (2020) and Ahmed et al., (2019)). It had a bigger non-pressurized cockpit and more advanced avionics such as auto pilot to help pilots fly easier. They strapped 17,248 photovoltaic cells onto this aircraft to supply power to the motors. The electric motors received a total of 69.6 horse power and they can travel a maximum speed of 140km/h powered by the solar cells (Solar Impulse 2015). This speeds and horse power cannot be compared with current airliners because HB SIA does not weigh as much and have designed the plane to use maximize aerodynamics. The reason behind creating such a huge wing span was to create maximum amount of lift to help during take-off (Sheikh et al., (2017), and Kashem et al., (2018)). The designer engineers figured out a way to keep the weight to the minimum yet keep it strength. They used carbon fiber for the wing and used a carefully engineered frame structure which maximized strength and kept the weight to a minimum. To keep the weight to a minimum the team used far more advanced technology that current airliners used to create such long but thin sheets of carbon fiber. The Solar cells powered the plane during the day and the remaining energy harnessed by solar panels is stored in the 633 kilogram lithium batteries to power the flight during the night (Zhu et al. 2014).

SoLong

The SoLong solar plane is a remote controlled plane developed by AC Propulsion. With a wingspan of 15.6 ft and weighing only 28.2 lb, SoLong was made to fly continuously without ever landing to recharge. This plane features an autopilot control system with GPS, barometric, and inertial references. In addition, the plane also includes a video camera giving pilots on the ground a view from above (Zhu et al. 2014, Dornheim & Michael 2009). What makes SoLong unique is its use of laptop derived lithium-ion batteries. Originally AC Propulsion outfitted SoLong with 100 LG Chem 18650 lithium-ion laptop cells to power its 1hp electric motor. These cells proved to be too small to store enough energy to power the craft throughout the entire night. They then fitted the plane with 120 Sanyo 18650 lithium-ion batteries. With the new Sanyo batteries SoLong managed to fly for over 48 hours nonstop in 2005, proving that it could store enough energy during the daylight hours to power the aircraft during the night. The Sanyo batteries held 214 watt-hr/kg (Safe et al., (2014), and Shaila et al., (2018)). This amount of power allowed the SoLong plane to capture enough of the suns energy during the day to enable it to fly at night. One of the reasons the flight could not be carried for more than 48 hours was due to pilot exhaustion. Flying the plane via remote control for more than 48 hours is tiresome effort (Dornheim & Michael 2009).

With solar panel efficiency and battery energy density always advancing, planes similar to SoLong could easily travel for days, without having to constantly glide the plane during the daylight hours. It would also be great as a surveillance tool where conventional planes cannot be used due to restrictions such as size and maneuverability.

Solar Panels Performance

Today, some photovoltaic solar cells have reached efficiencies of over 40% in lab conditions, and off-the-shelf solar panels from companies like Sunpower are reaching efficiencies of over 23% (SunPower 2008). Additionally new types of thin-film solar cells are being developed that would make the process of covering a plane in solar cells much easier, although efficiencies have lagged behind more traditional types of solar cells. Khandakar et al., (2019), Kashem et al., (2017) and Kho et al., (2017) stated that the loss in efficiency could be offset by the reduction in weight, and the fact that it should be possible to cover more of a planes surface with thin-film cells than would be possible with ordinary solar cells. With that said, new thin-film solar cells are beginning to achieve efficiencies close to that of their wafer based counterparts. Researchers at the U.S. Department of Energy’s National Renewable Energy Laboratory recently achieved efficiencies of 19.9% with copper indium gallium diselenide thin-film solar cells (U.S. Department of Energy’s National Renewable Energy Laboratory 2009).

With regards to solar powered aircrafts, I think thin-film solar cells hold much promise due to the ease with which they can be shaped to wings, flaps, and the body of the plane . Additionally thin-film solar cells have the potential to use less than 1% of the raw materials required to manufacture traditional wafer based solar cells (Green (2006), Chowdhury et al., (2019), Hong et al., (2018) and Kashem et al., (2016)). This reduction in raw material use should lead thin-film solar cells to be much less costly to produce than wafer based cells. There have also been developments in applying thin-film cells directly on many kinds of materials, negating the need for a separate substrate entirely (Terrazzoni et al., 2006).

Discussion

Engineers today are always looking to be pro-environmental and provide sustainable and renewable solutions to our daily life. From the Solar Powered aircrafts built so far we can see that few areas have been given utmost priority. According to Siddique et al., (2017) and Mubarak et al., (2016), Engineers in all these projects focused on keeping the weight of the aircraft as minimum as possible, provide the most efficient solar panels and saving the energy harnessed by the solar panels in batteries that are light in weight, yet are able to store the most energy. It is not feasible to get the best panels or the best batteries currently available in the market as they are too costly. Looking for alternative sources of power cannot mean exuberant prices. The other areas that need consideration are location of where the panels should be placed and energy management (Farivar et al. 2013, Xian-Zhong et al. 2013).

Chowdhury et al., (2019), Tabassum et al., (2016) and Shabrin et al., (2017) stated that Flights such as HB-SIA have shown that solar powered flights can travel more than 24 hours but they do not travel very fast, they cannot fly with heavy load nor do they travel at very high altitudes. Travelling for more than 24 hours is a tiresome task. Currently HB-SIA is circumnavigating the earth showing the world that this idea is becoming a reality (Fileds (2014), Kashem et al., (2020), and Nabipour-Afrouzi et al., (2018)). Pilots are heavily trained for these types of travel and aircrafts. Implementing a whole new system of flying would not be feasible due to extensive rebuilding of the whole piloting techniques. Therefore incorporating solar power into current airliners and providing some energy during cruising altitudes could be an option since aircrafts use less amount of power during this time compared to take off.

The wing has been the ideal location for solar panels in all the aircrafts. The wings of the aircraft play a huge role in controlling it. Therefore any changes that are to be made cannot affect its current purpose. Once the panels are placed in the wing, high efficient batteries are required to store the harnessed power. This energy should be incorporated into the flights current Engine Control System which would manage its power and provide power when needed.

Flights today use a lot of energy because of the weight it has to carry and the speed it travels. As discussed above HB-SIA Solar Impulse takes off at 70km/h and weighs similar to a family car therefore it does not require much power. It can afford to solely run on solar energy. With today’s technology we cannot do that on a jumbo jet. But we could apply a few panels so it could reduce fuel consumption by some percentage. By doing this we can make flights more fuel efficient and therefore move towards a sustainable future with the help of renewable technology. The figure below shows how aircrafts have been gradually becoming more fuel efficient but have not been making huge strides since 1980 (Low-Tech Magazine 2010).

Conclusion

In this paper, the various types of solar aircrafts available have been discussed. Solar powered aircrafts might not completely take over fuel powered aircrafts today as they cannot meet the demands of current airliners. This does not mean that they cannot be of use. Solar powered planes similar to that of SoLong could be used for surveillance purposes where conventional aircrafts cannot be used. Since current airliners are capable of carrying heavy loads as a step towards renewable energy some airliners could carry on some solar panels to help increase fuel efficiency and reduce pollution. Solar Impulse II is breaking new ground by flying around the world which gives hope that we are getting closer to the cleaner-renewable future that we need.

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