Centre for Air Power Studies (CAPS)
Forum for National Security Studies (FNSS)
54/16

AIRBORNE RENEWABLES: ARE WE READY FOR THE NEXT REVOLUTION?

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The Solar Powered Plane

On April 23, 2016 the zero–fuel solar plane with Pilot Bertrand Piccard at its controls crossed Pacific Ocean from Hawaii to Moffett airfield in Mountain View, Silicon Valley, South of San Francisco following a 62 Hour, non-stop flight.[1] The round-the-world flight by the aircraft named Solar Impulse 2 commenced in Abu Dhabi on March 9, 2015. This pioneering effort motivated by the urge to be the first in the world is also testing the limits of human endeavour while pushing the limits of energy storage systems fit enough to be used in airborne systems. The aircraft piloted by Bertrand Piccard, a psychiatrist specialising in hypnotherapy and André Borschberg, an aviator, have been exposed to thermal and barometric stresses due to non availability of air conditioning or pressurisation system owing to efforts to efficiently manage energy. These include flying as high as 8,500 meters during day to maximise exposure to sun in order to charge the batteries and utilising this potential energy by night to descend to 1500 metres.

At the heart of this zero-fuel solar plane and mounted below the wings are four brushless, sensorless motors, each generating 17.4 hp (Horse Power). Each of these is fitted with a two bladed, 4m diameter propeller along with a reduction gear limiting its rotation speed to525 rev/min. The entire system is 94% efficient, setting a record for energy efficiency and is powered by four 21 kWh lithium polymer batteries (Weight 633 kg). These batteries are charged by 17,248 mono crystalline silicon photovoltaic cells rated at 45 kW peak capacity placed on the wings, fuselage and the horizontal tail plane.[2] Thus for the first time ever the energy reserves in a flying airplane have been demonstrated to increase over a period of time. The maximum amount of 2409 kWh was produced in 117 Hours 52 Minute flight-time from Nagoya to Honolulu, a distance of 7212 Kms.

In this endeavour, hidden from plain sight is the technological revolution taking place on these airborne platforms ranging from advances in hi-tech energy efficient propulsion systems to energy-dense batteries. This pioneering flight to circumvent the globe has a stated goal of demonstrating the faith which needs to be placed in adopting renewable or clean technologies on ground to reduce energy consumption while generating profits and jobs.[3] This is displayed by the entire array of companies as diverse as Nestle and Dassault, which have been associated with the project. The professional marketing of these "path breaking" technologies coupled with this effort is also an attempt to fund and monetize the endeavour.

The Energy Crisis

India wanting to offload the dependence on oil, 80% of which is imported, released a long term strategic plan in 2011 which looks at the role of renewable energy as a key part of solution to nation's energy needs.[4] Accordingly, for the market development and financing of renewable energy projects, a separate financing institution called the Indian Renewable Energy Development Agency (IREDA) was set up as a public sector undertaking under Ministry of New and Renewable Energy (MNRE), Government of India (GoI). Extensive work to harness solar, wind, biomass and small hydro-power was carried out and stakeholders were identified which included various technical institutions for Research & Development (R&D). Two of these namely the Hydrogen fuel cell and the Solar Charged Lithium ion battery cell are of relevance in aerospace sector.

The Hydrogen Fuel Cell

Work on Air Independent Propulsion (AIP) by the Defence Research and Development Organisation (DRDO) [5] based on harnessing Hydrogen fuel cell is in progress. This form of Energy production by combining Hydrogen and oxygen has water as a by-product and is presently being utilised on manned space flights also. [6] However the major limitation of this technology is in its dependence on availability of Hydrogen, which as of now is quite difficult and costly to produce.

Another such project under aegis of MNRE, sanctioned in 2009, is 'Development and demonstration of diesel-hydrogen dual fuel SUV'.[7] This MNRE and Mahindra & Mahindra joint development project has resulted in development of Hydrogen-Diesel hybrid technology. The development of engine hardware, electronic controls and software on existing common rail direct injection diesel engine is likely to enter commercialisation in near future. This pioneering technology can be adopted for use on airborne systems provided the weight concerns are addressed.

Presently, research work in both these technologies remains oriented towards ground

based civilian applications only, with one exception of solar power being used to provide critical power onboard various space missions, including the Mangalyan launched by Indian Space Research Organisation (ISRO).[8]

Harnessing Solar Energy

It is easy to visualise the Sun to be the sustainer of all life. Harnessing this energy source is one of the cleanest method of meeting energy demands and this has been achieved through the photovoltaic solar cells charging an electrolyte in a Cathode-Anode configuration which provides a battery for storing and utilising the energy. Airborne systems as in Solar-Impulse 2, drones and electric planes use lightweight customised polymer battery packs (soft-packs) of Lithium-ion type as they provide maximum amount of energy density and high power output. However, once again it is the Ministry of Road Transport & Highways, which has directed this technology to be adopted by ISRO and Automotive Regulatory Authority of India (ARAI) for use on battery operated buses.[9]

Hence, there exists a hitherto huge unexploited opportunity for channelising these developments along with pioneering work being undertaken in the field of Nano-technology by DIAT-DRDO (Defence Institute of Advanced Technology-DRDO)[10] in developing a roadmap for utilising these renewable technologies for airborne applications.

Airborne Renewable Technology - A Roadmap

For utilising these technologies in future, even with a time frame of 20 years, the work needs to commence now. A stepped approach is needed towards developing an aerial platform such as an unmanned aerial System (UAS) for reconnaissance and surveillance purposes with extended on-station time using these renewable energy sources along with associated hardware, which utilise the renewable technology with additional spin offs resulting in reducing the country's fuel bill. The good news is, necessary work is already being undertaken across myriad institutions, spread across various ministries in GoI which is primarily oriented towards ground based systems.

Hence to plan, evolve, task, co-ordinate, and evaluate the inevitable adoption of renewable energy sources for military applications including airborne equipment, establishment of central monitoring agency is necessitated and recommended under Ministry of Defence. This would channelise and funnel these developments for their adoption in armed forces, with an ultimate aim of having energy efficient and as its use expands, a cost effective airborne platform for a variety of purposes ranging from reconnaissance and surveillance, with evident spinoffs in terms of indigenous capability development.

(Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily

reflect the position of the Centre for Air Power Studies [CAPS])

Notes

[1] The Indian Express, "Pacific Crossed, adventure continues- The Associated Press", April 25, 2016 p.11

[2] Batterybro.com, "Batteries for Electric Airplanes: Solar Impulse –II" https://batterybro.com/blogs/18650wholesalebatteryreviews/

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[3] www.solarimpulse.com, http://www.solarimpulse.com/adventure/technical-challenge-1 accessed May 03, 2016

[4] Ministry of New and Renewable Energy, GoI, "Strategic Plan for New & Renewable Energy Sector fro the Period 2011-17", February 2011 Section I para 1.2.1

[5] The Hindu Business Line, "DRDO to Develop Technology to Help Submarines remain underwater for Long", http://www.thehindubusinessline.com/economy/logistics/drdo-to-develop-technology-to-help-submarines-remain-under-water-for-long/article7869951.ece accessed May 05,2016

[6] www.nasa.gov, "Closing the Loop: Recycling Water and Air in Space", https://www.nasa.gov/pdf/146558main_RecyclingEDA(final)%204_10_06.pdf accessed May 09,2016

[7] Ministry of New & Renewable Energy GoI, " A Compendium of Research Development & Demonstration Projects for the Conclave on R&D in new and Renewable Energy on August 05,2014 at Vigyan Bhavan,New Delhi,projects Project No.-16 p.252

[8] www.isro.gov.in, "Mars Orbiter Mission Spacecraft", http://www.isro.gov.in/Spacecraft/mars-orbiter-mission-spacecraft accessed May 06,2016

[9] www.idrw.Org, "ISRO-ARAI's lithium-ion battery technology to be ready in 2017" http://idrw.org/isro-arais-lithium-ion-battery-technology-to-be-ready-in-2017/ accessed May 05,2016

[10] www.diat.ac.in, "DIAT-DRDO Programme on Nanomaterials Sanctioned by ER-IPER, DRDO on April 13,2012", http://diat.ac.in/DIAT-DRDO_Nanoprogramme_-_for_website.pdf accessed May 06, 2016