THE USE OF ELECTRIC ENGINES AS POWER UNITS OF AIRCRAFT

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Summary. The aim of this work is to evaluate issues of current and possible future uses of electric propulsion for aircraft. Consequently also highlighted the use of alternative sources to power these engines, such as hybrid engines, photovoltaic, fuel cells and batteries.

Keywords: electric engines in aviation, hybrid propulsion, photovoltaic, fuel cells, batteries

1. INTRODUCTION

With the rising price of fuel is the tendency to look for other sources that did not use fuel from mineral oil, but cleaner energy. In recent years, it shows that a solution could be in engines powered on electrical energy. Large number of companies has started with the development of electric propulsion for aircraft. In fact today, this development is limited and applied mainly for small motorized gliders and ultralights. The key to bridging the gap between aircraft powered by piston or jet engine and electric engine is in a large extent dependent on progress in battery technology. Improvement of the specific energy, density, performance and durability should be made before the electric powered planes can be compared to the performance, life and reliability of piston and jet engines.

2. ELECTRIC ENGINES IN AVIATION

As well as in conventional electric engines and aircraft electric engines it uses electromagnetic force to generate motion. Magnetic forces (attraction and repulsion) cause the electromagnet inside the electric engine rotates. A contact electric engine performs this function by creating the opposite charge that attracts and repels as rotor changes polarity. A contactless electric engine instead relies on a controller that performs the same function.

In these engines it produces a magnetic field as well as on the rotor and the stator with. These two fields leads to power that instantly produces a torque on the engine shaft. These fields should be generated when a change in rotation of the engine, otherwise ceased immediately after. This is done by switching on and off the poles at the right time, or varies power pole.

Control of the propulsion unit is very intuitive with only one driver moving forward and back. This eliminates the need for adjustment and monitoring of the richness of the mixture as the temperature of internal combustion engines. The optimal engine operation, battery status and the entire drive system ensures control unit (main control unit). All necessary information is displayed on the digital display located on the dashboard. [1]

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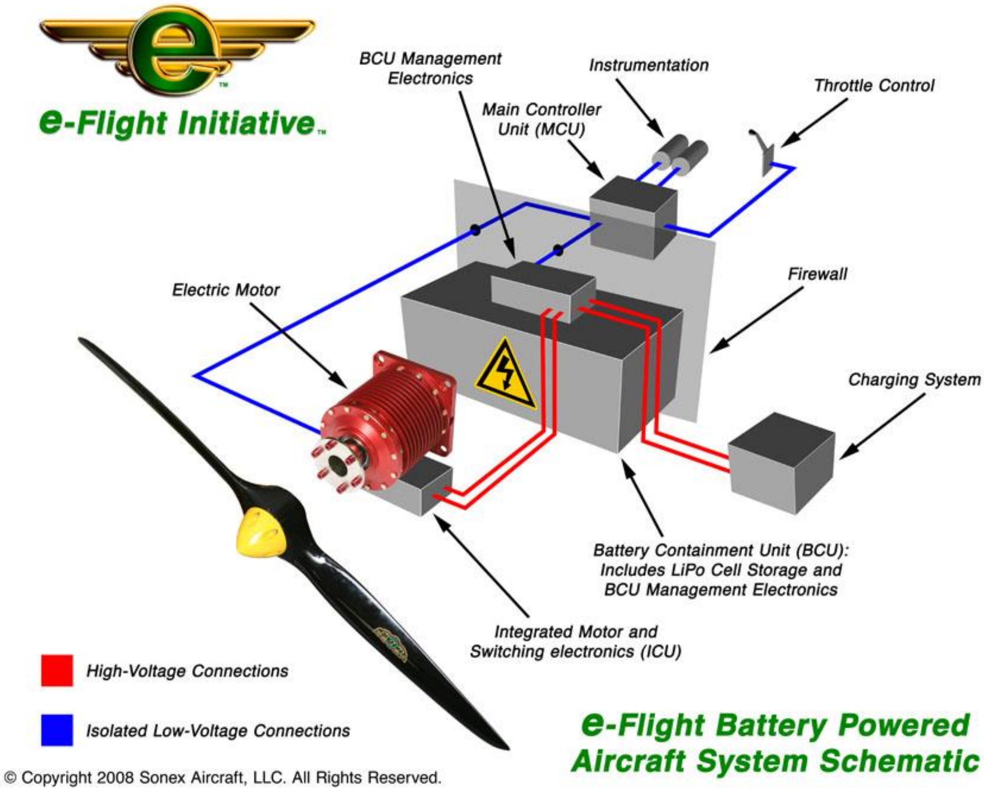

Figure 1 General wiring diagram of the electric motor [1]

Table 1 Overview of electric engines used in aviation

Engine	Power (kW)
AeroConversions E-Flight	37
Yuneec Power Drive 40	40
Yuneec Powe Drive 60	60
Sicme motori VA2-Sky	65
Rotex Electric BB 90-5	75
Emrax 207	80
Emrax 228	100
Emrax 268	160
Siemens Unveils	260

2.1. AeroConversions

This engine is the most powerful, lightest-weight, and efficient unit of this type ever produced. It is a 3 phase, 270 V, 200 A motor that will be over 90 percent efficient. It uses elegantly designed CNC machined anodized aluminum and nickel-plated steel parts in combination with “off the shelf” bearings, races, snap rings, magnets, etc. [2]

The prototype AeroConversions motor is slightly larger than a 35 ounce coffee can and weighs approximately 50 pounds. The motor is a modular, scalable unit. The motor core’s design has modular sections that can be reduced to a lower-output, smaller motor (shortened in length), or added upon to make a larger motor with a higher power output. [2]

Figure 2 Electrical engine AeroConverions E-Flight [2]

Engine application:

- Sonex aircraft

Figure 3 Aircraft Sonex [2]

2.2. Emrax

This drive is a Slovenian product of a completely new type of pancake axial flux synchronous electric motor, which will keep its capability for a long time if treated the right way. It can also work as a generator with the same technical data. Firstly the drive was developed for airplane. Therefore our target was to build reliable, low weight, high power direct drive electric motor with high efficiency. The drive was developed and tested by Roman Sušnik, dipl. ing. (Company Enstroj) on electric glider airplane Apis EA2, it was also laboratory tested in Piktronik (January 2011), Siemens (May 2012) and Letrika (November 2014) company. Furthermore our customers give us some test results which are comparable with our tests. In February 2014 thermal tests were performed on EMRAX motors. Motor was exposed to -40°C to +160°C for 17 days (24h/day), this means 408 hours non-stop. EMRAX passed this examination with excellent results, without any damages. [3]

Figure 4 Electrical engines EMRAX [3]

EMRAX engine 268 can achieve power up to 200 kW (a few seconds) at a weight of only 20 kg. Recommended operating performance is of the order of 160 kW. Engine torque reaches a maximum value of 500 Nm.

Engine applications:

- Hybrid Rotax 912, 914
- Axter system
- Apis EA2
- Sora-e

Figure 5 Sora-e [4]

2.3. Siemens Unveils

The electric engine is 5 times more powerful than other electric engines so far. It was developed by the German company Siemens. Its weight is just over 50 kg with an output of 260 kW at 2500 min.$^{-1}$, where the propeller is attached directly to the engine. Siemens estimates that its use can be applied for aircraft up to two tons. This will render the drive serial aircraft for four and maybe even more passengers.

Figure 6 Electrical engine Siemens [5]

To develop the motor Siemens studied every component of previous motors and optimized each to their technological limits. New simulation techniques and lightweight construction, the company said, enabled the drive system to achieve a unique weight-to-performance ratio of 5 kilowatts per kilogram. Comparable motors used in industrial applications deliver less than 1 kW per kg, while drive systems used in electric cars offer about 2 kW per kg. [5]

3. POWER SOURCE SYSTEM

3.1. Battery

Batteries that power the electric air engines consist of thin lithium-polymer cells. These batteries are different compared to other more robust, increased energy supply and lower cost compared to previously used battery in aviation. One drawback with this type of battery is an increased risk of fire if one of the elements is damaged or improperly loaded.

Advantages [7]:

- High capacity at small scale
- No memory effect
- Low self-discharge (about 5% per month)
- Simple and seamless involvement of a larger number of cells in series
- Suitable for nominal voltage of 3.7 V
- Long life (up to 2000 cycles up to 3 years)
- Is it necessary to completely discharge charging
- An acceptable temperature range (-10 to 50 ° C)
- Quick charge (up to 4 times the capacity of the cell)
- High discharge current (peak up to 50 times the capacity of the cell)

Disadvantages [7]:

- The possibility of ignition or explosion (short circuit - necessary internal protection)

- Capacity decreases battery even when not in use
- When the voltage drops below 2.7 V battery may be irretrievably damaged
- The battery can be called. "Solidify" (even with low self-discharge, after a year and a half unused)
- Over time, the pressure in the accumulator

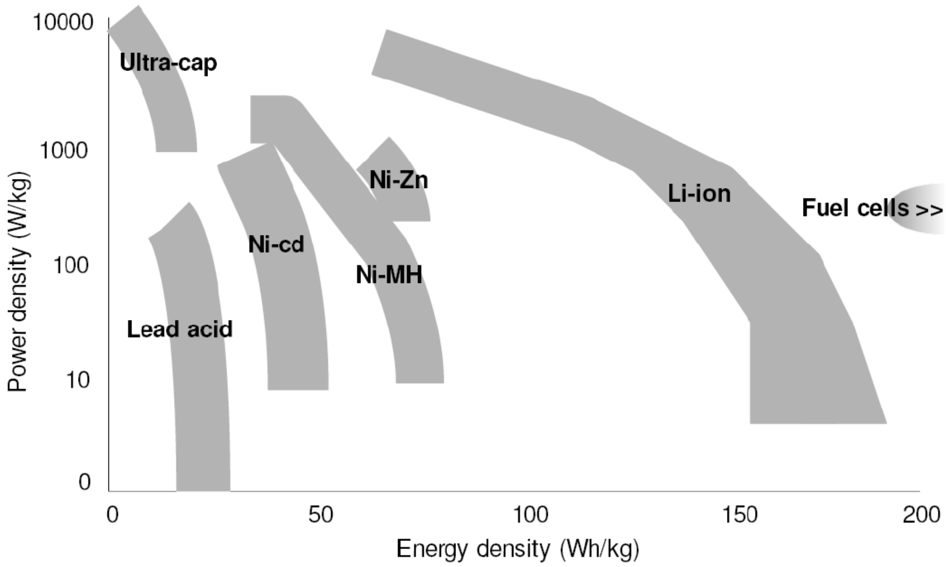

Figure 7 Energy storage technologies [6]

In aircraft is installed charging electronics unit, which enables charging directly from a standard outlet. Recharging is only possible through an external source of charging station which can shorten the charging time by up to 50 % while increasing the voltage to 400 V.

3.2. Photovoltaics

Photovoltaics (PV) is the name of a method of converting solar energy into direct current electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon commonly studied in physics, photochemistry and electrochemistry. A photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power. The process is both physical and chemical in nature, as the first step involves the photoelectric effect from which a second electrochemical process takes place involving crystallized atoms being ionized in a series, generating an electric current. Power generation from solar PV has long been seen as a clean sustainable energy technology which draws upon the planet's most plentiful and widely distributed renewable energy source – the sun. The direct conversion of sunlight to electricity occurs without any moving parts or environmental emissions during operation. It is well proven, as photovoltaic systems have now been used for fifty years in specialized applications, and grid-connected PV systems have been in use for over twenty years.[3] They were first mass-produced in the year 2000, when German environmentalists including Eurosolar succeeded in obtaining government support for the 100,000 roofs program. [10]

The efficiency of photovoltaic cells according to the type of substrate [9]:

- 4-8 % with amorphous silica
- 10 to 18.5 % with polycrystalline silicon
- 13-17 % with monocrystalline silicon for common deployment
- 34 % for high-quality monocrystalline cells for space purposes

Figure 8 Solar cells [8]

The application of photovoltaic cells:

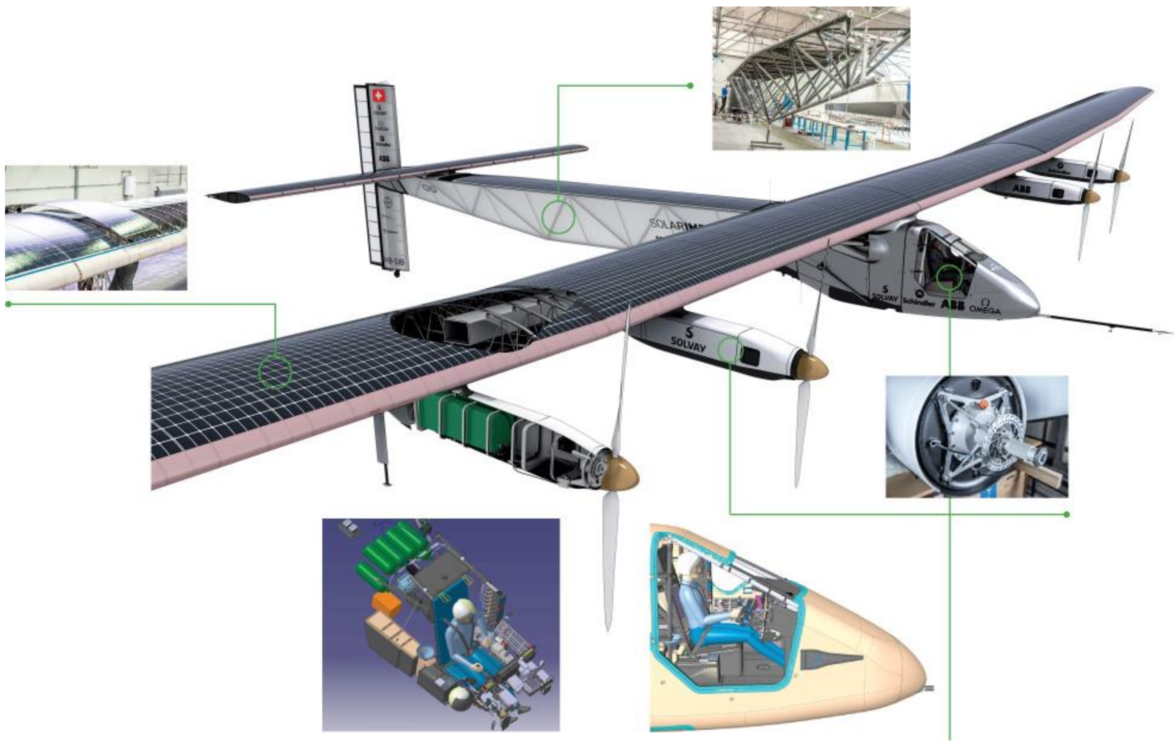

Figure 9 Solar Impulse 2 [11]

The Solar Impulse airplane landed in Switzerland this morning after a 26-hour flight that proved that a solar-powered airplane can fly in darkness. The propeller plane has nearly 12,000 solar cells on its 207-foot lightweight carbon-fiber wings. The cells stored enough energy between takeoff at 7 a.m. yesterday and nightfall last night to get pilot André Borschberg through the night at a maximum altitude of 28,000 feet.

3.3. Fuel cells

A fuel cell is a device that converts the chemical energy of a fuel (hydrogen, natural gas, methanol, etc.) and an oxidant (air or oxygen) into electricity. In principle, a fuel cell operates like a battery. Unlike a battery however, a fuel cell does not run down or require recharging. It will produce electricity and heat as long as fuel and an oxidizer are supplied. [12]

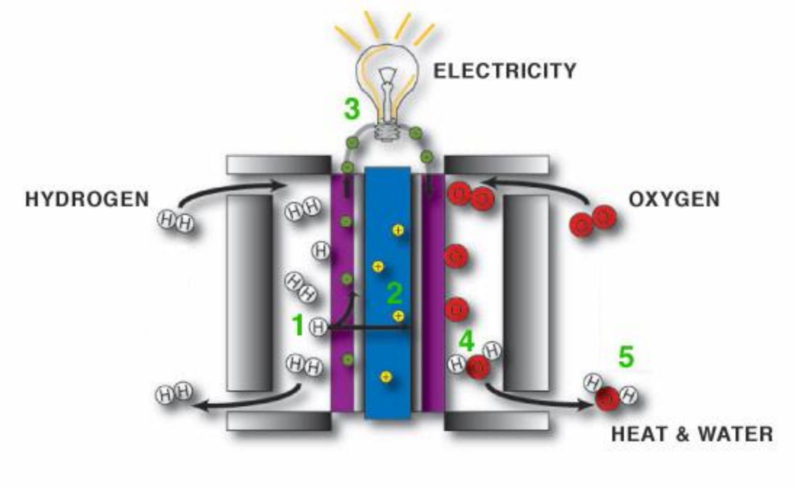

Figure 10 Fuel cell [12]

Fuel cell systems have an advantage over conventional CHP systems in that their heat to power ratios are lower. Engine-based systems (typically 1.5:1 heat to power) produce more heat than power, which can often lead to 'heat dumping' – a particular problem in buildings with low heat demand. Fuel cells have an even 1:1 heat to power ratio. [12]

The application of Fuel cell:

- SkySpark
- Dimona Katana DV20-100

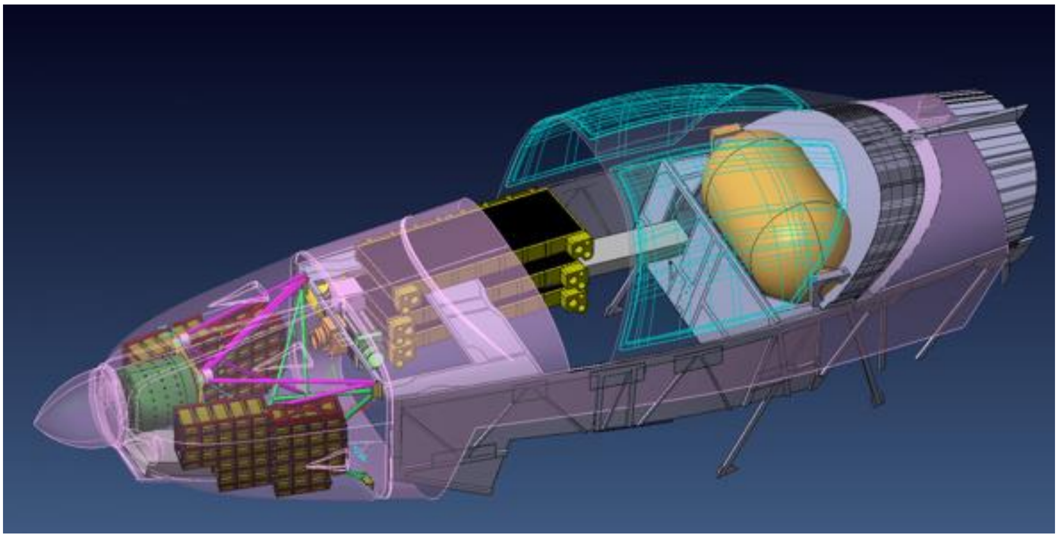

Figure 11 SkySpark CAD [13]

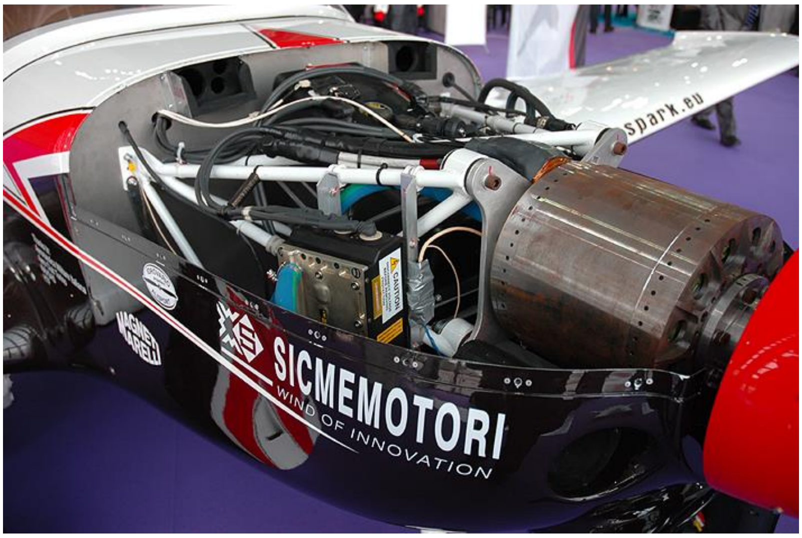

Figure 12 SkySpark [13]

4. COMPARISON OF ELECTRIC AND COMBUSTION ENGINES

The electric engine compared with the combustion engine advantages of simple construction, long service life, significantly higher efficiency allows energy recovery and moreover is light, small, quiet, cheap and does not need a starter or a large cooler. However, the electric engine has a major drawback and required electrical source. Currently, such a resource that would allow the same range and equally quick "refueling" of energy we have.

Table 2 Comparison of electric and combustion engines [14]

Combustion engine	Electric engine
The possibility of using different fuels	Electric battery
Fast refueling	Electric batteries require recharging time consuming
Great range	Small range
Saving fuel storage	Difficult and lengthy energy storage
The low effective force (max. 40%)	Effective force (despite 90%)
To start the necessary foreign machine (starter)	Self-running
Environmentally harmful	They are not harmful to the environment
No suitable course or size torque	The ideal torque curve

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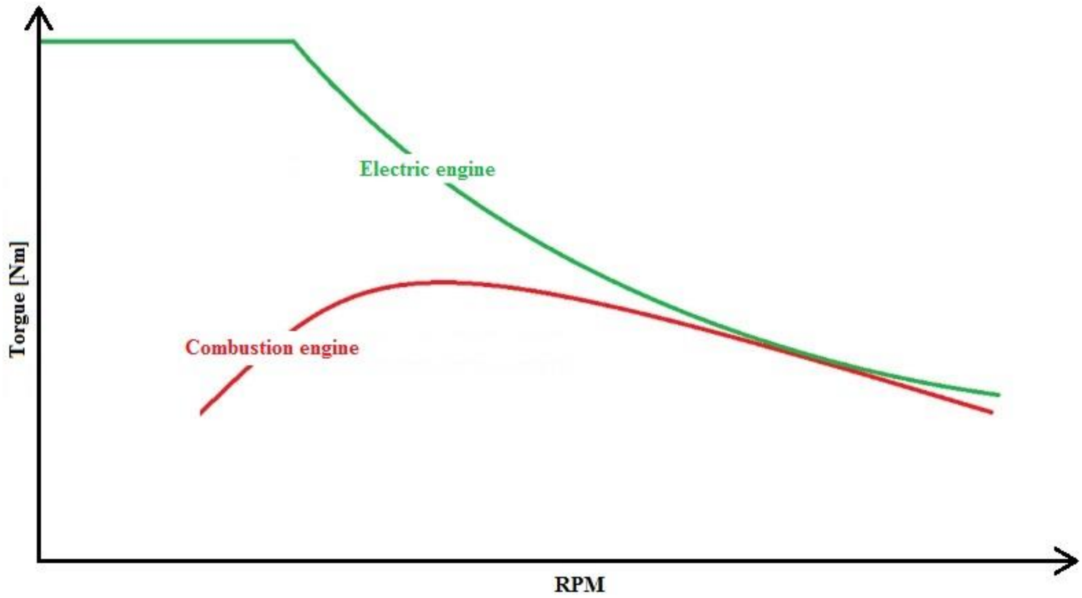

Figure 13 Comparison of maximal torque of the combustion and electric engine [14]

5. TRENDS

Future Vision by EADS (European Aeronautic Defence and Space Company) for commercial airlines, which should hit the market in 2050. In cooperation with Airbus created this ecological concept called eConcept. EConcept uses jet engine to generate electricity to provide power to six blowers. [15]

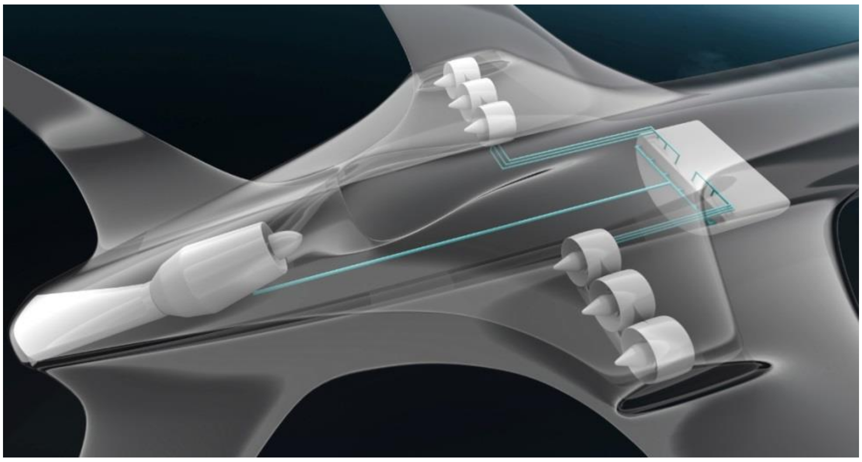

Figure 14 E-thrust system [16]

In 2012, Rolls-Royce invested £919 million on research and development, two thirds of which had the objective of further improving the environmental performance of its products, in particular reducing missions. [15]

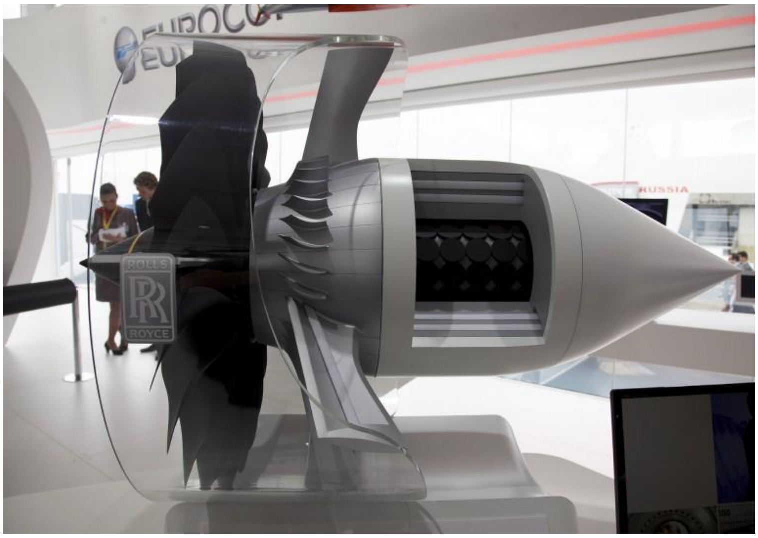

Figure 15 Engine Rolls Royce E-thrust [17]

Aircraft electric cars exist today only in the experimental form and still have a long way to its use in transport. A similar project is also working American Boeing in cooperation with the Agency NASA.

4. LITERATURE LIST

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