# Comparison of Sustainable Regional Aircraft Concepts

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The volume of government funded research on green aviation technologies has been continuously increasing over the years in an effort of finding means for bringing the global environmental impact of aviation down to the levels set by the Paris climate agreement. As a result, the main focus of the aviation research community has been shifting towards sustainable solutions of air transport with topics like electric propulsion systems and hydrogen powered aircraft. The internal German Aerospace Center (DLR) project EXACT (Exploration of Electric Aircraft Concepts and Technologies) is one such effort to improve the know how and capabilities on the topic of sustainable aviation. It also aims to provide an outline of the potential of different energy storage means and propulsion system technologies in terms of environmental impact. The resulting aircraft concepts are to be assessed using models for global environmental impact coupled with prediction models of the future air transport with a focus on the short-mid range and the regional market.

EXACT is currently in its mid phase, where a broad landscape of aircraft concepts has been analyzed at global-aircraft-fleet level. For the regional market, three types of solutions were modelled, an overview of which is shown in Fig. 1.


Fig. 1: Overview of the sustainable regional aircraft solutions modelled in EXACT.

All three aircraft have been modelled for the same top-level aircraft requirements (TLARs) and with consistent technology assumptions for entry into service (EIS) in 2040:

- D70-840-2040 – the baseline regional aircraft fueled by synthetic kerosene. The resulting model is around 30-40% more fuel efficient per passenger than a state-of-the-art turboprop of the same class (such as ATR72 or Q400), due to the assumed technology improvements in airframe mass, aerodynamically clean surfaces with fly-by-wire controls, and highly efficient EIS 2040 gas turbines.
- D70-LH2FC-2040 – a fuel-cell-driven aircraft with the fuel cells installed in ten pods distributed along the wing span, each driving an electric propeller. Each pod contains all the systems needed for the fuel cell and e-motor, including cooling. The pods are also assumed self-sufficient and independent of the other pods. The liquid hydrogen tanks providing the fuel for the fuel cells are integrated at the rear fuselage. The fuel cells are assumed to have a cruise efficiency of around 54% and a system-level specific power of about 1.5kW/kg.

- D70-PHEA-2040 – a plug-in hybrid-electric aircraft (PHEA) capable of all electric missions of up to ~300nm with the assumed 500Wh/kg battery cells. Similar to plug-in hybrid cars, a kerosene-powered gas turbine acts as a range extender providing the aircraft with the same payload-range capabilities as a conventional turboprop. The aircraft is propelled by ten distributed electric propellers installed across the wing span. The gas turbine, which is connected to a generator, is integrated in one of the inner-most nacelles, whereas a battery pack of the same mass in the symmetrical nacelle for mass-symmetry. The remainder of the batteries is divided between the other eight nacelles.

All three designs have been optimized in terms of fleet-level energy cost. A complete sizing loop (including propulsion integration effects) for the airframe mass, aerodynamics, engine sizing and low-speed and high-speed overall performance was used for the modelling. The modelling incorporates tools and capabilities from multiple DLR institutes participating in EXACT. The resulting aircraft models are provided for use by the project participants for the ongoing global environmental, life-cycle and cost studies, as well as for the disciplinary studies and tool development in the project.

The conference presentation will provide an overview and a breakdown of the aircraft design results, as well as the tools and capabilities used for the modelling and the assumptions used for the study.