PEM fuel cell and battery direct hybrid system in aviation

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The Institute for Engineering Thermodynamics has been working on battery and fuel cell direct hybrids for aircraft. This type of hybrid is more restricted in terms of load distribution in comparison to one using DC/DC converters. However it is more efficient, has fewer components and is therefore more cost effective. Due to the limited capabilities of load distribution the design process is more complex. All the components have to be carefully matched to each other. During this process many aspects related to the conditions under which the hybrid energy storage system has to operate have to be considered. Partial system failures, temperature changes, humidity changes etc. must be handled as they cannot be compensated for by simply adjusting the boost factor of a converter. Also recharging of the battery is quite difficult as several limitations have to be taken into account and the possibilities of adjusting the current into the battery are very limited. The only means to controlling charge current into the battery is by operating the fuel cells less efficiently. Furthermore the coulomb-efficiency of a battery causes a quite severe difference in the energy supplied to charge the battery from the fuel cell and that returned when discharging it. So the main question is how much battery recharging is required for safe operation of the airplane for example if the pilot has to touch-and-go or in case of failure of the fuel cell system. In some cases it may even be better to only use the battery for take-off and climb at the beginning of a flight.

The fuel cell system consists of several stacks that can be run entirely independent from one another. The system therefore has quite some redundancy built in. However as this system is coupled with the battery system most of the load, in case of single unit failure, is shifted to the battery system which then quickly discharges. Depending on the characteristics of the AC-inverter this could result in strong declination of the aircrafts range as well as strongly reduced maximum power. However there are possibilities to overcome this problem.

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