Low-Temperature Fuel Cell Systems for Commercial Airplane Auxiliary Power

SAND2010-6646P

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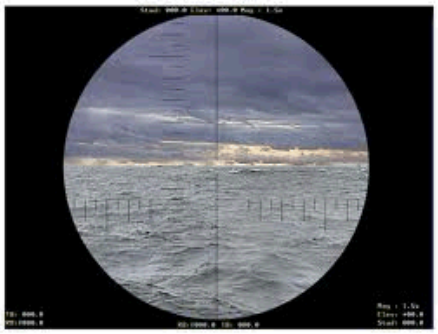
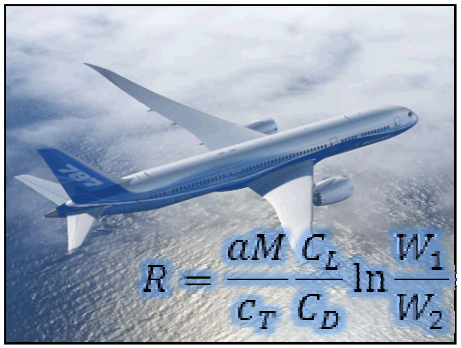
September 30, 2010

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

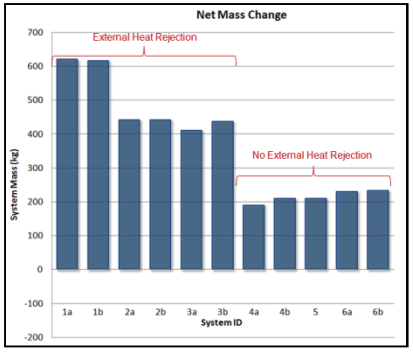
Here we briefly describes our ongoing study of fuel cell systems on-board a commercial airplane.



Scope



Method



Preliminary Findings

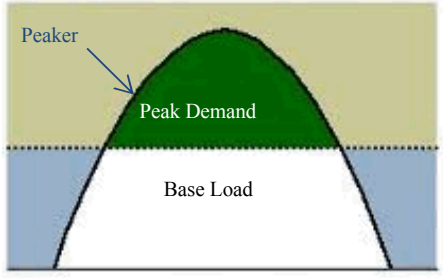
Sandia's current project is focused on PEM fuel cells applied to specific on-board electrical power needs.

Proton Exchange Membrane (PEM) Fuel Cell

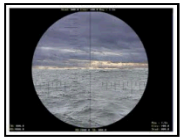
Galley

In-flight Entertainment (IFE)

Peaker Power



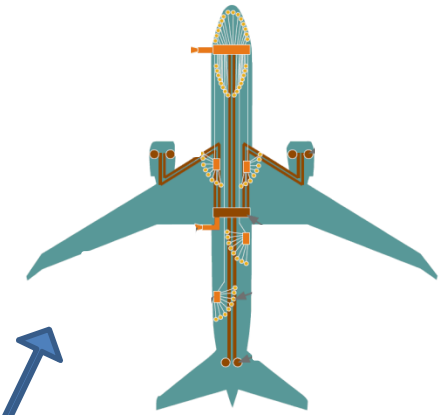
(Preliminary results are based on IFE study)



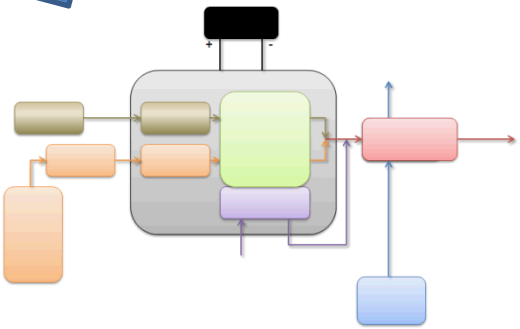
We want to understand how having a fuel cell on an airplane would affect overall performance.

Hardware Requirements and Sizing

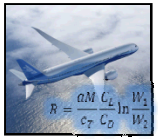
Electrical Architecture Design



Thermodynamic Systems Analysis

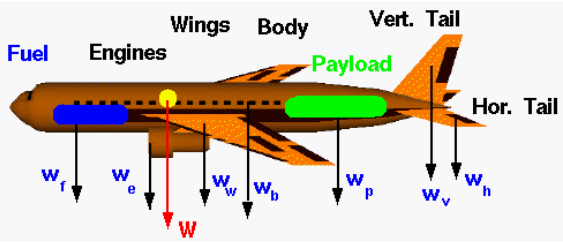


Airplane Performance



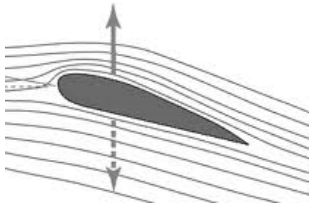
The fuel required to accomplish a mission is used to quantify the performance.

Empty Mass

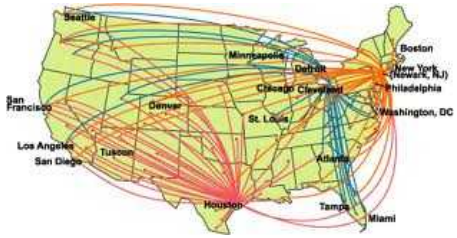


Drag

Lift



Range

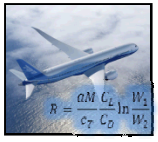


Velocity

TSFC*

Required Fuel

*TSFC: Thrust-Specific Fuel Consumption



Our analysis shows the differences between the base airplane and the airplane with the fuel cell.

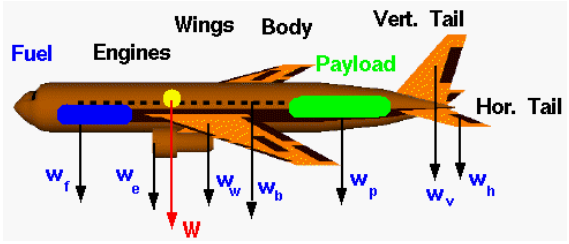
Base Airplane*

Compare

Airplane with fuel cell

Find

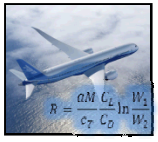
Change in Empty Mass



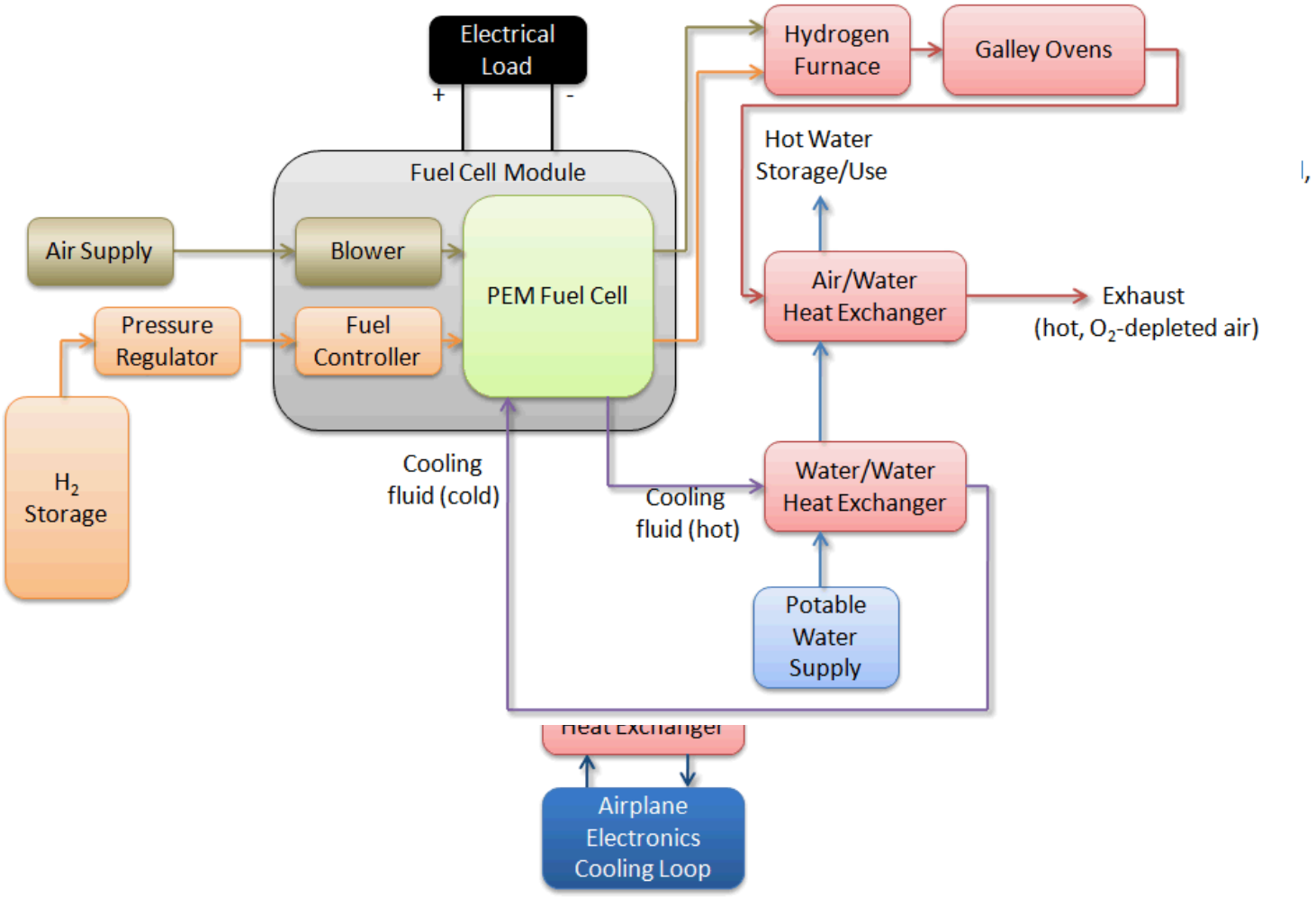
Change in Drag

Change in Required Fuel

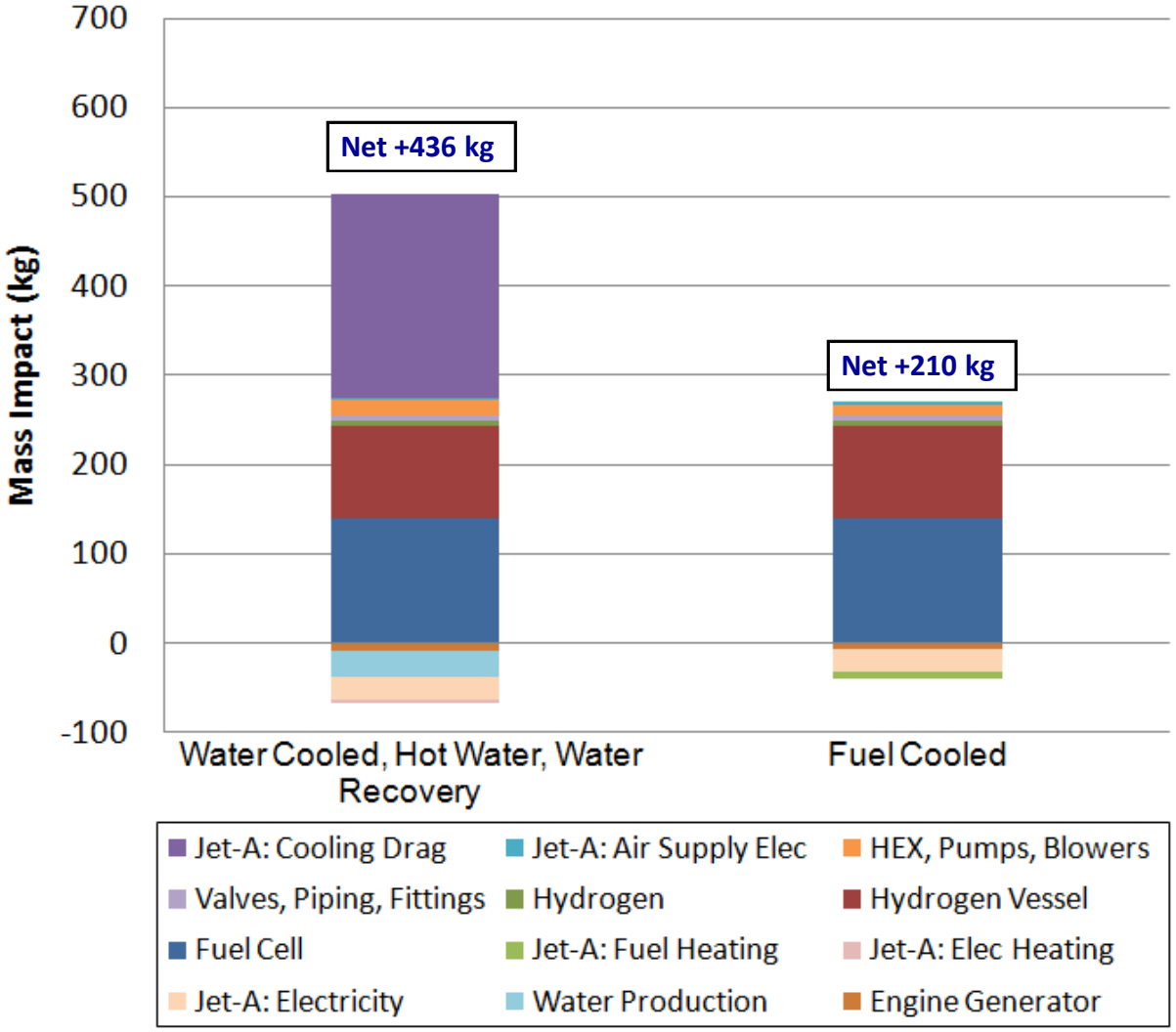
*Base Airplane and Mission: 787-8 derivative, 5 hr flight, 20 kW IFE load



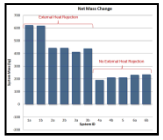
There are many ways of designing a system, depending on what you do with the waste heat.



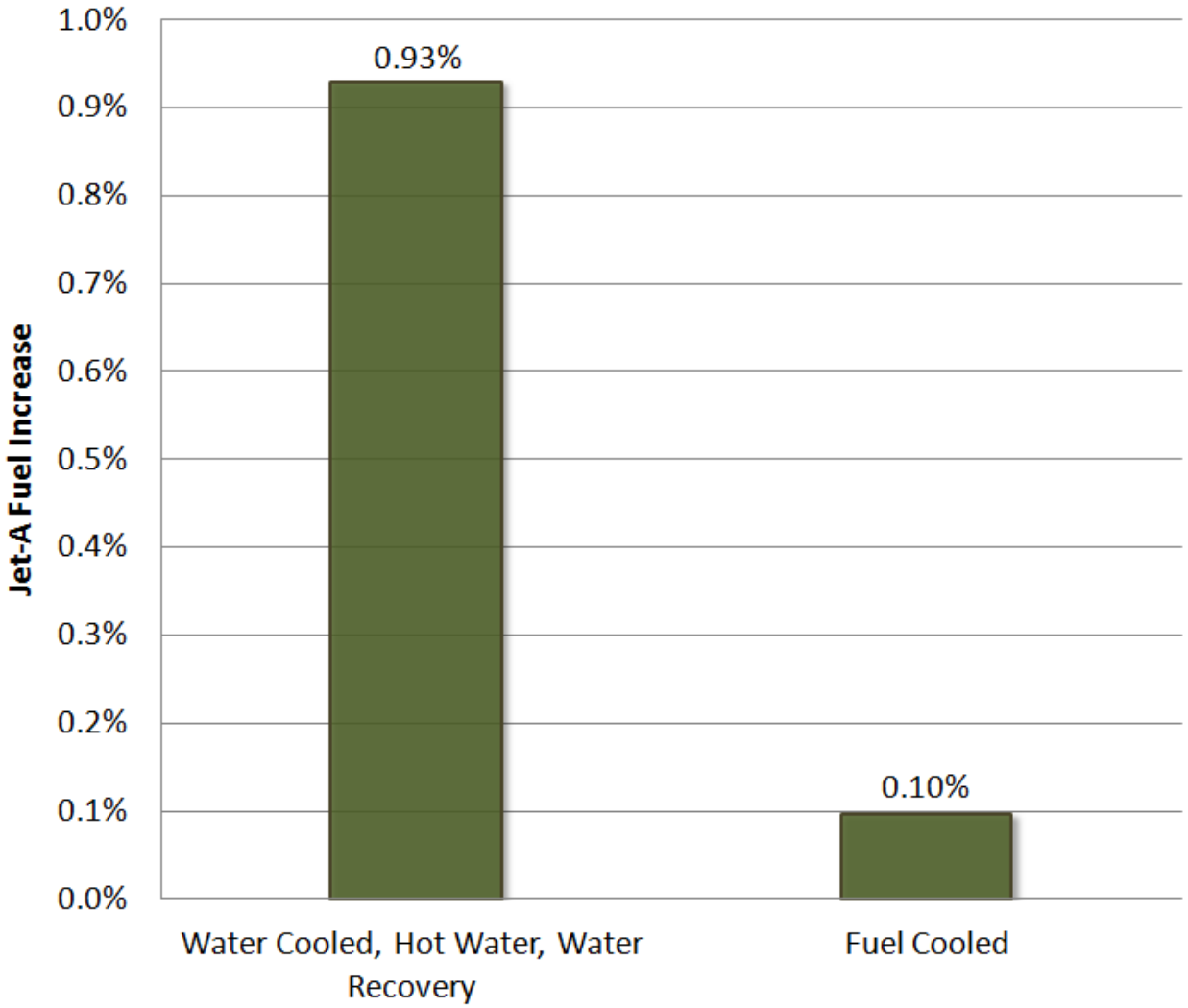
A system that requires outside air for FC cooling has a large mass penalty due to ram air cooling drag.



Data for: 5 hr flight, 20 kW (net) PEM for IFE, H_2 in 5,000 psi composite tanks

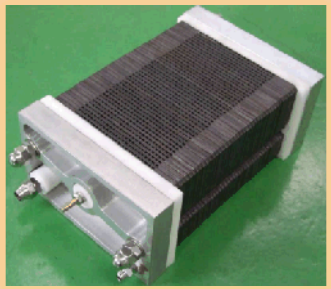


The bottom-line impact can be expressed as additional fuel required to complete the mission.



Early results suggest PEM fuel cells can be used on airplanes with manageable performance impact if heat is rejected properly.

Fuel cell generates heat



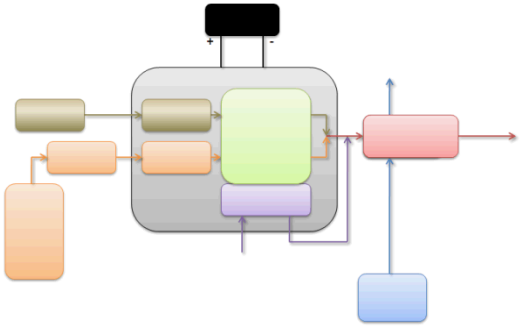
On-board uses cannot fully absorb waste heat

Cooling system has large drag penalty

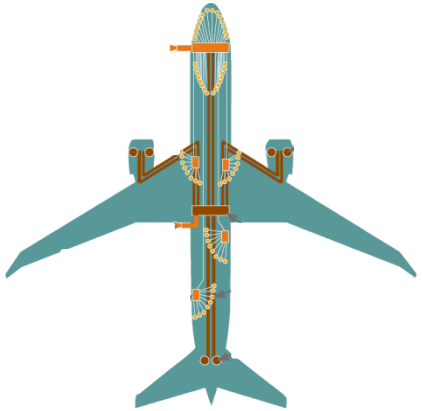
Reject through fuel system

For PEMs on aircraft, we are continuing to perform:

Thermodynamic analysis
(investigate configurations)



Integrated electrical design
(with dynamic modeling of the micro grid)



Hardware assessment
(performance, weight, and volume)

Galley and peaker application