Hydrogen Hybrid Power For Aviation Sustainable Systems (Hy2PASS)

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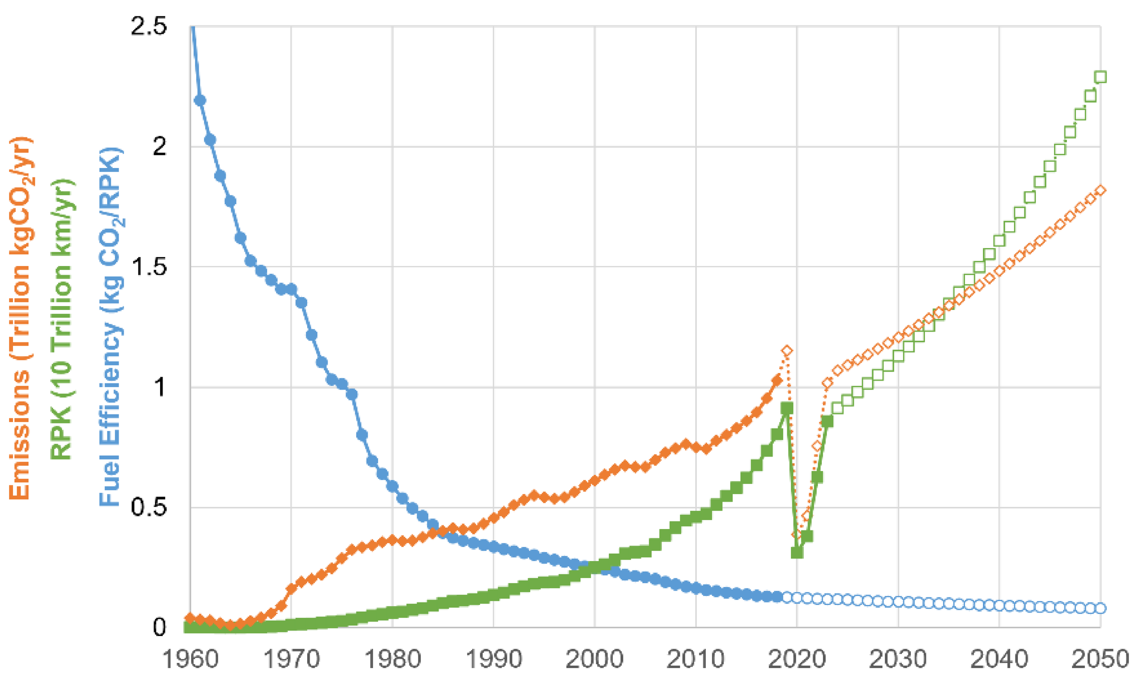
BACKGROUND

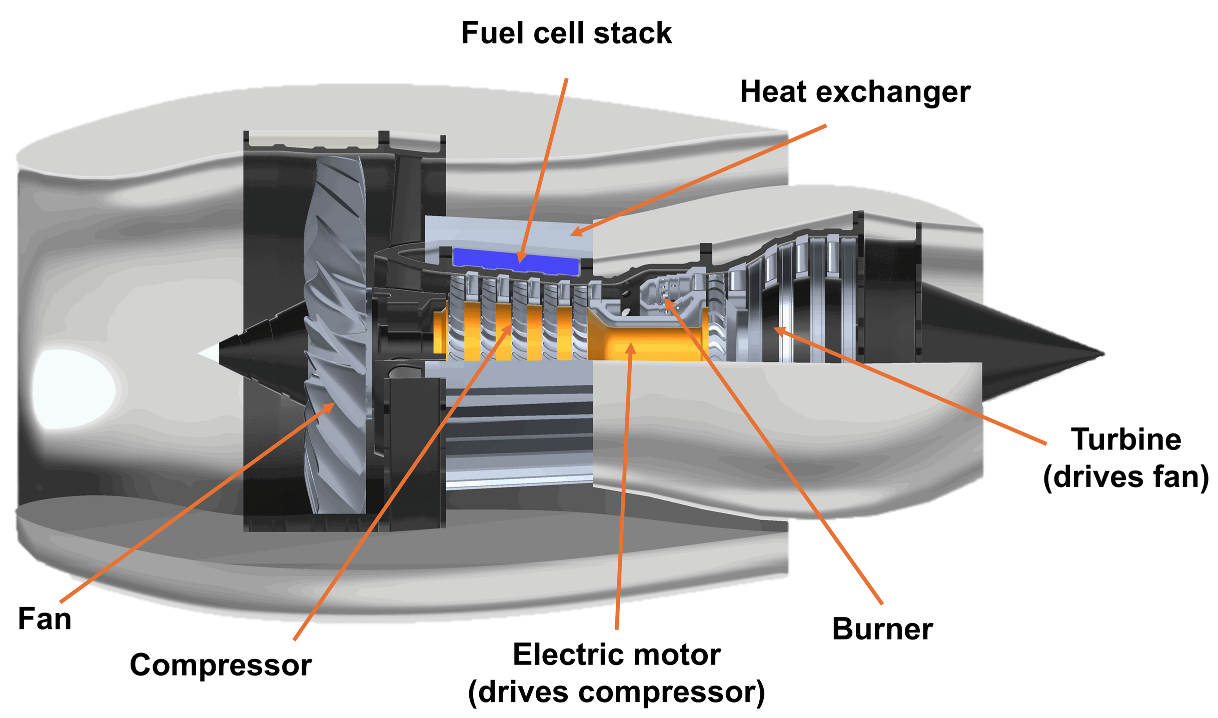
Owing to the extreme power and energy requirements of aircraft, aviation is recognized as the most challenging means of mass transportation to decarbonize. Historically, growth in air traffic has outpaced improvements in fuel efficiency, resulting in steady increases in global fuel consumption and emissions. Today, aviation is responsible for > 1 billion metric tons of CO_2 emissions per year.



Annual CO_2 emissions, air traffic (Revenue Passenger Kilometers), and fuel efficiency of global aviation, with future forecasts.

Hy2PASS CONCEPT

This program seeks to approach sustainable aviation challenges through development of Hydrogen Hybrid Power architectures for Aviation Sustainable Systems (Hy2PASS). This architecture utilizes a fuel cell to power an electrically driven compressor system, which is used to supercharge a combustor to improve specific work of the turbofan system.

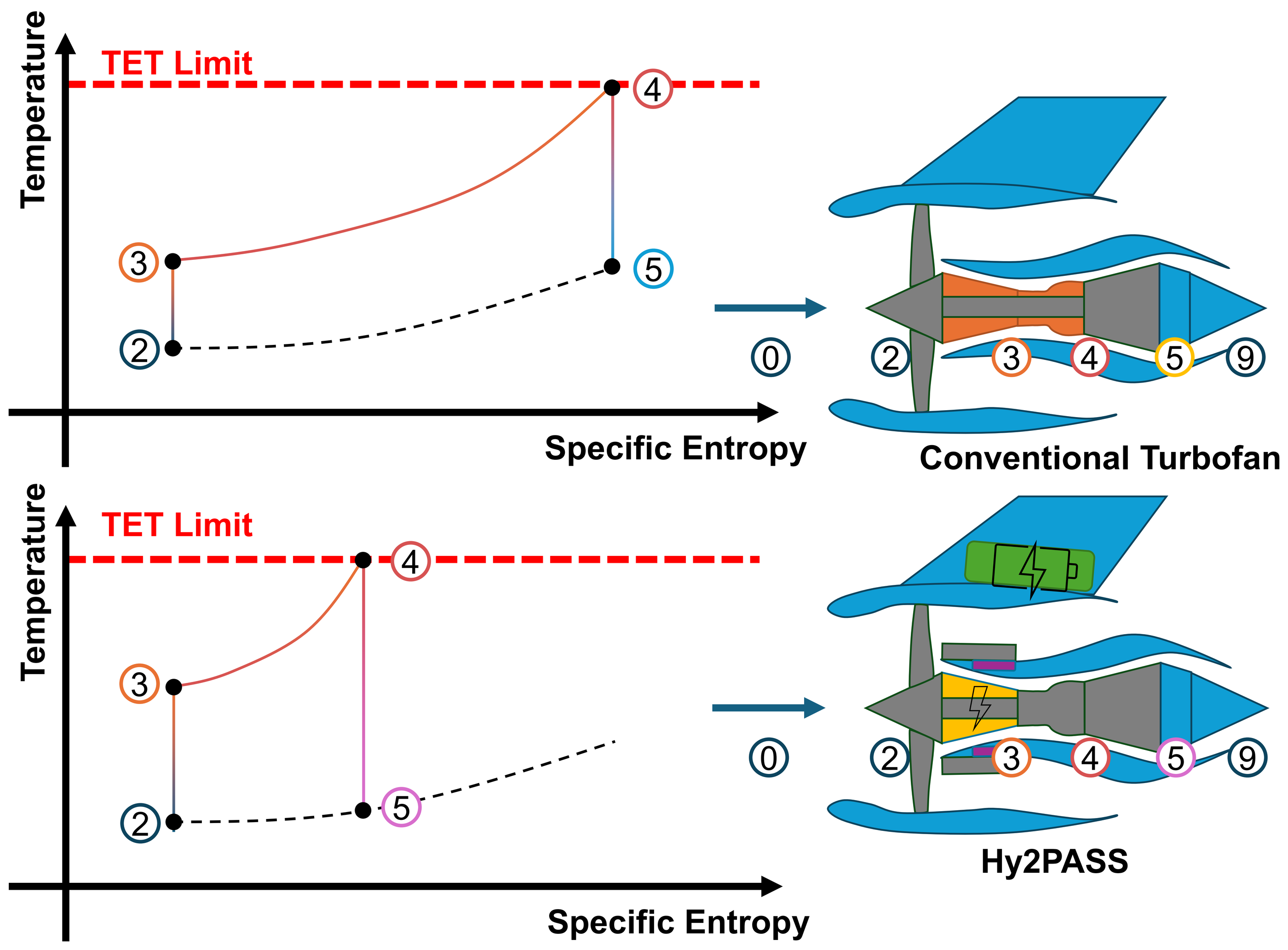


Hy2PASS fuel cell powered electric compressor system, integrated with supercharged turbofan.

The use of an electric motor allows the compressor to be operated at a mass flow and pressure ratio independent of the turbine and fan setting. Doing so provides new dimensions of adaptability of the engine cycle, increasing efficiency and improving thrust output at high altitudes.

INNOVATION

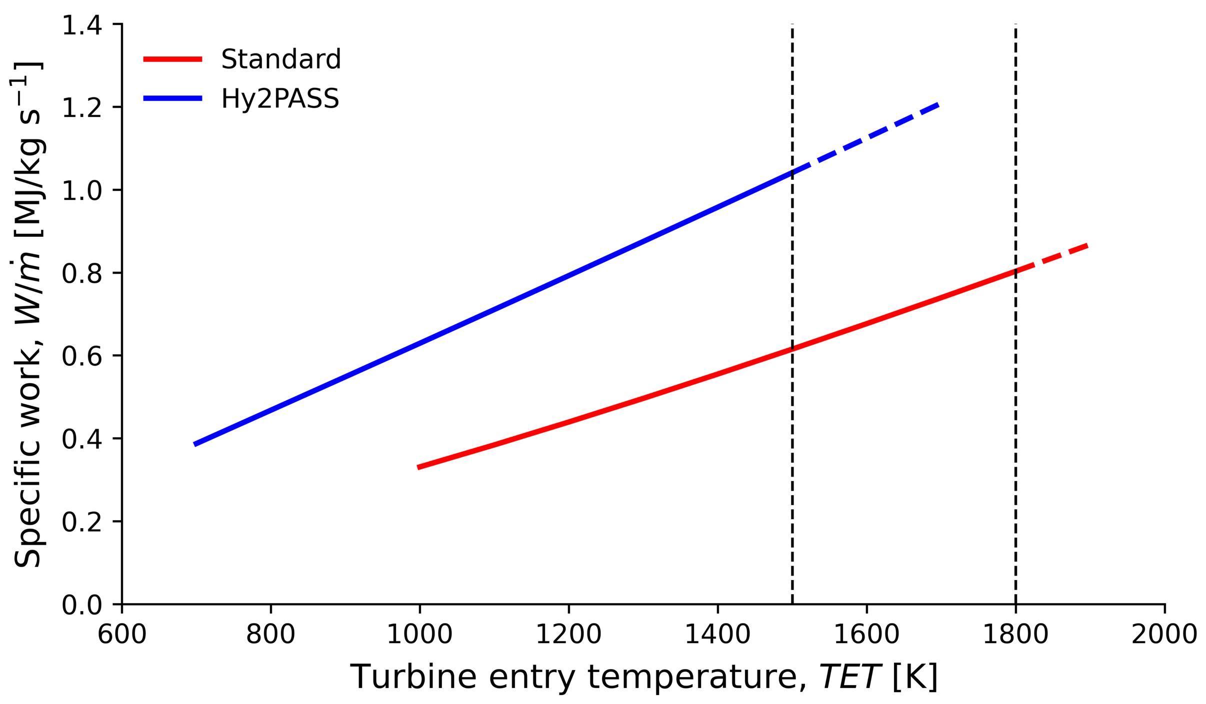
The Hy2PASS system relies on fundamental principles of the Brayton cycle, which describes the thermodynamics of gas turbine engines. As the compression of incoming air (oxygen) increases, a greater thermal engine efficiency is achievable.



T-s diagram of conventional turbofan and Hy2PASS configuration, where increase in compression enables greater turbine work extraction at lower specific entropy

As a result of this improved thermodynamics cycle, the Hy2PASS turbine is capable of producing greater specific work at a fixed turbine entry temperature. When compared to conventional turbofans, this outcome allows:

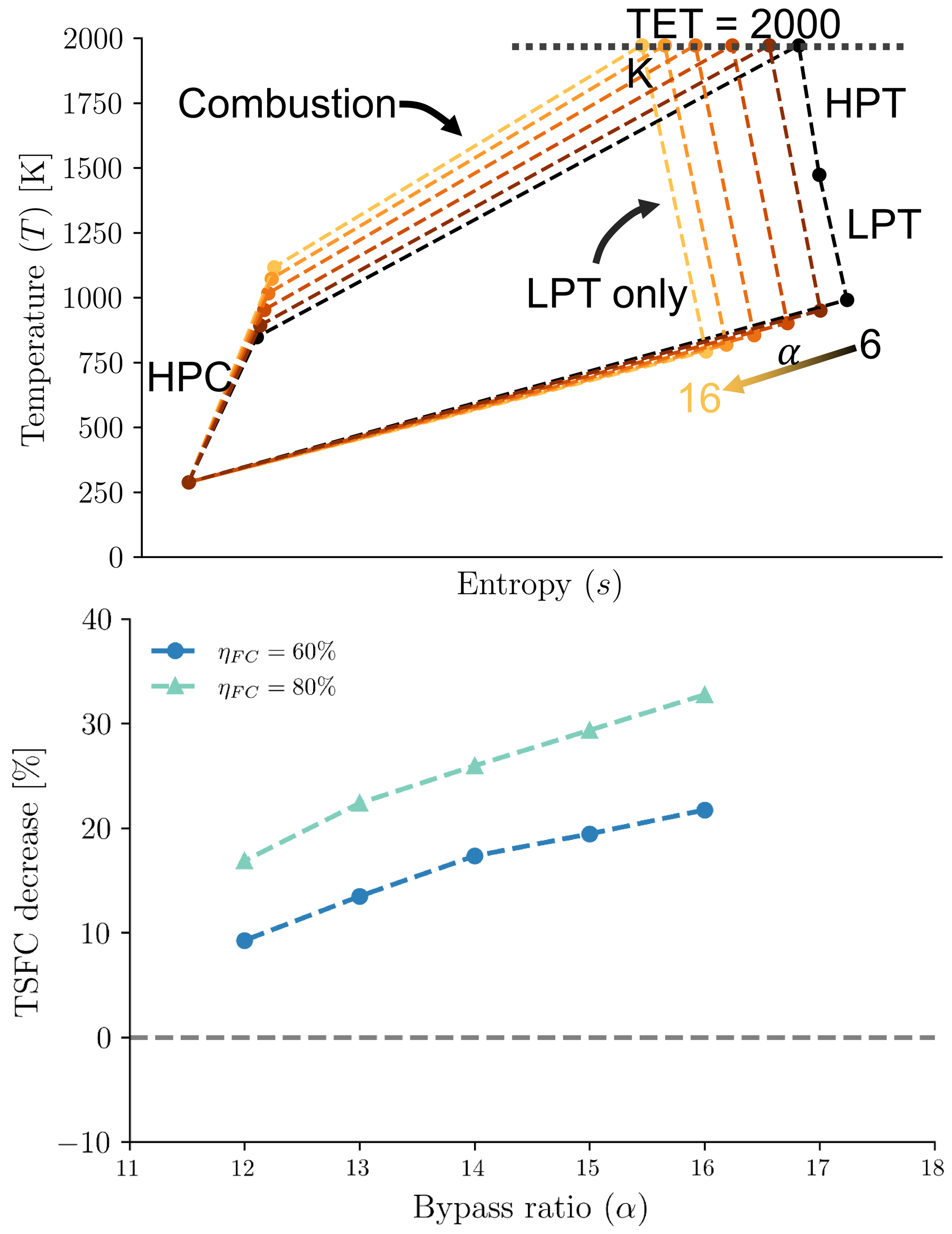
- The same turbine power to be produced at decreased core mass flow (increases bypass ratio and propulsive efficiency)
- A greater overall power to be produced at a fixed core mass flow, allowing for higher altitudes and climb rates
- A lower temperature turbine stage, alleviating challenges of material temperature limits



Comparison of specific work across a range of turbine entry temperatures, for conventional and Hy2PASS gas turbine engines

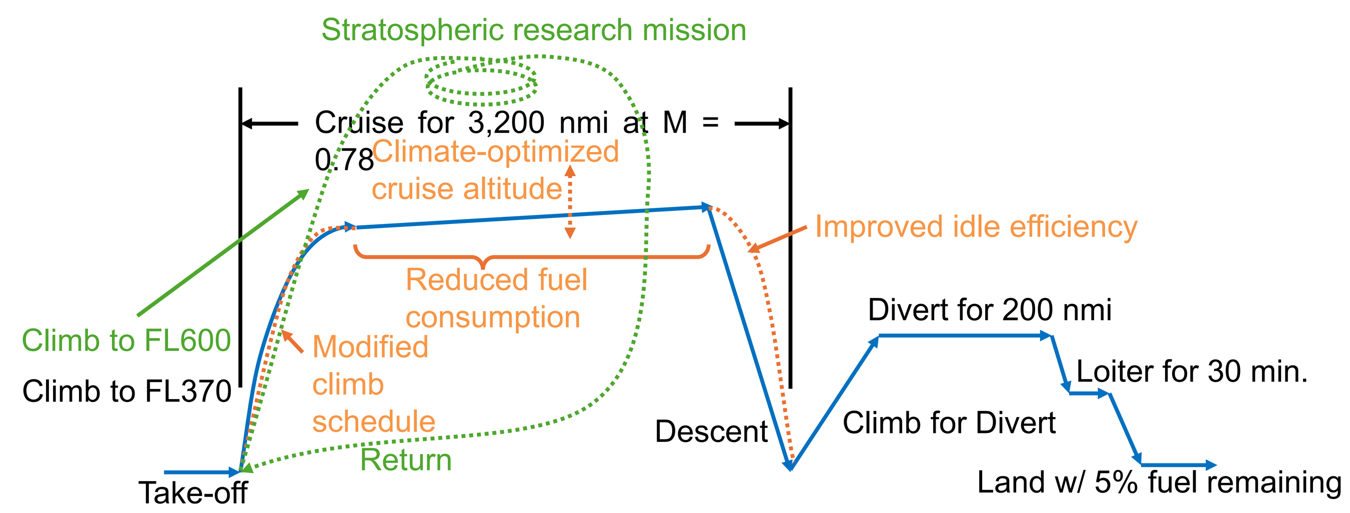
SIMULATION RESULTS

A quasi-1D propulsion simulation method was used to simulate the Hy2PASS system with typical losses across the engine components. The core operating principle of the Hy2PASS system was demonstrated to be technically feasible, resulting in specific fuel consumption reductions between 10-27%, depending on changes in assumed engine bypass ratio.



Non-ideal T-s cycle diagram of Hy2PASS concept, as compared to conventional engine (black), alongside fuel consumption reductions calculated from simulation.

The Hy2PASS propulsion system configuration can also be utilized to improve existing commercial aircraft missions or enable entirely new high-altitude missions.



Baseline mission (blue) for narrow-body aircraft, with mission capabilities of Hy2PASS system (orange), and high-altitude missions enabled by Hy2PASS (green)

ACKNOWLEDGEMENTS

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