#ArchitectingAviation

THE IMPACTS OF FUTURE ENERGY PRICES AND CLIMATE REGULATIONS ON THE RANKING OF AIRCRAFT TECHNOLOGIES

Evaluating long-term aircraft technology costs considering the growing uncertainty of future energy prices and evolving climate policies

Why can't we ignore energy price uncertainty?
Aircraft operating costs are influenced by a variety of factors. Forecasts of energy and carbon prices are key to long-term comparisons of aircraft types with different propulsion technologies and fuels. Energy costs typically account for 25-50% of an airline's total operating costs. Therefore, fluctuations in energy prices will have a significant impact on the evaluation of new aircraft technologies. This is even more relevant when considering new energy sources, such as hydrocarbon-based sustainable aviation fuels (SAF) or hydrogen, for which long-term price trends are uncertain.

Regulatory Challenges

In addition to energy price uncertainty, the aviation industry faces a number of regulatory challenges. Some of the most influential policies to consider include:

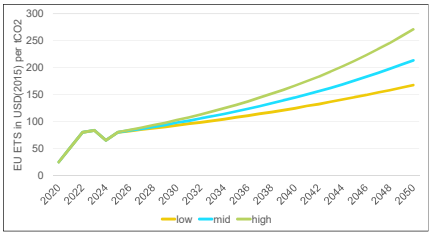
- Global CO_2 pricing (CORSIA)
- Regional CO_2 pricing (e.g. EU ETS)
- Sustainable Aviation Fuels blending mandates (e.g. ReFuelEU Aviation)

The introduction of climate instruments such as the EU ETS and CORSIA has introduced an additional factor of uncertainty into the equation. While an allowance for 1 ton of CO_2 in the EU ETS currently (March 2025) costs around €70, this is expected to rise sharply in the coming years due to a continuous reduction in available allowances. Globally, more countries are expected to introduce carbon pricing, which will increase the operating costs of aircraft powered by fossil fuels. The combination of carbon pricing and SAF blending mandates adds another layer of complexity: As the use of more SAF reduces the cost of carbon emissions, non-fossil fuels are likely to be more expensive than fossil Jet-A1.

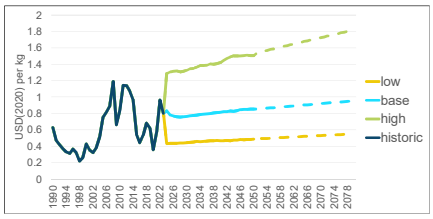
Analyzing the Effects

The main way to deal with uncertainty is to conduct a sensitivity analysis of the operating costs of the EXACT aircraft concepts with different scenarios on energy and carbon prices. For this purpose, the aircraft operating cost for different aircraft concepts were calculated.

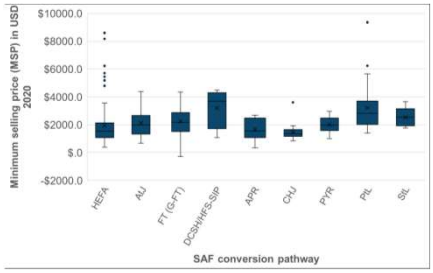
The economic analysis war performed using LYFE, a modular aircraft lifecycle simulation tool. It examines each phase in detail through discrete event simulation. Events vary in attributes (duration, cost, revenue, etc.) and informing metrics such as total cost or NPV.
The comparisons of the EXACT aircraft concepts are relative to the 250-seat turbofan aircraft (technology of the year 2040) with a base PtL price development.



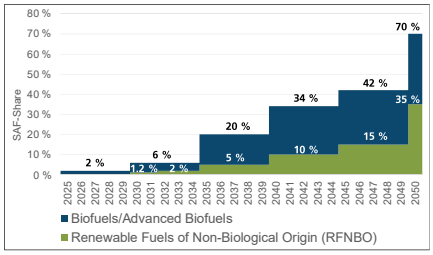
Regional CO2 pricing (EU ETS)



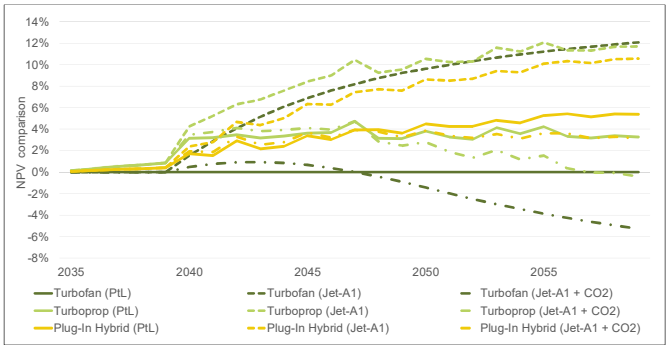
Even for conventional jet fuel (Jet-A1), there is significant uncertainty in future price forecasts.



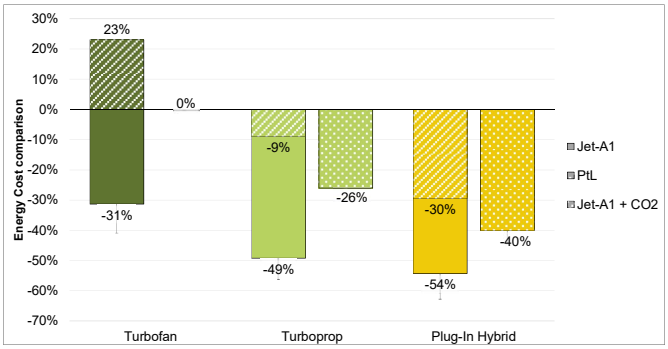
The future price of sustainable aviation fuels is uncertain, influenced by technological progress and feedstock availability.



SAF blending mandates like ReFuelEU Aviation will impact costs, as SAF is expected to remain pricier than fossil jet fuel long-term.



Net-present value comparison of the 250-seat turbofan, turboprop and plug-in hybrid concept over their lifetime (2040-2060).



The total energy costs (Jet-A1, Jet-A1 incl. CO2, PtL) for the 250-seat turbofan, turboprop and plug-in hybrid concept relative to the turbofan PtL case.

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