Content of the support material:

- Supplementary Figures
- Supplementary Tables
- Supplementary Methods

1. Supplementary Figures

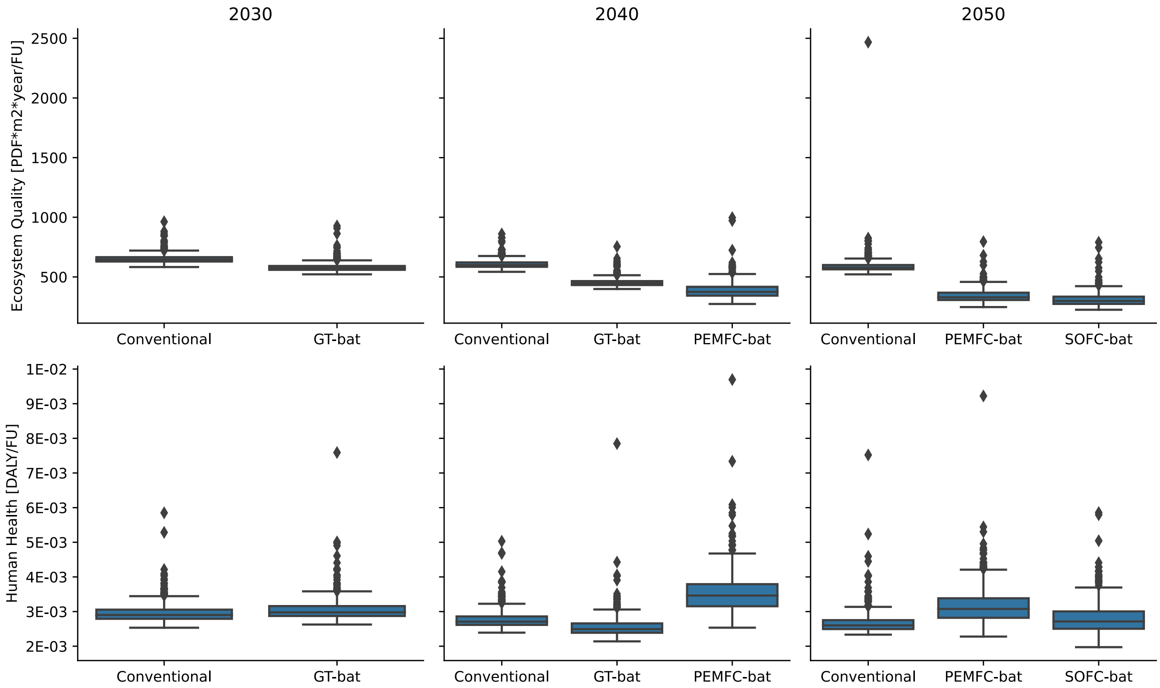

Figure A. 1: Endpoint level comparison between configurations fueled by kerosene and across time horizons for ecosystem quality and human health. The boxplots represent the distributions for each configuration obtained via Monte Carlo analysis (n=500, seed =35). The extremities of the boxplot and the central line represent the interquartile range and the median of the damage scores, while the whiskers illustrate the 95% confidence interval. Individual dots represent outliers. Abbreviations: alternative aviation fuels (AAF), proton exchange membrane fuel cell (PEMFC), solid oxide fuel cell SOFC, gas turbine with battery aircraft (GT-bat), human health (HH), disability-adjusted life years (DALY), ecosystem quality (EQ), potentially disappeared fraction of species (PDF). ***(Corresponds to Figure 2 in article)***

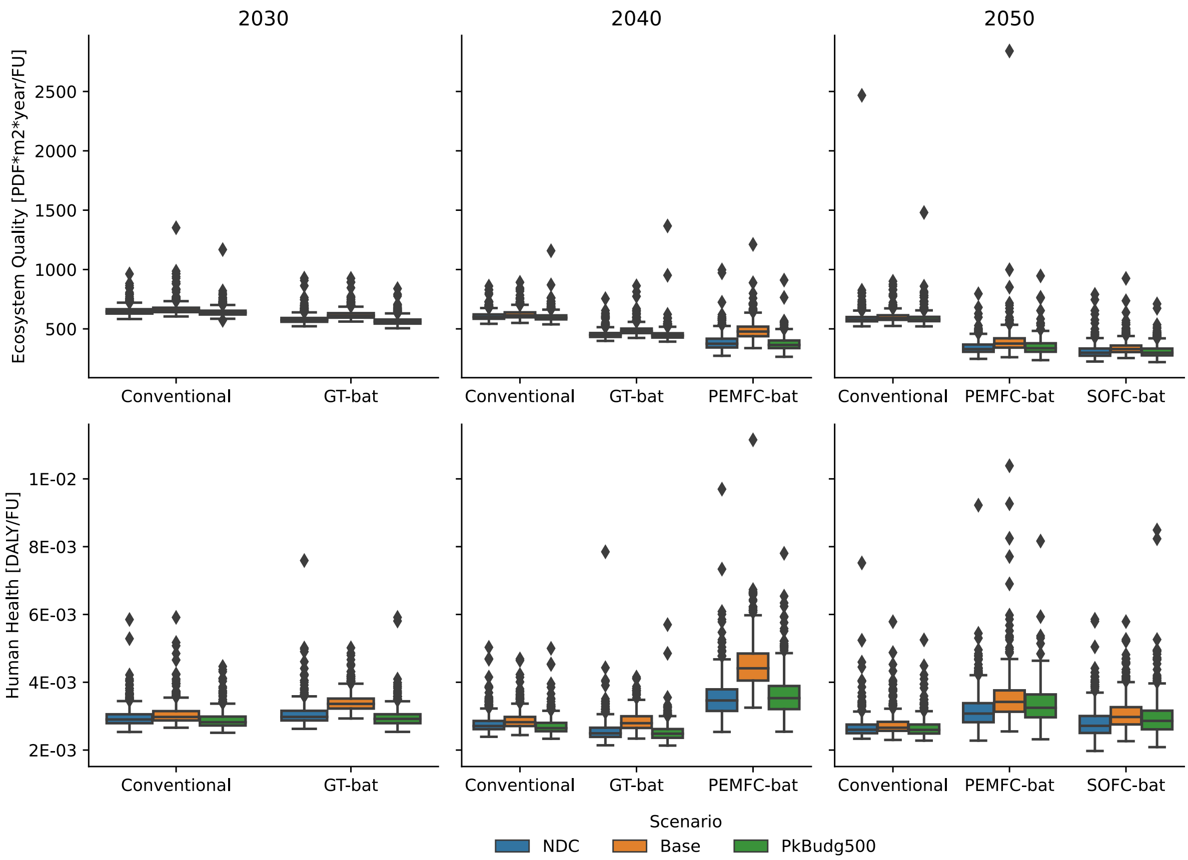

Figure A. 2 : Endpoint level sensitivity analysis using three SSP2 scenarios: NDC (central climate change scenario), Base (pessimistic climate change scenario), and PkBudg500 (optimistic climate change scenario . The boxplots represent the distributions for each configuration obtained via Monte Carlo analysis (n=500, seed =35). The extremities of the boxplot and the central line represent the interquartile range and the median of the damage scores, while the whiskers illustrate the 95% confidence interval. Additional abbreviations: proton exchange membrane fuel cell (PEMFC), solid oxide fuel cell (SOFC), gas turbine with battery (bat) aircraft (GT-bat), human health (HH), disability-adjusted life years (DALY), ecosystem quality (EQ), potentially disappeared fraction of species (PDF). ***(Corresponds to Figure 5 in article)***

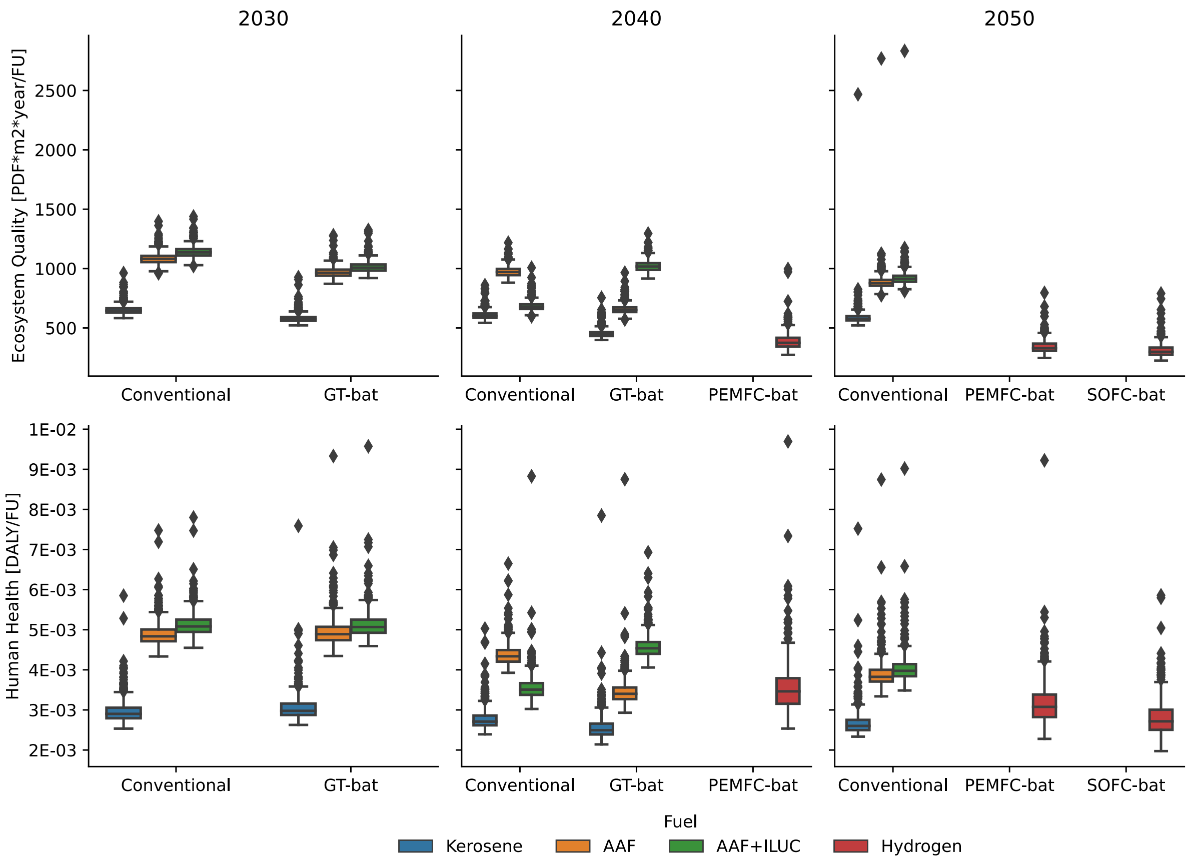

Figure A. 3: Endpoint level sensitivity analysis using alternative aviation fuel (AAF) for the conventional and gas turbine with battery aircraft (GT-bat) configurations with and without indirect land use change (ILUC) considerations. For the short-term time horizon, a more conservative AAF fuel was assumed . The boxplots represent the distributions for each configuration obtained via Monte Carlo analysis (n=500, seed =35). The extremities of the boxplot and the central line represent the interquartile range and the median of the damage scores, while the whiskers illustrate the 95% confidence interval. Additional abbreviations: proton exchange membrane fuel cell (PEMFC), solid oxide fuel cell (SOFC), human health (HH), disability-adjusted life years (DALY), ecosystem quality (EQ), potentially disappeared fraction of species (PDF). ***(Corresponds to Figure 6 in article)***

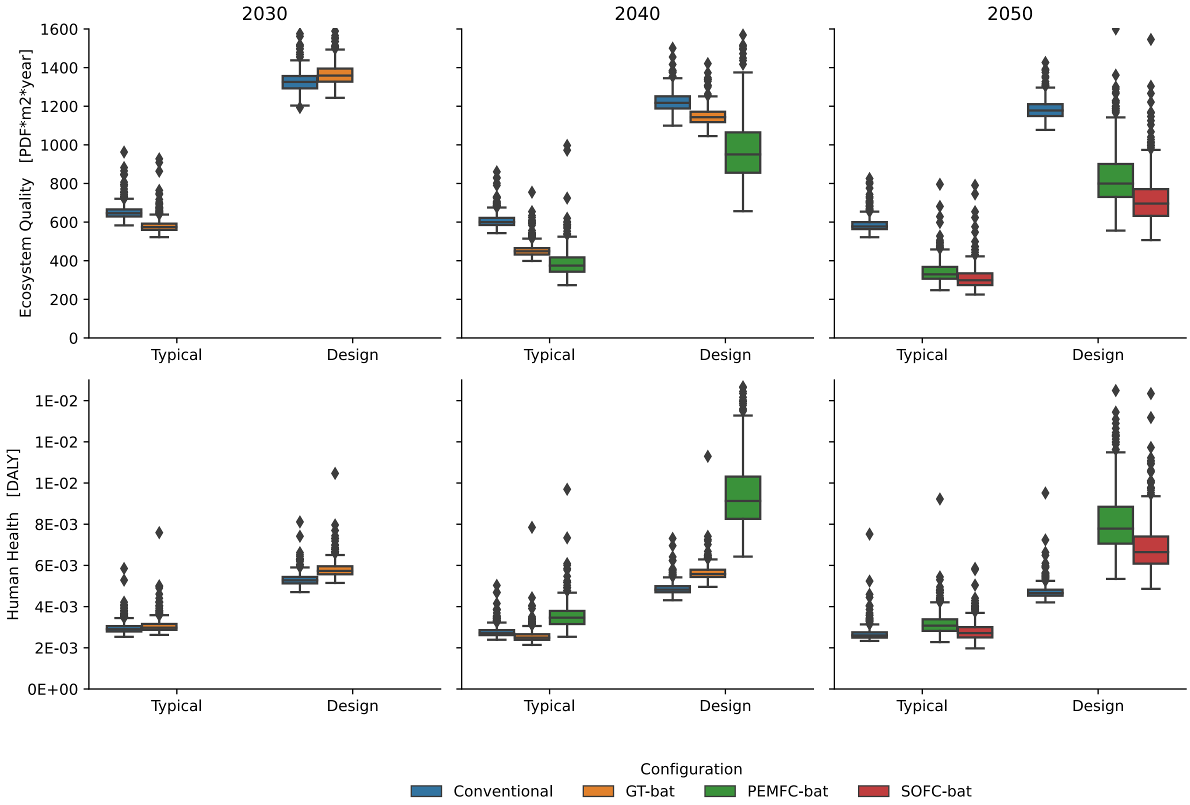

Figure A. 4: Endpoint level sensitivity analysis for the typical mission (200nmi) and a longer-range design mission (600nmi). The boxplots represent the distributions for each configuration obtained via Monte Carlo analysis (n=500, seed =35). The extremities of the boxplot and the central line represent the interquartile range and the median of the damage scores, while the whiskers illustrate the 95% confidence interval. Additional abbreviations: proton exchange membrane fuel cell (PEMFC), solid oxide fuel cell (SOFC), human health (HH), disability-adjusted life years (DALY), ecosystem quality (EQ), potentially disappeared fraction of species (PDF).

2 Supplementary table

Table 1: Characterized environmental impacts on midpoint level for the NDC scenario, with the typical mission (does not include AAF configurations). The values are based on medians obtained from Monte Carlo simulations (n=500, seed=35). All characterized results for all SSP scenarios, types of missions, and all types of fuels are available in electronic supplementary information "ESI_characterized_results".

Category	Conv. (2030)	GT-bat (2030)	Conv. (2040)	GT-bat (2040)	PEMFC-bat (2040)	Conventional (2050)	PEMFC-bat (2050)	SOFC-bat (2050)
Climate change, short term [kg CO2eq.]	1.89E+03	1.59E+03	1.71E+03	1.09E+03	3.61E+02	1.64E+03	2.89E+02	2.71E+02
Climate change, long term [kg CO2eq.]	1.93E+03	1.63E+03	1.75E+03	1.13E+03	3.98E+02	1.68E+03	3.23E+02	3.03E+02
Fossil and nuclear energy use [MJ dep.]	2.86E+04	2.65E+04	2.60E+04	1.82E+04	1.31E+04	2.46E+04	7.65E+03	6.76E+03
Freshwater acidification [kg SO2eq.]	1.52E-05	1.23E-05	1.42E-05	1.05E-05	9.73E-06	1.38E-05	8.11E-06	7.21E-06
Freshwater ecotoxicity [CTUe]	3.62E+07	4.28E+07	3.72E+07	4.66E+07	7.75E+07	3.77E+07	7.65E+07	6.93E+07
Freshwater eutrophication [kg PO4eq.]	6.79E-02	5.77E-02	6.17E-02	3.92E-02	3.44E-02	5.96E-02	3.20E-02	2.57E-02
Human toxicity cancer [CTUh]	5.59E-05	7.62E-05	5.68E-05	7.93E-05	1.56E-04	5.54E-05	1.49E-04	1.32E-04
Human toxicity non cancer [CTUh]	2.73E-04	3.20E-04	2.72E-04	3.27E-04	5.40E-04	2.70E-04	5.18E-04	4.67E-04
Ionizing radiations [Bq C14eq.]	1.51E+04	2.82E+04	1.34E+04	1.88E+04	4.88E+04	1.18E+04	2.21E+04	1.85E+04
Land occupation, biodiversity [m2eq*yr.]	3.24E+01	3.99E+01	3.28E+01	3.94E+01	6.66E+01	3.25E+01	5.78E+01	5.25E+01
Land transformation, biodiversity [m2eq.]	4.55E-01	4.60E-01	4.38E-01	4.11E-01	6.02E-01	4.23E-01	5.62E-01	4.89E-01
Marine eutrophication [kg Neq.]	1.53E-01	1.16E-01	1.48E-01	9.20E-02	8.76E-02	1.44E-01	8.10E-02	7.44E-02
Mineral resources use [kg dep.]	5.38E+01	5.51E+01	5.38E+01	5.49E+01	5.63E+01	5.38E+01	5.60E+01	5.60E+01
Ozone Layer Depletion [kg CFC-11eq.]	4.28E-04	3.44E-04	3.88E-04	2.30E-04	4.77E-05	3.74E-04	6.68E-05	5.27E-05
Particulate matter formation [kg PM2.5eq.]	3.67E-01	3.56E-01	3.40E-01	3.11E-01	3.76E-01	3.23E-01	3.10E-01	2.83E-01
Photochemical oxidant formation [kg NMVOCeq.]	7.50E+00	5.09E+00	7.04E+00	3.67E+00	2.00E+00	6.81E+00	1.61E+00	1.44E+00
Terrestrial acidification [kg SO2eq.]	1.27E-02	1.01E-02	1.19E-02	8.61E-03	7.98E-03	1.15E-02	6.64E-03	5.91E-03
Water scarcity [m3eq.]	1.51E+02	2.46E+02	1.50E+02	2.30E+02	5.98E+02	1.36E+02	4.99E+02	4.28E+02

3 Supplementary method for the multimodal comparison of environmental impacts at damage level.

The environmental impacts of each mode of transport were quantified for each time horizons using the same environmental database and impact assessment method as the aircraft configurations (Section **Error! Reference source not found.** of the main text). The selected modes or transport were: electric train (train (IT), modelled as “transport, passenger train | market for transport, passenger train | IT”), diesel train (train (GLO), modelled as “transport, passenger train | market for transport, passenger train | GLO”), and coach (coach (GLO), modelled as “transport, passenger coach | market for transport, passenger coach | GLO”).

The functional unit for the typical mission was 18520 passenger.kilometers (50 passengers travelling over 340 km), assuming a load factor of 1. It was set to 55550 passenger.kilometer from the design mission (50 passengers travelling over 1111 km).