**Executive Summary**

**Sustainable Regional Aviation**

Linnan Cao, Nick Matcheck, Marie Rajon Bernard, Mark Schefter, Jeff Sharp, Matthew Wald

Background:

Aviation emissions contribute 2% to global emissions, and they are forecasted to grow between 300 and 700% by 2050. The aviation sector is also one of the hardest to decarbonize due to the lack of readily available solutions. Short-haul flights play a major role since the carbon intensity of flights under 500km is twice as much as longer flights due to the disproportionate emissions associated with takeoff and landing. Three strategies exist for a more sustainable aviation sector: battery-electric airplanes, hydrogen-electric airplanes, and the use of sustainable aviation fuel instead of jet fuel. However, current solutions are only applicable for small aircraft. These emerging technologies along with new business models can reform inefficient short-haul routes, making regional airlines a key stakeholder in this transformation. Our work sought to assess whether these new aircraft designs coupled with policy incentives could create new business opportunities for sustainable regional air travel in California.

Study Methodology:

Our first step was to conduct research in order to understand advancements in regional aircraft technology. From that we found three potential airplanes for the green aviation of tomorrow, including the: 1) ZeroAvia 19-passenger’ hydrogen-electric airplane, 2) Faradair BEHA\_M1H 18-passenger hybrid electric aircraft (which uses batteries for ground operations and sustainable aviation fuel for the flight), and 3) Eviation Alice 9-passenger battery-electric aircraft. Three routes within California were chosen as a representative sample to assess whether a sustainable regional airline could be commercially viable. Those three routes are: 1) Oakland to Burbank, 2) San Luis Obispo to Sacramento, and 3) San José to South Lake Tahoe. Our next step was to develop an emission model to assess the environmental impact of those new aircraft as well as the alternative transportation modes that customers can take on those routes (bus, car, rail, and commercial aviation). After coming up with fuel lifecycle numbers, we developed a mode shift model to estimate both the number of people who would shift from other transportation modes to our new airline and the induced demand that would be generated in order to calculate the total environmental impact of making this new mode of transportation available. This mode shift is dependent on the ticket price for our new airline, and also on the convenience, travel time, frequency of service, novelty, safety, and public health (in light of the Covid 19 crisis). A thorough financial model was created to understand the main cost components and estimate a profitable ticket price. Our last step was to analyze potential policy recommendations to ensure the financial and environmental sustainability of our new airline.

Analysis:

The emission model showed that sustainable aviation largely outperforms commercial aviation and conventional cars on the three routes in question. It thus seems environmentally beneficial to use one of those airplanes for a new regional airline. After calculating those lifecycle numbers, the mode shift model enabled us to come up with a minimum number of passengers per year for each route to break even in terms of environmental impact. The financial model then showed that ZeroAvia 19-passenger aircraft is the most financially viable option of the three aircraft studied. It is less expensive than an equally sized turboprop aircraft but more expensive than most of the other modes (car, train, bus, and commercial aviation in a larger aircraft). In order to come up with policy recommendations to remedy the cost difference, we looked at the main cost levers associated with ZeroAvia operations and found that about 25% of the cost of each ticket can be attributed to fuel, 18% to taxes, and 15% to navigation and landing fees.

Policy recommendations:

Given that fuel, taxes, and fees are three key cost items, we propose policy recommendations that could be used to adjust each item. The first policy is to broaden the scope of the Low Carbon Fuel Standard (LCFS) to include fuel credits for aviation, which could help save about $25 (one-way trip) on ticket prices. The second one is a restructured landing fee that would be based on emissions during a landing and takeoff cycle instead of weight. This airport specific tax could reduce one-way ticket price by about $18. The last policy is a federal excise tax and flight segment fee reduction, which could further reduce ticket prices by about $15. It would be possible to create routes, segments and/or aircraft specifications for federal excise tax or flight segment fee reduction. Redirected subsidies from the Essential Air Service (EAS) program could help backfill lost revenue for airports.

Conclusion:

Implementing a combination of these three policies could make ZeroAvia not only the fastest transportation option but also one of the cheapest and more environmentally friendly options. The most viable policy is the Low Carbon Fuel Standard and the second one that we would recommend (in terms of efficiency, political acceptance and viability) is the new policy on landing fees.

When making a decision on travel mode, customers take into account three different parameters: travel time, cost, and greenhouse gas emissions. We thus came up with a price for each decision lever. The cost of time is based on the average hourly rate for California ($19.75/hr), and the cost of emissions is based on the social cost of carbon estimate ($160/ton CO2). Overall - with the policy recommended - not only is sustainable regional aviation already feasible, but ZeroAvia is also the cheapest option when considering total cost.

Limitations and Key Assumptions:

As with any study, our conclusions depend on a set of assumptions and have limitations. One of the first limitations is that for our greenhouse gas emissions and our financial model we only took into account fuel lifecycle numbers which does not encompass the infrastructure that has to be built. Besides, we narrowed down our study to three routes that we deemed representative of California routes, yet this is an important assumption. Another limitation lays in the fact that we developed our models on early design metrics, indeed none of those technologies are on the market yet. Finally, the last major assumptions and limitations that are worth mentioning are those concerning the number of passengers and the percentage of mode shift and induced demand.