Regional Air Mobility and Electrified Aircraft

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1. Introduction

I write frequently about electric mobility. Of course there are many flavors of electric mobility, and depending on volume of EVs for a particular type, I might write about it once a month (or more frequently) to once a year (or less frequently). This is about the latter, as you can probably guess from the title. Also, “electrified aircraft” will only be viable for a tiny subset of all aircraft, at least for the next two decades. All other aircraft will rely on clean-fuel to reduce their greenhouse gas (GHG) emissions during this time, and most will still be propelled by turbofans or turbo-props burning this fuel. I (and many others) call the “tiny subset” Air Taxis, and I last wrote about these a bit more than a year ago. See the description and link below.

Air Taxis, Starting to Takeoff? Although there are some flying EVs, these have hardly become mainstream, but the title version of these appear to (very slowly) taking off, and the amount of funds being pumped into them by major firms are taking off, big-time.

This post will review how air taxis from an earlier post have developed and review the current crop of air taxis most likely to quickly (and perhaps inexpensively) whisk you over the traffic in the next few years.

https://energycentral.com/c/ec/air-taxis-starting-takeoff

I just reviewed the above paper, and all I could add to this is, what I considered the most viable electric air taxi manufacturer then (referenced at the end of this paragraph), Joby Aviation, still appears to have the best chance of being fully FAA-certified in 2025. They also appear to have the best and most mature design.¹

However, about a week before this paper was due for posting, some new news hit the web which changes everything. I still believe that Joby has the best chance of being fully FAA certified in 2025, but one of their competitors just merged with a major partner and gained much credibility:

Around the mid of last year in July, Boeing and its joint-venture partner Wisk revealed their concept of operations for unmanned electric aircraft, or what was also known as pilotless air taxis. Then earlier this month, the aircraft manufacturer invested in Wisk and took full ownership in what was seen as a welcome turning point in the air taxi developer's four-year history.²

¹ Joby Aviation, Our Story, https://www.jobyaviation.com/about/
For the latest news on Joby Aviation, see my final comment at the end of this paper. Also, note that I’m planning a future post on the larger aircraft and “clean fuels” mentioned in the first paragraph above. Some of these fuels are reasonable analogs for existing jet fuels, and thus will not require significant airframe modification, but some (read: ammonia and especially hydrogen) will require major redesigns.

This post is about a document recently released earlier this year addressing the Air Taxi segment. This document was issued by an organization far more qualified than your author – the National Renewable Energy Laboratory (NREL). This paper will be a brief review of that document (referenced below).

The U.S. aviation system is an important part of the nation’s economy, transporting hundreds of millions of passengers and billions of pounds of freight annually. In the coming decades, air transportation of people and cargo is set to expand; however, several challenges currently face the aviation sector, including achieving greenhouse gas emissions reduction goals, serving larger populations through regional and local airports, managing aircraft noise, and reducing the cost of operations, to name a few.3

As battery chemistries have advanced, many entities—such as the Federal Aviation Administration, the National Aeronautics and Space Administration (NASA), and private industries—have expressed interest in understanding electric aircraft and the opportunities they present...

Electric aircraft have several major advantages and drawbacks compared to conventional aircraft. Advantages include having significantly lower operating costs, quieter operation, and usually the ability to generate additional torque, allowing them to take off from shorter runways (and land on shorter runways). Drawbacks include range concerns, lower passenger or cargo capacity, and charging times that would disrupt current commercial airline travel schedules.

Due to their advantages and drawbacks, electric aircraft are likely not as useful in a business-as-usual scenario, where they would be placed at large airport hubs to serve long flights. If electric aircraft were used in a more localized scenario, they have the potential to transform the U.S. transportation sector. Rather than flying in a traditional hub-and-spoke scenario with large concentrations of aircraft at large hubs, electric aircraft could connect smaller regional or local airports directly. At these smaller airports, electric aircraft could efficiently utilize shorter runways, and due to their quiet operation, electric aircraft could serve rural communities with fewer local noise impacts. Electric aircraft have the potential to help:

1. Increase mobility opportunities for rural or small communities.
2. Transform decentralized airports into renewable energy hubs, where local solar installations could power the electric aircraft...

3 Jordan Cox, Tom Harris, Kathleen Krah, James Morris, Xiangkun Li, and Scott Cary, NREL, “Impacts of Regional Air Mobility and Electrified Aircraft on Airport Electricity Infrastructure and Demand,” Feb 2023, https://www.nrel.gov/docs/fy23osti/84176.pdf
3. Decrease regional (short-distance) airplane travel costs.
4. Reduce ground transportation congestion and emissions.

2. Electric Infrastructure

This report summarizes an analysis of the electrical infrastructure that might be necessary to serve electric aircraft at a subset of airports where potential electric aircraft flight demand has been provided. Additionally, an estimate for the amount of on-site distributed energy resources (DERs)—i.e., solar photovoltaics (PV) and battery energy storage systems (BESS)—that could be used to serve electric aircraft in cost-effective scenarios is provided.

A team of researchers from the Georgia Institute of Technology (Georgia Tech) estimated the market potential for regional flights. These flight demand data were used to estimate the on-ground charging electricity demand needed to service regional electric aircraft. Several airports in this study volunteered their interval and monthly baseline electricity demand data to build a prototypical airport baseline electricity demand profile that could be scaled. Electricity cost rates were selected from the mid-Atlantic region or generated from mid-Atlantic regional averages. These electricity demand profiles and electricity cost rates were evaluated utilizing two tools from the National Renewable Energy Laboratory (NREL)—the REopt® and Engage™ models—for a total of 162 modeled airports in the mid-Atlantic region and one airport in Colorado (chosen based on data availability).

The capacity expansion and dispatch models estimated DERs that would be needed to support the hypothetical electric aircraft flight demand. Potential available land area at each airport was analyzed by NASA and provided to NREL as an upper limit for potential PV deployment.

The analysis resulted in a few key findings. First, in all cases, the electric aircraft charging electricity demand was larger than the airport baseline electricity demand for even a modest number of flights (approximately five per day). This meant that existing airport infrastructure was usually not sufficient to service electric aircraft.

Author’s comment: In the paragraph below, where “DER” (distributed energy resources) is used, you could probably substitute “photovoltaic arrays (PV) and battery energy storage systems (BESS)”. Also see the next paragraph.

Second, although Engage and REopt predicted different levels of DER deployment based on differences in model inputs, in almost all cases, some level of on-site electric infrastructure or DERs was recommended to economically serve electric aircraft. The buildouts of electric infrastructure or DERs were a reasonable amount (less than 1% of airport land used for DERs) for the airport size. This suggests that with proper planning and investment, electric aircraft could be supported at all airports studied. The economic benefit of DER buildout was likely due to the short window and high peaks of airplane charging that are particularly favorable when modeling BESS technologies.

Third, in those cases studied, airport land area was never a constraining factor in the buildout of PV. Often, the PV buildout was less than 1% of available land at airports, meaning that land area used by PV was not a significant burden on the airport, even in cases with high PV deployment.
3. Electric Aircraft

Parts of this report also look at hybrid aircraft. I will ignore these parts, as I have really not seen any interest in these designs in my research. Furthermore, one major advantage of battery electric aircraft is that their "fuel" is much less expensive than current aviation-fuel. This is especially true if PV is added to the small airports these electric aircraft are intended to fly from as suggested above.

Recently, electric aircraft have been reexamined as a potential carrier of passengers and cargo in a commercial setting, especially as battery chemistries and charging infrastructure have advanced. The image below (next page) shows NASA’s latest electric aircraft, the X-57, which was designed to demonstrate electric propulsion with distributed propellers along the span of the wing. Electric aircraft have several advantages over traditional fossil-fueled aircraft. First, because the power-to-weight ratio and efficiency of the motors are not largely dependent on peak power level (as opposed to fossil-fueled engines or turbines, which typically get more efficient and/or a higher power-to-weight ratio at higher peak power levels), electric aircraft can use distributed propulsion, where the propulsion system (in this case, electric motors and propellers) is distributed across the lift surface. This allows for increased efficiency and quieter operation. Additionally, because the motors are electric, this allows for additional torque at lower motor speeds. This excess torque can be used by the aircraft to operate propellers at lower speeds, reducing noise in cases where propeller noise may otherwise be the dominant noise source.
3.1. Charging Infrastructure

Similar to electric vehicles (EVs) today, there will be a range of charging speeds to meet electric flight demand in the future. A range of charging speeds could include slow charging that will charge the airplane within 1–8 hours and fast charging that will charge the airplane within as little as 15 minutes, to accommodate shorter times between flights. This range of charging times corresponds to a range of electric aircraft applications. Some cargo planes will fly to a location in the morning and stay all day only to return in the evening, whereas some passenger planes will land and take off as quickly as they can exchange passengers, maximizing operational-efficiency of the aircraft.

Electric vehicle supply equipment (EVSE) varies based on the onboard electronics of the EV. Traditionally, EVs have an onboard component to convert AC to DC for charging the batteries. In an electric aircraft, however, onboard charging electronics would be minimal to reduce weight. Instead, it is likely that electric aircraft will charge with DC…

For battery-electric aircraft to become viable in the market, the electric charging infrastructure must be developed in parallel with the aircraft while also addressing the challenges associated with integrating electric charging into existing airports.

The first charger of the right scale is being developed by Clay Lacy Aviation, a fixed-base operator service company. This firm has announced an agreement with electric aircraft manufacturer Eviation to provide charging for a nine-passenger aircraft, Eviation’s Alice. This charging system requires 30 minutes or less to charge per flight hour, with a maximum range of up to 815 kilometers. Eviation’s Alice eCargo planes are set to be deployed in 2024, kicking off the commercialization of electric aircraft within the short-haul aviation sector.

**Author’s comment:** Eviation’s Alice has been under development for about 10 years, but it only made its first flight in Sep 2022. Initial development was in Israel. I did not see that they have started the FAA certification process yet, and this generally takes several years. In spite of the above “2024” date, in a recent interview with the CEO, he said 2027 for the passenger version craft to be operational (Alice comes in two versions, passenger and cargo). It could be that the eCargo version (referenced above) has less stringent FAA requirements.

The above text indicates that the Alice has a range of 815 km (440 nautical miles (NM), each NM is 1.15 U.S. mile, and NM is the most common unit of distance measurement in the aviation industry). In a recent interview with Eviation’s CEO (referenced at the end of this paragraph, article also has some photos and images of Alice), he said that this range had been reduced to 250 NM. He also stated that 20-30% of the world’s air travel is 250 NM or less.⁴

I believe the Joby Air Taxi mentioned in the Intro was just was a passenger-carrier. For a review of autonomous cargo carriers, see the recent post summarized and linked below.

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⁴ Siddharth Gan, Airways, “CEO Interview, Eviation Alice’s Trajectory,” April 5, 2023, [https://airwaysmag.com/ceo-eviation-alices-trajectory/](https://airwaysmag.com/ceo-eviation-alices-trajectory/)
**eDrone Air Cargo:** As you’ve probably already guessed, we will be looking at airborne vehicles. Drones are generally considered unmanned and non-passenger vehicles. Drones can perform many functions. The small ones are mainly limited to surveillance and other imaging, but that is not what we are looking at here. Medium-sized drones have been used for cargo transport, and that is the main subject of this post (as you can probably tell by the title). However, a side-subject is crop-spraying by drones.

https://energycentral.com/c/ec/edrone-air-cargo

**Final author’s comment:** I researched the viability of the above described regional carrier electric-aircraft, using the larger San Francisco Bay Area as a model (since I’ve lived here most of my life).

First of all let me describe this area’s airports. There are four major (international) airports in this Area: San Francisco (SFO), Oakland (OAK), San Jose (SJC) and Sacramento (SMF). There are also seven major regional airports in this area: Sonoma County (STS), Napa County Airport (APC), Concord Buchanan Field (CCR), Stockton Metropolitan (SCK), Monterey Regional (MRY), Livermore Municipal (LVK), and Hayward Executive (HWD). All of the regional airports mainly serve general aviation, corporate and government flights, but many also have a small number of scheduled commercial flights.

Once we get away from the greater Bay Area, there are many smaller regional airports. For instance, my primary residence is in Livermore, but a have a mountain home in Arnold, in Calaveras County (Arnold is about 120 road-miles east of Livermore). There is a small regional airport, Calaveras County Maury Rasmussen Field (CPU), about 25 road-miles west of Arnold.

I see three distinct regional carrier roles for EV Aircraft. I’m assuming that Joby Aviation’s electric air taxi is the model for this, as it appears to be closest to FAA Certification. The other potential electric regional carrier mentioned in this paper is Eviation’s Alice. Joby’s air taxi can carry five passengers and is capable of vertical take-off and landings (VTOL). Alice is larger (9-passangers) and has a slightly longer range (220 NM vs. 150 NM) but can only take-off and land from a runway. Also note that the Joby air taxi’s range appears to adequate for a large majority of the trips described below.

**Potential Roles:**

1. Small regional airports to & from major regional airports, major international airports, other small regional airports, or major city centers (helicopter / VTOL landing pads)
2. Major regional airports to & from major international airports, other regional airports or major city centers (helicopter / VTOL landing pads)
3. Major international airports to major city centers (helicopter / VTOL landing pads)

I see role 1 as being mainly charter service, roles 2 and 3 being a mixture of charter service and regularly scheduled flights.

In a follow-up post to “eDrone Air Cargo” posted in April of this year (summarized and linked above), I am working on a future-paper on what seems to be the leader in this market. I just found this firm, but it has a different, more effective offering and much more experience. This future-paper will be posted in early August.
Finally, Joby Aviation has already achieved limited FCC Certification, which allows it to make limited “production aircraft” and ship these to customers. See the press release linked below for details.