ELECTRIFICATION OF GENERAL AVIATION FLEET

North Central Texas
Council of Governments

Dr. Stephen P. Mattingly
Nithisha Reddy Gudipati
Mino Aji
Ma Anjelika Pineda

UTA THE UNIVERSITY OF TEXAS AT ARLINGTON

STUDY GOALS

- ❑ Requirements for electrification
- ❑ Lifecycle Cost
- ❑ Cost Benefit Analyses
- ❑ Introduction of survey

CHECKLIST FOR ELECTRIFICATION

1. Electric aircraft : Electric motors, Reliability, Flying time , Efficiency of power distribution, Battery (energy density and power density), Life
2. Operational needs: Schedule, Turnaround time
3. Charging infrastructure: Battery, Charging capacity, Charging time, Cost, Usage, Life

…CONTINUATION

4. Grid capacity and Power requirements: Power capacity, Increased load from electrification, Possibilities of grid upgrade
5. Alternate energy resources: Solar Photovoltaic, Battery storage, Integrating distributed energy resources
6. Regulatory framework: Airworthiness standards: aircraft engines (14 CFR Part 33)
7. Financial considerations

FOSSIL FUEL AIRCRAFT EMISSIONS

EMISSIONS

- CO2 and water vapor
- Nitrogen oxides (Nox)
- Unburned hydrocarbons
- Carbon monoxide
- Sulphur oxides
- Traces of hydroxyl family and nitrogen compounds
- Small amounts of soot particles

HEALTH IMPACTS

- Morbidity
- Mortality
- Cancers
- Acute Exposure Mortality
- Acute Respiratory Symptoms Days
- Adults Chronic Bronchitis
- Asthma

HEALTH IMPACT FACTOR

- Cost of health damage due to air pollutant emissions
- $ Conversion factors from a 2016 study (Alrafea et al., 2016)

CO	NO2	PM2.5	SO2
0.64	73.85	83.36	24.50

- 2016 to 2023 health care inflation rate: 22%

AlRafea, Kamal, Ali Elkamel, and Sabah A. Abdul-Wahab. "Cost-analysis of health impacts associated with emissions from combined cycle power plant." *Journal of cleaner production* 139 (2016): 1408-1424.

ELECTRIC AIRCRAFT

- Emerging research and development
- Manufacturers: Airbus, Boeing, Pipistrel, Lilium, Joby Aviation, Eviation Aircraft, Electra Aero, Beta Technologies
- First electric aircraft: Pipistrel Alpha electro-2 seater
- Velis Electro by Pipistrel is certified to use in 30 countries
- Pricing: $140,000

Charging Infrastructure

- Similar to electric vehicle charging infrastructure.
- Requires higher power outputs and fast charging
- High power demand
- High-power chargers capable of delivering a large amount of electricity in a short period are crucial.
- Advanced cooling systems
- Manufacturers: **Green motion & Pipistrel**, **Beta Technologies**, Chargepoint, Boeing, Siemens

BENEFIT

- Reduced emissions: CO, NO, PM2.5
- Fossil fuel cost
- Lower maintenance costs

COST

- Electric Aircraft cost
- Infrastructure investments
- Electricity costs

- All costs and benefits are annualized based on interest rates

ELECTRIFICATION SCENARIOS

Flight schools

- All operations are electric
- 50% of operations are electric
- 25% of operations are electric
- 10% of operations are electric

Entire Airport

- All operations are electric
- 90% of operations are electric
- 80% of operations are electric
- 65% of operations are electric

Airport	100% flight school electrification		50% flight school electrification		25% flight school electrification		10% flight school electrification	
	min	max	min	max	min	max	min	max
Arlington Municipal (GKY)	7.96	8.44	7.52	8.44	6.38	7.82	5.24	8.44
Grand Prairie Muncipial (GPM)	9.44	9.48	9.40	9.48	9.33	9.48	9.77	10.16
Fort Worth Spinks (FWS)	6.84	7.89	5.97	7.78	4.99	8.19	2.96	6.99
Fort Worth Meacham	7.46	7.63	6.74	7.04	5.66	6.09	3.83	4.33
Fort Worth Alliance (Perot Field)	3.90	4.14	3.78	4.28	3.39	4.28	2.70	4.57
Addison	8.49	8.49	8.49	8.49	9.02	9.02	9.61	9.61
Dallas Executive	6.41	6.72	5.93	6.48	4.66	5.39	3.22	4.19
Denton Enterprise	6.63	6.92	5.81	6.26	4.55	5.14	2.95	3.62
Lancaster Regional	1.29	1.29	1.27	1.27	1.23	1.23	1.04	1.04
McKinney National	8.75	8.75	8.75	8.75	8.75	8.75	7.96	7.96
Mesquite Metro	7.15	7.16	7.14	7.16	7.11	7.16	7.54	7.68
Bridgeport Muncipal	1.30	1.30	1.49	1.49	1.09	1.09	1.85	1.85
Caddo Mills Muncipal	4.16	4.16	3.41	3.41	3.17	3.17	1.57	1.57
Cleburne Regional	5.21	5.21	4.27	4.27	3.14	3.14	1.96	1.96
Decatur Municipal	1.28	1.28	1.21	1.21	1.08	1.08	1.06	1.06
Gainesville Municipal	5.20	5.20	4.97	4.97	3.24	3.24	2.47	2.47
Granbury Regional	4.99	4.99	3.91	3.91	2.57	2.57	1.35	1.35
Mid-Way Regional	4.97	4.97	4.62	4.62	4.52	4.52	2.57	2.57
Mineral Wells	7.21	8.52	6.84	9.65	4.41	7.06	3.28	10.87
North Texas Regional	8.78	9.88	8.18	10.31	8.36	14.44	6.64	40.62
Rockwall Municipal	6.34	7.10	5.60	6.90	4.53	6.53	3.40	7.96
Terrell Municipal	6.92	6.92	6.09	6.09	4.91	4.91	3.70	3.70
Aero Country	2.51	2.51	1.39	1.39	0.73	0.73	0.89	0.89
Bourland Field	7.36	7.36	7.85	7.85	5.41	5.41	5.82	5.82
Hicks Airfield	7.03	7.03	6.32	6.32	5.27	5.27	3.62	3.62
Northwest Regional	10.62	10.62	9.17	9.17	7.21	7.21	5.13	5.13
Parker County	9.01	9.01	8.17	8.17	7.59	7.59	4.15	4.15
Sycamore Strip	0.76	0.76	0.39	0.39	0.20	0.20	0.13	0.13

Electrification of Flight schools

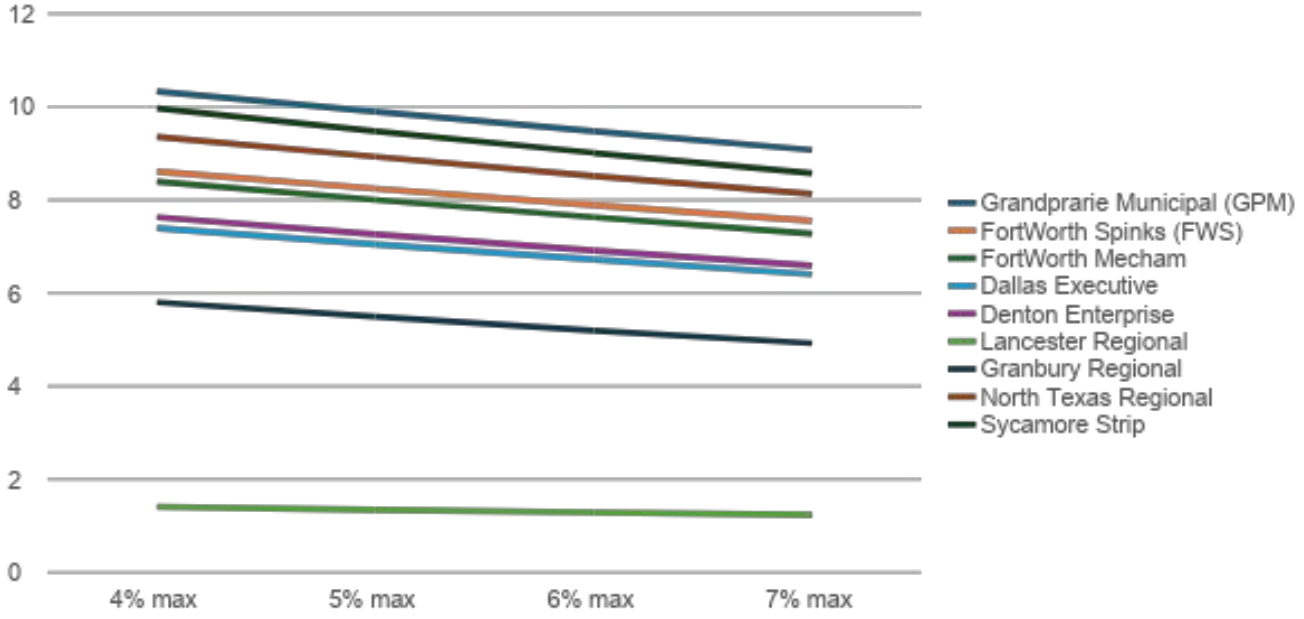
Airport	100% enitre airport electrification		90% enitre airport electrification		80% enitre airport electrification		65% enitre airport electrification	
	min	max	min	max	min	max	min	max
Arlington Municipal (GKY)	4.00	8.44	3.78	8.44	3.53	8.44	2.82	8.93
Grand Prairie Muncipial (GPM)	8.62	9.48	8.86	9.77	8.62	9.72	8.43	10.06
Fort Worth Spinks (FWS)	2.44	6.71	2.44	6.59	2.08	6.45	1.56	6.21
Fort Worth Meacham	2.40	2.84	2.40	2.64	2.04	2.44	1.50	1.83
Fort Worth Alliance (Perot Field)	3.77	4.14	3.85	4.24	3.74	4.21	3.58	4.25
Addison	8.49	-3.00	8.66	8.66	8.56	8.56	8.99	8.99
Dallas Executive	1.40	2.07	1.40	1.92	1.16	1.76	0.85	1.32
Denton Enterprise	2.49	3.11	2.49	2.91	2.12	2.69	1.60	2.09
Lancaster Regional	1.30	1.30	1.32	1.32	1.33	1.33	1.64	1.64
McKinney National	8.75	8.75	8.61	8.61	8.69	8.69	9.24	9.24
Mesquite Metro	6.92	7.16	6.87	7.11	7.03	7.35	7.17	7.67
Bridgeport Muncipal	1.30	1.30	1.47	1.47	1.40	1.40	1.88	1.88
Caddo Mills Muncipal	1.42	1.42	1.50	1.38	1.25	1.25	0.91	0.91
Cleburne Regional	1.16	1.16	1.17	1.07	0.97	0.97	0.69	0.69
Decatur Municipal	1.33	1.33	1.28	1.28	1.36	1.36	1.64	1.64
Gainesville Municipal	1.15	1.15	1.14	1.05	0.97	0.97	0.72	0.72
Granbury Regional	2.25	2.25	2.28	2.12	1.92	1.92	1.47	1.47
Mid-Way Regional	1.52	1.52	1.53	1.42	1.28	1.28	0.98	0.98
Mineral Wells	1.85	6.19	1.90	6.50	1.57	6.06	1.15	5.61
North Texas Regional	4.88	9.07	4.89	-6.31	4.40	-5.19	3.54	-2.98
Rockwall Municipal	2.52	5.34	2.49	5.03	2.18	5.08	1.67	4.57
Terrell Municipal	2.22	2.22	2.26	2.09	1.89	1.89	1.39	1.39
Aero Country	0.14	0.14	0.14	0.13	0.12	0.12	0.08	0.08
Bourland Field	2.63	2.63	2.73	2.54	2.30	2.30	1.76	1.76
Hicks Airfield	1.41	1.41	1.41	1.29	1.17	1.17	0.85	0.85
Northwest Regional	0.82	0.82	0.82	0.74	0.66	0.66	0.50	0.50
Parker County	4.49	4.49	4.56	4.29	3.92	3.92	3.09	3.09
Sycamore Strip	0.19	0.19	0.19	0.17	0.15	0.15	0.11	0.11

Electrification of Entire airport

Airport	100% entire airport electrification	90% entire airport electrification	80% entire airport electrification	65% entire airport electrification
Arlington Municipal (GKY)	1.29	1.18	1.06	0.75
Grand Prairie Muncipial (GPM)	1.20	1.10	0.99	0.70
Fort Worth Spinks (FWS)	0.90	0.82	0.74	0.52
Fort Worth Meacham	1.41	1.29	1.17	0.83
Fort Worth Alliance (Perot Field)	3.43	3.43	3.33	3.05
Addison	0.63	0.57	0.51	0.36
Dallas Executive	0.70	0.64	0.57	0.41
Denton Enterprise	1.23	1.13	1.02	0.73
Lancaster Regional	1.29	1.30	1.32	1.61
McKinney National	1.94	1.78	1.62	1.17
Mesquite Metro	1.34	1.22	1.11	0.81
Bridgeport Muncipal	1.22	1.36	1.29	1.64
Caddo Mills Muncipal	0.95	0.90	0.81	0.58
Cleburne Regional	0.70	0.64	0.58	0.40
Decatur Municipal	1.33	1.28	1.36	1.64
Gainesville Municipal	0.63	0.57	0.52	0.37
Granbury Regional	1.26	1.16	1.04	0.76
Mid-Way Regional	0.98	0.91	0.81	0.60
Mineral Wells	0.88	0.81	0.72	0.51
North Texas Regional	1.53	1.40	1.27	0.90
Rockwall Municipal	1.43	1.30	1.19	0.87
Terrell Municipal	1.15	1.06	0.95	0.67
Aero Country	0.03	0.02	0.02	0.01
Bourland Field	0.57	0.52	0.47	0.33
Hicks Airfield	0.66	0.60	0.54	0.38
Northwest Regional	0.27	0.25	0.22	0.17
Parker County	1.96	1.81	1.63	1.17
Sycamore Strip	0.11	0.10	0.09	0.06

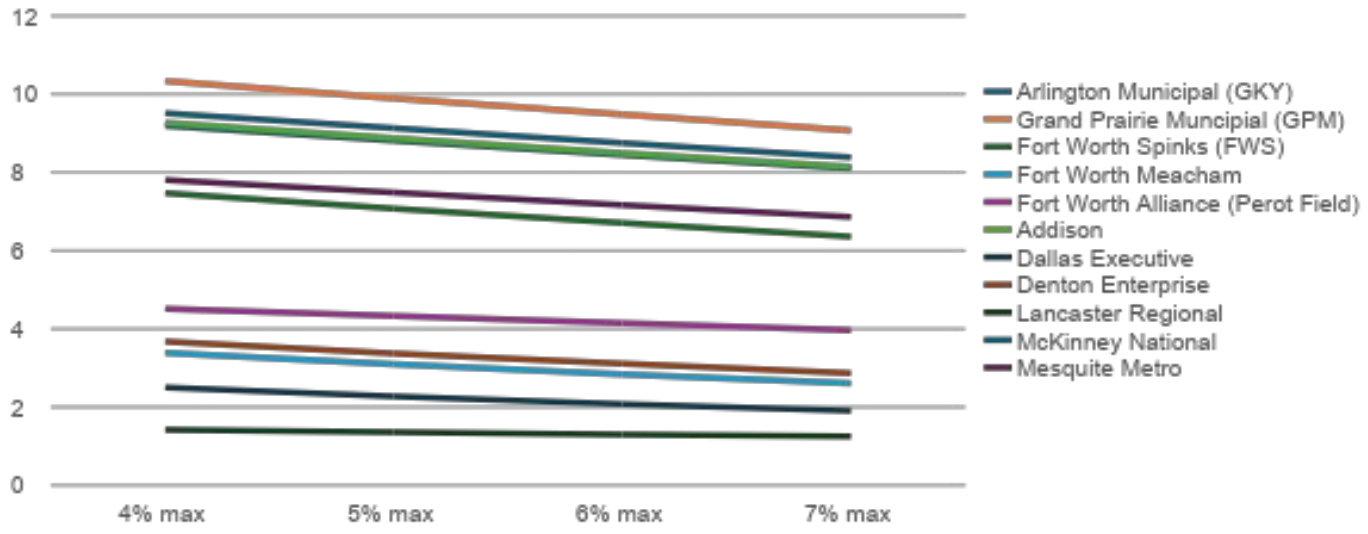
Replacement of fossil fuel aircraft with electric aircraft at full price

SENSITIVITY ANALYSIS



Benefit-Cost analysis for electrification of flight schools at different interest rates

Sensitivity Analysis: Benefit-Cost Ratio of flight school electrification at different interest rates



KEY FINDINGS

- Even if only10% of total operations are with electric powered aircraft, converting the flight school aircraft fleets appears promising at most airports
- With 100% of the flight operations electrified
  - Average BCA for converting the flight school fleets in the NCTCOG region is around 6 to 6.2 .
  - Average BCA for converting all aircraft in the NCTCOG region is around 2.92 to 3.34.
  - Regional BCA reduces to 1.11 when all fossil fuel aircraft are replaced with electric aircraft at full price.
    - this reduces to 0.78 when only 65% of flight operations are electric aircraft.
- Sensitivity analysis of the BCA at different interest rates shows that the B/C ratios decrease an increase in interest rates.
- Aero country and Sycamore strip are the only airports with B/C<1 even at 4% rates.

LIMITATIONS AND FUTURE RESEARCH

- Factors like fuel flowage fees, land leases, hanger rentals are not considered in this study.
- Aircraft based costs like maintenance costs and yearly depreciation are also not considered.
- Fuel costs are calculated assuming one hour per one takeoff and landing[1,2]
- Electrical charging costs are $5 for one hour of flight time[3]

1. Aircraft cost calculato (ACC); https://www.aircraftcostcalculator.com/AircraftOperatingCosts
2. Planephd data model; https://planephd.com/wizard/manufacturers/
3. Windy app blog: Meet the main electric planes companies; https://windy.app/blog/electric-planes-companies.html

UTA

QUESTIONS?

THANK YOU!