Techno-Economic Study on Aircraft Emissions Reduction at the YYC Calgary International Airport

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Abstract

A **techno-economic study** was conducted to identify a set of financial schemes and operational practices that the **Calgary Airport Authority** can implement to reduce aircraft ground emissions at the **YYC Calgary International Airport** in **three key operational areas:**

(1) Ground support equipment (GSE),
(2) Aircraft engines, and
(3) Aircraft gate operations.

Analysis of the aircraft's path from taxiing to gate operations shows that **energy efficiencies and emission reduction ranging from 85% to 95% could be achieved**. This study proposes an **incentive-penalty approach** to improve performance in GSE anti-idling practices and Auxiliary Power Unit (APU) substitution **to reduce emissions.**

SDGs Approach

Figure: Sustainable Development Goals #7 and #11 (United Nations, 2015).

Research Question

What are the potential reductions in emissions and financial impacts of policy mechanisms the Calgary Airport Authority (CAA) could effectively utilize to achieve measurable reductions in aircraft ground emissions at YYC Calgary International Airport (YYC)?

Project Boundary

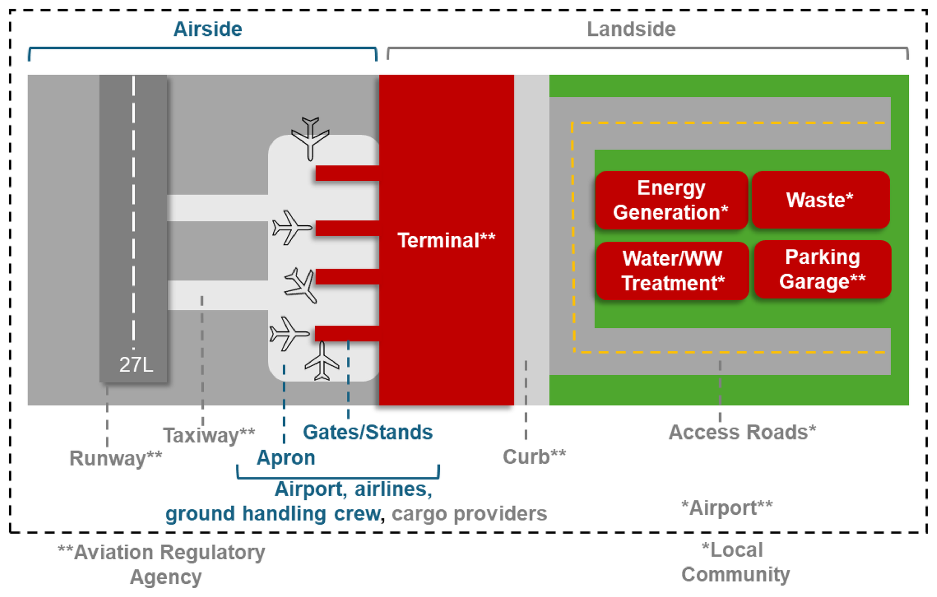


Figure: A typical airport's emission footprint (Adapted from Greer et al., 2020).

Business-as-Usual

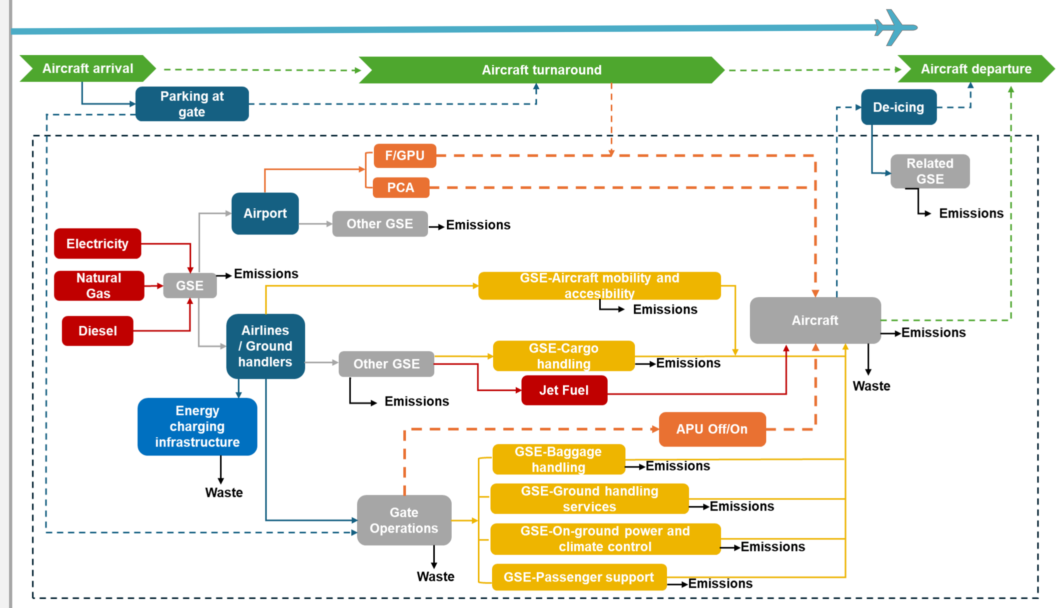


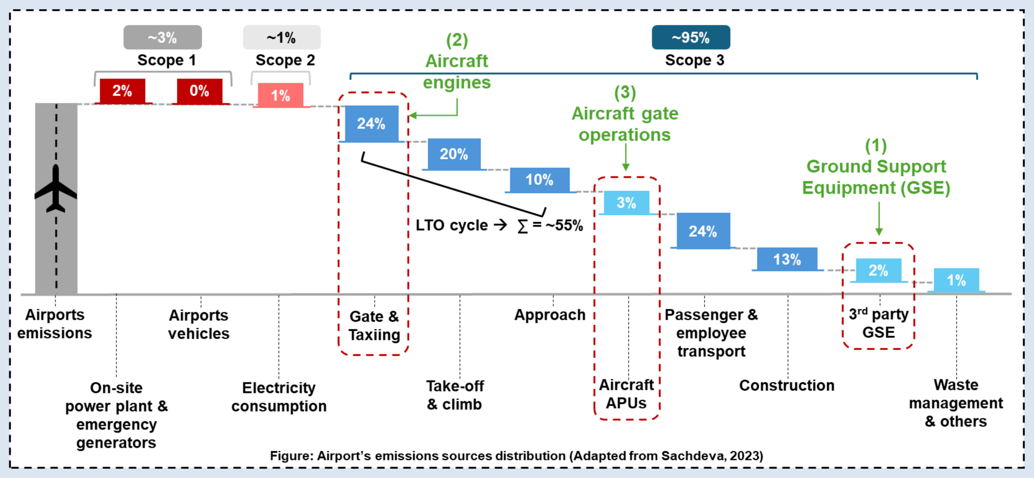
Figure: Aircraft operational pathway at YYC.

A baseline scenario was analyzed to identify current sources of aircraft emissions by key operational area, following the **aircraft pathway** from approaching YYC, during the LTO cycle, and at the gate.

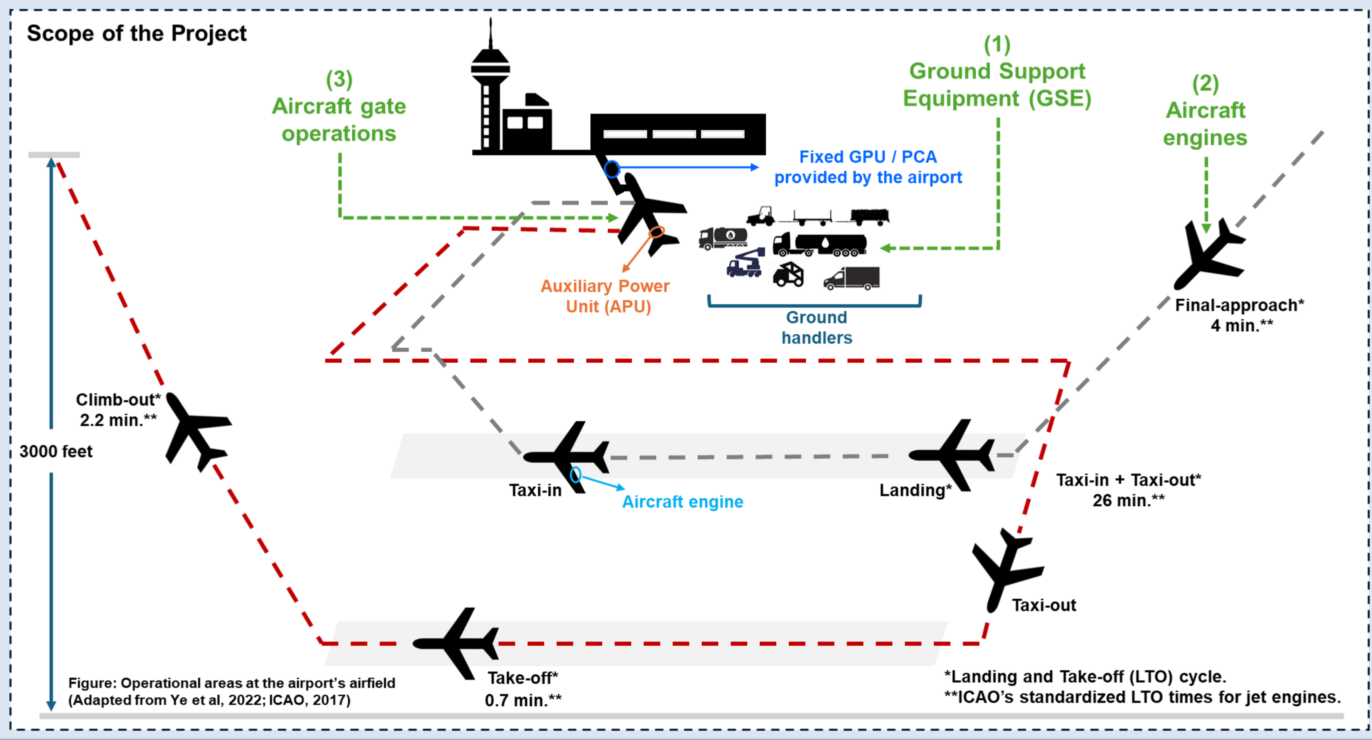
Airport and Aircraft Emissions

Airport emissions are derived from all airports' operations and activities associated with them:

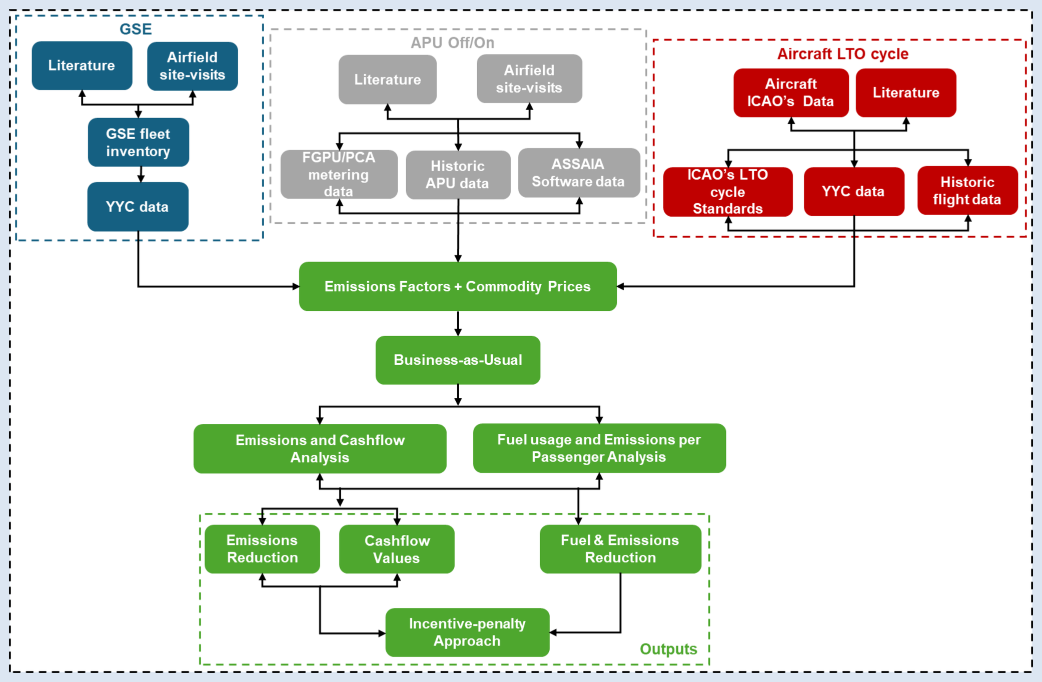
- Scope 1: emissions from owned or operated facilities.
- Scope 2: emissions from electricity used in stores, distribution centers, and other facilities.
- **Scope 3:** emissions from suppliers and consumers: flights, **aircraft ground movements, APU, third-party vehicles/GSE,** passengers traveling to the airport, staff commute, off-site waste management, off-site water management, staff business travel, non-road construction vehicles and equipment, de-icing substances, and refrigerant losses.



Aircraft ground emissions occur below 3,000 feet during the aircraft's standard **International Civil Aviation Organization (ICAO) landing and take-off (LTO) cycle**. This cycle comprises four stages: approach (descent and landing modes), taxiing (taxi-in and -out to/from the gate/runways), take-off, and climb-out phases.



Methodology



The study used a combination of **primary and secondary data** to analyze ground emissions. Primary data included fuel and emissions from **APUs**, electrical usage from GPU and PCA systems, and **GSE** inventory. Secondary data was sourced from the **ICAO's aircraft engine emissions databank** and Canadian government agencies. In addition, the research included on-site visits to the airfield.

Findings

(1) Ground Support Equipment:

A 20-year analysis of GSE shows significant advantages in switching from diesel to electric power:

- A **diesel GSE fleet produces over 18 times more emissions than an electric one**, and its annual energy consumption is also much higher.

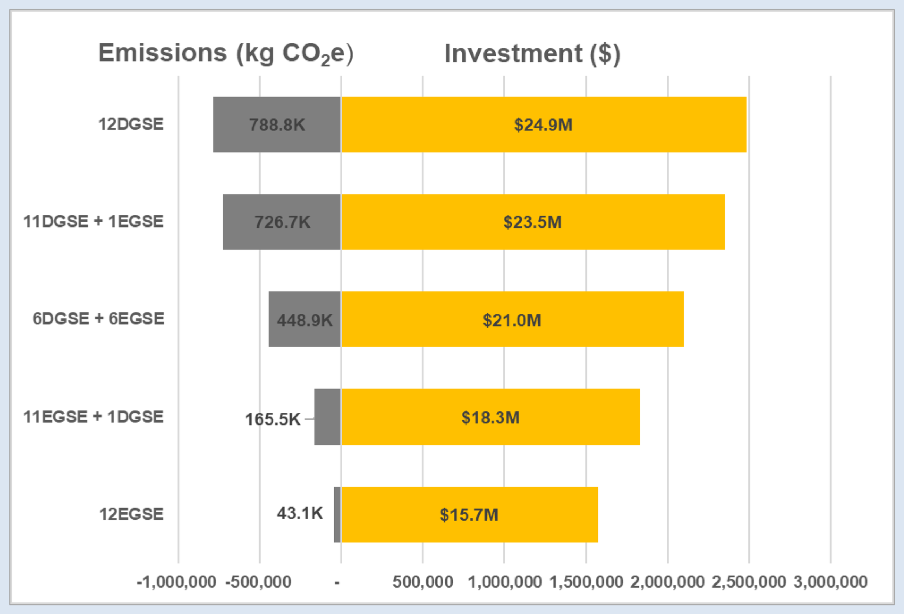


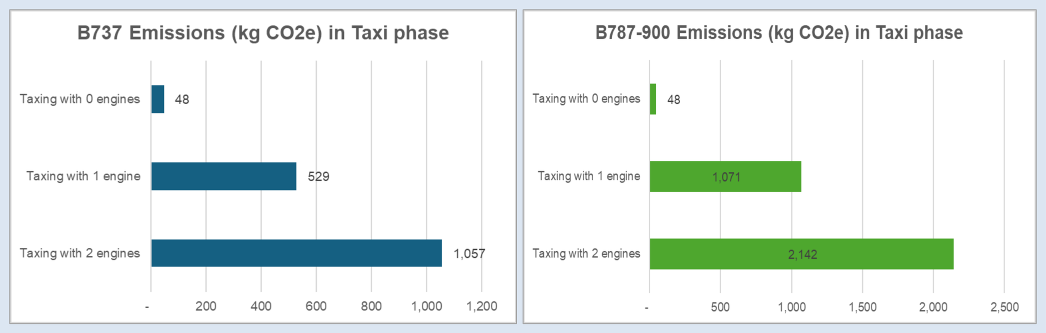
Figure: Economic and emissions sensitivity analysis results from Diesel/Electric Ground Support Equipment fleet configurations.

- The **combined costs of fuel and emissions for the diesel fleet eventually exceed the upfront investment for the electric fleet**, resulting in a net present value for the diesel fleet that is 58% higher than the electric one.

(2) Aircraft engines:

The analysis compares two aircraft types, the **Boeing 737** and the **Boeing 787-900**, showing:

- An **external electric GSE** for taxiing provides the most significant **emissions reduction -over 90%-** compared to both single- and two-engine taxiing.
- **Per passenger emissions** from aircraft during taxiing decrease significantly when using an external GSE for towing. Smaller planes, like the B737, produce **68.75% more** per passenger emissions than larger B787-900 aircraft.



Figures: Boeing 737 and Boeing 787-900 Emissions (kg CO_2e) in the taxi-in/taxi-out phases during the LTO cycle.

(3) Aircraft gate operations:

Using an electric GPU instead of the aircraft's APU at the gate **offers energy efficiencies and emission reductions higher than 85%.**

- Even **for a single flight turnaround,** this practice can **reduce jet fuel costs by up to 64%** and **emissions by up to 58% for domestic flights,** with higher reductions of **88% in fuel and 73% in emissions for international flights.**

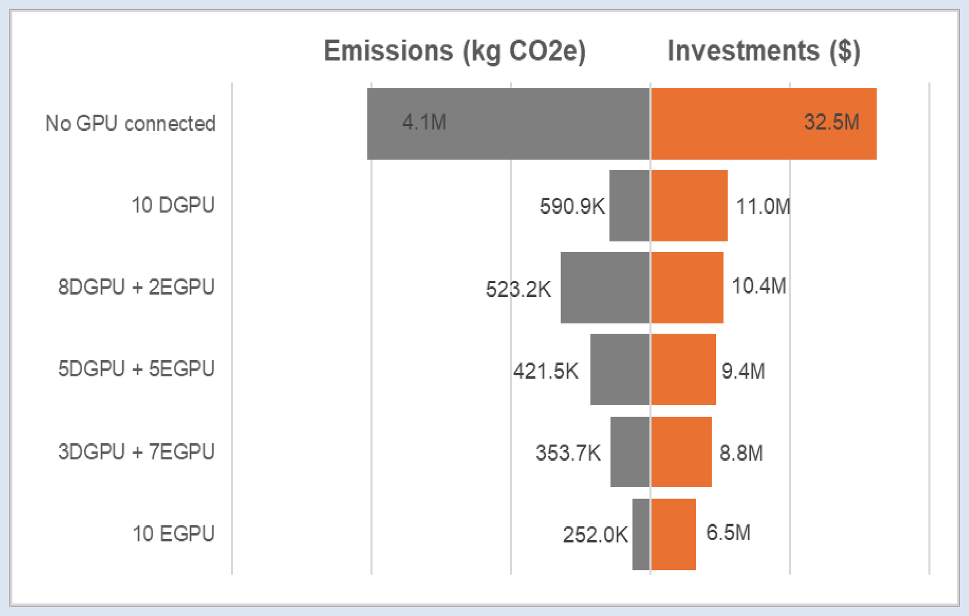


Figure: Economic and emissions sensitivity analysis results from Auxiliary Power Unit Off/On configurations.

Policy Mechanisms

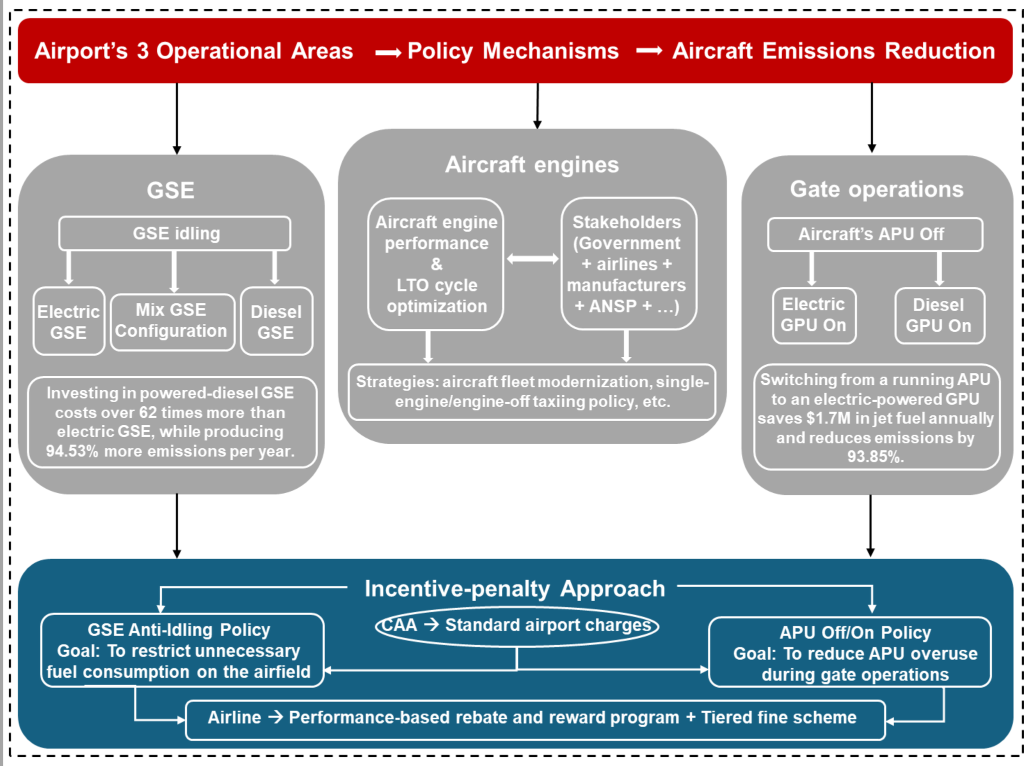


Figure: Financial schemes and operational practices analysis by operational area.

Conclusions

- Switching to an all-electric or mixed-electric/diesel GSE fleet can **reduce emissions from ground operations by up to 95%** compared to an all-diesel fleet, while also proving to be a wise long-term financial investment.
- With **APU substitution** procedures, annual **savings in aircraft fuel consumption** of $1.7M and an **emissions reduction** of 3.8M kg CO_2e can be achieved by using an electric-powered GPU.
- **Aircraft taxiing using an external GSE** provides significant **emissions reduction** of **91% and 95%** for the B737, and **96% and 98% for the B787-900,** when compared to single-engine and two-engine taxiing, respectively.

Limitations

- The analysis was restricted to 3 aircraft models, an average number of GSE, data constraints, and estimations of aircraft turnarounds related only to Concourse C at YYC.

Recommendations

- Based on the results, it is advisable that a more comprehensive analysis, including stakeholders and operational procedures, with a business case approach, be done to determine the range of discounts and charges for policy implementation.
- Future work could include optimizing GSE operations and scheduling, improving aircraft turnaround performance, incorporating changes in the emissions factor of the electrical grid, and modeling scenarios using a sample of current engine profiles of registered aircraft at YYC.

Acknowledgement

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