DECARBONIZATION STRATEGY

For the Region of Waterloo International Airport

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Region of Waterloo INTERNATIONAL AIRPORT

Empowering Climate Action

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Introduction

Airport & Regional Context

The Region of Waterloo International Airport (YKF) is owned by the Region of Waterloo and is located on approximately 1,000 acres of land in Breslau, Ontario. YKF is a full-service airport that consistently ranks among the top 20 busiest airports in Canada. The airport has two runways, a new terminal building, maintenance and support facilities, and a fleet of ground vehicles. The airport lands also host one of Canada's busiest flight training schools, a number of rotorcraft businesses, and charter, maintenance and service operations.

The Waterloo Region was the fastest growing region in Canada in 2020. Not only that, but YKF's proximity to the Greater Toronto Area makes the airport well-positioned to receive spillover air traffic from Toronto's Pearson International Airport. To meet this projected increase in demand, the airport has been expanding its Domestic Air Terminal Building with a new baggage and departure lounge, upgrading airside infrastructure and expanding groundside parking. Future expansions, including a new terminal building on a different site, is expected over the next 10 years.

In recognition that this growth must be sustainable, YKF has committed to measuring and reporting its greenhouse gas (GHG) emissions through the Airport Carbon Accreditation (ACA) program and is currently exploring ways to reduce and eliminate GHG emissions even as it grows.

About this Report

The purpose of this report is to present the GHG emissions reduction opportunities available to YKF both in the short-term and long-term. Short-term opportunities consist of "drop-in" ready actions that can implemented immediately with little to no capital investment. Long-term opportunities require more substantial capital investment and should align with the future development of YKF. A further section on Scope 3 emissions and stakeholder engagement focuses on positioning the airport as a strong sustainability partner for stakeholders.

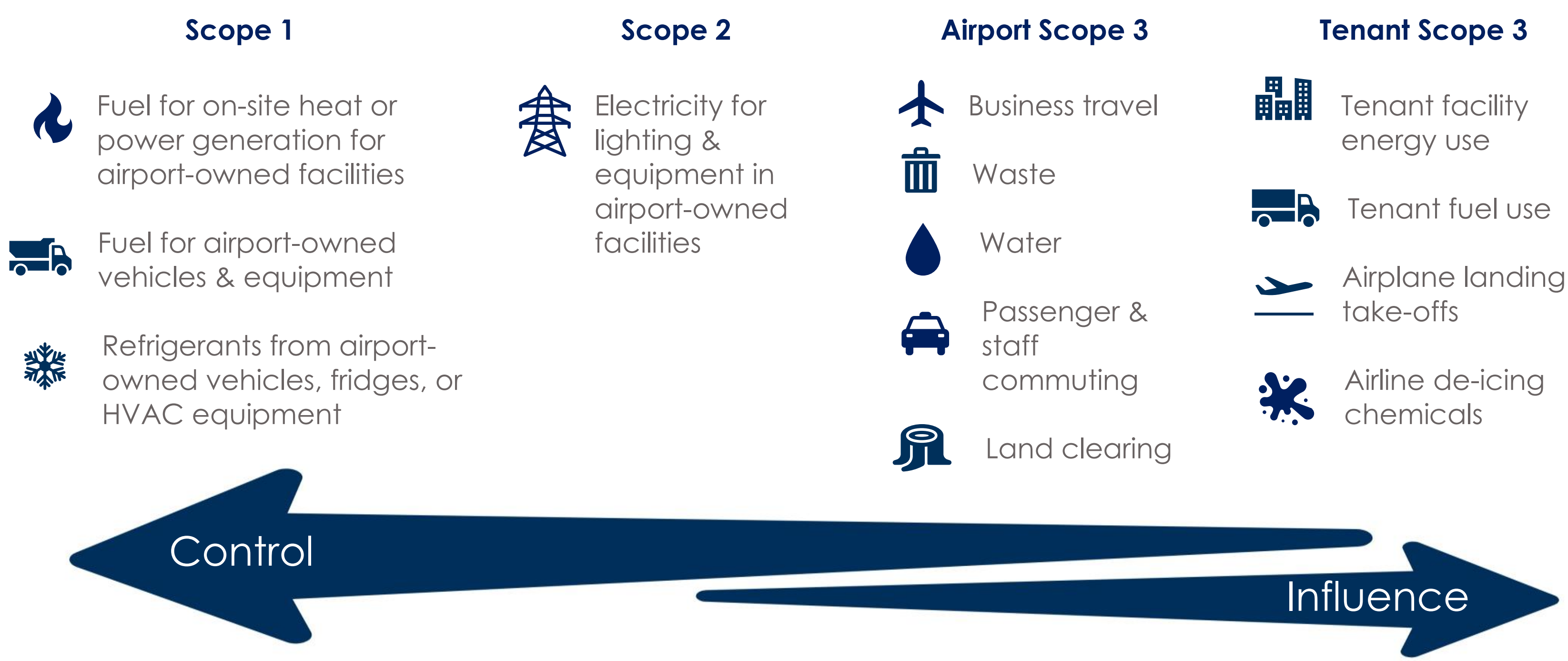
This report also recommends several GHG emissions reduction targets, with a goal of meeting or exceeding the targets set by the Region of Waterloo. Through its TransformWR Strategy, the Region has committed to two ambitious carbon reduction targets based on the emissions from a 2010 baseline. By 2050, the Region of Waterloo will have reduced its emissions by 80%. In the interim, the Region is targeting a 30% reduction by 2030.

Accounting for Emissions

Emissions are calculated in tonnes of carbon dioxide equivalent (tCO_2e), a universal value that synthesizes all six greenhouse gases into a single unit. The tCO_2e value for different GHGs is calculated based on their global warming potential (GWP) as established by the UN Intergovernmental Panel on Climate Change in their Sixth Assessment Report (UN IPCC, 2021).

Greenhouse gas emissions associated with airport activities are categorized into three scopes, in alignment with the GHG Protocol, ISO 14064-1 and the definitions of the Airport Carbon Accreditation program.

- **Scope 1** includes emissions from assets owned or controlled by the entity, such as gasoline from company vehicles or air conditioning units that release refrigerant gases.
- **Scope 2** includes emissions from energy purchased by the entity, such as electricity.
- **Scope 3** includes emissions from other indirect sources in assets owned or controlled by other entities, such as tenant energy use and business travel.



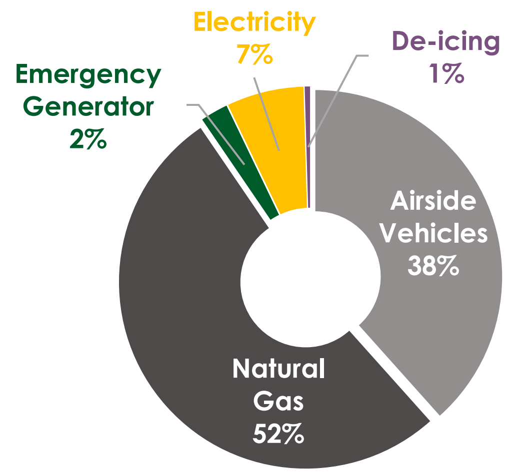
While the intention is to measure and reduce all airport emissions, Scope 3 sources are by definition controlled by other stakeholders and achieving Scope 3 reductions requires stakeholder engagement and participation. Therefore, GHG targets typically account for just Scope 1 and 2 emissions. As YKF has expressed interest in taking a leadership role in the community and for future involvement in the ACA program, Scope 3 emissions and reduction opportunities have been included in this report.

Emissions Profile

Scope 1 & 2 Emissions - Current

In 2021, The Waterloo Regional Airport's carbon footprint from Scope 1 & 2 emissions was 455 tCO_2e.

At 236.9 tCO_2e or 52% of the total, natural gas used for space and water heating in airport-owned and -operated buildings was the largest emissions source. The Terminal building and Firehall are the largest users of natural gas, consuming a combined 85% of the total 125,309 m^3 in 2021. Fuel (gasoline and diesel) used in airside vehicles was the second largest emissions source at 174.6 tCO_2e or 38% of the total. Purchased electricity for use by the airport generated 30.3 tCO_2e and is the third largest emissions source at 7% of the total. 4881 Fountain St N was the largest airport owned consumer of electricity at 75% of the total 2,514,044 kWh used in 2021. Emissions generated from emergency generators and de-icing chemicals are both under 5% of the total at 10.9 tCO_2e and 2.1 tCO_2e, respectively.



Emissions from refrigerants used in HVAC systems were not measured in 2021.

2021	2021	2021	2021
2.65 kgCO_2e/Pax	16.2 tCO_2e/FTE	3.41 kgCO_2e/aircraft	Total tCO_2e 455

Airport	ACA Level	Year	Passengers	Scope 1 & 2 Emissions (tCO_2e)	Emissions Intensity ($kgCO_2e$/PAX)
Honolulu	2	2021	5,808,303	50,000	8.608
Edmonton	1	2018	8,200,000	49,465	6.032
Saskatoon	1	2018	1,518,980	6,104	4.018
Waterloo	**1**	**2021**	**171,883**	**455**	**2.647**
Portland	2	2015	18,320,000	37,480	2.046
Atlanta	N/A	2014	96,178,899	190,000	1.975
Dallas	4	2021	65,726,296	129,157	1.965
Toronto	3	2018	49,500,000	89,130	1.801
Salt Lake City	2	2019	26,808,014	34,000	1.268
Los Angeles	3	2019	88,068,013	94,862	1.077
Ottawa	3	2019	5,106,487	5,020	0.983
San Diego	4	2021	15,600,000	5,920	0.379

Compared to other airports in North America who publicly report their carbon footprint, YKF's 2021 footprint ranked in the higher end of emissions per passenger. Differences in airport size and region contribute to the wide range of emissions intensities reported, as does the level of the Airport Carbon Accreditation Programme that each airport has achieved (generally airports who are further along in the program have lower emissions intensities, as they would have to demonstrate year over year emissions reductions in order to progress to levels 3 and 4). It should be noted that the data set includes a range of different reporting years, which limits the comparability of the figures. For example, YKF's 2021 emissions intensity is likely higher than it would typically have been, as the airport was grappling with significantly reduced passenger traffic in light of the COVID-19 pandemic.

In Spring 2022, YKF completed Phase 1 of a new Domestic Air Terminal Building. Phase 2 of the expansion is currently underway and scheduled for completion in mid-late 2023. Because of this construction activity, which will double the terminal's physical footprint, the 2021 emissions profile does not represent a current baseline.

Synergy reviewed electricity and natural gas invoices for 2022 and compared the values to 2021. With the completion of Phase 1 of the Domestic Air Terminal Building construction project, terminal natural gas use increased by 45% and terminal electricity use increased 22% year over year. With this additional energy use, while holding other emission sources constant, 2022 emissions are projected to be 511 tCO_2e, a 12% increase over 2021.

Building	Annual Consumption 2021 (kWh)	Annual Consumption 2022 (kWh)	% Change
4881 Fountain St N	**1,894,097**	**2,308,397**	**21.9% increase**
4685 Fountain St N	74,973	74,973	-
5015 Fountain St N	300,327	300,327	-
100 New Germany Lane	1,498	1,498	-
75 New Germany Lane (Main)	242,966	242,966	-
76 New Germany Lane (FP)	183	183	-
Total	**2,514,044**	**2,928,344**	**16.5% increase**

Building	Annual Consumption 2021 (m^3)	Annual Consumption 2022 (m^3)	% Change
Firehall	52,591	52,591	-
Hangar 6	4,878	4,878	-
Hangar 19	12,636	12,636	-
Maintenance Garage	1,547	1,547	-
Terminal	53,657	**77,629**	**44.7% increase**
Total	**125,309**	**149,281**	**19.1% increase**

2022

2.97 $kgCO_2e$/Pax

2022

18.2 tCO_2e/FTE

2022

3.83 $kgCO_2e$/aircraft

2022

Total tCO_2e **511**

Scope 1 & 2 Emissions – Future

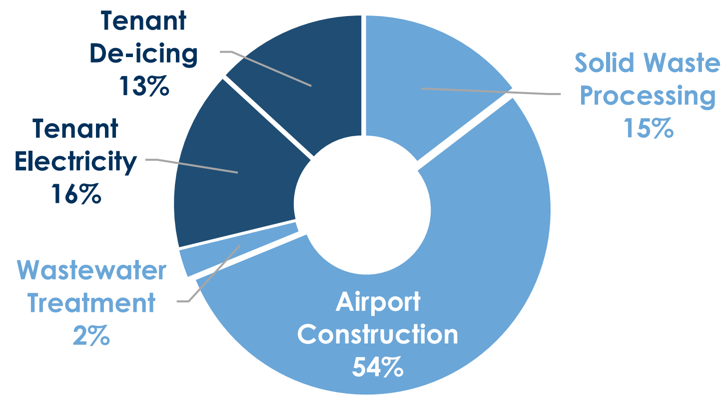
The Waterloo Airport continues to be one of the fastest growing airports in Canada. Over the next ten years the airport will undergo considerable infrastructure development in order to meet increased passenger demand. The result of growth may be a future carbon footprint that looks substantially different than what was measured in 2021.

The table below predicts changes in YKF's future emissions profile. Unless low-carbon alternatives can be found, emissions from natural gas for building heating and hot water and diesel and gasoline for the airport's fleet are projected to increase. This makes building heating and vehicle fuel the top decarbonization priorities for YKF.

Emission Source	Scope	Increasing Proportional to?	Significance	Notes
Natural gas	Scope 1	Building square footage	High	If natural gas is not phased out, consumption is likely to increase in line with additional terminal square footage and natural gas will remain the primary source of Scope 1 & 2 emissions at YKF.
Airside vehicle fuel consumption	Scope 1	# of vehicles / Aircraft LTOs	High	Similarly, if the airport fleet continues to run on gasoline and diesel, emissions from vehicles will grow proportional to the size of the fleet.
Emergency generators	Scope 1	Building square footage	Low	When the new terminal is built, new emergency generators will be required. However, they are not a significant emission source for the airport.
Airport de-icing	Scope 1	Runway square footage / Aircraft LTOs	Low	Emissions from airport de-icing will increase as the airport gets busier, however they will likely remain an insignificant portion of the footprint.
Airport purchased electricity	Scope 2	Building square footage	Medium	Electricity consumption is projected to increase significantly, especially as the airport adopts more electric equipment. However, emissions from electricity could be moderated procuring renewable electricity, either through the grid or through onsite generation.

Scope 3 Emissions - Current

Note: Scope 3 emissions are voluntarily reported at ACA Level 1 and YKF elected to complete a partial Scope 3 inventory for 2021. Emission sources not measured in 2021 include aircraft landings and takeoffs, passenger and staff commuting, and tenant energy use beyond electricity purchased from the airport.



In 2021, YKF generated a total of 208 tCO_2e from airport- and tenant-related Scope 3 emissions sources under measurement. Scope 3 emissions account for 31% of the airport's total 2021 carbon footprint.

At 112.8 tCO_2e, airport construction was the largest contributor of Scope 3 emissions. It is important to note that airport construction is a non-recurring source and will contribute to the carbon footprint only during years of construction activity. Purchased electricity from sub-metered tenants is the largest non-airport owned emissions source and the second largest Scope 3 emissions source at 32.5 tCO_2e (16%). Solid waste processing is a recurring airport owned scope 3 emission source that generated 30.4 tCO_2e in 2021. Emissions from airport de-icing activity came to 27.4 tCO_2e in 2021 and accounts for 13% of all Scope 3 emissions. YKF generated 5 tCO_2e from wastewater treatment in 2021.

Scope 3 Emissions – Future

Although not measured in 2021, emissions from aircraft landings and takeoffs are projected to be the most significant emission source at YKF, even after accounting for future development. Other significant Scope 3 emission sources included passenger and staff commuting and tenant energy use. These are the top decarbonization priorities for Scope 3 emissions.

Emission Source	Scope	Increasing Proportional to?	Significance	Notes
Aircraft Landings & Take Offs	Tenant Scope 3	Aircraft LTOs	High	This will likely be the largest emission source at the airport, even after accounting for future development.
Passenger & Staff Commuting	Airport Scope 3	PAX & Staff Numbers	High	Although not currently measured, emissions from passenger and staff commuting are also expected to be significant.

Emission Source	Scope	Increasing Proportional to?	Significance	Notes
Airport construction	Airport Scope 3	New terminal construction	High**	Airport construction will be a significant emissions source during years of major construction activity (e.g. Terminal expansion).
Solid Waste Processing	Airport Scope 3	PAX Numbers	Medium	Emissions from waste are a moderate portion of current scope 3 emissions, and will grow as the airport welcomes new passengers. Implementing some waste best practices could help keep waste emissions moderate (see page 14 for more details).
Wastewater Treatment	Airport Scope 3	PAX Numbers	Low	Emissions from wastewater treatment were just 2% of current Scope 3 emissions and are not expected to change significantly.
Other Tenant Energy Use	Tenant Scope 3	# Tenant Facilities	High	Tenant energy use, which includes fuel for vehicles, ground service equipment and boilers, is expected to be significant, especially as the number of tenants on airport lands grows.
Tenant sub-metered electricity	Tenant Scope 3	# Tenant Facilities	Medium	Tenant electricity use accounted for 16% of total Scope 3 emissions, and will grow as the number of tenants on airport lands grow. By providing tenants with access to renewable energy, emissions from tenant electricity can be reduced.
Tenant De-icing	Tenant Scope 3	Aircraft LTOs	Low	Emissions from tenant de-icing will increase as the airport gets busier, however they will likely remain an relatively small portion of the footprint.

Decarbonization Strategy

Synergy is proposing that YKF adopt three unique strategies for decarbonization – one for the short term, another for the long term and a third to manage Scope 3 emissions.

Short Term Strategy:

Focus on energy efficiency and drop-in replacements for existing equipment.

In the short term, as YKF continues its planned expansions to the terminal building and parking lots, the airport should focus on the "low hanging fruit" – actions can be implemented immediately with little to no capital investment. These include energy efficiency best practices like switching to LED lighting and improving heating efficiency, and procuring "drop in" alternatives to existing energy sources, including renewable natural gas and biodiesel.

Long Term Strategy:

Focus on electrification and on-site renewable energy production.

In the long term, with the construction of a brand-new terminal, YKF has the opportunity to make significant investments in low-carbon infrastructure and energy sources. The implementation of actions like phasing out natural gas in all buildings, electrifying the ground fleet and developing on-site renewables will ensure YKF realizes sustained growth at the airport while achieving emissions reductions.

Stakeholder (Scope 3) Strategy:

Position YKF as a strong sustainable aviation partner to airlines, flight school and tenants.

To manage Scope 3 emissions, in particular aircraft landings and takeoffs and tenant energy use, both of which are projected to be significant, YKF will have to work with tenants and other stakeholders. By engaging with them early, clearly communicating emissions goals and expectations, and exploring partnerships that advance innovations in low-carbon aviation, YKF will set itself up for successful Scope 3 emissions management.

Reduction Targets & KPIs

The Waterloo Airport aspires to set ambitious but achievable GHG emission reduction targets that align with the targets set by the Region of Waterloo. The Region has committed to a community GHG reduction target of 50% by 2030 and 80% by 2050 below 2010 levels.

Based on the current airport emissions profile, as well as projected trends in future emissions and the strategies and opportunities identified in this report, Synergy is recommending two options for the 2030 target – an intensity target and an absolute target. An intensity target reflects GHG performance improvements while considering organizational growth. Using an intensity target is more straightforward in a high growth period (see the Note about the Baseline Year box) and allows for better comparisons to other airports. However, it is less ambitious than an absolute target, and it does not guarantee absolute emissions reductions will be achieved.

Option 1: Intensity Metric

2030 Target Option 1: 50% reduction in Scope 1 and 2 emissions per passenger by 2030, compared to the 2021 baseline.

This target could be achieved by continuing with energy efficiency measures and fleet electrification. It would likely require either the addition of biodiesel to the airport's fleet, or the purchase of RNG credits.

Option 2: Absolute Reduction

2030 Target Option 2: 50% Reduction in Scope 1 and 2 emissions by 2030, compared to the projected 2023 baseline.

To hit this target, YKF would need to decrease emissions substantially over a seven-year period. This could be achieved through a combination of energy efficiency measures (~5% reduction), fleet electrification (~10% reduction), and biodiesel or RNG (remainder).

A Note about the Baseline Year

GHG accounting best practice states that the baseline year for an absolute target should be a "like for like" comparison to the target year. This means that the baseline year should represent the same organizational and operational structure as the target year, and in the event of major structural changes (such as building a new terminal), the baseline year should be re-calculated.

This means that if the airport chooses an absolute target, the baseline year should be 2023, the first full year in which the new Domestic Arrivals Terminal was operational.

Given the significant opportunities to reimagine airport energy infrastructure over the next few decades, Synergy is recommending YKF set the following 2050 target.

2050 Target: 80% Reduction in Scope 1 and 2 emissions by 2050, compared to the projected 2023 baseline.

Decarbonization Opportunities – Short Term

Short-term decarbonization opportunities are "drop-in" ready solutions that are intended to improve efficiency, reduce consumption, and encourage sustainability best practices. They can be implemented immediately, with little to no capital expenditure. Although reductions in greenhouse gas emissions from the short-term opportunities will be achieved, the overall impact on YKF's carbon footprint will be minor, as they will be counteracted by airport growth.

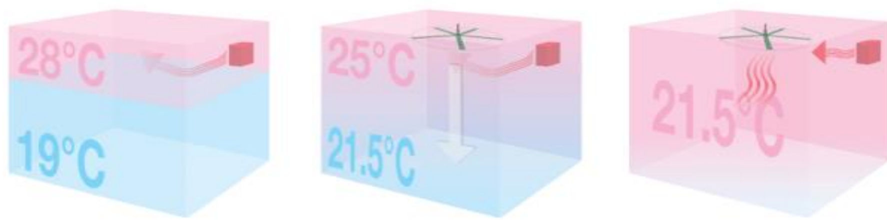
Energy Efficiency & Sustainability Best Practices

The following table lays out a series of recommended energy efficiency and sustainability best practices.

Area	Reduction Opportunity	Notes	Example in Practice
Energy Efficiency	**Finish upgrading lighting to LED (e.g. in the FEC)**	• LED lighting can reduce energy consumption and maintenance costs as compared to incandescent lighting (Program, Airport Cooperative Research, 2016)	**Buildings**: Miami Airport- 63% energy savings in cargo areas from switching metal halides to LED
Energy Efficiency	**Install motion sensor lights in hangars and the AOC**	• Motion sensors are particularly helpful in spaces that are infrequently used (e.g. hallways, washrooms and electrical room).	Adaptive Corridor Lighting Case Study University of California San Francisco: • 53-68% reduction in energy use in hallways
Energy Efficiency	**Check the phantom loads of appliances and electrical equipment**	• Use consumption meter to test • Use a timed power bar to automatically turn on and off electronics at set times during day	
HVAC Efficiency	**HVAC motor retrofits with Turntide Smart Motor System™**	• Turntide Smart Motor System™ is a drop-in upgrade to HVAC units that improves the energy efficiency of existing HVAC units.	Big Box Retailer: • HVAC Rooftop Unit Energy Savings-78% • 44,869 kWh annual energy reduction • Estimated ROI under 5 years
Heating Efficiency	**Building Automation System**	Enbridge runs a Commercial Custom Retrofit Program: Eligible projects can receive 50% of energy efficiency upgrade costs	

Area	Reduction Opportunity	Notes	Example in Practice
Heating Efficiency	**Minimize heat loss from open doors**	• Encouraging staff to not leave exterior doors open can prevent heat loss	
Heating Efficiency	**Ensure rooms are not being heated when empty**	• Programmable thermostats can be used to align heating with working hours	
Heating Efficiency	**Ensure window seals and building insulation is sufficient**	• A well-sealed building can reduce energy costs by 15%[2] (Energy Star, n.d.)	The Canadian Coalition for Green Health Care: Assessment of Window Replacement Project: Saved an estimated 75,557 liters of fuel oil for heating in the Weeneebayko General Hospital
Heating Efficiency	**Reduce heating temperature in vestibules**	• High heat loss in the area, as doors to outside opening frequently. Passengers are moving through quickly, and usually still wearing coats, so heating is unnecessary	
Heating Efficiency	**Install High Volume Low Speed (HVLS) fans in buildings with high ceilings e.g. aircraft hangars and warehouses**	• Air stratification is a main cause of heat loss in hangars (Figure 1) (Northern Dock Systems, 2021) • Recirculating air can reduce heating costs by 20-30 % (Table 1) (Taber & Steele, 2020)	See the case study in table 1 below.
Heating Efficiency	**Install a wastewater energy recovery system**	• There is significant energy lost when heated water is discharged as wastewater. • Wastewater recovery systems capture the energy from the water and recirculate it to be used in heating and cooling equipment or to pre-heat the incoming water supply	Sharc Energy: DC Water Administrative Building • Wastewater energy recovery system reduced heating demand by 244.7 GJ/ year
Water Efficiency	**Install low-flow aerators into all faucets to reduce water consumption**	Aerators can reduce water consumption in bathrooms and kitchens and are easy to install	
Water Efficiency	**Ensure airport staff and tenants regularly check for leaks**	• Improperly running toilets and urinals can waste 1,000's of L of water annually (Capital Regional District , n.d.). • Ensure staff and tenants are aware of whom to report issues with leaky fixtures	

Area	Reduction Opportunity	Notes	Example in Practice
Water Efficiency	**Upgrade any urinals, toilets, water consuming appliances to low flow and ENERGY STAR models**	• Upgrades in toilets and urinals to low-flow alternatives often have short payback periods	
Waste Reduction	**Ensure waste bins are well-labeled with symbols indicating types of acceptable waste.**	• Clear labelling with pictorial examples minimizes the prior knowledge and decision making required when disposing of waste.	OSCAR Sort: • Is an Artificial Intelligence waste sorting platform that through a camera and display screen informs users which waste stream to use.
Waste Reduction	**Engage with staff and tenants to run a monthly waste diversion contest**	• Friendly competition can be an easy way to gain active participation in sustainability initiatives	Waste Wars YVR • YVR hosts waste diversion challenges among Food and Beverage tenants



No HVLS fan system	HVLS Fan system turned on	HVLs Fan system running
Heating system causes air stratification	Air stratification begins to breakdown	Room is uniform in temperature

Figure 1. Heat stratification with and without ceiling fans[4]

- **RECOMMENDATION:** Implement energy efficiency best practices, and explore minor building retrofits, including equipment like the SHARC wastewater heat recovery system and the Turntide Smart Motor System™

Case Study::

HVSL fans used at an aircraft hangar in Frankfurt, Kentucky [4]

	HVLS Fan OFF	HVLS Fan ON
Total Use (GJ)	37.94	26.25
Total Cost	$ 276.52	$ 191.33
Total tCO_2e	1.89	1.30
Efficiency Improvement	0	30 %

Table 1 Summary of gas heater use in aircraft hangar with installed HVLS fans (values were converted to GJ from ft³)[4].

Renewable Natural Gas

Renewable natural gas (RNG) is a drop-in low-carbon energy alternative that replaces fossil-based natural gas. Once it has been captured and cleaned, RNG is chemically equivalent to natural gas that has been extracted from fossil reserves; the only difference is that RNG is produced from waste biomass, a renewable resource. Common RNG feedstocks include crop residues, captured landfill gas (LFG) and biogas created during wastewater treatment. As the source material for RNG is organic, the feedstock absorbs carbon dioxide as it grows and there is no net addition of carbon into the atmosphere from its combustion. Therefore, carbon dioxide emissions generated from the combustion of RNG are considered biogenic and are not included in Scope 1 emissions.

Case Study: RNG at YUL

In 2020, Montréal-Pierre Elliott Trudeau International Airport (YUL) included purchasing RNG as part of its carbon reduction measures. By purchasing 50,000 m^3 of RNG, YUL recorded a 2% reduction in 2021's stationary source emissions from their 2015 baseline.

A study examining the renewable natural gas feedstock potential in Canada concluded that agricultural areas in southwest Ontario are among the highest for RNG feedstock capacity in the country. This is due to the large corn-producing industry generating agricultural residues like corn silage and stover (Torchlight Biresources, 2020). Despite its favorable location, the airport itself does not have any opportunities to produce RNG onsite, as it does not deal with large volumes of waste biomass, nor does it operate its own landfill or wastewater treatment system. The Region of Waterloo, however, currently captures biogas from its wastewater treatment facility, which is used to power the treatment plant, and has indicated their intention to explore potential future renewable gas production at the Waterloo Landfill.

The airport's current natural gas supplier, Enbridge, is involved in several renewable natural gas projects across Ontario and has been actively integrating RNG into its natural gas pipeline network. For example, in October 2022, Enbridge helped Stanton Farms in Ilderton, Ontario, become Ontario's first agriculture-based RNG supplier (Enbridge, 2022). Enbridge also worked with the City of Hamilton to pilot "Ontario's first carbon-negative bus", which runs on 100% RNG captured from StormFisher's Biogas Facility in London, Ontario.

Because natural gas is distributed via a pipeline network, when consumers purchase RNG, they do receive a physical delivery of a different natural gas product. Instead, RNG is injected into the pipeline network on the consumer's behalf, and a crediting system is set up to allow the consumers to "claim" the emissions reductions associated with that RNG. These credits are known as Renewable Energy Credits (RECs).

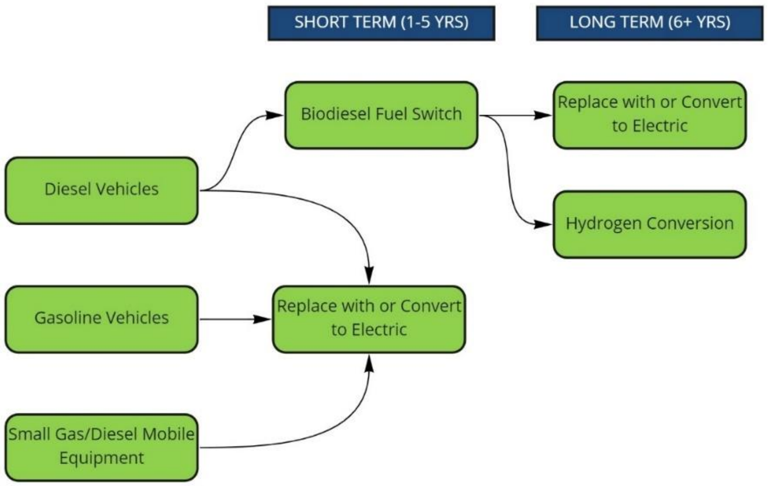
Enbridge currently offers a program called "OptUp", in which residential natural gas users pay a premium of $2/month to support increased RNG supply across the province. The program is also available to commercial account holders. However, it is not marketed as a renewable energy certificate, and it is unclear whether participating in the program would allow YKF to claim the reductions associated with the airport's RNG purchases. Instead, YKF could purchase RNG certificates from an alternate supplier, such as Bullfrog Power. Bullfrog sells "Green Natural Gas" credits for $4.90/GJ. Based on YKF's 2021 natural gas consumption, which totaled 4,674 GJ, it would cost an additional $22,902 per year to offset 100% of the airport's natural gas usage.

➢ **RECOMMENDATION:** Use RNG credits to offset the impact of natural gas in its existing facilities

One benefit of the credit approach is that it is flexible; YKF could scale RNG credit purchases up or down in order to ensure it can meet its GHG reduction targets. Depending on the volume of credits purchased, this action could eliminate up to 50% of YKF's Scope 1 and 2 carbon footprint.

Biodiesel

Biodiesel is a drop-in alternative to petroleum-based diesel that has the same stability and cold-flow performance. Natural Resource Canada reports that biodiesel-powered engines generate comparable torque and horsepower as diesel-powered engines.



Common feedstocks for biodiesel include plant oils, waste cooking oil, animal fats and biomass. Because of the range of different feedstocks, each of which has unique agricultural impacts, as well as variations in how biodiesel is processed, refined and transported, some biodiesel results in more significant GHG reductions over the lifecycle of the fuel than others. From a GHG perspective, biodiesel from waste feedstocks such as waste animal fats or agricultural waste is the most preferred, followed by biodiesel from local sources.

Biodiesel can be blended with regular diesel to reduce Scope 1 emissions within the YKF fleet. Biodiesel blends can range from B2 (2% biodiesel, 98% diesel) to B100 (100% biodiesel). Biodiesel is still a carbon-based fuel so burning it does produce carbon emissions. These emissions, however, are considered biogenic[1] and are reported separately from Scope 1 emissions.

The Region of Waterloo, which manages the airport's ground fleet and purchases fuel on the airport's behalf, has established a plan for electrifying several utility terrain vehicles (UTVs) and pickup trucks in the next ten years (for more information, see the Electrification section on page 19). However, several diesel-powered units within the airport's fleet will be challenging to replace with electric models in the short term due to their specialized nature and power demand. As an interim solution, biodiesel can provide significant fossil emissions reductions while utilizing existing vehicles and equipment.

Case Studies: Biofuels at STL & the City of Toronto

79% of St. Louis International Airport's ground fleet and equipment is powered by alternative fuels like biodiesel and CNG (FlyStl, 2018)

The City of Toronto Fleets Service Division has integrated B5, B10 and B20 into its Sustainable Fleets Plan (SFP). A published status update reported that the consumption of biofuels resulted in a combined GHG reduction of 893 tCO_2e in 2020 (City of Toronto Fleet Service Division, 2021).

Most diesel engines can utilize up to B100 (100% biodiesel) as a drop-in fuel. Some new vehicles may have warranty stipulations that will void coverage if biodiesel is used above a certain fuel content. Be sure to check warranties of newer diesel vehicles before utilizing biodiesel. Often there is a "break-in" period due to the natural detergent properties of biodiesel. This can result in poor engine performance, reduced fuel economy, and sootier exhaust in the short term as the biodiesel cleans out existing carbon deposits within the engine.

After this period, B100 biodiesel reduces fossil carbon emissions by 97-98% and reduces emissions of criteria air pollutants such as diesel particulate matter and black carbon. Fossil carbon emission reductions roughly track the biodiesel content in the fuel, so the percentage of biodiesel in the blend can be loosely used to determine emissions reductions.

Biodiesel also gels at higher temperatures than traditional diesel, making it challenging to use in the winter months. To avoid this situation, consider scaling up biofuel use in the summer months, and reducing it in the winter months.

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[1] *Biogenic carbon is categorized as carbon that is extracted from natural sources such as plants and animals (in contrast to carbon from fossil reserves), and so does not add additional carbon to the short-term carbon cycle. Other examples would be burning wood or land use changes.*

The Region reported having discussions about the use of biodiesel several years ago, however due to the performance and operational concerns described above, it was not pursued. Although consideration must be given to the concerns, biodiesel is a proven alternative that has been used in many airport use-cases, and a good transitional fuel that can reduce the airport's emissions in the short term. Equipment within the airport's fleet that would be good candidates for biodiesel are the loaders/bobcats, tractors and mowers, as they are fairly heavily utilized in the summer months.

Conestoga Meats, which operates a meat packing plant adjacent to the airport lands, produces large volumes of waste animal fats that are currently sold to a biofuel production plant in Louisiana. This points to an excellent opportunity to localize biofuel production, and the potential to host a biodiesel plant on the airport lands. The first step could be a research project or feasibility study in collaboration with Conestoga Meats and the University of Waterloo.

There are many biodiesel providers in Southern Ontario (this website and this one both provide a comprehensive directory), and the Airport's current fuel provider should be able to procure adequate quantities of biodiesel, which can be mixed directly with the airport's diesel fuel. Alternatively, a biodiesel-only fueling station could be located on site. In addition to serving airport-owned equipment, this station could also support the reduction of Scope 3 tenant emissions by making biodiesel available for tenant vehicles.

- **RECOMMENDATION:** Talk to the Region about procuring biodiesel for the airport's heavy fleet.

Decarbonization Opportunities - Long Term

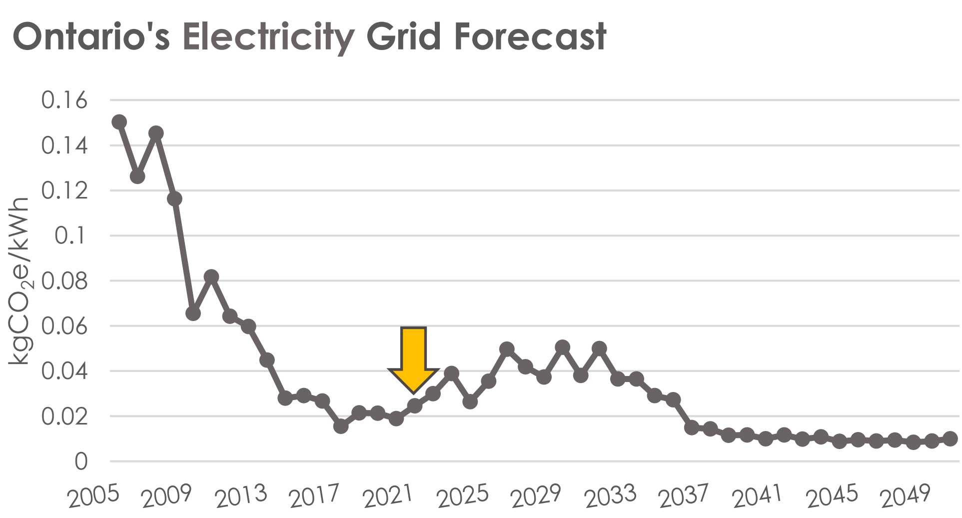
To achieve meaningful emissions reductions that will keep pace with GHG targets, decarbonization efforts must go beyond fuel switching and efficiency upgrades towards phasing out fossil fuel-based systems entirely. The development of a new terminal building offers an opportunity to make this transition. The following strategies are also in line with the Region's commitment to design all new Regional buildings to produce net-zero operational carbon.

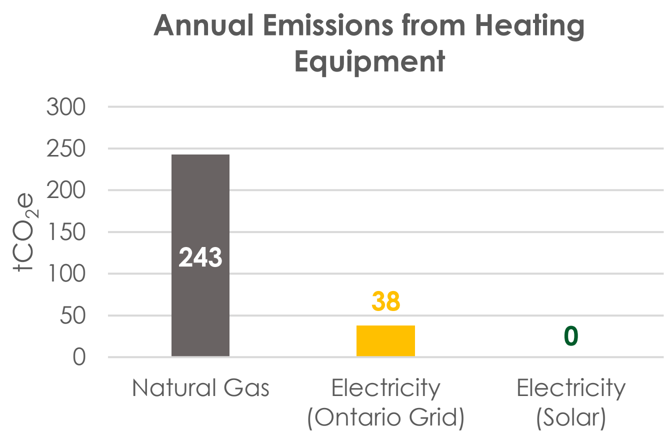
Electrification

In the long-term, the electrification of YKF's building heating, hot water systems, and ground fleet is one of the best opportunities to reduce and avoid GHG emissions at the airport.

As outlined in the Transform WR, The Region has committed to increasing electrification as part of its transition away from fossil fuels. By 2030 the Region intends to have 20% of buildings using electric heat pumps (or equivalent systems) and 85% of buildings by 2050. Additionally, the Transform WR has committed to 50% of gasoline and diesel vehicles be zero emission by 2030 and 99% be ZEV by 2050.

As fossil fuel systems are taken offline, the airport's electricity consumption will increase. Currently, Ontario's electricity grid is relatively clean due to the prevalence of nuclear power across the province (Ontario's grid emissions intensity in 2022 was 0.025 $kgCO_2e/kWh$, compared to Alberta's grid at 0.620 $kgCO_2e/kWh$ or Saskatchewan at 0.660 $kgCO_2e/kWh$). The figure to the right outlines the forecasted emissions for Ontario's power grid to 2050 (Canada Energy Regulator, 2021). Emissions from electricity are forecasted to rise from now until 2035 as Ontario transitions away from nuclear power. By the late 2030's, utility-scale renewable energy in Ontario will be prominent and electricity emissions will reduce once more.





Despite these fluctuations in future grid emissions intensity, electrification is guaranteed to lead to emissions reductions. For example, if YKF were to switch all existing natural gas heating to electric heat pumps powered by the Ontario grid, the airport would consume 985,850 kWh more electricity per year, but annual emissions from heating would be 84% lower, a reduction of 205 tCO_2e (approximately 45%) in the airport's Scope 1 and 2 footprint. If YKF could power those heat pumps with electricity from 100% renewable energy, emissions from heating could be eliminated entirely.

Note: The above calculation assumes an average natural gas heating efficiency of 65% and an electric heating efficiency of 90%. Ontario grid emissions are calculated based on the average expected grid emissions intensity from 2022 to 2030.

➢ **RECOMMENDATION:** As natural gas space heaters and boilers reach their end of life, replace them with high efficiency air source heat pumps and electric boilers.

The Region of Waterloo, which manages the airport's ground fleet, has the following 10-year plan for electrification and charging infrastructure at the airport (the airport currently has an EV charging station at the short-term parking lot, and one for the electric baggage tug in the outbound baggage area). Focusing on vehicles with electric alternatives currently available on the market, this plan could reduce up to 20% of YKF's fleet emissions, depending on the utilization of electric equipment. This would translate to a total decrease in Scope 1 and 2 emissions of 8-10%.

Year	Vehicle Type	Quantity	# Charge Stations
2024	UTV	2	2
2027	Pickup	1	1
2029	Pickup	1	1
2030	Pickup	1	1
	TOTAL:	**5**	**5**

Although electric alternatives are not currently available for the majority of the airport's off-road vehicle fleet, the next decade is likely to bring many new options to market. Manufacturers across all vehicle and equipment industries are scaling up research, development, and deployment of all-electric offerings. Companies like Volvo have various classes of electric heavy-duty trucks available, such as the Volvo VNR straight truck, which is a severe duty platform available in 4x2 and 6x4 configurations. It can be used for plow trucks, fuel trucks, garbage trucks, and the like (Volvo North America, 2022).

Alternatively, hydrogen is an increasingly attractive fuel for use in large equipment where the weight associated with large battery packs is currently not feasible. Vehicles and equipment powered by hydrogen fuel cells and electric motors (FCEV) have the same performance and emissions benefits of battery-electric vehicles while also allowing for easy and fast refueling where fuel is available.

Most major equipment manufacturers are investing in research and development of FCEVs, and they are regarded by many as the superior option for non-passenger vehicles and equipment. At the same time, several countries, including Canada and the USA, have released comprehensive hydrogen strategies that clearly define hydrogen as a key component of decarbonizing the transportation sector.

- **RECOMMENDATION:** Electrify the airport's ground fleet according to the Region's electrification plan and consider hydrogen-powered options for heavy equipment.

Renewable Energy Production

Many airports are beginning to generate renewable energy on-site as a way to increase their energy security and resilience and reduce GHG emissions. While these large-scale energy infrastructure projects require capital investment, it is possible to realize significant savings in energy costs with the right system and application. For airports who do not have the capacity to manage utility-scale powerplants, partnering with a company that specializes in renewable energy financing, development and operations is recommended.

Solar

Solar photovoltaic (PV) panels are an excellent fit for YKF due to their low cost. According to the International Energy, "Solar PV is becoming the lowest-cost option for new electricity generation in most of the world, which is expected to propel investment in the coming years." (International Energy Agency, n.d.)

Using the National Renewable Energy Lab's (NREL) PVWatts Calculator, Synergy has estimated the potential for electricity production through rooftop PV panels on the airport-owned Terminal building and Hangar 53. Electricity potential was also estimated for Parking Lot 4, assuming a canopy style system is installed over the parking spaces (VCT Group) is a local company that designs solar canopies). Annual electricity production potential for all three systems is **3,108,139 kWh** which accounts for 124% of YKF's 2021 electricity consumption (table below).

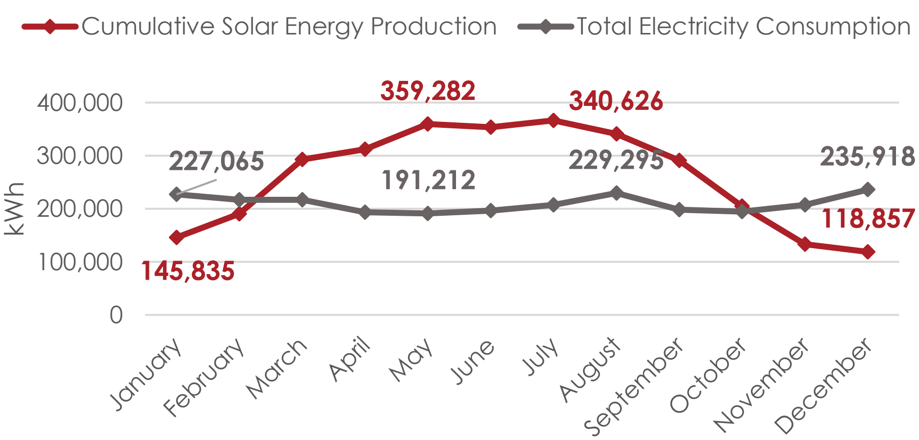
The electricity production potential for a rooftop solar system on the new terminal was also calculated based on the proposed phase one footprint and location included in the Terminal Feasibility and Site Selection Study. Estimated annual electricity production potential for the proposed terminal site is **2,543,089 kWh**.

It is important to note that solar electricity production exceeds consumption between the months of March and October but falls short of required consumption in the winter months. To supplement solar energy production, battery energy storage and/or electricity from Ontario's grid will be needed.

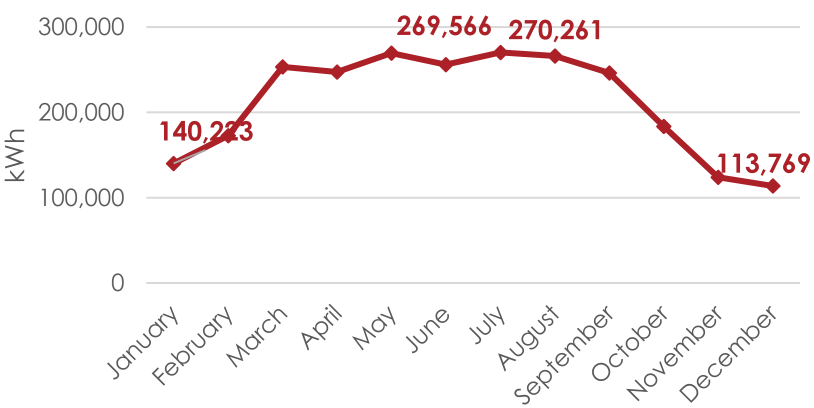
Note: See the Appendix B for the methodology of estimating electricity production potential

Property Name	Electricity Production Potential (kWh)	Consumption (kWh)
4881 Fountain St N Terminal Building	458,255	1,894,097
5015 Fountain St N (Hangar 53)	873,152	300,327
Parking Lot 4	1,776,732	N/A
Other Airport Electricity Buildings	N/A	319,620
Total	**3,108,139**	**2,514,044**
Proposed Location for New Terminal Building	2,543,089	TBD

Electricity Production Potential and Consumption of Airport Owned Buildings



Electiricty Production Potential at Proposed New Terminal Location



A potential option for YKF in integrating a solar energy system is to establish a load displacement project with their power provider Enova Power. In a load displacement project, YKF would maintain a connection to the grid for periods were supplemental power is needed, but all power created from the generation facility (solar panels) would be retained onsite. Any excess energy generated from the solar panels would be diverted to a battery energy storage system (BESS) to be used by YKF during times of low solar production like during the night. An advantage of a load displacement system is flexible energy management where the batteries can be deployed to lower YKF's need for grid power during periods of peak gird energy demand, resulting in lower energy costs. A load displacement project may also improve energy resiliency and lower emergency generator use at the airport by providing power from the batteries during power outages.

Microgrids are a similar opportunity to load displacement projects in that the airport generates and consumes onsite renewable energy that may also be stored in battery energy storage systems for future use. A distinction between the microgrids and load displacement projects is that energy generated for the solar panels in a microgrid may be transferred back to the grid during peak power demand.

Case Studies: Solar Energy Microgrids at Airports

Redwood Coast Airport (2022)

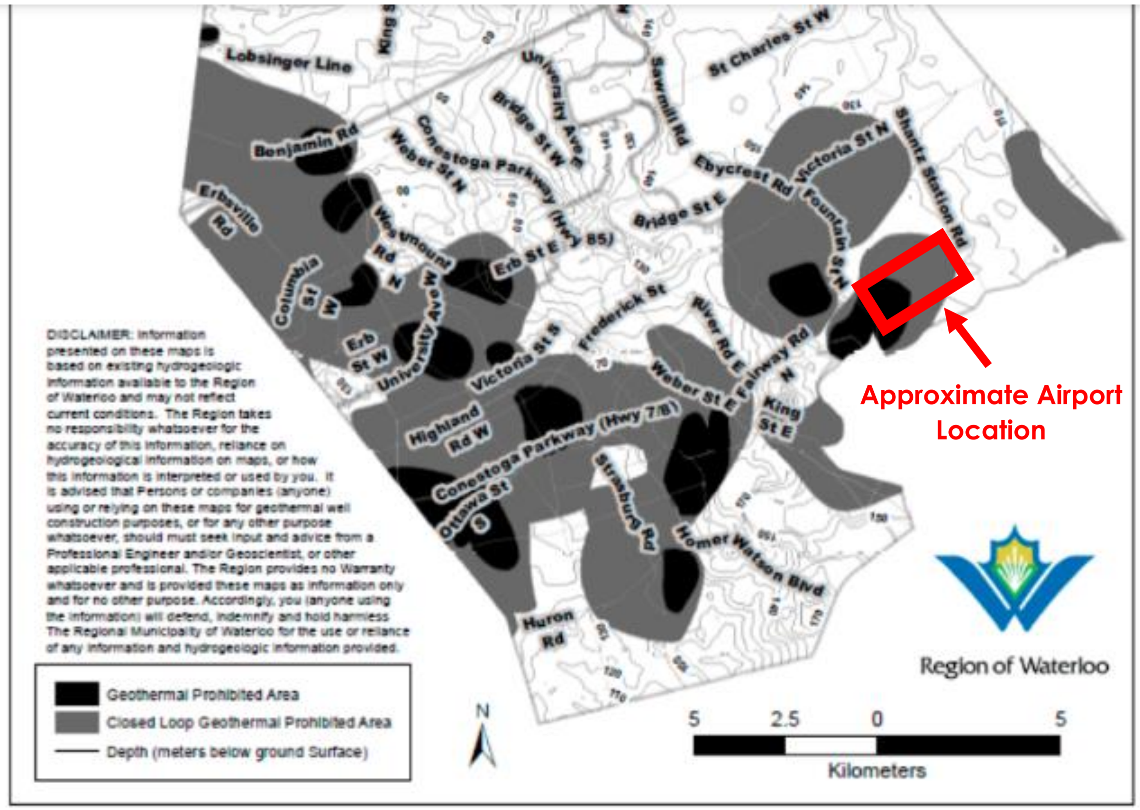
250 kW net metered system to offset airport electricity usage
2.3 MW solar array to feed into the grid
2 MW Battery energy storage system
Microgrid controller enables the system to island itself from the grid during a power outage

JFK Airport (2026)

7.7 MW rooftop solar array
3.7 MW of fuel cells (RNG + green hydrogen compatible)
2 MW Battery energy storage system
4 power islands (solar panels, storage, and automation controls

- **RECOMMENDATION:** Consider adding a solar canopy to the new Parking Lot 4 area.
- **RECOMMENDATION:** Conduct a solar feasibility study for the existing terminal and the new terminal.

Geothermal & District Energy



Geothermal is another attractive renewable energy option as it can be used to cover both heating and cooling energy loads. It pairs well with solar PV, which provides electricity.

In November, 2021, WR Community Energy commissioned a report that investigated the opportunity for open loop geoexchange (geothermal) systems in the Waterloo region. The report noted that the area is uniquely suited to open loop geoexchange systems due to the prevalence of major bedrock and overburden aquifer systems. However, geothermal systems must be sited at a sufficient distance away from aquifers used for municipal water supply, to avoid disrupting or contaminating drinking water.

The airport lands are located within established wellhead protection areas. In particular, according to the Terminal Feasibility and Site Selection Study, the proposed new terminal location is in an area identified as "having a low intrinsic vulnerability score, well head protection area C (WHPA-C) with a vulnerability score of 4 and significant groundwater recharge area (SGRA) with a vulnerability score of 2. There are no highly vulnerable aquifers (HVAs) within the airport lands.".

From maps included in the WR Community Energy report, it appears that the airport is mostly located within a "geothermal prohibited area". However, the Region does allow some shallow horizontal closed-loop systems and some vertical open-loop geothermal systems within well head protection areas, provided a study assessing the potential for negative impact has been conducted. To determine whether the airport lands are suitable for geothermal development, the airport should consult with Water Services staff at the Region.

The WR Community Energy report also noted that "the suggested minimum threshold for open loop heating and cooling of buildings in the commercial, industrial and institutional sector includes:

- a building size of at least 5000 m^2 ;
- a property size of 10,000 m^2 , or more; and
- a minimum well capacity in the order of 10 L/s"

This points to the opportunity for a District Energy System that would connect the airport to other industrial energy users in the vicinity, such as the new Conestoga Meats plant that has been proposed. In a District Energy System, users share heating and cooling loads, maximizing energy efficiency.

- **RECOMMENDATION:** Consult with the Region's Water Services department to determine the viability of either an open loop vertical or a closed loop horizontal geothermal system at the new terminal site.

Decarbonization Opportunities – Scope 3 & Stakeholders

Construction

The construction of the new terminal building will be an extensive project, likely requiring some land clearing activity and considerable building materials. Waste materials will be generated throughout the build. YKF should look to engage with construction contractors about implementing decarbonization actions throughout the different phases of construction.

- **RECOMMENDATION:** For existing buildings, roadways or vegetation that are to be removed, look for deconstruction and reuse opportunities before recycling. Examples of deconstruction and reuse opportunities include:
  - Dimensional lumber to concrete forms and back-framing
  - Concrete foundation and asphalt crushed and used as road base
  - Vegetation debris (trees and stumps) chipped for landscaping mulch or used as biofuel feedstock

- **RECOMMENDATION:** As part of the contract with construction contractors, ensure they will have a recycling system in place to collect different types of construction waste.

- **RECOMMENDATION**: Look to source sustainable building supplies
  - Choose environmentally preferred flooring options:
    - Salvaged wood from wreck homes & commercial demolition sites
    - Recycled tiles made from discarded glass or porcelain (easy to replace worn sections and uses less glue – better air quality)
    - Rubber flooring (100% renewable resource)
    - Bamboo, recycled cork, coconut timber & natural linoleum (biodegradable/non-toxic)
  - Utilize locally processed materials to reduce emissions from transportation and source from recycled or rapidly renewable materials.
  - Use non-toxic, or low/ no VOC sealants, paints, and finishes. Select products that meet Green Seal certification, Green Guard certification, or MAS Certified Green.
  - Use salvaged materials to create furniture, coverings, or other décor items.
  - Source timber from sustainable managed forests (FSC Certified).

Sustainable Aviation Fuels

Although not currently measured, emissions from aircraft landing and takeoff cycles are expected to be the single largest source of emissions at YKF. Because of their significance to the overall footprint, they are a critical component in YKF's decarbonization strategy, even though the airport has limited control over their production.

Many airlines are looking at reducing the GHG emissions of their current fleet using sustainable aviation fuel (SAF). SAF can be used as a drop in fuel in all major aircraft and is becoming available in increasingly large quantities.

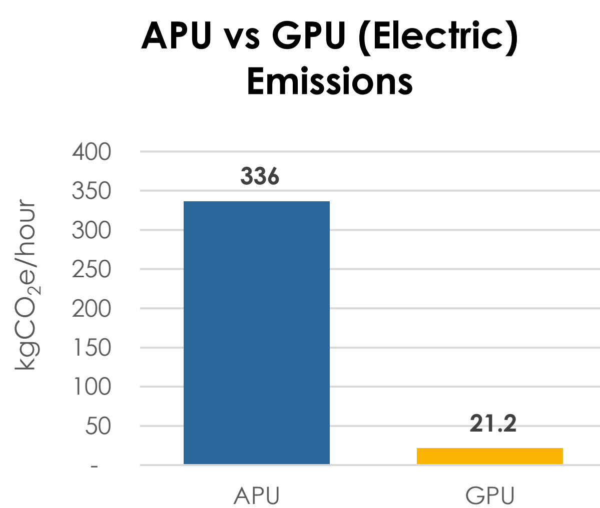
Canada's Aviation Climate Action Plan 2022-2030 includes the following "aspirational target": 10 per cent of airline fuel should be sustainable and derived from nonpetroleum sources — like forestry or agricultural waste, used cooking oil or green hydrogen — by 2030. Forecasting widespread adoption from 2030 onwards, the plan projects that 70% of aviation fuel will be SAF by 2050, representing a reduction of the aviation sector's emissions of up to 46.5% (Transport Canada, 2022).

West Jet used an SAF blend in all flights between Calgary and San Francisco from November 2022 to January 2023. The SAF was purchased from Neste, the world's largest SAF producer (Neste, 2023); San Francisco Airport purchases SAF from Neste, enabling the use of the fuel blend on this route.

Neste, along with other SAF producers, are planning to ramp up production significantly in the coming years – Neste expects to increase production by 15x in 2023, resulting in annual production volumes of over 1.8 billion litres (Neste, 2023). YKF has an opportunity to partner with Neste, bringing a supply of SAF to the airport, where it can be on sold to airlines. The use of SAF is a cornerstone of decarbonization for all major airlines, so not only will the availability of SAF at YKF support the decarbonization goals of the airline industry, but it will also make YKF a more attractive airport for airline tenants. This can be particularly effective for airlines with a goal of becoming "Canada's greenest and most sustainable airline" (Flair Airlines, 2022).

Electric Aviation

In November, 2022, the Waterloo Wellington Flight Centre, which is based at YKF, and the Waterloo Institute for Sustainable Aeronautics (WISA) at the University of Waterloo received the first electric training plane in Canada, the Pipistrel Alpha Electro. This is an early example of another trend in sustainable aviation – all-electric aircraft. YKF should continue supporting and encouraging the use of electric aircraft for its tenants by providing them with electric charging infrastructure.



Increasing air traffic at the Airport will result in increased demand for ground power unit (GPU) connections as an alternative to aircraft running fuel-powered auxiliary power units (APUs). Regulations are also likely to require consistently greater use of GPUs, where available, since GPUs are much less GHG-intensive than running APUs (see the figure to the right). While the current apron does not have sufficient electrical capacity to support GPUs, GPUs should be integrated into any new apron infrastructure.

➢ **RECOMMENDATION:** Install GPUs on the new apron and sub-meter airline tenants for the electricity consumption

Hydrogen Fueling & Hydrogen Production

As the airline industry decarbonizes, one alternative that is being heavily researched is hydrogen-electric powertrains, comprised of hydrogen fuel cells and electric motors. Companies such as ZeroAvia have successfully tested hydrogen-electric planes this year (2023) (Crownhart, 2023), with major airlines investing in the technology and establishing MOUs for future purchases (ZeroAvia, 2022). Hydrogen aircraft are still years away from being used for long commercial routes, but they are likely to be a major opportunity for regional flights, particularly for routes using planes with a capacity of 30 or fewer passengers.

The airport has several opportunities to support the adoption of hydrogen among regional carriers. One route would be to invest in hydrogen storage and fueling infrastructure, which would provide local carriers wishing to switch to hydrogen with a regional fueling hub. The Airport could also explore opportunities to produce hydrogen on site, using excess renewable energy generated by solar PV during the summer months to power the production of green hydrogen using electrolysis.

Edmonton International Airport (EIA) recently announced a collaboration with ZeroAvia to make EIA a hub for enabling zero-emissions flights in Canada (ZeroAvia, 2022), and the Calgary Airport Authority has committed to partnering on the Calgary Region Hydrogen Hub project (Calgary Airport Authority, 2022). If pilot projects at EIA and CAA prove successful, the next step in the collaboration will be establishing commercial hydrogen-electric flight routes. Should the Airport have hydrogen infrastructure available, they would be well aligned to leverage the work done by EIA, ZeroAvia, and the Calgary Region Hydrogen Hub, potentially positioning the airport as a link in what is a rapidly growing hydrogen ecosystem in Canada.

Infrastructure Considerations

Storage: Hydrogen must be in a liquid state for use in aviation, which requires cryogenic storage capable of maintaining the fuel at temperatures below 253 °C (the boiling point of hydrogen). Companies like Chart Industries and McDermott International manufacture cryogenic hydrogen storage tanks of various sizes that may be relevant to the airline industry.

According to Air Liquide, a 75-litre cryogenic tank can hold 5 kg of liquid hydrogen (Air Liquide, 2023). The low end of reported energy density of liquid hydrogen is 120 MJ/kg, and the average energy efficiency of aircraft is about 1 MJ/psgkm (2). This means that 1 kg of hydrogen contains enough energy for a 30-seat aircraft to travel approximately 4 km. A 30-seat aircraft travelling 1,000 km would therefore require approximately 250 kg of hydrogen to complete the one-way trip. To support trips of this length, YKF would likely want to provide storage for 5,000 kg or more. 5,000 kg of liquid hydrogen would require 75,000 litres of tank capacity. A vertical-oriented tank with a 50,000 L capacity would occupy a space approximately 3 metres in diameter by 13 metres high. Based on these figures, 200 m^2 is a conservative initial estimate for the space requirements for hydrogen storage and fueling infrastructure[3].

Transport: As with storage, transporting hydrogen requires cryogenic storage trailers. YKF will likely have to develop an agreement with a transport company that can lease or purchase trailers capable of cryogenic hydrogen transport.

Supply: Canada's Hydrogen Strategy emphasizes domestic hydrogen production, which is likely to translate into a continuing increase in availability of hydrogen in Canada. Companies like France's Air Liquide and US-based Air Products have both announced large hydrogen production projects in Canada.

The three methods most common hydrogen production methods currently (and anticipated) in Canada are as follows:

- Grey Hydrogen – hydrogen produced via steam-methane reforming. Greenhouse gas emissions are released during production, making grey hydrogen the most carbon-intensive source of hydrogen. The cheapest hydrogen to produce and very common in existing oil and gas industries in Canada.
- Blue Hydrogen – hydrogen produced via steam-methane reforming combined with carbon capture and storage technology. Less carbon-intensive than grey hydrogen, the carbon intensity is determined by the percentage of carbon that is captured during production. More expensive than grey hydrogen but generally cheaper than green hydrogen. Common in oil and gas industries in Canada.
- Green Hydrogen – hydrogen produced via electrolysis powered by renewable energy. Has a near-zero life cycle carbon intensity. Increasingly popular in Canada, particularly in regions with suitable access to renewable electricity production. Cost is tied to the source of renewable energy but is projected to decline steeply between now and 2050.

Production: Rather than buying hydrogen from the market, YKF could explore on-site production of green hydrogen utilizing excess renewable energy generated on-site.

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[2] This is a rough figure for aircraft in general and is not size-specific, however it is illustrative for the purposes of defining storage requirements both on aircraft and on the ground (Zheng, 2021).
[3] This figure is an estimate only and assumes transport of hydrogen to aircraft via cryogenic fuel trucks.

- **RECOMMENDATION:** Explore areas on airport lands suitable for hydrogen storage, fueling infrastructure, or production.
- **RECOMMENDATION:** Explore opportunities for hydrogen supply agreements with producers and airlines.

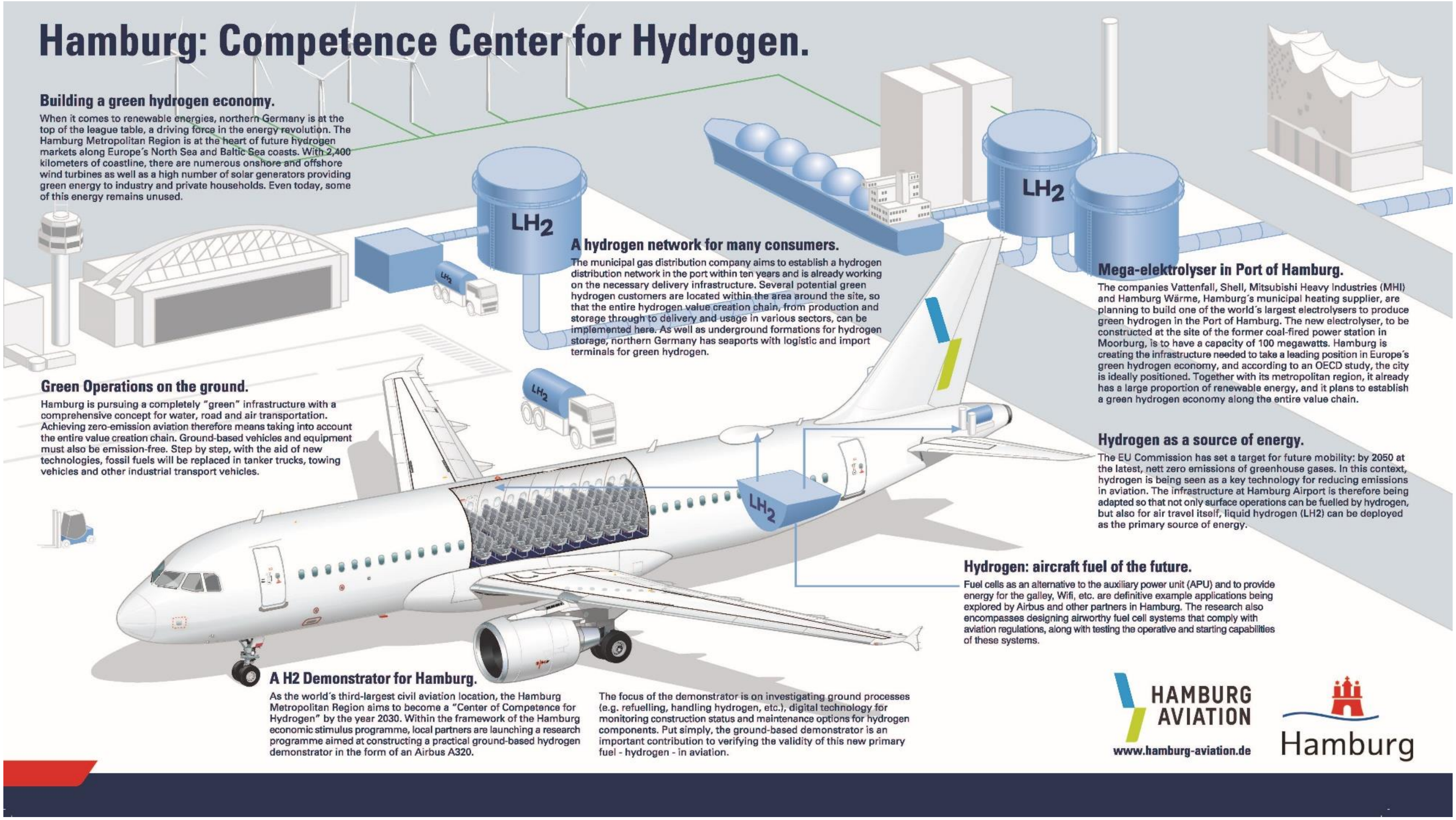


Figure 2: Proposed hydrogen ecosystem to advance the development of hydrogen aviation in Hamburg, Germany (Source: Hamburg Aviation - larger format image available for download here)

Public Transit

Passenger and staff commuting is also projected to be a significant Scope 3 emission source.

The airport is located within 3 km of a main GO and VIA rail line, the same line that services the Toronto Pearson International Airport (TPIA), and a future high-speed rail link to TPIA has been proposed. While light rail is an excellent low-carbon commuting option, it is still many years away. In the meantime, the airport is working on providing a regular Grand River Transit (GRT) bus that would connect the airport to the broader GRT network.

The airport has recently installed a passenger EV charging station in the short-term parking lot. Emissions from staff and passenger commuting will naturally decrease as the population shifts to EVs; however, there are additional actions the airport can take to incentivize and support the adoption of low-emission commuting methods. They include:

- **RECOMMENDATION:** Conduct a commuting survey to determine the top barriers/opportunities for low-emission travel methods. Re-survey staff and passengers every 3 years.
- **RECOMMENDATION:** Advocate for more frequent and efficient public transit from nearby municipal centres. Consider partnering with large institutional airport users, such as the University of Waterloo, to develop shuttle services and other low-emission commuting options directly between the two sites.
- **RECOMMENDATION:** Incentivize low-carbon commuting for staff by providing them with preferential parking for carpooling, free bus passes, or other incentives.

Tenant Engagement

Major development is expected to occur across the airport's lands over the next few decades. This points to the need to work collaboratively with tenants and other stakeholders to ensure new facilities are energy efficient and low-carbon.

- **RECOMMENDATION:** Develop a set of Green Development Guidelines that provides guidance to tenants and prospective developers looking to build new facilities on airport lands. A template has been provided as part of this Decarbonization Strategy.
- **RECOMMENDATION:** Establish a Climate Committee that includes representatives from key tenant groups. The Committee should convene regularly to discuss emissions reductions initiatives across the Airport.

- **RECOMMENDATION:** Separately meter all tenant electricity and incentivize tenants to reduce their own energy consumption.
- **RECOMMENDATION:** Implement a Tenant Data Sharing Policy in advance of the airport's application for ACA Level 3. This streamlines data collection and facilitates a discussion about energy efficiency.
- **RECOMMENDATION:** Implement an All-electric Ground Service Equipment Policy to reduce emissions from fixed base operators.

The Waterloo Institute for Sustainable Aeronautics (WISA) is the world's leading hub for sustainable aviation and aerospace research, technology, and education. Based at the University of Waterloo, WISA has a mandate to advance interdisciplinary research into sustainable aeronautics by partnering with industry, government and academia. WISA has expressed their interest in working hand in hand with the Waterloo Airport to advance their decarbonization efforts and demonstrate industry leadership.

Over the next few months, WISA intends to distribute up to $4M in research funds to 30-40 different research projects, each of which will be paired with an industry partner. Additionally, they are looking to establish an "Innovation Hub" at the Waterloo Wellington Flight School, which will act as a sandbox in which to test new sustainable aviation technologies. They are also developing two new e-learning professional development courses focused on Aviation Sustainability and Aviation Climate Change.

- **RECOMMENDATION:** Continue to build a strong partnership with WISA by identifying opportunities to collaborate on research projects, supporting the development of the Innovation Hub at WWFS, and inviting WISA to sit on YKF's future Climate Committee.

The Airport Carbon Accreditation Program

The Airport Carbon Accreditation (ACA) program is the only independent, institutionally endorsed global standard for carbon management at airports. The program guides airports through six levels of accreditation: Mapping, Reduction, Optimization, Neutrality, Transformation, and Transition. To participate in the ACA program, airports must submit annual applications that demonstrate their carbon management activities. To ensure transparency and accuracy, ACA applications must be verified by an independent third party every two years, and every time a new level is achieved. Below is a summary of program requirements at each level of accreditation.

airport carbon accredited
MAPPING

Level 1: Mapping

Level 1 is about understanding the airport's emissions profile. At Level 1, airports must:

- Measure their carbon footprint (Scope 1 & 2 only)
- Make a general policy commitment to emissions reductions.

airport carbon accredited
REDUCTION

Level 2: Reductions

At Level 2, airports must show they have the necessary plans, targets and programming in place to achieve real emissions reductions in their Scope 1 and 2 footprint. Each time the airport submits at Level 2, they must show that emissions have been reduced compared to the average of the last three reported years (or the last one or two years, if the airport does not have three years worth of carbon footprint measurements). In addition, airports must:

- Fulfill Level 1 requirements
- Create an emissions reduction target & develop a Carbon Management Plan to achieve that target
- Demonstrate a Scope 1 and 2 emissions reduction against a three-year rolling average.

Level 3: Optimisation

At Level 3, the program looks beyond airport-controlled sources and begins to include sources from airport stakeholders, such as aircraft take offs and landings and passenger commuting. The airport must develop a Stakeholder Engagement Plan and begin measuring stakeholder emission sources. The full Level 3 requirements are:

- Fulfill all Level 1 & 2 accreditation requirements
- Expand carbon footprint to include specific scope 3 emissions
- Develop a Stakeholder Engagement Plan

Level 3+: Neutrality

At Level 3+, airports offset all remaining Scope 1 and 2 emissions with high quality carbon credits. Airports can voluntarily offset emissions prior to the achievement of Level 3+.

- Fulfill all Level 1, 2 & 3 accreditation requirements
- Offset residual scope 1 and 2 emissions.

Level 4: Transformation

At Level 4, the emissions reduction ambition must be revised to align with the Paris Agreement (if it was not sufficiently ambitious before), and stakeholder commitment to emission reductions must be shown. The full Level 4 requirements are:

- Include additional scope 3 emission sources in the carbon footprint
- Create an absolute emissions reduction target in line with the IPCC 1.5°C or 2°C pathways
- Create an absolute emissions reduction policy
- Develop a carbon management plan to achieve this target
- Develop a Stakeholder Partnership Plan that includes reductions in Scope 3 emissions

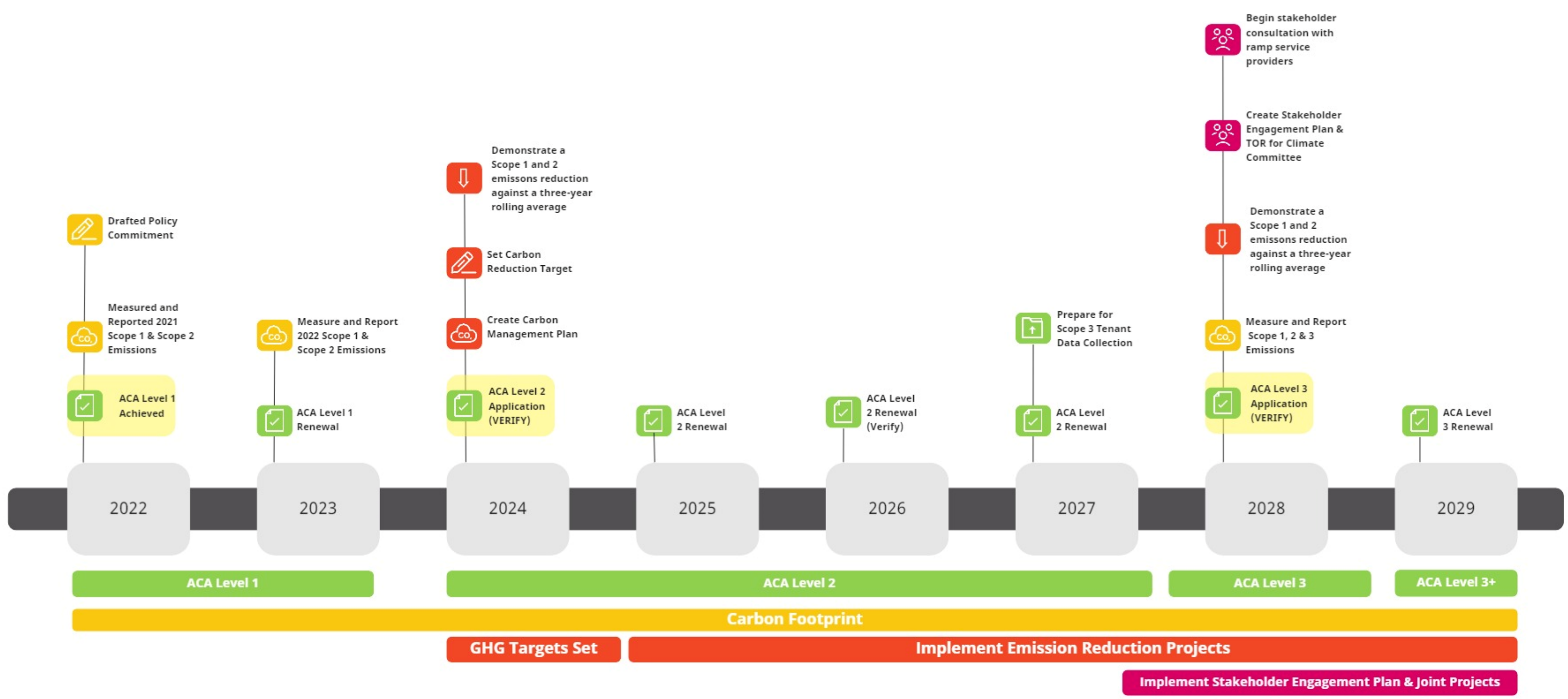
Level 4+: Transition

At Level 4+, airports offset all remaining Scope 1 and 2 emissions with high quality carbon credits. Airports can voluntarily offset emissions prior to the achievement of Level 4+. Once Level 4+ has been achieved, the airport must renew their accreditation every 3 years.

- Fulfill all Level 1, 2 & 3 accreditation requirements
- Offset residual scope 1 and 2 emissions.

Suggested ACA Timeline

The following pathway represents a suggested timeline for progressing through the various levels of the ACA program. Additional staff support and training will likely be required as the airport advances to Level 2 and 3.



Appendices

Appendix 1 – Solar Electricity Production Methodology

The National Renewable Energy Lab's (NREL) PVWatts Calculator was used as the primary tool for estimating electricity production potential. YKF's latitude and longitude were used to assign a grid cell from the NREL National Solar Radiation Database. From there, the system size was estimated by drawing a system that matched the total area of the building rooftop. For Parking Lot 4, the rows of parking lot spaces to mimic a potential canopy system,

System Features:

- Module type- Standard
- Array type- Fixed
- System losses – 14.0%
- Tilt-43.45°
- Azimuth- 180°

Results (solar radiation and AC energy by month) from the calculator were downloaded as a csv file and transferred to a solar estimate summary spreadsheet.

Terminal Building

Parking Lot 4

Proposed New Terminal Location

Appendix 2 - Templates for YKF and the ACA Program

To aid YKF in moving through the ACA program, customized templates have been created for managing required data internally.

1. Necessary for all levels of the program, the **Data Tracking Sheet (DTS) Template** has been designed to help with the annual data collection year over year. Customized to the emission sources and types of data required by the ACA reporting software, the DTS can be used internally by the YKF team to assign responsibility for data pieces.

2. The **Carbon Management Plan Template** provides the framework for YKF to report on previous sustainability initiatives, set a reduction target and map out the steps required to achieve the target in a concise document.

3. As part ACA Level 3, YKF will be required to engage with stakeholders about achieving emissions reductions. The **Stakeholder Engagement Plan Template** will allow YKF to identify key stakeholders, allocate responsibilities, and develop an implementation plan between the airport and stakeholders.

4. Finally, a **Green Development Guidelines Template** has been provided as a basis for encouraging tenants and prospective developers to adopt low-emission practices and limit future Scope 3 emissions.

References

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List of Acronyms

ACA- Airport Carbon Accreditation

APU- Auxiliary power units

B2- 2% biodiesel

B100- 100% biodiesel

BESS- Battery energy storage system

DTS- Data Tracking Sheet

EIA- Edmonton International Airport

FCEV- Fuel cells and electric vehicles

FSC- Forest Stewardship Council

GHG- Green House Gas

GPU- Ground power units

GWP- Global Warming Potential

HVA- Highly vulnerable aquifers

HVLS- High Volume Low Speed

kWh- Kilowatt-hour

LFG- Landfill Gas

m^3- cubic meters

MAS- Materials Analytical Services

NREL- National Renewable Energy Laboratory

PV- Photovoltaic

REC- Renewable energy credit

RNG- Renewable natural gas

SAF- Sustainable aviation fuel

SFP- Sustainable Fleets Plan

SGRA- significant groundwater recharge area

tCO_2e- tonnes of carbon dioxide equivalent

TPIA- Toronto Pearson International Airport

UN IPCC- United Nation Intergovernmental Panel on Climate Change

UTV- Utility terrain vehicles

WHPA-C- well head protection area C

WISA- Waterloo Institute of Sustainable Aviation

YKF- Region of Waterloo International Airport

Summary of Recommendations

- **RECOMMENDATION:** Implement energy efficiency best practices, and explore minor building retrofits, including equipment like the SHARC wastewater heat recovery system and the Turntide Smart Motor System™.
- **RECOMMENDATION:** Use RNG credits to offset the impact of natural gas in its existing facilities.
- **RECOMMENDATION:** Talk to the Region about procuring biodiesel for the airport's heavy fleet.
- **RECOMMENDATION:** As natural gas space heaters and boilers reach their end of life, replace them with high efficiency air source heat pumps and electric boilers.
- **RECOMMENDATION:** Electrify the airport's ground fleet according to the Region's electrification plan and consider hydrogen-powered options for heavy equipment.
- **RECOMMENDATION:** Consider adding a solar canopy to the new Parking Lot 4 area.
- **RECOMMENDATION:** Conduct a solar feasibility study for the existing terminal and the new terminal.
- **RECOMMENDATION:** Consult with the Region's Water Services department to determine the viability of either an open loop vertical or a closed loop horizontal geothermal system at the new terminal site.
- **RECOMMENDATION:** For existing buildings, roadways or vegetation that are to be removed, look for deconstruction and reuse opportunities before recycling. Examples of deconstruction and reuse opportunities include:
  - Dimensional lumber to concrete forms and back-framing
  - Concrete foundation and asphalt crushed and used as road base
  - Vegetation debris (trees and stumps) chipped for landscaping mulch or used as biofuel feedstock
- **RECOMMENDATION:** As part of the contract with construction contractors, ensure they will have a recycling system in place to collect different types of construction waste.

- **RECOMMENDATION:** Look to source sustainable building supplies
  - Choose environmentally preferred flooring options:
    - Salvaged wood from wreck homes & commercial demolition sites
    - Recycled tiles made from discarded glass or porcelain (easy to replace worn sections and uses less glue – better air quality)
    - Rubber flooring (100% renewable resource)
    - Bamboo, recycled cork, coconut timber & natural linoleum (biodegradable/non-toxic)
  - Utilize locally processed materials to reduce emissions from transportation and source from recycled or rapidly renewable materials.
  - Use non-toxic, or low/ no VOC sealants, paints, and finishes. Select products that meet Green Seal certification, Green Guard certification, or MAS Certified Green.
  - Use salvaged materials to create furniture, coverings, or other décor items.
  - Source timber from sustainable managed forests (FSC Certified).

- **RECOMMENDATION:** Install GPUs on the new apron and sub-meter airline tenants for the electricity consumption.

- **RECOMMENDATION:** Explore areas on airport lands suitable for hydrogen storage, fueling infrastructure, or production.

- **RECOMMENDATION:** Explore opportunities for hydrogen supply agreements with producers and airlines.

- **RECOMMENDATION:** Conduct a commuting survey to determine the top barriers/opportunities for low-emission travel methods. Re-survey staff and passengers every 3 years.

- **RECOMMENDATION:** Advocate for more frequent and efficient public transit from nearby municipal centres. Consider partnering with large institutional airport users, such as the University of Waterloo, to develop shuttle services and other low-emission commuting options directly between the two sites.

- **RECOMMENDATION:** Incentivize low-carbon commuting for staff by providing them with preferential parking for carpooling, free bus passes, or other incentives.

- **RECOMMENDATION:** Develop a set of Green Development Guidelines that provides guidance to tenants and prospective developers looking to build new facilities on airport lands. A template has been provided as part of this Decarbonization Strategy.
- **RECOMMENDATION:** Establish a Climate Committee that includes representatives from key tenant groups. The Committee should convene regularly to discuss emissions reductions initiatives across the Airport.
- **RECOMMENDATION:** Separately meter all tenant electricity and incentivize tenants to reduce their own energy consumption.
- **RECOMMENDATION:** Implement a Tenant Data Sharing Policy in advance of the airport's application for ACA Level 3. This streamlines data collection and facilitates a discussion about energy efficiency.
- **RECOMMENDATION:** Implement an All-electric Ground Service Equipment Policy to reduce emissions from fixed base operators.
- **RECOMMENDATION:** Continue to build a strong partnership with WISA by identifying opportunities to collaborate on research projects, supporting the development of the Innovation Hub at WWFS, and inviting WISA to sit on YKF's future Climate Committee.