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Addressing Greenhouse Gas Emissions from Business-Related Air Travel at Public Institutions: A Case Study of the University of British Columbia

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EXECUTIVE SUMMARY

Aviation is one of the fastest growing sources of greenhouse gas emissions, yet is not addressed in most national-, regional-, municipal-, or institutional-level climate action plans. There is a tremendous opportunity for leadership in tracking and mitigating aviation emissions from business at universities and other public sector institutions. In this paper, we conduct a case study of business-related air travel and associated emissions at the Vancouver campus of the University of British Columbia (UBC) in order to develop a roadmap for action for UBC as well as other academic and public-sector institutions.

In the case study, we present two analyses of business-related air travel emissions, one based on bottom-up data from eight units on campus (997 travellers) and another based on data collected by a central travel office via an online booking tool (3807 travellers), as well as a survey of faculty attitudes about business-related air travel, and an assessment of mitigation options including investment in Information and Communications Technology (ICT). The four key findings are:

Air travel emissions are significant in relation to other institutional emissions: We estimate that business-related air travel emissions at UBC total 26,333- 31,685 tCO_2e each year, equivalent to 63%-73% of the total annual emissions from the operation of the UBC campus. At a unit-by-unit level, emissions from business-related air travel in the Department of Psychology were similar to that from heating and providing electricity to the building housing the department. In the case of the Department of Geography, which recently switched to a more efficient heating system, the business-related air travel emissions were 30 times that of the building.

A small fraction of people are responsible for the majority of air travel emissions: The flight-level data analysis indicates that 50% of emissions are produced by 8-11% of the population, depending on the sample. The comprehensive bottom-up analysis of travel data from eight units indicates that the majority of trips are short in duration (median length of five nights) and the most common purpose of travel is in-person conference attendance (representing 55% of emissions).

Simple, cost-saving measures could lead to immediate emissions reductions: Using the bottom-up data from the eight units, we identify four cost-saving measures with the potential to collectively reduce emissions from business-related air travel at UBC by almost 12%: requiring economy class tickets and using ICT to replace same-day return trips, flights solely for lectures, and brief, long distance trips. More comprehensive policies are likely necessary to tackle the other 88% of business air travel emissions at UBC.

Improving ICT access is critical to shifting air travel behaviour: In a survey of air travel attitudes targeted at faculty members, the most common response to the question, "How could UBC support you to reduce your need to fly?" was to improve teleconferencing on campus (46%). Current obstacles to teleconferencing included a "lack of awareness of options" (39%) as well as "quality of the communication" (38%). The survey also showed that very few respondents purchase carbon offsets, citing cost and perceived lack of effectiveness as the primary obstacles.

Based on the findings of this case study, we developed a five-step roadmap for public sector institutions looking to track and address greenhouse gas emissions from business-related air travel:

1) Implement a centralized air travel emissions accounting system that is integrated into the financial management system

- Utilize a comprehensive tracking system to monitor mitigation progress
- Record relevant data as it is reported to avoid time-consuming retroactive date collection and reduce burden to staff and administrators

2) Integrate a central ICT strategy into climate action planning

- Create a campus-wide committee to oversee innovation efforts which might include: reviewing and updating software licenses, developing distributed facilities with state of the art videoconferencing hardware, and offering matching funds to units or organizations that host events with virtual meetings in place of air travel
- Improve teleconferencing facilities and promote institutions as leaders in developing virtual meeting technology and culture

3) Target easy, cost-saving actions, including requiring economy-class travel

- Choosing a higher class of travel was responsible for 7.8% of emissions in our bottom-up sample
- Addressing the "low hanging fruit" can build momentum towards more challenging, longer-term technological and behavioural changes

4) Develop a behavioural incentives program

- A program integrated with the ICT strategy is necessary to encourage broader shifts in institutional culture and individual behaviour surrounding air travel decisions
- Provide tailored, comparative feedback to travellers and to units on campus, and distribute information about how they can reduce their air travel

5) Consider employing offsets only if locally-based

- Offsets can be part of a mitigation approach but our survey shows that understanding and support for offsets is limited
- Implement a local offset scheme at the institution to increase transparency and employee support

1. INTRODUCTION

"Aviation technology innovations have transformed the way we live. They helped get us to the moon. Cutting emissions rapidly and making ourselves resilient to climate change is our generation's moon landing." Christiana Figueres (Air Transport Action Group, 2015)

Aviation emissions account for roughly 3.5% of total human-caused warming of the planet (Lee et al., 2009). These emissions are currently a small fraction of humanity's contribution to climate change, but the footprint of the aviation industry is expanding at a pace that could jeopardize efforts to avoid the 2°C warming limit agreed to under the United Nations Framework Convention on Climate Change (UNFCCC) (Bows-Larkin and Anderson, 2013).

Although the construction and operation of airport infrastructure and the manufacturing and maintenance of aircraft all create greenhouse gases, the majority of emissions associated with aviation comes from burning fuel to operate the aircraft (Chester and Horvath, 2012; Chester and Horvath, 2009). The compounds released during combustion of jet fuel include not only carbon dioxide (CO_2), but also a variety of chemicals that can interact with the atmosphere in complex ways, including: water vapour, nitrogen oxides, soot, hydrocarbons, and carbon monoxide (Wuebbles et al., 2007). Some of these particles cause cooling of the atmosphere, while others cause warming, but the net effect is an increase in radiative forcing, with a large degree of uncertainty over exactly how much additional warming is caused (Lee et al., 2009).

Ongoing improvements in aircraft efficiency offer limited hope for mitigating the climate impacts of air travel. In terms of aircraft, the latest generation of Boeing's 737 MAX delivers a 20% increase in fuel efficiency compared to the original generation - but this improvement has taken nearly 20 years to achieve (ICAO, 2016). A number of other measures such as lightweight materials, optimized routing, and electric taxiing are already being developed or implemented, but these improvements in efficiency have a minor influence on total emissions (Air Transport Action Group, 2015). More problematically, the number of aircraft in service may double in the next twenty years, due to 4-5% annual growth in both passenger and freight demand, such that assumed upgrades in technology will be unable to reduce either total emissions or radiative forcing from aviation by 2050 (Grote et al., 2014)

The obstacles to achieving carbon neutral air travel are even more onerous than stabilizing emissions. Airline carrier EasyJet claims that battery-powered aircraft could be operational within a decade, although they would only be able to power short-haul flights, which are less than two hours in duration (Monaghan, 2017). The CEO of Airbus has made similar predictions for hybrid technology: aircraft powered by a battery paired with jet fuel will be able to perform short-haul flights for 50-100 passenger aircraft by 2030 (Opperman, 2017). Two of the other more feasible paths toward carbon neutral air travel include biofuels and liquid hydrogen fuels. However, liquid hydrogen fuels will likely see uptake only if there is a more general move to a hydrogen-based fuel economy (Lee et al., 2009). As for biofuels, there are formidable difficulties in sourcing them sustainably given competition for land with agriculture (Tilman et al., 2009) and climate mitigation (Smith et al., 2016). It is unsurprising therefore that researchers have concluded that technological improvement in air travel without some shifts in demand are unlikely to be consistent with achieving a 2°C climate target (Girod et al., 2013).

Yet, aviation emissions are not addressed in most existing climate policy frameworks. Emissions from aviation and marine shipping are not covered by the UNFCCC and resulting protocols and agreements, including the 2015 Paris Climate Agreement. As a consequence, aviation emissions are generally excluded from accounting and reporting under province/state-, regional-, or institutional-level climate action plans. For example, under British Columbia's Greenhouse Gas Reduction Target Act, provincial public sector organizations are required to annually report and offset direct emissions from on-site combustion (Scope 1 emissions, according to the Greenhouse Gas Protocol developed by the World Resources Institute and the World Business Council for Sustainable Development) and indirect emissions from sources that are owned or controlled by the institution (Scope 2), but not emissions from sources not directly owned or controlled by the institution (Scope 3) like employee air travel or commuting (Ministry of Environment, 2016b). The province does require reporting and offsetting of business-related air travel emissions for ministerial business, but not for other public sector institutions, including universities and colleges, crown corporations, and health authorities.

There is a tremendous opportunity for leadership, both nationally and internationally, in measuring and addressing emissions from business-related air travel at universities and other public sector institutions. Programs to address business-related air travel emissions at universities, colleges, and other public institutions are currently rare. The few that do exist generally focus on emissions accounting and/or carbon offset programs. Several universities have carbon offset programs in place for their business-related air travel, including Cornell University, which supports a local program that provides energy efficiency improvements for low to moderate-income households in the area (Cornell University, 2017). While offsets are one way for an institution to address emissions from air travel, an argument can be made that public institutions should be leading the way on reducing demand – which means flying less. One example of institutions tackling demand reduction is the Stockholm Resilience Center which, in addition to offsetting all air travel, has attempted to minimize flights by installing meeting rooms with videoconferencing systems (Stockholm Resilience Centre, 2017).

This report develops a framework for addressing business-related air travel emissions at academic and public sector institutions in the province and beyond, through a case study at the Vancouver campus of the University of British Columbia (UBC). It presents a ground-up analysis of air travel emissions from units at UBC based on original travel requisitions, a survey of faculty attitudes about business-related air travel, and an analysis of mitigation options including incentive-based policies, information and communications technology (ICT), and offsetting based on the UBC data. It concludes with a roadmap for action on business-related air travel emissions, including a series of recommendations for tracking emissions, developing an ICT strategy, and implementing a mitigation plan, which may apply to a wide range of academic and other public sector institutions.

2. METHODS

In this study and in this report, “UBC” refers only to the Vancouver campus unless otherwise specified. At present, UBC does not have a method to calculate, mitigate, or offset emissions from all university-related air travel, referred to in this study as “business-related air travel” (University of British Columbia, 2010). The university does, however, report an estimate of Scope 3 emissions, including business-related air travel emissions, in its annual Carbon Neutral Action Report (University of British Columbia, 2016, 2017a). Air travel emissions from flights booked through Concur, UBC’s online air travel booking tool, are automatically estimated and displayed in pounds (lbs) not kilograms (kg) of CO_2. Total emissions from business-related air travel purchased through UBC is then estimated using the ratio of the university’s total air travel expenditures compared to the cost of flights booked though Concur.

For this analysis, we take a more comprehensive look at the drivers of business-related air travel emissions from UBC using both the Concur air travel data and bottom-up data from air travel requisitions (TR), collected from a series of administrative units, using a more detailed set of emissions calculations. The initial objective of this project was to conduct a complete emissions inventory for business-related air travel at UBC for the January 2015-June 2016 period (to cover a fiscal and a calendar year) using both the bottom-up approach and the Concur data from the UBC Travel Office. However, logistical challenges including the time-consuming nature of bottom-up data collection (processing rate of approximately 14 TRs per hour), the unavailability of some travel records, and resource limitations in the UBC Travel Office, made this goal unrealistic. Instead, we focus on a subset of UBC administrative units, and only employ the 2016 Concur data from the UBC Travel Office.

2.1. Collecting Data from Travel Requisition (TR) Forms

We conducted full audits of business-related air travel over the January 2015-June 2016 period for the 8 units (of the 26 contacted) who volunteered to participate, including the Department of Geography and the Department of Psychology. Relevant flight information was recorded by an undergraduate research assistant. This information included: TR number, date, airport codes, name (later anonymized), cost, ticket class, length of trip (in nights), primary and secondary purpose of the trip, and additional flight information (e.g., the number of flight segments). The costs of trips purchased in foreign currency were converted to Canadian dollars based on the exchange rate on the date of the TR form. When missing data was encountered, we assumed that flights without a stated ticket class were economy, since purchasing non-economy class tickets is technically only possible with permission of the appropriate Dean or Vice-President (University of British Columbia, 2017b). Although a "clear statement of the purpose" of the trip is required under UBC Policy 83 (Procedure 1.2.1.1) (Board of Governors, 2010), the purpose could not be discerned for some travel requisitions that we examined (4% were blank in this regard).

2.2 Emissions Calculator

We constructed a simple emissions calculator that functioned within an Excel spreadsheet. The BC government uses 2015 emissions factors (Ministry of Environment, 2016a) developed by the U.K. Department for Environment, Food & Rural Affairs (DEFRA). We employ similar emissions factors but follow a more detailed U.K. government process, now under the Department for Business, Energy & Industrial Strategy (BEIS), which has updated values for 2016. This more detailed process results in higher emissions per distance flown. The calculator was applied to the flight information collected via the bottom-up data collection and also to the 2016 Concur data from the UBC Travel Office.

The values used by the BEIS for the average amount of greenhouse gases (in units of carbon dioxide equivalent, CO_2e) produced per passenger kilometer (pkm) by domestic, short and long haul flights, accounting for average aircraft occupancy are shown in Table 1 (Ministry of Environment, 2016a). We have altered these to short (<463 km), medium (463-3,700 km), and long haul (>3,700 km) flights, respectively, so that they are relevant outside of the U.K. context. When calculating the distance travelled between airports, we find the great circle distance between the geographical coordinates of the two airports, and then apply an 8% uplift factor recommended by the BEIS to account for the additional flight length due to rerouting of planes, holding patterns, etc.

Additionally, we add two details to the emissions calculation that are not used by the BC government. First, we use the different BEIS emissions factors for economy, premium economy, business, and first class flights in order to account for the average extra space occupied by higher

Table 1: Emission factors for business-related air travel (kg CO_2e/passenger km)

Class	Long Haul	Medium Haul	Short Haul
Economy	0.14678	0.16508	0.27867
Economy plus	0.23484	0.24761	
Business	0.42565		
First	0.58711		

class seating. This approach assigns the additional emissions from a passenger occupying a disproportionate amount of aircraft space to that passenger's (i.e., UBC's) emissions inventory. Second, we include the literature-based radiative forcing multiplier of 1.9 to account for the disproportionate warming influence of high-altitude em issions from aircraft (Lee et al., 2009; BEIS, 2016). The value of 1.9 is the central estimate from the BEIS, and has large consequences for accounting, nearly doubling total emissions compared to a calculation that ignores radiative forcing.

Following standard emissions inventory practice, we account only for emissions from business-related air travel purchased through UBC (e.g., billed to the university or to a grant or fund held in a university account). Therefore, flights taken by non-UBC employees but paid for through UBC (e.g., an invited speaker whose travel costs are covered by UBC or a UBC grant) are included. Conversely, flights taken by UBC employees but paid for by an outside institution (e.g., another university paying for a UBC faculty member's travel for a colloquium) are not included, as they would be counted in the other institution's inventory.

2.3 Survey on Air Travel Attitudes Among UBC Faculty

We distributed an online survey, using UBC Faculty of Arts survey tool Qualtrics, to every academic department and institute at UBC to assess faculty attitudes about business-related air travel and mitigation options. The survey consisted of 13 questions and took respondents approximately five minutes on average to complete. All data was anonymized with a numeric key, although respondents were provided an option to permit linking their responses with their individual business-related air travel emissions data (available through the bottom-up data collection). The link to the survey was distributed to all units across campus by asking an administrator or faculty member in each unit to distribute the survey to their unit's listserv. The survey and data collection process were approved by UBC's Behavioural Research Ethics Board, per university regulations.

2.4 Interviews

To understand the various information and communications technology (ICT) (which includes teleconferencing and videoconferencing) options currently available at UBC, interviews were conducted with relevant UBC staff. These included interviews with a senior manager at UBC Information Technology (IT), a digital media specialist in the Faculty of Arts, and an audiovisual analyst in the Faculty of Medicine. A tour was also conducted of the videoconferencing facilities in the Faculty of Medicine.

3. RESULTS

The available air travel data suggests the business-related air travel emissions at UBC are between 26,333 and 31,685 tCO_2e/yr (Table 2), equivalent to 63%-73% of the annual emissions from the UBC campus for the 2015-2016 period[1] (University of British Columbia, 2016, 2017a). The two estimates for campus-wide air travel emissions are computed by multiplying the total emissions from the study samples (UBC Travel office data and bottom-up data collection, respectively) against the ratio of total campus-wide and total sample air travel expenditures. The estimated campus-wide air travel emissions are 2.1 to 2.5 times greater than that reported in UBC's Carbon Neutral Action Reports, which similarly use expenditures to extrapolate from UBC Travel office

[1] This refers to the 'offset-able' emissions, which excludes biogenic emissions and emissions from off-campus properties and the UBC properties trust.

data, because this study considers class of ticket and disproportionate warming influence of high-altitude emissions from aircraft.

To lend further perspective to the magnitude of these emissions, air travel in the Department of Psychology resulted in 415 tCO_2e of emissions, while the energy use for the building that houses the Department of Psychology produced just slightly more (455 tCO_2e) over a similar 18 month period from January 2016 to June 2017 (building emissions data were not available over the 2015 period due to missing data during renovations). Air travel in the Department of Geography resulted in 454 tCO_2e of emissions, while the Geography building (which has converted to a more efficient heating system) was responsible for only 14.1 tCO_2e. When buildings are heated and powered by low-carbon energy, the emissions associated with the business-related air travel of the occupants can dwarf the emissions from operation of the buildings in which they work.

Table 2: Comparison of the two sources of UBC business-related air travel

Source	Bottom-up Data Collection	UBC Travel Office
Sample	All flights with TR forms submitted to one of eight campus units	All flights purchased through an online booking tool (45% of UBC air travel by cost)
Time period	Jan 2015 – June 2016	Jan 2016 – Dec 2016
Number of trips	1,769 trips	10,253 trips
Number of travellers	997 individuals	3,807 individuals
Air travel emissions	3,018.81 tCO_2e	9,941.16 tCO_2e
Emissions per travel cost	1.65 kg CO_2e/$	1.42 kg CO_2e/$
UBC air travel emissions[1]	31,685.05 tCO_2e/yr	26,333.44 tCO_2e/yr
UBC offset cost[2]	$792,126/yr	$658,336/yr

[1] Estimate based on emissions per travel cost X total annual UBC air travel expenditures (2015-2016)
[2] Based on UBC air travel emissions and $25 per t$CO_2$e price in the provincial system

3.1 Drivers of Business-Related Air Travel Emissions

A comparison of the two samples suggests important patterns in air travel behaviour and use of the online booking tool. The emissions per trip were almost twice as high in the bottom-up data collection (1.71 tCO_2e/trip) than in the Concur bookings (0.97 tCO_2e/trip). Conversely, the emissions per traveller per year were higher in the Concur data (2.61 tCO_2e/person in the Concur sample and 2.02 tCO_2e/person in the bottom-up sample) because travellers in the Concur data took more than twice as many air travel trips per year (2.69 vs. 1.18 trips/year). These differences reflect the different sample populations; staff and administration, who may fly more often than faculty but over shorter distances, are more likely to use the Concur tool than faculty (e.g., staff and administration represent 22% of travellers whose positions were identified in the Concur sample, as opposed to 5% of travellers in the bottom-up sample). One implication is that data from an institutional booking system (e.g., UBC's Concur tool) may lead to an underestimate of institution-wide emissions because of differences in travel behaviour and related emissions per travel cost between employees who use the booking system (e.g., staff and administration) and those who book independently (e.g., faculty).

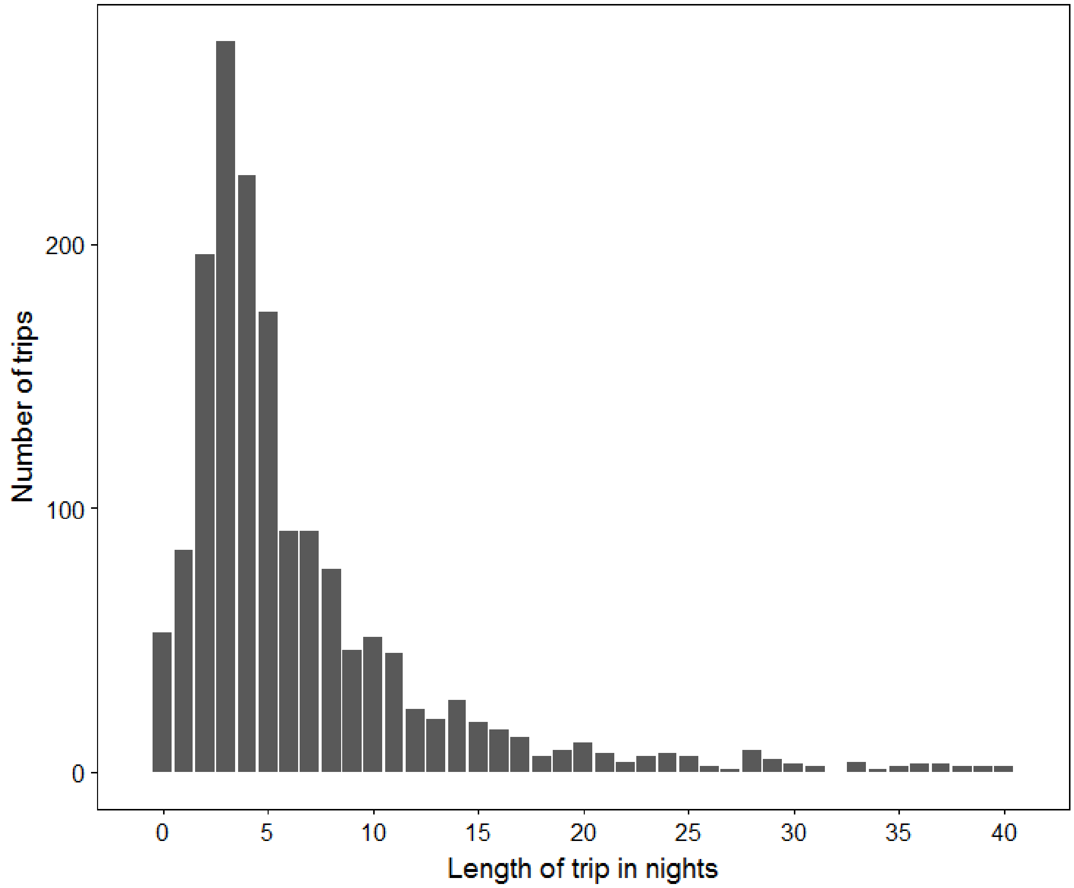

Figure 1: Histogram of trip length. Note that a small number of trips longer than 40 nights are not shown.

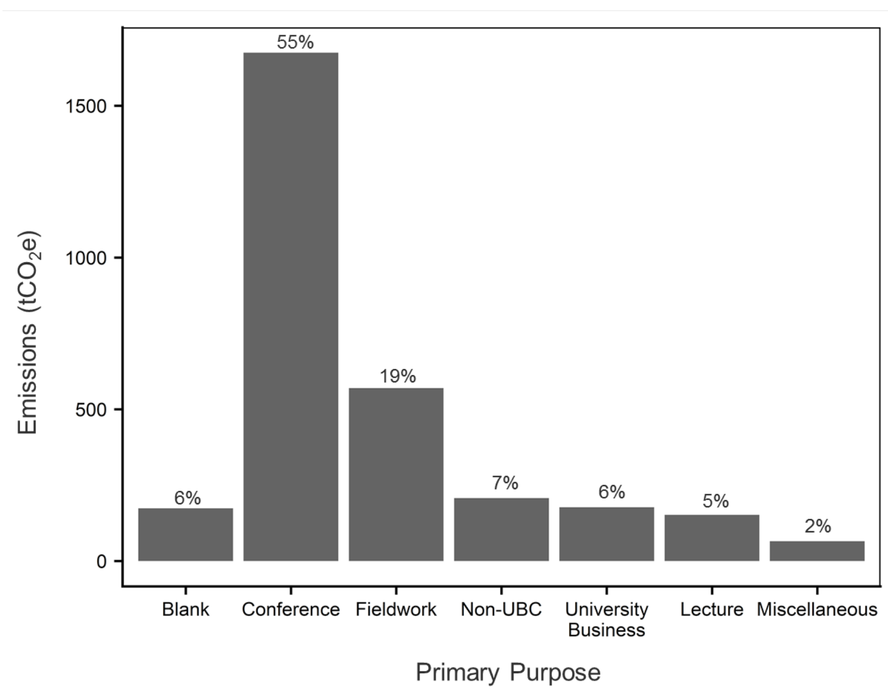

Figure 2: Emissions associated with each primary purpose of trip in the bottom-up sample of eight UBC campus units.

The more comprehensive bottom-up dataset further illustrates air travel behaviour on campus. In terms of length, only possible to calculate with the bottom-up data, most trips are short in duration; the median trip is five nights long, with less than 4% of trips over 40 nights in length (Figure 1). The emissions associated with conferences, which also includes workshops and other meetings, dominate in the bottom-up data over emissions from trips for other purposes (Figure 2). Fieldwork, which may be distant from Vancouver, is also substantial, contributing more than twice the emissions of university business or lectures. By contrast, UBC staff and administration travel may be more likely to consist of domestic and short haul flights (63% of flights by administration in the Concur sample were domestic compared to 42% for faculty).

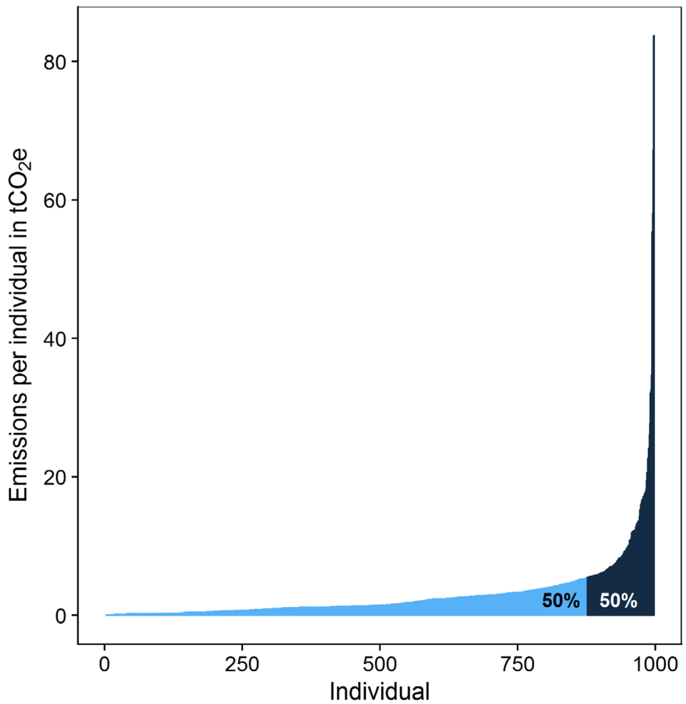

Figure 3: Business-related air travel emissions for the 997 individual travellers (one third of the people in the 8 units did not fly during the sampling period). Light blue indicates those travellers responsible for the first 50% of emissions and dark blue indicates those responsible for the second 50%

The datasets both indicate that UBC business-related air travel emissions roughly follow the Pareto Principle, where a disproportionate fraction of the effects (80%) can be attributed to a small fraction of causes (20%). We found that 36% of fliers were responsible for 80% of emissions in the Concur sample. The top fliers were even more prolific: 11% of fliers were responsible for half of all emissions. This analysis is unlikely to be skewed by only including members of the UBC community who already fly. A comparison of the top emitters in the departments in the bottom-up data to the air travel emissions from the entire department, which includes the many individuals who did not fly during the study period, finds a similar result (Figure 3). Of the approximately 1,509 individuals across the 8 departments in the sample during the study period (includes graduate students, staff, administration, research staff, and faculty), 121 (8%) produced half of all emissions and 377 individuals (25%) produced 80% of the emissions. Faculty are especially likely to be in this group; they represent 39% of total emissions in the Concur data sample and 47% of total emissions in the bottom-up data sample.

Table 3: Measures for mitigation

Mitigation Measure	Percent Reduction	Total Reductions Across Campus (tCO_2e)*	Savings per Tonne
Require only economy tickets	7.8	1,723	-
Replace flights for lectures**	4.0	884	$541
Replace brief, long distance trips	1.2	265	$652
Replace single-day return flights	0.3	66	$2,221
All measures combined***	11.7	2,591	-

* Calculated by applying percent reduction found in bottom-up sample to estimated campus-wide emissions
** If only trips of 2 nights or less were included, the reduction is 8.88 tCO_2e, or 0.3% of total emissions
*** Totals are smaller than the sum of all mitigation measures because some flights were removed to prevent double-counting (e.g., eleven trips were both lectures and non-economy class seating)

The total values are sensitive to the assumptions that inform our emissions calculator. For instance, without applying higher emissions factors for first class, business, and economy plus travel, the total emissions from the bottom-up sample would decrease by 8% to 2,782.23 tCO_2e. Similarly, if we had not employed the radiative forcing factor of 1.9, the total emissions in our bottom-up sample would decrease by 47% to 1,588.85 tCO_2e.

3.2. Tests of Mitigation Measures

We used the bottom-up flight data, which included more information (length of trip, class, purpose) than the Concur data, to test the impact of various mitigation measures on the total emissions from the sample. We focused on measures that could be taken by the individual flier or the institution: selecting direct flights, reducing brief long distance travel (one overnight), reducing one-day travel, requiring only economy class travel, and conducting invited lectures using ICT (Table 3).

1. Requiring only economy class tickets

Although purchasing non-economy class tickets at UBC is only possible with permission of the appropriate Dean or Vice-President, there were 97 trips that included at least one economy plus, business class, or first class leg in the bottom-up sample of 8 different academic units. We found that replacing these with economy class tickets would have resulted in a savings of 236.58 tCO_2e, or 7.8% reductions. This may be a conservative estimate as all tickets without a class description were assumed to be economy. The cost savings per tonne of this mitigation measure could not be computed for all flights, but an example is presented for a theoretical trip from Vancouver to New York (see inset box).

BOX A: COSTS AND BENEFITS OF DIFFERENT BOOKINGS

The differences in cost and emissions between direct, indirect, and higher class travel is illustrated with a theoretical trip from Vancouver to New York's JFK airport in November 2017, based on data collected from the Skyscanner booking tool (www.skyscanner.com). A first class flight (direct) is associated with four times the emissions of an economy class flight and about ten times the cost. A direct flight reduces emissions by 0.1 tCO_2e compared to an indirect flight, but the increased cost of $117 would be enough to purchase almost 5 tCO_2e of offsets at $25/t price in the provincial system.

Percent Reduction	Total Reductions Across Campus (tCO_2e)*	Savings per Tonne
7.8	1,723	-
4.0	884	$541
1.2	265	$652
0.3	66	$2,221
11.7	2,591	-

2. Reducing travel for lectures

Traveling for the sole purpose of giving a lecture or colloquia presentation could potentially be replaced in many instances with using ICT. In our sample, 56 trips were coded as lectures, without any secondary purpose provided. These trips accounted for 120.43 tCO_2e, which is 4% of total air travel emissions, and had a total cost of $65,107. However, this sub-sample includes many long trips, which implies an unrecorded secondary purpose (personal or professional). If only trips of 2 nights or less were included, the number decreases to 11 trips totalling 8.88 tCO_2e, or 0.3% of total emissions. These trips are examples of flights that could most likely be replaced as they were brief duration and solely for the purpose of delivering a lecture and any related quick interactions.

3. Reducing brief, long distance travel

Long flights where the entire trip is completed with one overnight represent ideal opportunities for mitigation using ICT. An example might be a return flight from Vancouver to Toronto, with one overnight. The flight duration of at least four hours in each direction and airport transit time leaves the flier with little time for work beyond a face-to-face meeting or a single lecture. Yet the trip requires 7,226 km of travel and produces 1.2 tCO_2e, equivalent to 6.0% of the annual footprint of the average Canadian (Environment and Climate Change Canada, 2017).

BOX B: UBC TO UBC-OKANAGAN TRAVEL

There is frequent air travel between Vancouver and Kelowna due to the unique relationship between UBC and UBC-Okanagan. There are 807 Vancouver-Kelowna flights in the Concur sample during the 2016 calendar year, including flights originating from UBC and UBC-Okanagan, with a total cost of $249,374 and 139.7 tCO_2e in associated emissions. Of the 807 flights, 515 (64%) were taken by administrators.

This frequent inter-campus travel represents an opportunity for mitigation. Reducing this travel by 50% through increased use of videoconferencing or other technologies would result in an almost 1% reduction in total emissions (based on the Concur data). Replacing a return flight with intercity bus travel saves approximately 0.31 tCO_2e, based on the BC government's standard for intercity transit (Ministry of Environment, 2016a). Mitigation measures could include incentivizing individuals to use videoconferencing, to travel by bus, or to carpool between Vancouver and Kelowna, as well as developing a semi-regular direct shuttle service between campuses.

In our bottom-up sample, there were 32 return flights of over 3,700 km round trip that included only 1 overnight. Eliminating these flights would result in emissions savings of 35.6 tCO_2e, or a 1.2% reduction of emissions in the sample. The cost associated with these flights was $23,915, for a mitigation savings of $652 per tCO_2e assuming no cost to the replacement virtual meeting. While videoconferencing equipment is expensive, much of the cost is in the initial upfront capital investment (see Discussion and Table 4) as opposed to flight costs which recur each meeting.

4. Reducing single day return flights

In the bottom-up sample, 53 flights had a departure and return flight scheduled for the same day. The extremely short duration of these trips implies that it might be possible to accomplish the goal of these trips without flying. These flights produced 8.23 tCO_2e, which would translate to a 0.3% reduction in emissions from our sample if they were eliminated. The costs associated with these flights was $18,281, so once again assuming no increased cost from the added use of technology, this results in a mitigation savings of $2,221 per tCO_2e.

5. Choosing direct flights

Booking direct rather than indirect flight routings has been promoted as a way to reduce air travel emissions (David Suzuki Foundation, 2017; Schlossberg, 2017) because direct flights cover less distance and avoid taking off and landing multiple times which requires disproportionate fuel (Lewis, 2013). Direct flights are already convenient for most travellers in terms of time, but are sometimes not available or are dis-incentivized by their price. Travel cost is a key consideration for public institutions; under UBC policy 83 (Line 1.4), individuals must "make the most economical travel arrangements possible" (Board of Governors, 2010).

Calculating the emissions savings from selecting only direct flights with the entire dataset is complicated by the unknown factor of availability at the time flights were booked. We tested the potential emissions savings and the costs of choosing direct flights using the Department of Geography sample; we approximated availability of flights by entering the same dates into the Skyscanner travel booking tool, but using upcoming months (e.g., April 20th, 2016 becomes April 20th, 2018) and recording the cost of the least expensive direct and indirect flights.

Of the 71 indirect flight routings in the sample that could theoretically be shortened to a direct route, only 14 (or 5.1% of all trips in the sample) were replaceable with direct flights using this approach. Two of these flights would have been prohibitively more expensive (over $2,000 in increased cost), leaving 12 realistically replaceable flights with a total savings of 1.80 tCO_2e per year (0.4% reduction in departmental emissions). The flight substitutions result in an average cost savings of $6.87; this may be a product of booking travel far in advance, as direct flights are not consistently cheaper than indirect alternatives. This is likely an overestimate of potential emissions reductions as taking a direct flight in these situations may have resulted in departure or arrival times that were either inconvenient or incompatible with the purpose of the trip. There could be marginal benefits to informing travellers of this mitigation measure, but the achievable emissions reductions are likely too small to warrant a change in policy or incentives. Most fliers travel direct when it is reasonably possible; 74% of the trips in the Department of Geography sample were direct.

3.3 Survey on Air Travel Attitudes

A total of 251 individuals from 19 different faculties responded to the voluntary survey between June 18 and October 16, 2017. Of those, 210 completed the survey: roughly half (49%) of the respondents were male, 146 (70%) were faculty (including emeriti and teaching faculty), 23 were graduate students, 9 were staff, and 6 were post-doctoral fellows. The response rate is estimated at a minimum 3%, based on the 146 faculty respondents out of 5,003 faculty working at UBC. The relatively low response rate may be due to the competing demands on faculty time as well as the difficulty reaching all units; of the 66 academic units contacted about the survey, only 41 confirmed sharing the survey with the faculty.

In response to the first question, "Which of the following motivates your decision to travel by air? (maximum of three options permitted)," the most popular response (143 individuals) was "Family time/leisure" (Figure 4). Although the survey was about business-related air travel at UBC, it is possible that many respondents reflected on their personal flying while answering this question. The next most popular responses – all of which were job or career related – are therefore more instructive. Of note, only 5.7% of respondents (12 individuals) selected "energy use/greenhouse gases" and no respondents selected air miles or the cost to taxpayers as among the three most important motivators for the decision to travel by air.

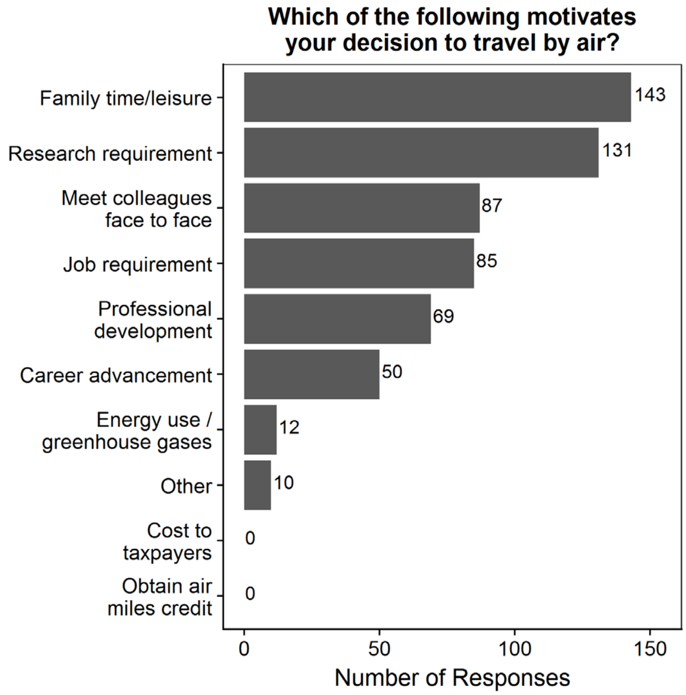

Figure 4: Responses to business-related air travel survey question regarding motivations for air travel

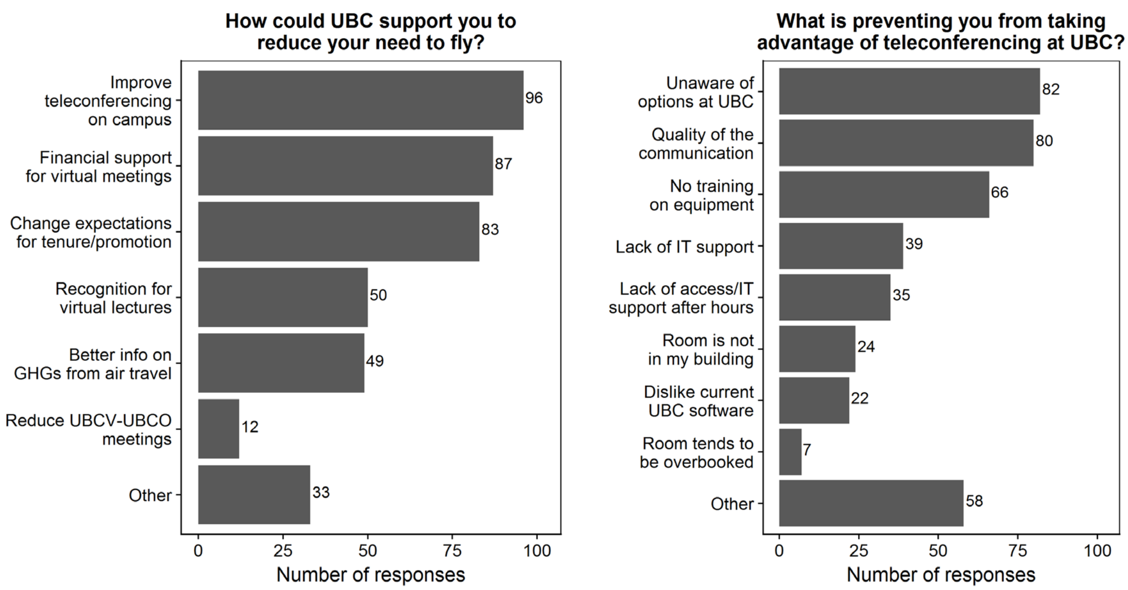

Figure 5: Responses to business-related air travel survey questions regarding (a) how UBC could support reduced air travel and (b) obstacles to use of teleconferencing on campus

When asked, "How could UBC support you to reduce your need to fly? (Check all that apply)", the most common response (45.7% of respondents) was to improve teleconferencing on campus (Figure 5a). Of those who responded "Other" and entered a reply, suggestions included "allow courses to be taken at a distance", "give enough time for alternative travel methods", "promote and support a culture of reduced acceptability for air travel", "more regional gatherings … that happen at the same time as other regional gatherings for international conferences (conference hubs)". In this same category, 8% of respondents (17 individuals) also voiced some version of the idea that UBC could or should not try to reduce their need to travel, for instance, "I travel because I feel the need to meet people face-to-face. UBC can't affect that." or "They should not try to reduce it."

In response to the follow-up question about teleconferencing as a way to reduce air travel (Figure 5b), the primary obstacle identified was lack of awareness of teleconferencing options at UBC (39%, or 82 respondents), followed closely by the quality of the communication (80 respondents). The fourth most common response was "Other" (58 responses with 56 written explanations). One common theme among the written responses (identified in 19 responses) was that teleconferencing is not an adequate substitute for certain needs (e.g., "Teleconferencing is not a substitute for on-site research or in-person interaction"). Of the written responses, 15 referred to specific technical issues such as poorly insulated rooms, incompatible headphones, a mismatch between the size of available rooms and the size of room needed, or glitches in specific software packages. Nine respondents also identified issues which we coded as "cultural" such as, "the norm in my field is to meet in person" or "lack of teleconferencing option for meetings attended".

Although the low response rate to the survey may introduce selection bias, the results suggest there is not a strong sample bias towards individuals uniquely knowledgeable about business-related air travel emissions or the topic of climate change. This is evidenced by the response to the final survey questions about carbon offsets (Figure 6a). Of the individuals surveyed, 70% claimed to never purchase offsets and 14% claimed to rarely purchase them. In response to the question "What is the primary barrier to purchasing carbon offsets?", 35% of respondents cited some version of cost (i.e., "Too expensive", "I don't get reimbursed", or "There is no budget for it") while 26% of respondents selected "I don't think it's effective", possibly reflecting deep knowledge of the subject (Figure 6b). The category with the most responses, however, was "Other". Most of the text responses in this category described lack of knowledge of offsets (12%, or 26 respondents) – "Never heard of it" – or a lack of interest in offsets (20 respondents or 9.5%) with responses suggesting disinterest ("I don't know how", or "Didn't think about it").

4. CHALLENGES AND OPPORTUNITIES: INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT)

ICT represents a potentially low-cost way to reduce business-related air travel and accompanying emissions while maintaining or even expanding contact and collaboration with outside individuals and institutions. Although the use of teleconferencing, videoconferencing, and other virtual meeting technologies may only modify or possibly even stimulate air travel (Haynes, 2010), there is recent evidence that in practice, they are capable of reducing air travel via substitution (Denstadli et al., 2013; Lu and Peeta, 2009). Many meetings, speeches, and lectures that in the past might have required air travel already take place using ICT – from conference calls to videoconferencing to the delivery of video feed – at universities and other public sector institutions. Emerging 'telepresence' or virtual reality (VR) technology promises to further reduce the gap between the virtual and in-person engagement experience. Recognizing the potential for ICT, the travel policy established in 2017 at UBC states that, "Travellers should strive to use available technology as a substitute for face-to-face meetings where possible" (University of British Columbia, 2017b).

From an emissions perspective, the lifecycle emissions of equipment and energy use for ICT is less than that of air travel, even when infrequently used, and can even be less than that of train travel, if used frequently (Borggren et al., 2013). Coroama et al. conducted a conference in two locations connected with ICT to reduce participant transportation emissions, and found total reductions of

37-50% even though participation increased compared to a single venue alternative (Coroama et al., 2012). While ICT has much potential for climate mitigation, there are important caveats to consider. Emissions from ICT will increase when more complicated equipment such as large LCD screens are used (Borggren et al., 2013), which should motivate institutions to carefully select the right technology for their needs. In addition, there are important rebound effects. For example, the ease with which modern communications technology permits contact between researchers in different locations has been critical in developing distant collaborations, which while important, can invite additional air travel. ICT can also lead to cost savings which may be redirected to other activities or purchases with their own emissions. When Matsuno et. al accounted for cost savings rebound effects, they still found videoconferencing resulted in 80% less emissions than a face-to-face meeting (Matsuno et al., 2007).

4.1. Information and Communications Technology at UBC

With 46% of survey respondents indicating that improvements in campus teleconferencing would help them reduce their need to fly, a strong argument can be made for the need for progress in this area. In the past, UBC employed a patchwork of ICT resources such that access to facilities and software can vary by faculty, building, and department. For instance, any employee in the Faculty of Arts can book a conference room with a high-definition camera, high-definition TV, and an omni-directional microphone for free and may necessitate a walk across campus (this may not be widely known; 48% of Faculty of Arts respondents in our survey reported being unaware of teleconferencing options).

Unfortunately, there has been little incentive for sharing of resources because units that make significant investments from their own budgets in technologies and in IT staff to support those technologies want sole or primary access for their own faculty and staff. Even for those who do have access to facilities, IT staff interviewed for this paper report that users desire same-day video/web conferencing in a nearby facility, such that booking a session in a different part of campus is not viewed as sufficient. The above and other limitations lead to low usage of existing facilities, which one IT staff estimated at as low as 8% for some rooms. Additionally, without a centralized support system, departments that invested in equipment

BOX C: ICT AT UBC MEDICINE

In 2005, UBC Medicine began a distributed program to increase enrollment and address the shortage of rural doctors. The program uses videoconferencing to bridge campuses as far apart as Vancouver, Victoria, Kelowna, and Prince George. For instance, lectures for first year students occur simultaneously, with a lecturer in one site speaking to students in that lecture hall and hundreds of kilometers away. Each lecture hall is equipped with microphones and cameras, such that if a student in Kelowna asks a question to the lecturer in Prince George, the audience can hear and see the question being asked.

Lectures receive IT support and a help desk is available for those booking a videoconferencing room (uses include a TEDx conference). Standardization reduces the demand for assistance; lecture theatres and smaller seminar rooms, often used for hospital-to-hospital communication, are highly similar. In each location, users will find the same button on a familiar touch-screen for projecting an image from a document viewer. Training on one site therefore applies to any of the sites.

Staff cautioned that these technologies are not a replacement for face-to-face interactions. Professors still like to travel regularly to the remote locations in order to build personal relationships with the students. Teleconferencing has therefore connected distant locations, but not wholly displaced flying.

may not have ongoing funding for maintenance. Because of these problems, UBC is in the midst of implementing a campus-wide pilot project, "UBC Collaboration Suite," which will be an "ecosystem of components" including Skype for Business and Pexip, a meeting platform that allows users to collaborate across audio, video, or web conferencing devices (UBC Information Technology, 2017).

Related technologies are also in use to create better learning environments without the need for travel (by air or otherwise). Senior Instructor Loch Brown and a team in the Department of Geography have experimented with immersive, 360° videos for field sites, such as Stanley Park in Vancouver, that allow students to participate in field trips without going to the actual location. This can have many benefits including ease of accessibility for disabled students, decreased departmental costs, and reduced transportation emissions. Conferences and lectures with options for pre-recorded lectures, livestreaming, or audience questions delivered by apps or text messages are also commonplace. The UBC Faculty of Medicine (see Box C) has been a leader in integrating these technologies into its educational mission.

4.2. Available and Emerging Technologies

There is no "one-size-fits-all" solution for ICT. More elaborate technologies are likely to come with higher price tags and embodied emissions, and should only be implemented if they will be used frequently. A list of currently available technology options is presented below in Table 4.

Table 4: Videoconferencing technologies

Technology	Description	Examples	Cost Range
Bridge platforms	Allows multiple types of devices and software (audio, visual, web conferencing) to be connected in one virtual meeting. Example: simultaneous connection between participants using Skype, a cellphone, and a room system	Bluejeans Pexip Cisco Meeting Server	Variable
Room-based systems *(prices and examples taken from UBC MED IT)*	Allows for direct communication with similar videoconference units, and in some cases, with outside devices (cellphones, PCs, etc.). Examples provided contained one omni-directional microphone for every two individuals, two projector screens, and video cameras to view participants and lecturers.	Small seminar room (6 people): Two microphones, one large screen and projector	$80-100,000
		Large seminar room (~40 people): Two projectors and large screens, 20 microphones	$200,000
		Lecture theatre (size varies, up to 350 people): Two projectors, camera for lecturer, camera to focus on participant with microphone, one microphone per two participants	$350-500,000 (Renewal every 8 years for ~$200,000)
Software	Free versions of this type of software usually support only video, while paid versions allow for options such as sharing spreadsheets and documents or having many participants join a single videoconference	Google Hangouts Skype for Business Cisco WebEx GoToMeeting Fuze Adobe Connect	Variable

ICT and telepresence technology is rapidly evolving. Before anticipating the coming technological developments, it may be informative to look back on the obstacles that ICT has already overcome. In the year 2000, Carville and Mitchell described issues with a class taking place by videoconference, which included lack of interactivity, audio lag, and poor video quality, such that a presenter had to stand still while lecturing (Carville and Mitchell, 2000). These obstacles have already been overcome, by UBC Medicine for example, due to technological advancement. Barriers do still exist which prevent videoconferencing technologies from seamlessly replacing face-to-face interactions. Many systems still deal with an inability to convey eye contact, which limits the realism of the communication experience (Vertegaal et al., 2003).

Solutions have already been proposed and include improvements in desktop videoconferencing (Grayson and Monk, 2003) or upgrades to VR headsets with avatars in 3D space or 3D video. Technologies like video headsets with multidirectional sound, and holograms superimposed on the user's actual environment, are already on the market. For example, Microsoft offers a VR headset (HoloLens) which can be paired with Skype to offer augmented reality videoconferencing. A participant on one end of the call can view the other participant's environment as if through their eyes. Additionally, participants can draw holograms which the other participants perceive as being in their environment. With this technology, an instructor could virtually label parts of the body for a student. This is an expensive technology ($7,500 CDN on Amazon), but cheaper alternatives like Google Daydream that pair with a user's smartphone have also been developed ($99 CDN on Amazon).

While impressive, these technologies still fail to address other obstacles to an authentic communication experience, including lack of physical proximity and presence (Richardson, 2012) and lack of physical contact (Baruffaldi et al., 2004). Perhaps technology may never replace face-to-face communication, but it could significantly close the realism gap that we experience today.

5. SUMMARY AND RECOMMENDATIONS

This report indicates that business-related air travel represents a substantial, unaddressed emissions burden. The emissions per UBC traveller in this study (2.02 tCO_2e/person and 2.69 tCO_2e/person in the bottom-up sample and Concur samples, respectively) are equivalent to 10-13% of the greenhouse gas footprint of the average Canadian and 16-21% of that of the average BC resident (Environment and Climate Change Canada, 2017). When extrapolated to the entire institution, annual business-related air travel emissions are equivalent to 63%-73% that of the UBC campus, and 1.3 to 1.6 times greater than the UBC emissions target for the year 2020.

This analysis also reveals the opportunities and challenges in measuring and addressing business-related air travel greenhouse gas emissions from large public sector institutions. The results show that many trips by air are potentially replaceable; most trips taking place at UBC are short (median length of five nights) and the most common purpose of trips was for conferences and meetings. Five simple "low-hanging fruit" mitigation measures, including eliminating higher class travel, and brief, long haul trips, could have reduced emissions by 11.7% (from our bottom-up sample), while also saving money. Efforts to address the remainder of business-related air travel emissions will require changes to actual and perceived professional norms (e.g., in-person attendance at international conferences) as well as the quality and awareness of alternative technological options. Our assessment of the state of virtual meeting and videoconferencing technology suggests potential for radical improvement in capacity and quality in the next few years provided adequate investment. While emerging technology may not be able to fully replicate the indirect benefits of in-person participation in meetings and conferences (e.g., networking, social interactions with peers), it could be critical in minimizing the need for brief single-meeting air travel discussed above, and in facilitating the broader cultural shift necessary to hold more virtual conferences, workshops, and meetings.

Based on this case study of UBC, we provide a five-step roadmap for public sector institutions in British Columbia and beyond looking to track and address greenhouse gas emissions from business-related air travel (Appendix A). The five recommendations are described below in detail:

Recommendation #1: Implement a process for tracking air travel emissions into the financial management system

A comprehensive system of tracking business-related air travel emissions is a necessary starting place for a mitigation strategy. The UBC case study demonstrates the difficulty of accurately assessing emissions from business-related air travel given typical booking and financial management systems. The data from the centralized booking tool was the most comprehensive, but nonetheless represented an incomplete assessment of travel from UBC, was biased towards administrative travel, and lacked necessary details on trip length, class of ticket, and purpose of travel. In contrast, the bottom-up data was time-consuming to collect (i.e., processing 100 TR forms required seven hours) and not feasible for the entire institution. While potentially more comprehensive, a bottom-up analysis could feature gaps and double-counting, due to duplicate forms submitted to multiple units and missing documents.

The solution is to integrate business-related air travel data reporting into the institution's existing financial management system, such that associated emissions could be automatically calculated and/or the data could be exported for annual emissions assessments (see Recommendation #4). Financial reporting software employed by staff to report and track expenditures can be updated to collect the data required to estimate and analyse air travel emissions for each flight: date of travel, airport codes, number of flight segments, cost, ticket class, length of trip (in nights), primary and secondary purpose. Inputting this data into the existing financial management system at the time of submitted TR forms would add minimal burden to staff or administrators. Emissions per flight can then be computed using the emissions calculator described in this study, either automatically within the financial management system or offline by the institution's climate action or sustainability office, and used to create quarterly or annual reports for individual travellers, individual units, and the entire institution.

A centralized reporting system increases the accuracy of institution-wide emissions reporting, and provides the more granular data necessary for individual units and the institution as a whole to track progress towards targets and to evaluate mitigation strategies. For example, one of the academic units included in this study has already expressed interest in continuing to track air travel emissions as flights are purchased in order to monitor annual mitigation progress.

Recommendation #2: Integrate a central information and communications technology strategy into climate action planning

The second crucial step in achieving the goal of minimizing emissions from business-related air travel is to integrate ICT into the central vision and mission of the institution. The evidence from this case study suggests that even at institutions like UBC, where sustainability is a core part of the mission, teleconferencing and telepresence efforts too often occur in silos. A centralized push is necessary to guide investments in new technologies and to integrate ICT into everyday operations; the ideal structure of such an effort will depend on the culture and size of the institution. At UBC, for example, virtual meetings are encouraged in the new travel expenditure guidelines. Yet at an institution with the size and complexity of UBC, few employees, particularly few of the faculty and researchers who make independent travel decisions, are likely to review the details of such policies. Large public institutions need more explicit programs and incentives for teleconferencing or telepresence to be actively considered whenever an employee makes an independent air travel decision.

In such large academic institutions, we recommend starting by creating a campus-wide committee, including representatives of IT, Sustainability and Engineering, Finance (Travel) and various faculties dedicated to incorporating virtual meetings and ICT into university business. This committee could oversee and/or advise on a suite of programs and policies:

- Integrating ICT into the operation of the institution. An example is formally updating standards surrounding promotion and tenure whereby equal "credit" is guaranteed for a lecture, talk, or testimony whether delivered in-person or virtually
- Incorporating virtual meetings, telepresence, and ICT into the university's research vision by encouraging academic research on the subject and seeking partnerships and funding from organizations and companies working on new technologies and their application
- Reviewing and regularly updating institution-wide software licenses for simple virtual meetings (e.g., UBC IT's new Collaboration Suite includes Skype for Business)
- Developing distributed facilities with videoconferencing hardware for more complex multi-party meetings, available for booking across the institution. A standardized system, as in UBC Medicine, improves ease of use and enables incorporation of new technology (e.g., 360° video)
- Establishing a central fund that provides grants to academic units or groups of units across campus to encourage bottom-up virtual meetings and ICT systems and solutions
- Offering matching money out of a central fund and/or in-kind contributions to units that make events virtual (e.g., a seminar series in which out-of-town speakers give virtual presentations)

Academic and other large public sector institutions have great potential to lead by example. Considering the emissions and cost of business-related air travel in developing ICT strategy (e.g., by including travel and sustainability representatives on the ICT committee) can help make a business case for new investments. At UBC, for instance, there may be a financial case for technological investments to replace many same-day or two-day flights between the Vancouver and Okanagan campuses.

Recommendation #3: Target easy, cost-saving actions, including requiring economy-class travel

Substantially reducing business-related air travel emissions at an institution like UBC requires broad shifts in institutional culture and individual behaviour. Nonetheless, this study identified several simple, cost-saving actions that could reduce emissions from the bottom-up sample by 11.7%. Addressing this "low hanging fruit" could produce the immediate action that can build momentum and enthusiasm within the institution for longer-term technological and behavioural changes.

The most effective single step would be to eliminate all non-economy ticket purchases. Even with the existing UBC restrictions on purchasing air travel in a class higher than economy [requires approval of the respective Dean or Vice President, according to Policy No. 83 (Board of Governors, 2010)], booking a higher class of travel was responsible for 7.8% of the air travel emissions in our bottom-up sample. Institutions like UBC could employ a stricter policy where only economy class tickets can be purchased, except in the case of a medical requirement. Individuals wishing to fly in a higher class or to upgrade their tickets could do so at their own expense so that the institution is not accountable for the added increase in emissions. Such a policy would be consistent with the expenditure guidelines for public institutions (e.g., UBC's new 2017 guidelines aim to "enhance stewardship of public funds") and public granting agencies (e.g., Canada's three federal research granting agencies prohibit billing air travel in a class higher than Economy).

Additional actions include incentivising the use of ICT for long-distance, short-haul trips and for trips to or from the institution for the sole purpose of delivering lectures. For example, following from recommendation #2, institutions could provide matching funding for virtual lectures series at the institution and/or could use the air travel cost savings to offer honorariums to guest speakers.

Recommendation #4: Develop a behavioural incentives program

The first three recommendations can create the foundation for a program that encourage the cultural and behaviour shifts necessary to address the majority of business-related air travel emissions (e.g., the other 88.3% in the bottom up sample). There are numerous, well studied ways to promote pro-environmental behaviours without the use of restrictive policies, including prompts, justifications, social modeling, and feedback (Osbaldiston and Schott, 2012). For instance, comparative feedback was shown to decrease workplace energy usage on a university campus (Dixon et al., 2015). Personalized communications to business fliers within the institution could simultaneously make use of several, similar strategies to promote reduced air travel.

The first step in this program could be to develop annual air travel emissions reports tailored for each individual and unit, using information from centralized air travel emissions accounting system (Recommendation #1) and telecommunications strategy (Recommendation #2). Social sciences research shows that providing individuals with data about their behaviour in contrast to that of their neighbours or peers can be an effective motivator of behavioural change. For example, showing households their own voting records in addition to the records of their neighbours (and vice-versa) can be twice as effective as only providing feedback to a household and over four times as effective as appeals to civic duty (Gerber et al., 2008). This effect has since been replicated (Panagopoulos, 2010), with similar successes described for tailored feedback in reducing household energy use (Abrahamse et al., 2007) and for increasing recycling participation (Varotto and Spagnolli, 2017). A forward thinking institution, or even an ambitious unit within an institution, might choose to make their emissions public knowledge as an additional form of accountability.

Personal annual reports would present the individual's air travel emissions data for the year and compare the emissions to that of others, including, for example, the mean and range for their administrative unit, that of other individuals at the same rank (e.g., assistant professors, etc.), and that of the average Canadian. Similarly, unit-level reports could present the emissions data for the unit, and the distribution within the unit, and compare the data to that of other units on campus. These reports would also provide recommendations and resources, including information on available videoconferencing facilities, available funds, and profiles of employees or units that have used these resources. The air travel attitudes survey suggests including this information is critical: 39% of respondents reported that they were unaware of teleconferencing options at UBC.

Regardless of the specifics of a behavioural incentive program, fostering support amongst key institutional stakeholders is critical. The program could be announced and promoted by leaders recruited from each unit who have volunteered to role model positive air travel behaviour, following the concept of social modelling (Osbaldiston and Schott, 2012). "Block leaders" or neighbours who lead by example, have been shown to improve recycling sorting (Mickaël, 2014) and recycling participation (Burn, 1991); "peer educators" have also been used to effectively reduce workplace energy usage (Carrico and Riemer, 2011). Unit leaders therefore may represent another way to reduce business-related air travel emissions.

In order to measure the success of such a program, we recommend that it be implemented in phases, with certain experimental units receiving trial versions so that the results can be compared to departments acting as controls. Not only could this be used to test the efficacy of an intervention, but it would also allow the university to receive feedback from the fliers before investing in a campus-wide system.

Recommendation #5: Consider employing offsets only if locally-based

The few existing programs designed to address emissions from business-related air travel have focused on purchasing offsets as a primary means of mitigation. For example, the 2010 UBC Climate Action plan notes the need to begin a dialogue on absorbing costs of carbon offsets for travel into research grants (University of British Columbia, 2010). Requiring individuals to purchase offsets could be part of a suite of mitigation efforts, but our survey indicated that this common approach to addressing air travel emissions is both unpopular and poorly understood. For example, the survey showed substantial opposition (26% of respondents) to offsets based on the premise that they are ineffective. The survey also indicated that understanding of offsets was not widespread, despite the centrality of sustainability and climate mitigation to UBC's mission. Any institutional air travel offsetting program may thus need an educational campaign to overcome opposition to requiring the additional expenditure.

The solution may be to only consider an internal offset program that directly reduces emission from the institution itself or from close partner institutions. For example, this may involve using funding from offset purchases to invest in new energy systems or building retrofits on campus. This internal offsetting approach could ameliorate the perception that the offsets are ineffective or lacking in transparency. With the development of an air travel emissions accounting system (Recommendation #1), the billing for offsets could occur directly within the financial management system, thus reducing any institutional burden.

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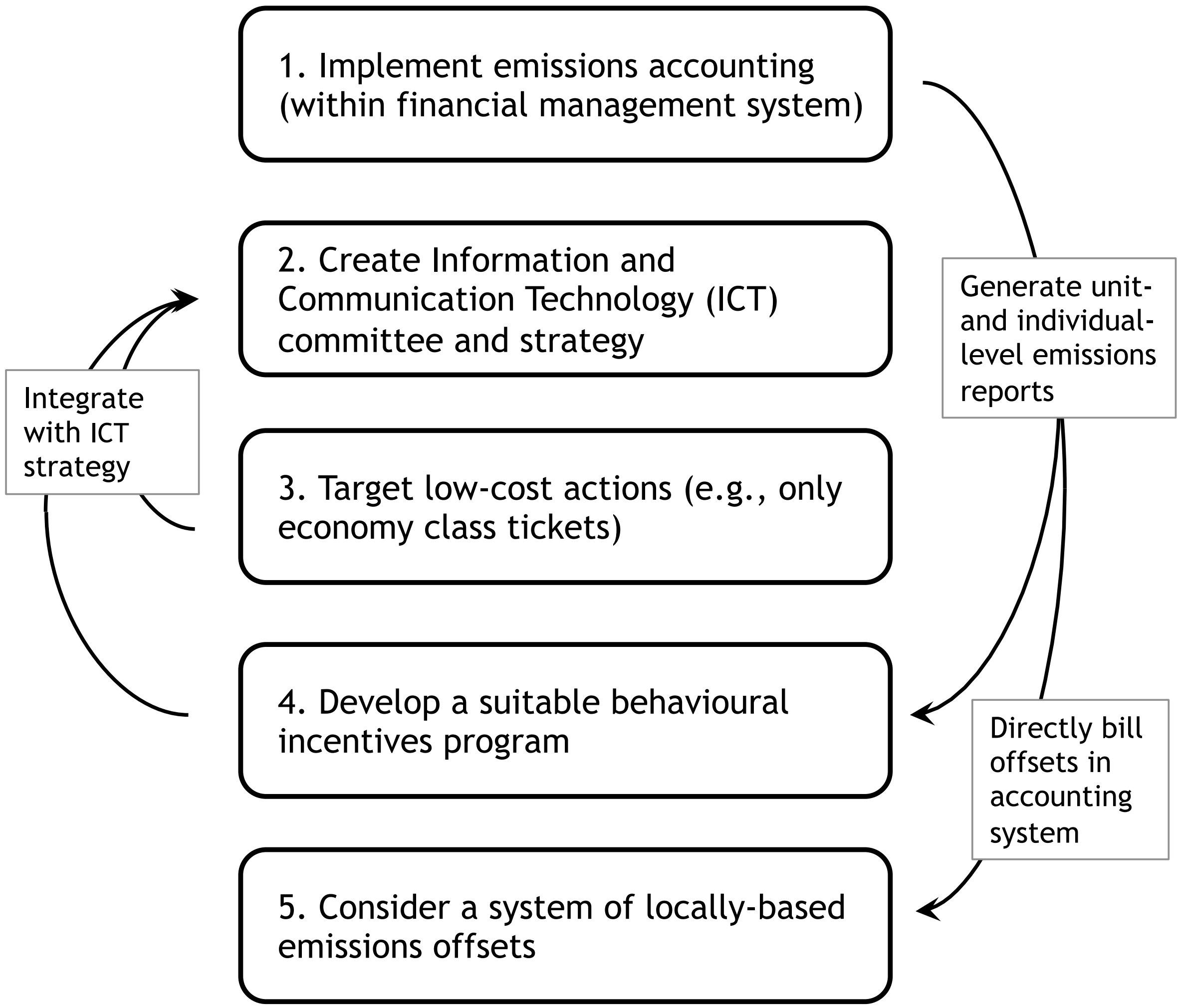
APPENDIX A: ROADMAP FOR ACTION ON BUSINESS-RELATED AIR TRAVEL EMISSIONS



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