Transportation

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Introduction and Background

There are two types of transportation emissions associated with the University. The first type comes from vehicles burning fuel directly on campus. According to the GHG protocol accounting system[1] this type of emissions belong to Scope 1. The University is directly responsible for scope 1 emissions and exercises full control over them. There are two sources of scope 1 emissions at Boston University: one is the BUS Shuttle which connects the Charles River Campus (CRC) with the BU Medical Campus (BUMC), and the second one is the BU fleet. The BU fleet encompasses all types of vehicles owned and operated by different departments such as the Boston University Police Department (BUPD), BU Athletics, Facilities Management and Planning and so on.

The second type of transportation emissions associated with BU are those emissions compelled by the University onto students and faculty but for which the University has no direct ownership or control. These are indirect transportation emissions also known as Scope 3 emissions[2]. The two main sources of scope 3 emissions with regard to transportation are employee commuting (category 7) and business travel (category 6). Employee commuting refers to emissions from the transportation of employees between their homes and their worksite. Business travel refers to transportation emissions from trips taken for business purposes, which in academia refers to car, train, or plane trips with the purpose of attending conferences, giving talks, or conducting fieldwork. All of these activities are conducted domestically but also, with increased frequency, internationally.

Boston University chose to be a globally important institution for higher education. Being a globally important university compels students and faculty to engage in significant air travel to attend classes, speak at conferences, and conduct research abroad. In 2016 approximately 9,000 students, a fourth of the entire student population, came from outside the US. Moreover the University operates through Global Programs a number of satellite campuses (London in the UK, Sydney in Australia, Geneva in Switzerland, Los Angeles and Washington D.C.) and several Study Abroad Programs in partnership with universities around the five continents.

The table below provides an overview of scope 1 and 3 emissions associated with the University for the year 2016[3]. Scope 1 emissions were calculated from actual fuel consumption data of the BU Shuttle and the BU fleet. Scope 3 estimate include emissions from the following categories: a) car commuting to the Charles River and Medical Campus b) faculty traveling via plane for business purposes and c) international and domestic students flying to Boston once a year to attend classes. As shown below, emissions from scope 3, just shy of 28,000 metric tons of CO2 equivalent are much larger than scope 1 emissions, which are approximately 2,800 metric tons of CO2 equivalent.

Figure 1. Transportation scope1 and 3 emission summary for Boston University in 2016

[1] http://www.ghgprotocol.org/corporate-standard

[2] ttp://www.ghgprotocol.org/standards/scope-3-standard

[3] Air travel, car commuting, and the BU Shuttle emissions are calculated based on the calendar year while emission from the fleet is calculated based on the fiscal year.

Category	Under University's direct control and ownership?	Emission (MT CO2 equivalent)	Percentage of total scope 1 and 2 emissions[4]
Scope 1	Yes	2,831 (actual)	2%
Scope 3	No	27,965 (estimate)	22%

It has to be noted that the estimate for scope 3 emissions carries significant uncertainty because flight tracking for faculty and staff is not systematic and there is no flight tracking for students. The actual value for scope 3 transportation emissions could be twice as much the current estimate. Future efforts should include a more accurate account of scope 3 emissions, which implies greater and more granular data collection of both flights and car commuting.

Chart 1. Estimated Scope 3 emissions with uncertainty bounds.

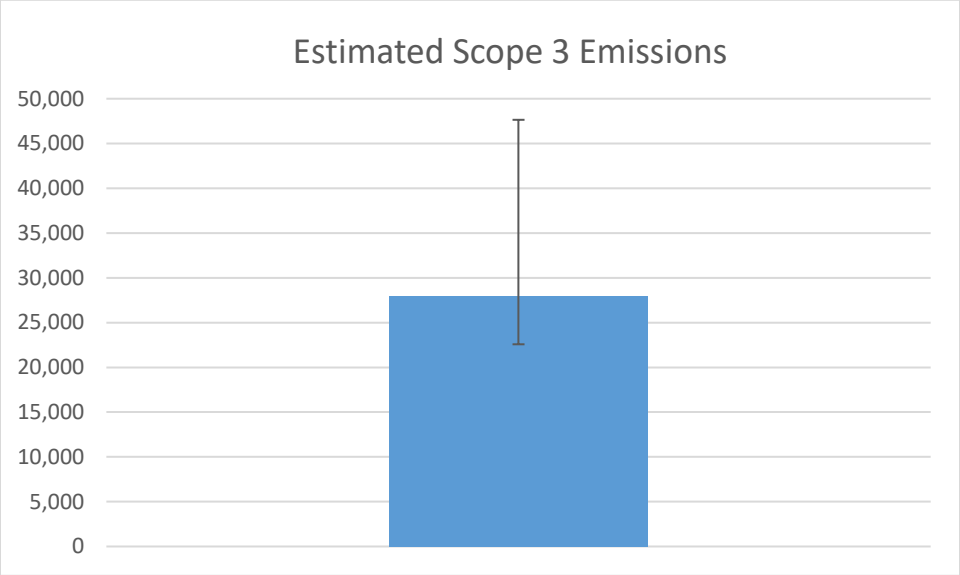
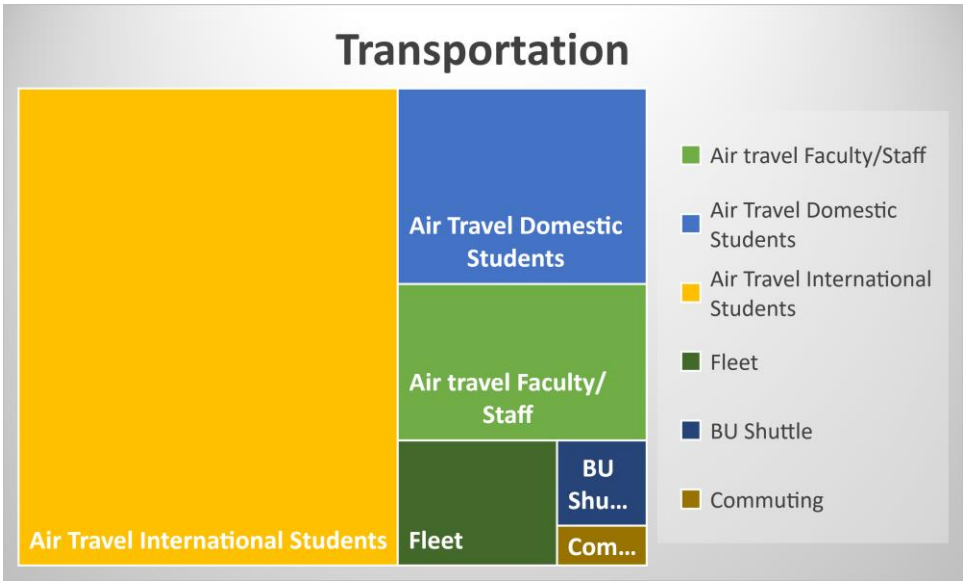


Chart 2. Visual breakdown of the University's transportation emissions

[4] Scope 1 and 2 emissions total to 124,296 MTCO2 for FY 2016, as described in the Energy chapter.



Recommendations summary

For emissions that the University owns and control, that is scope 1 emissions, this group recommends

a) Improve data collection and analytics to support decision making
b) pilot a change in the BU Shuttle route to allow for improved on-time services
c) conduct a feasibility study of the BU Shuttle fleet conversion to electric

As for the BU fleet this group recommends to pilot electric vehicles by 2020 and phase in electric vehicles as technology develops.

For scope 3 emissions, to reduce the number of single-occupancy vehicle commuting to campus on a daily basis the university should, among other things, this group recommends:

a) To replace outdates parking technology to allow for the integration of Permit Management System and Parking Access and Revenue Control Systems
b) To introduce zone parking policies and dynamic pricing

To address emissions from air travel this group recommends:

a) Tracking of air travel for both faculty and staff for trips funded by third parties
b) Identification of an offset program for students and faculty engaging in frequent air travel.

The rest of the document presents an in-depth analysis of each of the following transportation categories: air travel, Transportation Demand Management which is further broken down into walking, biking, the BU Shuttle, car commuting. Each section is organized with a description of the current status quo, the explanation for emission calculation when available, and recommendations on how to reduce emissions in the short and long term.

Summary of 2015 Estimated Co_2 Emissions from Faculty/Staff and Student Air Travel

Summary

We estimated CO_2 emissions from air travel by BU faculty/staff and students during the 2015 calendar year. International students comprised the largest portion of air travel emissions followed by domestic students and then faculty/staff. Estimates for faculty/staff are based on individual flights provided by Concur while estimates for students were based on an assumed single round-trip flight from the student's home state/country capital to Boston. This difference in available data is reflected in the larger uncertainty of student emissions. Table 1 summarizes the estimated emissions.

Table 1: Summary of Estimated CO2 Emissions from Air Travel

	Emissions (MT CO_2)	
	Best Estimate	Uncertainty Bounds
Faculty / Staff	4,000	3,300 – 6,600
Domestic Students	5,000	3,800 – 10,400
International Students	18,600	14,900 – 29,800

Uncertainties for the faculty/staff estimates are largely driven by the unknown load factor of the flight (i.e. how many passengers were actually on the flight). Uncertainties for students were also driven by uncertain load factors as well as uncertainty on the proportion of students that arrive to BU by air or other travel modes. The rest of this document details the estimation approach and results.

Estimating Faculty/Staff Emissions

We received all flights booked by faculty/staff on Concur, which includes the flight numbers, dates, airlines, and arrival and departure information. For each flight, we used a custom-built Python scrapper to look up historical flight records on flightstats.com[5] and recorded the aircraft information and flight distance. For each aircraft and flight distance, we computed CO_2 emissions using the European Environment Agency air pollutant emissions calculator[6], an Excel-based calculator that incorporates emissions from aircraft flight as well as taxi and loading times based on known fuel efficiencies of different aircraft and flight distances.

With the total emissions for each flight in the Concur data computed, the portion of each flight's emissions for which the BU faculty/staff member who took that flight is responsible depends on the aircraft capacity and load factor. Aircraft capacities were matched to the aircraft using the database at airlineupdate.com[7], and average monthly load factors (both domestic and international) were taken from the Bureau of Transportation Statistics.[8] Upper and lower bounds of uncertainty were set to 50% and 100% capacity, with the average load factor often being approximately 80%.

While the Concur flights data are rather precise, BU faculty/staff unfortunately do not book all business travel through Concur. A small survey of 15 BU faculty/staff revealed that on average the Concur flights account for approximately 55% of all business air travel. Based on this result, we assumed that a remaining 45% of faculty/staff air travel is proportionally equivalent to the Concur flights. The sum

[5] https://beta.flightstats.com/historical-flight

[6] EMEP/EEA Air Pollutant Emissions Inventory: http://www.eea.europa.eu/publications/emep-eea-guidebook-2016

[7] http://www.airlineupdate.com/content_public/codes/aircraft/aircraft-iata.htm

[8] BTS Load Factors: https://www.transtats.bts.gov/Data_Elements.aspx?Data=5

of both Concur and non-Concur emissions results in our final best estimate of 4,000 MT CO_2, with uncertainty bounds spanning 3,300 to 6,600 MT CO_2.

Estimating Student Emissions

Student flight emissions includes significantly greater uncertainty as the only data we received was the total number of students by state for domestic and country for international. Nonetheless, this information is enough to estimate a likely boundary of possible emissions. For our analysis, we computed three cases (base, worst, and optimistic) of CO_2 emissions from a single round-trip flight based on the direct distance from the student's home state/country capital to Boston.

Using the European Environment Agency air pollutant emissions calculator, we computed quadratic relationships between CO_2 and flight distance for every aircraft in the calculator. We included all possible aircraft in our analysis for flights less than 4,750 miles and only "Heavy" wake category aircraft for flights greater than 4,750 miles. Using different aircraft affected both the fuel consumed (and thus CO_2 released) as well as the per-passenger emissions as each aircraft has different passenger capacities. We included the highest and lowest emissions across all aircraft for our worst and optimistic cases, and we took the average across all aircraft as the base case.

It would be unreasonable to assume that all students fly to BU, especially for nearby domestic students (such as those from New England) and even some international students (e.g. Canada). Likewise, it would be equally unreasonable to assume that all students would drive from far away locations, such as California. As a result, we used three relationships between the distance to Boston and the percent of students that would fly. For our worst case, we assumed all students would fly – an obvious over-estimate, but nonetheless a confident upper-bound. For our base and optimistic cases, we used a quadratic relationship with flight distance. The base reaches 100% of students flying at 600 miles while the optimistic case reaches 100% at 1,000 miles. Figure 1 shows the three curves used in our analysis. After including a range of uncertainties, the estimated emissions for domestic students is 5,000 MT CO_2 with uncertainty bounds spanning 3,800 to 10,400 MT CO_2, and the estimated emissions for international students is 18,600 MT CO_2 with uncertainty bounds spanning 14,900 to 29,800 MT CO_2.

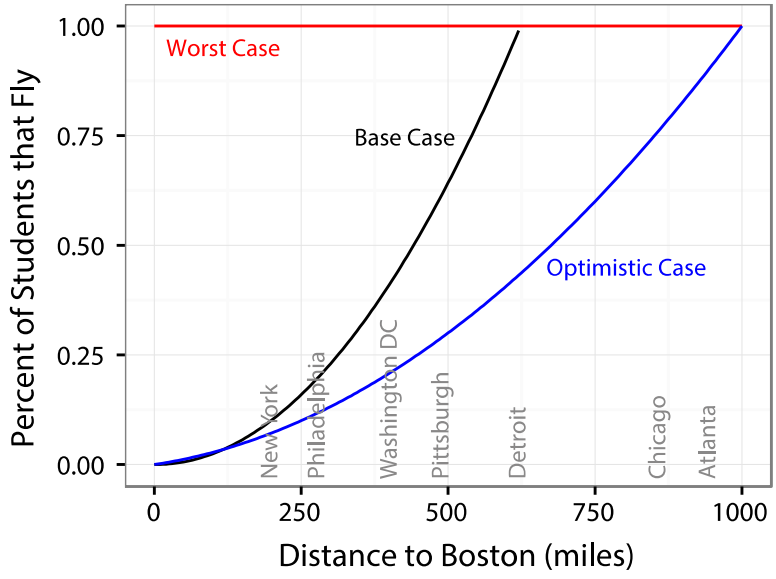


Figure 1: Functions used to estimate proportion of domestic students that travel to BU by air.

Detailed Estimated Emissions

Figure 2 compares the estimated CO_2 emissions from faculty/staff and all students. Comparing across all groups, the emissions from international students taking a single round-trip flight to Boston dwarfs all emissions by faculty/staff and domestic students combined, with an approximately 68% share of all air travel emissions. Domestic students also account for a sizeable portion of CO_2 emissions, although it is uncertain whether these emissions are greater or less than those by faculty/staff. Future work, including surveys of students, will help identify with greater certainty the true emissions associated with air travel.

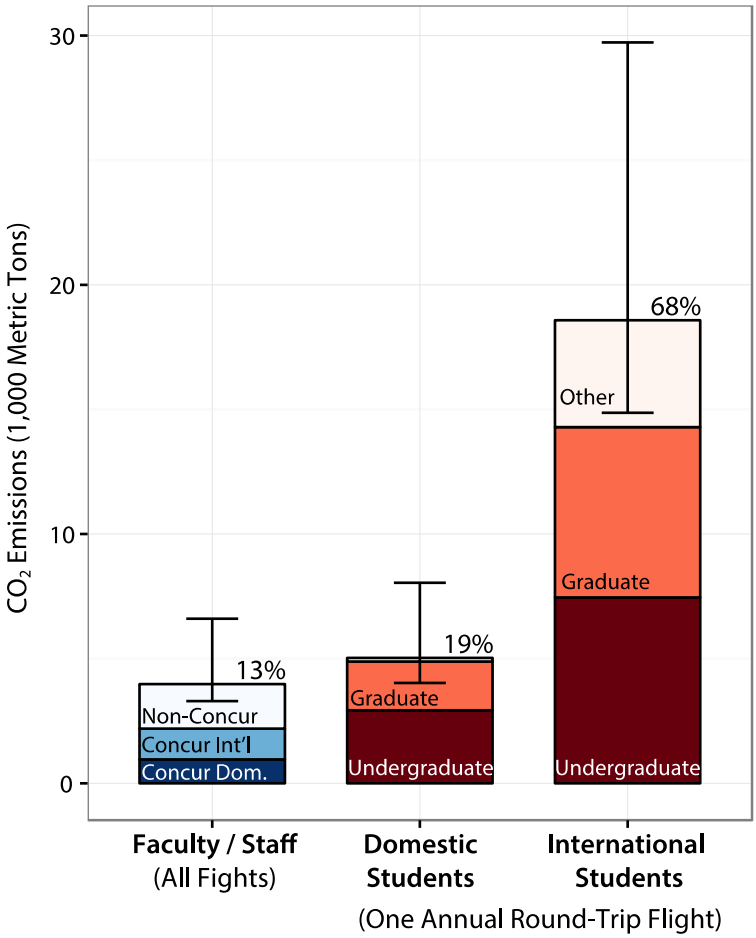


Figure 2: Estimated 2015 CO_2 emissions from faculty/staff and student air travel.

Figure 3 and Figure 4 break down the student emissions by state and country, respectively. As expected, students from further away locations (such as California, China, and India) accumulate greater emissions than those from closer locations. The total number of students from each location also affects the overall emissions, but distance still has a larger effect. For example, the 2,619 students from New York only produce an estimated 13.8 MT CO_2 from air travel whereas the 602 students from Texas produce an estimated 355 MT CO_2.

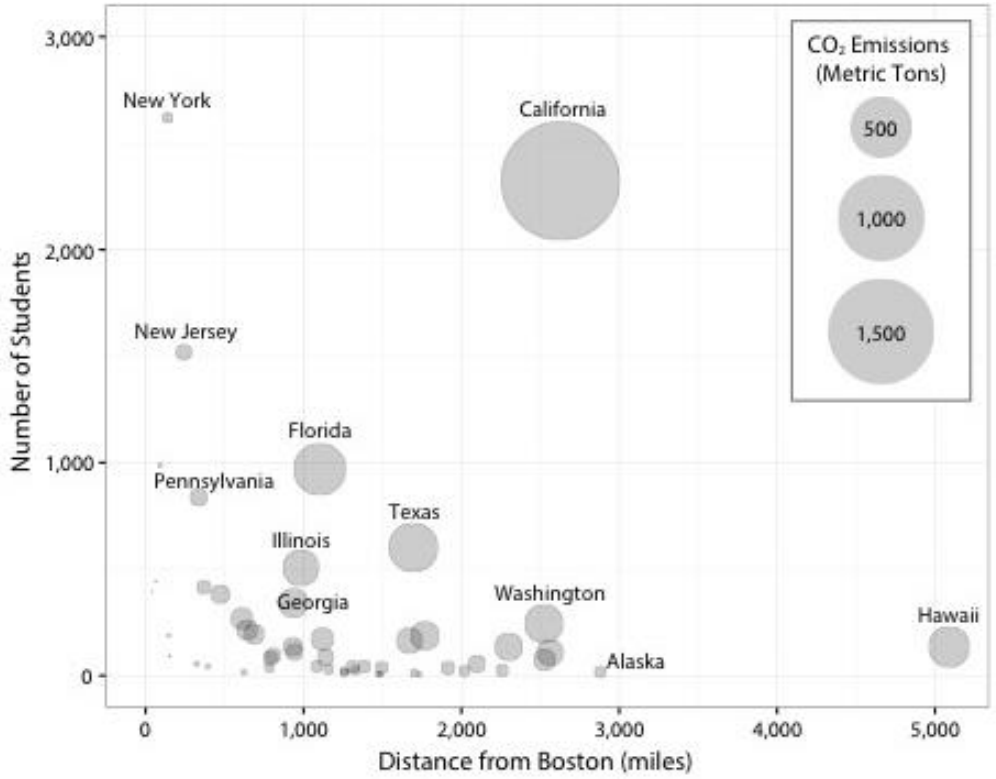


Figure 3: Domestic student CO_2 emissions by state.

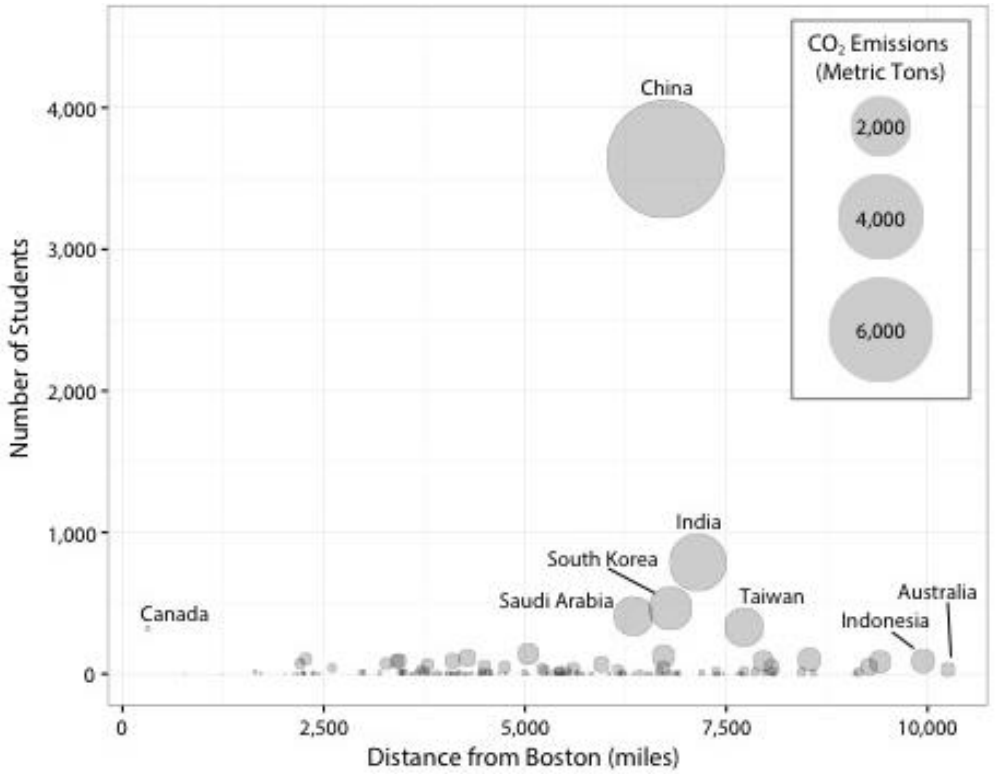


Figure 4: International student CO_2 emissions by country.

Air travel recommendations

As a first step we recommend that the university begin to track student air travel. Collecting this data will give us a baseline and allow us to analyze the feasibility of policies (surveys about travel could ask students what initiatives might encourage them to travel less), and would be the first step in establishing an offset program.

We also recommend that the university begin tracking all air travel by university affiliates for business, or academic purposes. Dynamic surveys could inform users about their carbon emissions and suggest offset options.

After tracking, the group recommends the evaluation of different offset programs for flights and offer the community a list of top programs along with an explanation for selecting certain offset programs over others.

Lastly, this group recommends initiatives to raise awareness among the community on emissions related to travel. One idea is to provide information about emissions for BU-related travel so that every time a flight is booked through Concur or other centralized system, the buyer sees the number of tons expressed in carbon emission equivalent associated with that particular trip.

Fleet

The Boston University fleet encompasses different vehicle types that belong to different departments. For example the BU Police Department owns its own fleet of police vehicles, Facilities Management & Planning owns many trucks, vans, SUVs, lawn mowers, and leaf blowers. The Athletics and Environmental Health & Safety departments also have their own set of vehicles.
The recommendation for this category is to pilot electric vehicles by 2020 and phase in electric vehicles as technology becomes available. The latter is a critical point because as noted above the BU fleet is composed of vehicles with a variety of specific requirements where electric technology penetration is still in the early stages.

Transportation Demand Management

Where We Are:

A conversation about transportation typically begins with commuting options, preferences, costs, access, and availability. Boston University has made a concerted effort to address transportation options on both its Charles River and Medical campuses with a focus on promoting sustainable choices for its students, faculty, and staff. This work complements municipal initiatives, particularly the City of Boston's recently-completed *"Go Boston 2030"* plan, which *"envisions a city in a region where all residents have better and more equitable travel choices, where efficient transportation networks foster economic opportunity, and where the City has taken steps to prepare for climate change."* Transportation Demand Management (TDM) programs are administered through Parking and Transportation Services (PTS) on the Charles River Campus and TranSComm on the Medical Campus

Commuting

Boston University has developed a TDM plan that seeks to balance current and future parking supply with reduced drive-alone demand that simultaneously decreases emissions. Why is TDM necessary at BU?

- TDM embraces a campus-wide discussion of traffic congestion, parking availability, access and mobility, and their impact on the campus environment and ongoing sustainability initiatives.
- TDM provides a greater range of student, faculty, and staff transportation options.
- TDM provides a means for BU to reduce drive-alone vehicle demand and associated emissions.
- TDM maintains the University's competitive position as an attractive workplace and academic environment.
- TDM proactively responds to future reductions in campus parking supply. Pursuing opportunities to redevelop existing surface parking lots to foster campus growth without related growth in motor vehicle traffic is of strategic importance to the University's academic mission.
- Reducing single occupancy vehicles through transportation mode shifts is essential to reduce emissions.

Figure 5. Over 2,600 faculty and staff live within three miles of the Charles River Campus and over 500 currently drive and park on campus.

Figure 6. Approximately 1,900 faculty and staff live within ½ mile of one seat transit options.

Figures 1 and 2 illustrate the opportunity to reduce single occupancy vehicle traffic and parking demand within a three mile radius of the Charles River Campus and the Medical Campus by encouraging mode shifts. And, there are also options for faculty and staff commuting from further distances using the Commuter Rail. TDM initiatives such as the MBTA subsidy benefit, ride share, and Hubway discounts for regular faculty and staff have reduced year over year (2016 to 2017) parking permit demand by 324 permits or 6.4%. However, over 6,000 parking permits are still issued on the Charles River and Medical campuses.

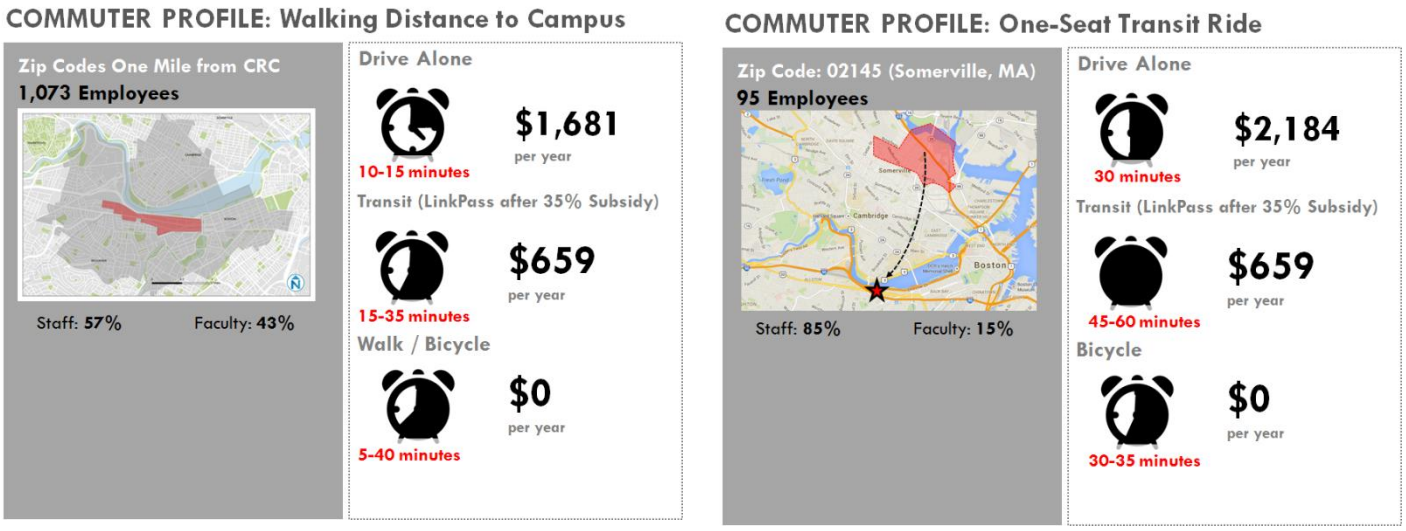


Figure 7. Illustrates two options that compare the time and costs of driving, bicycling, using the MBTA or walking to the Charles River Campus.

AUTOMOBILE COMMUTING EMISSIONS

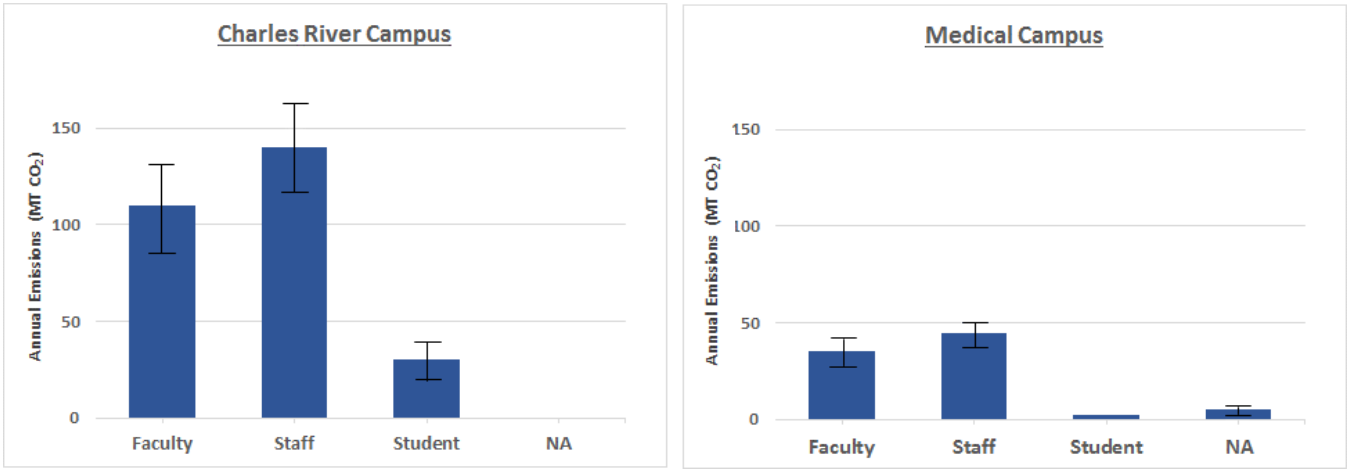


Figure 8: Annual Emissions in metric tons as a result of daily commuting to and from campus.

A recommendation for

Where We Need To Be: Sustainable Modes of Transportation

Ride Sharing

A significant number of Boston University employees drive alone to work. Sharing those rides with another employee represents an automatic 50% emissions reduction on those trips as well as a significant savings for the employees. Currently, only 38 Charles River Campus employees take advantage of our "Commute Better Together" program and split the cost of a half-price "carpool permit." The program also offers reserved parking and discounted day passes for occasional drive-alone trips. Employees can be matched with rides through Parking and Transportation Services' Commuter Preferences Survey and the Commonwealth of Massachusetts' NuRide system.

Walking

Boston is a walking city and Boston University is a walking campus. Just over 15% of Boston commuters walk to work – the highest rate of any city in the country according to the report issued in May 2014 by the American Community Survey (ACS) entitled *"Modes Less Traveled - Bicycling and Walking to Work in the United States: 2008–2012"*. Walking rates are even higher on the BU campus although north-south movement requires crossing Commonwealth Avenue and east-west movement requires navigating the BU Bridge area. BU has provided support for pedestrian improvements over the years, most recently with Phase II of the Commonwealth Avenue Improvement Project, a $20.4 million state undertaking that will transform the stretch of the avenue from the BU Bridge to Packard's Corner – the project will add a bicycle track and improve street crossings and is expected to be completed in the summer of 2019.

Bu Shuttle Bus

The Boston University Shuttle (the BUS) provides an efficient means of transportation for students, faculty, and staff between the Charles River Campus and the Medical Campus. The routes and service have gradually expanded since the service was introduced in 2004. The BUS fleet is made up of five 60-foot articulated buses with the ability to accommodate 100 passengers, and three 40-foot low floor buses with a capacity of 60 passengers.

The fleet is owned and operated by Academy Bus under a contract with BU that expires in 2022. The buses use biodiesel fuel and the entire fleet will undergo extensive refurbishment, which includes new fuel efficient engines in the summer of 2017.

In 2016, the BUS fleet logged 205,000 miles and provided service to approximately 1.8 million passengers with 12 stops that connect both campuses. The BUS fleet used 60,294 gallons of biodiesel fuel, averaging 3.4 miles per gallon.

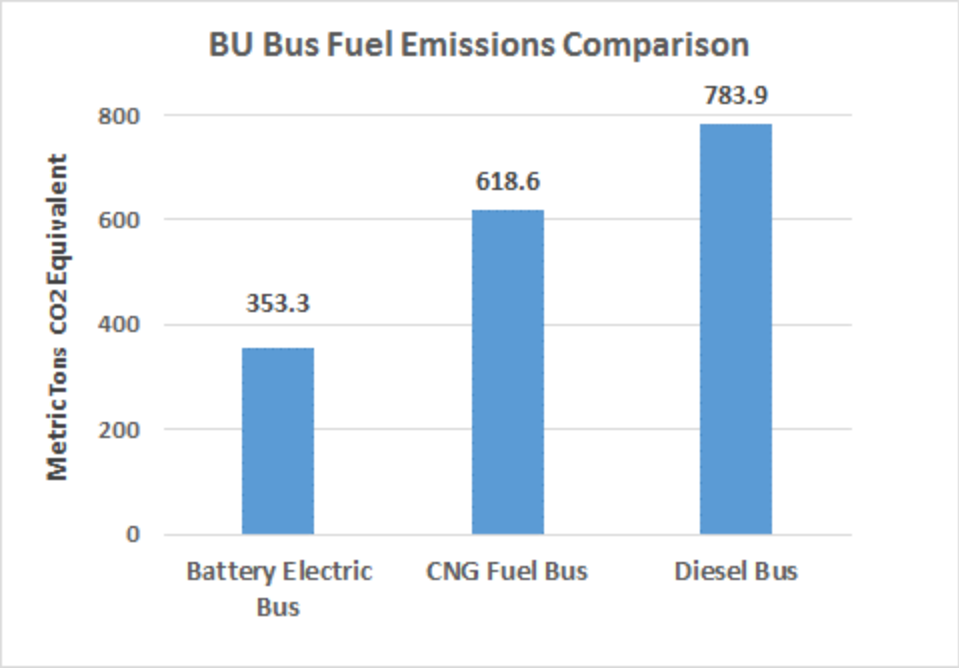


Figure 9: While BU is under contract for its existing biodiesel bus fleet until 2022, an emissions and cost study needs to be completed to more fully assess natural gas and electric options.

Bicycling

BU has made great strides in advancing bicycling to and on campus in recent years. However, riding a bike on the BU campus and in Boston still has its challenges, particularly in creating safer routes and finding secure and accessible bicycle parking. The University currently maintains 4,100 bike spaces (972 of which are protected within indoor bike parking rooms and protected bike cages on the Charles River and the Medical Center campuses). A bike safety website and smartphone app promotes education and awareness, and an interactive Google map of bike racks and routes is available. The University believes that more can be done to further support a highly sustainable transportation option that is expected to experience exponential growth in the coming years.

BU is a Bronze-level Hubway corporate partner, providing regular faculty and staff with discounted bike share memberships. Hubway members enjoy 24-hour access to 1,800 bicycles at 185 stations in four municipalities for $52.50/year (normally $99). There are five Hubway stations on the Charles River Campus and one on the Medical campus.

The University is currently developing a Master Bicycle Plan (MBP) and has engaged Toole Design Group to assist in this effort. BU and Toole are using community surveys and feedback in a holistic approach to assess the current state of bicycle facility planning and management, and to recommend additional and/or changes to existing facilities that will support BU's growing bicycle use and future campus development. The plan will focus on safety, improving and expanding campus bike facilities, and identifying the best and safest routes to and from surrounding communities. The MBP is expected to be completed in the fall of 2017.

Proposed Timeline & Costs

Boston University's TDM plan involves a set of strategies and investments for all modes of transportation with the objective of managing parking supply and demand while improving the quality of access and mobility while reducing our carbon footprint. Phase I of BU's TDM plan has been launched and the recommended initiatives and incremental investments include the following.

2017-2018: TDM Initiatives

Bicycling

- Expand BU's Bronze Membership with Hubway bike share to include students. BU presently encourages bike-share use by subsidizing faculty and staff memberships through this partnership at a cost of $5,000 annually based upon current participation.
  Cost: Estimated at $100,000 annually (based on projected participation) to be funded through the Parking and Transportation Services (PTS) operating budget.

- Offer the Federal Bicycle Commuter Benefit program to regular faculty and staff.
  Cost: Estimated at $80,000 annually (based on projected participation) to be funded through HR employee benefits.

- Complete Master Bicycle Plan.
  Cost: The cost associated with plan development has been funded through the PTS operating budget. The costs associated with short- and long-term improvements as noted above has yet to be determined.

The Bus

- Improve data collection and analytics utilizing automatic passenger count technology (APC) to support decision making and resource allocation with the goal of decreasing GHG emissions through maximizing route and schedule efficiencies.
  Cost: $0.

- Complete feasibility study (total capital and operating costs over useful life to include required charging station infrastructure) of bus fleet conversion from biodiesel to electric model by fall 2022.
  Cost: $0.

Commuting and Parking

- Evaluate the current use of and future demand for teleconferencing on campus. Raise awareness among the BU community of existing communication tools and software that could reduce the need for on-campus, face-to-face meetings and/or improve the communication experience.
  Cost: $0.

2019-2022: TDM Initiatives

Bicycling

- Implement Master Bicycle Plan recommendations for improvements to campus bike facilities.
  Cost: TBD.

The Bus

- Complete an in-use road study utilizing an electric 40-foot low floor bus on weekday and late night routes to assess functional capacity and cost.
  Cost: TBD.

Commuting & Parking

- Replace the decades old legacy based parking technology with a comprehensive, fully integrated Permit Management System (PMS) and Parking Access and Revenue Control System (PARCS). New parking systems are pivotal to the University's Transportation Demand Management (TDM) plan related to future parking supply and reducing drive-alone demand.
  Cost: $2.2 million for phased implementation with recurring annual net savings of approximately $90,000 achieved through improved efficiency in PTS operations.

- Introduce zone parking policies and dynamic pricing to encourage shift from drive alone to public transit, walking or bicycling.
  Cost: ***$0.***

- Upgrade BU Terrier Card ID's to integrate MBTA pass technology to simplify mass-transit use and reduce BU administration and distribution costs.
  Cost: TBD.

- Study construction and deployment of a multimodal transportation dashboard similar to MIT's Ride Amigos-based "AccessMyCommute" system. This dashboard could potentially allow regular faculty and staff to manage their commuting benefits, participate in commute challenges, find ride-share matches, and see day-to-day environmental, health, and monetary implications of their commuting choices through one central portal with minimal opt-in and effort.
  Cost: TBD.

- Study trip-planning app technology and identify a mobile-based system through which the BU community can make modal decisions (Walk? Bike? Wait for the shuttle?) based on real-time data including BU Shuttle, MBTA, Hubway, and traffic data.
  Cost: TBD.