Conserve by Transit II: Carbon Footprints of Florida's Public Transportation Agencies

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Executive Summary

Study Purpose

The purpose of this study was to assist Florida's public transportation agencies in preparing for anticipated changes in public policies to reduce emissions of greenhouse gases.

The purpose of this study was to assist Florida's public transportation agencies in preparing for anticipated changes in public policies to reduce emissions of greenhouse gases (GHGs). Public transportation agencies emit GHGs when they operate vehicles to provide public transportation services, including paratransit. They also emit GHGs when they operate non-revenue vehicles and when they maintain equipment and facilities. Most of the GHGs emitted from agency operations are in the form of carbon dioxide (CO_2), but vehicle operations also release small amounts of methane and nitrous oxide which, pound for pound, are much more powerful GHGs than carbon dioxide. Refrigerants that leak from vehicle air-conditioning equipment also are GHGs. In addition, GHGs are released when electricity is generated for use in offices, facility lighting, and other agency operations.

When the study was planned in 2009, applications for some federal energy reduction grants required information from transit agencies about the level of GHGs they emitted. State, federal, and international policies to reduce GHG emissions also were being considered. Several transit agencies in Florida were in the process of calculating their carbon footprints as part of a national grant application, and others had expressed interest in estimating their complete carbon footprint but needed technical assistance in completing this effort. To ensure use of a consistent methodology among the 29 Florida fixed route transit agencies and to establish a baseline carbon footprint for all the agencies, a statewide approach to estimating GHGs from transit agencies was required.

The Florida Department of Transportation (FDOT) sponsored a study entitled Conserve by Transit I, which looked at whether transit agencies might be able to earn credit for reductions in emissions that result from a mode shift from driving single occupancy vehicles to public transportation. That study considered only some GHGs and did not include complete emissions data.

The present study became Phase II of the Conserve by Transit Study, collecting baseline emissions data from Florida transit agencies to calculate a complete carbon footprint for each. FDOT anticipated that transit agencies could use these data when applying for grants or reporting emissions. The data also assist each agency in understanding where its emissions are generated so that it can plan for emissions

reduction. Most importantly, this study provides an emissions calculator for use by each transit agency and gives them guidance in updating and estimating future GHG emissions.

The study team worked with each of Florida's 29 fixed-route public transportation agencies to estimate its carbon footprint.

Methodology

A web conference was held in April 2010 with staff from several Florida transit agencies who had either expressed interest in understanding their carbon footprints or applied successfully for federal grants that required carbon footprints as part of the process. The agencies provided useful suggestions for measuring carbon footprints and agreed upon a uniform timeframe for estimating these emissions. A study approach also was agreed upon by the study team and participating transit agencies so everyone would understand what information would need to be collected and how that information would be used in estimating their carbon footprint.

The study team worked with each of Florida's 29 fixed-route public transportation agencies to obtain the data needed to estimate its carbon footprint. Reporting guidelines established by the Climate Registry in its General Reporting Protocol (GRP) and by the American Public Transportation Association (APTA) were used to calculate emissions and combine different types of emissions into a complete carbon footprint. The Climate Registry is a nonprofit organization of businesses and more than 35 states (including Florida). These members anticipated that eventually the federal government would require reporting of GHG emissions. The Climate Registry's collaborative effort developed reporting procedures as input to the design of federal requirements.

The original proposal for this study was to use fuel consumption data from the National Transit Database (NTD) for 2007 or 2008. This would have simplified data collection and reduced the burden on transit agencies, because they already had reported fuel use data to the NTD for these fiscal years. Because the GRP and APTA specify reporting for calendar years, this would have been a small deviation from their guidelines. However, the transit agencies that participated in the web conference suggested using more recent data, and they agreed that calendar-year data would be more useful as a baseline. Therefore, the study team agreed to request from the agencies data for calendar year 2009.

Participating transit agencies provided the data needed to calculate what the GRP refers to as Scope 1 and Scope 2 emissions. Scope 1 emissions are those that are under the direct control of the agencies. Under APTA guidelines, these include emissions from any transit service that an agency reports to the NTD. The data needed for Scope 1

emissions included fuel use for all of the agency's operations, including revenue service vehicles, non-revenue vehicles, non-electric heating of facilities, grounds keeping, and backup generators. The data also included the number of miles driven by each vehicle and whether in revenue service or not, as well as information on the age and type of vehicle. Some types of vehicles, such as diesel buses, could be grouped for the analysis, while others, such as cars, could not. Finally, Scope 1 data included information on the net use of refrigerants in vehicle and building air-conditioning systems, which proved to be the most difficult data to obtain.

Scope 1 emissions are those that are under the direct control of the agencies, including revenue service vehicles, non-revenue vehicles, non-electric heating of facilities, grounds keeping, and backup generators.

Scope 2 emissions are those from electricity that the agency purchases from electric utilities or others. They also include emissions from heating and cooling services purchased from others, such as district chiller plants (no agency reported such use).

Scope 2 emissions are those from electricity that the agency purchases from electric utilities or others.

A portion of each agency's Scope 3 emissions also was estimated. Scope 3 emissions are outside the direct control of the agency but are influenced by the agency's actions. Using spreadsheet tools developed by the Conserve by Transit I study, the study team estimated the emission reductions that result when there is a mode shift to public transportation from driving personal vehicles.

Scope 3 emissions are outside the direct control of the agency but are influenced by the agency's actions.

Data Collection

With the voluntary cooperation of the agencies, full or partial carbon footprints were estimated for 22 of Florida's 29 fixed route transit agencies, a participation rate of 75 percent. Ten agencies were able to provide complete data. One agency was able to provide data that the study team believes accounts for more than 95 percent of its carbon footprint. Another agency did not collect all of the necessary data but provided related data that overestimates its carbon footprint by no more than 4 percent. Twelve agencies provided portions of the data requested. Three of these twelve provided complete data except for refrigerant losses, for which they did not collect the necessary data. Seven agencies provided no data.

Full or partial carbon footprints were estimated for 22 of Florida's 29 fixed route transit agencies.

It was anticipated that data might be difficult to collect and that some agencies might not have all of the data needed. It was hoped that the offer of valuable and free information resulting from the study would encourage most of the agencies to participate fully in the study. While participation was voluntary, it required extra effort from staff who participated. Communications with some staff in small agencies indicated that they already had more work than they could manage since much of the required data are not the type of data the agencies usually have available. Additionally, data were requested regarding

purchased cooling services (now known, as a result of this study, not to be collected by Florida transit agencies).

After the study began, expected federal legislation did not pass, and state commitment to climate change diminished. These changes may have caused the transit agencies to be less willing to commit time and resources to this analysis.

Although calendar-year data was requested from the agencies, slightly more than half of the participating agencies provided data for their fiscal year 2009. When the 2009 version of the NTD was released near the end of the study, the study team compared it to data that the agencies had provided, as a check for quality, and verified that many agencies had provided fiscal year data. From discussions with agency staff, it is clear that agency recordkeeping is organized around fiscal year reporting. The study team believes that the reporting of fiscal year data for to this study reflects the extra work that reporting calendar-year data would have required.

Carbon dioxide (CO_2) from operating transit buses, rail, and vanpools contributes most of a typical public transportation agency's carbon footprint—approximately 82.5 percent.

Results: Transit Agency Carbon Footprints (Scopes 1 and 2)

As expected, carbon dioxide (CO_2) from operating transit buses, rail, and vanpools contributes most of a typical public transportation agency's carbon footprint—approximately 82.5 percent. These totals include emissions from generating electricity used to run transit revenue vehicles. Most CO_2 was from fossil fuel sources. For two large agencies, slightly more than 6 percent of their total footprint was CO_2 from biological sources, mostly as biodiesel. The trace gases methane (CH_4) and nitrous oxide (N_2O) were much smaller parts of the typical footprint than expected, accounting for about 0.3 percent. Losses of hydrofluorocarbon (HFC) and chlorofluorocarbon (CFC) refrigerants account for about 5.1 percent of the typical footprint. Except for the electricity used to power transit vehicles, which is a Scope 2 emission, all of these emissions are Scope 1 emissions.

Emissions from electricity (other than the electricity used to run revenue vehicles) range between 1.4 and 17 percent of an agency's footprint, with about 6.2 percent for a typical agency. However, with some exceptions, the larger the agency, the larger the share of its footprint comes from electricity. These emissions make up the remainder of the agencies' Scope 2 emissions.

Nonrevenue vehicles (used for maintenance, driver relief, travel to off-site meetings, or other purposes than carrying the agency's customers) account for about 2.3 percent of a typical agency's footprint, ranging between 0.2 and 8.7 percent. For some agencies, these percentages would be higher if the agency had been able to report the refrigerant

losses from its non-revenue vehicles separately from its revenue vehicles. However, many agencies reported a total amount of refrigerant losses that included all sources, and separating this between the vehicle types was not possible.

Fuel used for other purposes, such as heating, groundskeeping, and backup generators, accounted for about 0.1 percent of the typical footprint.

Transit ridership offsets about 39 percent of a typical transit agency's carbon footprint.

The typical values listed above do not sum to 100 percent because they are not weighted by agency size. Weighting the values would cause the percentages to be typical of large agencies and would de-emphasize the results from small agencies.

Results: Transit Agency Carbon Footprints (Partial Scope 3)

The study estimated the effect of mode shift, in which people switch from driving to using public transportation, and its effect on traffic congestion, as well as the combined effect of these changes on emissions. These effects were calculated using the spreadsheet tools developed in the Conserve by Transit I study and passenger data that agencies reported to the NTD. Not all trips made on transit will offset emissions. Some trips are made using paratransit services, and, by their nature, these trips are not intended to reduce congestion or emissions when compared to driving. The study team removed the portion of each agency's carbon footprint attributable to paratransit from the offset calculations. In addition, some trips made on fixed-route service are by people for whom transit is their only travel option. Therefore, the spreadsheets exclude those riders from the ridership calculations. However, because any given transit route may include people who choose transit over driving, as well as people whose only option is public transportation, it is not possible to exclude them from the carbon footprint.

Given these exclusions, transit ridership offsets about 39 percent of a typical transit agency's carbon footprint. Depending on the agency, estimates ranged between 21 and 67 percent. The weighted average for the 12 complete footprints was an offset of 54.2 percent. Larger agencies tend to have higher rates of carbon overhead, but they also tend to offset higher percentages of the broader footprints that include this overhead. However, this pattern in offsets depends, in part, upon the mode-shift factors developed in the CBT I study for its spreadsheets. All else being equal, if transit ridership increases as a result of more people switching from driving to riding public transportation, then agencies will offset higher percentages of their total footprints. Agencies also can increase the percentage of emissions

offset by their current ridership by reducing emissions, including reducing their carbon overhead.

To put the results here into the context of an emission trading system, if a Florida transit agency needed 100 permits to cover just the CO_2 emissions from its fixed-route and vanpool services, it might need approximately 120 permits to cover its complete carbon footprint for these services, including carbon overhead. If the trading system allowed offsets, the agency could generate offsets equivalent to just over 65 permits, based just on the CO_2 from avoided driving and traffic congestion.

It would be inaccurate to use the carbon footprints from this study to compare the emissions from taking a typical transit trip to the tailpipe emissions from taking the same trip by car.

It would be inaccurate to use the carbon footprints from this study to compare the emissions from taking a typical transit trip to the tailpipe emissions from taking the same trip by car. The carbon footprints calculated for transit agencies include emissions from activities such as maintenance, management, planning, and trips to reposition buses to serve different patterns of travel. The fuel used to make a simple trip by car does not. To make the car trip comparable to the transit trip, it would be necessary to include emissions for maintaining, storing, and parking the car and average them over the vehicle mileage. It is difficult to obtain these kinds of data to make the carbon footprint for a car trip comparable to one that includes the carbon overhead estimated for transit in this study. Thus, the Scope 3 offsets estimated in this study likely are too low, although it is not possible to estimate by how much.

As a result of this study, at least one agency plans to change its recordkeeping to estimate and monitor its refrigerant losses in the future.

Sharing the Results

Staff at the participating transit agencies now have a better understanding of the types of data required, the effort required to compile the data, and the relative importance of different activities to their carbon footprints. As a result of this study, at least one agency plans to change its recordkeeping to estimate and monitor its refrigerant losses in the future. The experience gained in this study, and changes that agencies make in their data systems as a result, will be useful if agencies desire to update their own carbon footprints.

From the perspective of monitoring and managing its own carbon footprint, an agency can simplify the estimates. First, it can use fiscal year data rather than calendar year data. Second, because the emissions of CH_4 and N_2O trace gases from motor vehicles take a great deal of data and work to estimate, agencies can dispense with them. These two gases contribute well under one percent of the carbon footprint for a typical agency. However, if an agency makes these simplifications for its own use, it should understand that future policies to reduce emissions of GHGs and application forms for grant funding might not accept them.

Copies of the spreadsheet workbook used to calculate the carbon footprint and a general version of the workbook will be provided to each agency for use in calculating its footprints for other years.

CBT I focused on increasing transit ridership as a strategy for offsetting emissions and, possibly, increasing revenue through the sale off offset credits. Such a strategy takes the agency's footprint as given. However, agencies also may want to manage and reduce their carbon footprints, rather than just offsetting them. The results of this study show that carbon overhead and losses of refrigerants contribute substantial shares of an agency's total carbon footprint. Electricity, the use of non-revenue vehicles, and losses of refrigerants cost money as well as creating emissions. Thus, reducing the size of its footprint can help the agency to reduce its costs. Agencies also may wish to manage and reduce their carbon footprints to reduce their exposure to risks to changing GHG policies and to be able to document reductions they have made if future policies are adopted to require reporting, trading, or reducing emissions. They also may wish to promote a "green" image.

Copies of the Excel 2007 spreadsheet workbook used to calculate the carbon footprint and a general version of the spreadsheet workbook, also in Excel 2007, will be provided to each agency for use in calculating its footprints for other years. Because of the diverse range of formats in which agencies maintain data, it is not possible to develop a single spreadsheet tool that can work with every format. A general version of the workbook was used at the beginning of the study and then altered as needed to accommodate each agency's data. No two workbooks are identical. The version that will be provided to the agencies is similar to the one in the study, but it is organized differently and should allow many agencies to enter their data without modification.

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List of Acronyms and Initialisms

APTA	American Public Transportation Association
CAT	Collier Area Transit
CBT I	Conserve by Transit I
CBT II	Conserve by Transit II (the study reported here)
CFCs	chlorofluorocarbons
CH_4	methane
CNG	compressed natural gas
CO_2	carbon dioxide
$CO_2(e)$	carbon-dioxide or CO_2 equivalent
CUTR	Center for Urban Transportation Research
ECAT	Escambia County Area Transit
FDOT	Florida Department of Transportation
FIU	Florida International University
FSU	Florida State University
FPTA	Florida Public Transportation Association
FTA	Federal Transit Administration
GHG	greenhouse gas
GRP	General Reporting Protocol
GVWR	gross vehicle weight rating
GWP	Global Warming Potential
JTA	Jacksonville Transportation Authority
kg	kilogram
HART	Hillsborough Area Regional Transit
HFCs	hydrofluorocarbons
LYNX	Central Florida Regional Transportation Authority
MCAT	Manatee County Area Transit
$MTCO_2(e)$	thousand metric tons CO_2 equivalent
N_2O	nitrous oxide
PCPT	Pasco County Public Transportation
PFC	perfluorocarbons
PSTA	Pinellas Suncoast Transit Authority
RTS	Gainesville Regional Transit System
SCAT	Sarasota County Area Transit; Brevard County Space Coast Area Transit
SFRTA	South Florida Regional Transportation Authority
UNF	University of North Florida
USEPA	United Stated Environmental Protection Agency
USF	University of South Florida
TCC	St. Lucie County Transit Treasure Coast Connector
TIGGER	Transit Investments for Greenhouse Gas and Energy Reduction
VOTRAN	Volusia County Transit
WHAT	Winter Haven Area Transit

Chapter 1 – Introduction

Purpose

The purpose of this study was to estimate the amount of greenhouse gases (GHGs) that each of Florida's public transportation agencies emitted in a common base year.

The purpose of this study, Conserve By Transit II (CBT II), was to estimate the amount of greenhouse gases (GHGs) that each of Florida's public transportation agencies emitted in a common base year and to provide this information to each agency in a consistent format, with documentation and advice to facilitate updating this information in subsequent years.

An estimate of total GHG emissions is referred to as a carbon footprint. It consists of emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). CO_2 is a byproduct of using fossil fuels to operate buses and other transit vehicles, as well as to heat buildings and generate electricity used for lighting, air-conditioning, and other purposes. CH_4 and N_2O are byproducts of using fossil fuels in internal combustion engines, including transit buses. HFCs are used in both stationary and mobile air-conditioning equipment. PFCs also are used in some air-conditioning equipment, particularly in heavy vehicles, and may be used in transit buses. SF_6 is used in manufacturing and should not be of concern for transit agencies. The amounts of these gases are weighted and combined into carbon-dioxide equivalent (CO_2[e]) as an estimate of the total footprint.

Scope 1 emissions are directly under control of the transit agency, such as fuel use.

Scope 2 emissions are from electricity, directly under control of the transit agency but purchased from others.

Current practice in estimating and reporting carbon footprints follows protocols developed by the Climate Registry, a nonprofit organization of businesses and more than 35 states (including Florida) whose members anticipated that the federal government would require reporting of GHG emissions; they participate in the Climate Registry as a collaborative project to develop reporting procedures as input to the eventual design of federal requirements. The Climate Registry General Reporting Protocol (GRP) [1] covers the six gases listed above and separates the carbon footprint into three "scopes":

- Scope 1 emissions are directly under control of the transit agency, such as fuel use. Some of the information required to calculate Scope 1 emissions already is collected by agencies for reporting to the National Transit Database (NTD).
- Scope 2 emissions are from electricity, heat, or cooling that are directly under control of the transit agency but purchased from others. Because transit agencies pay for electricity, they should have the necessary data but may need to compile it, because the only electricity use they report to the NTD is what they use

to power transit vehicles.

- Scope 3 emissions are outside the direct control of the agency but are influenced by the agency's actions, such as the emission reductions that result when someone uses transit to replace trips previously made by car or the emissions required to produce and deliver diesel fuel.

Organizations can voluntarily report their carbon footprints to the Climate Registry or to other organizations such as the Carbon Disclosure Project; they make the information available to investors and other interested parties. Organizations that report their carbon footprint are expected to report Scopes 1 and 2 completely, and these scopes together are considered a complete carbon footprint. Reporting of Scope 3 emissions is optional.

Scope 3 emissions are outside the direct control of the agency but are influenced by the agency's actions.

This study calculated emissions for Scopes 1 and 2 using the GRP. It also calculated a portion of Scope 3, using spreadsheets developed by an earlier study, Conserve by Transit I (CBT I) [2], to calculate reductions in emissions that result when people switch from driving to riding public transportation.

This study calculated emissions for Scopes 1 and 2. It also calculated a portion of Scope 3.

Study background

The study was conceived in 2009. At that time, it was widely anticipated that an international agreement would be reached in December of that year to reduce emissions of GHGs. The U.S. Congress was drafting legislation to reduce emissions in the United States, and a number of states, including Florida, were developing their own climate action plans to reduce emissions. The U.S. Environmental Protection Agency (USEPA) started to take steps to regulate CO_2 emissions, including requiring reporting of emissions. Some grant programs administered by foundations and by the federal government were requesting information about GHG emissions as part of their application processes. One of these, the Federal Transit Administration's (FTA) Transit Investments for Greenhouse Gas and Energy Reduction (TIGGER) program, provided funding for public transportation agencies to reduce GHG emissions.

Florida's Energy and Climate Change Action Plan [3], submitted to the Florida Governor's Office in late 2008, contained recommendations to increase the use of transit and to maintain or improve its cost relative to the costs of driving. Several public transportation agencies in Florida were expressing interest to the Florida Department of Transportation (FDOT) in having their carbon footprints estimated for use in applying for grants. Two agencies, Palm Tran and Broward County Transit, received TIGGER program funds in late 2009.

CBT I concluded that the best approach for Florida transit agencies to reduce the greatest amount of GHGs would be to aggressively increase passenger miles.

Anticipating the possibility that a cap-and-trade program might be established to reduce emissions, FDOT commissioned Florida State University (FSU) to conduct the CBT I study [2], which was completed in 2009. CBT I focused on estimating the effects that public transportation in Florida could have on energy consumption and GHGs by shifting travel from automobiles to public transit. The study concluded that the best approach for Florida transit agencies to reduce the greatest amount of GHGs would be to aggressively increase passenger miles. To accomplish this, transit agencies would need to enhance existing services, provide more efficient and effective transit services, and use cleaner technologies to support these services. Transit agencies also would need to monitor their own emissions of GHGs (both from the direct operation of transit vehicles and from supporting activities such as maintenance and administration) and monitor any reductions that result from the agencies' impact on travel by others. CBT I did not include data on transit agencies' Scope 1 and Scope 2 emissions other than the amounts of different fuels consumed by fixed-route transit vehicles, reported to the NTD. The CBT I study team also participated in a project by the American Public Transportation Association (APTA) [4] to interpret the Climate Registry's GRP for use public transportation agencies and provide guidance for agencies using the GRP.

A logical follow-up to CBT I was to help agencies develop a baseline carbon footprint to, help them plan for likely regulations and position themselves to benefit from efforts to reduce emissions.

Given CBT I's conclusions and the expectation that public agencies would be required to reduce GHG emissions, a logical follow-up to CBT I was to help agencies develop a baseline carbon footprint to monitor, reduce, or report their emissions. This information would help them plan for likely regulations and position themselves to benefit from efforts to reduce emissions. FDOT's Public Transportation Office asked the Center for Urban Transportation Research (CUTR) at the University of South Florida to estimate complete GHG emissions for each of Florida's public transportation agencies.

Neither the international agreement nor federal and state legislation were enacted as expected, and support appears to have declined for implementing policies to reduce emissions of GHGs. However, the information collected by this study still should be useful to the state's public transportation agencies. An agency's carbon footprint is an indicator of its vulnerability to increases in the price of fossil fuels (directly for vehicle operations and indirectly for electricity to support maintenance, administration, and other functions). It is also an indicator of vulnerability to any future policies to reduce GHG emissions (which, if implemented, would likely increase fuel prices or require expenditures to reduce emissions). Knowing the size and composition of its carbon footprint enables a transit agency to plan to reduce these vulnerabilities. Finally, the ability of public transportation agencies to document their GHG emissions and their impact on the emissions of others should enable them to play a more effective role in

developing and implementing state and local strategies to reduce emissions.

Data requirements and organization

The main contributors to Scope 1 of a transit agency's carbon footprint are:

- operation of revenue vehicles,
- use of non-revenue vehicles owned and operated by the agency,
- leakage or other loss of refrigerants used in air conditioners for vehicles or agency buildings,
- heating or cooling of buildings (except by electricity, which is included in Scope 2 below),
- operation of equipment to maintain vehicles, guideways, buildings, or grounds, and
- operation of emergency back-up generators.

Four categories of data are needed to calculate a transit agency's carbon footprint: fuel consumption, electricity consumption, vehicle mileage, and refrigerant losses.

The main contributors to Scope 2 of a transit agency's carbon footprint are:

- emissions from the generation of electricity purchased by the agency for any use (including the heating and cooling of buildings), and
- emissions from district heating or cooling services purchased by agencies for their facilities (such services were thought unlikely to be in use but needed to be checked).

Four broad categories of data are needed to calculate a transit agency's carbon footprint: fuel consumption, electricity consumption, vehicle mileage, and refrigerant losses. Data also include emission coefficients and instructions from the GRP.

Fuel consumption

Data on consumption of fuel is needed to calculate emissions of CO_2. It was anticipated that information on fuel consumption would be relatively easy to obtain for revenue vehicles, because agencies already collect and report it to the NTD. Data on fuel consumption for other uses were expected to involve much more effort to collect, especially for non-revenue vehicles that agencies use to support driver shift changes, maintain facilities, attend off-site meetings, etc. It also was unclear whether agencies would have records for minor uses such as gasoline used for groundskeeping (lawn mowing, leaf blowing), propane or other fuel for space heating during cold weather, or fuel used in emergency backup generators. These might simply be included as a part of total fuel consumption.

CO_2 can be calculated directly from the amount of fuel consumed.

The GRP provides emission coefficients that can be used to calculate emissions of CO_2 and the trace gases CH_4 and N_2O from electricity generation.

Using emission coefficients from the GRP, CO_2 can be calculated directly from the amount of fuel consumed. The GRP provides for different levels of data quality. The highest level would use the analyzed carbon content of fuel, reported in a fuel purchase contract. A lower level would apply a generic coefficient for each type of fuel, if the higher quality data are not available. The GRP provides these coefficients and detailed instructions for their use.

Electricity consumption

The second category is electricity purchased from utilities or others. The GRP provides emission coefficients that can be used to calculate emissions of CO_2 and the trace gases CH_4 and N_2O from electricity generation. These coefficients vary regionally. All of Florida's fixed-route public transit agencies are in the GRP's region 10, except for Bay Town Trolley, Escambia County Area Transit (ECAT), and Okaloosa County Transit, which are in the GRP's region 9.

It was anticipated that information on electricity use (and any fuel used to heat buildings) would be relatively easy to obtain, because it is a billable cost to the agency. It also was expected that some agencies might share offices or other facilities with other public agencies and that additional effort would be required to separate and account for use by the transit agency.

Vehicle mileage

The third category is vehicle mileage. Whereas CO_2 is a product of fuel consumption and can be estimated reliably from the quantity of fuel burned, the amounts of trace gases CH_4 and N_2O emitted depend on how the fuel is burned and on the technology used to control emissions. Emission control technologies for motor vehicles are regulated using limits on the amount of trace gases that can be released per mile the vehicle is driven. USEPA has estimated emissions per mile based on the type of vehicle and fuel and on the emission controls required when the vehicle was built. Multiplying these coefficients times the number of miles driven yields estimates of the trace gases. The GRP provides two sets of coefficients for different levels of data quality. The higher quality data include the specific emission control standard that each vehicle met when new (recorded on a sticker under the hood); lower-quality data use the vehicle model year, which might include a mix of different emission standards.

Coefficients for heavy-duty diesel engines, such as those used in transit buses, do not vary by the age of the vehicle, so it is possible to calculate trace gases knowing only the total number of miles that all such vehicles were driven. It was anticipated that this total would be relatively easy to obtain.

Coefficients for gasoline engines and for diesel engines used in passenger cars and similar small vehicles vary by the age and size of the vehicle, so it is necessary to know the mileage driven by each of these vehicles. It was expected that this would require more effort to obtain and that some agencies might not have recorded it, especially for non-revenue vehicles.

Coefficients for gasoline engines and for diesel engines in small vehicles vary by the age and size of the vehicle, so it is necessary to know the mileage driven by each of these vehicles.

Emission coefficients also are used to estimate emissions of trace gases from other sources, such as furnaces, generators, and small engines for lawn mowers, etc., but for these it is sufficient to know the type of application and fuel in order to select the proper coefficients.

Refrigerant losses

The fourth category is loss of refrigerants. This cannot be measured directly; it must be calculated from several quantities, separately for each type of refrigerant:

The fourth category is loss of refrigerants. This cannot be measured directly; it must be calculated.

(1) When an air-conditioner is maintained, the amount of refrigerant that is recovered from the equipment for re-use.
(2) When the maintenance is finished, the amount of refrigerant used to refill the equipment.
(3) If new equipment is purchased and does not come fully charged with refrigerant, so that the new owner has to fill it, the amount purchased to fill it.
(4) The total amount that the new equipment can hold (only for new equipment that does not come fully charged).
(5) If equipment is retired, the total amount of refrigerant this equipment can hold.
(6) The total amount of refrigerant removed from the equipment when it is retired is another.

Subtracting (1) from (2) is the amount lost to the atmosphere and is part of the carbon footprint. It is the *net* amount of refrigerant used when servicing equipment. Subtracting (6) from (5) and (4) from (3) accounts for changes in the stock of equipment. The sum of these three differences for a refrigerant is the total contribution of the refrigerant to the carbon footprint.

Supporting coefficients and instructions

With the four exceptions discussed in Chapter 4, the Climate Registry's GRP was straightforward to follow. Two of these exceptions required contacting the Climate Registry staff for guidance; the third did not but a clear example added to the many others provided by the GRP would be of benefit; the fourth was a problem in formatting. The GRP's coefficients as updated on March 29, 2010 [5] were used. In addition to the emission coefficients noted above, the GRP also includes global warming potential factors (GWPs) to convert different emissions of trace the trace gases and refrigerants into $CO_2(e)$.

Planned approach to data collection

To reduce the effort required of agencies, it was originally intended to collect data on a fiscal-year basis.

The plan for CBT II was to make two modifications to the GRP. The first was to change the reporting period. The GRP was developed to support reporting of carbon footprints for emission trading, and this was expected to require reporting of emissions on a calendar-year basis. In addition, the transit protocol developed by APTA [4], which follows the GRP and clarifies its application to public transportation agencies, specifies calendar-year reporting. To reduce the effort required of agencies who already report to the NTD some of the data needed to estimate their Scope 1 emissions, and because the NTD allows reporting on a fiscal-year basis, it was originally intended to collect data on a fiscal-year basis. As discussed later, this changed.

CFCs are GHGs that have high GWPs. CBT II reports CFCs to treat agencies consistently. Many transit agencies still use these gases as refrigerants.

The second planned modification to the Climate Registry's GRP involved refrigerants. The developers of the GRP used the reporting requirements of the Kyoto Protocol as a guide, anticipating that it would become a model for subsequent international agreements to reduce emissions. The Kyoto Protocol *excludes* emissions of chlorofluorocarbons (CFCs) such as R-22 (Freon), because these gases are already being phased out under the Montreal Protocol to protect the Earth's ozone layer [6]. However, CFCs are GHGs that have high GWPs; 1kg of R-22 has a GWP equivalent to 1,500 kg of CO_2 [7], compared to R-134a, which is in common use in transit buses and which has a GWP equivalent to 1,300 kg of CO_2 [1].

CBT II reports CFCs to treat agencies consistently. Many transit agencies still use these gases as refrigerants in vehicle air-conditioning systems, and many replacements for these gases have similarly high GWPs. Thus, an agency that uses R-22 exclusively would appear to have a smaller carbon footprint than a similar agency that uses R134a exclusively. In principle, an agency could reduce the effects of its operations on the climate by switching from equipment that uses R-22 or R-134a to equipment that uses a refrigerant with much lower GWP. However, this would appear as an increase in the footprint of an agency that was switching to the new refrigerant from R-22 and as a decrease in the footprint of an agency switching from R-134a, unless CFCs were tracked as part of the agencies' footprints. CBT II results report contributions of CFCs to agency footprints separately from those of other refrigerants, using GWPs for CFCs from [7].

The GRP requires an organization such as a transit agency to report emissions from all operations. In addition, the APTA reporting protocol for transit agencies requires reporting of emissions for all transit services reported to the NTD. Because paratransit service has different objectives and requirements than fixed-route service, FDOT asked that, to the extent that data permit, the study calculate emissions attributable to paratransit operations separately from each agency's

FDOT asked that the study calculate emissions attributable to paratransit operations separately from each agency's total.

total. It was not expected to be possible to separate some emissions, such as those from operating the agency's office buildings. In addition, it was anticipated that agencies would not have records that allow separate tabulation of other kinds of emissions (for example, from maintenance) attributable to paratransit operations.

During the planning for the study, the following data collection process was anticipated for calculating carbon footprints for 2007 or 2008:

1. Discuss with the transit agencies and FDOT whether to calculate the footprints for 2007 or 2008.
2. Acquire from the NTD data that the agencies had reported for the chosen year.
3. Send a letter of invitation from FDOT to each transit agency providing a general description of the study, an invitation to participate, a description of the additional data needed, and a request for identification of a point of contact.
4. Provide the point of contact with a more detailed list of the data needed.
5. Request the point of contact to gather and provide the data.
6. Review the data, note what was missing or unclear, and work with the agency to plan a site visit to meet with people who had access to the raw data, review records, gather what was needed, and leave clear directions for how to obtain additional information.
7. Receive and organize the remaining data and calculate the agency's carbon footprint.
8. Review the completed footprints with the participating agencies, possibly via site visits.

In consultation with FDOT's Public Transportation Office during the planning of the study, it was agreed that CUTR would lead the study and would work with Florida International University (FIU) and the University of North Florida (UNF). Each university was assigned a list of transit agencies to work with (Table 1).

Actual approach to data collection

In April, 2010, the study team met via web conference with members of FDOT and senior personnel from Hillsborough Area Regional Transit (HART), LeeTran, Palm Tran, Gainesville Regional Transit System (RTS), StarMetro, and Broward County Transit to discuss the study. These agencies were chosen because they had expressed interest in the study or had applied to the TIGGER grant program. Participants in the web conference agreed upon several changes to the original study plan:

Table 1. Florida transit agencies and university contact

	Agency	USF	UNF	FIU
1	Bay Town Trolley		X	
2	Space Coast Area Transit (SCAT)		X	
3	Broward County Transit (BCT)			X
4	Collier Area Transit (CAT)			X
5	Citrus County Transit[1]		X	
6	Escambia County Transit (ECAT)		X	
7	Gainesville Regional Transit System (RTS)		X	
8	Hernando Express Bus	X		
9	Hillsborough Area Regional Transit (HART)	X		
10	Indian River Senior Resource Association (GoLine)			X
11	Jacksonville Transportation Authority (JTA)		X	
12	Key West Transit[1]			X
13	Lake County (LakeXpress)		X	
14	Lakeland Area Mass Transit District (Citrus Connection)	X		
15	Lee County Transit (LeeTran)			X
16	Central Florida Regional Transportation Authority (LYNX)		X	
17	Manatee County Area Transit (MCAT)	X		
18	Martin Council on Aging (Community Coach)			X
19	Miami-Dade Transit (MDT)			X
20	City of Ocala Transit (SunTran Ocala/Marion Co Transit System)[1]		X	
21	Okaloosa County Transit (The Wave)		X	
22	Palm Beach County Transit (Palm Tran)			X
23	Pasco County Public Transportation (PCPT)	X		
24	Pinellas Suncoast Transit Authority (PSTA)	X		
25	Sarasota County Transit (also SCAT)	X		
26	St. Johns Council on Aging (Sunshine Bus)		X	
27	Council on Aging of St. Lucie, Inc. Treasure Coast Connector (TCC)			X
28	City of Tallahassee (StarMetro)		X	
29	South Florida Regional Transportation Agency (SFRTA)			X
30	Volusia County Transit (VOTRAN)		X	
31	Winter Haven Area Transit (WHAT)[2]	X		

[1]Citrus County Transit is considered a paratransit agency, Key West Transit is not considered an urban agency, and City of Ocala Transit is considered urban fixed-route. These three agencies do not report to the NTD. All were listed in the scope of work for the study.

[2]WHAT is in the process of consolidating with Lakeland Area Mass Transit District (Citrus Connection) but needed to be contacted separately to collect data for the baseline carbon footprint.

Representatives of the agencies suggested doing the calculations for 2009. It was also thought that it would be easier to obtain calendar-year data for the study.

- Representatives of the agencies thought it would be more useful to have data more recent than 2007 or 2008 and suggested doing the calculations for 2009. Because the agencies' submissions to the NTD would not be available until late in 2010, this would mean obtaining all of the data directly from the agencies. It was also thought that it would be easier to obtain calendar-year data for the study, as specified by the GRP, because the agencies might still be compiling the 2009 data.
- Agency heads suggested that the planned letter of invitation from FDOT to agency heads to participate in the study be a joint invitation from FDOT and the Florida Public Transportation Association (FPTA).
- Several agencies indicated that they planned to apply for the second round of grants from the TIGGER program, with applications due August 11, 2010. It was suggested that priority be given to collecting data from these agencies and that the study team provide guidance and technical review for the footprint portions of the applications.

The request letter indicated previously was sent in early May 2010 to the head of each agency listed in Table 1. Several agencies replied within one week, but responses slowed thereafter. Follow-up contact was made via e-mail messages, phone calls, and meetings at the spring 2010 FPTA workshop. Even with this effort, several agencies did not respond until September 2010.

The study team's experience with the designated contact persons varied greatly from agency to agency.

One agency, PCPT, declined to participate, citing limited staff resources. A second, VOTRAN, indicated that it had already contracted with a consultant to prepare a report that would include a carbon footprint. VOTRAN provided a draft of the report, which the study team reviewed and commented on, noting where some elements of the footprint had been omitted. VOTRAN offered to make the consultant's final report available when it was complete, and that report [8] is the basis for the carbon footprint reported for the agency in Appendix C.

The study team's experience with the designated contact persons varied greatly from agency to agency. In some cases, the contact person provided the data needed for the study. In other cases, the contact person delegated the role to someone else who then provided data for the study. In other cases, the contact person had too many responsibilities or seemed overwhelmed by the prospect of helping to compile the necessary information. Some of these eventually did provide complete data; others provided incomplete data and did not respond to requests to provide what was missing. A few provided no data at all. After extensive discussions among the study team and the agency's staff and director, Sarasota SCAT decided not to participate,

citing limited staff and a data management system that likely was not up to supporting this task. Okaloosa County Transit determined very late in the study that it did not have the necessary data.

Participation in the study was voluntary.

Eleven agencies initially reported that they planned to submit TIGGER applications, but some of these decided later not to complete their applications, and only a few asked the study team for technical support. Two Florida transit agencies—Jacksonville Transportation Authority (JTA) and StarMetro— were successful in their applications, although neither requested assistance from the study team. The study team compared the information requested by the TIGGER applications with that required by the GRP and noted that the TIGGER application requested less information.

Although calendar-year data was requested from the agencies, many provided fiscal-year data.

A draft spreadsheet template was prepared for collecting the initial round of data and sent to the designated contacts at each agency, requesting calendar-year data. Many agencies responded with questions about the spreadsheet and what data were needed, but a few agencies were able to begin collecting data, asking questions only as they got further into the process. Partial data began arriving in July 2010. The data were reviewed and questions and requests for clarification were made as necessary, usually accompanied by requests for additional data. Follow-up occurred frequently with agencies that were not providing data or that were responding late. Some agencies that had agreed to provide data did not, and some agencies that had provided partial data did not provide all of the necessary data.

In most cases it was unnecessary to make site visits to help collect data. Agencies that had a strong interest in the study were able to compile all of the necessary data without direct assistance, sometimes with support or information from the study team, but electronic communication sufficed. Several agencies encountered difficulty compiling the data, in some cases because of limitations on staff time, but the offer of on-site assistance was declined. Ultimately, few site visits were made.

Participation in the study was voluntary, and not all agencies were able or willing to follow through completely on their original willingness to provide data needed by the study.

Late in the study, the NTD data for fiscal year 2009 became available. Although calendar-year data was requested from the agencies, comparison of data received with fuel use data reported to the NTD for revenue vehicles made it apparent that many of the agencies had provided fiscal-year data to the study. This likely reflects the additional work that would have been needed to provide calendar-year data for a voluntary study.

Results of data collection

24 of the 31 agencies contacted provided data for the study.

Overall, 24 of the 31 agencies contacted provided data for the study. Table 2 summarizes the completeness of the data received. Ten agencies provided complete data. Two provided data that likely are within 5 percent of their complete footprint—one missing data and one overestimating its emissions. Two do not record the data needed to report refrigerants but provided complete data otherwise, and one of these has indicated that it plans to collect the necessary data in the future. There are still unresolved questions about the refrigerant data reported by another agency, which also may not be recording the necessary data. In total, 15 agencies provided complete or virtually complete data within the abilities of their recordkeeping systems; 9 provided partial data; 7 provided no data.

Fourteen agencies that provided data did so for their fiscal year 2009; seven provided data for calendar year 2009. Three others have not confirmed yet; the data for some differ from their NTD data but are similar enough to conclude that the data are for calendar-year 2009. The data that others provided to the study are sufficiently different from their NTD submissions that it is unclear what period they have reported.

Appendices A–C summarize the carbon footprint data provided by each agency.

Appendices A–C summarize the carbon footprint data provided by each agency. Appendix A includes carbon footprints that were considered to be complete or within 1-2 percent of complete. Appendix B includes a footprint where the error may be as much as 5 percent but could be smaller. Appendix C includes footprints that lack some of the data needed for a complete footprint. In several cases, agencies provided all the data requested, except in cases where they do not collect it (most commonly, for refrigerants). In other cases, the agencies did not report some of the necessary data (most commonly, the vehicle mileage required to estimate emissions of trace gases, although some omitted other data such as fuel use). In several cases, the values reported appear inconsistent (for example, too large compared to other reported activities or yielding unrealistic values in checks for data quality), and the inconsistency could not be resolved.

Appendices A–C use the same reporting format. Gases are reported separately, except in the case of refrigerants. Most agencies use either R-134a, a hydrofluorocarbon (HFC), or R-22, a chlorofluorocarbon (CFC). However, a few reported other types of refrigerants. To simplify the reporting, HFCs have been grouped together and converted to CO_2(e) for reporting in the tables. The same has been done for CFCs. Separate values are reported for fixed-route bus service, rail, vanpool, and paratransit services. In a few cases, agencies reported other types of fixed-route service, and these are shown as separate categories. Non-revenue vehicles are reported as a separate category. Some

Table 2. Summary of data received from each agency

Agency	Provided no data	Complete	Complete except for these data	Otherwise largely complete	Substantial omissions*	Reporting period
Bay Town Trolley	X					N/A
Space Coast Area Transit (SCAT)	X					N/A
Broward County Transit		X				FY 2009
Collier Area Transit (CAT)				Unresolved question on refrigerant data		Probably CY 2009
Citrus County Transit**					3,6	CY 2009
Escambia County Transit (ECAT)					2,3,5,6	FY 2009
Gainesville Regional Transit System (RTS)		X				FY 2009
Hernando Express Bus					3,4,5, 6	FY 2009
Hillsborough Area Regional Transit (HART)		X				FY 2009
Indian River Senior Resource Association (GoLine)		X				Probably CY 2009
Jacksonville Transportation Authority (JTA)	X					N/A
Key West Transit**					2,3	FY 2009
Lake County (LakeXpress)					2,6	CY 2009
Lakeland Area Mass Transit District (Citrus Connection)		X				Probably CY 2009
Lee County Transit (LeeTran)			Does not collect needed refrigerant data			CY 2009
Central Florida Regional Transportation Authority (LYNX)		X				FY 2009
Manatee County Area Transit (MCAT)		X				CY 2009
Martin Council on Aging (Community Coach)		X				FY 2009
Miami-Dade Transit (MDT)			Does not collect needed refrigerant data			FY 2009
City of Ocala Transit (SunTran Ocala/Marion Co Transit System)**	X					N/A
Okaloosa County	X					N/A

Agency	Provided no data	Complete	Complete except for these data	Otherwise largely complete	Substantial omissions*	Reporting period
Transit (The Wave)						
Palm Beach County Transit (Palm Tran)			Does not collect needed refrigerant data		6	FY 2009
Pasco County Public Transportation (PCPT)	X					N/A
Pinellas Suncoast Transit Authority (PSTA)		X				CY 2009
Sarasota County Transit (also SCAT)	X					N/A
St. Johns Council on Aging (Sunshine Bus)					4,5	FY 2009
Council on Aging of St. Lucie, Inc. Treasure Coast Connector (TCC)		X				FY 2009
City of Tallahassee (StarMetro)					1,4	CY 2009
South Florida Regional Transportation Agency (SFRTA)			Does not collect needed refrigerant data			CY 2009
Volusia County Transit (VOTRAN)					2,3,5	FY 2009
Winter Haven Area Transit (WHAT)					2,3	FY 2009

*Substantial omissions: 1=revenue vehicle fuel use; 2=revenue vehicle mileage; 3=non-revenue fuel and/or mileage; 4=electricity; 5=refrigerants; 6=unresolved questions.

**Citrus County Transit is considered a paratransit agency, Key West Transit is not considered an urban agency, and City of Ocala Transit is considered urban fixed-route. These three agencies do not report to the NTD.

agencies provided detail about the use of their non-revenue vehicles, but each used different categories, and many agencies provided no detail. To simplify reporting, non-revenue vehicles are reported as a single category.

Agencies that use electricity for moving revenue vehicles reported such use separately, as they would have done when reporting to the NTD, and all such uses have been reported in the appropriate revenue-vehicle category. The ability of agencies to report detail within their non-motive uses of electricity (lighting, offices, heating, or vehicle maintenance) is limited by how their facilities are metered. The tables report emissions from non-motive use of electricity in a single “Facilities (electricity)” category. All of the emissions from an agency’s facility maintenance (groundskeeping), use of backup generators, and heating by non-electric sources (natural gas, propane) were combined into a single “Facilities (other)” category.

Most agencies reported some of their data as totals that included more than one of these categories. By far, the most common instance was in reporting a single combined quantity of refrigerant losses for all revenue vehicles (and sometimes for their non-revenue vehicles as well), rather than reporting separate

totals for fixed-route bus, paratransit, and so forth. The tables in the appendices note where this occurred. By convention, when this occurred, the combined total was reported as part of the footprint for fixed-route bus service.

Totals are reported by gas, by activity, and for the agency's total footprint, all in kg of CO_2(e), plus the total footprint in metric tons (tonnes) of CO_2(e). The use of metric units and of CO_2(e) follow international agreements and the GRP [1]. The use of kg in the tables, rather than metric tons, was deemed necessary given the small quantities of some components of the footprints.

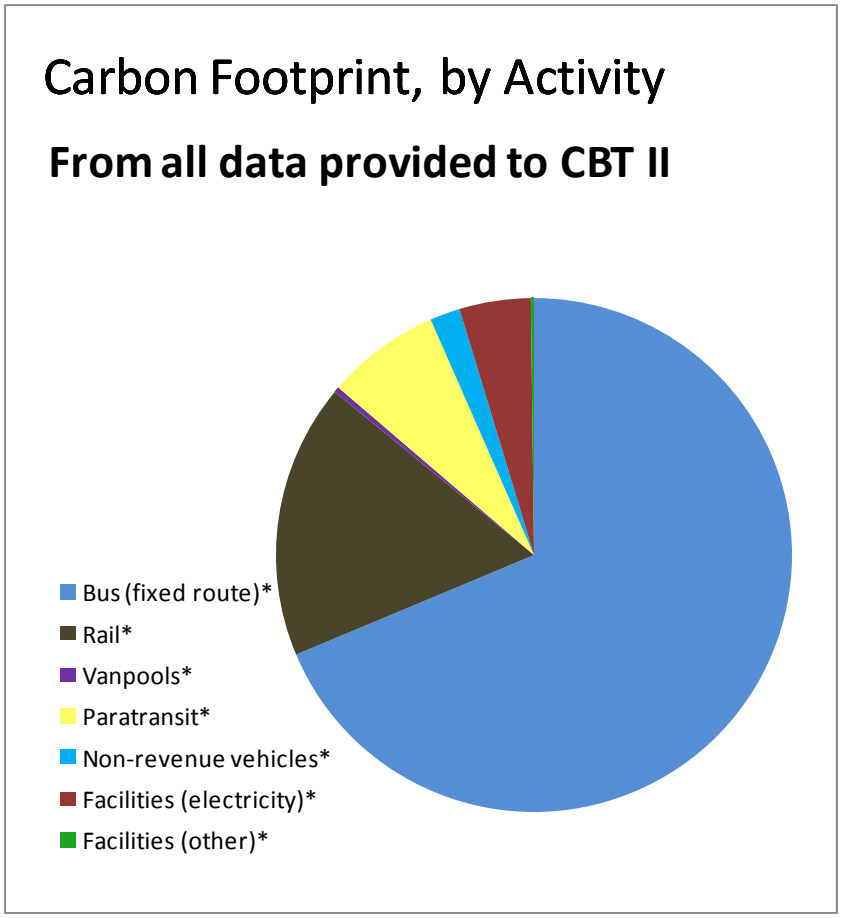
The 466 $MTCO_2$(e) in Table 3 likely includes between 75 and 80 percent of the total for all of the agencies that were invited to participate in the study, or about 0.5 percent of the total 2010 carbon footprint from on-road gasoline- and diesel-fueled transportation projected for Florida.

Approximate total footprint for public transportation in Florida

Figure 1 and Table 3 present the aggregate emissions reported by the 24 agencies that provided data for the study, using the table and chart formats described above. The percentages are weighted averages. This means that they are more representative of large agencies than of small ones. Chapter 2 presents unweighted averages, which are more representative of a "typical" agency.

The totals in Table 3 are underestimates, because12 of the agencies reported incomplete data, and some of these agencies, such as MDT, are large. In addition, as noted, seven agencies that were invited to participate in the study provided no data. Based on data reported to the NTD but not to the study, and the study team's understanding of the data reported to the study, the 466 $MTCO_2$(e) in Table 3 likely includes between 75 and 80 percent of the total for all of the agencies that were invited to participate in the study. A complete public transportation footprint thus would range approximately between 559 and 582 $MTCO_2$(e), or about 0.5 percent of the total 2010 carbon footprint from on-road gasoline- and diesel-fueled transportation projected for Florida [3].

Figure 1. Carbon Footprint for all data reported to CBT II



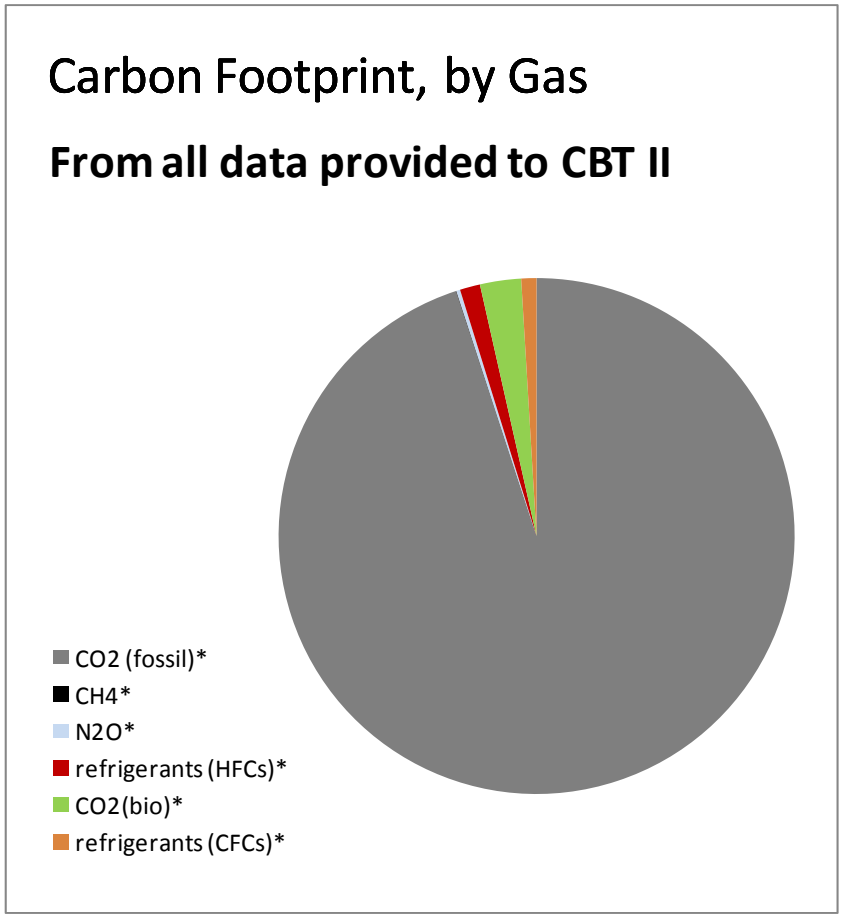


Table 3. Carbon footprint for all data reported to the study

Carbon Footprint for all data reported to CBT II

ACTIVITY GAS → ↓	CO_2 (fossil)* kg	CH_4* kg	N_2O* kg	refrigerants (HFCs)* kg CO_2(e)	CO_2 (bio)* kg	refrigerants (CFCs)* kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route) *	301,968,628	582	547	5,647,524	9,216,778	2,977,380	319,991,983	68.69%
Community bus*	75,874,238	3,758	1,342	0	2,563,865	1,372,350	80,305,446	17.24%
Vanpools*	1,578,633	48	30	2,268	27,077	0	1,618,426	0.35%
Paratransit*	32,721,219	756	641	218,949	122,541	0	33,277,356	7.14%
Non-revenue vehicles*	8,527,562	530	765	5,534	108,037	0	8,889,332	1.91%
Facilities (electricity)*	20,764,568	716	269	N/A	N/A	N/A	20,862,876	4.48%
Facilities (other)*	841,282	69	5	0	630	69,315	914,338	0.20%
							Total	
Total, by gas, kg CO_2(e)	442,276,131	135,618	1,115,761	5,874,275	12,038,927	4,419,045	**465,859,757**	in kg CO_2(e)
% by gas	94.94%	0.03%	0.24%	1.26%	2.58%	0.95%	**465,860**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- In most cases, fixed-route bus included all refrigerant losses reported by agency, regardless of type of service.
- Rail includes all reported fixed-guideway and "trolley" services.
- Several agencies do not collect the data on refrigerant losses needed for this study; amounts and percentages shown are underestimates.
- All totals are underestimates for Florida; 7 agencies provided no data and 12 provided incomplete data.

Chapter 2 – Components of Carbon Footprints

It should be noted that the averages reported in this chapter are not weighted by the size of the agencies or their combined footprints. Weighted averages would be disproportionately influenced by the results for the small number of large agencies that reported complete footprints, and they would not be representative of the full range of agencies.

CO_2 from revenue vehicle operations contributed 69.2–94.2 percent of the total estimated carbon footprint.

Carbon dioxide

CO_2 was, by far, the dominant component of each agency's carbon footprint. For agencies that provided enough data to make it meaningful to calculate a percentage, CO_2 from revenue vehicle operations contributed 69.2–94.2 percent of the total estimated carbon footprint, for an average of 85.6 percent.

Less biofuel and CNG were being used than expected.

Less biofuel and CNG were being used than expected. Among the agencies that reported complete footprints, CO_2 of biological origin emitted by revenue vehicles accounted for 6.9 percent of SFRTA's footprint, and 6.1 percent of LYNX's. Gainesville RTS had the next-highest percentage, at 0.2 percent, and seven agencies reported none at all. Of the agencies with incomplete footprints, Key West Transit reported the highest percentage, at 16 percent, and the missing portions of the footprint probably would not reduce this much below 15 percent. LeeTran and Palm Tran had percentages of 7.3 percent and 5.1 percent, and if they had complete footprints, these might be a percentage point lower.

The trace gases CH_4 and N_2O accounted for much smaller proportions of carbon footprints than anticipated.

Trace gases

The trace gases CH_4 and N_2O accounted for much smaller proportions of carbon footprints than anticipated. Based on guidance maintained by the USEPA [9], emissions of these gases were expected to account for up to 5 percent of the footprints from operating vehicles. Among the 12 agencies listed in Appendices A–B, the largest percentages of these two gases in agency footprints were for GoLine at 1.3 percent and SFRTA at 0.7 percent. For the rest, the percentage ranges from 0.04–0.3 percent, with an average of 0.3 percent. GoLine provided less detail than other agencies in the vehicle mileage for its paratransit vehicles, and conservative assumptions were made to estimate the trace gases from these vehicles. Under less conservative assumptions, GoLine's trace gas percentage probably would have been in the same range as that of other agencies. The percentage for SFRTA is higher because of its use of diesel railroad locomotives.

As newer buses with better emission controls replace older ones, the absolute amount of emissions of these gases per vehicle-mile is expected to decline. However, because new requirements to improve vehicle fuel economy also will reduce emissions of CO_2, it is unclear whether the share of the footprint attributable to these two trace gases will increase or decrease as agencies replace their older vehicles.

Refrigerants

Refrigerants account for between 1.8 and 9.5 percent of the footprint, with an average of 5.4 percent.

Except for TCC, among the 12 agencies listed in Appendices A–B, refrigerants account for between 1.8 and 9.5 percent of the footprint, with an average of 5.4 percent. TCC reported refrigerant losses that amount to 9.5 percent of its total footprint. It was confirmed that the losses are high because of malfunctions in equipment used to maintain their vehicles. LYNX reported the lowest percentage. SFRTA's refrigerants are a lower percentage than the average, likely reflecting differences between buses and rail equipment. This is despite the fact that SFRTA did not have the maintenance records necessary to provide the data requested. Agency staff indicated that the amount reported is higher than actual losses, accounting for just less than 4 percent of its footprint, which means that actual losses are less than the 5 percent *de minimis* the GRP allows for missing emissions. For this reason, and because the reported amount is lower than the range reported by agencies that have complete data, the SFRTA footprint was treated as complete, even though its reported refrigerant losses are too high. Amounts reported by bus agencies that did not have data to report net losses were greater than the 5 percent *de minimis* limit for missing data, so their footprints are considered incomplete.

Agencies use much more R-22 refrigerant than anticipated.

Agencies use much more R-22 refrigerant than anticipated. Weigel et al. [6] note that resources for calculating emissions from public transportation, such as the Climate Registry's General Reporting Protocol, have tended to ignore R-22. They suggest that this is because:

- R-22 is being phased out worldwide under the Montreal Protocol, which prohibits sale of new equipment using R-22 after 2009, and
- R-22 was not included in the Kyoto Protocol.

They note that R-22 can be used to service equipment until 2020 and that recovered and recycled R-22 can be used afterward.

Non-revenue vehicles

Use of non-revenue vehicles contributes about 0.2–8.7 percent of each agency's footprint.

Among complete footprints, the use of non-revenue vehicles contributes about 0.2–8.7 percent of each agency's footprint, with an average of 2.2 percent. Among these agencies, Community Coach had the highest percentage, at 8.7 percent, followed by LYNX at 5.4 percent. In many cases, data on refrigerants for non-revenue vehicles were reported as part of a total that included revenue vehicles, so the

actual contribution of non-revenue vehicles may be slightly higher than this range.

Electricity

There appears to be a general tendency for electricity's share of the footprint to be larger for larger agencies.

For the 12 agencies listed in Appendices A–B, the use of electricity for facilities (as opposed to propelling vehicles) accounts for between 1.4 and 17.0 percent of the agency's footprint. Except for Community Coach, whose facility electricity accounted for 17 percent of its footprint, there appears to be a general tendency for electricity's share of the footprint to be larger for larger agencies. Electricity accounted for about 9–10 percent of HART's and PSTA's footprints, 7.6 percent of SFRTA's, about 4 percent of MCAT's, and 2–3 percent for Gainesville RTS and Citrus Connection.

For agencies listed in Appendix C, the pattern of reported electricity use is less clear. The data that MDT reported for its MetroMover and rail services combined electricity used to move vehicles with electricity used in other activities such as lighting and administration. The remaining electricity reported accounts for 0.3 percent of its footprint, but this percentage would be higher if the motive and non-motive uses had been reported separately. Electricity accounted 13.5 percent of for Key West Transit's footprint, but this may reflect missing data for other footprint components. The data missing for other agencies in Appendix C makes it difficult to discern a pattern.

Chapter 3 – Comparison with Conserve by Transit I

CBT I [2] estimated emission reductions attributable to people using public transportation instead of driving. These include the direct effects of switching transportation modes (and not emitting while driving a car) and the effects of the mode switching on emissions from traffic congestion. CBT I used fuel and ridership data reported to the NTD for 2006 to calculate CO_2 from fuel consumed in fixed-route transit service (bus, automated guideway, and rail) and to estimate emission reductions from switching to these services.

The present study made similar estimates using 2009 data, taking into account the differences between the emissions from direct fuel use in vehicle operations in CBT I and the complete carbon footprints estimated here. In addition to fixed-route service, the complete footprints include emissions from paratransit service and vanpool service and "carbon overhead" from other emissions reported by the agency. This carbon overhead comes from refrigerants, from heating, lighting, and cooling facilities, and from operating motor vehicles that do not provide direct passenger service but that are necessary for maintenance or other agency operations. The analysis compares an agency's combined Scope 1 and Scope 2 emissions to the emissions that are offset as a result of using the agency's service, which are part of Scope 3 emissions.

CO_2 released from fuel consumption in fixed-route services in 2009 accounts for 24 to 84 percent of the total carbon footprint for that year.

This section provides a detailed description of the analysis for the 12 complete or nearly-complete footprints compiled shown in Appendices A and B, followed by a less-detailed description of the analysis for the partial footprints shown in Appendix C.

The core fixed-route activities, including trace gases and refrigerant losses as well as CO_2, account for 42 to 92 percent of the total carbon footprint.

Agencies with complete or nearly complete footprints

The CO_2 released from fuel consumption in fixed-route services in 2009 accounts for 24 to 84 percent of the total carbon footprint for that year (Table 4, column B). If TCC and WHAT are excluded, because paratransit is a disproportionately large share of their footprints (Table 4, column A), the direct fuel consumption for fixed-route services contributes between 64 and 84 percent of the total footprint. Community Coach reported totals for its entire system, rather than reporting separate totals for its paratransit and fixed-route services; for this agency, the total CO_2 was allocated in proportion to the CO_2 calculated from the agency's 2009 NTD data for fixed-route and for paratransit.

The core fixed-route activities, including trace gases and refrigerant losses as well as CO_2, account for 42 to 92 percent of the total carbon

footprint (Table 4, column C). Again excluding TCC and WHAT, the core activities account for between 69 and 92 percent of the total footprint. These percentages are more subject to error than those in column B, because most agencies that reported refrigerant losses did so as a single total for all vehicles, rather than breaking it out by type of service or separating the losses between revenue vehicles and non-revenue vehicles. Most agencies probably do not maintain this level of detail in their maintenance records. For convenience, except where an agency reported refrigerants by type of service, the total refrigerant losses were included in fixed-route bus service. Thus, except for HART and MCAT, the core activities' share of the total footprint is too high, because it includes refrigerant losses for vanpool, paratransit, or non-revenue vehicles.

Table 4. Comparison of CBT I emissions with complete or nearly complete footprints

Agency	A % of total footprint reported as paratransit (all gases)	B % of total footprint which is CBT I core (CO_2 only)	C % of total footprint which is CBT I core activity (all gases)	D CBT I core (CO_2 only) as % of total footprint that was NOT reported as paratransit
Broward County Transit	15.1%	76.3%	78.8%	92.9%
Gainesville RTS	6.7%	83.7%	88.6%	95.0%
HART	4.7%	73.1%	81.5%	85.5%
GoLine	27.1%	68.4%	71.3%	97.7%
Citrus Connection	12.9%	75.2%	83.2%	95.5%
LYNX	13.3%	64.0%	71.9%	83.0%
MCAT	25.1%	66.5%	68.8%	91.9%
Community Coach	59.6%	9.7%	74.2%	74.3%
PSTA	7.8%	75.8%	80.3%	87.1%
TCC	58.3%	26.2%	35.7%	85.6%
SFRTA	0.0%	80.5%	92.0%	92.0%
WHAT	36.9%	53.3%	59.8%	94.7%

Accounting for paratransit

The scope of work for the study directed that, wherever possible, emissions from paratransit be tracked separately from fixed-route emissions. Column D in Table 4 and columns D and E in Table 5 show one effort to do so. In Table 4, Column D shows CO_2 emissions from each agency's fixed-route services as a percentage of the portion of its footprint that it reported in any category other than paratransit. These CBT I core emissions range from 74 to 98 percent of the total footprint. Excluding Community Coach, whose data combined fixed-route with its paratransit service, these core emissions range from 83 to 98 percent. Again, except for HART and MCAT, the agencies reported totals for refrigerants that combine fixed-route and paratransit services. Because of the convention of reporting these totals as fixed-route bus, the amount that was reported for paratransit alone is too small, which also would make the values in column D underestimate the actual percentages.

At the same time, the values that agencies reported for paratransit are too small because they do not include emissions from the "carbon overhead" of non-revenue vehicles, non-motive electricity, and

Table 5. Allocation of carbon overhead to paratransit

Agency	A % of total footprint reported as carbon overhead (facilities plus non-revenue vehicles)	B % of total footprint reported as paratransit (all gases) (Column A from Table 4)	C % of total footprint estimated as paratransit (including carbon overhead)	D CBT I CO_2 as % of total footprint excluding revised paratransit	E CBT I core (CO_2 only) as % of total footprint that excludes reported paratransit (Column D from Table 4)
Broward County Transit	6.1%	15.1%	16.5%	91.3%	92.9%
Gainesville RTS	4.7%	6.7%	7.4%	90.4%	95.0%
HART	12.4%	4.7%	5.4%	77.3%	85.5%
GoLine	1.7%	27.1%	28.3%	95.3%	97.7%
Citrus Connection	3.9%	12.9%	14.6%	88.0%	95.5%
LYNX	13.2%	13.3%	15.6%	75.8%	83.0%
MCAT	6.1%	25.1%	26.7%	90.8%	91.9%
Community Coach[1]	25.7%	59.6%	85.9%	69.0%	74.3%
PSTA	11.9%	7.8%	9.3%	83.6%	87.1%
TCC[1]	6.0%	58.3%	69.0%	84.5%	85.6%
SFRTA[2]	8.0%	0.0%	0.0%	80.5%	92.0%
WHAT	3.3%	36.9%	40.9%	90.1%	94.7%

[1]Allocation includes allocation of large amounts of refrigerants between fixed-route and paratransit.
[2]Agency does not provide paratransit service.

other emissions from operating and maintaining agency facilities. For example, paratransit and fixed-route service may be operated out of the same building, so some of the electricity used by the building should be allocated to fixed-route service and some to paratransit. In Table 5, column A shows the percentage of each agency's total footprint that is attributable to carbon overhead. Carbon overhead accounts for 2 to 26 percent of each agency's total footprint, and between 2 and 13 percent if Community Coach is excluded. Allocating some of the carbon overhead to paratransit and some to other services would increase the values in Table 4, column A and reduce them in Table 4, column D.

Table 5 shows the results of such an allocation based on the percentage of CO_2 from fuel use (and electricity for moving vehicles) in each type of service. For example, if an agency's fuel use in paratransit vehicles accounts for 25 percent of the total CO_2 from fuel used in fixed-route, paratransit, and vanpool services combined, then 25 percent of the emissions from non-revenue vehicles, electricity, and other energy used in facilities have been allocated to paratransit. A few agencies reported refrigerant losses by types of service, but most reported a total that combines losses in all services; in the latter case, the total refrigerants have been allocated to different transit services in proportion to each service's total CO_2 emissions. Other bases for allocating the carbon overhead are possible, but fuel use for revenue vehicles is a very large percentage of the total footprint, and it should be a broad indicator of the relative importance of different services within an agency's overall operations.

Column B in Table 5 shows the percentage of each carbon footprint reported as being for paratransit (this repeats what was shown as column A in Table 4, to simplify comparisons). Column C shows the estimated percentage of each carbon footprint attributable to paratransit, including the allocated carbon overhead. Column D shows the core CBT I CO_2 emissions as a percentage of the total footprint, excluding reported paratransit and the carbon overhead allocated to paratransit. Column E repeats the values from Column D of Table 4, to simplify comparisons. As can be seen, allocating the carbon overhead reduces the share of the total footprint attributable to fixed-route and vanpool service.

Column D in Table 5 indicates that the direct CO_2 emissions from fixed-route services accounted for between 69 and 95 percent of the fixed-route (and vanpool) footprint, including allocated carbon overhead.

A point of comparison between CBT II and CBT I was to update CBT I's estimates of emission reductions attributable to public transportation. These reductions are considered to be Scope 3 when calculating the carbon footprint.

Estimating emission offsets

A second point of comparison between CBT II and CBT I was to update CBT I's estimates of emission reductions attributable to public transportation. These reductions are considered to be Scope 3 when calculating the carbon footprint. They are influenced by the public transportation agency, but they are not under the agency's direct control. An agency can provide service, for example, but it is not in control of how many people use the service or how much they use it.

The first step was to obtain and review the spreadsheets that the CBT I study used to estimate these emission reductions and create space within them to run updated estimates based on 2009 data. In addition, new spreadsheets were created for Key West Transit, Sunshine Bus, LakeXpress, Collier Area Transit, and Community Coach, which reported footprint data to CBT II but that were not included in CBT I.

To reduce the burden on the agencies, CBT II used the fiscal-year 2009 data on unlinked passenger trips and passenger-miles that each agency reported to the NTD. Key West Transit does not have data in the NTD, but it published comparable data for 2008 [10], which were used instead. These differences create small inconsistencies for those agencies that provided carbon footprints for calendar 2009 rather than fiscal 2009, but these likely are small enough that they do not affect a broad comparison between the footprints and the reductions.

Trip data for fixed-route services were entered into the spreadsheets, as done in CBT I, and vanpool trip data were entered as well. Use of the vanpool data required two additional assumptions.

First, the original spreadsheets contain factors for converting between passenger miles and equivalent vehicle miles to calculate fuel consumption avoided by taking the bus. The intent is to account for the fact that a bus trip may not be as direct as a car trip, and the CBT I

Emission reductions offset between 24 and 80 percent of the CO_2 emissions from vehicle operations and between 21 and 69 percent of the broader footprint that excludes paratransit.

calculations assumed that a 10-mile bus trip might be equivalent to an 8.26 mile car trip. A search for a similar conversion factor for vanpooling turned up only one value based on old data, which assumes a 10-mile passenger trip by vanpool is equivalent to 8.696 miles by car [11].

Second, the CBT I spreadsheets contained "mode-shift" factors to estimate the percentage of transit passenger trips that result from people switching from driving to riding transit (as opposed to riding transit because they have no alternative). This allows an estimate of how many car trips are avoided because of transit use and the fuel these trips would have used. A search for a comparable value for vanpooling did not turn up any estimates. For the current study, it was assumed that 80 percent of vanpool trips result from switching from driving, based on analysis of carpool data for the State of Washington by one of the current authors. The 80 percent value assumes that most people who vanpool could drive instead, but that some may have switched from carpooling or fixed-route transit service.
Except for these new coefficients, the same equations and coefficients were used as in CBT I [2]. No attempt was made to update that study's forecasts or scenarios for years later than 2009.

The CBT I spreadsheets yield estimates of metric tons of CO_2(e) reduced from mode-shifting and from reduction in congestion attributable to cars not being driven. These include CO_2 from automobile fuel plus estimates of the trace gases CH_4 and N_2O from driving. The CBT I report [2] does not mention refrigerant losses.

These estimated emission reductions offset part of the emissions released by the transit agency. The CBT I spreadsheets estimate only the agency's CO_2 emissions from fuel or electricity used in moving its vehicles. The CBT I spreadsheets use slightly different emission coefficients than the GRP [5].

Table 6, Column A, shows the direct CO_2 emissions from each agency's fixed-route and vanpool service, calculated as part of the footprints in the present study using the GRP coefficients. This amount is the CBT I core plus the emissions from fuel burned in vanpool vehicles. Column B shows the complete carbon footprint for each agency, excluding the portion estimated for paratransit. Columns C and D show the emission reductions calculated by the CBT I spreadsheets for 2009 from mode shifting and alleviation of traffic congestion. Column E shows the percentage of the direct emissions from Column A that are offset by the reduced emissions in Columns C and D. Column F shows the percentage of the non-paratransit carbon footprint offset by these same reductions. Emission reductions offset between 24 and 80 percent of the CO_2 emissions from vehicle operations and between 21 and 69 percent of the broader footprint that excludes paratransit.

Computing the percentages based on the sum of the emissions and offsets, in the last row of the table, yields weighted average offsets of 66 percent for vehicle operations and 55 percent for the broader footprint excluding paratransit. HART, PSTA, and LYNX have relatively high carbon overheads compared to the smaller agencies (Table 5, column A), and their large totals dominate the weighted averages.

Carbon overheads (including refrigerant losses) are significant portions of an agency's carbon footprint.

These results show that carbon overheads (including refrigerant losses) are significant portions of an agency's carbon footprint. In addition, larger agencies tend to have higher rates of carbon overhead, but they also tend to offset higher percentages of the broader footprints that include that overhead. However, the percentage of the footprint that is offset depends in part upon the mode-shift factors developed in the CBT I study for the spreadsheets. The spreadsheets for agencies that serve more than 1.25 million people use a mode-shift factor of 0.47; those for agencies that serve less than 0.5 million people use 0.34; and those for agencies in between use 0.42.

CBT I [2] examined the effects of ridership on emission offsets. All else being equal, if transit ridership increases as a result of more people switch from driving to riding public transportation, then agencies will offset higher percentages of their total footprints. However, agencies also can increase the percentage of emissions offset by their current ridership if they manage their footprints to reduce emissions, including reducing their carbon overhead.

If a Florida Transit agency needed 100 permits to cover the CO_2 emissions from its fixed-route and vanpool services, it might need 120 to cover its complete carbon footprint for these services, including carbon overhead. The agency could generate offsets equivalent to just over 65.

To put the results here into the context of an emission trading system, if a Florida transit agency needed 100 permits to cover just the CO_2 emissions from its fixed-route and vanpool services, it might need approximately 120 permits to cover its complete carbon footprint for these services, including carbon overhead. If the trading system allowed offsets, the agency could generate offsets equivalent to just over 65 permits based just on the CO_2 from avoided driving and traffic congestion.

Agencies with incomplete footprints

Table 7 shows the same comparison between footprints and offsets for the agencies whose footprints are incomplete. The broader footprints shown in column B, therefore, are underestimates, and percentages that are shown as offset in column F would be lower if the complete footprint were available. The percentages of vehicle fuel use offset range from just less than 16 to nearly 69 percent. The percentages of the broader footprint offset range from 11 to 66 percent. Again, the percentages offset tend to be higher for larger agencies, although this conclusion might change if the footprints for all of these agencies were complete. The weighted averages in Table 7 are dominated by MDT.

Interpreting, comparing, and using the results

Use of the results of this study is not recommended to compare transit with other modes of passenger transportation.

Comparable data are not available for the "carbon overhead" from driving and other modes needed to make such comparisons meaningful.

Use of the results of this study is not recommended to compare transit with other modes of passenger transportation. Ideally, one would like to compare energy use or emissions between modes on a per-passenger-trip or per-passenger-mile basis, especially for specific types of trips such as commuting. It may tempting to include the "carbon overhead" estimated by this study when making comparisons between the carbon intensity of public transportation and that of other transportation modes, especially single occupancy automobile use. However, because carbon footprints are defined using "scopes," comparable data are not available for the "carbon overhead" from driving and other modes needed to make such comparisons meaningful. In addition, there are different types of transit trips. Therefore, the offsets calculated and presented above should be regarded as lower bounds on the actual percentage of the footprint offset.

Transit agencies provide multiple types of services. A few agencies have recordkeeping systems that enable them to separate most of the elements of their carbon footprints into broad services (fixed-route bus, rail, or trolley; paratransit; vanpool). However, none of them do so for electricity and, given the nature of electricity metering, such detail is probably beyond the ability of most transit agencies. A few were able to do this for only parts of their refrigerant losses. Some were not able to separate refrigerants by service type at all, although they were able to track total refrigerant use. In addition, it is unlikely that agencies can distinguish within the fixed-route services between people who choose to ride transit instead of using other transportation modes and those for whom the choice is among transit, some other non-driving mode, or not making the trip.

This inability is important, because some of the route structure of fixed-route transit service and its resulting emissions results from a focus on the second group of riders ("transit-dependent" riders), while the effects of mode choice on emissions are meaningful for the first group of riders ("choice" riders). Some routes are planned to provide areal coverage to enable as many people as possible to have access to the transit system, even if only a small proportion of the people who receive that access actually use it. Such routes may require more vehicle miles and emissions per passenger-mile than one planned in a denser area with greater service frequency to attract more choice riders. The carbon footprints estimated in this study do not distinguish between the types of fixed-route riders. A proper comparison between GHG emissions of transit and other modes should focus on the purpose

Emissions that result from trips provided as a social service to persons who could not otherwise travel should be compared to emissions from other means of delivering comparable service to the same population.

of the service being provided. Emissions from service provided as an alternative to car use should be compared to emissions from car use on a functional basis that includes all of the activities that support the delivery of the passenger trips (including maintenance and other activities required to support driving personal vehicles, which are included in the transit agencies' carbon footprints and would need to be estimated for personal vehicles). Emissions that result from trips provided as a social service to persons who could not otherwise travel should be compared to emissions from other means of delivering comparable service to the same population, such as paratransit, vanpools, or other alternative service strategies.

Table 6. CO_2 emissions and footprint offset by use of public transportation (agencies whose footprints are complete or nearly complete)

Agency	A CO_2 emissions from fixed-route and vanpool operations (metric tons)	B Total footprint, excluding paratransit and carbon overhead allocated to it ($MTCO_2[e]$)	C Emission reductions from mode shift ($MTCO_2[e]$)	D Emission reductions from congestion mitigation ($MTCO_2[e]$)	E % of Column A offset by Columns C and D	F % of Column B offset by Columns C and D
Broward County Transit	48,475	53,084	29,456	7,210	75.6%	69.1%
Gainesville RTS	8,692	9,617	3,065	383	39.7%	35.8%
HART	21,493	27,323	10,732	1,439	56.6%	44.5%
GoLine	891	935	332	25	40.2%	38.3%
Citrus Connection	4,037	4,585	893	62	23.7%	20.8%
LYNX	36,885	47,537	24,948	4,452	79.7%	61.8%
MCAT	2,717	2,994	811	60	32.0%	29.1%
Community Coach[1]	35	51	10	0	30.6%	21.1%
PSTA	24,768	29,644	9,335	1,247	42.7%	35.7%
TCC[1]	408	483	120	5	30.5%	25.8%
SFRTA[2]	28,666	35,616	21,010	872	76.3%	61.4%
WHAT	1,043	1,157	286	20	29.3%	26.4%
Total	178,110	213,025	100,996	15,776	65.6%	54.8%

[1]Allocation includes allocation of large amounts of refrigerants between fixed-route and paratransit.
[2]Agency does not provide paratransit service.

Table 7. CO_2 emissions and footprint offset by use of public transportation (agencies whose footprints are incomplete)

Agency	A CO_2 emissions from fixed-route and vanpool operations (metric tons)	B Total footprint, excluding paratransit and carbon overhead allocated to it ($MTCO_2[e]$)	C Emission reductions from mode shift ($MTCO_2[e]$)	D Emission reductions from congestion mitigation ($MTCO_2[e]$)	E % of Column A offset by Columns C and D	F % of Column B offset by Columns C and D
CAT[1]	3,029	2,712	1,098	47	37.8%	42.2%
Citrus County Transit[2]	1,508	1,640	N/A	N/A	N/A	N/A
ECAT	3,375	4,013	672	48	21.3%	18.0%
Hernando Express Bus	466	469	74	6	17.1%	17.0%
Key West Transit	757	1,094	97	22	15.8%	10.9%
LakeXpress	806	820	130	7	16.9%	16.6%
LeeTran	6,800	7,943	2,202	133	34.3%	29.4%
MDT[3]	159,057	166,484	90,116	18,868	68.5%	65.5%
Palm Tran[3]	17,745	20,609	7,670	1,048	49.1%	42.3%
Sunshine Bus	404	406	124	6	32.1%	32.0%
StarMetro[4]	0	340	1,581	189	N/A	521.2%
VOTRAN	7,149	7,846	2,972	143	43.6%	39.7%
Total	201,097	214,374	106,736	20,516	51.1%	59.4%

[1]Calculations for CAT exclude vehicle refrigerants, which appear to be much too high.

[2]Citrus County Transit did not report passenger data to NTD, so offsets cannot be estimated.

[3]MDT and Palm Tran did not collect the necessary data for refrigerants.

[4]StarMetro did not report vehicle fuel use, so most of its footprint is not available for these calculations.

Chapter 4 – Lessons Learned

Making contact with the transit agency

When the person designated to work with the study was part of the agency's planning staff, data were received that were more complete than when the designated person was in the maintenance department.

The initial effort to contact agency heads was based on an expectation for transit agency organization that appears common for large transit agencies whose primary mission is providing fixed-route service and whose paratransit, vanpool, or other services are small in comparison to their fixed-route service. These agencies tend to be single organizations headed by an individual. It was found that smaller agencies or agencies whose primary mission is providing paratransit or similar services to persons who have limited transportation options sometimes have other organizational structures. These agencies may be operated by a larger organization, such as a city, a metropolitan planning organization (MPO), or an area agency on aging, that otherwise has little to do with transit service and that operates the transit service in partnership with other organizations. Finding the appropriate agency head in these cases proved to be challenging.

Agency heads designated a variety of staff to work with the study team. Although there were exceptions, it was noted that when the person designated to work with the study was part of the agency's planning staff, data were received that were more complete than when the designated person was in the maintenance department. In many cases, the designated persons were not technical staff, and the study team worked with the designated person as a go-between to communicate with the people who understood the details of how the data were recorded and what they showed.

Difficulties in using the Climate Registry General Reporting Protocol

The GRP does not provide emission coefficients for hybrid buses.

In general, the Climate Registry's General Reporting Protocol was straightforward to apply once the agency data were in hand. However, four difficulties were encountered in using the protocol.

Emissions from hybrid buses

One difficulty was a gap in coverage that probably reflects a lack of data. The procedure for calculating emissions of CH_4 and N_2O is to multiply vehicle miles by an emission coefficient that reflects the efficiency of emission control equipment. PSTA reported using hybrid buses that, because of their use of electricity, should be expected to have lower emission rates per mile than comparable buses using a conventional power train. The GRP does not provide emission

coefficients for hybrid buses. The Climate Registry acknowledged the gap and advised using the coefficients for standard vehicles. As noted in Chapter 2, the contribution of these two trace gases to each agency's footprint was much smaller than anticipated, so this assumption has a relatively small effect on the estimated size of the footprint.

Light-duty vs. heavy-duty vehicles

The GRP provides vehicle emission coefficients for CH_4 and N_2O based on fuel type (diesel or gasoline), and by whether vehicles are light-duty or heavy-duty vehicles.

The second difficulty involved an unclear definition that, in turn, is limited by the availability of data. Table 13.3 of the GRP [1] provides vehicle emission coefficients for CH_4 and N_2O based on fuel type (diesel or gasoline), by the class of emission standards the vehicle's emission controls are designed to meet, and by whether vehicles are light-duty or heavy-duty vehicles. Table 13.4 of the GRP provides similar information, but coefficients are based on model year instead of class of emissions standards. These coefficients were compiled originally by the USEPA for use in its analyses. Cars, sport-utility vehicles, and pickup trucks marketed to households clearly use the light-duty vehicle coefficients. Standard large diesel transit buses clearly use the heavy-duty vehicle coefficients for diesel vehicles. However, the protocol provides no direct guidance about what to use for vehicles between these two extremes. These vehicles include small buses, many paratransit vehicles, large passenger vans, large pickup trucks, and some service vehicles such as bucket trucks used to maintain lighting and other infrastructure above street level. The Climate Registry provided additional information on the source of the coefficients and advised that "medium-duty" vehicles having 8,500 Gross Vehicle Weight Rating (GVWR) or more should be regarded as "heavy-duty."

"Medium-duty" vehicles having 8,500 Gross Vehicle Weight Rating (GVWR) or more should be regarded as "heavy-duty."

Using the year, make, and model information provided by the transit agencies, more information was sought about these types of vehicles. Many vehicles were simply described with a "Class" number that corresponds to a range of GVWR; Classes 3 through 8 have GVWR of more than 10,000, making them "heavy-duty" vehicles for purposes of footprint calculations. Class 1 vehicles have GVWR of 6,000 or less, making them "light-duty" for the calculations. Class 2 vehicles contain both "light-duty" and "heavy-duty" vehicles, including large pickup trucks and passenger vans. The research team found ranges of GVWR for individual models, depending on the engine and other options ordered with the vehicle. However, the transit agencies provided little information about these options. The U.S. government's website www.fueleconomy.gov provides lists of vehicles that have GVWR between 8,500 and 10,000 [12] [13], but these lists note that some of the models listed also were available in configurations outside this range. A tax preparation document [14] provided additional detail for 2005 model year vehicles. As a general rule, trucks with model numbers containing "150" or "1500" were shown as light-duty in the document, as were eight-passenger vans; trucks with model numbers containing "250" or "2500" or higher were shown as heavy-duty, as

were vans designed originally designed for more than eight passengers. Where these documents and model-specific Internet searches could not determine a likely GVWR value, it was assumed that the vehicle was "heavy-duty," which would overestimate emissions if the vehicle was actually "light-duty." Even with this assumption, however, emissions of CH_4 and N_2O accounted for only 0.3 percent of a typical agency's footprint.

Even with access to the vehicles and owner's manuals, transit agencies would find it difficult and time-consuming to determine the appropriate light- or heavy-duty class for some vehicles.

Even with access to the vehicles and owner's manuals, transit agencies would find it difficult and time-consuming to determine the appropriate light- or heavy-duty class for some of the Class 2 vehicles. This seems a likely source for error in reporting, even if its effects on the total footprint would be small. It would be helpful if the Climate Registry could provide additional detail within its GRP about the 8,500-GVWR threshold, how the threshold relates to vehicle classes, and the kinds of models likely to be included in the two different duty classes. USEPA's "Climate Leaders" program [15] uses the same emission coefficients and would benefit by providing similar guidance.

Biofuels

The third difficulty encountered was a lack of clarity in the directions for calculating emissions from biofuels. Table 12.1 of the GRP provides coefficients for estimating CO_2 for different fuel types, when the exact carbon content is not known from contract or measurement data. The coefficient provided for biodiesel is for pure or unblended biodiesel. To calculate the CO_2 emissions from what an agency reported as biodiesel, it is necessary to know the proportion of carbon from fossil vs. biological sources and then use the emission coefficients for each portion of the carbon. Thus, for B20 biodiesel, which is a blend of 20 percent pure biodiesel and 80 percent pure fossil diesel, the CO_2 content is equal to 80 percent of the amount of B20 multiplied by the coefficient for pure fossil diesel plus 20 percent of the amount of B20 multiplied by the coefficient for pure biodiesel. The GRP then requires that each of these amounts be reported separately. The GRP contains many examples of calculations, but it does not do so for biodiesel (or for gasoline blended with ethanol). The GRP would be easier to apply if it presented such an example for biodiesel or a similar blend.

The GRP contains many examples of calculations, but it does not do so for biodiesel (or for gasoline blended with ethanol).

Several transit agencies reported using biodiesel, and it was necessary to clarify whether the quantity reported as "biodiesel" was pure biodiesel or a blend and, if the latter, what percentage of the carbon was biological. As of this writing, confirmation of this from one agency has not been received.

HART, Community Coach, and Palm Tran reported their gasoline as 90 percent gasoline and 10 percent ethanol, and this information was used to calculate their footprints; Community Coach was the only agency that provided a certificate of analysis from its supplier to

support this blend. These were the only agencies that reported use of a gasoline-ethanol blend and the percentage of ethanol. MCAT reported gasoline as being blended externally with up to 10 percent ethanol. It was conservatively assumed that 5 percent was ethanol. In Florida, during 2009, most gasoline contained some ethanol, up to 10 percent, but the exact percentage in a gallon is unknown unless specified in a fuel contract or certificate of analysis from the fuel supplier. No other agencies reported gasoline blended with ethanol. Therefore, it was conservatively assumed that all other gasoline reported is 100 percent gasoline from fossil sources. This is an issue not just for separating fossil CO_2 from biological CO_2, but also for calculating the total amount of CO_2, because burning a gallon of ethanol releases 5.75 kg of CO_2, while burning a gallon of unblended gasoline releases 8.78 kg of CO_2.

In Florida, during 2009, most gasoline contained some ethanol, up to 10 percent.

It was conservatively assumed that all other gasoline reported is 100 percent gasoline from fossil sources.

Burning a gallon of ethanol releases 5.75 kg of CO_2, while burning a gallon of unblended gasoline releases 8.78 kg of CO_2.

As of December 31, 2010, all gasoline sold in Florida must contain 9–10 percent ethanol, and the law that requires this also requires the ethanol to be of biological origin [16]. Unless documentation is available to justify other calculations, footprints for Florida transit agencies in calendar year 2011 or later or in fiscal year 2012 or later should assume that "gasoline" is 9 percent ethanol, of biological origin, and 91 percent gasoline from fossil sources. The Climate Registry may want to provide guidance for states that specify only a maximum or a minimum percentage of ethanol.

Inconsistent formatting of emission coefficient tables for trace gases

The GRP [1] and its file of updated coefficients [5] contain extensive tables of coefficients for estimating the amounts of CH_4 and N_2O emitted from various fuels and combustion processes. Most of the tables, including some for transportation, list the coefficient for CH_4 first, followed by the one for N_2O. A few of the tables, including tables 13.3 and 13.4 used to calculate emissions per vehicle-mile from US cars and trucks, list the coefficient for N_2O first, followed by the one for CH_4 (the coefficients for Canadian cars and trucks are in same order as for most of the tables). This led to some errors in transcribing coefficients into the spreadsheets. The Climate Registry may want to use the same order for coefficients throughout its entire GRP and tables. Users of the GRP need to be aware that the order varies between tables, and exercise care when selecting them for calculations.

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Recordkeeping

Agency recordkeeping appears to be very tightly structured toward reporting data for fiscal years; reporting data for calendar years or other periods requires more effort. This was anticipated at the beginning of the study, and comments by agency personnel at the April 2010 advisory web conference confirmed this. Slightly more than half of the agencies reported fiscal-year data for the study, despite being

asked for calendar-year data. Several agencies also reported portions of their data by month for fiscal years 2008 and 2009, requiring extraction of the specific months from each to obtain the total for calendar year 2009. This experience indicates that agency data systems are not set up to report summaries except on a fiscal-year basis, and more effort was required to gather calendar- than fiscal-year data.

Agencies tended to provide data fairly easily and quickly for variables such as fuel use that are reported to the NTD. Agency staff had more difficulty with variables such as vehicle mileage, electricity use, and data on non-revenue vehicles.

Agencies tended to provide data fairly easily and quickly for variables such as fuel use that are reported to the NTD. Agency staff had more difficulty with variables such as vehicle mileage, electricity use, and data on non-revenue vehicles. This difference may simply reflect the fact the designated points of contact in the agency may have been familiar with the agency's system for reporting to the NTD, but it may also reflect the fact that some agencies do not routinely monitor or report some of the data needed to estimate a carbon footprint.

Some agencies have comprehensive computerized databases that track all of the data required to calculate a complete carbon footprint (even though these seem to have been designed to report summaries for fiscal years and not calendar years); others do not. One medium-sized agency that did not participate cited the difficulty of assembling the paper records containing the data.

Current recordkeeping at most agencies does not appear to support reporting of electricity or refrigerants separately between fixed-route and paratransit or other services. Electricity metering at some agencies enables reporting of electricity use for different purposes such as lighting, offices, maintenance, and powering vehicles; at others it does not, especially when an agency's offices and maintenance facilities are located in the same building.

Agencies that contract for services, either for purchased transportation or for maintenance, often had difficulty in reporting data that was in the possession of their contractors. This was a particular problem for data on vehicle mileage and the use of refrigerants. Some maintenance of air-conditioning systems for revenue vehicles is performed under warranty, and some is done under a service contract. The organization doing the service usually has the information, but obtaining it takes more effort than if the transit agency does the work itself.

It proved more difficult to obtain data on refrigerant use than on other components of the carbon footprint.

In general, it proved more difficult to obtain data on refrigerant use than on other components of the carbon footprint. Some agencies rely on other organizations to maintain their mobile air-conditioning equipment and, therefore, do not have their own records. Some of these were able to obtain the information from their service contractors, but others were not. A more important reason may be that the information required for this part of the footprint is harder to explain than for other components. For example, fuel use, electricity

use, and mileage are easily understood, and there are instruments in common use to measure these directly. For refrigerants, when equipment is serviced, refrigerant is taken out of equipment and then put back in, with refrigerant added as needed. This additional quantity is what is needed for the footprint, and it is not measured directly but is calculated as the difference between two other quantities that are measured. The request for this difference proved more difficult to communicate than expected.

When equipment is serviced, refrigerant is taken out of equipment and then put back in, with refrigerant added as needed. This additional quantity is what is needed for the footprint.

Recordkeeping at some agencies definitely does not support reporting of refrigerant emissions. One agency with in-house maintenance keeps records on the amount of refrigerant it uses to charge cooling equipment, but not on how much it recovers from equipment when preparing it for maintenance. (The agency indicated it will begin to record how much it recovers, so that in future years it will be able to report the amount used to replace losses.)

For refrigerants such as R-22, which is being phased out under the Montreal Protocol, the USEPA's regulations implementing the Protocol require fairly detailed recordkeeping. It was anticipated that information needed to calculate this refrigerant's contribution to the footprint for the footprint would available. Such records do not need to be kept for R-134a, the other refrigerant in common use for transit vehicles. However, as an item that contributes to the cost of servicing equipment, it does need to be tracked.

Chapter 5 - Recommendations for Estimating and Using Future Footprints

Updating the Footprints

In the absence of strong policies to reduce GHG emissions, public transportation agencies that want to monitor and manage their carbon footprints probably will need to do this on their own.

In the absence of strong policies to reduce GHG emissions, public transportation agencies that want to monitor and manage their carbon footprints probably will need to do this on their own. The agencies that participated in this study now have a better understanding of the types of data required, the effort required to compile the data, and the relative importance of different activities to their carbon footprints. With the few exceptions noted in Chapter 4, the Climate Registry's GRP provides clear documentation, examples, and coefficients for calculating updated footprints. (One agency indicated that it plans to change its recordkeeping to enable it to estimate refrigerant losses.)

Tools

Each participating transit agency will be provided with a copy of the Excel 2007 workbook used to calculate its carbon footprint and with a general version of the workbook.

Each participating transit agency will be provided with a copy of the Excel 2007 workbook used to calculate its carbon footprint and with a general version of the workbook. Because of the diverse range of formats in which agencies maintain data and provided it to the study, it is not possible to write a single spreadsheet tool that can work with every format. The study began with a general version of the workbook and then altered it as needed to accommodate the data each agency provided. The general version is similar to the one used in the study team, but it is organized differently. The revised organization should allow most agencies to enter data without modifying the spreadsheet. Developing a spreadsheet that would allow more agencies to use the workbook without modifying it would make the spreadsheets more complicated for all agencies to use. The general version has been tested by entering the data from the original spreadsheets for each agency and comparing results to the original. Appendix D provides directions for using the general version.

If enough agencies express interest updating and managing their carbon footprints, FDOT or FPTA might consider supporting the development of software tools, such as more general spreadsheets or web-based forms, that agencies could use to enter data, calculate emissions, and prepare summaries for managing footprints, applying for grants, or reporting to organizations that require or track carbon footprints.

Data from purchased transportation and purchased services

Several Florida transit agencies contract for purchased transportation and had difficulty obtaining the necessary data from the contractor.

This was a particular problem for obtaining mileage for individual vehicles or types of vehicles and for obtaining information on quantities of refrigerants added to make up for losses. An agency that wants to estimate its carbon footprint on a routine basis should include a requirement in its contracts for purchased transportation services (those that it would report to the NTD) that contractors maintain and provide the data needed for this purpose. It also is recommended that the contract designate a point of contact in the contractor organization responsible for providing the necessary data to the agency.

An agency that wants to estimate its carbon footprint on a routine basis should include a requirement in its contracts that contractors maintain and provide the data needed for this purpose.

Simplifying the estimates

The Climate Registry developed its reporting protocol to help companies and agencies meet anticipated reporting requirements of a system for trading emissions and verifying claims of valid emission offsets (as well as for other purposes, such as providing consistent, clear information that investors could use to compare the risks faced by different organizations, and that organizations could manage their carbon footprints). Some of the reporting requirements add complexity or effort to the process of calculating carbon footprints. An organization that wants to manage its carbon footprint might consider simplifying the estimates, *unless* it also needs to report its footprint to others for trading, offsets, compliance with government reporting requirements, or comparison with other organizations. Two simplifications would allow effective management of the carbon footprint but with less effort in gathering data to calculate emissions.

Two simplifications would allow effective management of the carbon footprint but with less effort in gathering data and calculating emissions.

One is to do the calculations on a fiscal-year basis rather than a calendar-year basis. While calendar-year reporting probably would be required for participation in an emission-trading system, any consistent estimating period is sufficient for an organization to manage its carbon footprint. Florida's transit agencies organize their data management around a fiscal year schedule, in part because they are public agencies subject to accounting requirements set by different political jurisdictions and in part because of the requirement to report to the NTD (which allows fiscal-year reporting). They could easily manage their carbon footprints on the same fiscal-year schedule. In the case of Florida, switching to a fiscal-year basis would sacrifice relatively little in the ability to compare agencies within the state. Of the 33 Florida agencies that reported data to the NTD in 2009, 28 reported using a fiscal year of October 1–September 30; four used a fiscal year of July 1–June 30; and one (a vanpool-only agency that was not part of this study) used a fiscal year of January 1–December 31.

One is to do the calculations on a fiscal-year basis rather than a calendar-year basis.

The second simplification involves calculations of the trace gases CH_4 and N_2O, which account for less than 1 percent of a typical agency footprint. Emissions of these gases from buses and other motor vehicles are closely related to fuel consumption and CO_2 emissions. Reductions in vehicle mileage will tend to reduce emissions of these

two gases as well as of CO_2. However, calculating emissions of CH_4 and N_2O requires substantial additional data on the mileage of individual vehicles or groups of vehicles; even though transit agencies may have this data, using it to estimate these trace gases requires a disproportionate amount of work relative to other components of the carbon footprint. If an agency wants to manage its carbon footprint, and if it does not need to include the trace gases for purposes of trading, or other reporting, or comparison with other agencies, it could reasonably ignore motor vehicle operations as a source of these two gases. Emissions from other sources, such as electricity, are easily estimated and should continue to be tracked. If black carbon is ever formally integrated into carbon footprint calculations, it should be estimated at least once before determining whether or not its management requires annual estimates.

Calculating emissions of CH_4 and N_2O requires substantial additional data. If an agency wants to manage its carbon footprint, it could reasonably ignore motor vehicle operations as a source of these two gases.

A third possibility for simplification would appear to be to ignore non-electric heating, groundskeeping activities, and emergency generators. Very little data were received about these activities, and the information that was received indicates that these activities account for very small percentages of carbon footprints. However, unlike the trace gases CH_4 and N_2O from vehicle emissions, which can be managed effectively in large part by managing CO_2 emissions, emissions from groundskeeping and emergency generators are not strongly related to other components of the agency's carbon footprint, and they must be managed directly. For this reason, it is recommended to continue to estimate them directly.

Offsetting vs. managing carbon footprints

The original context for CBT I and the present study assumed that an emission trading system would be created as part of a policy to reduce GHG emissions; that transit agencies would be allocated permits for emissions roughly comparable to their present emissions, but somewhat below them; that agencies might be able to earn credits for the reduced emissions that result from the use of their services; and, if so, that agencies could sell the credits to other organizations that needed them, earning additional revenue in the process. Alternative designs for trading systems might have required agencies and others to purchase permits from the government, but allowing credit for reductions would reduce the number of permits that that agencies would need purchase. The results presented here indicate that agencies would need additional permits beyond those that would be expected based on revenue vehicle operations alone and that a policy that would require agencies to purchase permits would have additional costs to cover the electricity and refrigerant emissions, relative to those for just emissions from vehicle fuel use.

The policy environment has changed in the past year, making an emission trading system or other strong policies to report or reduce GHG emissions seem unlikely for the next several years. However, the policy environment could change just as dramatically again. Agencies may wish to manage and reduce their carbon footprints to reduce their exposure to risks that state or federal GHG policies may change to require either reporting or reduction of emissions. Documentation of emissions and efforts to reduce them could be useful in establishing compliance with future requirements.

The results of this study show that carbon overhead and losses of refrigerants contribute substantial shares of an agency's total carbon footprint.

In addition the results of this study show that carbon overhead and losses of refrigerants contribute substantial shares of an agency's total carbon footprint. Electricity, the use of non-revenue vehicles, and losses of refrigerants cost money as well as creating emissions. Thus, reducing the size of its footprint can help the agency to reduce its costs. An agency also may wish to reduce emissions to promote a "green" image.

Although Chapter 3 described a process to allocate carbon overhead to different types of transit service, reducing carbon overhead is probably accomplished most effectively by looking at its individual components, regardless of the type of service they support.

Managing carbon overhead: Electricity

Reducing carbon overhead is probably accomplished most effectively by looking at its individual components.

Displacing purchased electricity by generating electricity from non-emitting technologies, such as photovoltaic panels, is attractive from a public-relations perspective, and it may be cost-effective in some settings. Less glamorous but often more cost-effective measures include electric end-use efficiency. Such measures include installing cooling, lighting, and other equipment that requires less electricity to accomplish its task; requiring such improvements from service contractors (such as vending-machine services in cafeterias or break areas); use of day-lighting to reduce the need for indoor lighting; installing insulation, weather-stripping, and improved windows to reduce space heating and cooling requirements; and installing outdoor lighting fixtures that direct light where it is needed rather than allowing it to radiate to areas that do not require artificial light. Use of more efficient lighting, cooling, and heating can reduce life-cycle costs as well as electricity use and its associated emissions.

Managing carbon overhead: Non-revenue vehicles

Emissions from non-revenue vehicles may be more difficult to manage. In large agencies, many of these vehicles are large, specialized vehicles used in maintenance. Agencies may have few choices in acquiring or using these vehicles, although they may have more options about the type of fuel used in these vehicles; either CNG or biofuels would reduce emissions of CO_2 from fossil sources. For more general-purpose

vehicles, options exist to replace old vehicles with more fuel-efficient ones, and to schedule the use of general purpose vehicles to favor use of the more efficient ones when possible. Training vehicle operators in efficient vehicle operation can reduce fuel consumption, although this may require refresher courses and motivational tools to maintain efficient driving behavior.

Managing carbon overhead: Refrigerants

The first step for an organization that wants to reduce its emissions is to understand where its emissions come from.

One agency indicated that it has reduced refrigerant losses by adopting a more aggressive maintenance program to prevent, identify, and repair leaks. Intuitively, this is a reasonable strategy, but research may be needed to measure its effectiveness and cost. Another strategy is to consider refrigerant losses when acquiring equipment or refitting existing equipment. The refrigerants in most common use by transit agencies have very high GWPs, with one pound of refrigerant equivalent to 1,300 or 1,500 pounds of CO_2. Other refrigerants have much lower GWPs, although some may require use of equipment that needs more energy to operate, and some may present toxicity or other hazards if released by a vehicle crash. Air-conditioning equipment in different applications—buildings, buses, trains, and cars—may require different strategies for reducing emissions, both because of how the compressor is powered, and because of vibrations and other aspects of the equipment's operating environment.

Conclusion

Public transportation agencies that provided data to the CBT II study now have information showing that vehicle operations account for only 70 to 95 percent of their carbon footprints, and some understanding that other activities can be important contributors to their footprints.

Public transportation agencies in Florida account for less than 1 percent of the state's transportation carbon footprint. The CBT I study examined how these agencies could help reduce the state's transportation carbon footprint, by providing service that encourages people to ride public transportation instead of driving.

CBT II has examined transportation emissions from a different perspective, focusing on public transportation agencies own emissions. Options exist for any individual or organization to reduce its carbon footprint. The first step for an organization that wants to reduce its emissions is to understand where its emissions come from. In the case of public transportation, the obvious source is the consumption of fossil fuels to provide bus, rail, paratransit, and vanpool services. However, Public transportation agencies that provided reasonably complete data to the CBT II study now have information showing that these vehicle operations account for only 70 to 95 percent of their carbon footprints, and agencies that provided incomplete data have some understanding that other activities can be important contributors to their footprints. All of the agencies that participated will have a spreadsheet that they can use to update their future carbon footprints, to monitor change and to monitor the effects of any efforts they make to reduce

emissions. Agencies that choose to monitor and reduce their footprints will be better able to respond to any future policies that require them to report or reduce their emissions.

References

[1] The Climate Registry (2008). *General Reporting Protocol v. 1.1*, May, 2008, accessed March 2011 at http://www.theclimateregistry.org/downloads/GRP.pdf

[2] Melanie Simmons, Harrison Higgins, and Paul Ruscher (2009). *Conserve by Transit: Analysis of the Energy Consumption and Climate Benefits of Transit*, Tallahassee: Florida State University Center for Demography and Population Health. Accessed February 2011 at http://www.dot.state.fl.us/transit/Pages/ConservebyTransitFinalReport.pdf

[3] Center for Climate Strategies (2008). *Florida's Energy and Climate Change Action Plan*, October 15,2008, accessed March 2011 at http://www.flclimatechange.us/ewebeditpro/items/O12F20127.pdf

[4] American Public Transportation Association (2009). *Quantifying Greenhouse Gas Emissions from Transit*, August 14, 2009, APTA SUDS-CC-RP-001-09, accessed March 2011 at http://www.aptastandards.com/Portals/0/SUDS/SUDSPublished/APTA_Climate_Change_Final_new.pdf

[5] The Climate Registry (2010). *2010 Climate Registry Default Emission Factors*, released January 5, 2010, with updates of March 29, 2010, accessed March, 2011 at http://www.theclimateregistry.org/downloads/2010/08/Default-Emissions-Factors.xls

[6] Brent Weigel, Frank Southworth, and Michael Meyer (2010). "Calculators to Estimate Greenhouse Gas Emissions from Public Transit Vehicles," *Transportation Research Record* 2143, accessed at http://trb.metapress.com/content/h256h1n6h4n35011/fulltext.pdf

[7] IPCC (2007). *Fourth Assessment: Changes in Atmospheric Constituents and in Radiative Forcing*, Table 2.14, p. 213, accessed March, 2011 at http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter2.pdf

[8] Volusia County MPO (2010). *Integrated Sustainability Implementation Plan (Final)*, August 3, 2010, accessed April, 2011 at http://www.volusia.org/votran/Sustainability.pdf

[9] USEPA (2005). *Greenhouse Gas Emissions from a Typical Passenger Vehicle*, February, 2005, EPA420-F-05-004, accessed March, 2011 at http://www.epa.gov/otaq/climate/420f05004.pdf

[10] City of Key West (2010). *Key West Transit Development Plan 2010-2019,* Table 2-14. Key West: Key West Department of Transportation, accessed March 2011 at http://www.keywestcity.com/docs/transportation/20102019TDPFINALREPORT.pdf

[11] Mark DeLucchi (1996). *Emissions of Criteria Pollutants, Toxic Air Pollutants, and Greenhouse Gases, from the Use of Alternative Transportation Modes and Fuels*, Table 42, p. 142. Report UCD-ITS-RR-96-12, Davis, CA, University of California—Davis, accessed March, 2011 at http://www.uctc.net/papers/344.pdf

[12] No author (2009). *Example of Vehicles with GVWR between 8,500 and 10,000 lbs*, accessed March 2011 at http://www.fueleconomy.gov/feg/pdfs/Cat3VehicleList.pdf

[13] No author (2010). *Examples of 1984-2010 Model Year Vehicles with Gross Vehicle Weight Rating (GVWR) Greater than 8,500 lbs. and Less than or Equal to 10,000 lbs*, accessed March 2011 at http://www.fueleconomy.gov/feg/pdfs/HeavyTrucks081409.pdf

[14] William D. Sanders (2005). *Annual Depreciation Limits and Gross Vehicle Weight Ratings for Trucks, Vans & Sport Utility Vehicles,* accessed March 2011 at http://www.hoffmanwhite.com/Articles/GVWR%20Vehicle%20Listings.pdf

[15] USEPA (2009). *Climate Leaders: Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobile Combustion Sources*. Washington, DC: US Environmental Protection Agency,

Office of Air and Radiation, accessed March 2011 at http://www.epa.gov/climateleaders/documents/resources/mobilesource_guidance.pdf

[16] Florida Enrolled House Bill 7135 (2008), accessed March, 2011 at http://www.myfloridahouse.gov/Sections/Documents/loaddoc.aspx?FileName=_h7135er.xml&DocumentType=Bill&BillNumber=7135&Session=2008

Appendix A: Carbon Footprints for Individual Public Transportation Agencies—Complete or Negligible Omissions

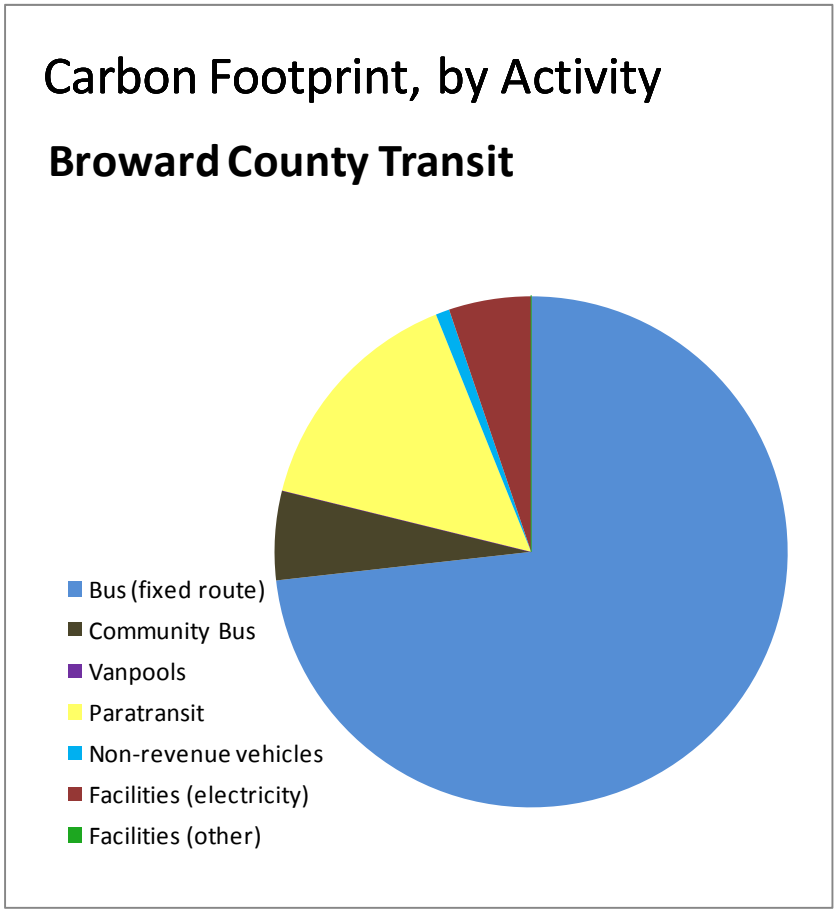
The agencies in this appendix provided either complete carbon footprint data or, based on the results from those that did, omitted data that are unlikely to increase their footprint by more than 1-2 percent. In the case of SFRTA, the agency submitted data that *over*estimates its carbon footprint, probably by no more than this range.

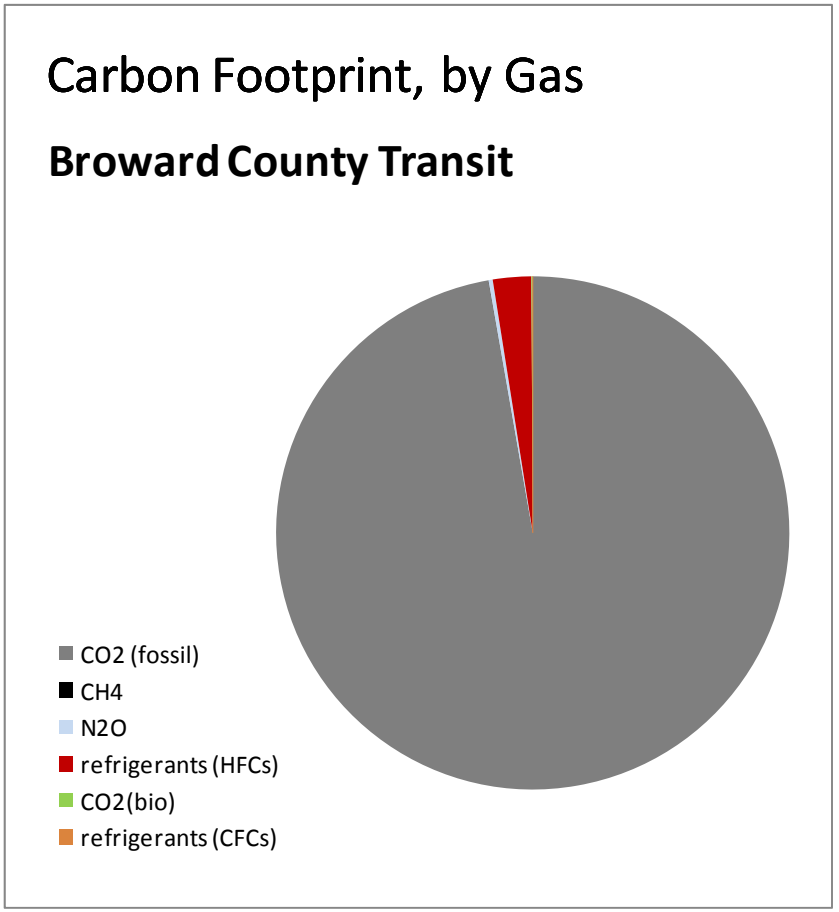
Although the total footprints for these agencies are complete or reasonably complete, they contain varying levels of detail. For example, Community Coach provided fuel use and refrigerant losses as totals for all of its services, rather than reporting values from its fixed-route service separately from its paratransit service. This was easier for them, and the focus on collecting the data was to get each agency's total footprint with as much detail as it was willing to provide. Except for HART and MCAT, the agencies listed in this appendix provided total refrigerant losses without separating them by type of service, or distinguishing between revenue and non-revenue vehicles. Most agencies provided a single total for non-motive electricity use, but any use for moving vehicles was reported separately from non-motive uses. Several provided additional detail for non-motive uses, but the ability to do so depended on which facilities have their own electric meters, and the categories vary too widely to be summarized.

The amount of refrigerant losses that TCC provided appears very high for a small agency. These agencies advised that the amount they reported represents actual losses, and they attribute much of it to equipment failure during servicing of vehicle air-conditioning units. They reported a small amount of CNG used in their facility. They reported this as gallons, which is not adequate for estimating emissions. The calculations for their footprint use a very conservative estimate that is still is less than 0.1 percent of their total footprint.

As noted in the main report, SFRTA reported data for refrigerant losses that are too large, but that bound the size of these losses at no more than five percent of the agency's total footprint. Their footprint summary includes the data they reported on refrigerant losses as very a conservative estimate of the actual losses.

Items highlighted in gray in the summary tables are missing or not fully resolved (in some cases, not resolvable given present recordkeeping). Many of these items do not affect the total size of the agency's carbon footprint but rather the allocation of emissions among different activities.


Carbon Footprint, by Activity
Broward County Transit
Bus (fixed route)
Community Bus
Vanpools
Paratransit
Non-revenue vehicles
Facilities (electricity)
Facilities (other)

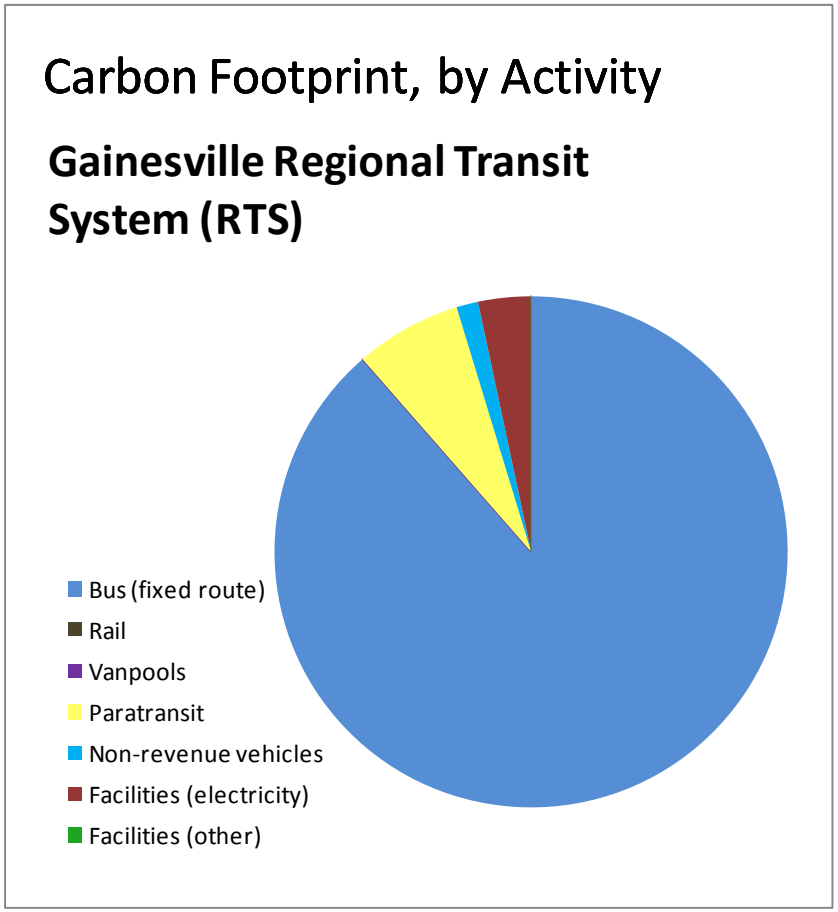

Carbon Footprint, by Gas
Broward County Transit
CO2 (fossil)
CH4
N2O
refrigerants (HFCs)
CO2(bio)
refrigerants (CFCs)

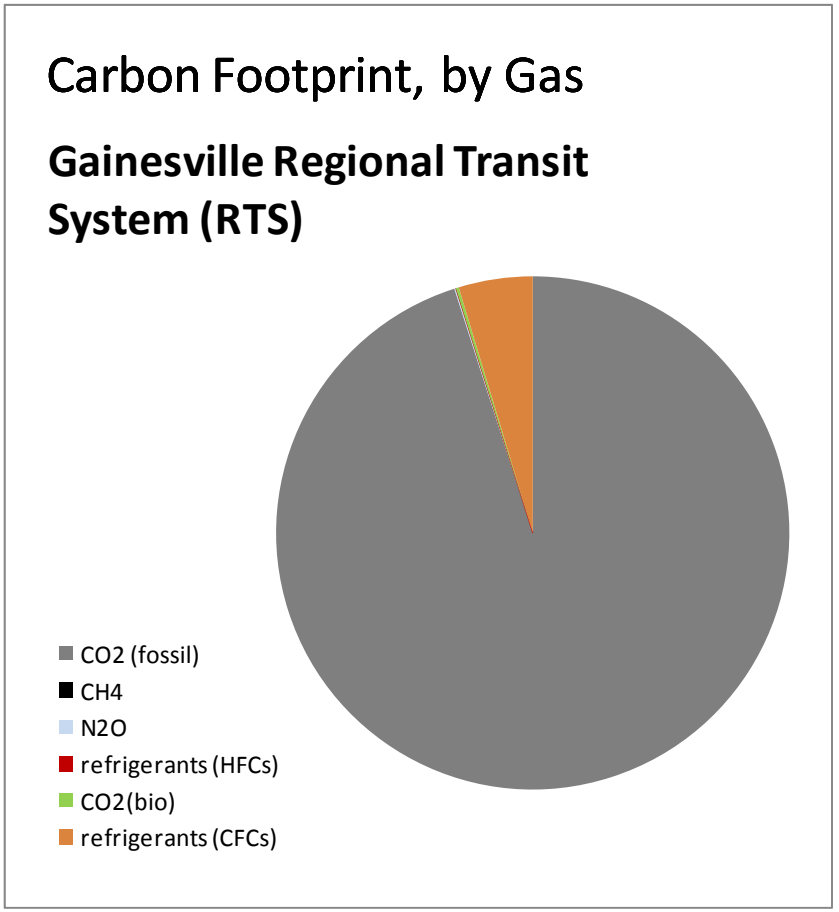
Carbon Footprint for Broward County Transit

ACTIVITY GAS → ↓	CO_2 (fossil)* kg	CH_4 kg	N_2O kg	refrigerants (HFCs) kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	44,980,717	79	75	1,534,049	0	0	46,539,561	73.22%
Community bus	3,494,074	40	58	0	54,887	0	3,567,782	5.61%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit	9,484,998	351	328	0	0	0	9,593,986	15.09%
Non-revenue vehicles*	547,719	41	25	0	0	0	556,198	0.88%
Facilities (electricity)	3,286,861	114	42	N/A	N/A	N/A	3,302,355	5.20%
Facilities (other)*	0	0	0	0	0	0	0	0.00%
							Total	
Total, by gas, kg CO_2(e)	61,794,368	13,141	163,436	1,534,049	54,887	0	**63,559,882**	in kg CO_2(e)
% by gas	97.22%	0.02%	0.26%	2.41%	0.09%	0.00%	**63,560**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- CO_2 from fuel use for a few diesel non-revenue vehicles is included in fixed route bus total; total CO_2 is correct.
- Agency has small amount of non-electric heat in maintenance facilities; much work to collect data, likely *de minimis*.
- Agency reported one total for all refrigerant use, listed here as fixed route bus.


Carbon Footprint, by Activity
Gainesville Regional Transit System (RTS)
Bus (fixed route)
Rail
Vanpools
Paratransit
Non-revenue vehicles
Facilities (electricity)
Facilities (other)

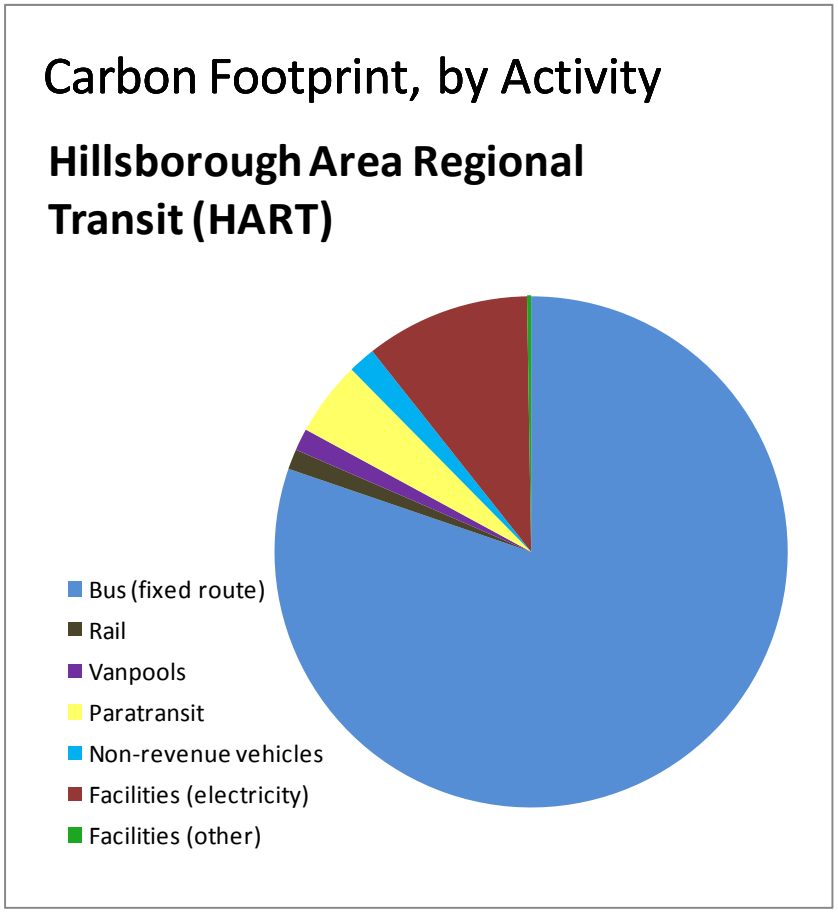

Carbon Footprint, by Gas
Gainesville Regional Transit System (RTS)
CO2 (fossil)
CH4
N2O
refrigerants (HFCs)
CO2(bio)
refrigerants (CFCs)

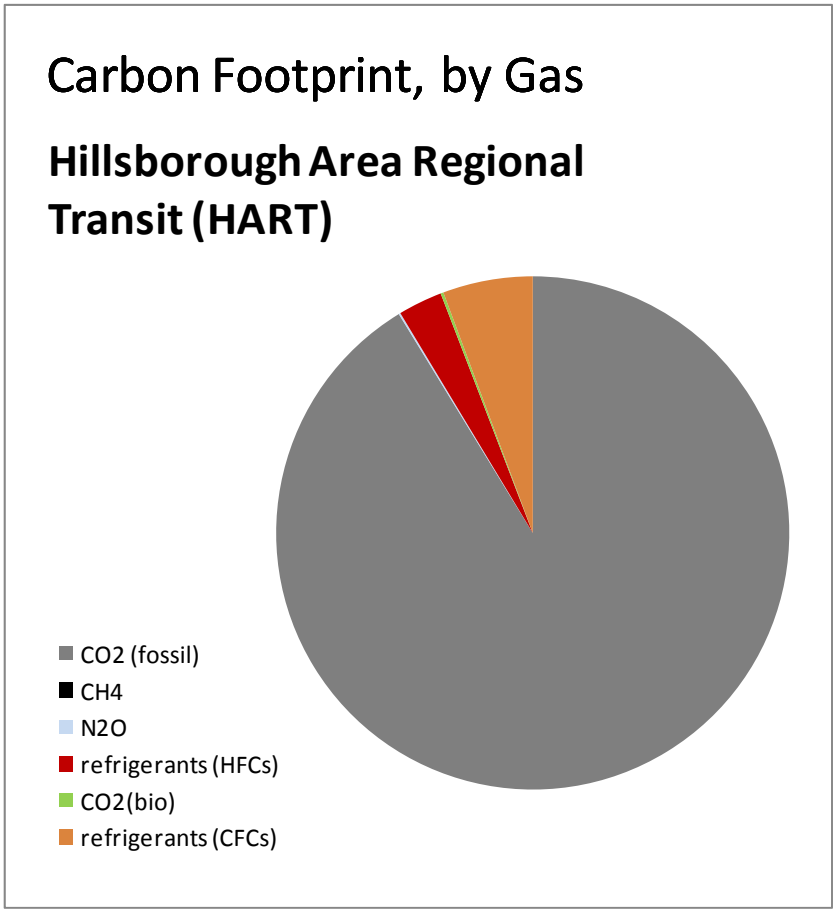
Carbon Footprint for Gainesville Regional Transit System (RTS)

ACTIVITY GAS → ↓	CO_2 (fossil) kg	CH_4 kg	N_2O kg	refrigerants (HFCs) kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	8,692,079	15	14	0	19,845	483,756	9,200,263	88.55%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit	696,675	22	12	0	0	0	700,882	6.75%
Non-revenue vehicles	140,550	3	4	0	0	0	141,722	1.36%
Facilities (electricity)	345,199	12	4	N/A	N/A	N/A	346,826	3.34%
Facilities (other)*	0	0	0	0	0	0	0	0.00%
							Total	
Total, by gas, kg CO_2(e)	9,874,503	1,096	10,492	0	19,845	483,756	**10,389,693**	in kg CO_2(e)
% by gas	95.04%	0.01%	0.10%	0.00%	0.19%	4.66%	**10,390**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- No data on heating or groundskeeping.


Carbon Footprint, by Activity
Hillsborough Area Regional Transit (HART)
Bus (fixed route)
Rail
Vanpools
Paratransit
Non-revenue vehicles
Facilities (electricity)
Facilities (other)

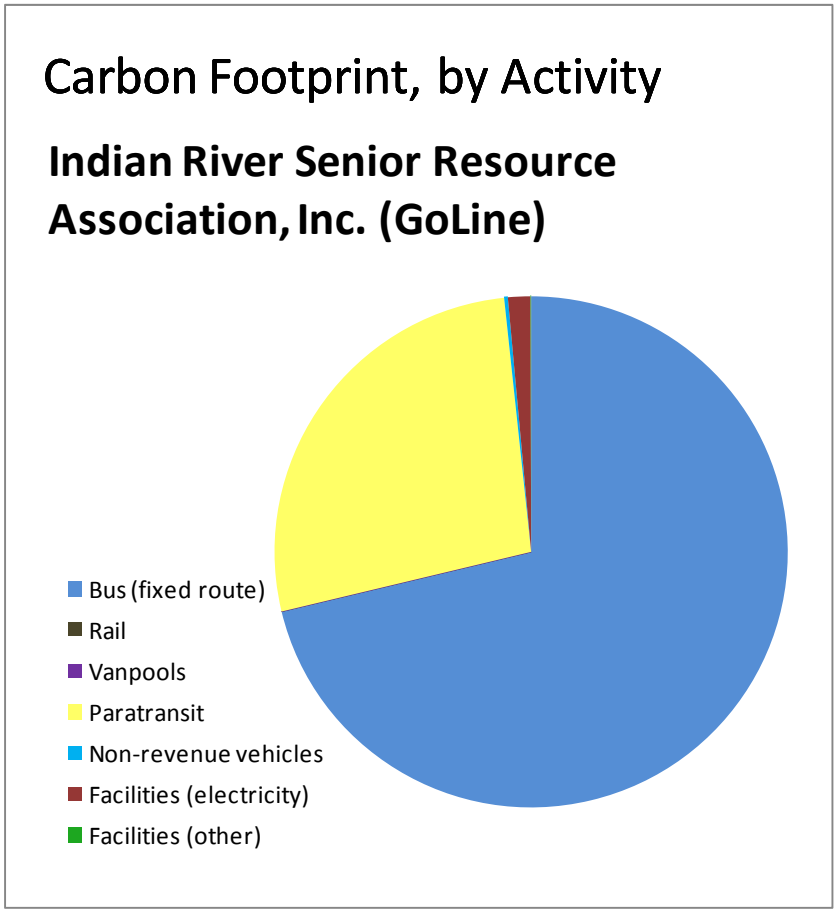

Carbon Footprint, by Gas
Hillsborough Area Regional Transit (HART)
CO2 (fossil)
CH4
N2O
refrigerants (HFCs)
CO2(bio)
refrigerants (CFCs)

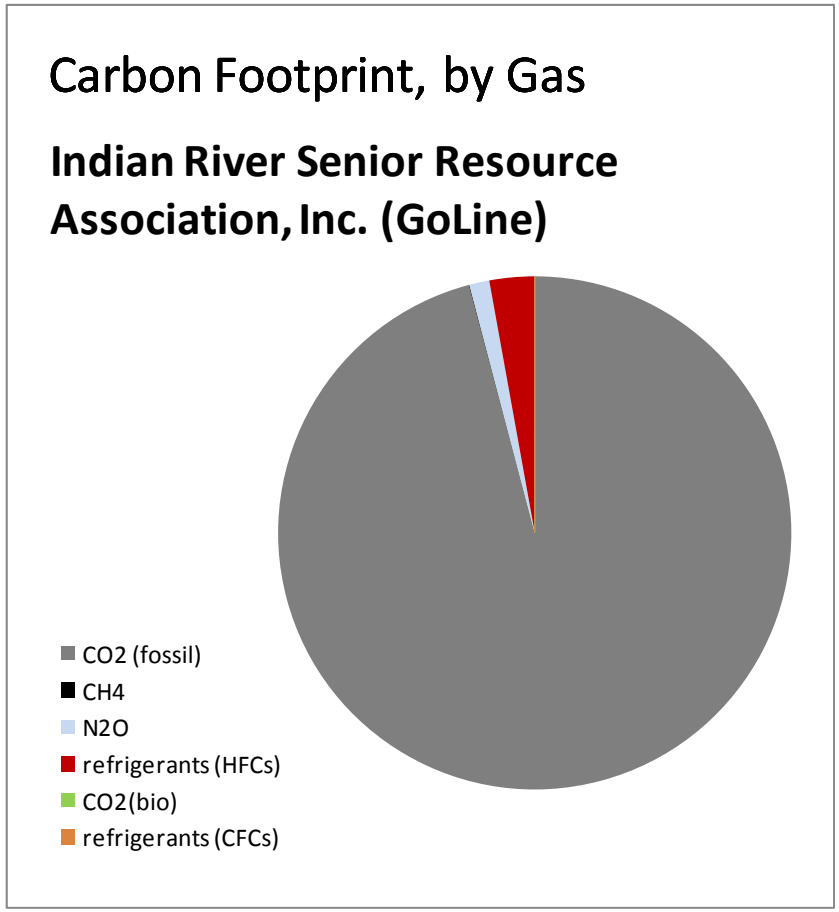
Carbon Footprint for Hillsborough Area Regional Transit (HART)

ACTIVITY GAS → ↓	CO_2 (fossil) kg	CH_4 kg	N_2O kg	refrigerants (HFCs) kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	20,754,469	44	41	793,787	0	1,623,407	23,185,443	80.24%
Rail	366,840	13	5	0	0		36,569	1.28%
Vanpool	372,105	10	6	2,268	27,077	0	403,361	1.40%
Paratransit	1,351,018	6	6	7,257	0	0	1,360,210	4.71%
Non-revenue vehicles	467,931	12	7	3,175	22,758	0	496,201	1.72%
Facilities (electricity)	2,991,724	104	38	N/A	N/A	N/A	3,005,827	10.40%
Facilities (other)	59,804	3	2	0	278	13,608	74,490	0.26%
							Total	
Total, by gas, kg CO_2(e)	26,363,891	4,017	32,579	806,487	50,112	1,637,015	**28,894,102**	in kg CO_2(e)
% by gas	91.24%	0.01%	0.11%	2.79%	0.17%	5.67%	**28,894**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Refrigerants reported for fixed-route bus may include some from paratransit and rail; totals for refrigerants are correct.


Carbon Footprint, by Activity
Indian River Senior Resource Association, Inc. (GoLine)
Bus (fixed route)
Rail
Vanpools
Paratransit
Non-revenue vehicles
Facilities (electricity)
Facilities (other)


Carbon Footprint, by Gas
Indian River Senior Resource Association, Inc. (GoLine)
CO2 (fossil)
CH4
N2O
refrigerants (HFCs)
CO2(bio)
refrigerants (CFCs)

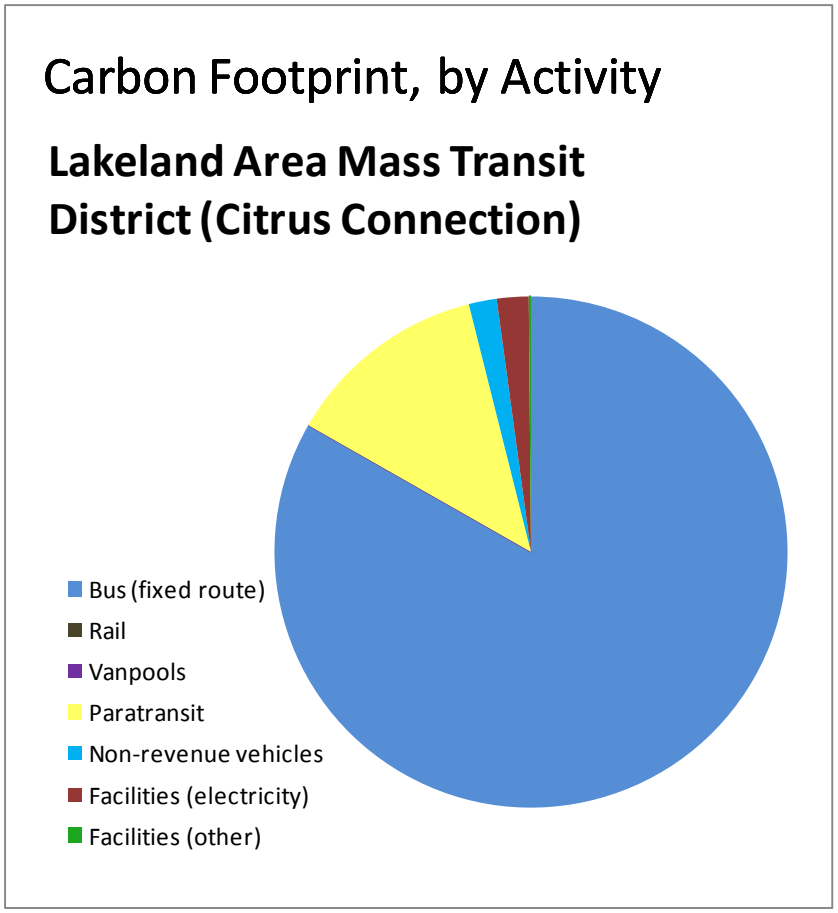
Carbon Footprint for Indian River Senior Resource Association, Inc. (GoLine)

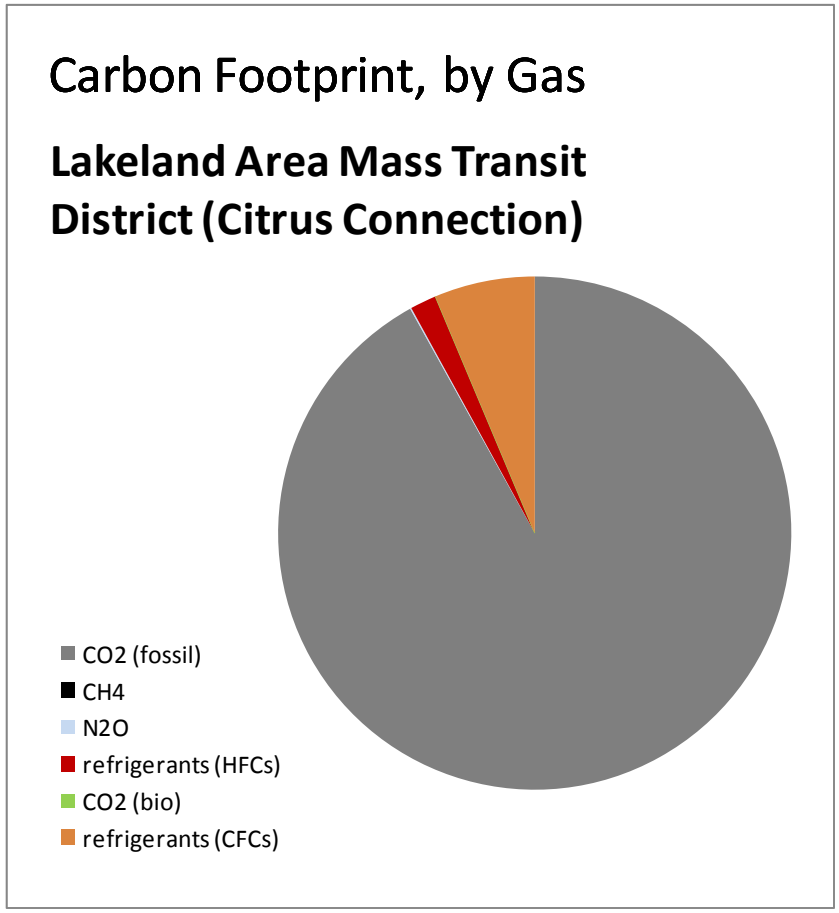
ACTIVITY GAS → ↓		CO_2 (fossil) kg	CH_4 kg	N_2O kg	refrigerants (HFCs) kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)		891,068	3	3	37,031	0	0	928,999	71.27%
Rail	0	0	0	0	0	0	0	0.00%	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%	0.00%
Paratransit		336,648	22	50	0	0	0	352,619	27.05%
Non-revenue vehicles		3,029	0	0	0	0	0	3,057	0.23%
Facilities (electricity)		18,381	1	0	N/A	N/A	N/A	18,468	1.42%
Facilities (other)		421	0	0	0	0	0	423	0.03%
								Total	
Total, by gas, kg CO_2(e)		1,249,548	532	16,456	37,031	0	0	**1,303,567**	in kg CO_2(e)
% by gas		95.86%	0.04%	1.26%	2.84%	0.00%	**1,304**	**1,304**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Provided range of model years and total miles for paratransit; if provided miles by year, CH_4 and N_2O would be lower.
- Provided one total for refrigerants, all refrigerants reported here as fixed-route bus.

A5: Summary for Lakeland Area Mass Transit District (Citrus Connection)





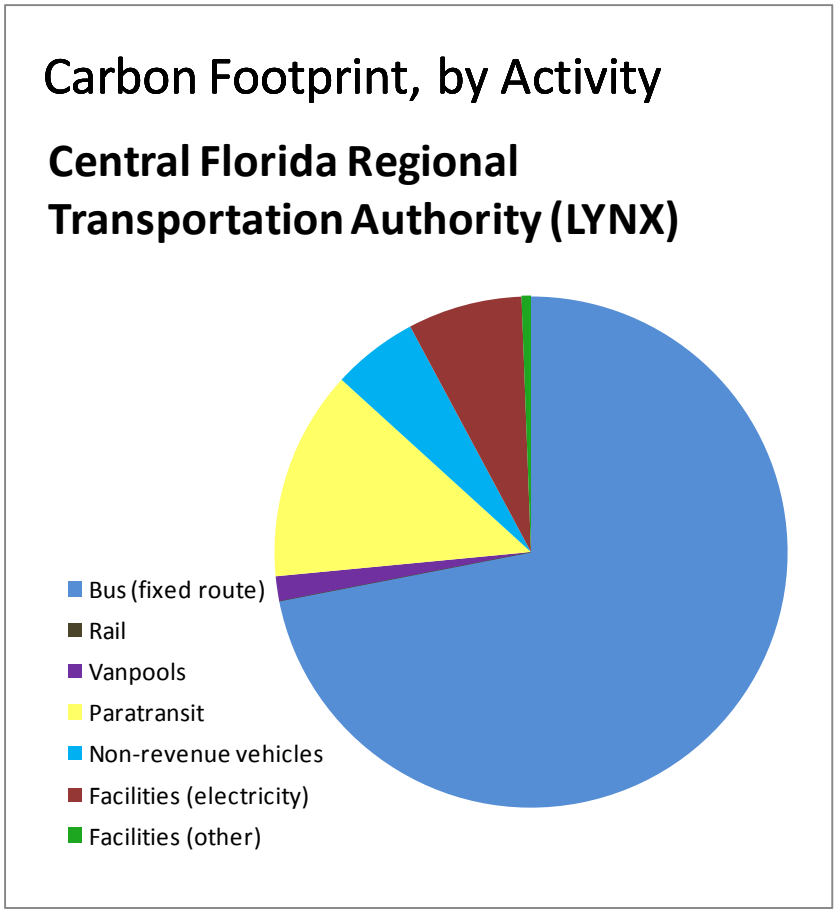
Carbon Footprint for Lakeland Area Mass Transit District (Citrus Connection)

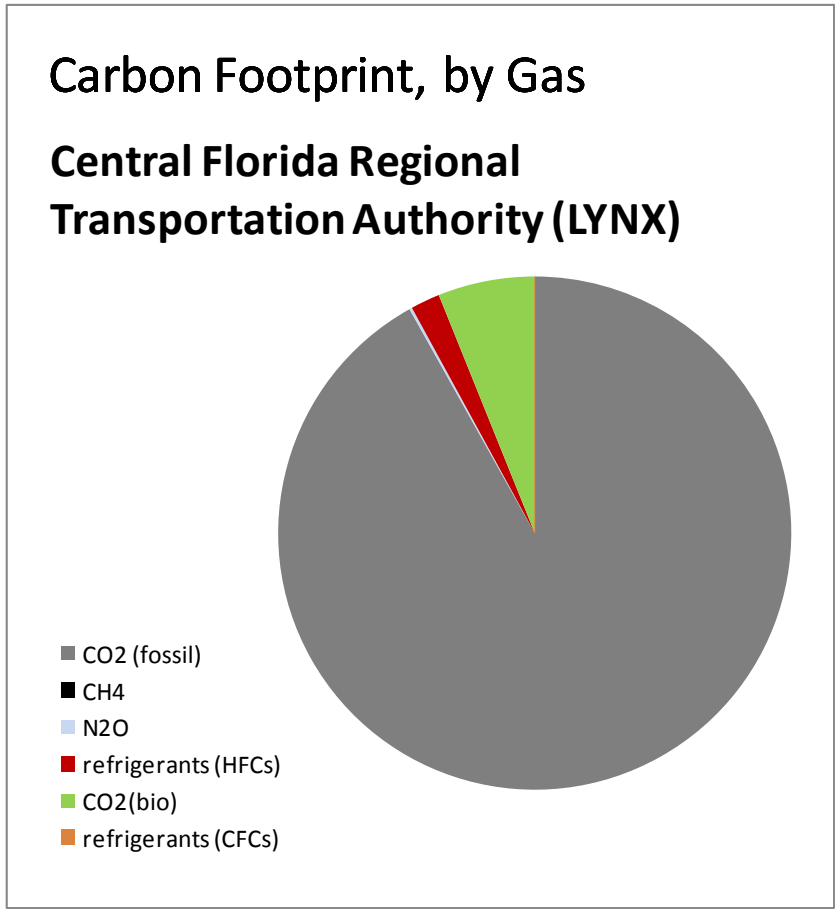
ACTIVITY GAS → ↓	CO_2 (fossil) kg	CH_4 kg	N_2O kg	refrigerants (HFCs) kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	4,037,003	7	7	88,451	0	340,194	4,467,852	83.23%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit	689,185	2	2	0	0	0	689,903	12.85%
Non-revenue vehicles	93,177	4	5	0	0	0	94,736	1.76%
Facilities (electricity)	107,261	4	1	N/A	N/A	N/A	107,766	2.01%
Facilities (other)	7,658	0	0	0	0	0	7,727	0.14%
							Total	
Total, by gas, kg CO_2(e)	4,934,284	362	4,694	88,451	0	340,194	**5,367,984**	in kg CO_2(e)
% by gas	91.92%	0.01%	0.09%	1.65%	0.00%	6.34%	**5,368**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Refrigerants not separated by activity; total reported is listed under fixed route bus.

A6: Summary for Central Florida Regional Transportation Authority (LYNX)





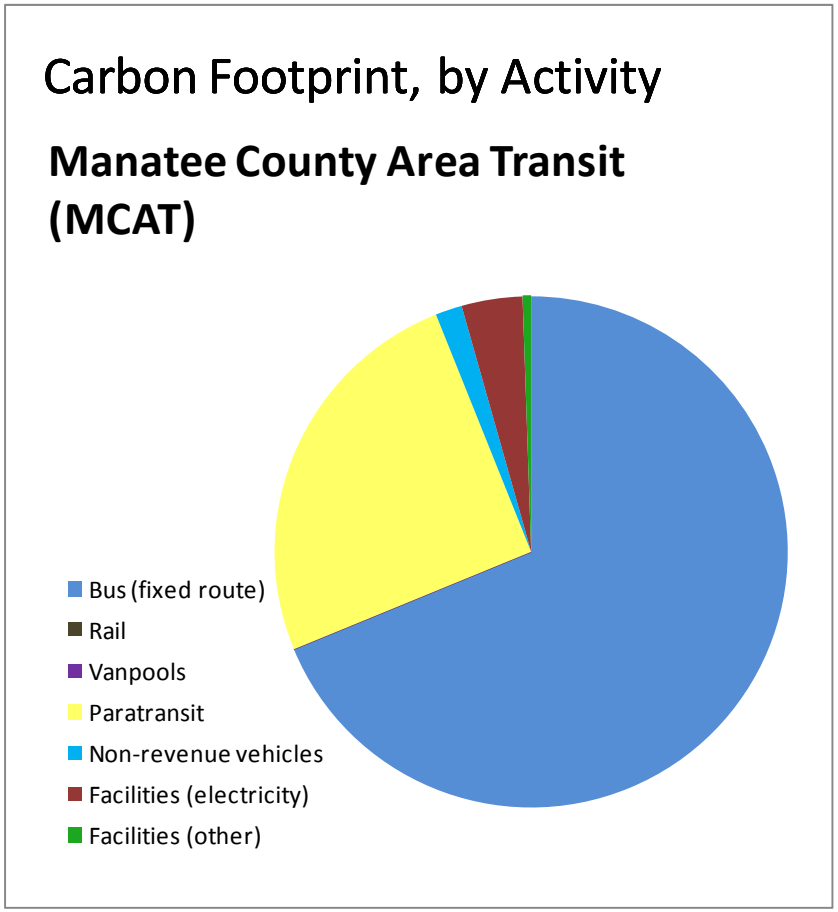
Carbon Footprint for Central Florida Regional Transportation Authority (LYNX)

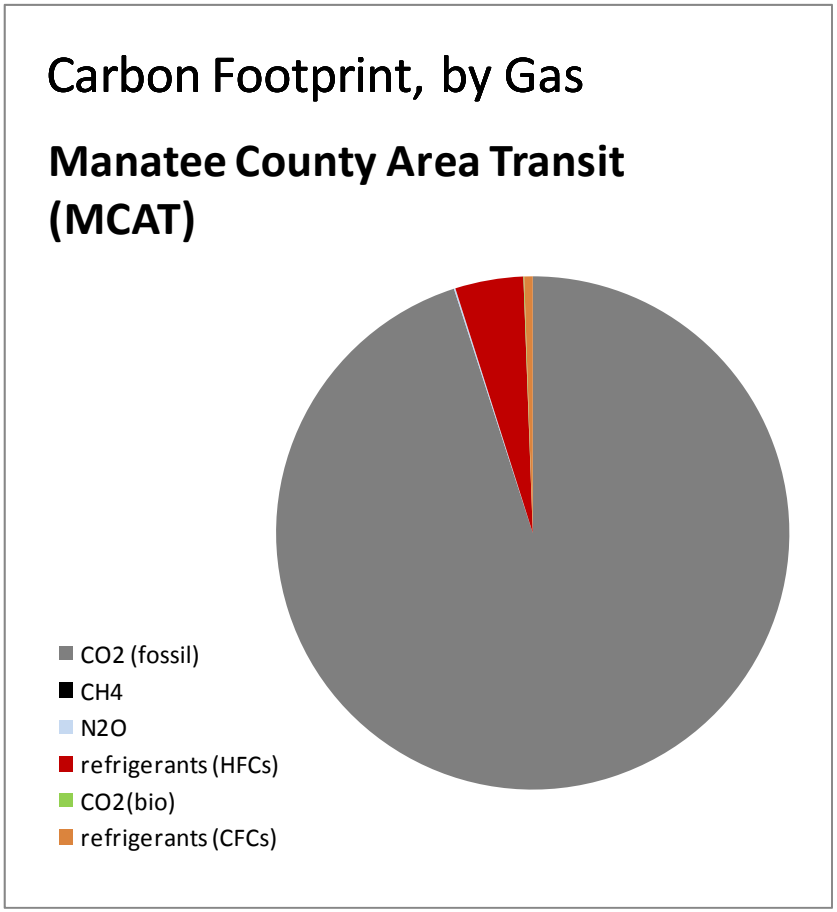
ACTIVITY GAS → ↓	CO_2 (fossil) kg	CH_4 kg	N_2O kg	refrigerants (HFCs) kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	36,027,288	84	79	1,040,414	3,435,929		40,529,942	71.95%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	857,630	38	23	0	0	0	865,413	1.54%
Paratransit	7,417,247	290	160	0	0	0	7,472,990	13.27%
Non-revenue vehicles	3,048,091	18	21	0	0	0	3,054,954	5.42%
Facilities (electricity)	4,055,892	141	52	N/A	N/A	N/A	4,075,011	7.23%
Facilities (other)	332,371	32	1	0	0	0	333,232	0.59%
							Total	
Total, by gas, kg CO_2(e)	51,738,519	12,648	104,033	1,040,414	3,435,929	0	**56,331,543**	in kg CO_2(e)
% by gas	91.85%	0.02%	0.18%	1.85%	6.10%	0.00%	**56,332**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Agency purchases B99 and blends it with petrodiesel; resulting blend has varied.
- Agency did not provide breakout of refrigerants by activity; all allocated to fixed bus service.
- CO_2 from biological sources used in both fixed-route bus and vanpool service, not separable in data; total recorded here as fixed-route bus.

A7: Summary for Manatee County Area Transit (MCAT)





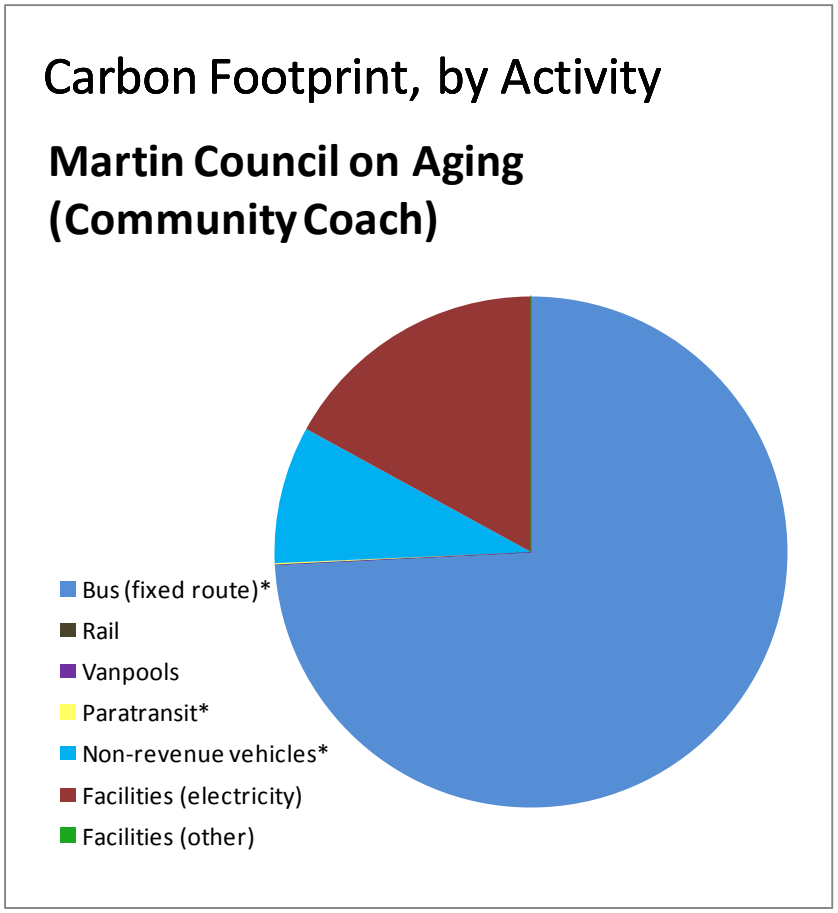
Carbon Footprint for Manatee County Area Transit (MCAT)

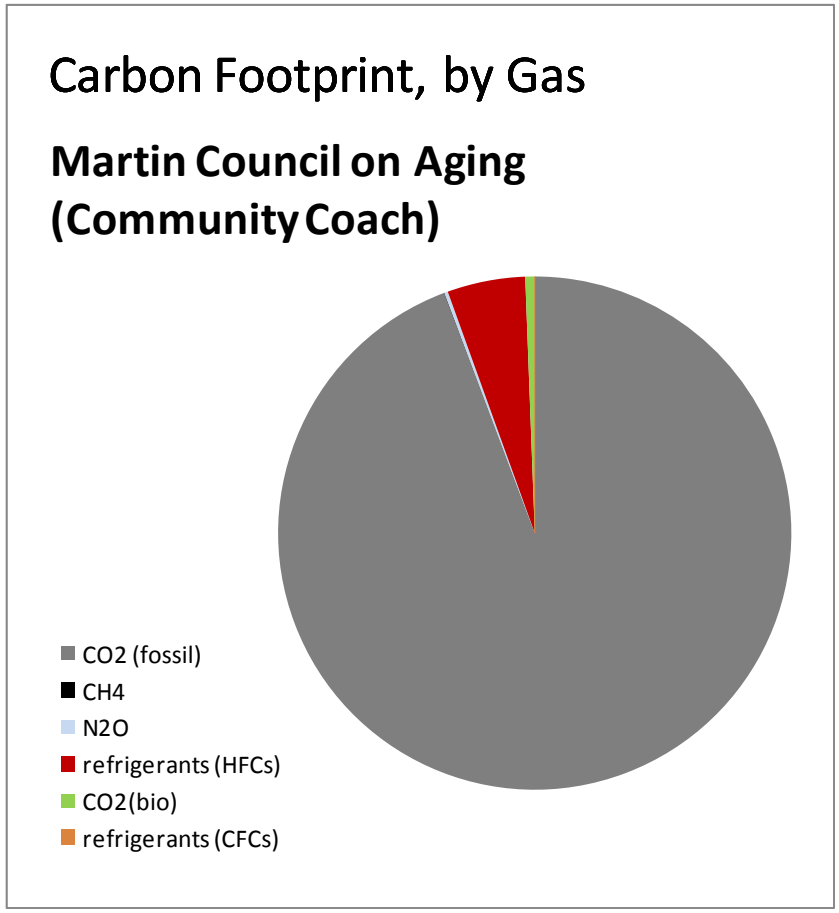
ACTIVITY GAS → ↓	CO_2 (fossil) kg	CH_4 kg	N_2O kg	refrigerants (HFCs) kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	2,716,684	7	6	90,809	0	0	2,809,574	68.79%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit	943,622	3	3	81,964	0	0	1,026,614	25.14%
Non-revenue vehicles	63,516	2	1	2,359	2,189	0	68,548	1.68%
Facilities (electricity)	156,861	5	2	N/A	N/A	N/A	157,600	3.86%
Facilities (other)*	0	0	0	0	0	21,687	21,687	0.53%
							Total	
Total, by gas, kg CO_2(e)	3,880,683	370	3,961	175,132	2,189	21,687	**4,084,023**	in kg CO_2(e)
% by gas	95.02%	0.01%	0.10%	4.29%	0.05%	0.53%	**4,084**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Gasoline for staff vehicles reported as "up to 10% ethanol," externally blended; assumed 5% or E5.
- No data on groundskeeping or heating.

A8: Summary for Martin Council on Aging (Community Coach)





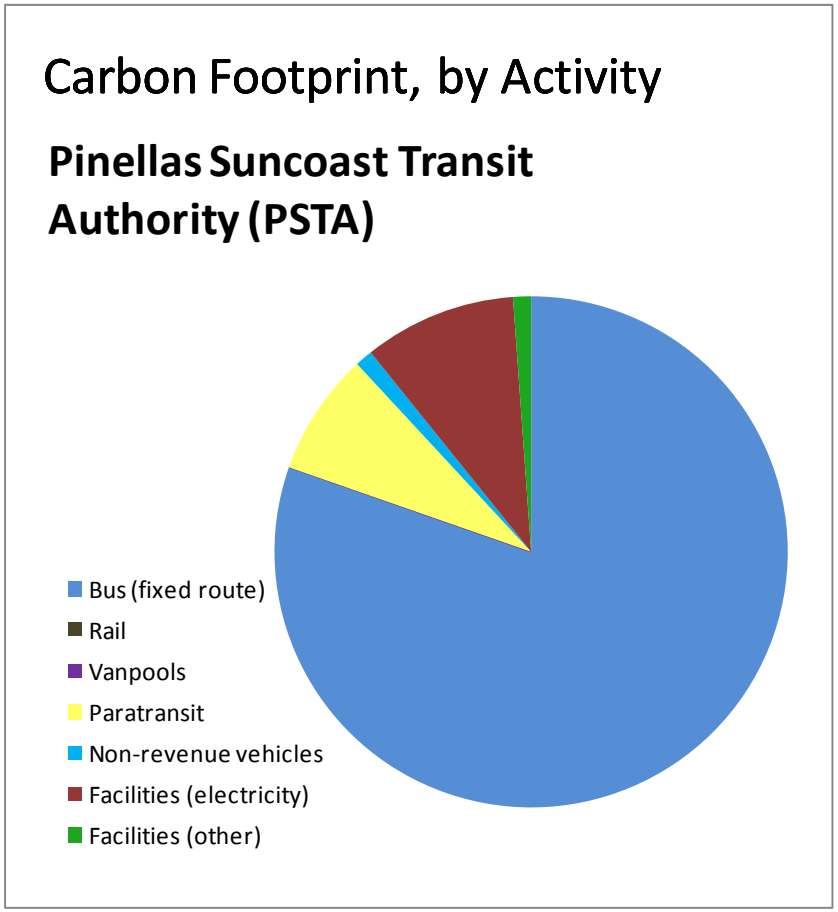
Carbon Footprint for Martin Council on Aging (Community Coach)

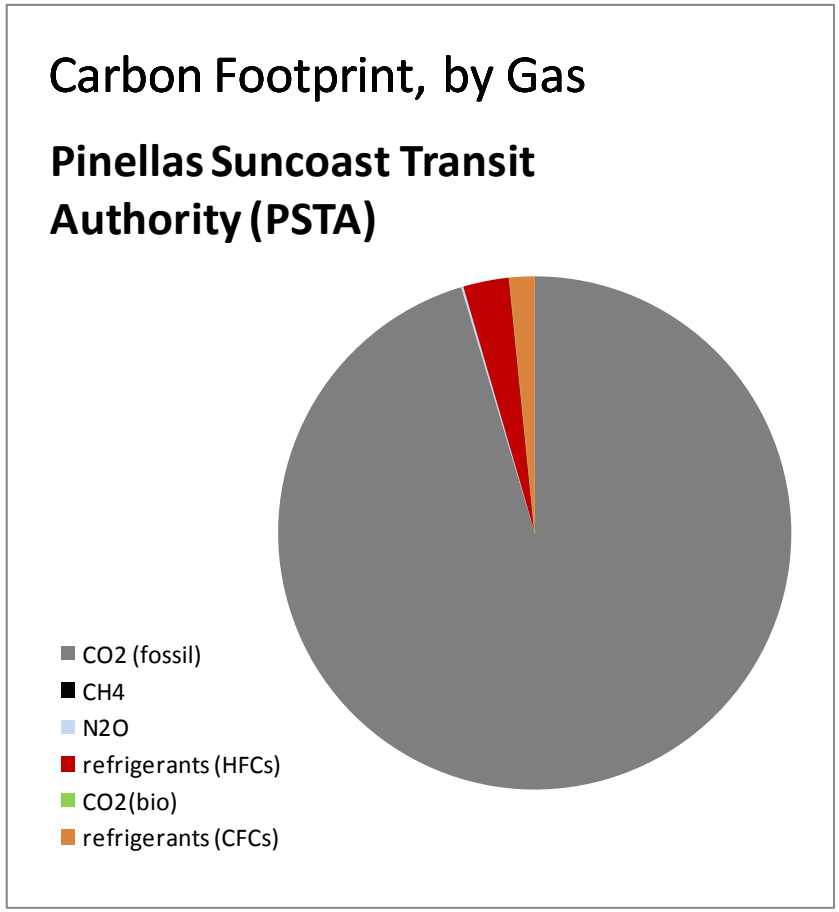
ACTIVITY GAS → ↓	CO_2 (fossil) kg	CH_4 kg	N_2O kg	refrigerants (HFCs) kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)*	249,150	1	1	17,690	0	0	267,079	74.22%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit*	0	1	1	0	0	0	307	0.09%
Non-revenue vehicles*	29,003	0	0	0	2,110	0	31,180	8.67%
Facilities (electricity)	60,982	2	1	N/A	N/A	N/A	61,269	17.03%
Facilities (other)	0	0	0	0	0	0	0	0.00%
							Total	
Total, by gas, kg CO_2(e)	339,134	89	812	17,690	2,110	0	**359,835**	in kg CO_2(e)
% by gas	94.80%	0.02%	0.23%	4.95%	0.59%	0.00%	**360**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Agency lists no gasoline-powered revenue vehicles; all gasoline reported here as non-revenue support vehicles.
- Agency reported total fuel and refrigerants combining both fixed-route and paratransit service, shown here as fixed route.
- Agency provided certificate of analysis showing gasoline with 10% ethanol, which is assumed to be of biological origin.

A9: Summary for Pinellas Suncoast Transit Authority (PSTA)



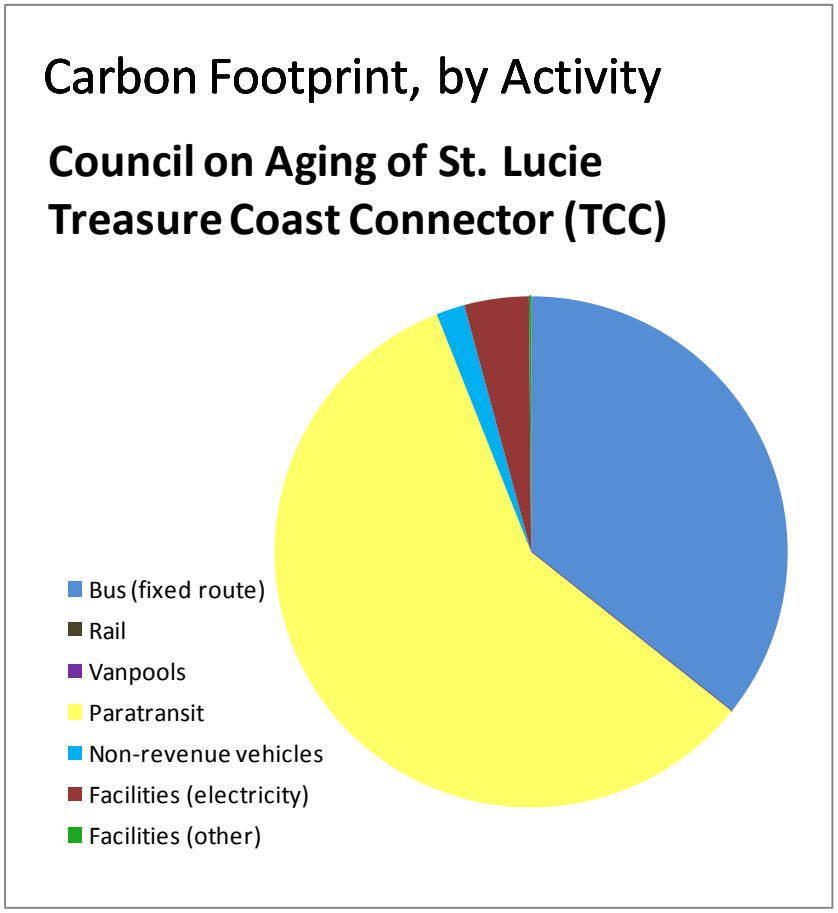


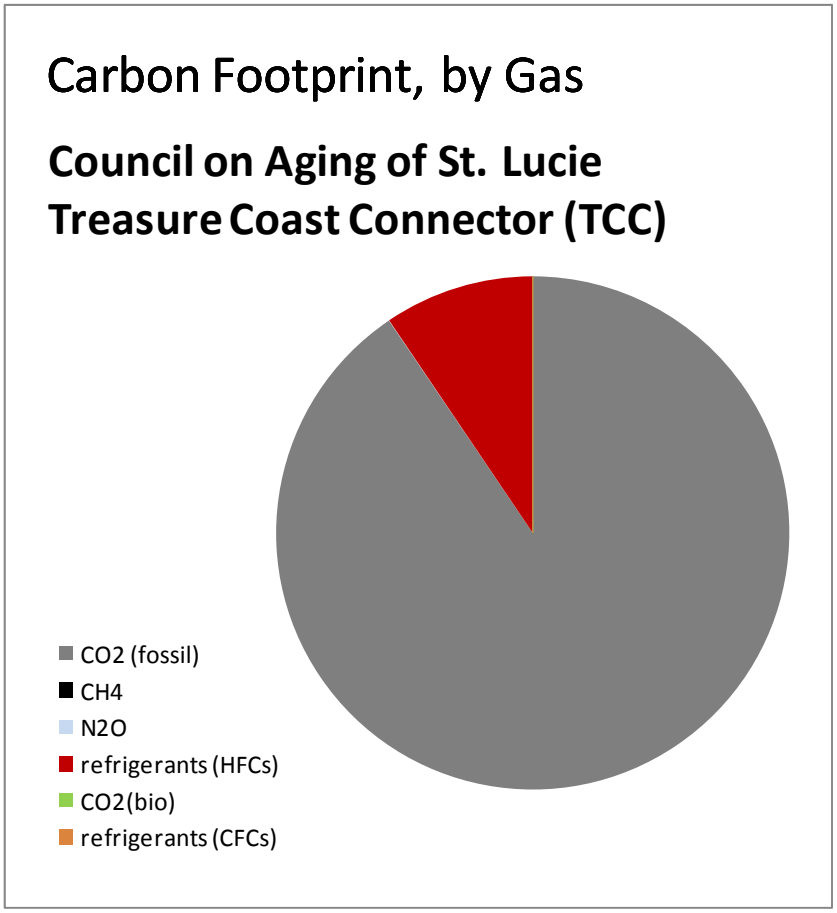
Carbon Footprint for Pinellas Suncoast Transit Authority (PSTA)

ACTIVITY GAS → ↓	CO_2 (fossil) kg	CH_4 kg	N_2O kg	refrigerants (HFCs) kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	24,768,337	50	47	951,750	0	517,095	26,252,796	80.35%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit	2,524,092	13	34	0	0	0	2,535,054	7.76%
Non-revenue vehicles	358,900	14	15	0	0	0	363,914	1.11%
Facilities (electricity)	3,137,230	109	40	N/A	N/A	N/A	3,152,019	9.65%
Facilities (other)	369,798	34	1	0	0	0	370,897	1.14%
							Total	
Total, by gas, kg CO_2(e)	31,158,357	4,633	42,843	951,750	0	517,095	**32,674,679**	in kg CO_2(e)
% by gas	95.36%	0.01%	0.13%	2.91%	0.00%	1.58%	**32,675**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Data on refrigerants provided as totals for all vehicles, reported here all as fixed-route bus.
- Agency operates some hybrid buses, estimated trace gases using standard coefficients per Climate Registry.


Carbon Footprint, by Activity
Council on Aging of St. Lucie Treasure Coast Connector (TCC)
Bus (fixed route)
Rail
Vanpools
Paratransit
Non-revenue vehicles
Facilities (electricity)
Facilities (other)

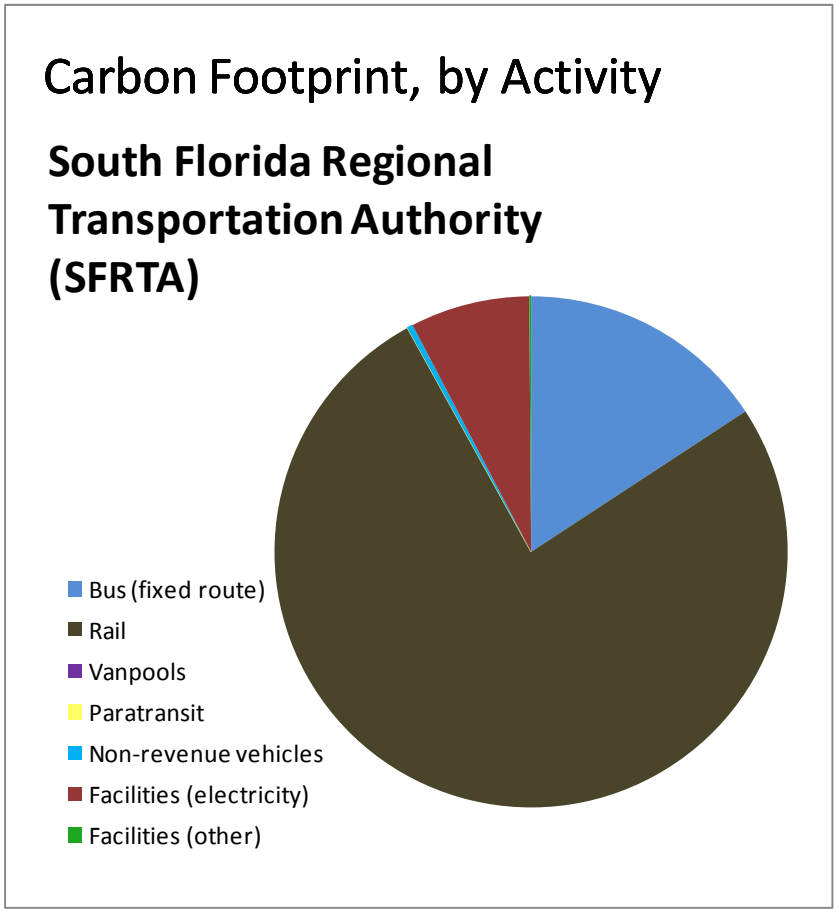

Carbon Footprint, by Gas
Council on Aging of St. Lucie Treasure Coast Connector (TCC)
CO2 (fossil)
CH4
N2O
refrigerants (HFCs)
CO2(bio)
refrigerants (CFCs)

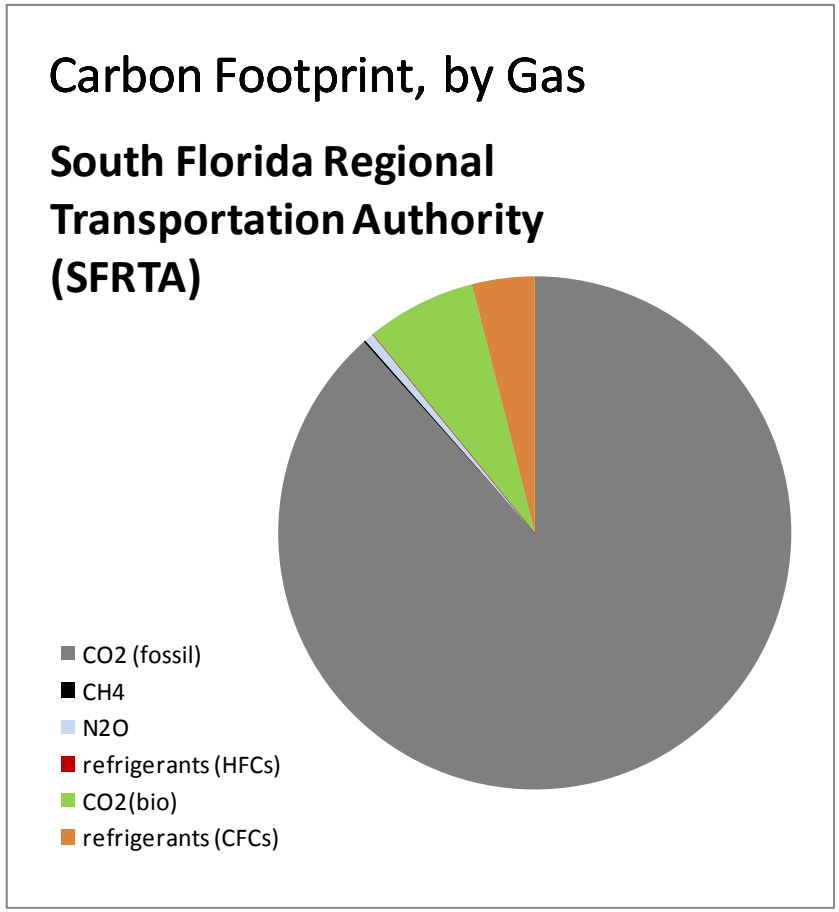
Carbon Footprint for Council on Aging of St. Lucie Treasure Coast Connector (TCC)

ACTIVITY ↓ GAS →	CO_2 (fossil) kg	CH_4 kg	N_2O kg	refrigerants (HFCs)* kg CO_2(e)	CO_2(bio) kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	408,400	0	0	147,418	0	0	555,818	35.67%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit	908,690	0	0	0	0	0	908,690	58.32%
Non-revenue vehicles	27,913	0	0	0	0	0	27,913	1.79%
Facilities (electricity)	63,398	2	1	N/A	N/A	N/A	63,697	4.09%
Facilities (other)*	2,042	0	0	0	0	0	2,061	0.13%
							Total	
Total, by gas, kg CO_2(e)	1,410,443	49	269	147,418	0	0	**1,558,178**	in kg CO_2(e)
% by gas	90.52%	0.00%	0.02%	9.46%	0.00%	0.00%	**1,558**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Agency reported one total for all refrigerants, shown here for fixed-route bus.
- Agency verified that refrigerants reported are losses, much resulting from equipment failure while servicing vehicle air-conditioners.
- Agency reported a small amount of CNG used in facilities, but did not report units; amount involved is conservatively less than 0.1% of total footprint.


Carbon Footprint, by Activity
South Florida Regional Transportation Authority (SFRTA)
Bus (fixed route)
Rail
Vanpools
Paratransit
Non-revenue vehicles
Facilities (electricity)
Facilities (other)


Carbon Footprint, by Gas
South Florida Regional Transportation Authority (SFRTA)
CO2 (fossil)
CH4
N2O
refrigerants (HFCs)
CO2(bio)
refrigerants (CFCs)

Carbon Footprint for South Florida Regional Transportation Authority (SFRTA)

ACTIVITY GAS → ↓	CO_2 (fossil) kg	CH_4 kg	N_2O kg	refrigerants (HFCs) kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs)* kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	5,615,265	3	3	0	0	0	5,616,315	15.77%
Rail*	23,050,488	2,015	655	0	2,468,676	1,372,350	27,136,853	76.19%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit	0	0	0	0	0	0	0	0.00%
Non-revenue vehicles	129,242	6	5	0	0	0	131,000	0.37%
Facilities (electricity)	2,678,054	93	34	N/A	N/A	N/A	2,690,678	7.55%
Facilities (other)	6,710	0	0	0	0	34,020	40,791	0.11%
							Total	
Total, by gas, kg CO_2(e)	31,479,759	44,479	216,352	0	2,468,676	1,406,370	**35,615,637**	in kg CO_2(e)
% by gas	88.39%	0.12%	0.61%	0.00%	6.93%	3.95%	**35,616**	in tonnes CO_2(e)

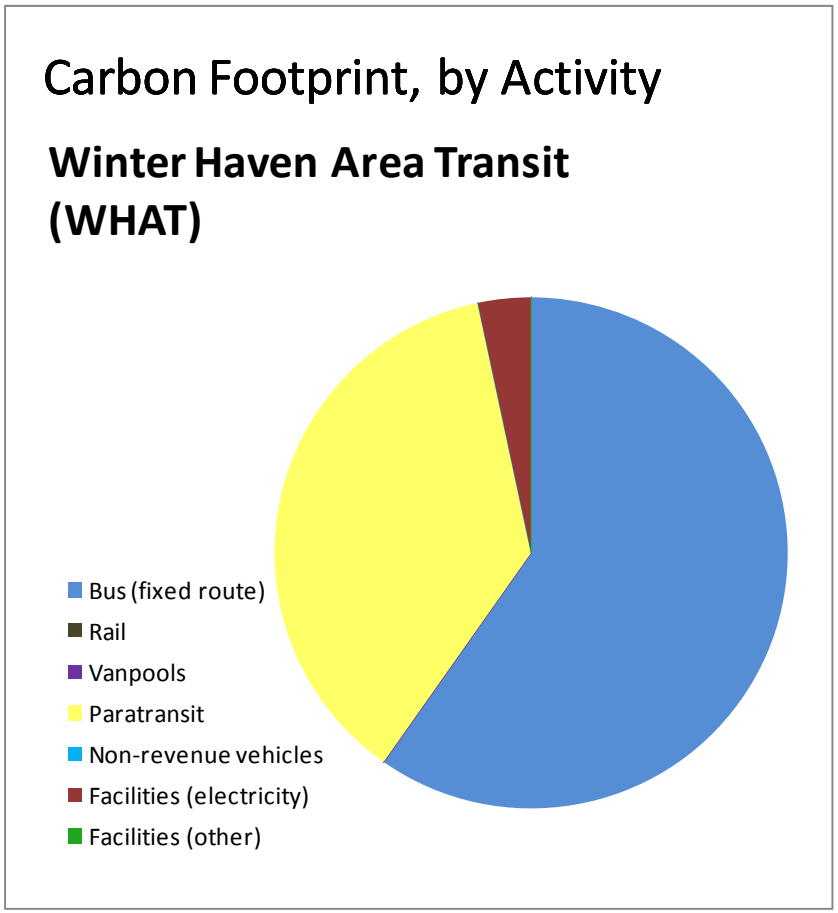
Notes: * Indicates missing or preliminary data

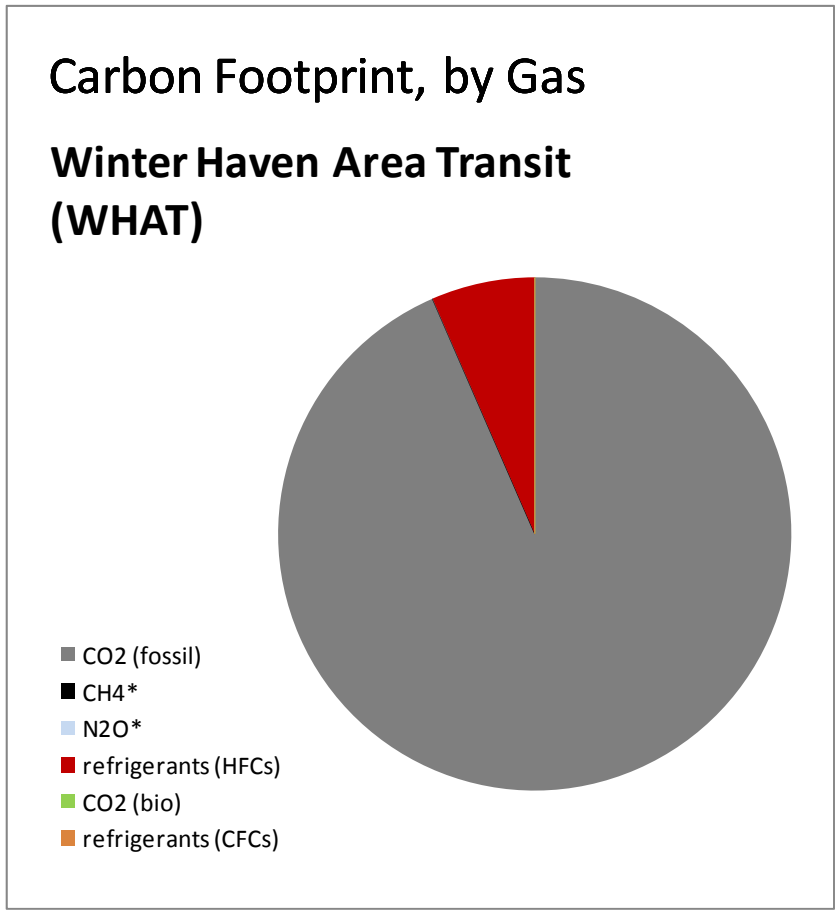
- Reported full charge for refrigerants; no data on net use.

Appendix B: Carbon Footprints for Individual Public Transportation Agencies—Multiple, Probably Small Omissions

The agency in this appendix provided incomplete carbon footprint data and, based on the results from those that submitted complete data, the missing data could increase its footprint by up to 5 percent. Items highlighted in gray in the summary tables are missing or not fully resolved (in some cases, not resolvable given present recordkeeping). Some of these items do not affect the total size of the agency's carbon footprint but rather the allocation of emissions among different activities.

B1: Summary for Winter Haven Area Transit (WHAT)





Carbon Footprint for Winter Haven Area Transit (WHAT)

ACTIVITY GAS → ↓	CO_2 (fossil) kg	CH_4* kg	N_2O* kg	refrigerants (HFCs) kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	1,043,042	0	0	127,664	0	0	1,170,705	59.77%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit	722,485	0	0	0	0	0	722,485	36.89%
Non-revenue vehicles	0	0	0	0	0	0	0	0.00%
Facilities (electricity)	65,171	2	1	N/A	N/A	N/A	65,478	3.34%
Facilities (other)	29	0	0	0	0	0	29	0.00%
							Total	
Total, by gas, kg CO_2(e)	1,830,726	48	260	127,664	0	0	**1,958,698**	in kg CO_2(e)
% by gas	93.47%	0.00%	0.01%	6.52%	0.00%	0.00%	**1,959**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Agency reported refrigerants as total, all reported here under fixed-route bus.
- No data provided on non-revenue vehicles.
- No data provided on mileage for bus, paratransit.

Appendix C: Carbon Footprints for Individual Public Transportation Agencies—Omissions are Large or of Uncertain Size

The agencies in this appendix provided incomplete carbon footprint data. For some, based on the results in Appendices A–B, the missing data probably would increase their footprint by more than 5 percent. For others, the size of the omissions is uncertain. The following notes summarize what omissions or uncertainties remain. Agencies were asked about these uncertainties and, except where noted, have not provided additional information.

CAT reported refrigerant use that was similar in quantity to what much larger agencies reported, yielding a share of the total much larger than other agencies. It is believed that they reported purchases or full equipment charges rather than net use, but this was not confirmed. CAT also reported mileage but not fuel use for paratransit. It is unclear whether the paratransit fuel use is included in their fixed-route data or whether it is missing.

Citrus County Transit did not report to NTD for 2009, so its data cannot be checked for consistency and magnitude. The agency's website indicates that it provides paratransit service, but the data provided show fixed-route only. The agency provided no data on its non-revenue vehicles.

ECAT did not report data on how far its vehicles were driven, and it did not report data on refrigerants or on facilities, other than electricity. In addition, it reported an unusually high share of diesel fuel use in its non-revenue vehicles, which could be correct but also could indicate an error.

Hernando Express Bus provided data on fuel use and vehicle use for its fixed-route and paratransit vehicles. These data yield unrealistically high values of fuel economy (miles per gallon), which means that either the fuel use or the vehicle mileage, or both, are in error. The fuel use values reported are roughly 10 times as large as those the agency reported to NTD for 2009, but it is unclear where the error(s) are. The agency provided no data on electricity, refrigerants, or non-revenue vehicles.

Key West Transit provided data only on its bus fuel use, electricity consumption, and refrigerants. It did not report data on its non-revenue vehicles, mileage for its revenue vehicles, or any non-electrical energy used in its facilities.

LakeXpress reported refrigerant use that appears much too high. The agency also provided no data on vehicle miles driven or on groundskeeping or heating, but the refrigerants are the greatest source of uncertainty for this agency.

LeeTran provided complete data except for refrigerants. The values reported for refrigerants were the amounts purchased, not net consumption after accounting for the amount recovered during equipment servicing. The agency does not record the data needed to report net use. The refrigerants reported have been excluded from the charts and table for the agency.

MDT provided complete data except for refrigerants. The values they reported for refrigerants included full charges, not net consumption after accounting for the amount recovered during equipment servicing. The agency does not record the data needed to report net use but reported that it will change

its recordkeeping so that it can report net use in the future. The refrigerants it reported have been excluded from the charts and table for the agency.

Palm Tran provided data on the amount of refrigerants purchased, but does not record net use. The agency reported paratransit service in its 2009 NTD report but provided no data on such service to the study.

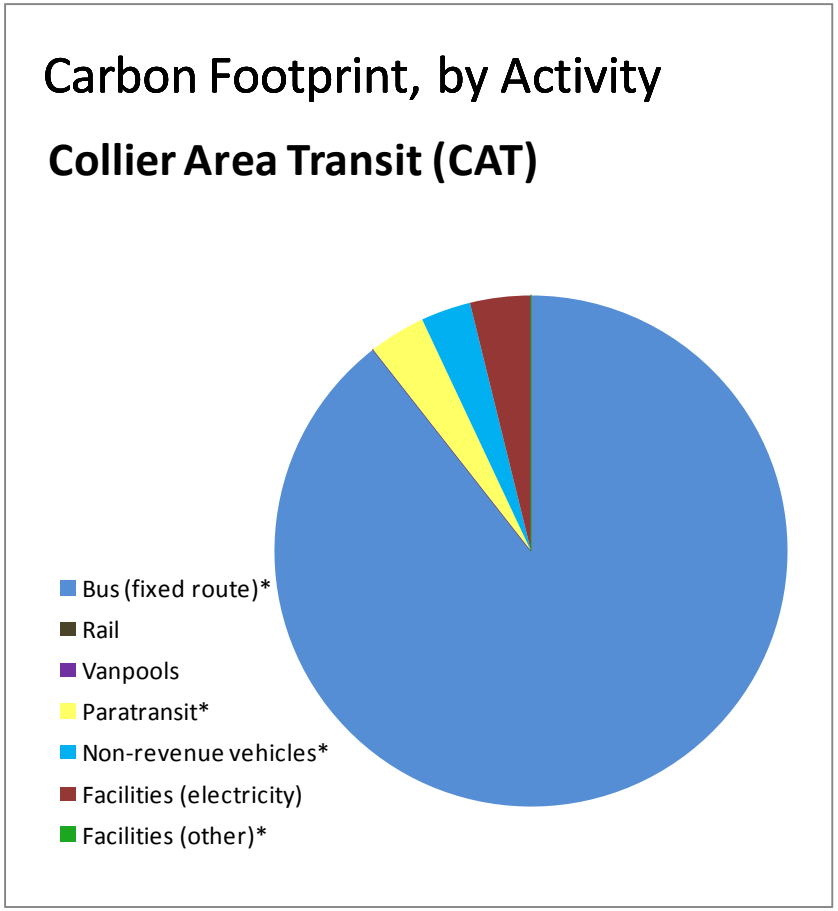
St. John's County provided no data on refrigerants, electricity, groundskeeping, or heating.

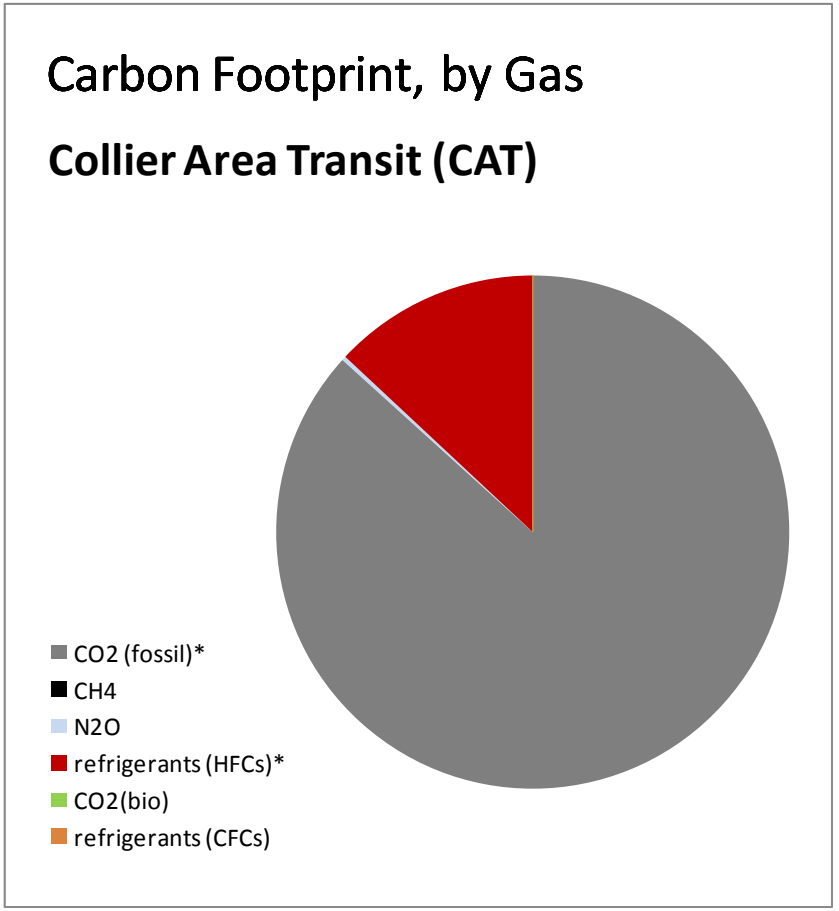
StarMetro reported no data on fuel use or electricity use; it did report refrigerants and detailed data on vehicle use.

As noted in the main report, VOTRAN engaged a consultant to calculate a carbon footprint, among other tasks, before the beginning of this study. The consultant's report did not list refrigerant use or non-revenue vehicle emissions, and it omitted some fuel that VOTRAN had reported to NTD for 2009.

Items highlighted in gray in the summary tables are missing or not fully resolved (in some cases, not resolvable given present recordkeeping). Many of these items do not affect the total size of the agency's carbon footprint but rather the allocation of emissions among different activities.

C1: Summary for Collier Area Transit (CAT)





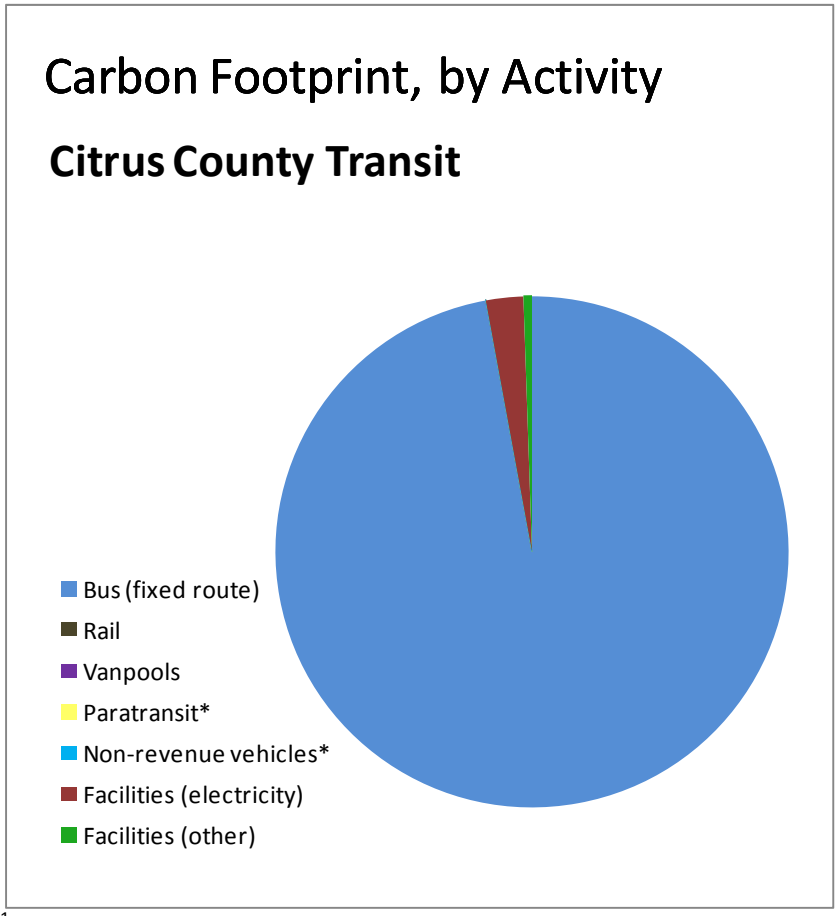
Carbon Footprint for Collier Area Transit (CAT)

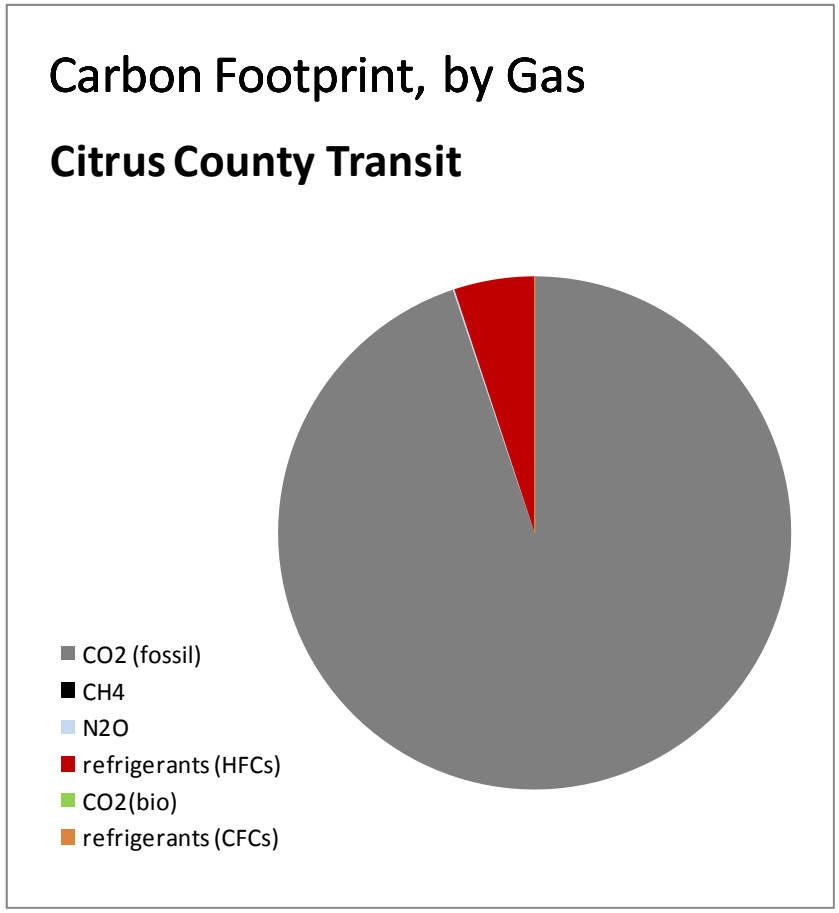
ACTIVITY GAS → ↓	CO_2 (fossil)* kg	CH_4 kg	N_2O kg	refrigerants (HFCs)* kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)*	3,029,070	7	8	365,595	0	0	3,397,305	89.42%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit*	0	19	20	129,727	0	0	136,361	3.59%
Non-revenue vehicles*	118,916	2	2	0	0	0	119,563	3.15%
Facilities (electricity)	145,337	5	2	N/A	N/A	N/A	146,022	3.84%
Facilities (other)*	0	0	0	0	0	0	0	0.00%
							Total	
Total, by gas, kg CO_2(e)	3,293,323	700	9,906	495,323	0	0	**3,799,251**	in kg CO_2(e)
% by gas	86.68%	0.02%	0.26%	13.04%	0.00%	0.00%	**3,799**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Data on refrigerants looks too high.
- No data on groundskeeping or heating.
- Agency reported mileage and refrigerants but no fuel use for paratransit.

C2: Summary for Citrus County Transit[1]





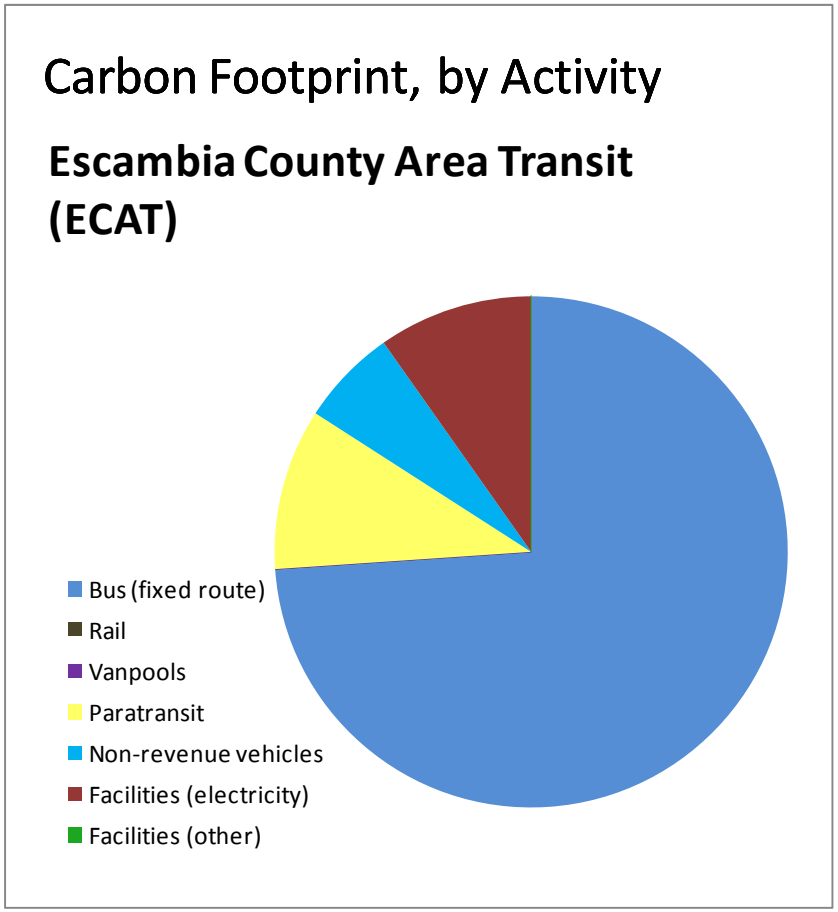
[1] Citrus County Transit is considered a paratransit agency. It does not report to the NTD.

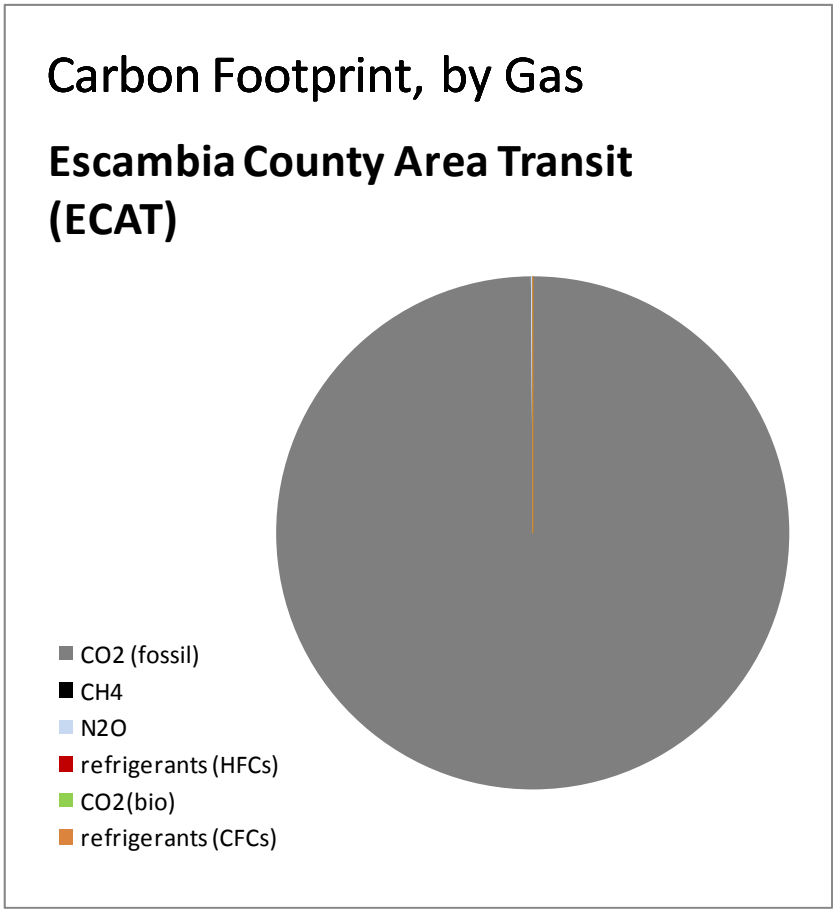
Carbon Footprint for Citrus County Transit

ACTIVITY GAS → ↓	CO_2 (fossil)* kg	CH_4* kg	N_2O* kg	refrigerants (HFCs) kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	1,508,160	5	4	83,143	0	0	1,592,708	97.10%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit*	0	0	0	0	0	0	0	0.00%
Non-revenue vehicles*	0	0	0	0	0	0	0	0.00%
Facilities (electricity)	38,469	1	0	N/A	N/A	N/A	38,651	2.36%
Facilities (other)	8,780	1	0	0	0	0	8,859	0.54%
							Total	
Total, by gas, kg CO_2(e)	1,555,409	148	1,516	83,143	0	0	**1,640,217**	in kg CO_2(e)
% by gas	94.83%	0.01%	0.09%	5.07%	0.00%	0.00%	**1,640**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- No data provided on paratransit; website indicates the agency provides paratransit.
- No data submitted on non-revenue vehicles.


Carbon Footprint, by Activity
Escambia County Area Transit (ECAT)
Bus (fixed route)
Rail
Vanpools
Paratransit
Non-revenue vehicles
Facilities (electricity)
Facilities (other)

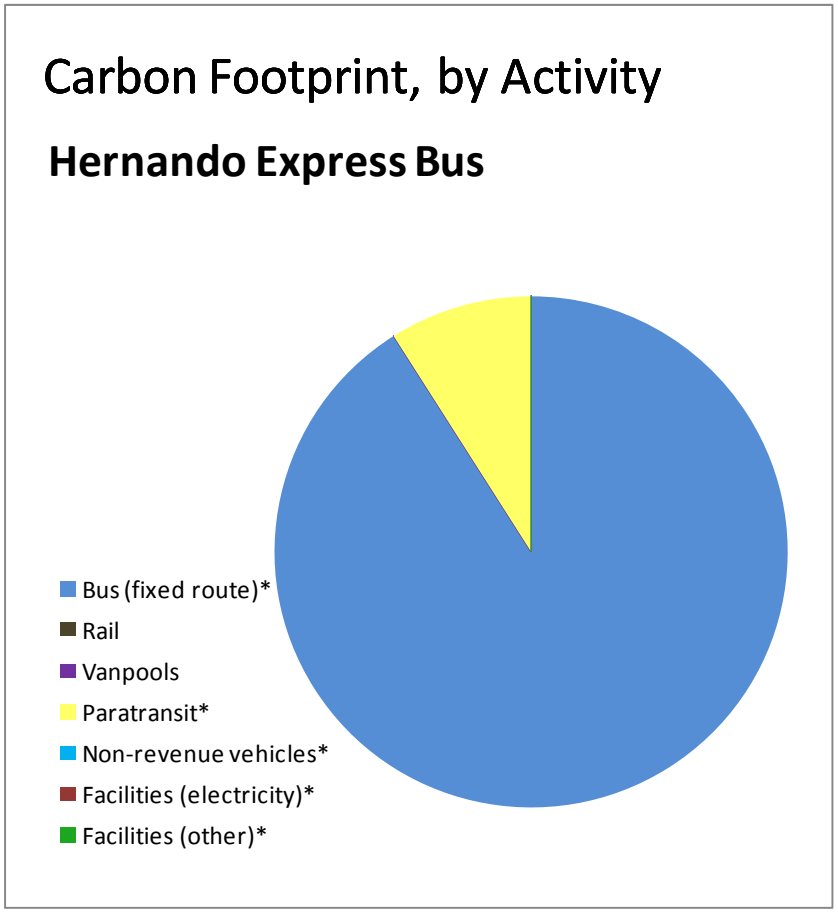

Carbon Footprint, by Gas
Escambia County Area Transit (ECAT)
CO2 (fossil)
CH4
N2O
refrigerants (HFCs)
CO2(bio)
refrigerants (CFCs)

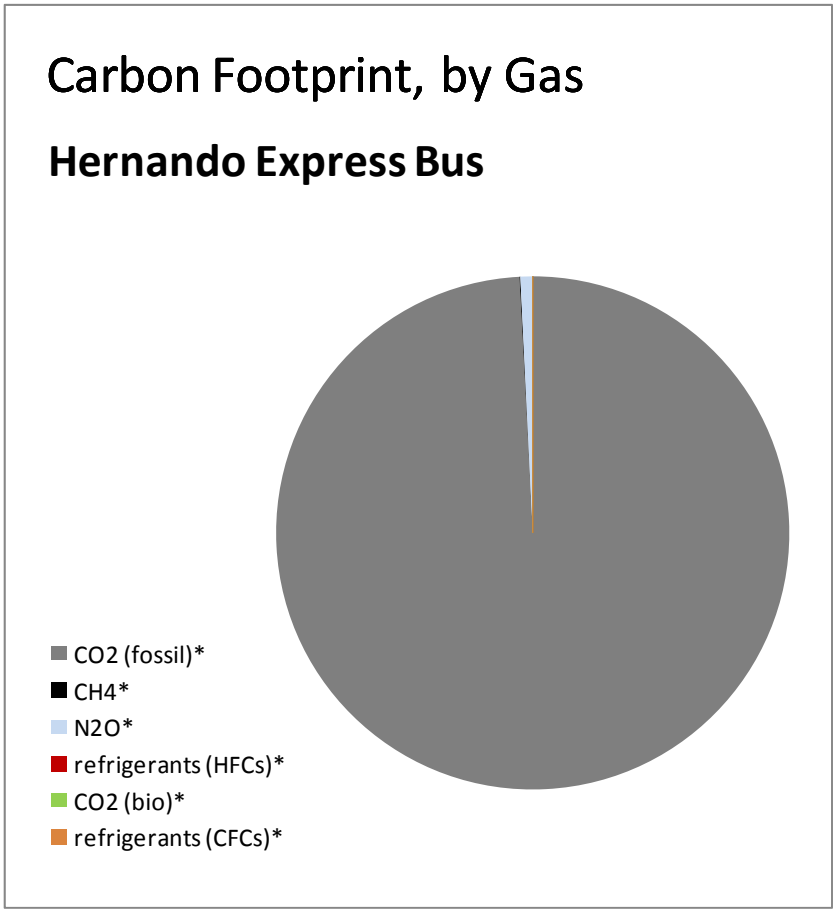
Carbon Footprint for Escambia County Area Transit (ECAT)

ACTIVITY GAS → ↓	CO_2 (fossil)* kg	CH_4* kg	N_2O* kg	refrigerants (HFCs)* kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs)* kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)*	3,374,967	0	0	0	0	0	3,374,967	73.93%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit*	464,015	0	0	0	0	0	464,015	10.16%
Non-revenue vehicles*	276,927	24	9	0	0	0	280,117	6.14%
Facilities (electricity)	443,447	8	8	N/A	N/A	N/A	445,962	9.77%
Facilities (other)*	0	0	0	0	0	0	0	0.00%
							Total	
Total, by gas, kg CO_2(e)	4,559,355	679	5,026	0	0	0	**4,565,060**	in kg CO_2(e)
% by gas	99.88%	0.01%	0.11%	0.00%	0.00%	0.00%	**4,565**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- No data submitted on mileage or refrigerants.
- Amount reported for diesel in non-revenue vehicles appears much too high.
- No data on heating or groundskeeping.


Carbon Footprint, by Activity
Hernando Express Bus
Bus (fixed route)*
Rail
Vanpools
Paratransit*
Non-revenue vehicles*
Facilities (electricity)*
Facilities (other)*


Carbon Footprint, by Gas
Hernando Express Bus
CO2 (fossil)*
CH4*
N2O*
refrigerants (HFCs)*
CO2 (bio)*
refrigerants (CFCs)*

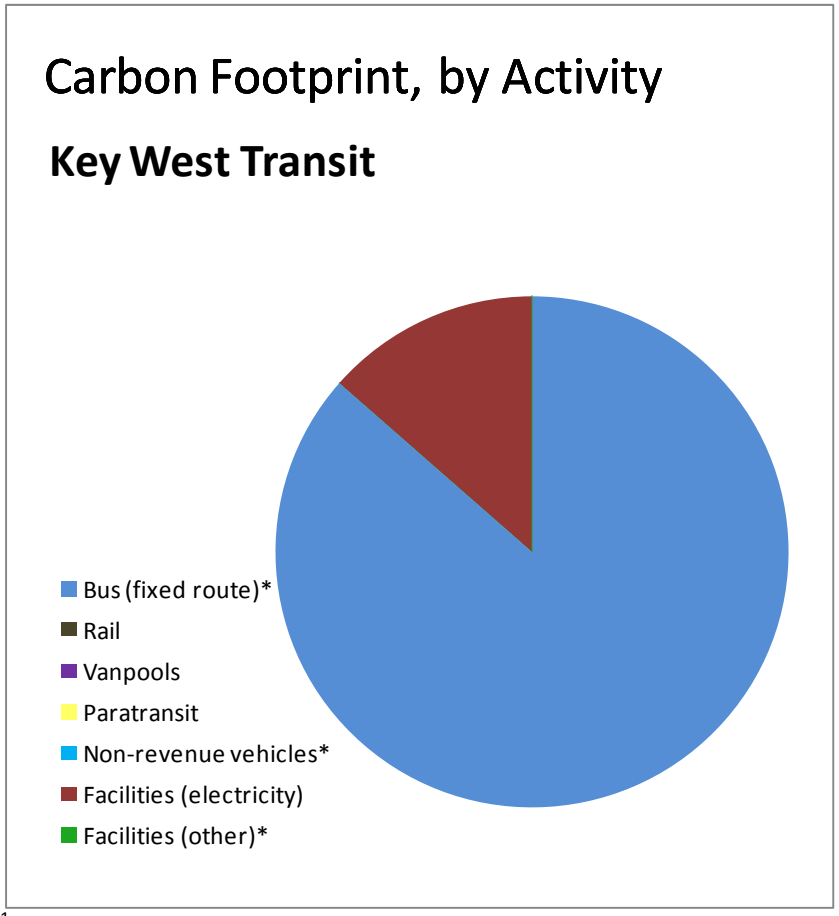
Carbon Footprint for Hernando Express Bus

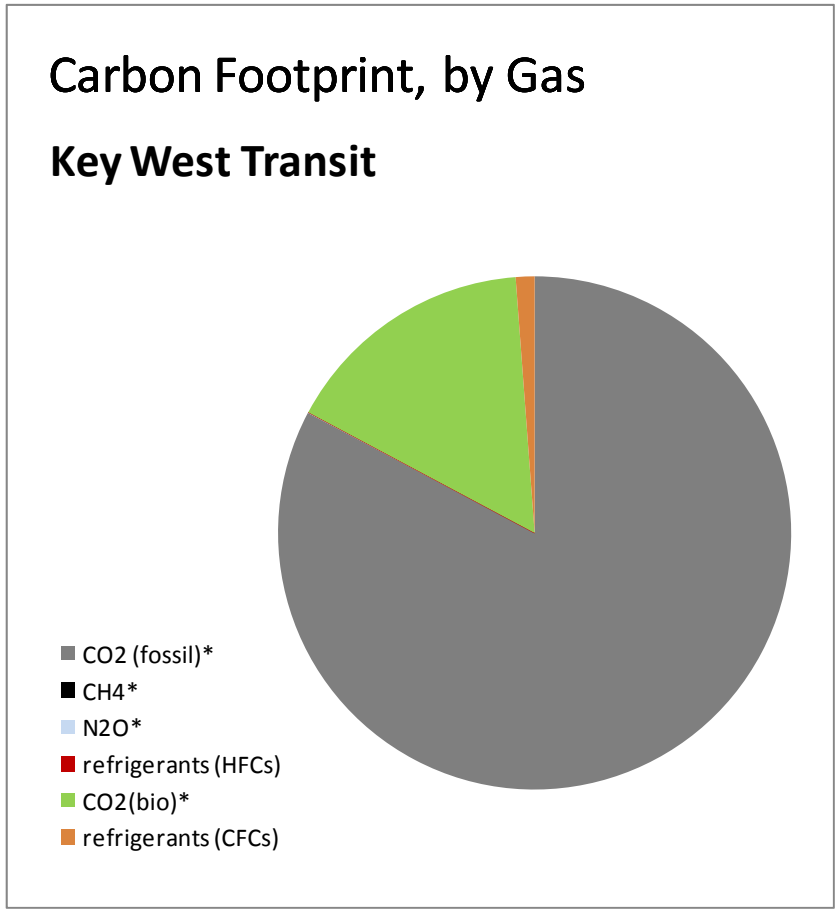
ACTIVITY GAS → ↓	CO_2 (fossil)* kg	CH_{4*} kg	N_2O* kg	refrigerants (HFCs)* kg CO_2(e)	CO_2 (bio)* kg	refrigerants (CFCs)* kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)*	465,505	11	10	0	0	0	468,805	90.97%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit*	45,567	3	3	0	0	0	46,531	9.03%
Non-revenue vehicles*	0	0	0	0	0	0	0	0.00%
Facilities (electricity)*	0	0	0	N/A	N/A	N/A	0	0.00%
Facilities (other)*	0	0	0	0	0	0	0	0.00%
							Total	
Total, by gas, kg CO_2(e)	511,072	286	3,978	0	0	0	**515,336**	in kg CO_2(e)
% by gas	99.17%	0.06%	0.77%	0.00%	0.00%	0.00%	**515**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Mileage reported may be for vehicle lifetime, not 2009; vehicle mileage and fuel use provided for bus and paratransit operations yield estimates of miles/gallon that are unrealistically high, making questionable one or more of the footprint elements calculated.
- No data provided on non-revenue vehicles, electricity, or refrigerants.
- No data provided on groundskeeping or heating.

C5: Summary for Key West Transit[1]





[1] Key West Transit is a fixed-route agency, not considered urban. It does not report to the NTD.

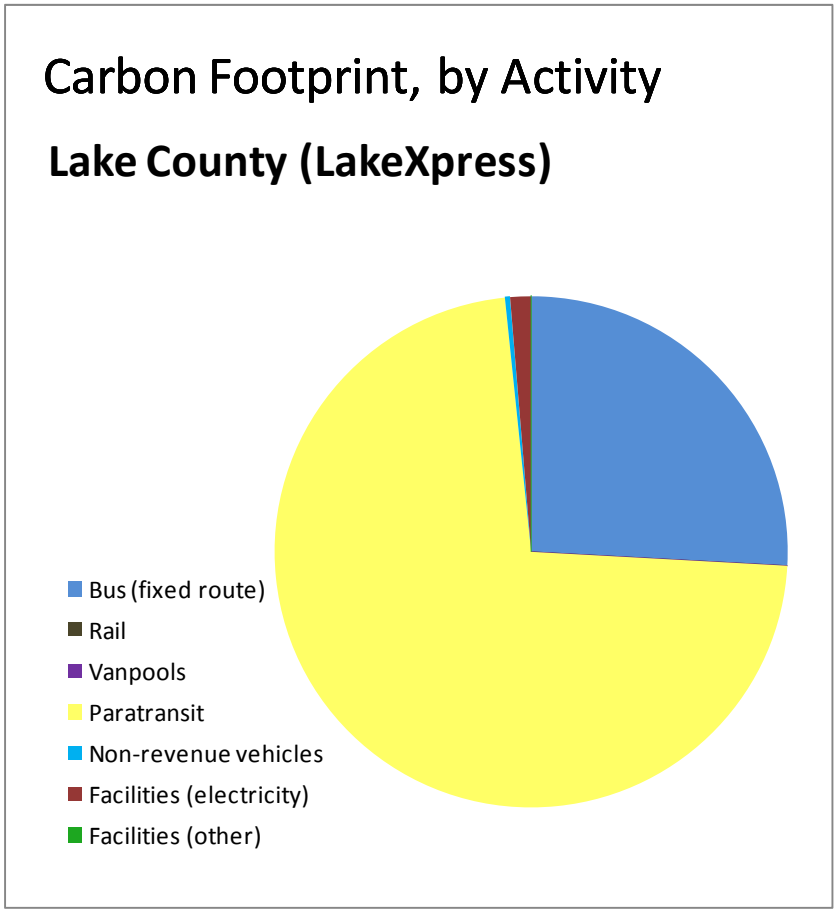
Carbon Footprint for Key West Transit

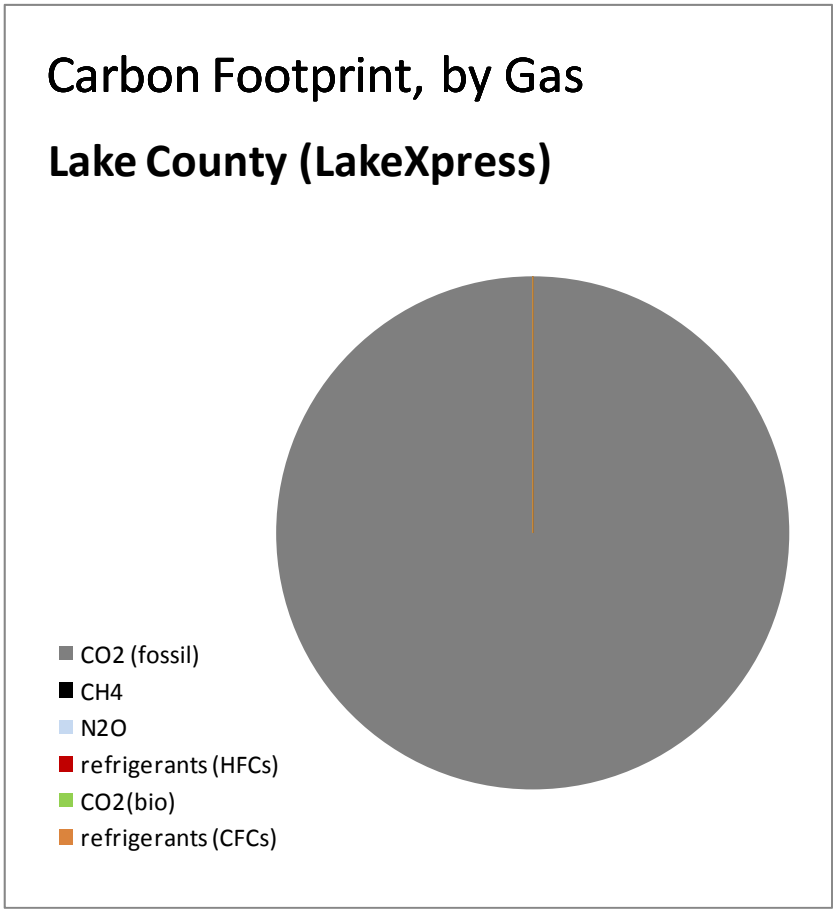
ACTIVITY GAS → ↓	CO_2 (fossil)* kg	CH_4* kg	N_2O* kg	refrigerants (HFCs) kg CO_2(e)	CO_2(bio)* kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)*	757,394	0	0	0	175,254	12,927	945,576	86.45%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit	0	0	0	0	0	0	0	0.00%
Non-revenue vehicles*	0	0	0	0	0	0	0	0.00%
Facilities (electricity)	147,481	5	2	N/A	N/A	N/A	148,176	13.55%
Facilities (other)*	0	0	0	0	0	0	0	0.00%
							Total	
Total, by gas, kg CO_2(e)	904,875	108	587	0	175,254	12,927	**1,093,751**	in kg CO_2(e)
% by gas	82.73%	0.01%	0.05%	0.00%	16.02%	1.18%	**1,094**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Agency provided no data on vehicle mileage, non-revenue vehicles, groundskeeping, or heating.
- According to its website, the agency provides no paratransit services.

C6: Summary for Lake County (LakeXpress)





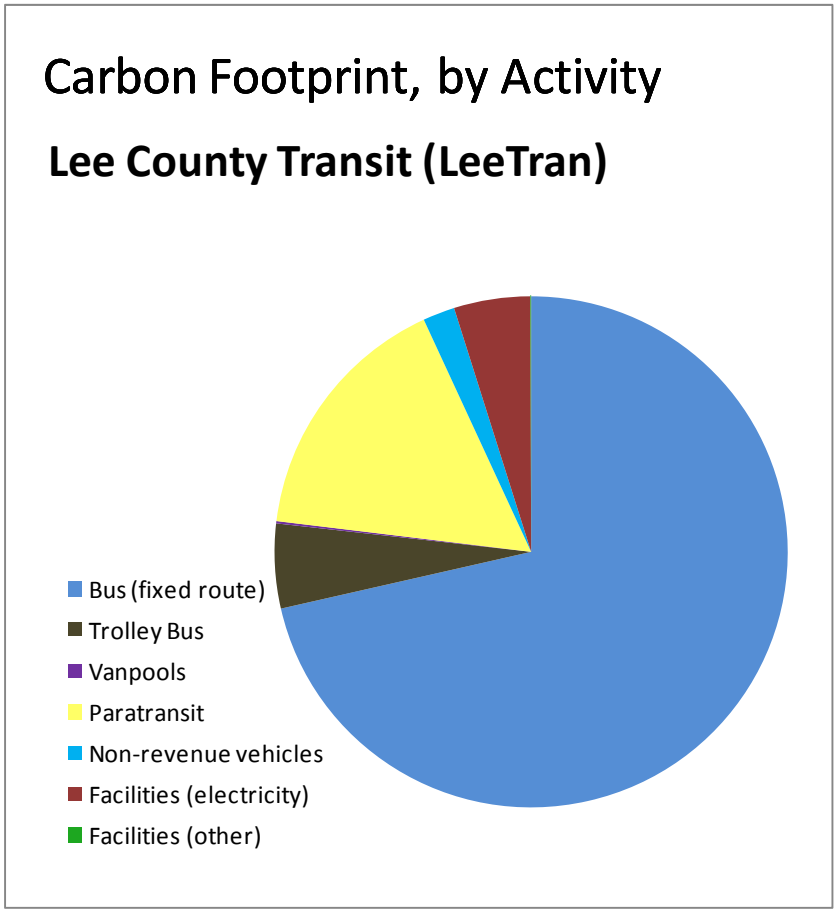
Carbon Footprint for Lake County (LakeXpress)

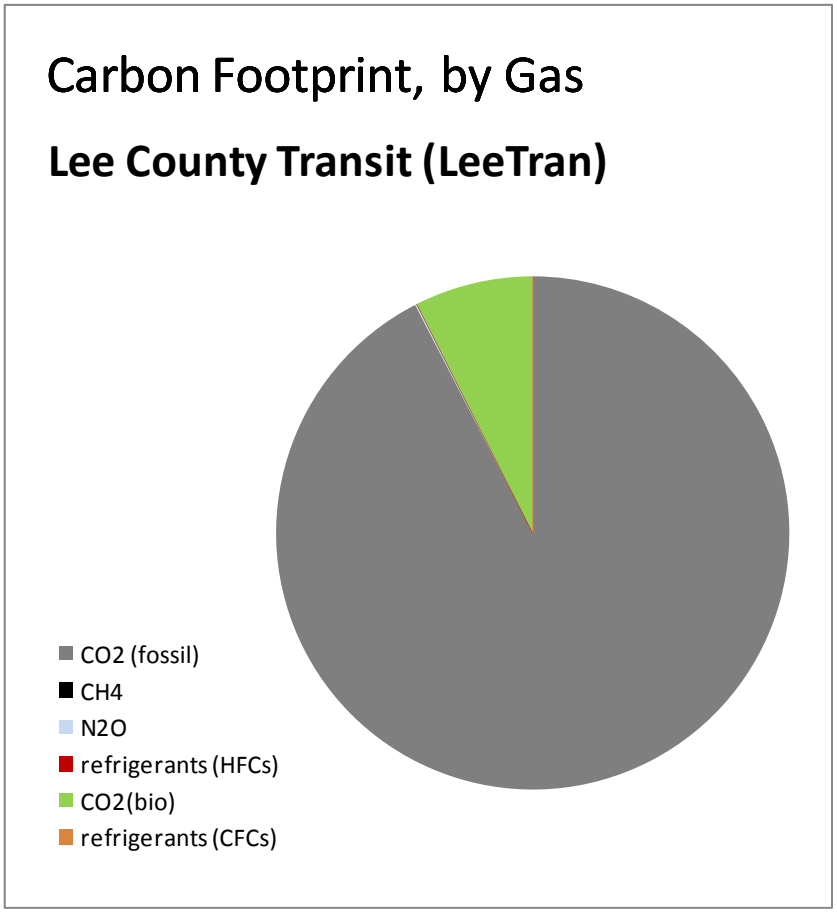
ACTIVITY GAS → ↓	CO_2 (fossil) kg	CH_4* kg	N_2O* kg	refrigerants (HFCs)* kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	806,355	0	0	0	0	0	806,355	25.86%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit	2,260,354	0	0	0	0	0	2,260,354	72.50%
Non-revenue vehicles	10,000	0	0	0	0	0	10,000	0.32%
Facilities (electricity)	40,834	1	1	N/A	N/A	N/A	41,026	1.32%
Facilities (other)*	0	0	0	0	0	0	0	0.00%
							Total	
Total, by gas, kg CO_2(e)	3,117,544	30	163	0	0	0	**3,117,736**	in kg CO_2(e)
% by gas	99.99%	0.00%	0.01%	0.00%	0.00%	0.00%	**3,118**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Refrigerants appear much too high and were excluded.
- No vehicle miles reported.
- No data on groundskeeping or heating.

C7: Summary for Lee County Transit (LeeTran)



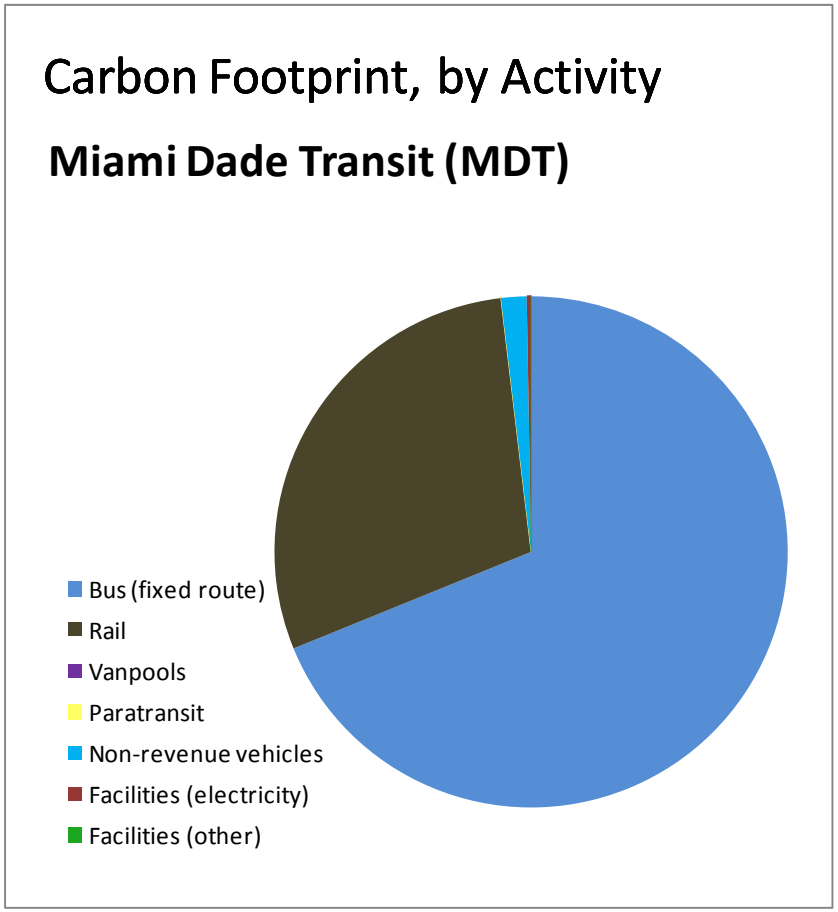


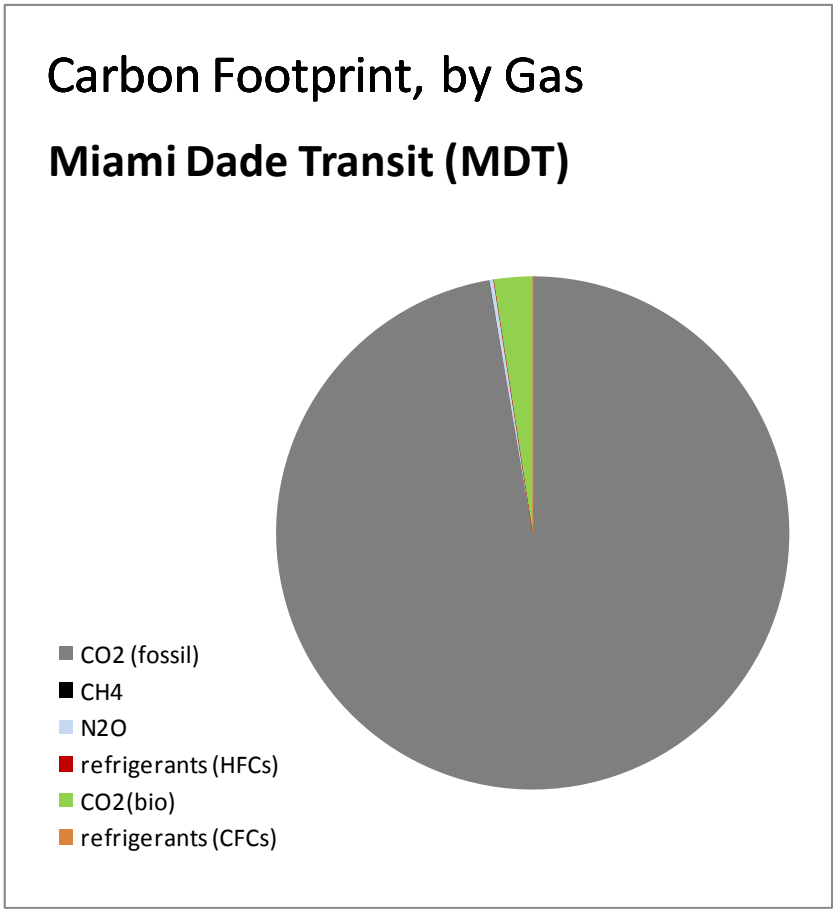
Carbon Footprint for Lee County Transit (LeeTran)

ACTIVITY GAS → ↓	CO_2 (fossil) kg	CH_4 kg	N_2O kg	refrigerants (HFCs)* kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs)* kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	6,316,363	14	13	0	540,761	0	6,861,572	71.44%
Trolley bus	470,628	2	2	0	40,301	0	511,442	5.33%
Vanpools	13,326	1	2	0	0	0	14,081	0.15%
Paratransit	1,430,993	7	6	0	122,541	0	1,555,581	16.20%
Non-revenue vehicles	179,142	6	7	0	12,241	0	193,809	2.02%
Facilities (electricity)	460,933	16	6	N/A	N/A	N/A	463,106	4.82%
Facilities (other)	4,280	0	0	0	352	0	4,638	0.05%
							Total	
Total, by gas, kg CO_2(e)	8,875,665	963	11,404	0	716,197	0	**9,604,229**	in kg CO_2(e)
% by gas	92.41%	0.01%	0.12%	0.00%	7.46%	0.00%	**9,604**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Refrigerant totals reported were too high; agency reported purchases, not net use.


Carbon Footprint, by Activity
Miami Dade Transit (MDT)
Bus (fixed route)
Rail
Vanpools
Paratransit
Non-revenue vehicles
Facilities (electricity)
Facilities (other)

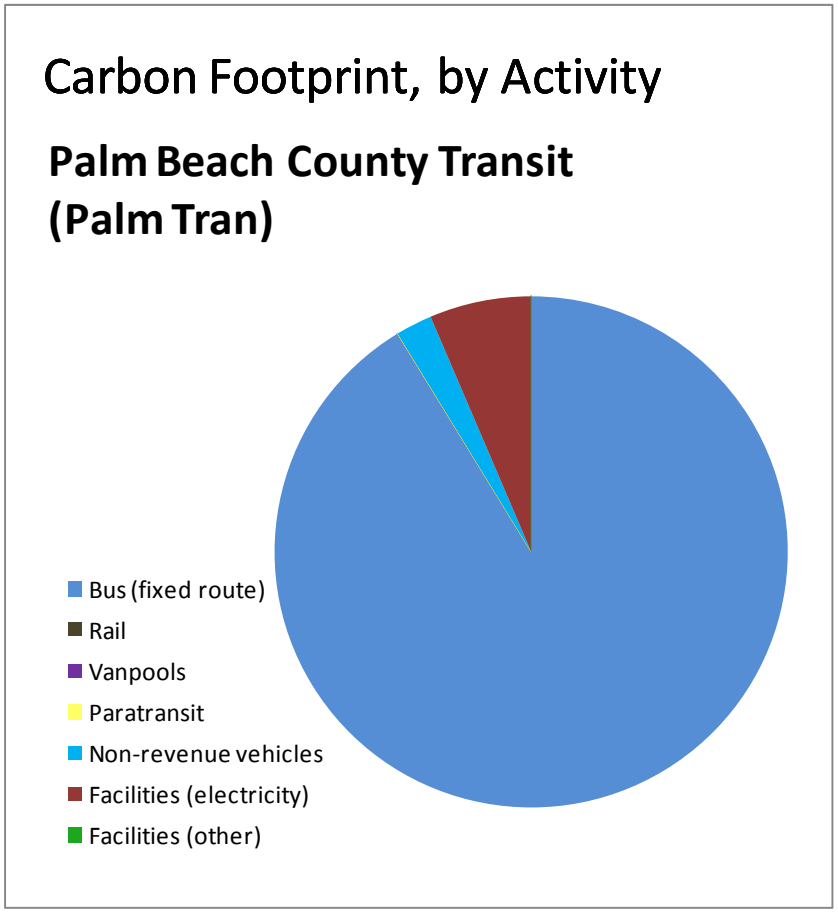

Carbon Footprint, by Gas
Miami Dade Transit (MDT)
CO2 (fossil)
CH4
N2O
refrigerants (HFCs)
CO2(bio)
refrigerants (CFCs)

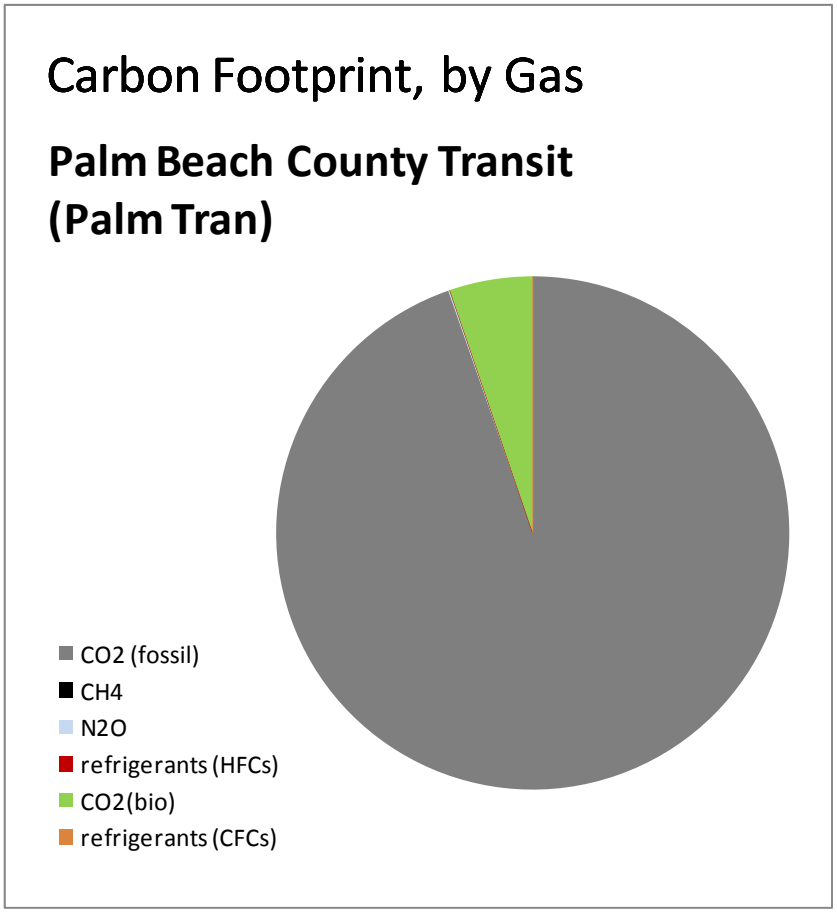
Carbon Footprint for Miami-Dade Transit (MDT)

ACTIVITY GAS → ↓	CO_2 (fossil) kg	CH_4 kg	N_2O kg	refrigerants (HFCs)* kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs)* kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	110,564,326	194	182	0	3,996,650	0	114,621,588	68.85%
Rail*	48,492,208	1,689	623	0	0	0	48,720,799	29.26%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit*	0	0	0	0	0	0	0	0.00%
Non-revenue vehicles	2,442,220	382	651	0	37,706	0	2,689,767	1.62%
Facilities (electricity)*	449,766	16	6	N/A	N/A	N/A	451,886	0.27%
Facilities (other)	0	0	0	0	0	0	0	0.00%
							Total	
Total, by gas, kg CO_2(e)	161,948,520	47,889	453,276	0	4,034,355	0	**166,484,041**	in kg CO_2(e)
% by gas	97.28%	0.03%	0.27%	0.00%	2.42%	0.00%	**166,484**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Rail includes both MetroMover and MetroRail; reported as containing motive power, lighting, escalators, and building use
- Agency uses both HFCs and CFCs; recordkeeping does not collect necessary data; agency is revising to report for future years.
- Purchased paratransit reported to NTD but not to this study.
- No data on groundskeeping or heating.


Carbon Footprint, by Activity
Palm Beach County Transit (Palm Tran)
Bus (fixed route)
Rail
Vanpools
Paratransit
Non-revenue vehicles
Facilities (electricity)
Facilities (other)


Carbon Footprint, by Gas
Palm Beach County Transit (Palm Tran)
CO2 (fossil)
CH4
N2O
refrigerants (HFCs)
CO2(bio)
refrigerants (CFCs)

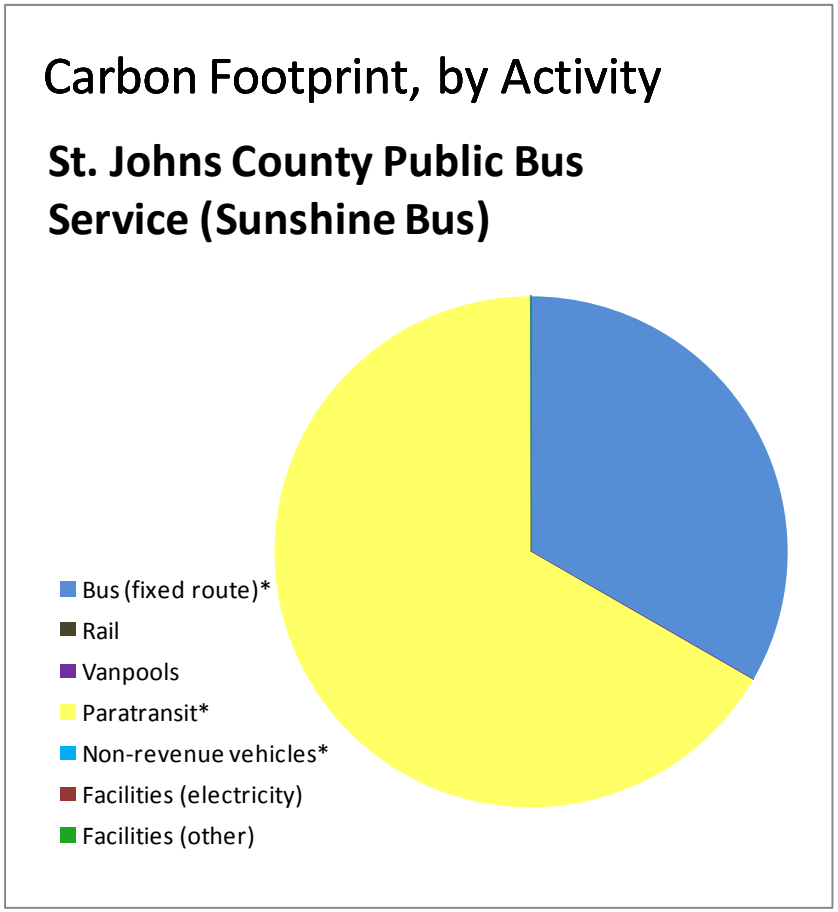
Carbon Footprint for Palm Beach County Transit (Palm Tran)

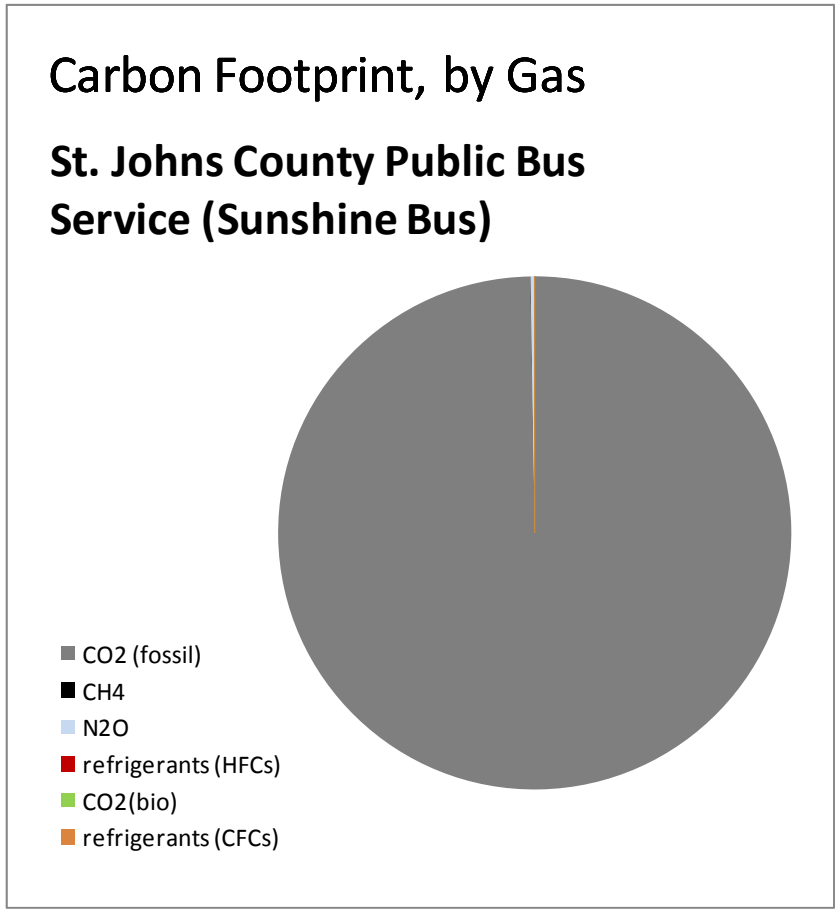
ACTIVITY GAS → ↓	CO_2 (fossil) kg	CH_4 kg	N_2O kg	refrigerants (HFCs) kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs)* kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	17,744,847	42	40	0	1,048,339	0	18,806,457	91.25%
Rail	0	0	0	0	0	0	0.00%	0.00%
Vanpools	0	0	0	0	0	0	0.00%	0.00%
Paratransit*	0	0	0	0	0	0	0	0.00%
Non-revenue vehicles	441,737	12	10	0	31,032	0	476,131	2.31%
Facilities (electricity)	1,319,882	46	17	N/A	N/A	N/A	1,326,104	6.43%
Facilities (other)*	0	0	0	0	0	0	0	0.00%
							Total	
Total, by gas, kg CO_2(e)	19,506,467	2,106	20,748	0	1,079,371	0	**20,608,692**	in kg CO_2(e)
% by gas	94.65%	0.01%	0.10%	0.00%	5.24%	0.00%	**20,609**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Purchased paratransit reported to NTD but not to this study.
- Agency reported purchase of the CFC R-22 but does not collect data on net use.
- No data on groundskeeping or heating.

C10: Summary for St. John's Council on Aging (Sunshine Bus)



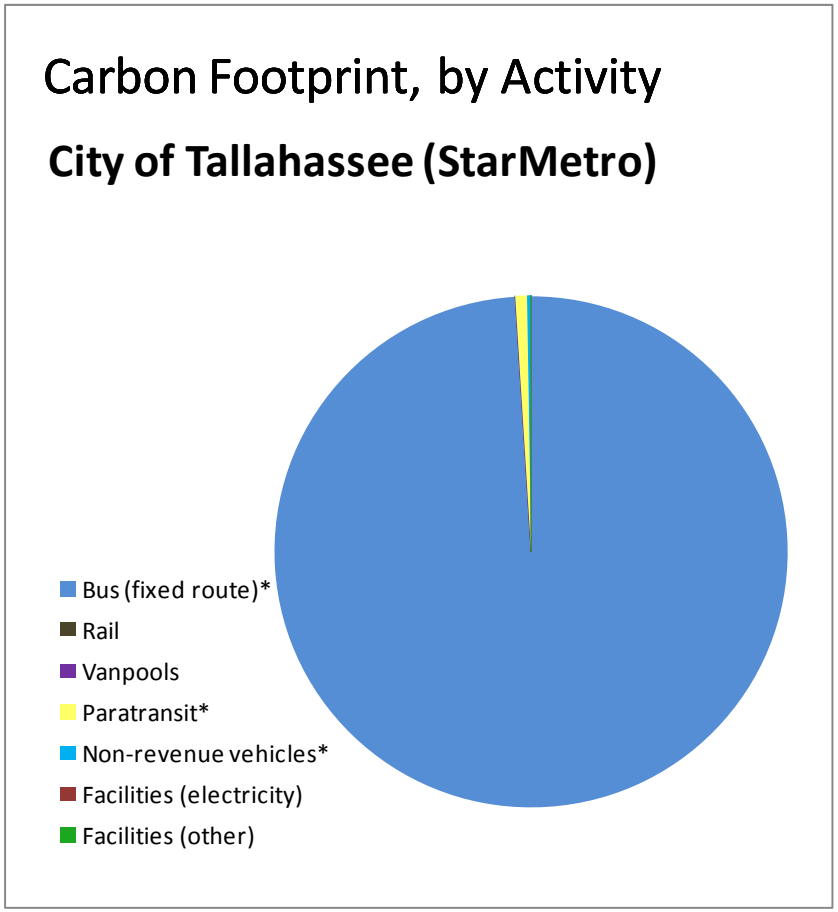


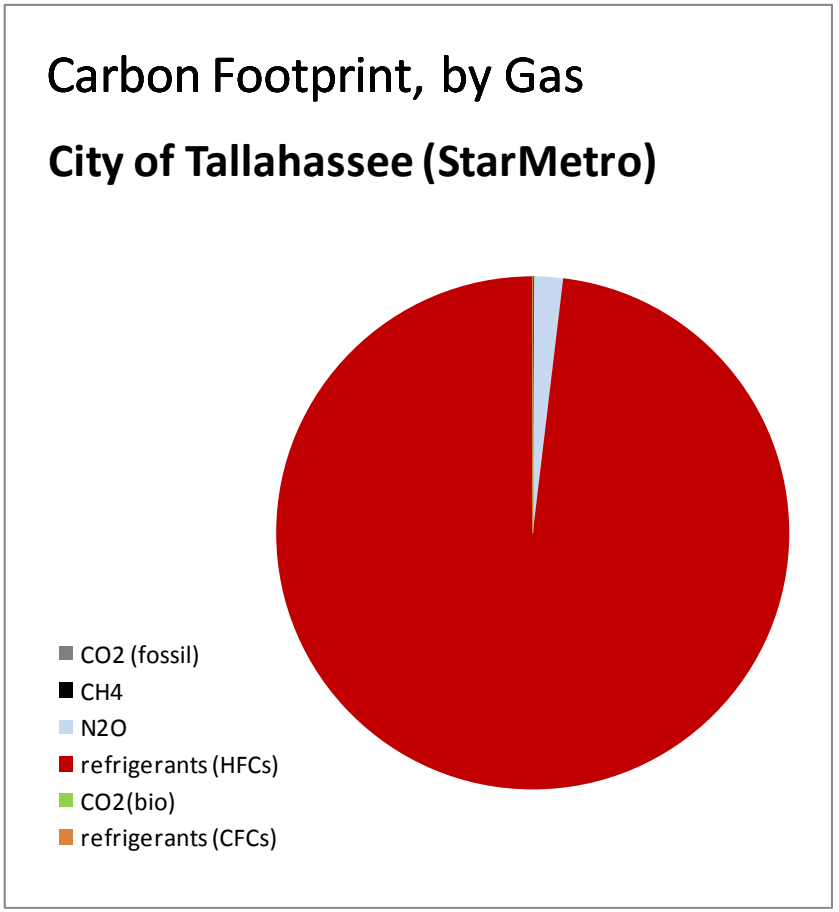
Carbon Footprint for St. Johns Council on Aging (Sunshine Bus)

ACTIVITY GAS → ↓	CO_2 (fossil) kg	CH_4 kg	N_2O kg	refrigerants (HFCs)* kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs)* kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	404,332	5	3	0	0	0	405,384	33.31%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit	808,439	11	7	0	0	0	810,815	66.62%
Non-revenue vehicles	922	0	0	0	0	0	930	0.08%
Facilities (electricity)*	0	0	0	N/A	N/A	N/A	0	0.00%
Facilities (other)*	0	0	0	0	0	0	0	0.00%
							Total	
Total, by gas, kg CO_2(e)	1,213,692	324	3,112	0	0	0	**1,217,128**	in kg CO_2(e)
% by gas	99.72%	0.03%	0.26%	0.00%	0.00%	0.00%	**1,217**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- No refrigerants reported.
- No electricity reported.
- No data on groundskeeping or heating.


Carbon Footprint, by Activity
City of Tallahassee (StarMetro)
Bus (fixed route)*
Rail
Vanpools
Paratransit*
Non-revenue vehicles*
Facilities (electricity)
Facilities (other)


Carbon Footprint, by Gas
City of Tallahassee (StarMetro)
CO2 (fossil)
CH4
N2O
refrigerants (HFCs)
CO2(bio)
refrigerants (CFCs)

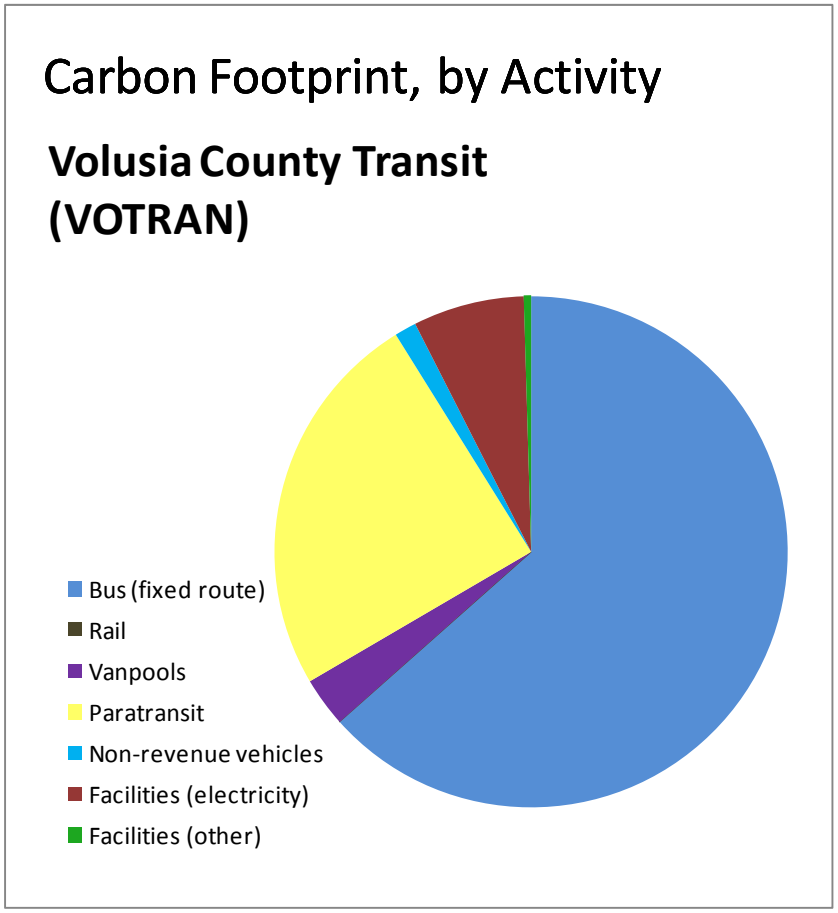
Carbon Footprint for City of Tallahassee (StarMetro)

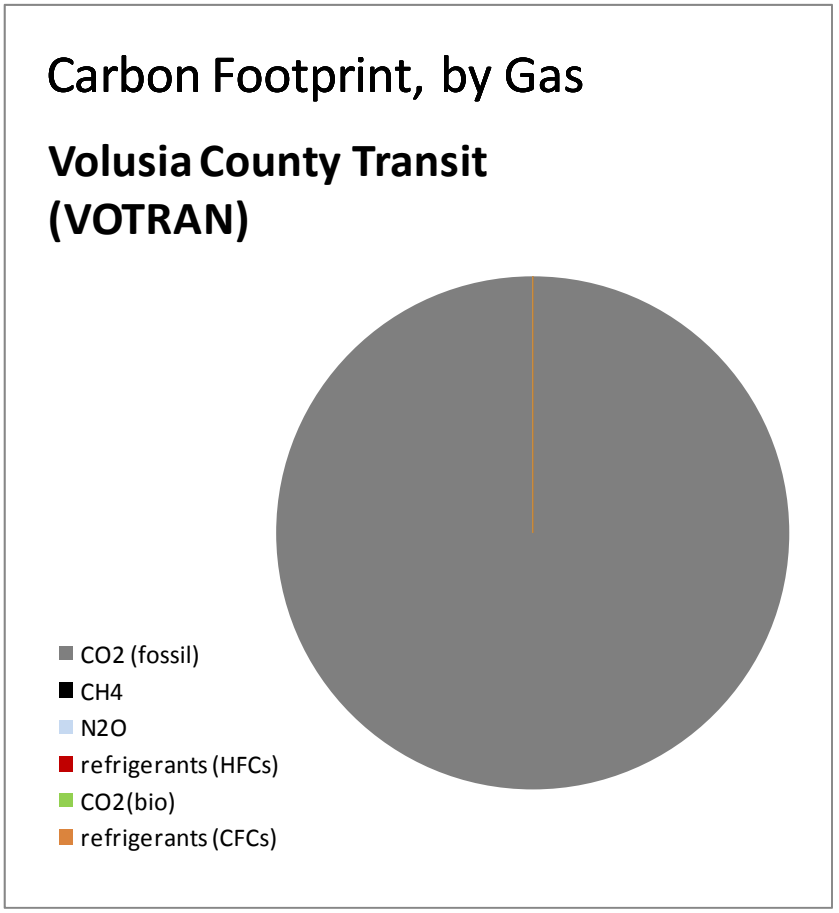
ACTIVITY GAS → ↓	CO_2 (fossil)* kg	CH_4 kg	N_2O kg	refrigerants (HFCs) kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs) kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)*	0	11	10	369,723	0	0	373,113	99.01%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	0	0	0	0	0	0	0	0.00%
Paratransit*	0	6	9	0	0	0	2,769	0.73%
Non-revenue vehicles*	0	2	3	0	0	0	964	0.26%
Facilities (electricity)*	0	0	0	N/A	N/A	N/A	0	0.00%
Facilities (other)*	0	0	0	0	0	0	0	0.00%
							Total	
Total, by gas, kg CO_2(e)	0	399	6,724	369,723	0	0	**376,846**	in kg CO_2(e)
% by gas	0.00%	0.11%	1.78%	98.11%	0.00%	0.00%	**377**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Received total refrigerants without breakdown by activity; all are reported with fixed-route bus.
- No fuel use or electricity reported.
- No data on groundskeeping or heating.

C12: Summary for Volusia County (VOTRAN)





Carbon Footprint for Volusia County Transit (VOTRAN)

ACTIVITY GAS → ↓	CO_2 (fossil) kg	CH_4* kg	N_2O* kg	refrigerants (HFCs)* kg CO_2(e)	CO_2 (bio) kg	refrigerants (CFCs)* kg CO_2(e)	Total, by Activity kg CO_2(e)	% by Activity
Bus (fixed route)	6,813,807	0	0	0	0	0	6,813,807	63.45%
Rail	0	0	0	0	0	0	0	0.00%
Vanpools	335,572	0	0	0	0	0	335,572	3.12%
Paratransit	2,637,190	0	0	0	0	0	2,637,190	24.56%
Non-revenue vehicles*	148,627	0	0	0	0	0	148,627	1.38%
Facilities (electricity)	751,407	26	10	N/A	N/A	N/A	754,949	7.03%
Facilities (other)*	49,389	0	0	0	0	0	49,389	0.46%
							Total	
Total, by gas, kg CO_2(e)	10,735,992	550	2,993	0	0	0	**10,739,534**	in kg CO_2(e)
% by gas	99.97%	0.01%	0.03%	0.00%	0.00%	0.00%	**10,740**	in tonnes CO_2(e)

Notes: * Indicates missing or preliminary data

- Consultant's report listed quantity by fuel type from FY2009 NTD; quantities by bus, vanpool, and paratransit are from 2009 NTD.
- Value reported for non-revenue vehicles is difference between consultant totals and NTD; includes diesel fuel only.
- Consultant report did not list values for gasoline; 2009 NTD lists gasoline for vanpools and paratransit, which are included in activity totals here.
- Consultant values for propane and fuel oil reported here under Facilities (other); insufficient information to estimate trace gases in this category.
- Consultant reported values of CO_2(e); insufficient information to disaggregate this into constituent gases except for electricity.
- Consultant's report did not list vehicle mileage or refrigerants.

Appendix D: Spreadsheet for Calculating Transit Agency Carbon Footprints

Each participating agency will be provided with a copy of the Excel 2007 spreadsheet workbook used to calculate its carbon footprint and a general version of the spreadsheet workbook, also in Excel 2007. Because of the diverse range of formats in which agencies maintain data and provided it to the study, it is not possible to write a single spreadsheet tool that can work with every format. The study began with a general version of the workbook and then altered it as needed to accommodate the data each agency provided. The general version described below is similar to the ones used in the study but it is organized differently. The different organization should allow many agencies to enter their data without modifying the spreadsheet. However, some will need to do so. Writing a spreadsheet that would allow more agencies to do so would make more complicated for all agencies to use.

The workbook contains four spreadsheets for entering data—three sheets of coefficients, two of which are used automatically and one of which is a reference for manual entry by the user, and one summary sheet of results.

Entering data on fuel consumption and electricity

Fuel consumption and electricity consumption are entered into two sheets: **Fuel & Electricity (revenue)**, and **Fuel & Electricity (all other)**.

Consumption of fuel by revenue vehicles is entered in the **Fuel & Electricity (revenue)** sheet. The service categories are those used by the NTD, although to simplify the table some categories not reported by Florida transit agencies have been eliminated. Fuel categories are generally the same as the NTD. Some have been eliminated because Florida agencies did not report them. However, the following changes have been made to be consistent with the way that most agencies reported data to the study, or to simplify the spreadsheet.

Liquid fuels are entered in gallons (not thousands of gallons) for each type of service.

Electricity purchased from utilities to operate revenue vehicles is entered in kilowatt-hours (not thousands of kilowatt-hours) for each type of service.

Compressed natural gas (CNG) is entered in standard cubic feet. The NTD allows this to be entered in the equivalent of gallons of diesel or other fuels, and accommodating this for the few agencies that report CNG makes the spreadsheet much more complicated for all users. Agencies should request the standard cubic feet, or a conversion factor, from their CNG supplier.

Gasoline is entered in gallons of what is purchased as “gasoline.” Florida law requires all “gasoline” to contain 9-10% ethanol of biological origin, starting in calendar year 2011. The spreadsheet will divide a gallon of “gasoline” into gasoline and ethanol for calculating the footprint and will apportion it between fossil and biological sources, assuming 9% ethanol. If an agency has a fuel contract that specifies 10% (or higher percentages), the actual percentage which is ethanol should be entered in column O for the service using the fuel, as a decimal fraction (for example, 10% should be entered as 0.10). If an agency purchases ethanol to run vehicles as ethanol, the gallons of ethanol purchased should be entered in column G.

Diesel fuel purchased as "diesel" is entered in column B. Diesel fuel purchased as "biodiesel" is entered, in gallons of what was purchased, in column J, and the percentage of this which is of biological origin is entered in column P, as a decimal fraction (for example, 10% should be entered as 0.10). The percentage from biological sources will be in the fuel purchase contract or, more simply, in the "B" number (B20 biodiesel is 20% biological and 80% fossil). For example, to enter 15,000 gallons of B20 for fixed-route bus, enter 15000 in cell J14, and 0.20 in cell P14. If an agency purchases B100 and does its own blending, it should enter the gallons of B100 in column J, 1.0 in column P, and the gallons of fossil diesel in column B. If the percentage from biological origin is omitted from column P, the spreadsheet will assume the entire amount of "biodiesel" is from fossil sources.

Florida lies in two different regional electricity grids. The default calculations are set up for the grid that serves most of the state. Baytown Trolley, ECAT, and Okaloosa County Transit are served by the other grid. These three agencies will need to copy values from cells (T28:V28) to (T27:V27). This change will carry over to all electricity calculations throughout the workbook. The coefficients involved reflect differences in fuel mix and emission controls between the two regional grids. Agencies outside Florida will need to identify their regional grid in the GRP, go to the **Coefficients (Electricity)** sheet, convert the coefficients for their grid as was done for the two grids serving Florida, and enter the appropriate coefficients in (T27:V27).

The spreadsheet calculates CO_2 from all energy sources, plus trace gases CH_4 and N_2O from electricity, and these are used by the **Summary** sheet. "Commuter Rail," "Heavy Rail," and "Light Rail" are grouped together as "Rail" in the **Summary** sheet. "Bus" appears as "Bus" in the **Summary**, "Demand Response" appears as "Paratransit" and "Vanpool" appears as "Vanpools." The other categories do not appear in the **Summary**, and an agency that wants to can either create additional rows in the **Summary**, or modify the formulas in the **Summary** to group the additional services into one of the four shown there. Consumption of fuel for all purposes *except operating revenue vehicles* is entered in the **Fuel & Electricity (all other)** sheet. The sheet is divided into a top section for non-revenue vehicles, and a bottom section for facilities. The format and entry conventions in each section are the same as for the **Fuel & Electricity (revenue)** sheet, including the splitting of "gasoline" and "biodiesel." Agencies that use different categories of activity should modify the category labels in column A. They are a convenience for entering data and the spreadsheet does not use them

If the agency has any all-electric non-revenue vehicles and meters its consumption separately from other uses, the electricity used to charge these can be entered in the electricity columns for the non-revenue vehicles. Otherwise, it should be reported for whatever category it is metered in as part of facilities consumption. If the agency uses any plug-in hybrids for non-revenue vehicles, the electricity used to charge them should be entered as above, and any fuel should be entered in the appropriate fuel column of the spreadsheet, in the non-revenue vehicles section

The sheet contains calculations for trace gases from gasoline used in small engines (for example, lawn mowers or leaf blowers used in groundskeeping), from diesel fuel used in backup generators, and from natural gas used in furnaces or hot-water heating. These will be handled properly if the gasoline use by small engines is recorded in column (C16:C17), if diesel used in generators is entered in cell B27, and if natural gas for water or space heating is entered in H15. Using different fuels in these or other applications will require consulting the GRP to determine the trace-gas coefficients for the fuel and type of application, and then creating formulas within this spreadsheet to estimate the coefficients. Setting

up calculations for all possibilities would greatly complicate the spreadsheet for the majority of Florida agencies.
Emissions from all electricity consumption reported in the facilities consumption section will appear as "Facilities (electricity)" in the **Summary** sheet. Emissions from all other fuel use in the facilities consumption section will appear as "Facilities (other)".

Entering data on vehicle mileage

The **Vehicle Mileage** sheet is used to calculate emissions of the trace gases CH_4 and N_2O from vehicle operations. The sheet is divided into four sections: non-revenue vehicles, fixed-route bus, paratransit, and vanpools. The four sections have identical formats and use. The description here focuses on non-revenue vehicles because these generally require the greatest effort, but the steps are similar and often simpler for other types of vehicles.

The only information required to be entered in this sheet is the number of miles each vehicle was driven, and an emission coefficient for each of the two trace gases emitted. The coefficients depend on the fuel type and Gross Vehicle Weight Rating (GVWR) of the vehicle, and either the model year or the type of emission standards the vehicle was designed to meet. The model year typically is available from the vehicle inventory. The type of emission standards is posted on the underside of the hood. If working with model year, it may be convenient to enter the fuel type and the make, model, and year of the vehicle in addition to the mileage, to help with looking up the coefficients. If working with the type of emission standards, it may be convenient to enter the fuel type and emission category along with the mileage. Additional columns may be inserted into the spreadsheet, as long as the mileage appears in the blue-shaded column (Column E in the original spreadsheet). Additional rows may be inserted to accommodate additional vehicles; if rows are added, they must be inserted between the dark lines delimiting each group of vehicles.

Generally speaking, passenger cars, sport-utility vehicles, minivans, and small pickup trucks are considered light-duty vehicles (any vehicle with a GVWR of less than 8,500) and these use the light-duty emission coefficients. Any vehicles with a GVWR of 8,500 or more are considered medium-duty or heavy-duty and use the heavy-duty emission coefficients (which cover both medium- and heavy-duty vehicles). The GVWRs for vans designed to carry 8 or more passengers, and for pickup trucks with model name including E or F 250 or higher, or 2500 or higher, need to be checked to determine whether the vehicles use the light- or heavy-duty coefficients.

To illustrate the use of model-year coefficients, a gasoline-powered 2005 F-150 pickup with a GVWR of 6,200 would use a light-duty coefficient. The **Coefficients (VMT)** sheet contains a table of model-year coefficients in columns H-J. The light-truck coefficients are in rows 21-37, and the ones for 2005 are in row 34, with 0.0101 grams N_2O emitted per mile, and 0.0157 grams CH_4 emitted per mile. These two values need to be copied into columns J and K for this vehicle. If a vehicle model year is more recent than the most recent model year coefficient in the table, use the most recent coefficient. For example, for a 2010 car, use coefficients for model year 2008.

Similarly, a gasoline-powered car that meets USEPA Tier 1 emission standards would use coefficients from the control technology table in columns B–D of **Coefficients (VMT)**, from row 7 in this example. The values of 0.0429 grams N_2O per mile and 0.0271 grams CH_4 per mile should be copied into columns J and K for this vehicle.
When the mileage and coefficients are complete, the spreadsheet will calculate the emissions from each vehicle, sum them, and transfer the sum to the **Summary** sheet.

All large diesel transit buses are heavy-duty and use the same coefficients regardless of make, model, or year. For this reason, it is possible to enter a total mileage for all of these vehicles into the fixed-route bus section of the **Vehicle Mileage** sheet, and copy the emission coefficients once for the total mileage. Federal clean-air regulations have gradually reduced the emission limits for gasoline vehicles, and light-duty diesel vehicles, which leads to the greater variation.

Once an agency has entered all of its vehicles and their emission coefficients into the **Vehicle Mileage** spreadsheet, it can update its carbon footprint in subsequent years by removing vehicles that have been sold, and adding vehicles and coefficients for vehicles acquired since the last footprint. This will probably be simpler than looking up all of the coefficients each year.

Trace gases for rail service are calculated automatically on the **Fuel & Electricity (revenue)** sheet, either as part of the electricity emissions from electrically-driven rail or in a special section for diesel locomotives. These transfer automatically to the **Summary** sheet and require no additional input from the user.

Entering data on refrigerants

The **Refrigerants** sheet lists all of the refrigerants for which global warming potentials are available from the GRP, plus R-22, the CFC used by many of Florida's public transportation agencies. R22, HFC-134, and HFC-134a account for almost all of the refrigerants that Florida's transit agencies reported during the study. For each of these refrigerants, the **Refrigerants** sheet contains rows to allow separate entries for use in buses, rail, vanpools, paratransit, non-revenue vehicles, and in facility air-conditioning or heat-pump systems. These are the *only* rows that now transfer automatically to the **Summary** sheet from the **Refrigerants** sheet. Agencies that use other refrigerants and that also monitor use by type of service or other application should create additional rows for that refrigerant, copy the cells C–F from the original row into the new row, and link to the row from the appropriate cell in the **Summary** sheet.

The **Refrigerants** sheet lists five columns. All of the agencies that reported refrigerant data did so in pounds rather than kilograms, so the sheet has been designed for all data to be entered in pounds of refrigerant. If data are entered as kilograms, then all refrigerant data must be entered as kilograms, and cell F2 must be cleared.

The *net* amount of refrigerant used to service equipment is entered in column K. This value is the difference between the amount of refrigerant used to fill the equipment at the end of service, and the amount recovered from the equipment at the beginning of service. For example, if 8 lbs of R-22 are recovered from a vehicle being serviced, and if 10 lbs are used to recharge the equipment after service is complete, the net difference is 2 lbs, which should be entered into the appropriate R-22 row.

If new equipment is purchased and does not come fully charged with refrigerant, so that the new owner has to fill it, the amount purchased to fill it should be entered in column G.

The total amount that the new equipment can hold (again, only for new equipment that does not come fully charged), should be entered in column I.

If equipment is retired, the total amount of refrigerant this equipment can hold should go in column M. If the agency removes refrigerant from equipment when it is retired, the total amount of refrigerant removed from such equipment during the year should be entered in column O.

Supporting coefficients

Coefficients (Fuel Use), **Coefficients (VMT)**, and **Coefficients (Electricity)** contain copies of the updated coefficient tables from the GRP [5], which were used in the study. Table numbers in these sheets are from the GRP. Before updating their carbon footprints, users of the spreadsheets should check with the Climate Registry for updated emissions coefficients and should copy the updated emission tables into the appropriate sheet. Other sheets in the workbook link directly to cells in the **Coefficients (Fuel Use)** and **Coefficients (Electricity)** sheets. Therefore, when updating the tables in these sheets, users need to check that the new tables are of the same size and in the same order as those the ones here.

Coefficients from the **Coefficients (VMT)** table must be copied manually to appropriate rows in the **Vehicle Mileage** sheet. No links need to be checked when updating the tables in the **Coefficients (VMT)** sheet, but the order of the CH_4 and N_2O coefficients needs to be confirmed before replacing the current tables with updates (see page 34 in Chapter 4). Links between the **Vehicle Mileage** and **Summary** sheets assume that N_2O coefficients are to the left of those for CH_4.

Summary

The **Summary** sheet contains the carbon footprint, summarized and charted as in Appendices A-C. It also reports the amounts of the footprint from Scopes 1 and 2. The Scope 3 calculations reported in Chapter 3 were made using separate spreadsheets from [2] and are not part of the workbook.