U.S. Airport Greenhouse Gas Emissions Inventories

State of the Practice and Recommendations for Airports

Volpe Center Report

for the

FAA Office of Airport Planning

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Notice

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13. ABSTRACT (Maximum 200 words)

This document presents highlights from five research reports on airport greenhouse gas (GHG) emissions inventories. It presents the most salient findings for policy makers and U.S. airports seeking to better understand and inventory airport GHG emissions. The emphasis in this summary is to provide recommendations on reasonably accurate and low cost methods to inventory airport GHGs. The first step in reducing GHG emissions is the development of a baseline inventory. Inventorying GHG emissions at airports can help airport officials better understand emissions trends; identify the sources and activities where there are opportunities for GHG reduction; set GHG reductions targets; and track progress toward meeting targets. Information on the usability, affordability, and reliability of various inventory methods is provided to help airports make the most of limited resources.

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Acronyms and Abbreviations

Abbreviation	Term
ACA	Airport Carbon Accreditation Program
ACERT	Airport Carbon and Emissions Reporting Tool (Version 3.0)
ACI	Airports Council International
ACRP	Airport Cooperative Research Program
ACRP 11	ACRP 11: Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories
AEDT	Aviation Environmental Design Tool
APU	Auxiliary Power Unit
Carbon Neutral	Zero Greenhouse Gas Emissions Annually on a Net Basis
CO_2	Carbon Dioxide
CO_2e	Equivalent Carbon Dioxide
EDMS	Emissions and Dispersion Modeling System
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
FEMP	Federal Energy Management Program
GAV	Ground Access Vehicle
GSE	Ground Support Equipment
GHG	Greenhouse Gas
HVAC	Heating Ventilation and Cooling
LTO	Landing and Takeoff
M&V	Measurement and Verification
TCR	The Climate Registry
VALE	Voluntary Airport Low Emissions FAA Grant Program
VMT	Vehicle Miles Traveled
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

Executive Summary

This document presents highlights from five research reports that the Volpe Center developed for the Federal Aviation Administration (FAA) Office of Airport Planning and Programming (APP) on airport greenhouse gas (GHG) emissions inventories. The summary presents the most salient findings for policy makers and U.S. airports seeking to better understand and inventory airport GHG emissions. The emphasis in this summary is to provide recommendations for reasonably accurate and low cost methods to inventory airport GHGs.

The impetus for the research was FAA's desire to understand the state of the practice of GHG inventories at airports, since the first step in reducing GHG emissions is the development of a baseline inventory. Inventorying GHG emissions at airports can help airport officials better understand emissions trends; identify the sources and activities where there are opportunities for GHG reduction; set GHG reductions targets; and track progress toward meeting targets. Information on the usability, affordability, and reliability of various inventory methods can help airports make the most of limited resources.

Some U.S. airports have completed GHG emissions inventories but few are required to do so, and inconsistent methodologies for collecting and analyzing data make comparison between airports difficult. The Airport Cooperative Research Program (ACRP) "Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories" (ACRP 11) describes a suite of optional methods that airports may use to estimate various GHG emissions sources. This research built on ACRP 11 by comparing estimation methods and focusing on their respective data needs, amount of time and effort required, and expected results. In particular, this research compared detailed, time-consuming methods with relatively straightforward, cost effective methods in order to see how different the results would be, helping airports gauge the value of investing in more detailed methods.

Following the key findings and background sections, Chapter 3 describes best practices for GHG emissions inventories, based on interviews with airport practitioners, as well as tools and methods for estimating GHG emissions from various sources and their relative accuracy, precision, and required level of effort. Chapter 4 highlights opportunities to formalize results through voluntary reporting frameworks. Chapter 5 outlines an approach for airports to reduce or eliminate GHG emissions. The appendix provides a list of U.S. airports that have developed GHG inventories.

Key findings from the research include the following:

- There are certain organizational and strategic best practices that can help airports inventory emissions more effectively, regardless of the estimation tools and methods employed.
- Simple spreadsheet estimation tools, such as the Airports Council International (ACI) Airport Carbon Accreditation (ACA) Airport Carbon Emissions Reporting Tool (ACERT), provide a reasonable level of accuracy for some GHG emissions sources when compared to more detailed estimation methods.
- Modeling results from the Aviation Environmental Design Tool (AEDT)), for airports that can readily access them, provides a reliable and effective way to estimate aircraft GHG emissions.

Airports that do not have access to aircraft emissions estimated with AEDT or another model may find it easiest and least expensive to collect aircraft fuel consumption data and apply emission factors in ACERT or a similar tool. A comparison of the fuel-based method and AEDT yielded comparable results.

- Ground access vehicles (GAV) that are owned and operated by airport tenants are one of the most challenging emissions sources to estimate, and airports have used a variety of methods and assumptions to inventory them. Based on a preliminary analysis of one U.S. airport, the ACERT generic aircraft method does not appear to provide a reasonable level of accuracy when compared to the ACERT detailed method or other detailed methods.
- For tenant operated ground service equipment (GSE), estimating GHG emissions using fuel usage records would be the most accurate. However, obtaining this data from multiple tenants can be difficult. Thus, using an estimate of activity along with a simplified but accurate model such as ACERT is the best approach.
- Auxiliary power units (APU) can be estimated in AEDT, but significant data are required to conduct the analysis. For airports without detailed APU activity data, the ACERT provides a simplified approach, but this research did not evaluate the accuracy of this method. APU GHG emissions can also be estimated using two methods recommended by ACRP 11.
- For estimation of methane (CH_4) and nitrous oxide (N_2O) airports may need to supplement ACERT with another tool, such as the Federal Energy Management Program (FEMP) tool. ACERT does not evaluate these GHG pollutants.

1 Background

1.1 Research Purpose

This document distills information from five research reports that Volpe prepared for the Federal Aviation Administration (FAA) Office of Airport Planning and Programming (APP). The overall purpose for the research was two-fold: to provide information to FAA decision makers on the state of the practice of airport greenhouse gas (GHG) inventories and to summarize key information that may assist airports in conducting GHG emissions inventories. The research sought to provide airports with information that would help them to choose among various inventory methods, given anticipated tradeoffs with respect to the amount of time and money that airports invest and the relative accuracy and precision that they may expect of the resulting estimates.

A GHG emission inventory is an integral component of climate change mitigation planning and achieving environment and energy sustainability goals. Inventorying GHG emissions at airports can help airport officials better understand emissions trends; identify the sources and activities where there are opportunities for GHG reduction; and set GHG reductions targets and track progress toward meeting targets. Some commercial service airports have been monitoring and reporting carbon dioxide (CO_2) and other GHG emissions for over a decade as part of their sustainability initiatives. During this time, the practice, regulatory environment, and voluntary initiatives related to GHG tracking and reporting has evolved rapidly.

The impetus for these reports is FAA's desire to better understand the state of the practice for GHG inventories at airports, since the first step in reducing GHG emissions is the development of a baseline inventory. Information on the usability, affordability, and reliability of various inventory methods can help airports achieve this goal.

1.2 What Are GHG Emissions?

GHGs trap heat in the atmosphere, making the earth's surface warmer than it would be absent these gases. Human activities are responsible for almost all of the increase in atmospheric GHGs over the last 150 years.[1] Carbon dioxide represents the majority of GHG emissions and is generally used as the benchmark gas when discussing carbon emissions. It is released, for example, when fossil fuels are burned to generate electricity or to power vehicles. Lesser contributions to GHG emissions come from nitrous oxide (N_2O), methane (CH_4), refrigerants such as hydrofluorocarbons (HFCs), and other compounds that also contribute to global warming. Each GHG has a different global warming potential; the term "equivalent CO^2" (CO_{2e}) takes into account the reactivity and longevity of the gases in the atmosphere, which affect their potency as greenhouse gases.

[1] IPCC (2007). Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis.* *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

1.3 What is an Airport GHG Inventory and Why Is It Important?

A GHG inventory is an accounting of GHGs emitted to or removed from the atmosphere over a period of time. There are environmental and financial reasons to inventory GHG emissions at airports. States and localities around the country have introduced goals to reduce CO_2 and subsequently their contributions to global warming. Airport GHG reduction initiatives can play an important role in achieving these goals. In addition, since GHG emissions are directly related to energy consumption, reducing or eliminating CO_2 and other GHGs can lower energy bills and airport operating costs.

A number of airports in the U.S. are taking measures to reduce carbon emissions. San Francisco International, Denver International, Barnstable Municipal, Austin-Bergstrom, and Indianapolis International are just a few. As more airports seek to reduce GHG emissions and energy consumption, low cost approaches to developing inventories becomes more important.

1.4 Efforts to Develop Consistent Airport GHG Inventory Methods and Tools

A wide variety of GHG reporting protocols are currently in use for airports, but they share several common traits. For example, they refer to the same fundamental principles and frameworks that early precedents established, such as the GHG Protocol developed by the World Resources Institute and the World Business Council for Sustainable Development. Additionally, GHG reporting protocols allow reporting entities varying degrees of flexibility in selecting the methodology for calculating emissions and/or in selecting the scopes of emissions to consider. There are more than 150 airports worldwide that have prepared GHG inventories at varying levels of detail.[2]

The Airport Council International (ACRP) ACRP 11 outlines a variety of methods for inventorying airport emissions and identifies a "preferred" approach for estimating each source.[3] The ACI Airport Carbon Accreditation (ACA) Program provides estimation guidance, a reporting framework, and a spreadsheet-based estimation tool, ACERT. The FAA Sustainability Grants Pilot Program enabled a diverse set of 44 airports[4] to develop Sustainability Master or Management Plans that include explicit GHG inventories, as well as emission reduction targets and activities. For additional information on FAA's work to support sustainability planning and to learn about future grant programs, visit www.faa.gov/airports/environmental/sustainability/.

1.4.1 GHG Scopes

GHG reporting tools and protocols generally sort emissions into three categories called "scopes." For airports, scopes are distinguished as:

- Scope 1: direct emissions – GHG emissions from sources owned/operated by the facility;

[2] www.airportcarbonaccreditation.org/airport/participants.html lists 153 airports that have completed GHG inventories.
[3] http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_011.pdf
[4] See list at www.faa.gov/airports/environmental/sustainability/.

- Scope 2: indirect emissions – GHG emissions indirectly emitted based on the facility's operation, specifically, specifically purchased steam and electricity; and
- Scope 3: other/indirect emissions –GHG emissions from sources with no direct facility control; can include a wide range of sources depending on the analysis boundary, including but not limited to aircraft emissions, ground access vehicles (GAV), tenants, and waste management. The vast majority of airport GHG emissions fall in this category.

Table 1 summarizes the three scopes and their definitions according to ACRP 11 and Airports Council International (ACI).

Table 1. GHG Scope Definitions from ACI and ACRP 11

	Scope 1	Scope 2	Scope 3	Link
ACI	Emissions owned and controlled by the airport operator, such as energy generation and airport vehicles.	Emissions from the off-site generation of energy purchased by the airport operator.	Emissions owned and controlled by airport tenants and other stakeholders including: • Aircraft activity in airport area; • Airline and other tenant vehicles GSE, and energy usage; • GAV for staff and passengers including buses and train;	www.aci.aero/About-ACI/Priorities/Environment/ACERT
ACRP 11	Direct emissions include airport operator emissions associated with 1. Fuel necessary to power airport-owned on- and off-road vehicles 2. Direct energy necessary to power airport facilities (i.e., natural gas, fuel oil).	Indirect emissions include purchased electricity	Indirect and optional emissions include 1. Tenant emissions; 2. Public ground travel on- and off-airport; and 3. Airport employee commute emissions.	http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_011.pdf

The airports that have estimated all sources of GHG emissions at their airports have found that Scope 3 (indirect emissions from aircraft and ground vehicles) contribute the largest share, approximately 80-90 percent of total CO_{2e}, while direct Scope 1 and 2 emissions collectively represent 10-20 percent.[5] Figure 1 illustrates the proportional generation of GHG emissions by scope at 13 U.S. airports. Nine of the 13 airports have Scope 3 emissions that exceed 90 percent of overall GHG emissions. Aircraft emissions data for John Wayne Airport and Westchester County Airport only include GHG emissions from the LTO cycle. If cruise GHG emissions had been included for these two airports, the proportion of total GHG emissions ascribable to Scope 3 would have been substantially higher.[6]

[5] Not all airport GHG inventories have evaluated Scope 3 emissions.

[6] Of the airport inventories that Volpe reviewed, ATL, DEN, PHL, and SAN reported their combined LTO and cruise aircraft emissions, while other airports only reported their LTO emissions.

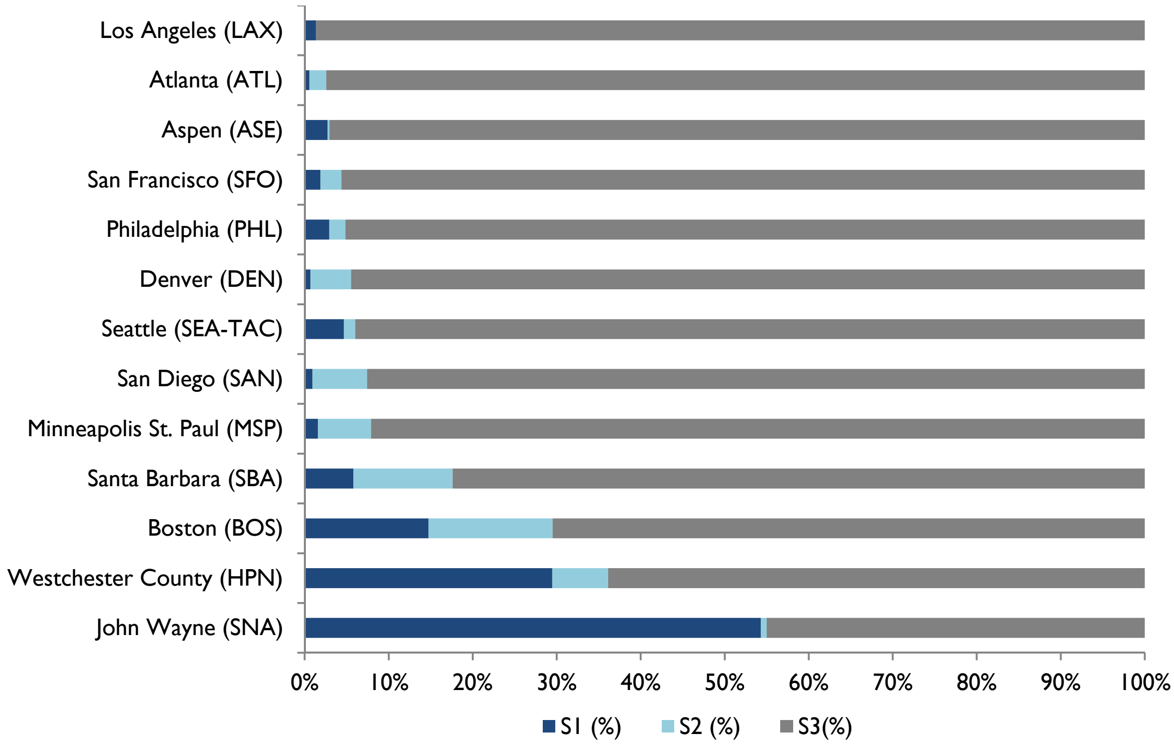

Figure 1. Comparison of Scope 1, 2, and Aircraft GHG Emissions for 13 U.S. Airports

With few exceptions, airports are not currently required to inventory and report carbon emissions to any U.S. regulatory body. The Environmental Protection Agency's (EPA) Mandatory Reporting Rule requires that certain stationary sources report GHG amounts annually if they reach or exceed a threshold of 25,000 metric tons of CO_{2e}.[7] Although the rule does not specifically include airports, it is applicable to the largest and busiest airports. The airports that comply with the rule only report emissions from electric generators and stationary fuel combustion, and not necessarily from other emission sources, such as GSE, service vehicles, tenant operations, and fuel use.

[7] See EPA, *Mandatory Greenhouse Gas Reporting Rule, Federal Register*, October 30, 2009. www.epa.gov/climatechange/emissions/ghgrulemaking.html

2 Best Practices

Given the fast pace of evolution and adoption of GHG inventory practices, an airport survey in 2014 similar to one the General Accountability Office conducted in 2010 would likely reveal a much greater number of airports that have voluntarily conducted baseline GHG emissions inventories. A number of airport GHG inventories are in response to stricter state-level GHG reporting regulations, while the majority are voluntarily performed. In researching best practices for airport GHG inventory methods, Volpe developed inventories for two airports, identified and evaluated over two dozen airport GHG inventories, and researched literature on developing airport GHG inventories. Summarized below are findings from this research.

2.1 Gathering Data for the Airport GHG Inventory

Airports conducting a GHG inventory for the first time will face different challenges than those that have prior experience preparing a GHG inventory. Airports interviewed as part of Volpe's analysis stated that establishing lines of communication and collecting information on energy consumption for the first time took significant effort. First-time inventory preparers should consider dedicating staff and resources; establishing data collection systems and liaisons; and defining data inputs and expectations. These proactive activities can save time and improve data quality. Airports stated that once systems were in place to collect data for the inventory (which is typically updated on a regular basis) the data collection and compilation effort was less time intensive.

To further facilitate inventory development, airports may consider initiating data gathering efforts with an announcement or request from a high level official. Consensus among airport staff interviewees was that developing a GHG inventory is much easier once personal connections have been established and lines of communication among airport departments opened.

Once an airport has created a GHG inventory, it should consider formalizing and refining processes for quality assurance and data validation to improve accuracy and precision. For example, Denver International Airport has a utility tracking database software system and uses dedicated liaisons to field inquiries quickly. Now much of the time spent on GHG inventory efforts at the airport is devoted to quality control.

Airports might also recognize development of airport GHG inventories as a low-cost add-on to required airport monitoring and reporting of criteria pollutants emissions in non-attainment and maintenance areas per the EPA Green Book[8] or to conform to air quality regulated emissions.

Volpe's review found that different airports can have different understandings of what GHG emissions sources are Scope 1 versus Scope 3. Examples include employee commutes and fire training. Some airports may categorize these sources as Scope 1 and others as Scope 3. For comparability of GHG inventories across

[8] See www.epa.gov/airquality/greenbook/

airports, it is important to clearly categorize emissions that are under the control of the airport[9] as Scope 1.

2.2 Tools and Methods

There are multiple ways to estimate GHG emissions from each airport source. Some methods require little time, effort, and/or data, whereas other more detailed methods may require considerably more of these inputs. Generally, detailed methods generate more accurate results. In order to decide whether the enhanced accuracy of detailed methods warrants the greater investment, airports may wish to consider the following questions:

- **How large is this emissions source relative to overall airport emissions?** If the source is a relatively small component of overall emissions, it may not be worth investing a great deal of resources to estimate.
- **Is the airport prepared to take actions to reduce emissions from this source?** Investments to better understand a particular emissions source could be very beneficial if the airport is in a position to implement corresponding emissions reduction strategies.
- **Are the data inputs for a particular estimation method currently available, or can the airport easily obtain them?** If not, the airport may need to provide a stronger justification for using that particular method.

Most airports interviewed had a difficult time approximating the percentage of effort required to estimate emissions for each scope. However, one large airport estimated the percentage of labor hours needed to estimate each scope as follows: Scope 1, 30 percent; Scope 2, 50 percent; Scope 3, 20 percent.

For Scope 1 and 2 emissions at airports, Volpe evaluated two Excel spreadsheet-based tools: the ACI ACERT and the Federal Energy Management Program (FEMP) tool. Both tools are easy to use and publicly available at no cost to airports, and both can help reduce the complexities associated with developing airport GHG inventories. Each tool has advantages but overall ACERT would be the most useful for the majority of airports.

ACERT Advantages
The ACERT tool is designed for airports and is thus more tailored than FEMP, which is designed for use by government agencies. ACERT provides a single unified worksheet for Scope 1, 2, and 3 emissions, while FEMP contains a dozen worksheets, some of which are irrelevant for most airports. ACERT provides a means to calculate aircraft emissions, whereas FEMP does not. ACERT provides explicit fields for airport-specific sources such as de-icing fluids, but this must be inferred in FEMP under the fugitive emissions worksheets.

FEMP Advantages
In general, the FEMP tool is more comprehensive than ACERT. No refrigerant or construction fields are

[9] In addition to uniform standards on an emissions source level, there may be a need to standardize the threshold of "influence." For example, in the case of employee commutes, at an airport that offers free parking and thus incentivizes its employees to drive to work, this emissions source could be called Scope 1; whereas at an airport that provides employees with cash commuter benefits and charges market rate fees for parking, it could be called Scope 3.

provided in ACERT, even though these are typical emission sources at airports; FEMP contains comprehensive worksheets that accommodate these sources. The FEMP tool provides specific worksheets for purchased chilled water and combined heat and power, whereas ACERT does not. FEMP also estimates a range of GHG emissions, while ACERT focuses on CO_2.

Figure 2 shows the coverage of the FEMP tool and ACERT in relation to typical airport needs. The text entries describe specific emissions sources, and their locations within the Venn diagram show whether or not they are typical airport GHG sources and whether or not ACERT and the FEMP tool provide means of calculating their GHG emissions. For example, “aircraft” emissions appear within the airport GHG sources circle and the ACERT circle, but not within the FEMP circle.

For Scope 3 emissions, Volpe reviewed the Aviation Environmental Design Tool (AEDT) and other tools, described in Section 2.5.

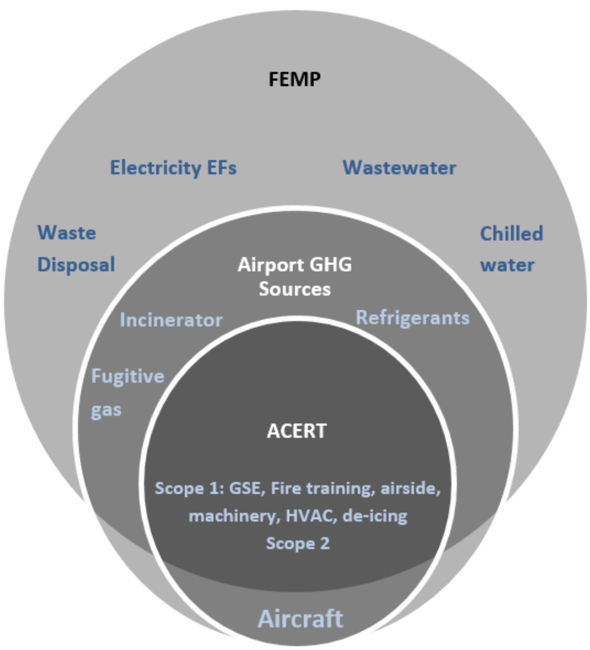

Figure 2: Relationship between GHG Sources Evaluated by FEMP and ACERT, and Airport GHG Sources

2.3 Approaches for Inventorying Scope 1 GHG Emissions

As mentioned earlier, Scope 1 or “direct” emissions are airport-controlled, produced within the airport boundaries, and associated with:

1. Fuel, such as gasoline, diesel, compressed natural gas, propane, jet fuel, or other fuels used to power airport-owned aircraft and vehicles, including GSE, APU, and ground access vehicles;
2. Fuel used to power airport-owned power sources (emergency generators, permanent electricity generation units), building heating systems (boilers and furnaces);
3. Fuel used for de-icing;

4. Refrigerants used in air building air conditioners;
5. Fuels used in fire training;
6. Construction activity.

For airport-owned stationary sources, ACRP 11 recommends calculating GHG emissions using fuel consumption data and emission factors for stationary source units. Fuel purchase records are recommended to be used for fuel consumption.

For mobile sources such as ground access vehicles, ACRP 11 recommends using activity data in conjunction with modeling tools such as EPA's MOVES (formerly MOBILE) or the California Air Resources Board EMFAC tool. This recommendation stems from the potential difficulty airports may have in obtaining fuel records for ground access vehicles. While it may be difficult (or impossible) to obtain fuel records for Scope 3 GAV, airports are often able to obtain fuel records for their own vehicles. For this reason, using fuel consumption to estimate airport-owned ground access vehicles is the most accurate and easiest approach. More information on estimating GAV emissions is provided below in Scope 3 emission section.

For airport owned ground service equipment, ACRP 11 recommends using either fuel-based or activity-based approaches. The fuel-based calculation, in which the gallons of each fuel combusted is multiplied by the GHG emissions factor for the respective fuel, is the recommended and most common method to inventory Scope 1 emissions. Fuel-based calculations are typically easier and more accurate than activity-based calculations, in which the make, model, run time, duty cycle, and other factors are required to estimate the fuel consumption of each piece of airport-owned and controlled equipment. In addition, with activity-based approaches, a modeling tool such as EPA's NONROAD needs to be used once activity data is collected. A more detailed discussion of GSE emissions can be found in the Scope 3 section below on GSE.

The majority of Scope 1 emissions are made up of fuel consumption for highway and nonroad vehicles and stationary sources. Once fuel consumption for these sources has been collected, GHG emissions are relatively easily calculated using one of the publicly available tools such as ACI's ACERT or the FEMP GHG tool. To assist in calculating Scope 1 emissions using an inventory tool such as ACERT, it is beneficial for airports to maintain a database software program for collecting and housing all vehicle fuel logs and utility consumption data for natural gas, fuel oil, propane, or other fuels. In some cases, airports are already collecting this information for air quality reporting purposes (criteria pollutants). In these cases, inventorying Scope 1 emissions is relatively straightforward and involves inputting fuel consumption figures into a calculation tool which applies an emission factor to the fuel quantities. Output sheets display the results of the calculation in GHG tons per year.

Construction-related emissions can be more difficult to inventory since the airport often hires a contractor to perform the work. Thus, fuel records for the machines are not under the control of the airport operator. In addition, construction machines move from job to job and refueling records are not usually precise enough to estimate how much fuel the machines used while at the airport. ACERT does not calculate emissions associated with construction activity. For an airport developing its first inventory, excluding construction equipment emissions may be the best approach. In subsequent years when the airport has a procedure in place for tracking activity, construction related emissions should be included in the GHG inventory.

2.4 Approaches for Inventorying Scope 2 GHG Emissions

Scope 2 GHG emissions are produced indirectly when airports purchase power from offsite energy sources such as: electricity generation; chilled water; or purchased hot water or steam. As shown in Figure 1, Scope 2 emissions as a percentage of overall emissions can vary considerably from airport to airport. Scope 2 emissions at 13 airports with GHG emission inventories ranged from less than 1 percent to 15 percent of total GHG emissions.

Scope 2 GHG emissions are readily calculated using power demand data and emission factors (in pounds per mWh for electricity for example) from available tools. Although the available tools provide look-up tables that make electricity-related GHG emissions easy to estimate, background information is provided here on the approach. In general, when preparing GHG emission inventories, airports should use emission factors for electricity generation that reflect the emissions associated with regional or local electricity generation rather than using default U.S. values: ACRP 11 recommends that airports use power demand data and local electric emission factors to calculate Scope 2 GHG emissions. The reason for this is that electricity-related emissions vary considerably from power plant to power plant and from region to region. Regions that are heavily reliant on older electricity generating units fired by coal can have emissions that are twice as high as regions that rely on low carbon sources such as nuclear, hydro, wind, solar, and natural gas. This is reflected in the ACRP 11 recommendation that airports use power demand data and local electric emission factors to calculate Scope 2 GHG emissions.

The two tools discussed above, ACERT and FEMP both rely on accurate regional data provided by the U.S. Environmental Protection Agency's (EPA's) eGRID[10] data base which provides regional values. In addition, eGRID references sources on local emissions information for Scope 2 calculations. Each tool calculates GHG emissions using total annual purchased kilowatt hours (kWh) data, which can be entered into the tool in spreadsheet format. Volpe compared the results of the two tools with four airport-developed Scope 2 emissions estimates. Figure 3 compares the airport's own Scope 1 and 2 combined GHG inventories, the ACERT result, and the FEMP result for the airports evaluated. In addition to comparing the four airport-estimated Scope 2 GHG emissions with the FEMP and ACERT results, Volpe prepared inventories for two airports that had not developed GHG inventories. In these two cases, the zero line in the graph represents the FEMP result.

[10] www.epa.gov/energy/egrid

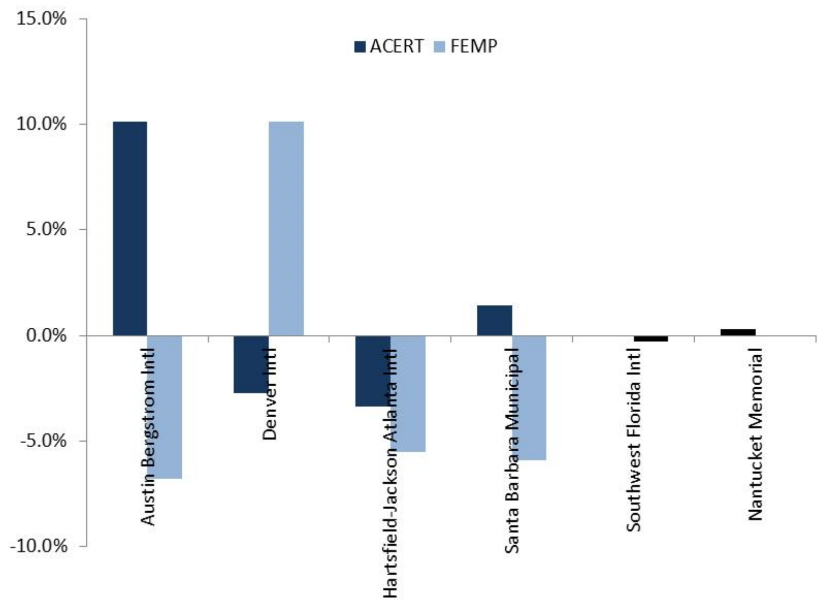

Figure 3: Results of Airport GHG Inventories, FEMP, and ACERT model Results for Scopes 1 and 2 Combined

In the case of the four airports with existing Scope 2 GHG inventories, the FEMP and ACERT results were within 10 percent of the airport's own estimation. For Southwest Florida and Nantucket, where the airport did not prepare its own inventory, the FEMP and ACERT results were less than 1 percent different. Consistent with Volpe's findings, ACERT states that it is an approximation tool and that its "Scope 1 and 2 emissions were within 5-10 percent of those from detailed inventories."[11]

The results of Volpe's analysis show that Scope 2 emissions are easily inventoried, given the availability of accurate annual electricity and other power usage information for an airport that excludes tenant-related electricity usage for restaurants, shops, vehicles, or other purposes. One caveat is that not all airports meter tenant electricity usage separately from airport electricity usage. Since tenant electricity usage is a Scope 3 source, an airport may need to estimate the percentage of electricity used by tenants so this can be excluded from the airport inventory. One airport stated they estimated the tenant share of electricity demand based on the ratio of square footage dedicated to tenant operations versus airport-owned operations.

Volpe found ACERT was simpler to use for estimating Scope 2 GHG emissions than the FEMP tool. However, ACERT allows an airport to calculate GHG emissions from purchased electricity, steam, and hot water but not chilled water. If an airport purchases chilled water, then the FEMP tool can be used to estimate GHG emissions from this energy source. In addition, ACERT estimates emissions for CO_2 but not CH_4, N_2O and other GHG sources. FEMP provides an estimate of emissions from these additional GHGs which will make the inventory slightly more accurate. However, CH_4 and N_2O typically comprise only a small fraction (approximately 3 percent) of the overall GHG inventory, while the use of two models increases complexity for an airport.

[11] See ACERT ver.2 flyer at www.aci.aero/About-ACI/Priorities/Environment/ACERT.

2.5 Approaches for Inventorying Scope 3 GHG Emissions

Developing an inventory of Scope 3 emissions can be challenging given the variety of emissions sources included in this category and multiple data sources required to undertake the estimation. Here too, as with Scope 1 and 2 however, recently developed tools and models designed for airport use can greatly simplify this effort and provide airports with accurate inventories of Scope 3 GHG emissions. The use of these simplified approaches substitutes for the airport or airport consultant's use of complex modeling tools, such as the EPA MOVES or NONROAD models, and for some sources AEDT, thus eliminating a large portion of the complexity associated with the GHG inventory. However, airports will still need to collect the vehicle activity or fuel data that serves as the basis of the GHG inventory. Approaches for each type of Scope 3 GHG emissions are described below.

2.5.1 Aircraft

ACRP 11 provides three alternative methods for estimating aircraft emissions, of which Method 2 is indicated as the preferred approach:

- **Method 1** uses airport fuel sales data for all departing flights to calculate emissions;
- **Method 2** combines fuel sales with available modeling tools (AEDT/Emissions and Dispersion Modeling System (EDMS)) to calculate LTO GHG emissions separately from cruise operations. This preferred Method 2 relies on FAA models and data; and
- **Method 3** also relies on FAA data and fuel consumption models (such as AEDT or EDMS) to estimate fuel consumption and associated GHG emissions.

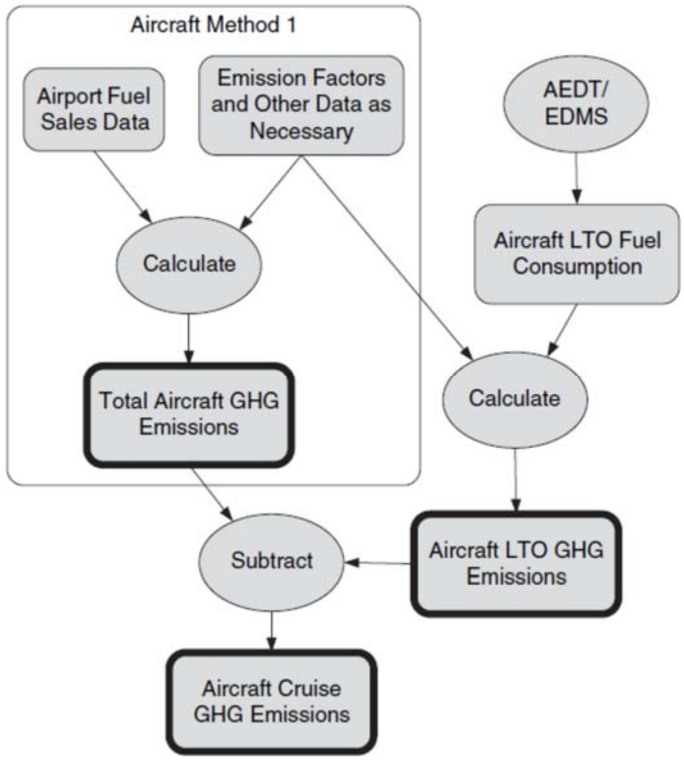

Figure 4: Preferred Method for Calculating Aircraft GHG Emissions from ACRP 11

Based on the three ACRP methods, Volpe compared four approaches for estimating aircraft GHG emissions using combinations of available data sources together with the ACERT and AEDT in order to determine the simplest method which also provides accuracy:

- **AEDT**: Aviation activity data (both LTO and cruise) using the AEDT (ACRP 11 method 3);
- **ACERT fuel**: Aviation gasoline and jet fuel sales data and the ACI ACERT tool (ACRP 11 method 1);
- **ACERT detailed aircraft**: Aviation activity data and the ACERT tool (detailed method);
- **ACRP 11 method 2**: Fuel consumption data (ACERT calculation) *and* AEDT results to separate LTO and cruise emissions.

The results of these different approaches were then compared to one another and, where data were available, to the result obtained by the airport or airport's consultant in their GHG inventory.

In choosing a method to estimate aircraft emissions, an airport needs to consider data availability, in-house expertise in the use of modeling tools, and the level of effort that can be devoted to the inventory. The estimated level of effort involved in the four methods evaluated in this study ranged from days to weeks. The fuel-based ACERT method only required referencing the fuel sales data from the airports, converting them to metric units, and manipulating a few cells in the ACERT tool. This method is the fastest of all options evaluated in this study. Significantly more effort, however, was involved in using the ACERT detailed aircraft method. The ACERT detailed aircraft method requires that all aircraft types operated at the target airport in the inventory year be classified among 136 categories, each with their own emission factors within the tool. Not only does this effort require time and research but aircraft may not be classified the same way by different people using the tool.

If an airport has access to historical aircraft activity modeling runs (EDMS or AEDT for example), then estimating aircraft GHGs based on activity via AEDT takes very little time, as the operation only involves a database query. The U.S. DOT maintains a database of aircraft CO_2 and fuel consumption data (LTO and cruise) for individual U.S. airports and can query the database for airports. For airports using AEDT for the first time, gathering the data for and running AEDT can take considerable time and effort.

Based on Volpe's experience, and given the recommendations of ACRP 11, if an airport can readily access AEDT modeling results for their facility, AEDT is a reliable and effective way to estimate aircraft GHG emissions:

- AEDT is the only available method that could generate both LTO and cruise emissions in a single step, without the need for additional data entry into a second tool, such as ACERT;
- The model is continually updated, providing robust and up to date GHG estimates based on the current aircraft and engine fleet, as well as current airport characteristics; and
- CO_2 inventory data already exist for many U.S. airports, and thus no data collection on the part of the airport would be needed.

Alternatively, for airports that do not have access to aircraft emissions estimated with AEDT or another model, it may be easiest and least expensive to collect fuel consumption data and apply emission factors in ACERT to calculate aircraft GHG emissions. Based on Volpe's analysis of 11 airports, this approach appears to yield accurate inventory results for a majority of airports with little effort, as seen in Figure 5. Percent differences between the ACERT and AEDT result are shown above the two bars for each airport in the figure. The results are relative to ACERT. For seven of the 11 airports, results using the ACERT fuel method were within 10 percent of the AEDT result. For four airports, results were less consistent: three have results for ACERT that were within 20 to 35 percent of AEDT, and for one airport, CO_2 was 60 percent lower with ACERT than AEDT. Still, the close relationship seen in Figure 5 between the ACERT fuel method and the AEDT results for the majority of airports indicates that calculating aircraft GHG emissions from fuel consumption may be a cost effective approach for airports without the ability to undertake modeling.

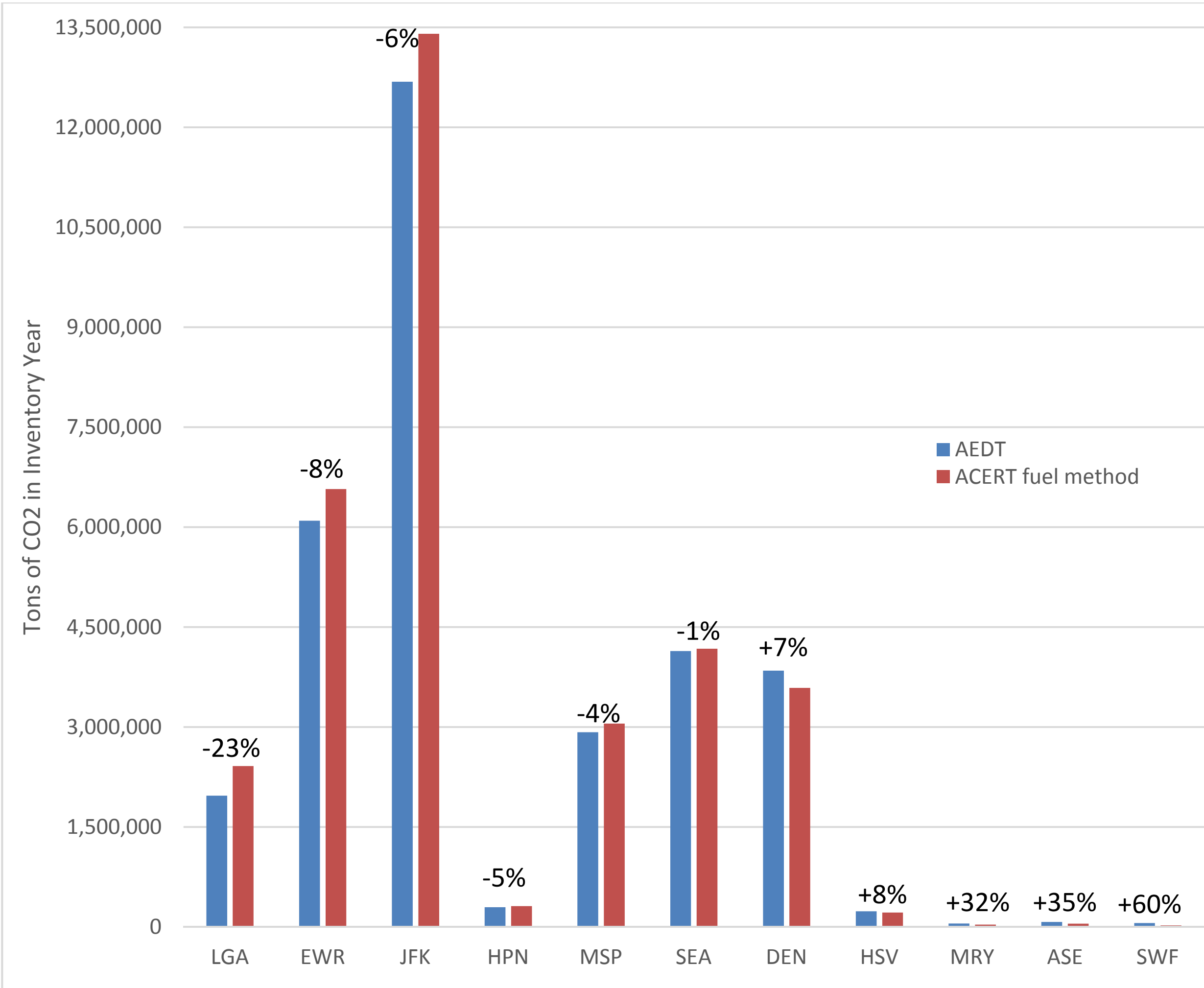

Figure 5. Comparison of 11 Airport Aircraft GHG Emissions Inventories Using AEDT and ACERT Fuel Method

2.5.2 Auxiliary Power Units

ACRP 11 recommended two approaches to estimating APU-related GHG emissions. A third approach is also described here as an alternative. ACRP 11 recommends the fuel method for calculating APU-related GHGs. In this method, the volume or mass of JetA used to power aircraft engines is collected by the airport. Since JetA is also used to power the APU units, the GHG emissions from APU usage is captured when the GHG emissions associated with the fuel use is calculated. The drawback of this approach is that APU-related GHGs are not separated from aircraft engine emissions.

The alternative, second method recommended by ACRP 11 includes the first step described above. GHGs from jet fuel usage are calculated but in a second step, aircraft GHGs are calculated using a model such as AEDT for aircraft LTO. Then the LTO emissions are subtracted from the fuel emissions. The difference will be the APU-related GHG emissions.

A third method is to use ACERT to estimate APU-related emissions. In ACERT, there are default values for taxi time and APU operation before and after flights. ACERT has a default value of 5 minutes of taxi time and 10 minutes prior to take off and after landing. Based on this assumption, the model applies emission rates and emission factors to the assumed activity data and calculates total APU-related GHGs. While APU-related GHGs are small relative to emissions from the main aircraft engines, longer APU operating times could result in much higher GHG emissions than is assumed by ACERT. ACERT does, however, allow the user to input taxi times for individual airports. Therefore, if an airport is able to collect APU operating times from tenants, it is optimal for the purposes of developing the GHG inventory to use this airport-specific data in ACERT.

AEDT also allows a user to estimate GHG emissions associated with APU. However, there are no default operating times in AEDT and so the model is more complex to use for the APU GHG estimation. Unless the airport operator or its contractor is already running AEDT, it is sufficiently accurate and much easier to use ACERT for APU calculations.

Volpe reviewed the approaches that 12 domestic airports have used to estimate APU GHG emissions and found that they spanned the three methods noted above. Other airport GHG emissions reports that Volpe reviewed did not mention APUs (e.g. Huntsville International (2010))[12] or noted that APUs were not assumed to operate while aircraft are at their gates due to landline power being provided, e.g., John Wayne Orange County (2014).[13]

[12] Greenhouse Gas Emissions Inventory for the City of Huntsville and Madison County, Alabama. 2010. www.hsvcity.com/natres/Madison_County_AL_GHG_2010_Inventory.pdf
[13] www.ocair.com/communityrelations/settlementagreement/docs/DEIR617/Appendices/AppendixE-Greenhouse-Gas-Technical-Report.pdf

Table 2. Approaches to Estimating GHG Emissions from APUs

Apply EDMS defaults for average APU types and operating times	BOS FAT HPN MRY
Use airport-specific APU operating times	MSP SFO SDI
Jet fuel consumption analyzed as a part of overall aircraft emissions (ACRP 11 Method 1 or 2)	*Method 1* ATL DEN *Method 2* PHL SEA
APUs not assumed to operate due to landline power provided	SNA

Many airports, particularly medium- and large-sized airports, are increasingly installing preconditioned air and gate power at a majority of boarding areas, reducing the need for the use of APUs. This shifts APU-related emissions ownership to the potentially cleaner (depending on regional electricity production assumptions) Scope 2 realm. At airports where APUs are used and GHGs from them have been estimated, no one approach to accounting for APU GHG emissions emerged as most prevalent.

2.5.3 Ground Support Equipment

To calculate GHG emissions for Scope 3 GSE, ACRP 11 recommends using estimated activity levels (usage hours) for each piece of GSE, multiplied by the emissions factor for each respective make and model. ACRP 11 recommends using EPA's NONROAD model to calculate GSE-related GHG emissions. An alternative approach is to use fuel sales data and emission factors, provided that fuel sales data are available. Using this method, diesel, gasoline, compressed natural gas and other fuel sales in gallons are multiplied by GHG emission factors specific to the fuels.

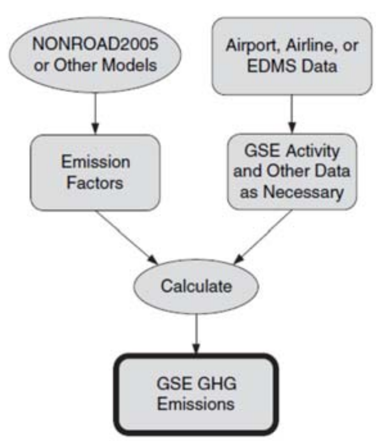

Figure 6. Graphic Showing GSE Method Preferred by ACRP 11

Of the airports reviewed for the GSE analysis, two used fuel usage data and two used EPA's NONROAD model. Denver International Airport used GSE fuel sales data and fuel-specific emissions factors from The Climate Registry to estimate total CO_2, N_2O, and CH_4 for GSE sources. The fuel sales data did not include fuel delivered independently by tenants to their hangars or other facilities. Santa Barbara Municipal Airport used information from a survey on GSE fleet mix, operating characteristics, engine type, and fuel type; operating times from EDMS5.0.2; and gasoline and diesel usage information from annual records.

Seattle Tacoma International Airport used NONROAD2005 to develop a range of emission factors associated with various horsepower ranges of nonroad equipment which were used as surrogates for GSE. Seattle Tacoma then applied the emission factors to (1) GSE operating times and fuel type data collected in a 2000 survey and (2) default data for GSE in EDMS. GSE emissions were computed as the product of each vehicle type's total hours of use, horsepower, emission rate, and load factor. Westchester County Airport used two methods to collect data on tenant GSE: (1) Tenants were given forms requesting information on their GSE inventories in order to verify (2) data collected directly from GSE at the beginning and end of the year. Fuel flow in grams per horsepower-hour was obtained from the EPA's NONROAD model. Using the fuel type and horsepower rating of the engine, an appropriate fuel flow was identified for each GSE and converted into gallons per horsepower-hour. The total volume of fuel consumed was calculated as a product of the fuel flow and total hours of operation of each GSE. If only odometer readings were available for a GSE, the total mileage was converted to hours using EPA's combined highway and city fuel efficiency for the specific vehicle. The total fuel consumption was then used to calculate the GHG emissions.

The ACERT results for GSE emissions, which were fuel-based, were principally the same as the estimates the airports obtained in their respective, detailed inventories. ACERT only slightly overestimated GSE emissions for each of the airports, below 4.4 percent, as shown in Figure 7. These data suggest that using ACRP 11's Method 1 in tandem with ACERT is a viable alternative to conducting detailed GSE emissions inventories for those airports unable to do so.

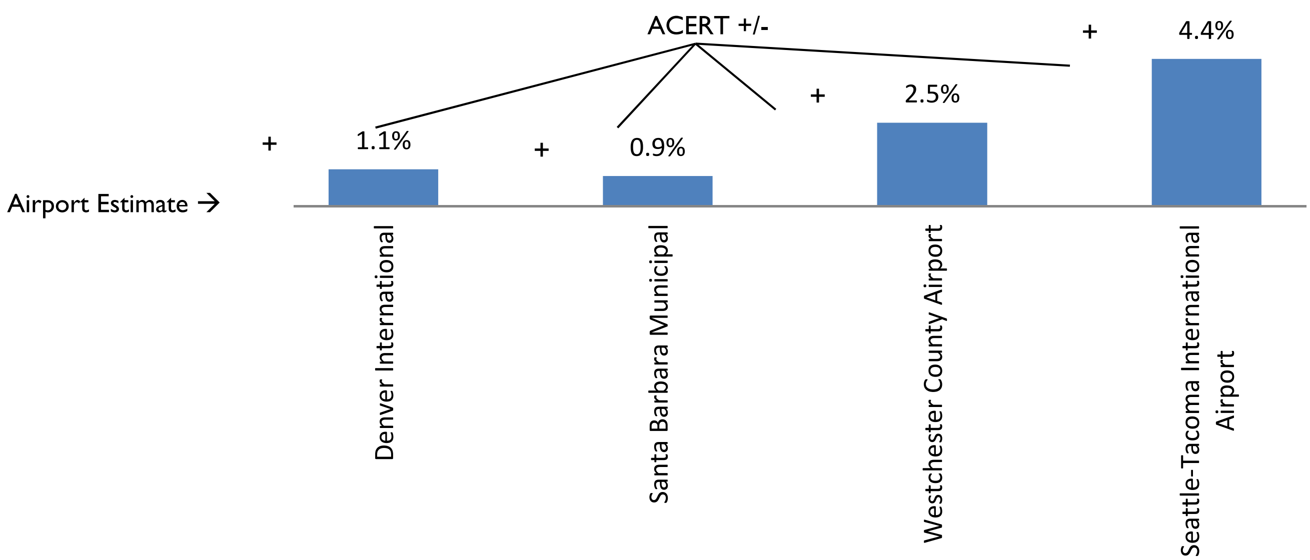

Figure 7. ACERT Emissions Estimates Relative to Airport Estimates

2.5.4 Ground Access Vehicles

Ground access vehicles, or GAV, are vehicles that transport people to, from, or within an airport. According to ACRP 11, Scope 3 GAV include vehicles that the airport does not directly own or control. They may be controlled or owned by airlines, aircraft operators, tenants, or the public.

ACRP 11 provides three alternative methods for GAV emissions estimates (on a spectrum from least to most detailed) and recommends the second one in this list:

- **Method 1** uses average vehicles miles travelled (VMT) and average vehicle emission factors (for all vehicle types combined).
- **Method 2** uses category-specific VMTs and estimated emission factors (categories may be based on vehicle type, size, age, mileage, emissions control, and fuel type).
- **Method 3** combines category specific VMT data with a model, such as EPA's MOBILE6.2 to calculate specific emission factors and thus GHG emissions.

The ACERT tool provides a simpler estimation method that does not require the user to estimate VMT, and it also provides a VMT-based estimation method that falls within the description of the ACRP 11 recommended "Method 2," described above. Although the simplified ACERT method is less time and resource-intensive, it also appears to be less accurate; a preliminary comparison using data from one airport suggested that the simplified method may overestimate emissions. Additional case studies and comparisons for other airports could help to show whether or not this is a common and generally applicable trend for the GAV component of ACERT or whether it is an anomaly.

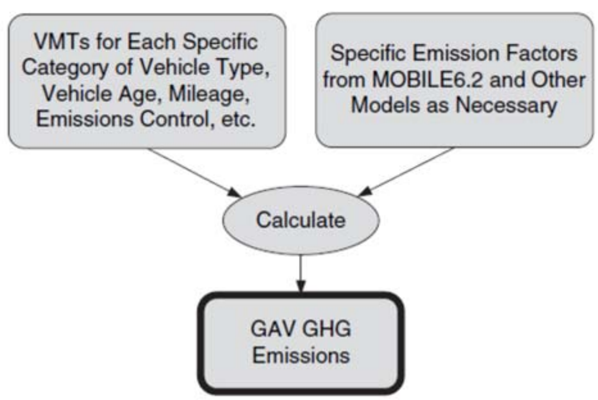

Figure 8. Preferred ACRP 11 Method for GAV GHG Inventory

2.5.4.1 Required Data

Most methods require an estimate of VMT as a primary data input, which typically requires detailed records or counts of vehicle traffic and an estimation of the distance traveled to and from the airport. There are a variety of methods to estimate the former (counts of vehicle traffic) as well as the latter (distance traveled to and from the airport). For example, Boston Logan International Airport obtained vehicle counts by installing automated traffic counters at all airport entrances and exits. The airport turns the raw traffic count data into estimates for VMT through the use of a microscopic traffic simulation model of the 2007 Logan Airport; the airport does not include off-airport GAV emissions in its calculations.

The Hartsfield-Jackson International Airport in Atlanta estimated GAV VMT by studying traffic patterns during one particular week (known to be a peak week for traffic). The airport then extrapolated from that to derive an estimate of VMT for the entire year. The peak week transportation study included a traffic count and a survey of passengers to ask about the origination of their travel. By combining the data from the count and the survey, the airport was able to estimate the average distance people travel to get to the airport. After estimating VMT, the airport used emissions factors from the EPA *Climate Leaders GHG Inventory Protocol Module Guidance: Optional Emissions from Commuting, Business Travel and Product Transport*.[14]

As an alternative to doing primary data collection, the Denver International Airport was able to obtain relevant vehicle activity data from the local metropolitan planning organization.

2.5.4.2 Comparison of Methods

Volpe used GAV data from Hartsfield-Jackson International Airport in Atlanta to compare the results that may be obtained from various methods:

- Atlanta 2012 inventory results;
- ACERT simplified estimate (using distance to city center as a proxy for average travel distance to the airport);
- ACERT simplified estimate (using average distance from traveler surveys);
- ACERT detailed estimate, which is equivalent to ACRP 11 Method 2 (using distance to city center); and
- ACERT detailed estimate, which is equivalent to ACRP 11 Method 2 (using average distance from traveler surveys).

Figure 9 shows the percentage deviation from the Hartsfield-Jackson Atlanta airport estimate for each of the ACERT generated estimates. As compared to the simplified estimates, both of the detailed ACERT estimates were much closer to the values produced in the detailed Atlanta airport GHG inventory. However, the simpler of the two detailed estimates (the one that used the distance to city center to calculate VMT for passenger vehicles) deviated much more than the estimate that used the weighted adjusted average distance based on travel survey data. The importance of estimating a more accurate average travel distance may depend on the surrounding land-use patterns for a particular airport. Atlanta has a sprawling, suburban development pattern, so in this case simply using the distance to city center to estimate VMT may compromise accuracy more than for a dense city with more concentrated development. Additional case studies and comparisons for other airports could help to show whether this hypothesis is correct.

[14] www.epa.gov/climateleadership/documents/resources/commute_travel_product.pdf

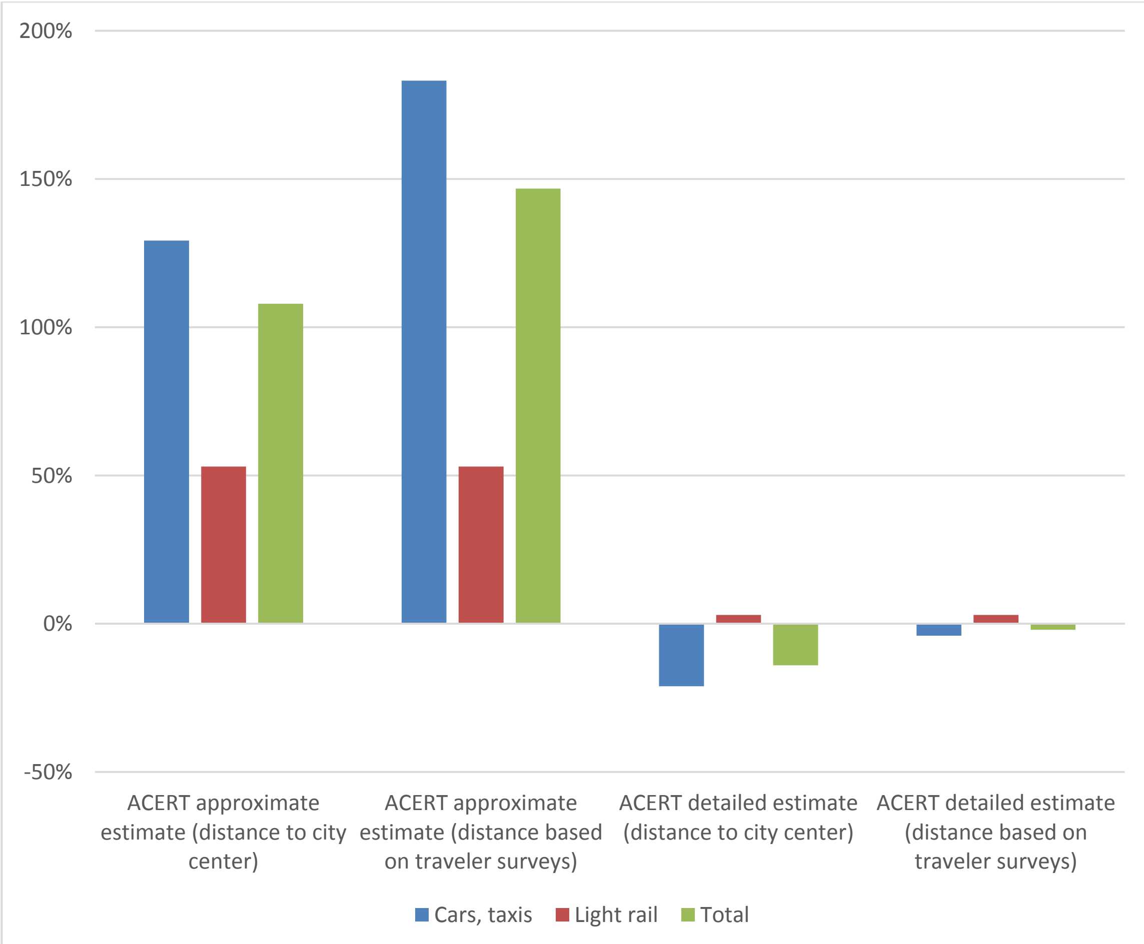

Figure 9. ACERT Emissions Estimates for GAV Relative to Atlanta Airport Estimates

Although the detailed ACERT estimates appear to be much more accurate (within 20 percent) than the approximate estimates, they also require more initial preparation because the airport must estimate VMT for each vehicle type prior to using ACERT. As described above, it is complicated to estimate VMT for specific vehicle types, and airports have used a variety of approximation methods to attempt this. Another alternative approximate estimation method for GAV GHG described in ACRP 11 is to estimate a composite VMT for all vehicle types and then use a generic emissions factor to estimate emissions (Method 1 described above). ACERT does not provide a way to input generic VMT data, but if an airport had a generic value for VMT available, staff could easily do this simple calculation outside of ACERT.

3 Voluntary Reporting Frameworks

Several nonprofit organizations operate voluntary reporting frameworks that allow airports to submit their GHG inventory results. Airports may choose to report GHG inventory results to a voluntary reporting framework for a variety of reasons. Each framework varies, but benefits may include:

- Demonstrated legitimacy of reported results, especially when a framework requires third-party certification;
- Publicity, especially if the framework allows airports to post inventory information online in a publicly-accessible, searchable database;
- A reporting tool that facilitates calculations and/or organization of the data and results;,
- Suggested inventory methods;
- Potentially attracting airport improvement funding from federal, state, local, and other sources since the airport could be seen as proactive/progressive.

There are a variety of voluntary reporting frameworks, but only a few are most relevant for airport GHG inventories. These include the ACRP 11, ACA, and the Carbon Registry (TCR). ACRP 11 differs from the other two in that it provides guidance but does not provide a central mechanism to collect, verify, publish, or house inventories. In contrast, ACA and TCR both provide a means for airports to report their inventories to a central body. ACA provides a reporting framework and optional spreadsheet calculation tool (ACERT) which are both designed specifically for airports. TCR is a reporting framework that is not specific to airports, but there are a number of airports that have reported through it.

4 Next Step: Reducing GHG Emissions

Currently over 150 airports worldwide have registered with the ACI Airport Carbon Accreditation program: 20 airports worldwide are accredited for carbon neutrality with this program, with more than 130 others accredited for inventorying and reporting their baseline GHG emissions. [15] Seattle Tacoma International Airport is the first U.S. airport certified to Level 2 ("demonstrated Carbon reductions" by 8 percent in the past 3 years), and it has also developed plans for Level 3 certification ("demonstrated reductions plus optimization with partners.")[16] In the case of these airports that have registered, carbon neutrality is limited to sources under the control of the airport, or "Scope 1 and 2" emissions.

Volpe's report entitled "Achieving Airport Carbon Neutrality" provides a guide for airports wishing to reduce or eliminate GHG emissions from existing buildings and operations.[17] In many cases, airports are pursuing one approach to reduce GHGs, such as installing renewable energy or purchasing offsets, but are not taking advantage of the full suite of tools available to reduce GHGs and energy consumption. Reaching carbon neutrality typically requires the use of multiple mechanisms to first minimize energy consumption and then maximize renewable energy use. The guide offers a flexible, step-by-step outline for planning and achieving airport carbon emissions reduction or neutrality that builds on existing resources such as ACRP Report 56.[18] The steps include:

- Conducting background research and inventory airport GHG emissions;
- Determining the scope of the carbon neutral airport project;
- Contracting with an energy services company (ESC);
- Implementing renewable energy;
- Purchasing offsets if needed; and
- Communicating project results.

Although the above six steps are recommended to reach carbon neutrality in the guide, an airport does not need to undertake each step in this process. Should an airport want to reduce GHGs but not necessarily reach carbon neutrality, the guide provides intermediate steps toward carbon neutrality that an airport wanting to minimize effort and risk could choose to take. For example, an airport could opt simply to purchase offsets such as Green-e (electricity generated from renewable energy and marketed by utilities) and skip the other carbon neutral steps outlined in the report.

If the airport wants to undertake a more comprehensive GHG reduction effort or even reach full carbon neutrality, the first step the airport should take would be to carry out initial research and due diligence. This research may include a review of: the airport's existing contractual and financial obligations; potential conflicts with natural or cultural resources on airport property; and other potential barriers to an energy services

[15] See totals at www.airportcarbonaccreditation.org/airport/participants.html.
[16] http://aviationbenefits.org/newswire/2014/09/sea-tac-airport-first-airport-in-north-america-to-have-airport-carbon-accreditation/
[17] http://ntl.bts.gov/lib/56000/56800/56886/Achieving_Airport_Carbon_Neutrality.pdf
[18] http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_056.pdf

contract or the siting of renewable energy facilities on airport land. Additionally, the airport should determine at the outset which scopes of GHGs to address in the neutrality project.

Once initial research is complete, the airport should select the best option for establishing an ESC contract to minimize energy consumption in a way that also minimizes upfront cost to the airport. In some cases such a contract can also be used to implement on-site renewable energy production. The report guides an airport through the steps of selecting a favorable ESC contract, including a comparison of the different contracting mechanisms; how to evaluate procurement methods and solicit a proposal; and how to select the best proposal and enter into the contract.

The ESC is responsible for implementing energy conservation measures (ECMs), which reduce the airport's energy consumption. However, the airport should be in frequent communication with the ESC and any other entities that have jurisdiction to secure financing for the project. Should the airport wish to reduce electricity consumption from plug loads—which are not addressed by the ESC—this would be the airport's responsibility, and the workflow for this approach is discussed.

The ownership and financing of ECMs have significant implications for lifecycle cost, contractual obligations, and administrative burden. For example, if an airport elects to use an energy services agreement (ESA) or managed energy services agreement contract to complete projects, financing will not be necessary. However, if an airport chooses to use an energy services performance contract or another mechanism, third-party financing may be necessary. There are a number of implications and factors the airport should consider in choosing financing mechanisms.

In addition to ECMs, an airport may also consider pursuing on-site renewable energy production. In one common approach, the ESC is responsible for analyzing the potential for on-site generation, evaluating financing options, and completing all necessary permitting. However, if the ESC is not covering renewable energy as part of the contract, the airport would need to analyze all of this on its own. In this case, the airport will need to evaluate on-site renewable energy production potential, including how to use publicly available online estimation tools. A number of types of renewable energy can be evaluated, the most common being: solar photovoltaic, geothermal, and wind. Each of the renewables has factors to consider, such as glare, allowable height of wind turbines, wind conditions, and underground pipe or utility lines. The guide explains how to select financing mechanisms, issue requests for proposals for installation, and begin research on required permits.

Airports may not want to install on-site renewable energy, or in some cases, on-site renewable energy generation and ECMs may not be enough to eliminate all GHG emissions. If this is the case, the purchase of renewable energy credits, utility green pricing, and offsets can be used by an airport to reach carbon neutrality. Once an airport has reached its GHG reduction goals, other considerations, such as communicating the benefits of the carbon neutrality project to the public and certification options for airports that wish to certify to carbon neutrality can be considered.

Appendix A Airport GHG Inventory Summary

Federal and State GHG Reporting							
Program name	**Sources covered**	**Location**	**Scope (1, 2, 3)**	**Method required for calculation**	**GHGs covered**	**Affected airports**	**Voluntary or Mandatory**
Regional Greenhouse Gas Initiative (RGGI)	Power plants over 25 MWh annually	CT, DE, MA, MD, ME, NH, NY, RI, VT	1	Continuous emissions monitor (CEM) per 40 CFR Part 75	CO_2 required SF_6 and CH_4 for offsets	None	M
EPA Mandatory Greenhouse Gas Reporting Rule (MRR)	Stationary sources over 25,000 tons	nation-wide	1	Electronic Greenhouse Gas Reporting Tool (e-GGRT)	CO_2, CH_4, N_2O, SF_6, NF_3, HFCs, PFCs	BOS, DEN, LAX, MSP, ORD, SFO, etc.	M
The Climate Registry	All sectors	U.S. Canada Mexico	1, 2, 3	Climate Registry Information System (CRIS)	CO_2, CH_4, N_2O, SF_6, HFCs, PFCs	BOS[1] SEA PDX JFK LGA EWR etc.	V + M

[1] Mandatory

California Global Warming Solutions Act of 2006	Certain facilities that directly emit GHGs, suppliers of certain fuels and carbon dioxide, electric power entities	CA	1, 2, 3	EPA MRR and California e-GGRT; the California Air Resources Board uses IPCC guidelines and GHG reporting protocol to separate international from domestic aviation emissions, and intrastate from interstate flights	CO_2, CH_4, N_2O, SF_6, NF_3, HFCs, PFCs		
Massachu-setts Environmental Policy Act	Any source filing environmental notification form	MA	1, 2, 3	Building energy modeling, MOVES, ISO emission factors	CO_2 required, and possibly other pollutants	BOS	M
Emissions Inventory Program	Stationary sources emitting criteria pollutants above threshold; electrical power transmission and distribution emitting SF_6; all GHG manufacturing facilities	ME	1	Maine Air Inventory Reporting System (MAIRIS) – Per Chapter 137, Section 5, a seven-step hierarchy for emission estimation methods is provided for various sources.	Criteria pollutants, air toxics, CO_2, CH_4, N_2O, SF_6, HFCs, PFCs	All	M
Maryland Greenhouse Gas Emissions Reduction Act of 2009 (GGRA)	All sectors except manufacturing; aircraft operations	MD	N/A[1]	EPA SIT with data from EIA and FAA's Terminal Area Forecast System	CO_2, CH_4, N_2O, SF_6, HFCs, PFCs	All	V

[1] Not available or not apparent

Minnesota Statute § 216H.021	All facilities regulated under Title V and all facilities with CO_2e emissions exceeding threshold	MN	N/A	Reporters submit data through MN's Consolidated Emissions Data Repository (CEDR)	CO_2, CH_4, N_2O, SF_6, HFCs, PFCs	All	M
NC Division of Air Quality Voluntary Reporting Program	All facilities regulated under Title V	NC	1	Method based on Climate Registry TCR, WRI, and EPA – voluntary reporting via Air Emissions Reporting On-line (AERO) tool	CO_2, CH_4, N_2O, SF_6, HFCs, PFCs	All	V
New Jersey Global Warming Response Act of 2007	Electricity generating units, fossil fuel manufacturers and utilities, and natural gas utilities	NJ	N/A	Best available quantification method from CEM, PEM, Dept. approved and supervised source emission testing performed during reporting or prior year, mass/material balance, AP-42 or other EPA-approved emission estimation method, manufacturer's estimate, industry council or organization emission factor	CO_2, CH_4	None	M
New Mexico Greenhouse Gas Emissions Reporting and Quantification Procedures (20.2.73 NMAC)	All facilities regulated under Title V	NM	1, 2, 3 http://www.nmenv.state.nm.us/aqb/GHG/ghgrr_index.html	EPA MMR. NM provides Emissions Quantification Procedures that describe the requirements (e.g., calculation methods, emissions factors) for mandatory GHG emissions reporting. For sources not covered by Title V, entities must use web-based Air Emissions Inventory	GHG emissions and criteria and hazardous air pollutants	All	M

				Reporting.			
OR Department of Environmental Quality Greenhouse Gas Reporting Requirements (349-215-0010)	Entities releasing more than 2.5k metric tons of CO_2e annually; suppliers of fuels and electricity	OR	N/A	EPA MMR; entities use OR's EZ-Flier tool	CO_2, CH_4, N_2O, SF_6, HFCs, PFCs	All	M
Pennsylvania Climate Change Act of 2008 (Act 70)	All	PA	1, 2, 3	Pennsylvania has endorsed the following voluntary offsets registries: Climate Action Reserve and the Gold Standard Foundation.	CO_2, CH_4, N_2O, SF_6, HFCs, PFCs	All	V
Inventory of Voluntary Actions to Reduce Greenhouse Gases	Any direct emissions source owned or leased by business or government entities in TX	TX	1	Entities interested in reporting voluntary actions to reduce GHG may provide emissions reduction data using a spreadsheet-based Voluntary GHG Report Form.	CO_2, CH_4, N_2O, SF_6, fluorinated gases	All	V
Washington Administrative Code 173-441	Entities emitting more than 10k metric tons of CO_2e annually, suppliers of fuels equivalent to at least 10k metric tons of CO_2e annually, and vehicle fleets emitting more than 2.5k metric tons of CO_2e annually	WA	1	EPA MRR - eGGRT	CO_2, CH_4, N_2O, SF_6, NF_3, HFCs, PFCs	M: Any exceeding reporting threshold V: All	V + M
Wisconsin Chapter NR 438	Entities emitting 100k or more tons of CO_2 annually	WI	1	Compilation of Air Pollutant Emission Factors, AP-42, USEPA-OAQPS	PM_{10}, SO_2, NOx, CO, VOC	All	M

Voluntary Airport GHG Inventories							
Airport name	**Sources covered**	**Location**	**Entity preparing inventory**	**Method**	**GHGs included**	**Year reported**	**Voluntary or Mandatory**
Atlanta	Stationary and mobile sources	GA	City	ATL is currently developing a comprehensive GHG inventory to include emissions from airlines and secondary sources. Expected completion: 2014	n/a	2008-2010	V
Aspen Pitkin County	Facilities, private and commercial aircraft	CO	City	11 Excel worksheets that document data sources, assumptions, caveats, calculations, and methodologies were uses to inventory CO_2 emissions for Aspen, CO	CO_2	2004	V
Austin-Bergstrom	Facilities; and aircraft, separately	TX	City	Not specified. Method designed to address local conditions.	CO_2e	2009	V
Burlington	Airport facilities	VT	City	ICLEI's Emissions Analysis Protocol	CO_2e	2007	V
Charlotte	Airport facilities and vehicles	NC	City	Local Government Operations Protocol tailored to local conditions	CO_2, CH_4, N_2O, SF_6, HFCs, PFCs	2008	
Chicago (O'Hare, Midway)	Fuel sold	IL	Center for Neighborhood Tech-nology	ACRP Guidebook	CO_2, CH_4, N_2O, SF_6, HFCs, PFCs	2000 and 2005	V
Denver	Aircraft, airport ground fleet, facilities, and ground access	CO	City	2006 IPCC Tier 1	CO_2, CH_4, NOx	1990—2005	M

Port Authority of NY/NJ (JFK, LAG, Newark, Teterboro, Manhattan Heliport, AirTrain JFK, AirTrain Newark, Kennedy Internationa l Airport Cogeneratio n	Facilities, airlines, container terminals	NY	Port Authority of NY/NJ	2006 IPCC guidelines	CO_2, CH_4, N_2O, SF_6, HFCs, PFCs, NOx, SO_2	2012	V
Lee County	Fuel sold	FL	County	ICLEI-Local Governments for Sustainability	CO_2, CH_4, N_2O, SF_6, HFCs, PFCs	2010	V
Los Angeles (LAX, ONT, VNY)	All on- and off-airport emission sources associated with LAX	CA	Los Angeles World Airports	CCAR General Reporting Protocol, Version 3.1; practices acceptable by EPA, CARB, South Coast Air Quality Management District	Bio-CO_2, NBio CO_2, CH_4, N_20	2012	M
Metropolita n Airports Commission	Aircraft, facilities, electricity, ground access vehicles, ground support equipment	MN	Public corp-oration	Level 2 inventory based on ACRP Guidebook recommendations	CO_2, CH_4, N_2O, SF_6, HFCs, PFCs	2009	V

Philadelphia	Facilities, ground support, fleet vehicles, construction equipment, aircraft, public vehicles	PA	Airport	ACRP Guidebook	CO_2, CH_4, N_2O, SF_6, HFCs, PFCs	2009	V
Port of Portland	Port equipment, vehicles, and facilities; aircraft; ground support equipment; passenger vehicles	OR	Port	Method in accordance with Climate Registry protocols	CO_2	2008	V
Port of Seattle (Sea-Tac, King County)	Ground support equipment, stationary sources, ground access vehicles	WA	Port	Synthesis of methods from 1996 IPCC, EPA, WRI, ICLEI, NONROAD2005	CO_2 is reported, other GHGs tracked	2006	V
Sacramento	Aircraft, ground support equipment, parking, off-airport roadways, all operations	CA	County	2006 IPCC Tier 2; CARB OFFROAD 2007	CO_2, CH_4, N_2O, SF_6, HFCs, PFCs	2007 and 2009	M
San Diego	Aircraft, auxiliary power units, ground support equipment, fuel facilities, stationary sources, motor vehicles	CA	San Diego County Regional Airport Authority	ACRP Guidebook; FAA's EDMS5.1	Criteria pollutants, CO_2, CH_4, N_2O	2009	M
Santa Barbara	Aircraft and operations	CA	County	CARB methods, ICLEI	CO_2, CH_4, N_2O, SF_6, HFCs, PFCs	2012	M

Salt Lake City	Ground activities, facilities, departing aircraft	UT	City	Not specified	CO_2, CH_4, N_20, SF_6, HFCs, PFCs	2009	V
San Francisco	Aircraft and operations	CA	City	BAAQMD' Source Category Methodologies	CO_2, CH_4, N_2O, SF_6, HFCs, PFCs	2010	M