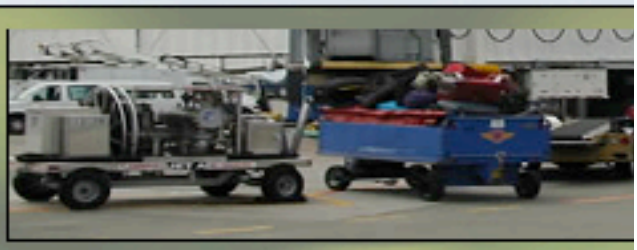
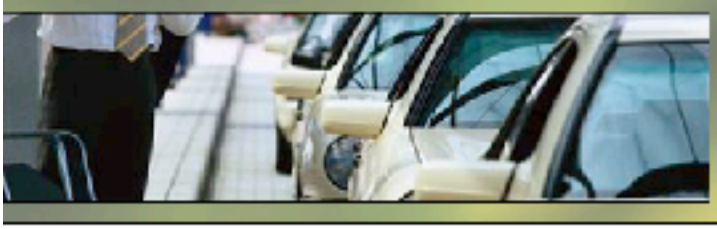
PHL PHILADELPHIA INTERNATIONAL AIRPORT

Greenhouse Gas

Emissions Inventory

Final Report
June 2009


CLEAN AIRPORT PARTNERSHIP Inc.

The Environmental Consulting Group

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1. Executive Summary

Philadelphia International Airport (PHL) is committed to environmental stewardship and exceeding its environmental requirements. Its policy is to fully comply with all applicable environmental rules, laws, and regulations, and to minimize the impacts of its operations and activities. As part of this commitment, PHL has voluntarily developed a baseline greenhouse gas (GHG) emissions inventory, which will guide the Airport in minimizing its climate change impacts and reducing its GHG emissions.

The base year for the inventory is 2006, which was selected during a meeting of the PHL Green Airport Air Quality and Climate Change Subcommittee (12/12/08) as a recent year with readily available data. The inventory includes emissions from sources that are owned and controlled by the airport, emissions from tenant (e.g., airline and rental car) operations, as well as emissions from passengers and employees coming and going from the airport, which the airport only indirectly influences. The protocol used for developing the inventory is based on an April 2009 report by the Transportation Research Board of the National Academies' Airport Cooperative Research Program (ACRP) *Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories*. This report has been included as an appendix so it is readily available for reference.

The ACRP report is a comprehensive protocol developed specifically for airports and is broken down into three categories: (1) airport operator owned and controlled sources, (2) airline, tenant, and aircraft operator sources, and (3) public sources, which include emissions from passenger traffic to the airport. The inventory protocol is based on essential studies published by the Intergovernmental Panel on Climate Change (IPCC), the U.S. Environmental Protection Agency, the World Resource Institute (WRI), and the International Council for Local Environmental Initiatives (ICLEI). Some of the significant assumptions for developing the inventory are based on the recommendations of these groups. For example, the IPCC recommends each airport include aircraft emissions from the airport, as the flight's origin, to its final destination. This will allow other airports, regions, and countries to combine airport inventories without double counting. The inventory also includes emissions from each passenger's full roundtrip travel from home (or other point of origin) to the airport and return, or from the airport to the local destination and back for visitors to the area.

In addition to the sources that routinely operate at PHL, the inventory also includes an estimate for construction vehicle emissions. Information on actual construction activity at the airport was not available, so to illustrate this source category, a forecast for construction emissions during the first year of construction on the Capacity Enhancement Program (2008 activity forecast from the CEP Air Quality Technical Report) was used as a basis. However, since there was no major construction project underway during 2006, 10% of these emissions were assumed to reflect a more likely level of construction activity. This approach is helpful to illustrate the contribution of construction at the airport, although it is only an estimate.

Total GHG emissions for PHL during 2006 were 4.7 million metric tons of carbon dioxide equivalent (CO_{2e}). Most of these emissions are the result of aircraft fuel consumption (4.1 million metric tons of CO_{2e} or 87% of the total) included in the airline, tenant, aircraft operator category. Airport owned and controlled sources were 0.2 million metric tons CO_{2e}, equivalent to about 4.5% of the total inventory. While this seems small relative to the aircraft emissions, it is still in the ballpark of emissions from large commercial businesses. For example, annual emissions from global

operations of Johnson & Johnson are 0.8 million metric tons; Office Depot generates 0.4 million metric tons per year; and Starbucks emits 0.3 million metric tons annually. And each of these inventories represents hundreds, if not thousands, of individual facilities at widely distributed locations compared to PHL activity within the bounds of the airport. The public source category of the inventory is 0.4 million metric tons of CO_{2e}, somewhat more than the airport's portion. Table 1 is a summary of the complete GHG inventory for PHL. Figures 1 and 2 illustrate the breakout of the overall inventory.

Table 1: Philadelphia International Airport Greenhouse Gas Emissions Inventory

2006 Inventory Year User/Source Category	CO_2 (metric tons/year)	CH_4		N_2O		Total CO_{2e} (metric tons/year)	% of Category	% of Total
		metric tons/ year	CO_2 Equivalent, CO_{2e} (metric tons/year)	metric tons/ year	CO_2 Equivalent, CO_{2e} (metric tons/year)			
Airport Operator Owned/Controlled								
Facilities/Stationary Sources	14,723.0	3,122.3	78,056.6	0.0	8.4	92,788.0	44.4%	2.0%
Purchased Facility Power	82,529.0	2.2	54.8	1.4	404.0	82,987.8	39.8%	1.8%
Ground Support Equipment	1,594.7	0.1	2.0	0.0	11.5	1,608.2	0.8%	0.0%
Fleet Vehicles (Shuttles)	3,505.5	0.2	4.3	0.1	26.8	3,536.5	1.7%	0.1%
Construction Equipment	25,565.4	12.6	314.7	6.5	1,950.9	27,831.0	13.3%	0.6%
Total Airport Operator	127,917.5	3,137.3	78,432.5	8.1	2,401.5	208,751.5		4.5%
Airlines/Tenants/Aircraft Operator Owned/Controlled								
Aircraft (including APU)	4,030,503.2	114.1	2,851.5	88.5	26,358.8	4,059,713.5	99.7%	87.0%
Ground Support Equipment	3,796.5	0.5	11.3	0.2	68.2	3,876.0	0.1%	0.1%
Ground Access Vehicles	9,088.4	0.4	11.2	0.2	69.4	9,168.9	0.2%	0.2%
Faciltiy Power (included in Airport)	0.0	0.0	0.0	0.0	0.0	0.0	0.0%	0.0%
Total Airlines/Tenants/Aircraft	4,043,388.0	115.0	2,874.0	88.9	26,496.3	4,072,758.4		87.3%
Public Owned/Controlled								
Public Vehicles	300,779.6	8.9	222.8	12.8	3,814.1	304,816.5	79.5%	6.5%
Shuttles and private vehicles	78,540.2	0.1	1.5	0.1	27.7	78,569.4	20.5%	1.7%
Total Public	379,319.8	9.0	224.3	12.9	3,841.7	383,385.9		8.2%
GRAND TOTAL EMISSIONS	4,550,625.3	3,261.2	81,530.8	109.9	32,739.6	4,664,895.7		100.0%

Figure 1: PHL Airport GHG Emissions Inventory for 2006 (4,329,021 Tons CO_{2e})

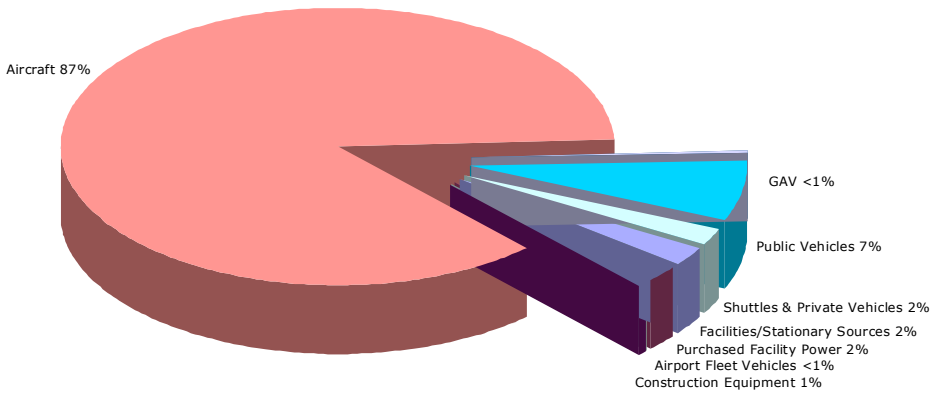
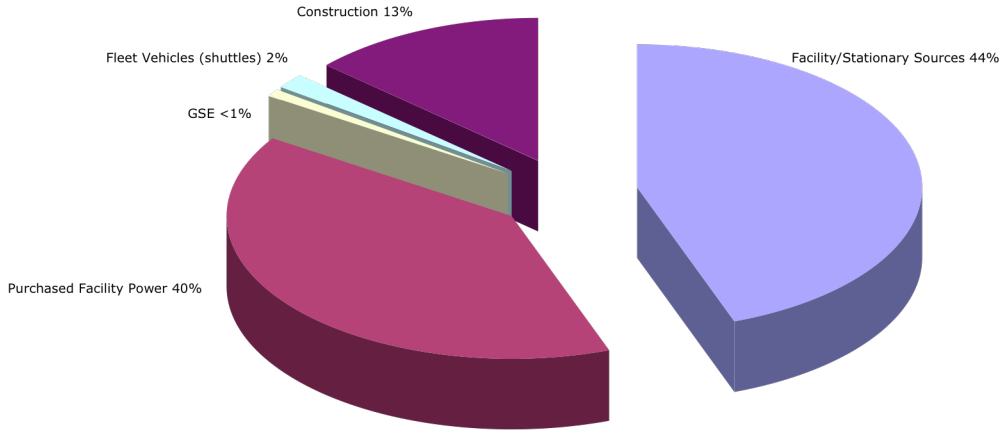


Figure 2: GHG Emissions from PHL Owned and Controlled Sources (208,752 Tons CO_{2e})



In addition to the inventory, a computational spreadsheet used to quantify the inventory is provided to allow airport staff to update the inventory for other baseline years, easily test the inventory's assumptions, and assess the impact of alternative data sources. At the writing of this report, data for some smaller source categories is unavailable (see section 4.4, page 11) and in some cases, data from a different year was the only information available. Where this occurred, the data was adjusted to represent 2006 conditions. For example, to adjust 2005 data to represent 2006 operations, the 2005 data was multiplied by a ratio of 2006 passengers to 2005 passengers (31,768,272÷31,495,385=1.009). All instances of data from a year other than 2006 are highlighted in the computational spreadsheet. Details of the computational spreadsheet are presented in Chapter 5 of the report.

2. Introduction

The potential impact of human activities on global climate is a matter of growing concern. Internationally, this concern led to the 1992 negotiations establishing the United Nations' Framework Convention on Climate Change (UNFCCC) and the subsequent negotiation of the Kyoto Protocol to the UNFCCC that established emission reduction and limitation targets for six greenhouse gases (GHG) emitted as a result of human activities. Although the United States did not ratify the Kyoto Protocol, domestic actions to curb GHG emissions have progressed on several fronts with States and local jurisdictions taking the early lead in setting emission targets. National legislation is now being debated in the US Congress and an aggressive approach to controlling GHG emissions is supported by the President.

In its 1999 report, *Aviation and the Global Atmosphere*,[1] the Intergovernmental Panel on Climate Change (IPCC) reported that the aviation sector is responsible for 2-3 percent of global emissions of GHGs. The combination of anticipated growth in demand for aviation services coupled with emission curbs for major emitters in other sectors has led to projections that aviation's share of global emissions could double by 2050. While the overwhelming majority of the sector's emissions are due to aircraft activity and not airport operations, broad interest in the entire sector's emissions is driving some jurisdictions and airports to develop airport emission inventories. Across the country airports are also becoming sensitized to their climate responsibilities as a result of requests for information coming from their customers and other stakeholders.

Philadelphia International Airport (PHL), like many other airports today, is modernizing and expanding to meet the needs of the flying public. At the same time concerns about the potential for climate change due to emissions of GHG are growing. Cities, states, and regional groups are making commitments to GHG emission reductions. Pennsylvania and Philadelphia are both engaged in climate commitment programs. Philadelphia has made commitments to reduce its GHG emissions as part of the Large Cities Climate Leadership Group, which is supported by the Clinton Climate Initiative. Ten Northeastern and Mid-Atlantic states surrounding the eastern end of Pennsylvania have formed the Regional Greenhouse Gas Initiative (RGGI), a mandatory, market-based effort to cap and reduce by 10% greenhouse gas emissions from the power sector by 2018. Pennsylvania is an official observer to this group and may become a full member in the near future. For these reasons PHL has created a GHG emission inventory to determine the airports climate emissions.

Sources of GHG emissions at typical airports include a variety of sources. They are summarized in Table 2.

[1] IPCC, 1999. "Aviation and the Global Atmosphere." Cambridge University Press, New York, NY.

Table 2: Sources of GHG Emissions at PHL Airport
Airport Sources
• Boilers • Fire Training Facilities • Purchased Electric Power • Emergency Generators • Ground Support Equipment (e.g., snow removal, airport fleet vehicles) • Employee Shuttles • Construction Equipment (e.g., tractors, dozers, trucks, and compressors)
Tenant Sources
• Aircraft engines • APUs • Ground Support Equipment (e.g., baggage tugs, belt loaders, aircraft tugs, ground power units, trucks, and vans) • Rental Car Shuttles
Public Sources
• Ground Access Vehicles (e.g., automobiles, taxis, limos) • Shuttles and Private Vehicles (e.g., rental cars, hotel shuttles

Approaches for quantifying emissions from some of these sources are well defined while methodologies for other sources are less well defined. However, many of these sources, such as aircraft, are not under the direct control of PHL.

It is possible there are CO_2 sinks on the airport; that is, vegetation or other processes that consume CO_2. This is unlikely to be significant relative to the size of the total emissions and these are not accounted for in this inventory.

Waste management, notably recycling, may demonstrate some GHG emission benefits, however, a complete life-cycle analysis of the waste management activities both on and off the airport is required to quantify these impacts. The ACRP protocol recommends that airports not include this emission source.

3. Notes on the Protocol

The purpose of this inventory is to provide PHL with a basic understanding of GHG emissions from airport operations, both those directly controlled by PHL as well as those of tenants and travelers. It is intended to be a comprehensive inventory of all sources and emissions. It will serve as a valuable baseline for tracking GHG emissions changes over time and considering potential national, regional, or local regulation of GHG emissions.

Each of the sources included in the inventory have been categorized so that other types of inventories could readily be prepared. For example, PHL may find it appropriate to develop an inventory for a GHG registration program. These types of inventories typically emphasize only direct emissions, that is those from airport owned or controlled sources, and possibly indirect emissions, which occur away from the airport but reflect the airport's electricity use. A comprehensive inventory of sources and source categorization allows maximum flexibility and use of the information that has been compiled. Source categories are shown in the computational spreadsheet and can be used to create different types of inventories.

This inventory, following the recommendations of ACRP's *Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories*, tracks emissions of the three primary pollutants identified in the Kyoto Protocol, CO_2, CH_4, N_2O. Primarily associated with refrigeration systems, the three halogenated compounds identified in the Kyoto Protocol, SF_6, HFC, and PFC, are not prevalent at airports so represent only a very small contribution to the inventory which captures more than 95% of total GHG emissions associated with PHL operations. The 95% target for closure of the inventory is a common standard supported by most internationally recognized authorities and protocol-development organizations.

Emissions are reported in metric tons (2,200 lbs) per year, which is the international convention used in GHG inventories. In the computational spreadsheet, emissions are often calculated in pounds and then converted to metric tons in the inventory summary. Also, emissions of CH_4 and N_2O are computed in metric tons and then converted to CO_2 equivalent (CO_{2e}). Both values are included in the inventory summary. This allows all emissions values to be combined into totals representing all emissions.

Where possible, computations of emissions relied on fuel use as the input data. This is the most accurate way to compute emissions since all carbon in the fuels is assumed to be converted to CO_2. CO_2 is approximately 70% of a combustion source's emissions, with 30% H_2O, and much less than 1% of all other pollutants. CH_4 and N_2O are components of this final portion although their portion varies by source type. After computing CO_2 emissions, appropriate factors are applied to this amount to estimate CH_4 and N_2O emissions. The factors are summarized in the conversion factors section of the computational spreadsheet.

The GHG protocol follows international guidance on computing emissions. For two sources, aircraft and passenger vehicles, the methods for computing emissions are somewhat different from conventional computations used for NEPA air quality analyses, for example. To ensure consistency among different airport inventories and make it easier to combine airport emissions regionally or nationally without double counting, the protocol includes all aircraft GHG emissions for the departure leg of each flight. This is represented by the amount of fuel loaded onto aircraft at each airport. Also, for passenger travel, the protocol recommends using the full roundtrip fuel use rather than just the fuel consumed on airport roadways. This is to acknowledge that travel to the airport (and back) is associated with a passenger's need to travel.

4. Sources and Data Inputs

This chapter describes the various emissions sources included in the inventory. They are organized according to airport sources, tenant sources, and public sources.

4.1 Airport Sources

Airport sources are those owned by the airport and in the airport's control. They include airport ground support equipment (GSE), contracted shuttle buses, stationary sources, emergency generators, fire training facilities, electric power use, and construction equipment.

4.1.1 Airport GSE

Airport GSE includes airport fleet vehicles and ground service equipment like SUVs (e.g., Ford Explorer and Escape); sedans (e.g., Ford Taurus and Crown Victoria); pickup trucks (e.g., Dodge Dakota and Ford F350); vans, mowers, sweepers, scooters, snow blower trucks, dump trucks, fire trucks, rescue vehicles, tractors, and backhoes. Airport employees or contractors generally operate these vehicles. There were approximately 233 vehicles in service in 2006.

CO_2 emissions from these vehicles are computed based on their fuel use. This equipment is fuelled onsite at stations controlled by the airport. Fuel use information came from PHL. 2006 fuel use was: gasoline 97,252 gallons, diesel 65,723 gallons, and CNG 10,629 gallons of gasoline equivalent (gge).

4.1.2 Contracted Shuttle Buses

Contracted shuttle buses include shuttles that provide employee and passenger transportation to and from the parking lots. There were 25 shuttle buses in service in 2006.

CO_2 emissions from these vehicles are computed based on their fuel use. This equipment is fuelled onsite at stations controlled by the airport. Fuel use information came from PHL. 2006 fuel use was: diesel 345,251 gallons.

4.1.3 Stationary Sources

Stationary sources at the airport include the central utility plant, maintenance building, satellite thermal plant, old terminal building, and international terminal plant, which all have natural gas boilers.

CO_2 emissions from these facilities are computed based on their fuel use. All of this equipment uses natural gas supplied by Philadelphia Gas Works (PGW). Fuel use information came from monthly fuel bills for meters at each building. 2006 natural gas consumption was 2,691,605 ccf.

4.1.4 Emergency Generators

Emergency generators are available to provide back up power in the event the airport looses its electrical power. The generators are tested periodically and run during power outages.

CO_2 emissions from two emergency generators are computed based on their fuel use. The two generators use diesel fuel. Fuel use information was not available as of the writing of this report and is not included in the inventory.

4.1.5 Fire Training Facilities

Emergency response staff must train regularly to be ready for any emergency that may arise at the airport. As part of their training, propane fires are set and extinguished by the staff.

CO_2 emissions from fire training facilities are computed based on their fuel use. Fuel use information came from PHL. 2006 fuel use was: propane 8,404 gallons.

4.1.6 Electric Power Use

Electrical power is used throughout the airport for heating and cooling, lighting, and electric services such as escalators, elevators, and automatic doors. The airport's electric power use includes electricity used by tenants since there is insufficient sub-metering to enable those sources to be broken out separately.

CO_2 emissions, CH_4 emissions, and N_2O emissions are based on EPA's eGRID 2005 data for the eGRID RFC East subregion, which includes PHL, as recommended by the ACRP *Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories*. 2005 eGRID data, the latest available, should be sufficient for creating a 2006 GHG emissions inventory since characteristic emission rates for a geographic region change little from year to year. PHL's electricity is supplied by PECO, which is included in the RFC East GHG annual output emissions rates. Emissions per unit of power output (and hence total emissions associated with airport electricity use) would likely be lower if PECO-specific data were used in view of its high nuclear and wind-generating capacity compared to other utilities in the region.

CO_2 emissions, CH_4 emissions, and N_2O emissions from electric power production required to supply electricity to PHL are computed based on the airport's electric use. Electric consumption information came from monthly power bills by individual meters throughout the airport. 2006 electrical use was 159,728,810 kWh.

4.1.7 Construction Equipment

Emissions from construction activity result from the operation of heavy equipment in the process of grading, paving, cement pouring, materials transportation, and related activities. No data on 2006 construction activity was readily available. To strive for a comprehensive inventory, construction activity was based on modeling completed as part of the air quality analysis for the PHL Capacity Enhancement Program (CEP). Activity data equivalent to 10% of the first year of CEP construction (2008), Alternative A was used to represent construction emissions for 2006.

Fuel consumed by construction vehicles was back-calculated from the modelled emissions and assumed to be all from diesel fuel use. Heavy, medium, and light duty trucks were included in the computations for both on-highway use (e.g., dump trucks, cement trucks) as well as construction site use (e.g., graders and tractors). The calculations assume vehicle idle fuel usage was equal to 10% of moving fuel use. Also, construction worker commuting was assumed equal to 5% of moving plus idling fuel use in construction equipment. All of these assumptions could easily be modified for a future inventory.CO_2 emissions from these vehicles were then computed based on their calculated fuel use of 2,517,916 gallons of diesel.

4.2 Tenant Sources

Tenant sources are those emissions sources that are operated by airport tenants, including airlines, concessionaires, rental car agencies, and similar groups. Many of the sources come from operations on the airport proper; however, this category also includes emissions from rental car shuttles, which operate on and off of the airport. Emissions from rental car trips are included in Public Sources.

4.2.1 Aircraft

Aircraft fuel is the largest source of fuel use and consequently CO_2 emissions at PHL. As noted in Chapter 3, the PHL GHG inventory includes all aircraft fuel use from gate of origin at PHL to the gate at the destination airport. Fuel uploaded to aircraft through the airport's fuel tanks and hydrant system is to represent all fuel used to travel from PHL to destination airports. This is the recommendation of the IPCC and suggested in the ACRP *Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories*. This category includes all commercial service flights.

Airlines do not track APU fuel use separately from main engine fuel use. As a result, APU CO_2 emissions are included with aircraft emissions.

CO_2 emissions are calculated based on fuel uploaded at PHL. Fuel throughput was provided by airlines, a third-party fuel service provider who works for the airlines, as well as the fixed-based operators (FBOs)[2]. 2006 fuel use was: Jet A 421,175,283 gallons and AvGas 48,838 gallons.

4.2.2 Airline GSE

Airline GSE includes baggage tugs, belt loaders, aircraft tugs, cargo lifts, lavatory service trucks, water trucks, ground power units, air start units, and general service trucks. Most of these vehicles operate solely on the airport although some trucks and vans are operated off the airport occasionally.

CO_2 emissions from these vehicles are computed based on their fuel use. This equipment is fuelled onsite on the tarmac adjacent to the terminal gates. Fuel use information came from airlines and fuel service companies employed by the airlines. 2006 fuel use was: gasoline 159,471 gallons and diesel 745,703 gallons.

4.2.3 Ground Access Vehicles

Tenant ground access vehicles include rental car shuttles. These shuttles transport passengers between the airport terminals and the rental car lots.

CO_2 emissions were calculated based on annual vehicle usage (vehicle miles travelled) and estimated fuel economy representative of vehicles in the category. Data used to calculate total VMT for the category came from a DOA draft report, *Evaluation of Rental Car Shuttle Bus Operations*. 2006 fuel use was: diesel 895,105 gallons. (Note: shuttle bus data was reported for 2005 operations, which were adjusted to 2006.)

4.2.4 Stationary Sources/Facility Power

No independent tenant stationary sources were identified for the inventory. Electricity use by tenants is included in airport usage since electricity service to airport tenants is not metered separately.

4.3 Public Sources

Public sources include the vehicles passengers use coming and going to and from the airport, which are divided into two categories. Public vehicles include personal passenger cars and limousines and taxis that passengers use to get to the airport. Shuttles and private vehicles include

[2] Companies reporting fuel use included: Atlantic Aviation, SkyTanking, USA Express, US Airways, and UPS.

all buses, vans, and similar vehicles used to transport passengers from commercial parking lots and hotels. It also includes rental cars.

4.3.1 Public Vehicles

Public vehicles are assumed to be passenger cars. Private shuttles are assumed to be rental car buses and hotel buses. Airport buses, employee buses, and service vehicles are assumed to be part of the airport vehicle fleet.

The ACRP protocol suggests using the full round trip distance for each traveller. For PHL, this distance was assumed to be equivalent to the average round trip distance between the airport and the 14 largest Census Tracts (2000) in Philadelphia (47 miles roundtrip). Average vehicle mileage of 23.9 miles/gallon was taken from EPA data for passenger cars.

CO_2 emissions are based on fuel use computed from the number of vehicle trips, which was taken from the CEP report (2004 data was adjusted to 2006), trip length, and mileage. All vehicle fuel is assumed to be gasoline. The number of private vehicle trips was estimated using annual garage parking, plus the annual terminal traffic at departure and arrival roadways. 2006 fuel use was estimated to be gasoline 33,893,600 gallons.

4.3.2 Shuttles and Private Vehicles

Shuttles and private vehicles include rental cars and vehicles used to transport passengers from commercial parking lots and hotels. The number of rental car trips and commercial parking lot and hotel shuttle trips were estimated from 2004 data from the CEP air quality analysis using annual terminal traffic at departure and arrival roadways. (Note: 2004 data was adjusted to 2006.)

Round trip distance and trip share assumptions are: 35% of trips are from commercial lots 5 miles away on average (10 mile round trip), 15% of trips are from rental car lots 1 mile away on average (2 mile round trip), and 50% of trips are from hotels 13.07 miles (26.14 mile round trip) assuming average distance is distance from airport to city center (13.07 miles as computed by Mapquest using primary, non-Interstate roadways). An average shuttle mileage of 8 miles/gallon was taken from DOE, 2007 for a medium truck. All shuttle fuel is assumed to be diesel.

CO_2 emissions are based on fuel use computed from the number of vehicle trips, trip length, and mileage. 2006 fuel use was diesel 7,735,373 gallons.

4.4 Data Considerations in Inventory

This report is missing data from some minor categories, which was not available during the project. Data from the following sources is not accounted for in the inventory:

- 2006 aviation gasoline and Jet A dispensed by one of two FBO
- 2006 diesel fuel and fuel oil used as back up for natural gas to boilers
- 2006 emergency generator fuel use

Now that a structure and protocol for PHL's GHG emissions inventory has been established, it will be easy to routinely (e.g., quarterly or annually) update the inventory. This will allow the airport to track its GHG emissions. Improvements in certain data categories can also be made. For example, PHL recently installed an AVI system to track commercial vehicle trips through the airport. This will provide much more precise data for computing emissions from these sources. Similar opportunities for other sources will likely arise as well.

5. Computational Spreadsheet

The computations used to quantify GHG emissions in the inventory, as described in the previous chapter, were automated in an Excel spreadsheet. The spreadsheet is available to airport staff to update inputs to calculate an inventory for another year, to reflect alternative assumptions for those computations that were not based directly on fuel use, or to add data that was not available when this report was finalized. Printouts of key sections of the spreadsheet are reproduced in this chapter to aid the reader in better understanding the computational process.

The first page of the spreadsheet is a summary of the airport-wide inventory broken out by category: Airport Operator Owned/Controlled, Airlines/Tenants/Aircraft Operator Owned/Controlled, and Public Owned/Controlled. Emissions of CO_2, CH_4, and N_2O and their CO_2 equivalents (CO_{2e}) are shown for each category as appropriate. Columns for percentage of emissions by category and by total inventory are also shown to illustrate their relative emission contribution.

In the computation summaries, input values are shown with a surrounding border and computed values are shown without. The computed values are then carried forward to the summary table. In some instances, data was not available for 2006 and 2005 data was used as an input and adjusted to reflect 2006. The relationship between annual passengers is used to adjust data from one year to represent another year. For example, where data was available for 2005 only, to adjust it to represent 2006, multiply the 2005 data by (2006 Passengers/2005 Passengers) or 31,768,272/31,495,385 = 1.009. Data for annual passengers for 2003-2008 were taken from PHL Aviation Activity Reports and are included in the spreadsheet for use as necessary. Inputs adjusted from 2005 data are highlighted in the spreadsheet.

Many computations require reference data to convert from one unit of measure to another, to determine the reference CO_2 content of individual fuels, or to convert CH_4 and N_2O emissions to CO_{2e} emissions. These reference values are all included in a worksheet labelled “Conversion Factors.” Source documents are also referenced in this section. Source documents are called out according to publishing agency and year of publication in the spreadsheet as appropriate.

Computational Spreadsheet – Summary

2006 Inventory Year User/Source Category	CO_2 (metric tons/year)	CH_4		N_2O		Total CO_{2e} (metric tons/year)	% of Category	% of Total
		metric tons/ year	CO_2 Equivalent, CO_{2e} (metric tons/year)	metric tons/ year	CO_2 Equivalent, CO_{2e} (metric tons/year)			
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Shuttles and private vehicles	78,540.2	0.1	1.5	0.1	27.7	78,569.4	20.5%	1.7%
Total Public	379,319.8	9.0	224.3	12.9	3,841.7	383,385.9		8.2%
GRAND TOTAL EMISSIONS	4,550,625.3	3,261.2	81,530.8	109.9	32,739.6	4,664,895.7		100.0%

Computational Spreadsheet – Airport Sources 1

Inventory Year **2006**

Airport GSE (includes all airport owned vehicles including snow removal, fleet vehicles, etc.) (~233 vehicles in 2006)

Fuel Use	2006		Emissions	lbs
Gasoline	97,252	gallons	1,902,641	CO_2
Diesel	65,723	gallons	1,471,152	CO_2
CNG	10,629	gge	141,791	CO_2
		GSE Total	3,515,583	

Contracted Shuttle Buses (Includes 25 buses in 2006)

Fuel Use	2006		Emissions	lbs
Gasoline	0	gallons	0	CO_2
Diesel	345,251	gallons	7,728,098	CO_2
CNG	0	gge	0	CO_2
		Shuttle Total	7,728,098	

Stationary Sources

Central Utility Plant, maintenance building, satellite terminal plant, old terminal building, international terminal plot

Fuel Use	2006		Emissions	lbs
Natural Gas	2,691,605	ccf	32,458,068	CO_2
			62	N_2O
			3,122	CH_4

Emergency Generators

Fuel Use	2006		Emissions	lbs
Diesel		gallons		CO_2
		Stationary Sources Total	32,458,068	CO_2
			62	N_2O

Fire Training

Fuel Use	2006		Emissions	lbs
Propane	8,404	gallons	107,613	CO_2

Electric Power

Electricity	2006		Emissions	lbs
Electric power	159,728,810	kwh	181,942,296	CO_2
			4,835	CH_4
			2,989	N_2O

Computational Spreadsheet – Airport Sources 2

Natural Gas Consumption for Heating Plants

Data is provided on a Fiscal Year basis so only consumption for CY 2006 taken from reports for FY2006 and 2007

Meter Number	1986385	1514011	1989655	1,989,656	1954684
First half '06	453,540	374,560	45,245	40,644	182,640
Second half '06	278,160	261,480	49,463	43,169	205,670
Total Year	731,700	636,040	94,707	83,813	388,310

Meter Number	1438471	1426741	1987499	1,722,900	1906651
First half '06	83,912	220,332	250	24,285	66,808
Second half '06	35,350	261,480	0	10,460	37,791
Total Year	119,262	481,812	250	34,746	104,599

Meter Number	1909395
First half '06	10,697
Second half '06	5,669
Total Year	16,365

Electricity Use

Meter	**2006 Usage**	
4701 Island Rd (4203B)	156,997,437	kwh
11 Hog Island Rd ((4205A)	335,400	kwh
8300 Essington Ave (4183A)	63,678	kwh
8401 Executive Ave (4206 A)	1,115,564	kwh
Hog Island Rd (4206B)	864	kwh
8200 Bartram Ave (4207A)	151,876	kwh
4701 Island Ave (4208A)	0	kwh
Tinicum Island Rd (4211A)	18,681	kwh
Hog Island Rd (4212A)	165,216	kwh
Hog Island Rd (4212B)	806,400	kwh
2 Hog Island Rd (4213A)	48,920	kwh
688 Front St (4301A)	62	kwh
8501 Hog Island Rd (4303A)	24,712	kwh
	159,728,810	kwh

Computational Spreadsheet – Airport Sources 3

Construction Equipment

Based on modeling completed in CEP 2004 back calculate fuel consumed by construction vehicles. Assume 2006 construction activity was 10% of this level of activity.
Assume vehicle idle fuel usage equal to 10% of moving fuel use
Assume construction worker commuting equal to 5% of moving + idling fuel use
Use data for first year of CEP construction (2008); Alternative A
Assume all diesel fueled

	Heavy Truck	Medium Truck	Light Truck	
% of fleet (use)	75%	20%	5%	Moving trucks est.
	90%	7%	3%	Onsite trucks est.
Fuel Economy mile/gallon	5.8	8.0	16.2	DOE 2007
NOx Emissions Factors grams/mile	0.38	0.32	0.25	CEP 2004 (for 2010)

Compute grams/gallon

	2.20	2.56	4.05

Fleet average 2.37 grams/gallon Moving trucks
2.28 grams/gallon Onsite trucks

NOx Emissions CEP 2004

Moving trucks	21.5	tons/year
Onsite Equipment	42.6	tons/year

Compute annual gallons of fuel consumed by construction equipment

Moving trucks	8,245,829		
Onsite eqmt	16,933,327		
Total CEP	25,179,156	gallons	Diesel
Estimate 2006	**2,517,916**	**gallons**	**Diesel**

Computational Spreadsheet – Tenant Sources 1

Inventory Year **2006**

Aircraft (includes fuel uploaded at PHL on all aircraft - commercial)

Fuel Use	**2006**		**Emissions**	**lbs**
Jet A	421,175,283	gallons	8,884,692,595	CO_2
AvGas	48,838	gallons	896,421	CO_2
		Aircraft Total	8,885,589,016	

APU Fuel burned in APU is included in the total amount of aircraft fuel.

GSE

Fuel Use	**2006**		**Emissions**	**lbs**
Gasoline	159,471	gallons	3,119,891	CO_2
Diesel	745,703	gallons	5,249,749	CO_2
CNG	0	gge	0	CO_2
		GSE Total	8,369,640	

GAV (includes rental car shuttles)

Fuel Use	**2006**		**Emissions**	**lbs**
Gasoline	0	gallons	0	CO_2
Diesel	895,107	gallons	20,036,082	CO_2
CNG	0	gge	0	CO_2
		GAV Total	20,036,082	

Stationary Sources/Facility Power

Included in airport electric power consumption

Electricity	**2006**		**Emissions**	**lbs**
Electric power	0	kwh	0	CO_2
			0	CH_4
			0	N_2O

2005 data - adjusted

Computational Spreadsheet – Tenant Sources 2

Rental Car Shuttles	Annual VMT* Miles	Bus Type*	Fuel Economy‡ Miles/gallon
Avis	800,153	Gillig, 40ft	2.28
Hertz	642,327	Gillig, 40ft	2.28
National/Alam	721,240	Ford E-450	9.33
Budget	721,240	Ford E-450	9.33
Dollar	484,355	Ford E-450	9.33
Enterprise	450,848	Ford E-450	9.33

* - Annual VMT and Bus Type DOA 2006

‡ - Fuel economy from DOA 2006 with Ford E-450 based on a ratio of Larg CNG to Small CNG times Large Diesel to compute a small diesel fuel economy

Jet fuel	**2005**	**2006**
		421,175,283

Diesel Fuel (GSE)	**2005**	**2006**
		745,703

Gasoline Fuel (GSE)	**2005**	**2006**
		159,471

Aviation Gasoline	**2005**	**2006**
		48,838

Computational Spreadsheet – Public Sources 1

GAV

(includes private passenger vehicles; full round trip from origin to PHL)

Parking Garage Annual Volume — CEP 2004

Garage total	3,238,266
Economy Lot	269,664
Employee Lot	2,388,852

Terminal Annual Volume — CEP 2004

	Departure	Arrival
Termina A - West	469,756	1,210,523
Termina A - East	776,903	
Terminal B/C	903,376	1,499,603
Terminal D	1,264,726	1,047,915
Terminal E	1,391,199	1,734,480
Terminal F	379,418	216,810
	5,185,378	5,709,331

From CEP Table D-8. Assume airport bus, employee bus, and service vehicles are included in airport-owned emissions based on fuel use. Assume passenger car, limo, and taxi. Assume rental bus and hotel bus are private shuttles.

Rental Cars - Hertz and Budget

398,215 — CEP 2004

Total Annual Personal Passenger Vehicles (adjusted to 2006)

17,235,256

Assume each vehicle makes a round trip from the passenger origin to the airport and back.

Round trip distance

47 miles*

Total annual passenger vehicle miles traveled

810,057,044 miles

Average vehicle mileage for the fleet

23.9 miles/gallon — EPA 2005-2

Annual Fuel Use

33,893,600 gallons **gasoline**

*Round trip distance based on the average round trip distance between the airport and the 14 largest Census Tracts (2000) in Philadelphia.

Computational Spreadsheet – Public Sources 2

Shuttles and Private Vehciles

Fuel use assumptions for shuttles and private vehicles

Assume Airport bus, employee bus, and service vehicle mileage is accounted for in airport fuel use.
Assume shuttles and private vehicles includes hotel, rental, and Park-and-Ride buses

Terminal Annual Volume — CEP 2004

	Departure	Arrival
Termina A - Wes	198,743	325,216
Termina A - East	162,608	
Terminal B/C	307,148	542,025
Terminal D	252,946	361,351
Terminal E	343,283	505,891
Terminal F	216,810	198,743
	1,481,538	1,933,226

Total Annual Shuttles and Private Vehicles (adjusted to 2006)

3,635,898

Assume each vehicle makes a round trip from commerical lot, hotel, or rental car lot. Assume all diesel.

Average round-trip travel distance assumptions

35%	Commercial Lot	10	miles	est
15%	Rental Car Lot	3	miles	DOA 2006
50%	Hotel	26.14	miles	
				From city center (Mapquest)

Round trip distance

17.02 miles

Total annual passenger vehicle miles traveled

61,882,986 miles

Average vehicle mileage for the fleet

8 miles/gallon — DOE, 2007

Annual Fuel Use

7,735,373 gallons **Diesel**

Computational Spreadsheet – Conversion Factors and References 1

CONVERSION FACTORS
The conversion factors listed here are used in computation of emissions for all sources.

Unit Conversions

1 pound	0.0004536	metric ton
1 gram	0.000001	metric ton
1 kilogram	0.0001	metric ton
1 Mg	1	metric ton
1 Gg	1,000	metric ton
1 pound	0.4536	kilogram

Fuel Density

Jet A	6.84	lb/gal
AvGas	6	lb/gal

CO2 Equivalencies

Pollutant	GWP100
CO2	1
CH4	25
N2O	298
SF6	22,800

100-year GWPs from IPCC Fourth Assessment Report (2007)
http://www.ipcc.ch/ipccreports/assessments-reports.htm

Fuel type	Pollutant	Factor	Unit of measure	Source
Jet A	CO2	21.095	lb/gal	EIA 2008
AvGas	CO2	18.355	lb/gal	EIA 2008
Diesel	CO2	22.384	lb/gal	EIA 2008
LNG	CO2	4.46	kg/gal	EPA 2005
Gasoline	CO2	19.564	lb/gal	EIA 2008
LPG	CO2	12.805	lb/gal	EIA 2008
Natural gas	CO2	53.06	kg/mmBtu	EPA 2008
Natural gas	CO2	120.593	lb/1000ft3	EIA 2008
Natural gas	CO2	12.059	lb/ccf	conversion from EIA 2008
Jet A	CO2	71,500	kg/TJ fuel	IPCC 2006
AvGas	CO2	69,300	kg/TJ fuel	IPCC 2006
Jet A	CH4	0.27	g/gal	EPA 2005
AvGas	CH4	7.04	g/gal	EPA 2005
Jet A	N2O	0.21	g/gal	EPA 2005
AvGas	N2O	0.11	g/gal	EPA 2005
Natural gas	CH4	5	g/GJ	EPA 2008
Natural gas	CH4	0.00116	lb/ccf	conversion from EPA 2008
Natural gas	N2O	0.1	g/GJ	EPA 2008
Natural gas	N2O	2.32E-05	lb/ccf	conversion from EPA 2008
Natural gas	CO2	13.34	lb/gge	NIST Handbook 44, Appendix
Electric Power Conversion				
Electricity	CO2	1,139.07	lb/MWh	2007 EPA eGRID for RFC East
	CH4	30.27	lb/GWh	(2005 data)
	N2O	18.71	lb/GWh	

Computational Spreadsheet – Conversion Factors and References 2

PHL Commercial Aircraft Passengers used to adjust data (PHL Aviation Activity Reports)

Year	Passengers
2003	24,671,075
2004	28,507,420
2005	31,495,385
2006	31,768,272
2007	32,211,439
2008	31,834,725

The relationship between annual passengers is used to adjust data from one year to represent another year. For example, if data is available for 2005 only, to adjust it to represent 2006, multiply the 2005 data by (2006 Passengers/2005 Passengers) or 31,768,272/31,495,385 = 1.009

Vehicle Reference Data

Vehicle type	Fuel type	Pollutant	Factor	Unit of measure	Source
Passenger car	gasoline	N2O	0.0158	g/mile	EPA 2007
Passenger car	gasoline	CH4	0.0110	g/mile	EPA 2007
Diesel van	diesel	N2O	0.0015	g/mile	EPA 2007
Diesel van	diesel	CH4	0.0010	g/mile	EPA 2007
Construction	gasoline	N2O	0.2200	g/gal	EPA 2007
Construction	gasoline	CH4	0.5000	g/gal	EPA 2007
Construction	diesel	N2O	0.2600	g/gal	EPA 2007
Construction	diesel	CH4	0.5000	g/gal	EPA 2007

Computational Spreadsheet – Conversion Factors and References 3

Reference Sources

EIA 2008 Energy Information Administration, *Voluntary Reporting of Greenhouse Gases Program, Guel nad Energy Source Codes and Emission Coefficients. Http://www.eia.doe.gov/oiaf/1605/coefficients.html, 2008.*

EPA 2005-1 U.S. Environmental Protection Agency, *Climate Leaders Greenhouse Gas Inventory Protocol - Design Principals. May 2005*

EPA 2008 U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006.* EPA430-R-08-005. April 2008 May 2005

IPCC 2006 Intergovernmental Panel on Climate Change, *2006 IPCC Guidelines for National Greenhouse Gas Inventories* 2006

NIST Handbook 44 National Institute of Standards and Technology, *Specificatoins, Tolerances, And Other Technical Requirements For Weighing and Measuring Devices, Handbook 44,* 2007

DOE 2007 Department of Energy, *Transportation Energy Data Book, 26th ed.* ORNL-6978, Oak Ridge National Laboratory, Oak Ridge, TN, 2007.

DOA 2006 DOA June 2006 - "Evalution of Rental Car Shuttle Bus Operations" Technical Memorandum, June 2006 - Internal DOA use only.

CEP 2004 Philadelphia International Airport Capacity Enhancement Program; Air Quality Technical Report, Air Quality Protocol, 2004. Reference Only.

EPA 2005-2 U.S. Environmental Protection Agency, *Emission Facts: Greenhouse Gas Emissions from a Typical Passenger Vehicle,* February 2005

Appendix

The appendices referenced in this report can be found online as follows:

- ACRP Report 11: Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories - http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_011.pdf

- ACRP Appendices to ACRP Report 11: Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories - http://onlinepubs.trb.org/onlinepubs/acrp/acrp_webdoc_002.pdf