

Rob and Melani Walton Sustainability Solutions Initiatives

2012 Greenhouse Gas Emissions Inventory for Government Operations

A comprehensive report
prepared for



City of Phoenix
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Acronyms

AZNM	Arizona and New Mexico eGRID Subregion
ASU	Arizona State University
CAP	Climate Action Plan
CARB	California Air Resources Board
CCAR	California Climate Action Registry
CEQ	President's Council on Environmental Quality
CH ₄	Methane
CNG	Compressed Natural Gas
CO ₂	Carbon Dioxide
CO ₂ e	Carbon Dioxide Equivalent Emissions
eGRID	EPA's Emissions & Generation Resource Integrated Database
EIA	U.S. Energy Information Administration
EN	Energy Efficiency & Renewable Energy
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FTE	Full-time-equivalent
GHG	Greenhouse Gas
GAC	Granulated Activated Carbon
ICLEI	International Council for Local Environmental Initiatives
IGCC	International Green Construction Codes
IPCC	Intergovernmental Panel on Climate Change
JPA	Joint Powers Authority
LED	Light Emitting Diode
LEED	Leadership in Energy and Environmental Design
LGOP	Local Government Operations Protocol
LNG	Liquid Natural Gas
LPG	Liquefied Petroleum Gas
MT	Metric Tons
N/D	Nitrification/Denitrification
NERC	North American Electric Reliability Corporation
N ₂ O	Nitrous Oxide
NO _x	Nitrogen Oxides
SW	Solid Waste
T&D	Transmission & Distribution
TN	Total Nitrogen
TR	Transportation
TRP	Trip Reduction Program
WWT	Wastewater Treatment
WWTP	Wastewater Treatment Plant

Executive Summary

The city of Phoenix 2012 Greenhouse Gas Emissions Inventory for Government Operations is an update to *The city of Phoenix 2005 Greenhouse Gas Emissions Inventory for Government Operations*. The 2005 report provided both the baseline greenhouse gas (GHG) emissions inventory and technical support for *The city of Phoenix 2009 Climate Action Plan for Government Operations* (CAP). The 2005 report projected that city of Phoenix (Phoenix) emissions would increase by 14% if the city did not take appropriate action. As a result, the Phoenix City Council, in December 2008, adopted a mandate to reduce GHG emissions from city operations to 5% below the 2005 level by 2015.

The 2012 report provides information on Phoenix's progress in meeting its emissions reduction goals. The major findings of the 2012 report are:

- While developing the 2012 GHG inventory, the reported 2005 GHG emissions were revised from 618,682 metric tons (MT) of CO₂e to 678,150 MT CO₂e based on the addition of previously unaccounted for emission sources and revised methodology for GHG emissions accounting.
- Overall emissions from Phoenix municipal operations equaled 629,504 MT CO₂e in 2012.
- The city has met and surpassed its 2015 goal for emissions reduction as overall emissions from Phoenix municipal operations between 2005 and 2012 fell from 678,150 to 629,504 MT CO₂e or about 7.2%.
- The largest reduction in GHG emissions came from increasing the efficiency of Phoenix landfill gas collection systems, which reduced emissions from 88,960 to 48,880 MT CO₂e between 2005 and 2012, thereby preventing 40,080 MT CO₂e from being released into the atmosphere.
- Building electricity use increased by 3.2%, due to the addition of 4,640,009 sq. ft. of space. Despite this increase, purchased electricity emissions for Phoenix buildings and facilities fell overall by 2.2% or 8,513 MT CO₂e. Reductions were the result of installation of solar power, improved building efficiency standards, and energy efficiency upgrades to Phoenix facilities (e.g. streetlights and traffic lights), as well as a cleaner, more efficient regional electricity mix, the latter providing the bulk of the reduction in emissions per square foot.
- Water service emissions, including those from water distribution and wastewater treatment, fell by 6% or 10,551 MT CO₂e overall due to lower energy consumption. However, water distribution emissions increased due to the addition in the 2012 inventory of 2,996 MT CO₂e from the transportation and regeneration of granulated activated carbon (GAC).

- Phoenix fleet emissions decreased by 4.5%, or 6,068 MT CO₂e. Implementation of biofuel policies drove the reduction.
- Emissions from employee commuting increased by 16% or 5,009 MT CO₂e due largely to a change in sampling and calculating commuting behavior.

Although Phoenix has met and surpassed its original goal, the city is planning to implement several projects that will further reduce GHG emissions. This will allow the city to offset future GHG emissions due to anticipated population growth as well as maintain the quality of life of the city. Planned projects between 2012 and 2015 include:

- Phoenix's Better Building Challenge that targets a 20% reduction in Phoenix building energy consumption by 2020 and an estimated 2-3% reduction in building and facility electricity and natural gas consumption by 2015. This program is projected to reduce emissions by 16,658 MT CO₂e.
- Retrofitting 2,489 high-pressure sodium streetlight bulbs of the total inventory of 90,700 with light-emitting diode (LED) fixtures to reduce electricity consumption per unit by half; and 100% conversion of traffic lights to reduce traffic light electricity consumption by 65%. These measures will reduce emissions by 2,136 MT CO₂e.
- Stage 1 of the PHX Sky Train connecting the 44th Street Station, East Economy Parking to Terminal 4 will reduce GHG emissions from Compressed Natural Gas (CNG) by an estimated 30% from 2012 by reducing inter-terminal busing. Stage 1a of the PHX Sky Train, connecting to Terminal 3 and scheduled for completion in 2015, will eliminate inter-terminal busing. The PHX Sky Train will be an interim net emitter due to the increased emissions from electricity consumption until the Sky Train is completed to the Rental Car Center, which will then also eliminate the Rental Car Center busing.
- Currently under consideration is replacing wastewater digester gas flaring with a process that will separate methane from the digester gas and introduce the extracted methane into the natural gas pipeline. Some of the methane will be flared with the remaining constituents of the digester gas, which would significantly reduce GHG emissions from the 91st Avenue WWTP. If the project is implemented, the city of Phoenix could avoid the direct emission of 1,325 MT CO₂e by diverting the gas from flaring.
- Eighty-five Phoenix solid waste trucks will be converted to CNG from B20 biodiesel, reducing emissions by 630 MT CO₂e and contracted solid waste haulers will switch to B20 biodiesel from diesel fuel, reducing emissions by 1,357 MT CO₂e.
- Phoenix solar energy projects are expected to reduce emissions by 6,216 MT CO₂e.
- Increased diversion of green wastes from the Phoenix's SR-85 landfill will reduce landfill gas generation further.

It is estimated that these planned projects will further reduce GHG emissions for a total expected reduction from 2005 of 12%. This translates to an estimated reduction between 2005 and 2015 as shown in Figure 1.

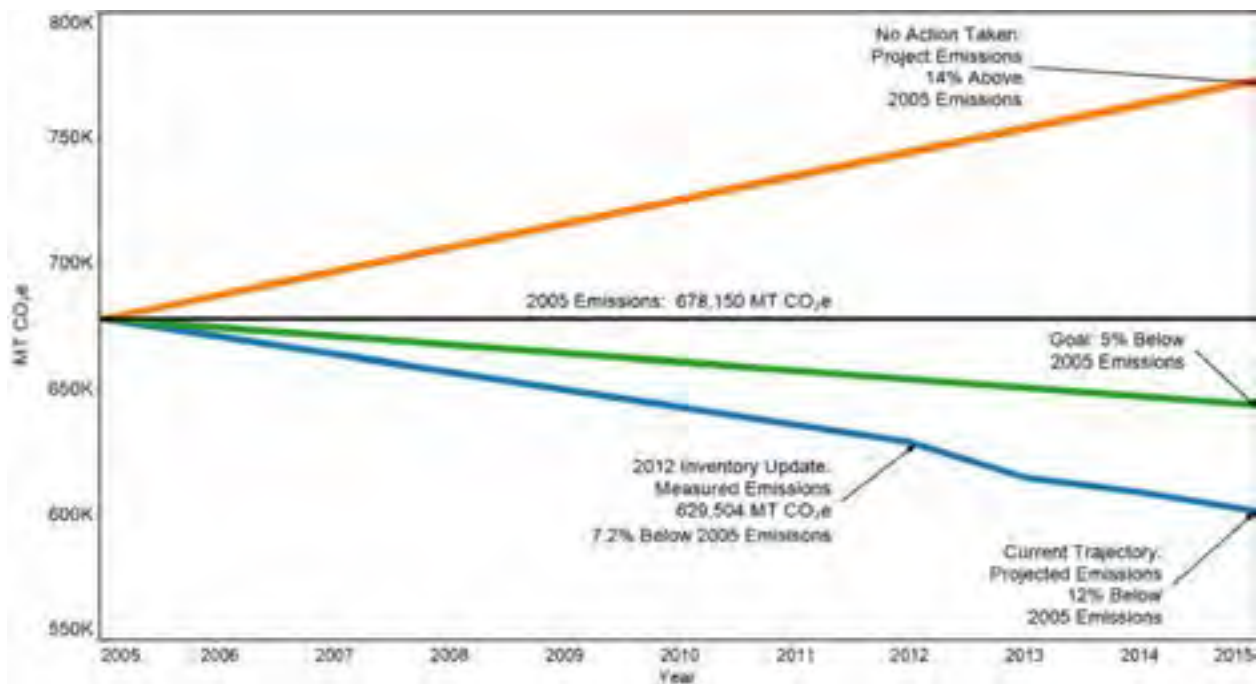


Figure 1. Current GHG Emissions Trajectory Compared to 5% Reduction Goal and Projected Business As Usual (BAU).

As the city continues to grow, the 2012 GHG emissions inventory will be a significant resource for decision makers. Additional recommended actions include:

- 1) An annually updated inventory that accurately evaluates the effectiveness of GHG emission mitigation efforts and climate action technologies, programs and policies.
- 2) A regional inventory that would identify opportunities for reducing emissions outside of city operations. This inventory should include major residential, commercial, and industrial contributors and provide a comprehensive assessment and benchmarking of regional GHG mitigation and climate adaptation programs and options to strengthen and expand the city's and region's efforts.
- 3) Development of city and region-wide risk and vulnerability assessments that identify both climate and non-climate related risks as well as a city resiliency plan to provide planning, mitigation and adaptation options. These tools will enable the city to ensure that its population and resources are less vulnerable and more resilient to socioeconomic and environmental stressors.
- 4) A performance dashboard that presents the results of GHG emissions inventories in an accessible manner to city staff and the public. Transparency and accountability are critical in ensuring that emissions reduction efforts remain active.

1. Introduction

In December 2008, the Phoenix City Council adopted a goal to reduce greenhouse gas (GHG) emissions¹ from city operations to 5% below the reported 2005 levels of 618,682 metric tons (MT) CO₂e by 2015.² It is important to note that in developing the 2012 GHG inventory, the reported 2005 GHG emissions were revised from 618,682 MT CO₂e to 678,150 MT CO₂e based on the addition of previously unaccounted for emission sources and revised methodology for emissions accounting. This change allows for a more accurate comparison between 2005 and 2012 emissions and a sound baseline for moving forward.

The effort began with an inventory of the city's 2005 emissions from municipal operations, which established a baseline and provided technical support for *The city of Phoenix 2009 Climate Action Plan for Government Operations* (CAP). The report also forecast a 14% increase, to 706,000 MT CO₂e, by 2015 if the city maintained a business as usual approach. In response, CAP identified 10 measures to decrease emissions in energy use, transportation, and solid waste. To assess the impact of these mitigation measures to date, the city of Phoenix (Phoenix) commissioned Arizona State University's (ASU) Global Institute of Sustainability and its Sustainability Solutions Services to update the inventory and analyze its performance.

This report provides an updated inventory of 2012 emissions from municipal operations in six sectors—Buildings and Facilities, City Vehicle Fleet, Wastewater Treatment, Solid Waste, Employee Commute, and Granulated Activated Carbon (GAC) Hauling and Regeneration. These sectors are categorized into three scopes to capture direct emissions (Scope 1) and indirect emissions (Scopes 2 and 3).³ The update provides a direct comparison to the 2005 inventory as well as a revised baseline for future inventories. Tracking emissions over time will allow Phoenix to evaluate the effectiveness of its emissions reduction policies and programs. Furthermore, the inventory provides a platform for Phoenix to compare itself to other municipalities and discover best practices for reducing its carbon footprint.

Section 1 is an overview of the major findings of the 2012 GHG Inventory update. Section 2 describes the methodology for the 2012 GHG Inventory Update including the

¹ Hereafter referred to as *emissions*.

² Metric Tons (MT) CO₂e: Carbon dioxide equivalent metric tons. This is consistent with the established international standard for comparison of the global warming potential of different greenhouse gases relative to CO₂. For example, methane CH₄ has a global warming potential (GWP) that is 21 times more than carbon dioxide; N₂O has a GWP of 310. See Appendix B.

³ Scope classifications are explained in more depth in the methodology section.

Local Government Operations Protocol for emissions accounting, the organizational boundaries, emissions scope definitions, and methodological revisions between the 2005 and 2012 GHG inventories. Section 3 includes a summary of inventory results by reporting sector including Buildings and Facilities, City Vehicle Fleet, Water Distribution and Wastewater Treatment Processes, Solid Waste, Employee Commute, and GAC Hauling and Regeneration for water treatment. Section 4 tracks the trajectory of Phoenix emissions to 2015. Section 5 provides internal and external benchmarks for Phoenix operations. Section 6 details biogenic emissions—non-fossil CO₂ emissions that are not included in Phoenix’s total emissions. Section 7 provides recommendations for future emissions reductions programs. Finally, Section 8 is a status update to the 2009 CAP.

Major Findings

The revised baseline total emissions for 2005 are 678,150 MT CO₂e, up from the originally published 618,682 MT CO₂e (Table 1). Based on this revised figure, emissions from Phoenix government operations fell by 7.2%, from 678,150 to 629,504 MT CO₂e between 2005 and 2012. With this decrease, Phoenix has achieved and surpassed its 5% reduction goal. The reductions can be attributed to a combination of internal and external measures including city policies, technology advances, and programs, as well as revised methodology and additional sources of emissions accounting.

External measures impacting the reduction include a decrease in the EPA’s Emissions & Generation Resource Integrated Database (eGRID) regional factor.⁴ eGRID inventories the environmental attributes of electric power generation and its effect on air emissions for every power plant in the United States. Phoenix is in the Arizona and New Mexico (AZNM) subregion. The carbon intensity of the AZNM fell by 9%, translating in an eGRID emissions factor reduction of 1,316 lb. CO₂e/MWH to 1,196 lb. CO₂e/MWH due primarily to Arizona’s and New Mexico’s renewable energy policies.

Phoenix has reduced its emissions in almost every category except employee commuting. The city’s overall reduction is largely due to the decrease in landfill gas, fleet, and city facilities emissions. Fugitive emissions were significantly reduced at two landfills with enhanced methane capture systems. Emissions also decreased at the city’s wastewater treatment plants. These advancements reduced emissions of fugitive

⁴ The Emissions & Generation Resource Integrated Database (eGRID), developed by the EPA in collaboration with the Energy Information Administration (EIA), the North American Electric Reliability Corporation (NERC), and the Federal Energy Regulatory Commission (FERC), is a comprehensive source of data on the environmental characteristics of almost all electric power generated in the United States. Detailed information can be found at <http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html>.

landfill and wastewater methane emissions by 39,783 MT CO₂e, a 40.7% reduction from 2005 levels.

Table 1: Comparing 2005 and 2012 GHG Emissions by Scope and Sector in MT CO₂e					
Scope 1	2005 (Original)	2005 (Revised)	2012	2005-2012 Change	% Change
Buildings & Facilities (therms)	7,425	7,398	7,318	-80	-1.1%
Fleet Fuels	122,141	135,563	129,495	-6,068	-4.5%
Fugitive and Process Emissions	92,133	97,740	57,957	-39,783	-40.7%
Scope 1 Total Emissions	221,699	240,701	194,770	-45,931	-19.1%
Scope 2	2005 (Original)	2005 (Revised)	2012	2005-2012 Change	% Change
Buildings & Facilities (kWh)	176,426	184,381	190,357	5,976	3.2%
Street Lighting	36,828	38,522	37,649	-873	-2.3%
Traffic Signals	7,396	7,737	7,399	-338	-4.4%
Water Distribution	85,007	88,919	84,619	-4,300	-4.8%
Wastewater Treatment	63,604	66,530	57,552	-8,978	-13.5%
Scope 2 Total Emissions	369,261	386,089	377,576	-8,513	-2.2%
Scope 3	2005 (Original)	2005 (Revised)	2012	2005-2012 Change	% Change
Employee Commute	27,722	30,863	35,872	5,009	16.2%
Transmission Distribution Loss	0	20,496	18,290	-2,206	-10.8%
GAC Hauling and Regeneration	0	0	2,996	2,996	N/A
Scope 3 Total Emissions	27,722	51,360	57,158	5,799	11.3%
GHG Inventory	2005 (Original)	2005 (Revised)	2012	2005-2012 Change	% Change
Total Scope 1 and 2 Emissions	590,960	626,790	572,346	-54,444	-8.7%
Total Scope 1, 2 & 3 Emissions	618,682	678,149	629,504	-48,645	-7.2%

Note: Totals may not sum due to independent rounding.

2. Methodology

Local Government Operations Protocol

In order for cities to quantify emissions in a meaningful way, a standardized approach is critical. It allows individual cities to compare year-to-year results as well as their practices and procedures to other municipalities across the country. Phoenix's 2005 baseline emissions inventory was based on the Local Government Operations Protocol (LGOP), developed by the International Council for Local Environmental Initiatives (ICLEI – now officially called 'ICLEI – Local Governments for Sustainability'), the California Climate Action Registry (CCAR), the California Air Resources Board (CARB), and The Climate Registry (The Registry). The LGOP serves as a national standard for quantifying and reporting emissions associated with government operations. To ensure consistency for this update, ASU used the 2010 version (Version 1.1) of the protocol for both 2012 and the revised 2005 emissions inventories.

This protocol provides a template for entering a variety of resources and data in the development of a comprehensive inventory report. Emissions are measured directly from sources such as landfill monitoring systems or through calculation-based methodologies. In the latter case, activity data is collected and multiplied by an emission factor (e.g., CO₂ emitted/kWh) to calculate the total emissions. The LGOP provides emission factors for most calculation methodologies used in the report. Measured or calculated emissions are then converted to a carbon dioxide equivalent (CO₂e), using the conversion factors shown in Appendix B. CO₂e is an equivalent based on the emission's potential for global warming compared to that of carbon dioxide.

2012 vs. 2005 Methodology

The 2012 GHG emissions inventory methodology generally follows that of the 2005 inventory. However, some technical improvements have been made to most accurately reflect emissions quantification. In 2010, ICLEI and partners released the latest LGOP Version 1.1. This update included several changes to figures, methods and other factors. Details can be found on the [ICLEI website](#). In addition to the LGOP update, the following changes to methodology were made to correct, amend or update the 2005 data and more accurately reflect 2012 emissions:

- Estes Landfill was added to both inventories;
- Employee commuting emissions at sites with less than 50 employees added to both the 2005 and the 2012 inventories;
- In 2005, wastewater treatment emissions were estimated using population-based data. In 2012, site-specific data were used where applicable;

- The 2012 model includes transmissions and distribution (T&D) loss in the electricity grid as scope 3 emissions. This loss was excluded in 2005; and
- The 2012 model calculates biogenic CO₂ emissions from the flaring of methane gas at landfill and wastewater treatment plants, non-fossil biofuel emissions, and the combustion of biogas at the 91st Avenue Wastewater Treatment Plant on-site for boilers. Biogenic CO₂ emissions were not calculated in the original 2005 inventory but included in the revised 2005 inventory.

Estimating Tailpipe Emissions of CH₄ and N₂O

The methodology used to estimate tailpipe methane (CH₄) and nitrous oxide (N₂O) emissions changed between the two GHG inventories. In 2005, the Clean Air-Cool Planet's GHG modeling software was used to estimate fleet emissions of methane and nitrous oxide. The 2012 inventory uses the Climate Registry's simple estimation method for tailpipe methane and nitrous oxide emissions via a fuels' carbon dioxide content that provides a comprehensive estimation of emissions across all fuel and vehicle types. The data-reporting format change avoided the need to track vehicle mileage for use of per mile CH₄ and N₂O emissions factors used in the 2005 emissions.

Site-specific CH₄ Emissions from Wastewater Treatment

The 2005 CH₄ emissions values from Wastewater Treatment used in this report vary from the previously reported values. In 2005, CH₄ emissions from the 23rd Avenue and 91st Avenue Wastewater Treatment Plants (WWTP) were modeled on LGOP population-based estimation methods. Data provided for the 2012 inventory contained CH₄ production, flaring, and on-site use data for both 2005 and 2012 at the 91st Avenue WWTP. 2005 data was revised using this site-specific data for consistency. Additionally, in the previous 2005 emissions model, flaring emissions were not separated into 91st Avenue and 23rd Avenue components. These are separated into two emissions sources in the 2012 Inventory update.

Backcasting N₂O Emissions from Wastewater Treatment

Effluent N₂O emissions are based on the total nitrogen (TN) content of the effluent and estimated either via population-based methods or site-specific data. The two methods were tested for 2012 population and site-specific data. When comparing the results, there was an order of magnitude reduction in N₂O emissions from population-based calculations to site-specific effluent data. Using population-based emissions estimation methodologies for 2005 and site-specific emissions estimation methodologies for 2012 would create an order of magnitude reduction in emissions that is an artifact of the methodology. Therefore, the 2005 effluent N₂O emissions in this inventory have been backcasted from 2012 site-specific data using the 2005-2012 population indexes. The

backcasting approach was used because there was incomplete data to verify the previous 2005 calculations.

Alternative Fuel Estimates for Employee Commuting

Employee commuting data is based on an annual survey conducted by the Maricopa County Trip Reduction Program (TRP) regarding employees' means of commuting throughout the week. While the survey asks employees if they use an alternative fuel vehicle, the type of fuel is not specified. Alternative fuel vehicle ownership data for Arizona were obtained from the federal Energy Information Administration to estimate alternative fuel employee commuting. It was assumed that statewide alternative fuel vehicle ownership patterns were representative of Phoenix employees.⁵

Organizational Boundaries

Given the variety of governmental structures, the LGOP provides two emissions reporting approaches for defining the boundaries of what to include in the inventory: the first approach is *operational control* and includes those operations in which the local government has the authority to introduce and implement operating policies; the second is *financial control* and includes those operations that are fully consolidated in financial accounts. More detail on both approaches can be found in the LGOP Version 1.1.

City of Phoenix Boundary Guidelines

The city uses the operational control approach as it most accurately represents emission sources within the city's control. The boundaries of the 2012 inventory follow the same guidelines as the 2005 baseline inventory. However, it expanded upon the 2005 inventory by tabulating emissions from T&D loss in the electricity grid, calculating biogenic emissions—emissions from non-fossil carbon sources—resulting from municipal operations, and including the additional considerations outlined below.

T&D loss can account for up to 25% of generated electricity, demonstrating the added benefit of developing on-site renewable energy projects. Including T&D loss in an inventory is a GHG accounting standard endorsed by the President's Council on Environmental Quality (CEQ) and complies with the ICLEI LGOP protocol. Furthermore, electricity use by municipal operations typically is one of the largest municipal emissions sources—resulting in 60% of the city's emissions. Therefore accounting for T&D loss creates a richer picture of the GHG impact of municipal electricity consumption. Biogenic emissions are emissions from non-fossil carbon sources—such as biodiesel and ethanol in blended biofuels—and the conversion of methane to carbon dioxide resulting from methane flaring.

⁵ U.S. Energy Information Administration (2013). Renewable & Alternative Fuels. Alternative fuel vehicle data. URL: <http://www.eia.gov/renewable/afv/users.cfm>

Other considerations included the 91st Avenue WWTP emissions and if they should be part of the inventory. This plant accepts wastewater from several other cities and is operated under a formal Joint Powers Authority (JPA) agreement. Although the LGOP accounting system recommends that JPA's be excluded from the inventory, the full emissions from this facility have been included as Phoenix operates the facility and is listed as the responsible party on the facility's air and water permits. Inclusion of the plant's full emissions will be re-evaluated in the future if other partners in the facility develop their own inventories and wish to include their share of the emissions from the facility.

Phoenix also reviewed options for including the facilities that are owned by Phoenix but leased to other entities. Consistent with the operational control in the protocol, the inventory would generally not include energy used at city-owned leased facilities. However, a unique circumstance occurs at Phoenix Sky Harbor International Airport. The airport could have excluded facilities that are leased to tenants (airlines, restaurants, gift shops, etc. which account for 1/3 of the terminal areas and 1/3 of common use areas) on a proportional basis because the costs of the energy used at those airport facilities are allocated to tenants based on the size of revenue-generating area. However, Phoenix chose to include emissions from the entirety of the airport-owned facilities as the airport runs the building energy systems and pays the energy bills.

Finally, Phoenix could choose not to report Employee Commute and GAC Hauling and Regeneration emissions because it does not maintain direct operation control and therefore is not required to report those emissions. However, because Phoenix has influence over its employees commuting habits through various rideshare incentives and telecommuting, it chose to include these emissions in the inventory as Scope 3 emissions (Scope classifications explained below). It also chose to report emissions from GAC hauling and regeneration as Scope 3 emissions despite the fact that these operations are outsourced as the city holds financial control; considers it an area over which it has influence; and data for this activity is relatively easy to obtain and evaluate.

Scope Classifications and Sectors

In accordance with the protocol, emission sources from city operations are categorized into "Scope 1, 2, or 3" emissions. The scope indicates if emissions are direct or indirect emissions in order to improve transparency and to provide utility for different types of climate policies and goals. The Scope categories are illustrated in Figure 2.

- Scope 1: All direct emissions from operational sources owned or controlled by Phoenix.

- Scope 2: Indirect emissions associated with the consumption of purchased or acquired electricity, steam, heating or cooling that occur at sources not owned or controlled by Phoenix.
- Scope 3 (optional under the protocol for cities to include in their inventories): All other indirect emissions not covered in Scope 2, such as transport-related activities in vehicles not operated by Phoenix (e.g., employee commuting and business travel) and outsourced activities. This report includes employee commuting and the outsourced activity GAC Hauling and Regeneration.

In addition to categorizing emissions by scope, the inventory is organized into six sectors to make it more relevant to Phoenix policy making and project management.

- Buildings and Facilities
- City Vehicle Fleet
- Water Distribution and Wastewater Treatment
- Solid Waste
- Employee Commute
- GAC Hauling and Regeneration

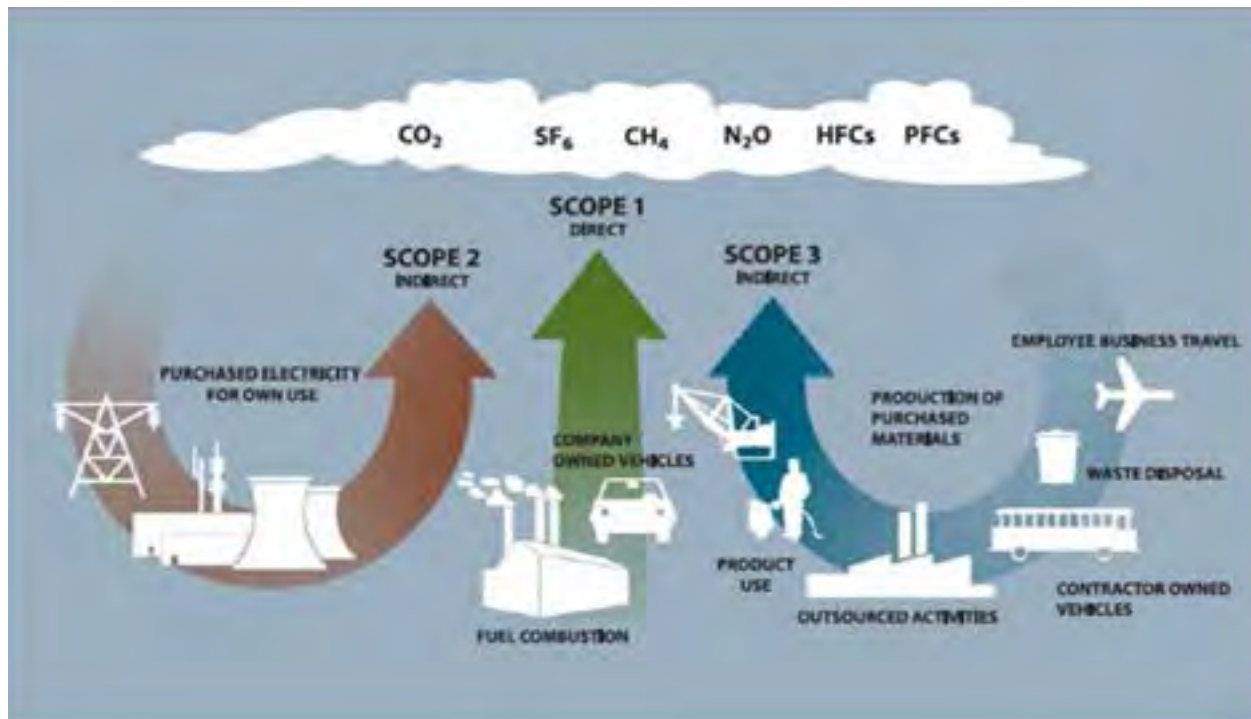


Figure 2: Overview of Scopes and Emissions Sources, LGOP. Source: *The city of Phoenix 2005 GHG Emissions Inventory for Government Operations* (2009). Adopted from *World Resources Institute GHG Protocol Corporate Accounting and Reporting Standard* (Revised Edition), Chapter 4, 2004.

3. Results

Summary

2005 vs. 2012: What Changed?

Between the 2005 baseline and the 2012 update, Phoenix experienced a number of changes that impacted emissions. These include:

Between 2005 and 2012, the city's population fell from 1,552,259 to 1,473,405 residents.

Concomitantly, the number of full-time-equivalent (FTE) employees fell from 14,667 to 12,849.

Inversely, the gross square footage of city buildings and facilities increased by 4,676,009 (18%) from 25,948,884 to 30,624,893 square feet.

Finally, the AZNM regional eGRID factor decreased by 9%. The reduced carbon intensity of the AZNM, from 1,316 lb. CO₂e/MWH to 1,196 lb. CO₂e/MWH, is a result of the adoption and implementation of renewable energy policies in both Arizona and New Mexico.

Emissions Sources and Distribution

Emissions in Phoenix are largely attributed to three sectors: buildings and facilities, fleet fuel usage, and water distribution and wastewater treatment. Figure 3 (next page) provides an overview of the relative magnitude of MT CO₂e emissions by source and scope.

2012 Overall Findings

7.2% decrease
2.2% beyond Phoenix's 2005 Goal!

Emissions Sources

- Solid Waste
- Buildings and Facilities
- City Fleet
- Water Distribution and Wastewater Treatment
- Employee Commute
- GAC Hauling & Regeneration

City Action Highlights

- Advanced methane capture systems at certain city landfills
- Biodiesel and ethanol alternative fuel programs
- Energy efficient streetlight, traffic signal, water distribution and wastewater treatment upgrades
- Energy efficiency measures in over 45 city buildings
- City solar power projects

Future Reduction Opportunities

- Energy efficiency upgrades
- Clean energy acquisition and generation
- Decrease fleet vehicle miles driven and replace fossil-based fuels with biofuels
- Emissions capture for powering facilities or offsetting emissions
- Employee and management buy-in and engagement in alternative commuting options

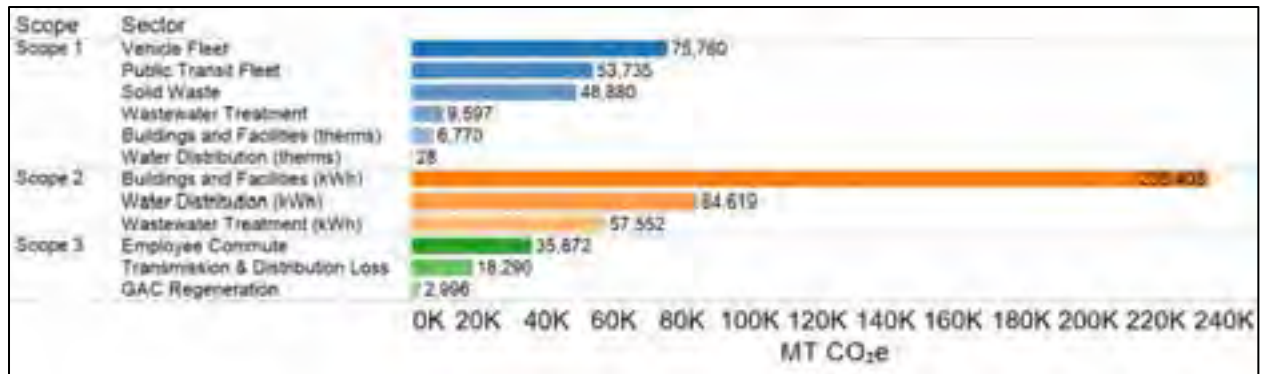


Figure 3: 2012 Emissions by Scope and Sector

As illustrated in Table 2, purchased electricity (Scope 2 emissions) used in city buildings and facilities account for approximately 60% of all city emissions.

Table 2: 2012 Emissions by Scope and Sector (MT CO₂e)				
Sector	Scope 1	Scope 2	Scope 3	Total
Buildings and Facilities	6,770	235,405	18,290	260,465
Public Transit Fleet	53,735	0	0	53,735
Vehicle Fleet	75,760	0	0	75,760
Wastewater Treatment	9,597	57,552	0	67,149
Solid Waste	48,880	0	0	48,880
Employee Commute	0	0	35,872	35,872
GAC Hauling & Regeneration	0	0	2,996	2,996
Water Distribution	28	84,619	0	84,647
Total	194,770	377,576	57,158	629,504

City Action Highlights

The city exceeded its 2005 goal and reduced emissions by 7.2%. Total emissions fell from the revised 678,150 MT CO₂e in 2005, to 629,504 MT CO₂e in 2012. Emissions have decreased from 2005 levels in a number of areas with the exception of employee commuting emissions, which increased from 13.0 MT CO₂e to 15.7 MT CO₂e per full or part-time employee. Also, increases were seen due to GAC Hauling & Regeneration, which is a new Phoenix service as illustrated in Figure 4 (next page).

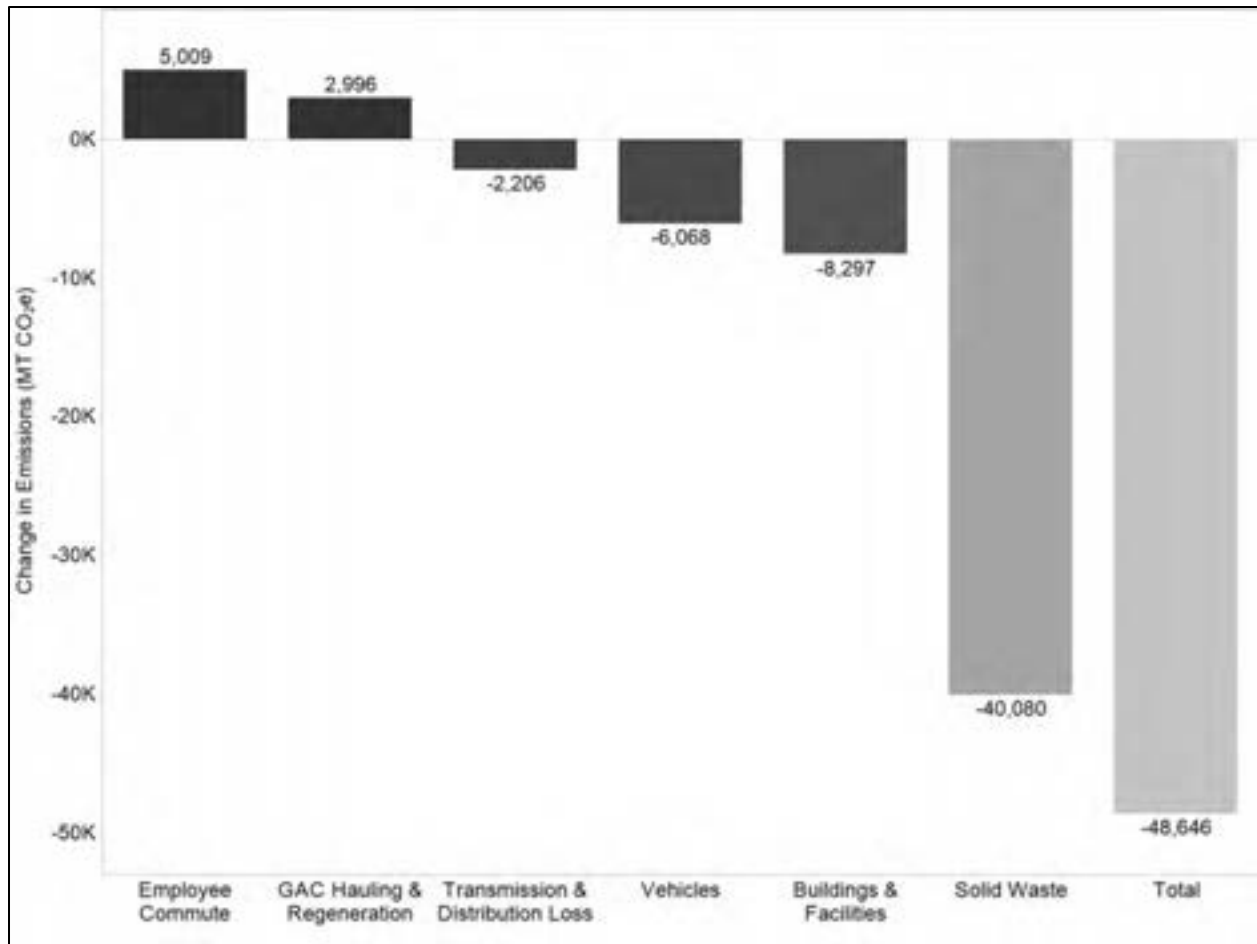


Figure 4: Changes in Emissions between 2005 and 2012

The overall reduction is primarily the result of increased efficiency in the capture rates of fugitive emissions at Phoenix Solid Waste landfills. GAC Hauling and Regeneration is part of the Water Distribution and Wastewater Treatment section, but has been reported separately as a Scope 3 emission since it provides a significant portion of emissions in this sector. Buildings & Facilities and Vehicles also had a significant decrease between reporting years. T&D loss (Scope 3) is a new inventory item to the 2005 and 2012 inventories and shown separately.

Decreased energy consumption and renewable energy development at wastewater treatment and water distribution facilities also played a major role in decreasing municipal emissions. For example, the Lake Pleasant solar facility in Northwest Phoenix, constructed by the Phoenix Water Services Department in December 2012 to help power the Lake Pleasant WTP, is expected to generate approximately 10.7 million kWh of low carbon electricity each year or about 49% of the city's annual solar power generation.

Additionally, Phoenix implemented successful biodiesel and ethanol alternative fuel programs⁶, which replaced approximately 3 million gallons of diesel fuel with B20 biodiesel and 287,000 gallons of gasoline with E85 ethanol fuel. The city has also been replacing both its traffic signals and high-pressure sodium streetlights with energy efficient LED lights.

Future Reduction Opportunities

Phoenix has a significant opportunity to reduce future emissions through the following activities:

- Energy-efficiency upgrades
- Clean energy acquisition
- Decreasing vehicle emissions at the same rate or more than fleet decreases
- Capture emissions and use them to power city facilities or offset emissions elsewhere
- Employee and management buy-in and engagement in alternative commuting options
- Take advantage of new technology as it becomes available

⁶ Biodiesel fuel used is B20, a 20% biodiesel/diesel fuel blend and the ethanol fuel used is E85, an 85% ethanol/gasoline fuel blend.

Findings by Sector for 2012

Buildings and Facilities

2005 vs. 2012: What Changed?

Between 2005 and 2012, Phoenix expanded its building space by 18% from 25,984,884 sq. ft. to 30,624,893 sq. ft.

In addition to sq. ft. growth, the Aviation Department took operational control of the Rental Car Center busing. This occurred during 2005 and therefore, only partial year emissions for the 2005 inventory were captured.

Traffic signal conversion to LEDs began.

In addition, the eGRID factor decreased by 9%.

Emissions Sources and Distribution

Overall, city buildings consumed 16% more purchased electricity but 10% less natural gas.

Street lighting consumed 8% more purchased electricity.

Traffic signals and water distribution each consumed 5% more purchased electricity in 2012 than in 2005.

Wastewater treatment consumed 5% less purchased electricity.

Overall emissions in the Buildings and Facilities sector decreased by 2.2% despite the city taking operational control of the Rental Car Center busing and the area of city-operated buildings and facilities growing by almost 5 million square feet, which increased building electricity use by 3.2%. A combination of solar energy development on city facilities, and energy efficiency upgrades to city buildings and facilities account

2012 Buildings and Facilities Findings

Total Emissions: 384,894 MT CO₂e
61% of municipal operations emissions
2.2% decrease from 2005 levels
Emissions per square foot of building space
reduced by 12% from 2005 levels

Emissions Sources

- Electricity and natural gas used for city buildings
- Streetlights
- Traffic Signals
- Energy for Water Distribution and Wastewater Treatment Facilities

City Action Highlights

- 45+ energy efficient building and facility measures implemented
- Energy efficient LED lights in 100% of new traffic signals & streetlights
- 65% of existing traffic signals converted to LED lights
- Water Service Department installed 7.5 MW of solar power at its Lake Pleasant Water Treatment Plant
- Aviation installed 5.4 MW of solar power on the East Economy Parking garages and the Sky Harbor Rental Car Center facilities

Future Reduction Opportunities

- Building and facility energy efficiency upgrades
- Clean energy acquisition and generation

for most of the decrease (see Appendix C & D for a list of projects). A cleaner regional electricity supply also helped lower emissions from buildings and facilities. Figure 5 demonstrates the percentage increase and decrease by subsector for municipal operations.

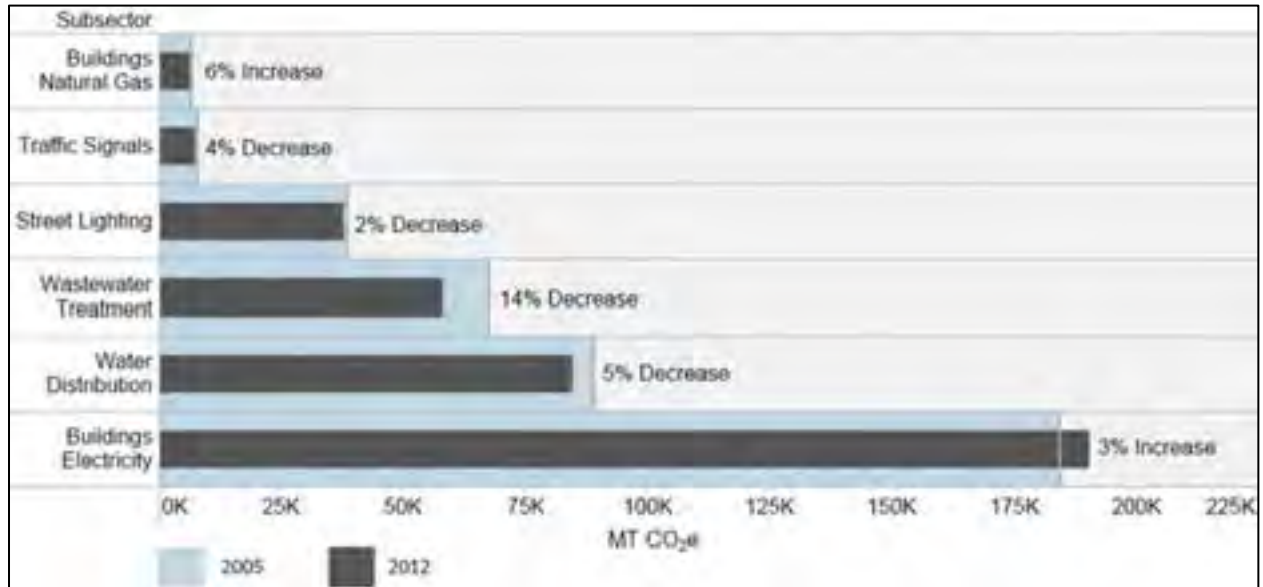


Figure 5: 2005 and 2012 Buildings and Facilities Emissions

Building emissions stem from both electricity and natural gas. While measuring the emissions of electricity is relatively straight forward, natural gas is measured by volume requiring a conversion to its heat equivalent or therms to calculate energy use and emissions from that energy. Table 3 provides a breakdown of energy use in Building and Facilities sectors and the resulting emissions by subsector.

Table 3: 2012 Buildings and Facilities Emissions by Subsector			
Subsector	Total kWh	Total therms	MT CO ₂ e
Buildings - Electricity	350,720,652	--	190,357
Buildings - Natural Gas	--	1,275,585	6,770
Street Lighting	69,365,290	--	37,649
Traffic Signals	13,631,679	--	7,399
Water Distribution	155,904,799	5,195	84,646
Wastewater Treatment	106,036,261	98,036	58,073
Total	695,658,681	1,378,816	384,894

City Action Highlights

Energy efficient measures were implemented in over 45 city buildings (see Appendix A) and the Phoenix Green Building Code was adopted to facilitate energy efficient new construction. Additionally, the city installed 20 solar power generating systems between GHG inventories. These upgrades, along with the eGRID factor decrease, reduced emissions per square foot of city operated buildings space by 12%, from 7.35 to 6.44 kg CO₂e per sq. ft.

As part of the 2009 CAP, the city currently has an additional 12 solar power projects planned for installation before 2015 (See Appendix C). These installations demonstrate Phoenix’s continuing commitment to reaching its 15% renewable energy goals as well as reducing operational emissions.

The city increased emissions efficiency of streetlight and traffic signals through the installation of 200 LED streetlights and 718 LED traffic signals—Phoenix had 25 LED traffic signals in 2005. Overall emissions from the traffic signal and street lighting sector increased due to the additional load of traffic signal cameras. However, traffic signals and streetlights emitted less per light, decreasing from 7.97 to 6.70 MT CO₂e per traffic signal and 0.046 to 0.042 MT CO₂e per streetlight. Table 4 outlines the GHG intensity increases and efficiency gains for select Building and Facilities indicators.

Table 4: Buildings and Facilities Emissions Indicators and Percent of Change			
Indicator	2005	2012	% Change
Building Space (sq. ft.)	25,948,884	30,624,893	18%
Emissions per sq. ft. (kg CO ₂ e)	7.35	6.44	-12%
Employees (Full Time Equivalent):	14,667	12,849	-12%
Electricity Emissions per Cooling Degree Day (CDD)	39.2	37.6	-4%
Building/Facilities Emissions per F/PTE	13.01	15.34	18%
GHG Emissions Per Traffic Signal	7.97	6.70	-16%
GHG Emissions Per Street Light	0.46	0.42	-9%

Future Reduction Opportunities

Phoenix has the opportunity to significantly reduce emissions from buildings and facilities through two avenues. Efficiency upgrades will significantly decrease electricity use in city operations, and clean energy acquisition and generation will further decrease the emissions from these sources and help the city meet its goals.

City Vehicle Fleet

2005 vs. 2012: What Changed?

Phoenix increased its vehicle fleet by 21% between 2005 and 2012. The number of Public Works' vehicles in the city's fleet was 7,288 in 2012, up from 6,035 vehicles in 2005.

Despite increasing the vehicle fleet, the total reported miles driven by the fleet fell by 9% from 52,825,683 miles in 2005 to 48,022,781 miles in 2012.

All diesel fleet vehicles operated by Public Works and Aviation have converted to B20 biodiesel. However, Ultra Low Sulfur diesel fuel continues to be used in specific situations, such as emergency generators and fueling sites with low throughput. This is in large part because biodiesel is inappropriate in such situations.

The switch to B20 biodiesel and E85 ethanol avoided approximately 8,300 MT CO₂e in vehicle fleet emissions overall.

Aviation reduced its fleet gasoline consumption by 11% due in large part to its significant use of E85 Ethanol.

Aviation is also the city's highest department user of CNG increasing its use by 14% from 2005-2012. Aviation CNG use is expected to decrease after 2012 as the PHX Sky Train reduces inter-terminal bus usage.

City Vehicle Fleet

Total Emissions: 129,495 MT CO₂e
21% of municipal operations emissions
4.5% decrease from 2005 levels

Emissions Sources

- Gasoline
- Compressed Natural Gas (CNG)
- Biodiesel
- Liquefied Natural Gas (LNG)
- Diesel
- Liquefied Petroleum Gas (LPG)
- Ethanol
- Aviation gasoline (Police Department Aircraft)
- Jet Fuel A (Police Department Aircraft)

City Action Highlights

- Biodiesel alternative fuel program
- Ethanol alternative fuel program

Future Reduction Opportunities

- Decrease fleet vehicle miles driven and replace fossil-based fuels with biofuels

Table 5 shows fuel consumption in 2005 and 2012 and the percent of change based on fuel type.

Table 5: Changes in Total City Fleet Fuel Consumption			
Fuel Type	2005 (Gallon/GGE)	2012 (Gallon/GGE)	% Change
Gasoline	3,172,441	3,200,758	1%
Diesel	5,452,613	3,324,829	-39%
B20 Biodiesel	--	3,034,345	N/A
CNG	1,744,813	1,349,993	-23%
LNG	7,917,008	6,222,272	-21%
E85 Ethanol	--	287,438	N/A
LPG	14,392	--	N/A
Aviation Gasoline (Police aircraft)	2,401	5,975	149%
Jet Fuel A (Police aircraft)	163,160	222,283	36%

Emissions Sources and Distribution

Emissions per vehicle maintained by Public Works fell from approximately 9.8 to 7.6 MT CO₂e per vehicle, despite an increase to the number of vehicles (Table 6). The average fleet vehicle drove 6,500 miles in 2012, down 9% from 8,674 miles in 2005. Emissions rose slightly from 1.13 to 1.17 kg CO₂e on a per mile basis. To counter the increase in emissions per mile, the city will need to decrease vehicle miles driven or increase the use of alternative fuels.

Table 6: City Fleet Indicators Change			
Public Works Fleet (unless otherwise stated)	2005	2012	% Change
Number of Vehicles	6,090	7,387	21%
MT CO ₂ e per Vehicle	9.8	7.6	-23%
Vehicle Miles Traveled	52,825,683	48,022,781	-9%
kg CO ₂ e per Fleet Mile	1.13	1.17	3%
Fleet Mile Per Vehicle	8,674	6,500	-25%
Aviation Fleet: kg CO ₂ e per Mile	Mileage data not available for 2006	1.31	N/A
Aviation Fleet: MT CO ₂ e per Vehicle	Vehicle Number data not available for 2005	10.3	N/A
Police Aircraft: (kg CO ₂ e per flight hour)	301.3	382.3	27%
Police Aircraft: MT CO ₂ e per Aircraft	123.0	169.3	38%

Figure 6 shows the percentage of change in emissions from the City Fleet based on the fuel type. The insert includes projections (2012* bar) that show the emissions, an additional 6,207 MT CO₂e, that would have occurred from diesel fuel had no biofuel policy been adopted.

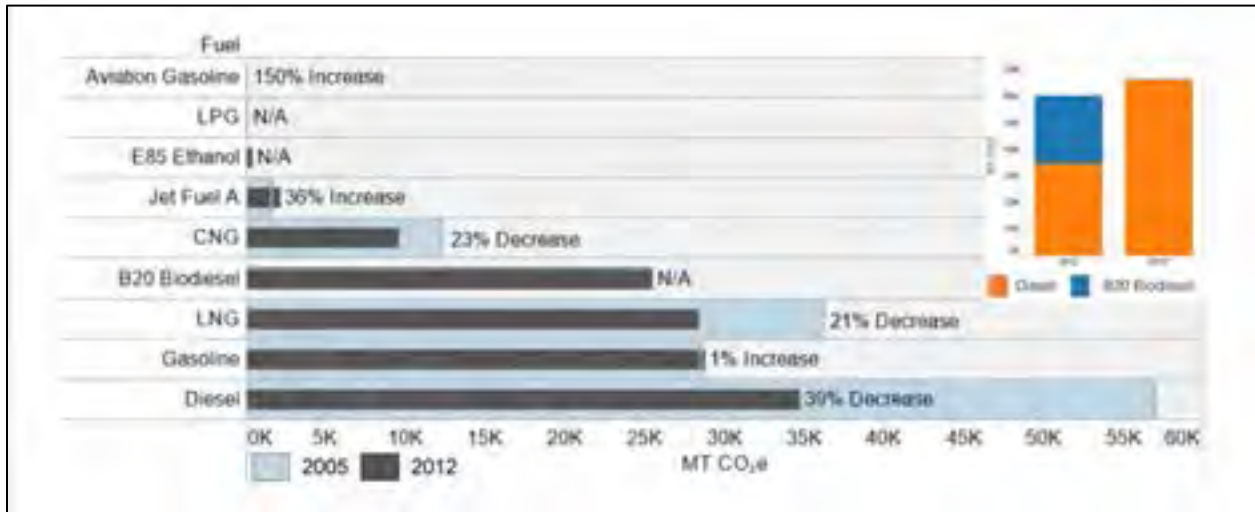


Figure 6: Changes in Emissions from the City Fleet between 2005 and 2012

GHG emissions from biofuels have both a fossil and biogenic emissions component. Fossil emissions, CH₄ and N₂O, result from the combustion of the gasoline fraction of the biofuel blend. Biogenic emissions result from the combustion of biomass-derived fuel. Fossil emissions add new GHG gases to the atmosphere, whereas biogenic emissions release GHG gases that were previously absorbed by the biomass.

City Action Highlights

Policies that encouraged the use of B20 biodiesel and E85 ethanol prevented fossil fuel emissions.

Future Reduction Opportunities

Public Works has the opportunity to further decrease its fleet emissions per mile. This can be accomplished with decreasing gasoline miles and/or the conversion of additional fleet vehicles to alternative fuels, which will further reduce fossil fuel emissions.

Water Distribution and Wastewater Treatment Processes

2005 vs. 2012: What Changed?

The Cave Creek Water Reclamation Plant was taken offline in January 2010 as an efficiency measure due to wastewater flows into the plant being at only half of the plant capacity. Future wastewater flows will be reviewed to determine if there is a need to return the plant to service.

In January of 2007, the Lake Pleasant WTP came online. The treatment process at the Lake Pleasant WTP meets the recent changes in the drinking water regulations and replaces the outdated treatment process at the Verde WTP. The Verde WTP was closed in December 2011.

Volumes treated at city of Phoenix water treatment and wastewater treatment plants decreased over this time period.

The Water Services Department finished construction of a 7.5 MW solar power facility at the Lake Pleasant WTP.

The 2012 inventory includes emissions from the hauling and regeneration of granulated activated carbon (GAC) for water treatment that were not included in the 2005 inventory.

Emissions Sources and Distribution

Emissions from Water Services (water distribution and wastewater treatment) decreased by 11% overall between 2005 and 2012 as indicated in Figure 7 (next page). The largest decreases were a result of reduced energy consumption at water treatment facilities and wastewater treatment plants. The changes in the GHG emissions from both WWTPs are due to a combination of reasons. The population changes had an impact as well as the changes in operation at the WWTPs and the reduced water usage from newer residential appliances.

Water Distribution and Wastewater Treatment Processes

Total Emissions: 154,792 MT CO₂e
25% of municipal operations emissions
6.3% decrease from 2005 levels

Emissions Sources

- Water distribution stationary & process emissions
- 23rd Avenue and 91st Avenue wastewater treatment plants stationary & process emissions

City Action Highlights

- Water Service Department's Lake Pleasant solar facility generates around 10.7 million kWh annually
- Water conservation and less volumes at WTPs and WWTPs have reduced treatment energy requirements

Future Reduction Opportunities

- Expand water conservation outreach
- Take advantage of new technology as it becomes available.

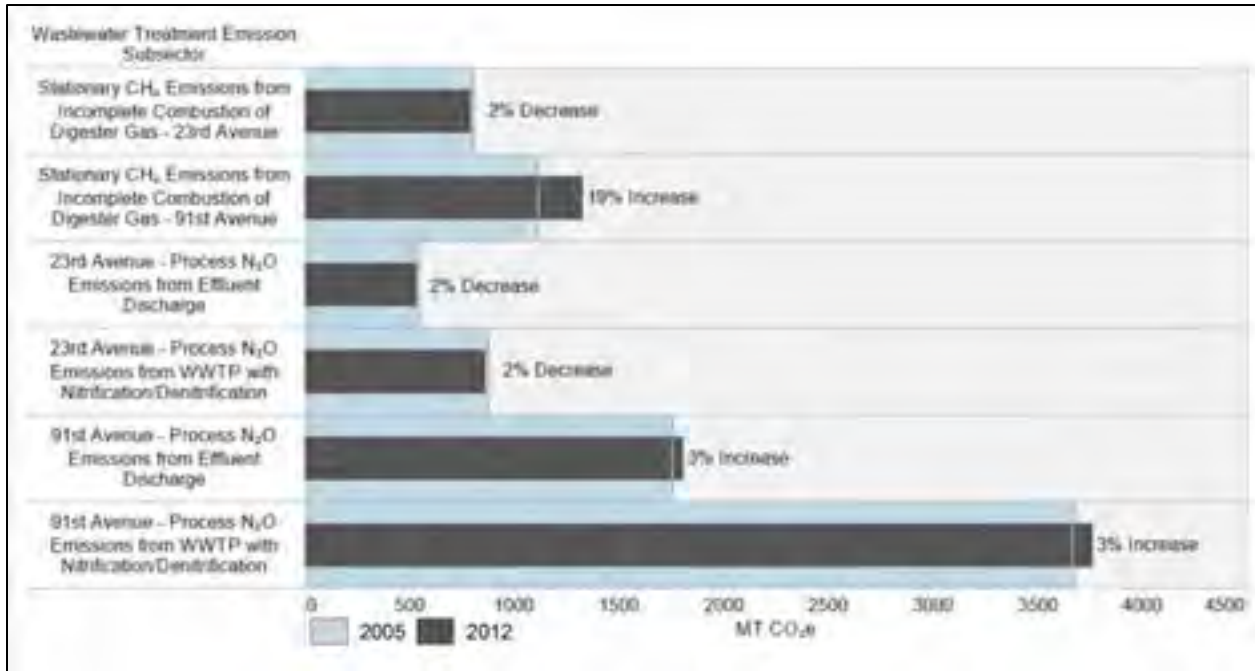


Figure 7: Changes in Emissions from Water Services by Subsector from 2005 and 2012

Figure 8 shows 2005 and 2012 process emissions from Phoenix WWTPs. While emissions decreased at the 23rd Avenue WWTP, they increased at the 91st Avenue WWTP. This was due primarily to a larger regional population being serviced by the 91st Avenue plant.

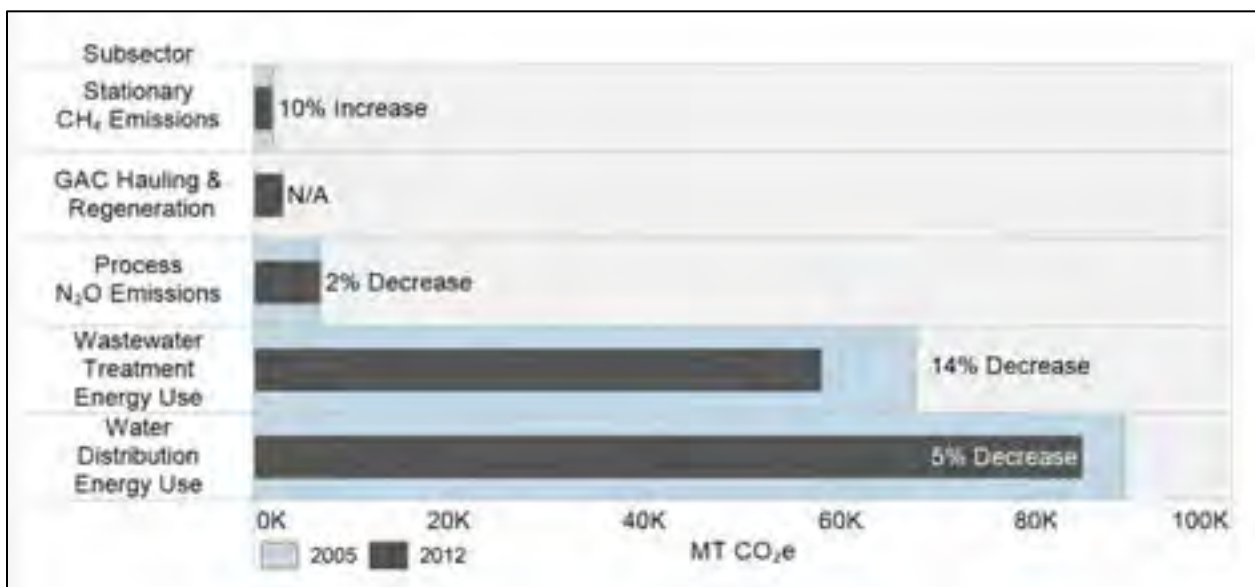


Figure 8: Changes in Emissions from Wastewater Treatment Processing between 2005 and 2012

Emissions are generated from the energy used in both distribution and treatment as well as from the regeneration of GAC used in the treatment process to remove disinfection byproducts. The WWT process itself also generates CH₄ and N₂O from the incomplete combustion of digester gas, the nitrification/denitrification process, and effluent discharge. Overall, Water Services emitted 9,077 MT CO₂e of these emissions. In 2012, energy consumption for water distribution and wastewater treatment was the most significant contributor, emitting a total of 142,719 MT CO₂e (Table 7). GAC hauling and regeneration is a new activity for Phoenix, so no 2005 benchmark exists.

Table 7: 2012 Water Services Emissions by Subsector				
Subsector	Total kWh	Total therms	Total gallons (diesel)	MT CO ₂ e
Water Distribution Electricity	155,904,799	--	--	84,619
Wastewater Treatment Electricity	106,036,261	--	--	57,552
Water Distribution Natural Gas	--	27,480	--	28
Wastewater Treatment Natural Gas	--	98,036	--	520
GAC Regeneration	--	554,400	5,268	2,996
Wastewater Treatment Processes	--	--	--	9,077
Total	261,941,060	679,916	5,268	154,792

Water Services indicators in Table 8 show that while less drinking water was treated more GHG emissions were emitted in 2012 per billion gallons treated. This may be due to the fact that most electricity uses are fixed and new requirements for GAC added the need to pump water to the GAC filters. The large solar facility at the Lake Pleasant WTP came on line in December 2012, so its full effect is not shown in 2012 data.

Table 8: Water Services Emissions Indicators			
Indicator	2005	2012	% Change
Gallons of drinking water treated (billion gallons)	109.4	100.8	-8%
MT CO ₂ e per billion gallons water treated	813	839	3%
Million Gallons of wastewater treated	69,523	62,868	-10%
MT CO ₂ e per Million Gallons Wastewater Treated	1.10	1.07	-3%

City Action Highlights

In December 2012, the Water Services Department finished construction of a 7.5 MW solar power facility at the Lake Pleasant WTP. In addition, water conservation efforts and increased use of water-efficient appliances have reduced water demand and wastewater volumes at water and wastewater treatment plants, thereby consuming less energy.

Future Reduction Opportunities

Water and Wastewater treatment operations have additional opportunities for reducing emissions by expanding water conservation outreach efforts in order to further reduce residential and commercial water demand and wastewater volumes to be treated.

Solid Waste

2005 vs. 2012: What Changed?

The city closed Skunk Creek landfill in 2006 and improved the landfill gas collection system at the landfill to capture fugitive emissions.

Additionally, the State Route 85 (SR 85) Landfill is developed with ongoing installation of a landfill gas collection system that includes horizontal wells that can capture gas while waste is still being placed in the landfill. This avoids fugitive methane emissions as early as possible in the process.

Mulching increased from 15,616 tons in 2005 to 20,832 tons in 2009. In 2012 Phoenix diverted even more green waste from going into the SR-85 Landfill, as 32,975 tons of green waste was mulched.

Emissions Sources and Distribution

Fugitive CH₄ emissions from landfills were reduced by 45% due to the installation of advanced landfill gas capture systems at the Skunk Creek and SR-85 landfills. This reduction was the most significant of any city emissions sector.

The SR-85 Landfill, which opened in 2006, is the only operational landfill managed by the city of Phoenix. It includes the ongoing landfill gas collection system mentioned previously. Rated as 90% efficient, it avoids a significant amount of fugitive methane emissions. Average capture efficiency of landfill gas at the city landfills is approximately 84%. Landfill gas at those sites will continue to diminish due to the natural decline of methane production over time as the landfills are closed and no longer receiving waste. Figure 9 (next page) details the change in emissions by facility.

Solid Waste

Total Emissions: 48,880 MT CO₂e
7.8% of municipal operations emissions
45% decrease from 2005 levels

Emissions Sources

- Flared methane from landfill gas capture systems
- Fugitive methane from the landfill surface

City Action Highlights

- 90% efficient methane capture system at newly opened SR-85 landfill
- Increased methane capture efficiency with improvements at Skunk Creek landfill

Future Reduction Opportunities

- Capture CH₄ and use it to power its facilities or offset emissions elsewhere
- Invest in new, more efficient technologies to convert waste for alternative uses as it becomes available

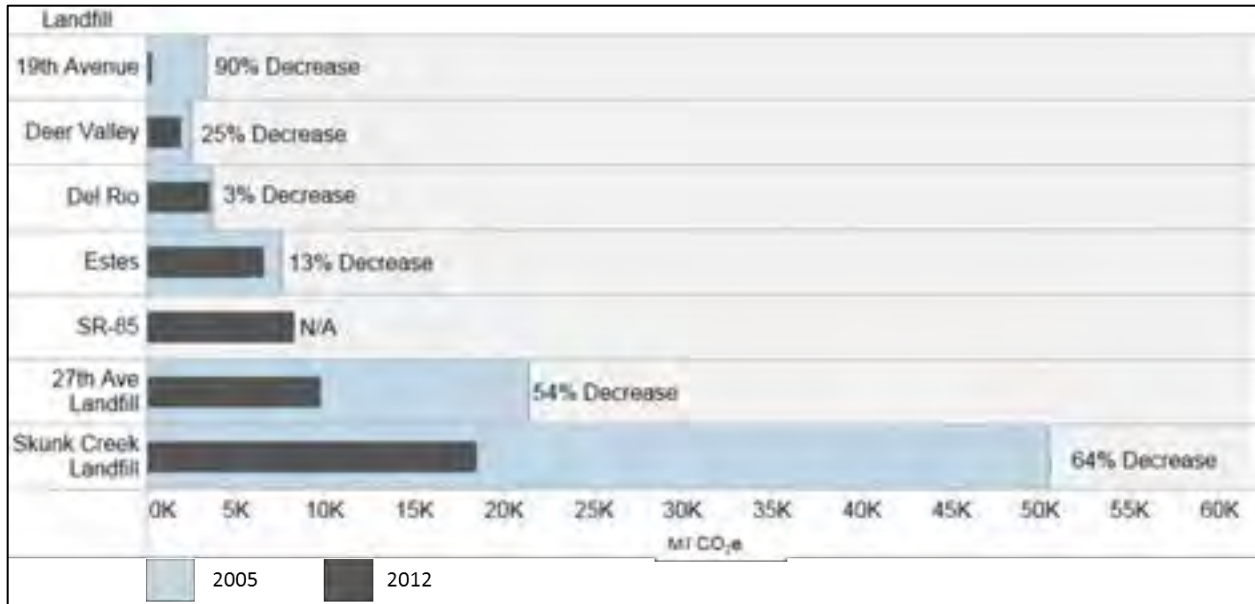


Figure 9: Changes in Emissions at Phoenix Landfills between 2005 and 2012

Table 9 provides an overview of the amount of methane (CH₄) collected and flared, the resulting methane released after flaring, and the MT CO₂e emissions produced from the released methane at each facility.

Table 9: 2012 Solid Waste Emissions by Landfill			
Landfill	Tons CH ₄ Collected/Flared	Tons CH ₄ Released	MT CO ₂ e Emitted
Skunk Creek	5,307	878	18,442
27th Avenue	2,501	465	9,760
Del Rio	168	170	3,570
Deer Valley	239	91	1,911
19th Avenue	84	15	322
Estes	N/A	313	6,577
SR85	3,705	395	8,298
Total	12,004	2,328	48,880

Note: Totals may not sum due to independent rounding.

Table 10 (next page) depicts the percent of change in annual solid waste tonnage received by Phoenix landfills and the average percent of MT CO₂e per ton captured due to improved gas capture systems. The 2005 numbers are for the Skunk Creek landfill, which closed in 2006. 2012 numbers are for the SR-85 landfill, which replaced Skunk Creek as the city's active landfill.

Table 10: Annual Solid Waste Received by Landfill (tons)			
Indicator	2005	2012	% Change
Annual Waste Received by Landfill (Tons)	1,046,862	818,303	-22%
kg CO ₂ e Per Ton of Waste	85.0	59.7	-30%
Average % CH ₄ Capture	68%	84%	22%

City Action Highlights

The solid waste emissions decreased significantly from 2005 levels due to expanded gas collection systems, as well as the natural decrease of emissions from closed landfills. Skunk Creek landfill was closed in 2006 with a final cap and expanded collection system, improving its methane capture rate from 50% to 85%. The SR-85 landfill was fully operational in 2007, with a 90% methane capture efficiency rate.

NOTE: Landfill GHG emissions in this report will differ from data reported to the Environmental Protection Agency for its GHG mandatory reporting. This GHG update uses formulas contained in the Local Government Operations Protocol to calculate emissions, while EPA uses its own separate and different methodologies for both GHG emissions and estimated gas collection system capture rates. While EPA specifies use of a capture rate formula which relies on cover type and area, this GHG update estimates capture rates at its landfills using operational indicators, such as status of ongoing gas well installation at SR85, which includes horizontal wells, surface monitoring, flare data, and landfill cover maintenance.

Future Reduction Opportunities

Solid Waste operations have additional opportunities for reducing emissions through energy efficiency and alternative energy sources, especially in capturing CH₄ and using it to power its facilities or offset emissions elsewhere. They can make the most of new technology and programs, especially those that divert waste for alternative energy generation.

Employee Commute

2005 vs. 2012: What Changed?

Employee commuting miles increased by 22% from 2005 levels.

2005 commuting miles data did not include miles by bus or light rail, which are both included in 2012 data. Light rail did not exist in 2005.

2005 employee commuting data was updated to include volunteer sites (work sites with less than 50 employees), which were not included in the original report. The 2005 data was revised for those sites and estimated using the average annual commuting statistics for city employees that year. In 2012, volunteer site data was available for inclusion in the inventory.

Alternative fuel vehicle commuting miles by fuel type was estimated for 2005, while 2012 used actual AFV ownership data.

Lastly, employee commuting done in city vehicles is not counted as employee commuting to avoid double counting. Estimated employee commuting in city vehicles in 2005 was approximately 4.4 times greater than the actual data in 2012, which may be a contributing factor in the 2005-2012 estimated increase in emissions.

Emissions Sources and Distribution

Fuel use from personal vehicles, vanpools, bus transit and light rail is used to account for commuting emissions. Alternative fuel vehicle commuting is estimated from statewide ownership data obtained from the EIA. Emissions from bus commuting are reported in the Public Transit sector. Instances of employees commuting in city vehicles are counted as Vehicle Fleet emissions.

The city of Phoenix also participates in the valley-wide Trip Reduction Program (TRP) overseen by Maricopa County Air Quality Department. This program allows employers to generate a yearly analysis of employee commuting from voluntary employee surveys.

Employee Commute

Total Emissions: 35,872 MT CO₂e
5.6% of municipal operations emissions
16% increase from 2005 levels

Emissions Sources

- Gasoline
- Compressed Natural Gas (CNG)
- Electric
- Liquefied Petroleum Gas (LPG)
- Ethanol

City Action Highlights

- Construction of light rail
- Employee Rideshare Program

Future Reduction Opportunities

- Encourage employee buy-in and engagement in alternative commuting options
- Promote the use of alternative fuel vehicles

The 2012 inventory captures commuting data for all of city of Phoenix employees generated through TRP. The city's 2005 TRP survey accounted for only 65% of city employees, as it was limited to only those sites with 50 or more employees. The 2005 data has been adjusted to account for 100% of 2005 employees for consistent and more accurate comparison with 2012 data.

Table 11 breaks down 2012 employee commuting emissions by fuel type or by mode of transportation and the resulting emissions.

Table 11: 2012 Employee Commute Emissions by Fuel Type/Mode		
Fuel Type	Total Vehicle Miles	MT CO ₂ e
Gasoline	93,917,068	35,179
Electric	118,470	31
CNG	172,979	50
LPG	83,046	26
E85	766,210	43
Bus‡	4,503,309	483
Light Rail‡	376,188	62
Total	99,937,270	35,872

‡ Not surveyed in 2005. Note: Totals may not sum due to independent rounding.

City Action Highlights

The Phoenix Light Rail opened in 2008, providing city employees another opportunity to commute by public transit. The city also continued its employee rideshare program, providing carpool-parking subsidies, free bus/light rail passes for employees, emergency ride home cab vouchers, telecommuting, bicycle facilities and other incentives.

Future Reduction Opportunities

The city has a tremendous opportunity to reduce employee commuting emissions. This may be accomplished through educational and incentive programs as well as increased opportunities for encouraging the use of mass transit and carpooling.

4. Emissions Trajectory Toward 2015

The city of Phoenix has several GHG reduction projects planned between now and 2015. Table 12 shows estimated reductions in MT CO₂e from these projects.

Table 12: Estimated GHG Emissions Reductions from 2013 through 2015 (MT CO₂e)

Reduction Program	2013	2014	2015	Total Reduction
Solar PV Installations	6,181	35	0	6,216
Better Building Program - kWh	5,520	5,360	5,205	16,085
Better Building Program - therms	196	191	185	572
Traffic Signals Efficiency Upgrade	0	0	1,676	1,676
Streetlights Efficiency Upgrade	142	171	147	460
Sky Train Aviation CNG Reduction	1,527	0	382	1,909
Contracted Waste Haulers to B20	1,357	0	0	1,357
Converting City haulers from B20 to CNG	274	119	237	630
Ceasing Flaring at 91st Ave WWTP*	0	0	1,325	1,325
Estimated Reduction	15,197	5,876	9,157	30,230

* Sale of biogas emissions

Projects include:

- Continue building energy efficiency efforts to reduce emissions by 16,658 MT CO₂e.
- Further retrofitting of 2,489 high-pressure sodium (HPS) streetlight bulbs and conversion of 100% of the traffic lights to LED to prevent 2,136 MT CO₂e.
- Planned solar energy projects are expected to reduce emissions by 6,216 MT CO₂e by 2015.
- Conversion of 85 Phoenix solid waste trucks to CNG from B20 biodiesel, reducing emissions by 630 MT CO₂e. Contracted solid waste haulers will switch to B20 biofuel from diesel fuel, further reducing emissions by 1,357 MT CO₂e.
- Currently under consideration is replacing flaring technology with digester gas technology at the 91st Avenue WWTP. Decreased flaring would reduce emissions by 1,325 MT CO₂e.
- Completion of the PHX Sky Train Stage 1A will eliminate CNG emissions from Sky Harbor inter-terminal buses in 2015, reducing Aviation's CNG fuel consumption by 32% from 2012 levels when Stage 1 and Stage 1A were not yet completed. (Note: Stage 1A reductions will not be completely captured in the 2015 annual inventory). However, an additional 12,000,000 kWh/year of electricity will negate the inter-terminal CNG busing reduction until the PHX Sky Train is completed to the Rental Car Center, which will then also eliminate the Rental Car Center busing. The PHX Sky Train will also reduce commuting emissions to and from Phoenix Sky Harbor.

5. Benchmarks

The 2012 inventory update lays the foundation for both internal and external benchmarking for future emissions inventories. Internal benchmarks are measured in the inventory as a measure of GHG intensity, the amount of greenhouse gases emitted for a particular output (e.g., MT CO₂e per sq. ft. of city operated building space), or GHG efficiency, which increase as city service is provided with less associated emissions (e.g., gallons of treated water per MT CO₂e emitted). Table 13 details the benchmarks and how they are measured.

City Operations Indicators	2005	2012	Unit
Employees	14,667	12,849	employees
Building Area	25,948,884	30,624,893	sq. ft.
Volume of Water Treated	109.4	100.8	billion gallons
Volume of Wastewater Treated	69.5	62.9	billion gallons
Total Emissions per Employee (F/PTE)	46.2	49.0	MT CO ₂ e/employee
Vehicle Emissions per Employee (F/PTE)	9.2	10.1	MT CO ₂ e/employee
Emissions per sq. ft.	7.35	6.44	kg CO ₂ e/sq. ft.
Cooling Degree Day GHG Intensity	39.16	37.58	MT CO ₂ e/CDD
Building/Facilities Emissions per F/PTE	13.01	15.34	MT CO ₂ e/employee
Emissions Per Traffic Signal	7.97	6.70	MT CO ₂ e/Signalized Intersection
Emissions Per Street Light	0.46	0.42	MT CO ₂ e/Street Light
Number of Vehicles (PW Fleet only)	6,090	7,387	vehicles
Vehicle GHG Intensity	10	8	MT CO ₂ e/vehicle
Annual Fleet Miles (PW Fleet only)	52,825,683	48,022,781	mi
Vehicle Mile GHG Efficiency (PW)	1.13	1.17	kg CO ₂ e/mi
Commuting Gasoline Miles Traveled	81,781,407	93,917,068	mi
Commuting Gasoline Miles Per Employee	5,576	7,167	mi/employee/year
% Single Occupancy Vehicle	73.8%	74.1%	%

External benchmarks are based on community-wide emissions, which Phoenix has yet to measure. Community-wide emissions would include, but would not be limited to: emissions from residential, commercial and industrial electricity usage; and emissions from commuting into and out of the city; total vehicle miles driven within the city; and private waste handling.

6. Biogenic Emissions

Biogenic emissions are produced through the combustion or decomposition of biologically-based materials rather than fossil fuels.^{7,8} Biogenic emissions do not count as a fossil GHG emission and are tabulated as informational items for the purposes of the 2012 Inventory update. Table 14 shows biogenic emissions from city of Phoenix government operations in 2005 and 2012.

Biogenic CO ₂ summary	2005	2012
Biogenic Landfill Emissions	66,739	74,946
Biogenic B20 Biodiesel Emissions	--	5,735
Biogenic E85 Ethanol Emissions	--	1,405
On-Site Biogas Use — 91st Ave. WWTP	4,083	2,701
Flared Biogenic Wastewater CO ₂ — 91st Ave. & 23rd Ave. WWTPs	58,146	37,117
Total biogenic emissions	128,967	121,904
% of Fossil Emissions	19.0%	19.4%

Sources of biogenic emissions come from blended biofuels, such as B20 biodiesel and E85 ethanol, municipal landfills, and wastewater treatment plants. For blended biofuels, the biofuel component of the fuel is considered biogenic while the emissions, primarily N₂O and CH₄, from the diesel or gasoline component are considered to be fossil emissions.

At landfills and wastewater treatment plants, microorganisms produce both CH₄ and CO₂ in approximately equal parts—ranging from 50/50 to 60/40. The CO₂ produced is considered to be biogenic, but the CH₄ is not, as it occurs from anaerobic decomposition conditions created by humans such as in the operation of a landfill.

⁷ RTI International, 2010. Greenhouse Gas Emissions Estimation Methodologies for Biogenic Emissions from Selected Source Categories: Solid Waste Disposal Wastewater Treatment Ethanol Fermentation. URL: http://www.epa.gov/ttnchie1/efpac/ghg/GHG_Biogenic_Report_draft_Dec1410.pdf

⁸ EPA, 2013. Carbon Dioxide Emissions Associated with Bioenergy and Other Biogenic Sources. URL: <http://www.epa.gov/climatechange/ghgemissions/biogenic-emissions.html>

7. Recommendations for Future city of Phoenix GHG Inventories for Government Operations

The 2012 update of the 2005 emissions inventory reflects the city of Phoenix's leadership in municipal climate action and progress in reducing greenhouse gas emissions. To further Phoenix's commitment to climate leadership and its GHG reduction program, the following actions are recommended:

1. The city of Phoenix should consider implementing an annual inventory update policy to more accurately identify and effectively influence the drivers of change in emissions and provide feedback to department managers on the success of GHG reduction programs and policies.
2. Transparency and accountability are critical in ensuring that emissions reduction efforts remain active. A city of Phoenix online GHG dashboard would present the results of emissions inventories in an easily accessible way. This tool could be made available to city staff to increase awareness and involvement in the effort to reduce emissions. The dashboard could also be made available to the public to educate and encourage community support for climate action.
3. Greenhouse gases are not contained by city boundaries. The actions of each city and town in the Phoenix Metro area affect neighboring towns, cities, and tribes. A comprehensive view of regional emissions is critical in order to target major GHG emissions contributors that impact Phoenix's efforts. A Regional GHG Emissions Inventory would ensure that the city's efforts are effective; encourage collaboration across the Valley; and identify additional opportunities for reducing emissions in residential, commercial, and industrial areas.
4. Climate changes pose a greater threat to certain populations and resources within Phoenix. A Risk & Vulnerability Assessment would identify those populations and resources at the greatest risk. It would also enable the city to develop and analyze a variety of climate change scenarios to inform resilient development strategies (e.g. infrastructure, transportation).
5. The city of Phoenix has had great success in its GHG emissions reduction projects and programs and has, in fact, surpassed its 2015 reductions goal. Therefore, setting New Climate Reduction Targets could help ensure that the city continues its success in climate leadership.

8. Climate Action Plan Review

In December 2008, the Phoenix City Council adopted Resolution Number 20759, which states:

WHEREAS, the City of Phoenix is committed to sustainability and protection of our natural resources.

WHEREAS, the Mayor and City Council recognize the importance of reducing GHG emissions to mitigate the impact of global climate change.

NOW, THEREFORE, BE IT RESOLVED BY THE COUNCIL OF THE CITY OF PHOENIX AS FOLLOWS:

SECTION 1. Adopts a goal to reduce GHG emissions from City operations to 5% below the 2005 levels by 2015.

Emissions Reduction Measures

In response to the adoption of the resolution, the city developed ten emissions reduction measures from a review of its sustainability programs, options for new or enhanced programs, measures used by other cities, and discussions with key department staff and management. Measures were selected based upon their ability to provide cost effective and measurable emissions reductions over time. They were grouped into three sectors that reflect the city's major sources of emissions: energy use, transportation and solid waste. Table 15 lists each measure, its category and the estimated emissions reduction. The total estimated reduction of 120,428 MT CO₂e would result in a 5.3% reduction from the 2005 levels.

Table 15: Summary of CAP Measures with Reduction Goals	
	GHG Reduction MT CO ₂ e
Energy Efficiency (EN)	
EN-1: WWT Digester Gas Projects (91 st & 23 rd Avenue Plants)	40,916
EN-2: Renewable Energy Goal (15% renewable by 2025)	35,000
EN-3: Energy Efficient Traffic Signals	1,885
EN-4: Energy Efficiency: Existing Buildings	1,215
EN-5: Energy Efficiency: New Construction	697
Transportation (TR)	
TR-1: Alternative Fuels	9,028
TR-2: Automated Train at Sky Harbor Airport: Stage I	5,519
TR-3: Employee Rideshare Program	3,019

Solid Waste (SW)	
SW-1: Methane Collection at Landfills (SR-85 & Skunk Creek)	21,432
SW-2: Green Waste Mulching & Recycling	1,717
Total	120,428

The following sections summarize performance against each measure and evaluate the city’s progress towards its reduction goals.

Energy Efficiency & Renewable Energy

The measures in the Energy Efficiency & Renewable Energy (EN) category are associated with electricity and natural gas used to operate city buildings and facilities.

EN-1: Wastewater Treatment (WWT) Digester Gas Projects: Use the CH₄, CO₂, and other GHG emissions from the 91st Avenue and 23rd Avenue plants to produce electricity or substitute for natural gas. The digesting process “scrubs” captured biogas rather than flaring it to generate fuel and/or electricity. The city can then use the fuel to displace the use of purchased electricity or natural gas, thereby reducing emissions for its operations, or market the fuel/electricity to a third party.

Status: Although no reduction has been achieved to date, planning is underway for a project at the 91st Avenue WWTP. A similar project is being considered for the 23rd Avenue plant.

EN-2: A Renewable Energy Goal: 15% of the total energy-use in municipal operations to be generated from renewable sources by 2025. This measure includes solar projects and gas-to-energy projects at 27th Avenue and Skunk Creek landfills.

Status: Currently, over 14 MW of solar capacity has been installed with an additional 1.2 MW under development. This is 3% of the city’s total energy-use. Phoenix continues to pursue city/utility solar partnerships, rooftop, open space, and landfill solar as well as the landfill gas projects above. See Appendix B for a list of current solar projects.

EN-3: Energy Efficient Traffic Signals: Retrofit traffic and pedestrian control signals with Light Emitting Diode (LED) technology. Replacing existing signals as well as requiring LED signals for new/modified intersections contributes towards the goal of 40% by 2015 and 100% LED signals by 2025. This measure assumes a 54% decrease in electricity use compared to incandescent traffic signals.

Status: Of the 971 intersections with signals in 2005 and 1105 intersections in 2012, 718 have been converted to LEDs. This amounts to 65% of the city's existing signals, far ahead of the targeted 40% conversion by 2015. Therefore, the city has updated its goal to 100% LED traffic signals by 2014. Emissions decrease from 7.97 to 6.70 MT CO₂e per traffic signal. However, the increased energy efficiency has been offset by additional capabilities and energy loads from cameras and network radios on the new LED units.

To further its energy efficiency efforts, the city's Street Transportation Department adopted LED fixtures as its new standard street light fixture in 2012. To date, 200 out of the city's approximate 90,000 street lights have been converted to LED fixtures. These LED installations use almost 50% less wattage than high-pressure sodium lighting, decreasing the emissions in the 2005 street light inventory from .046 per street light to .042 MT CO₂e per streetlight in 2012.

EN-4: Energy Efficiency in Existing Buildings and Facilities: The city's CAP goal is to improve energy efficiency and conservation efforts in city facilities. The Energy Savings Reinvestment Fund (Energy Conservation Fund) was targeted to help reduce 2005 electricity use by 1.5% in 60% of the buildings managed by the Public Works department through energy efficiency retrofit projects. It also assumed that Aviation would achieve a 1.0% reduction of 2005 energy use, based upon ongoing equipment replacements and projects.

Status: Energy efficiency measures have been implemented in 45 city facilities using federal American Recovery and Reinvestment Act funds, as well as the city's Energy Conservation Fund. See Appendix D for a list of the energy efficient projects on existing facilities.

As a further demonstration of its commitment to energy efficiency, Phoenix has signed on to the U.S. Department of Energy's Better Buildings Challenge committing to a 20% energy reduction by 2020. The reduction will be based on the city's 2009 energy use.

EN-5: Energy Efficiency for New Construction: Phoenix estimated an energy savings of 14% from better energy efficiency in new construction by requiring that projects overseen by the Engineering and Architectural Services Department (EAS) meet a minimum of 2 Leadership in Energy and Environmental Design (LEED) points for energy performance. Aviation and Water Services Departments' construction projects were not included in the 2009 CAP, as these departments manage their own projects and sufficient data was not available at that time.

Status: The 2006 Phoenix Energy Conservation Code, which establishes regulations for energy efficient buildings using prescriptive and performance-related provisions, required all new buildings to meet minimum LEED standards. In 2012, the city amended its building code to increase energy efficiency requirements to roughly 30% more than the 2006 code. It also adopted the International Green Construction Codes (IGCC) as a supplement to the 2006 code standards.

The IGCC “is intended to safeguard the environment, public health, safety and general welfare through the establishment of requirements to reduce the negative impacts and increase the positive impacts of the built environment on the natural environment and building occupants.” Use of the city’s 2012 IGCC is optional.

Transportation (TR)

TR-1: Alternative Fuels: Power the city fleet through the use of CNG, LNG, ethanol flex-fuel, and hybrid technology. This measure focuses on the transition to biodiesel (B20) and expansion of ethanol (E85) because the two fuels are expected to result in the greatest increase during the 2005-2015 timeframe. This measure includes plans to construct four E85 compatible tanks for Public Works and one for Aviation to fuel approximately 500 flex-fuel vehicles by 2015. The GHG reduction potential was estimated at 5,752 MT CO₂e for biodiesel and 3,276 MT CO₂e for E-85 fuel.

Status: All diesel fleet vehicles have been converted to biodiesel. However refueling tanks at certain facilities may still contain Ultra Low Sulfur diesel because the tanks there turn over slowly due to minimal use and B20 has separation issues during long durations of storage. Public Works currently manages four E85 tanks. Aviation manages one E85 tank. The 2012 inventory has estimated that the use of B20 Diesel has avoided 6,207 MT CO₂e emissions and E85 fuel has avoided gasoline 2,582 MT CO₂e emissions; thereby, closely approaching the estimates of the 2009 CAP for overall emissions reduction.

TR-2: Automated Train at Sky Harbor Airport: Provide service from the Light Rail to Terminal 4 by 2015. This represents Stage I of the Phoenix Sky Train, which is assumed to eliminate the need of 29 CNG buses with a GHG reduction potential of 5,519 MT CO₂e. NOTE: The original measure target of eliminating a certain number of buses has been updated to reducing estimated Aviation CNG usage by 32%. The potential emissions reduction target has not changed.

Status: In progress. The reduction of CNG emissions from the PHX Sky Train are not included in the 2012 GHG emissions inventory as Stage 1 was not carrying passengers until April 2013.

TR-3: Employee Rideshare Program: Provide incentives such as carpool parking subsidies, free bus/light rail passes for employees, emergency ride home cab vouchers, telecommuting, and bicycle facilities to encourage participation in the travel reduction program. Phoenix aims to expand employee participation from 26% in 2005 to 40% in 2015 with an estimated emissions reduction of 3,019 MT CO₂e. The calculation is based on the number of employees who work at sites with 50+ employees.

Status: The Phoenix Light Rail opened in 2008, providing city employees another opportunity to commute by public transit. Despite this addition, participation in the employee rideshare program remained at approximately 26% in 2012. Employees still use gasoline as the primary fuel for commuting, averaging about 93,910,834 total vehicle miles. However, alternative fuels and modes of transportation (i.e., bus and light rail) now account for 6% or 6,026,437 total vehicle miles. Emissions from the use of gasoline equal 35,176 MT CO₂e while the total emissions from electric, CNG, LPG, E85, Bus and Light Rail commuting equal only 695 MT CO₂e.

Solid Waste (SW)

SW-1: Methane (CH₄) Capture at Landfills: Improve and expand CH₄ capture for the Skunk Creek and SR-85 Landfills to achieve an estimated 21,432 MT CO₂e reduction in GHG by 2015.

Status: The increased landfill gas capture at the Skunk Creek Landfill from 50% in 2005 to 85% in 2012 has resulted in a reduction of fugitive emissions of 15,734 MT CO₂e. The SR-85 Landfill opened in 2006 with a 90% efficient capture system that has resulted in the avoidance of 15,561 MT CO₂e. Both emission reductions are calculated based on improved CH₄ collection efficiency beyond the EPA industry standard collection rate of 75%.

SW-2: Green-Waste Mulching & Recycling: Divert green waste from landfills to reduce methane emissions from organic materials. Mulching services are provided through a contractor at the 27th Avenue Transfer Station.

Status: 15,616 U.S. tons of green waste were mulched in 2005. The tonnage has steadily increased as indicated in Table 16 (next page).

Table 16: Diverted Green Waste		
Year	Diverted Green Waste (Tons)	Averted Methane Emissions (MT CO ₂ e)
2009	20,832	871
2010	24,982	1,045
2011	29,269	1,224
2012	32,975	1,379
2013 ^s	37,023	1,549
2014 ^s	41,070	1,718
2015 ^s	45,118	1,887
Total	108,058	9,673

^s *Estimated.*

In addition to mulching, the city of Phoenix was a pioneer in the use of rubberized asphalt to reduce the amount of material going to the landfill. Rubberized asphalt results lower noise levels and less tire wear as well as in approximately 1,500 tires used for every lane-mile. The Street Transportation Department continues to use asphalt rubber hot mix as the primary overlay in their arterial street maintenance program. Regionally, over 2 million used tires are recycled annually in Maricopa County diverting an enormous amount of material and reducing landfill emissions.

Appendix A: CAP Status Table

2009 Measures	Estimated Reduction MT CO ₂ e	2009 Assumptions	2012 Status	2012 Reduction MT CO ₂ e
<p>EN-1: WWT Digester Gas Projects (91st and 23rd Avenue plants):</p> <p>Captures methane generated in treatment process to produce electricity/substitute for natural gas</p>	40,916	<ul style="list-style-type: none"> Projects will use 3.2 million ft³/day— amount of methane flared at both plants in 2007 	<ul style="list-style-type: none"> Planning is underway for a Wastewater Treatment (WWT) Digester Gas project at the 91st Avenue WWTP. A similar project is being considered for the 23rd Avenue plant. 	N/A
<p>EN-2: Renewable Energy Goal (15% by 2025):</p>	35,000	<ul style="list-style-type: none"> Two landfill gas-to-energy projects and various solar projects will displace 61,295,474 kWh of electricity with renewable energy. 	<ul style="list-style-type: none"> 14 MW of solar capacity installed. 22,785,313 kWh was produced in March 2011-2012. 1.2 MW of solar capacity under development. Phoenix continues to pursue city/utility solar partnerships, rooftop, open space, and landfill solar On target to meet the 15% by 2025 goal 	N/A
<p>EN-3: Energy Efficient Traffic Signals:</p> <p>Phased program to replace incandescent traffic signals with LED technology</p> <p>LED signals as standard requirement for new/modified</p>	1,885	<ul style="list-style-type: none"> 40% of street intersections will be converted between 2005-2015; electricity use at each intersection will be 54% less than 2005 signals All new intersections will use LED signals 	<ul style="list-style-type: none"> 718 signalized intersections have been converted to LEDs, 65 % of the 1105 existing signalized intersections The goal has been updated to 100% LED traffic signals by 2014. Increased energy efficiency is offset by additional capabilities and energy loads on the new LED units (e.g., cameras, network radios). In 2012, Phoenix adopted LED fixtures as its new standard streetlight 	N/A

intersections			<p>fixture.</p> <ul style="list-style-type: none"> 200 out of the city's approximate 90,000 streetlights have been converted to LED fixtures. These LED installations use almost 50% less wattage than high-pressure sodium lighting. 	
EN-4: Energy Efficiency: Existing Buildings	1,215	<ul style="list-style-type: none"> 1.5% reduction of 2005 electricity in 60% of buildings managed by Public Works Department 1% reduction of 2005 energy use in Aviation equipment replacements and projects 	<ul style="list-style-type: none"> Energy efficiency measures implemented in 45 city facilities utilizing the federal American Recovery and Reinvestment Act funds. Energy CIP Budget (Savings Reinvestment Fund): identifies and implements energy efficiency improvements to existing facilities. Phoenix has signed on to DOE's Better Buildings Challenge and has committed to a goal of 20% energy reduction by 2020, based on a 2009 baseline. 	N/A
EN-5: Energy Efficiency: New Construction Engineering and Architectural Services Department. LEED standard	697	<ul style="list-style-type: none"> Energy use in buildings & facilities will increase by 1% per year – half of that growth will be from new buildings but with 14% better energy efficiency 	<ul style="list-style-type: none"> Phoenix currently operates under the 2006 Phoenix Energy Conservation Code, based on the 2006 IECC (International Energy Conservation Code) and also requires all buildings to meet minimum LEED standards. The 2011 Phoenix Green Construction Code is optional and was based on the 2008 National Green Building Standard ICC-700. Amendments to the 2012 building codes were adopted by City Council 	N/A

Future plans to include Aviation & Water Services Departments			<p>on May 15, 2013. The 2012 IECC is roughly 30% more energy efficient than the 2006 IECC.</p> <ul style="list-style-type: none"> Energy efficient projects listed in Appendix B 	
TR-1: Alternative Fuels: Bio-diesel Blend B20 & Ethanol Blend E85	9,028	<ul style="list-style-type: none"> Use of B20 will reduce petroleum diesel use by 20% in Aviation + Public Works fleet (B20 has 2% lower fuel energy density) Four new E85 tanks will fuel 500 vehicles by 2015 Use of E85 will reduce petroleum gasoline by 85% in each vehicle in the E85 fleet. Estimated total E85 use will be 437,500 gallons (E85 has 28% lower fuel energy density causing a 245 gallons/year increase per vehicle. In 2005 630 gallons/year was used per vehicle) 	<ul style="list-style-type: none"> All diesel fleet vehicles have converted to B20; however refueling tanks at certain facilities may still contain diesel because of minimal use and B-20 separation issues during long periods of storage Public Works has four E85 tanks and Aviation has one E85 tank. 	<p>B20: 6,207</p> <p>E85: 2,582</p>
TR-2: Automated Train at Sky Harbor Airport: Stage 1	5,519	<ul style="list-style-type: none"> Original target of 29 CNG buses that will be eliminated has been updated to a 32% reduction in Aviation vehicle CNG use. 1% electricity growth for Aviation buildings 	<ul style="list-style-type: none"> This measure began service in April 2013 and does not affect the 2012 Inventory. 	N/A
TR-3: Employee Rideshare Program Carpool subsidies, free employee bus/light rail for employees, bike facilities, et al	3,019	<ul style="list-style-type: none"> Increase participation from 30% to 40% Based on # of city staff who work at sites with more than 50 employees 	<ul style="list-style-type: none"> Participation remained at approximately 26% 	0

SW-1: Methane Collection at Landfills (SR-85 & Skunk Creek)	21,432	<ul style="list-style-type: none"> • SR-85 will open with a 90% efficiency capture rate system • Skunk creek will increase to a 85% capture rate system • Calculations based off difference from EPA standard of 75% 	<ul style="list-style-type: none"> • SR-85 opened in 2006; 90% capture rate • Collection efficiency at Skunk Creek increased from 50% in 2005 to 85% with final cap in 2006 	Skunk Creek: 31,295
SW-2: Green Waste Mulching & Recycling	1,717	<ul style="list-style-type: none"> • Mulching will increase from 15,616 tons (2005) to 25,000 tons (2009) and continue at that level through 2015. 	<ul style="list-style-type: none"> • In 2009 Phoenix diverted 20,832 tons of green waste; in 2012 Phoenix diverted 32,975 tons. 	N/A
TOTAL	120,428			40,879 [‡]

[‡]The total GHG reduction listed as resulting from CAP measures is lower than the overall reduction between 2005 and 2012 because reductions from the installation of solar energy projects and energy efficiency projects are reflected in overall building and facility electricity data and individual projects could not be disaggregated from the reported data. Additionally, any GHG reductions that were undertaken and not listed in the CAP are not listed in this CAP status table. Therefore, the total reductions from CAP measures are less than total GHG reductions reported.

Appendix B: Greenhouse Gas Equivalents*

Greenhouse Gas	Carbon Dioxide Equivalent
Carbon Dioxide (CO ₂)	1
Methane (CH ₄)	21
Nitrous Oxide (N ₂ O)	310
Hydrofluorocarbons (HFCs)	43-11,700
Perfluorocarbons (PFCs)	6,500-9,000
Sulfur Hexafluoride (SF ₆)	23,900

*Only carbon dioxide, methane and nitrous oxide were included in the 2005 and 2012 inventories

Appendix C: Solar Projects and Partnerships

Solar Projects/Partnerships				
Project #	Description	Completed	kW	Projected kWh/year
1	Pecos Park & Ride (SRP partnership)	2007	100	160,000
2b	Parking lot PV lighting system (32 ea. 40 W fixtures)	2007		17,520
3	Camp Colley (City-owned, off-grid)	2009	8.45	15,210
6	Phoenix Convention Center - West Building (City-owned)	2009	100	165,000
2a	North Gateway Transfer Station (City-owned)	2009	7	12,250
4	North Mountain Park Visitor Center (City-owned)	2010	3.15	5,670
5	Pecos Community Center (SRP lease-purchase/City-owned)	2010	30	54,000
12	Paradise Village Apts. (Housing)	2010	1.95	3,218
13	McCarty on Monroe (Housing & NSD)	2010	30	52,500
7	Washington Adult Center	2011	10	17,500
8	Audubon Visitor Center	2011	30	52,500
14	Maryvale Pool	2011	15	26,250
17	US Airways Parking Garage	2011	238	392,700
18	ASU Downtown - Walter Cronkite School of Journalism	2011	77	134,750
20	Burton Barr Central Library	2011	150	262,500
9	Fire Training Academy	2012	10	17,500
10	Fire Station #72	2012	10	17,500
11	Fire Station #1	2012	20	35,000
15	Sunnyslope Community Center - Main & Gym	2012	100	165,000
16	Downtown Transit Building	2012	30	52,500
19	Metro Facilities Bldg.	2012	90	157,500
21	Phoenix Children's Museum	2012	85	148,750
22	Aviation (East Economy Garages & Rental Car Center)	2012	5,400	8,775,000
23	Lake Pleasant	2012	7,500	10,740,318
24	Walker Building	2013	10	17,500
		Total	14,056	21,498,136
	<u>Under Development / Measure 3</u>			
	Downtown Parking Garages	2013	1.18 MW	

Appendix D: Energy Efficiency Projects

Energy Efficiency Projects	
Central Precinct	Service Center - Salt River SC Operations - EMD Building
Desert Horizon Precinct	Service Center - Union Hills Operations
Cactus Park Precinct	Burton Barr - Central Library
Public Safety Building	McDowell Senior Center
Police Dept. Crime Lab	Senior Opportunities West Senior Center
Fire Dept. - Operations Phase1	Watkins Emergency Shelter
Fire Dept. - Operations Phase2	Central Family Service Center Operations
Fire Dept. - Resource Management	Maryvale - 800 Precinct
Fire Station 01- District Office	Police Academy
Fire Station 09	Fire Station 18
Fire Station 11	Fire Station 23
Fire Station 20	Fire Station 25
Fire Station 29A	Fire Station 26
Fire Station 29B	Fire Station 28
Fire Station 33	Fire Station 43
Fire Station 41	Okemah Service Center
Fire Station 52	Glenrosa SC Operations
Fire Station 56	Glenrosa SC Operations - Multi
Adams St - Training Building	Glenrosa SC Operations CO1
Public Works Equipment Management Complex Operations	Palo Verde Park & Library
Service Center - Salt River Rear 4	Ocotillo Library
Service Center - Salt River SC - Storage	Saguaro Library

Appendix E: Findings by Scope

The following appendix presents city of Phoenix emissions broken down by scope instead of by reporting sector as in the text of the report. Overall emissions breakdowns are shown in Figures 10 and 11.

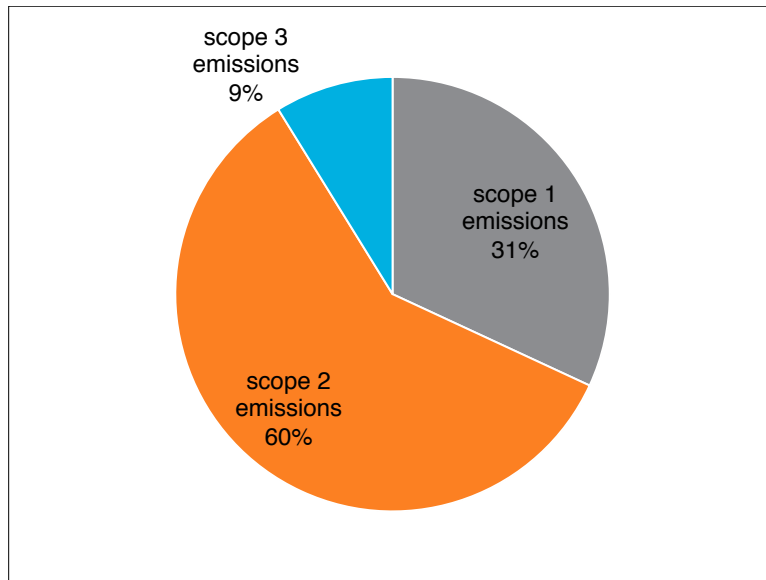


Figure 10: 2012 Emissions by Scope

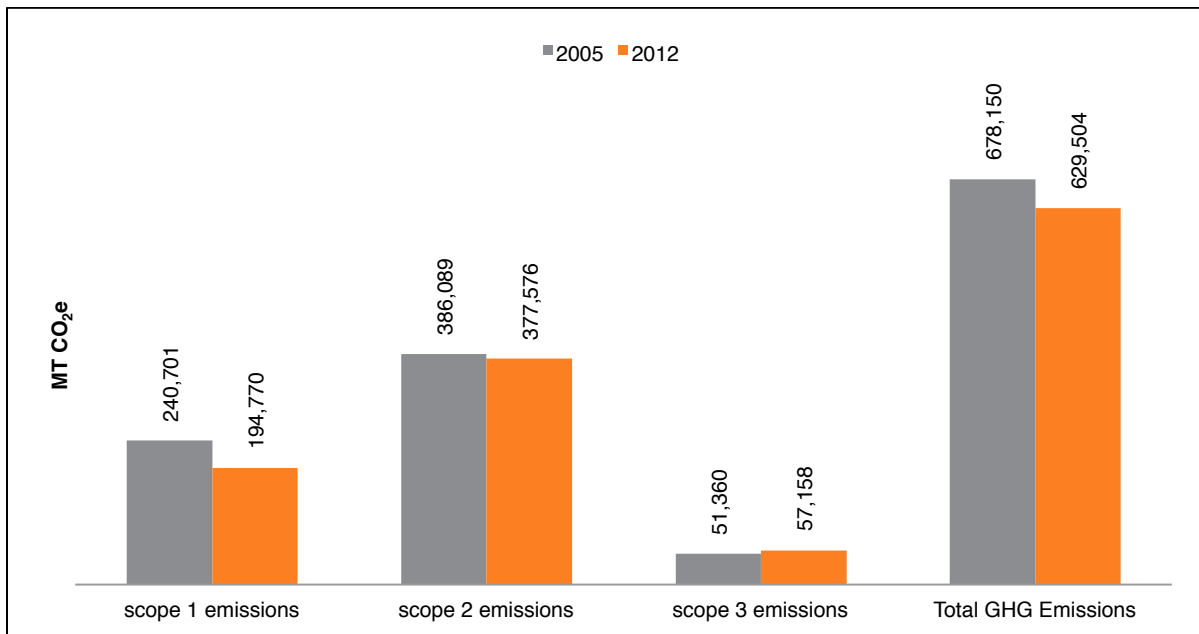


Figure 11: Municipal operations comparison, 2005 and 2012

Scope 1

Scope 1 emissions account for 31% of the city's total emissions with a total of 194,770 MT CO₂e. From 2005 to 2012, emissions from Scope 1 decreased 19%. Scope 1 is comprised of stationary combustion, fleet fuels and fugitive and process emissions from landfills and wastewater treatment plants (Figure 12). Stationary combustion includes emissions from natural gas usage in municipal buildings, wastewater treatment, and water distribution. Fleet fuels include gasoline, diesel, B20 biodiesel, compressed natural gas (CNG), liquefied natural gas (LNG), E85 Ethanol, liquefied petroleum gas (LPG), Aviation gasoline, and jet fuel. Fugitive emissions include those released from landfill methane gas, wastewater methane emissions and wastewater nitrous oxide emissions.

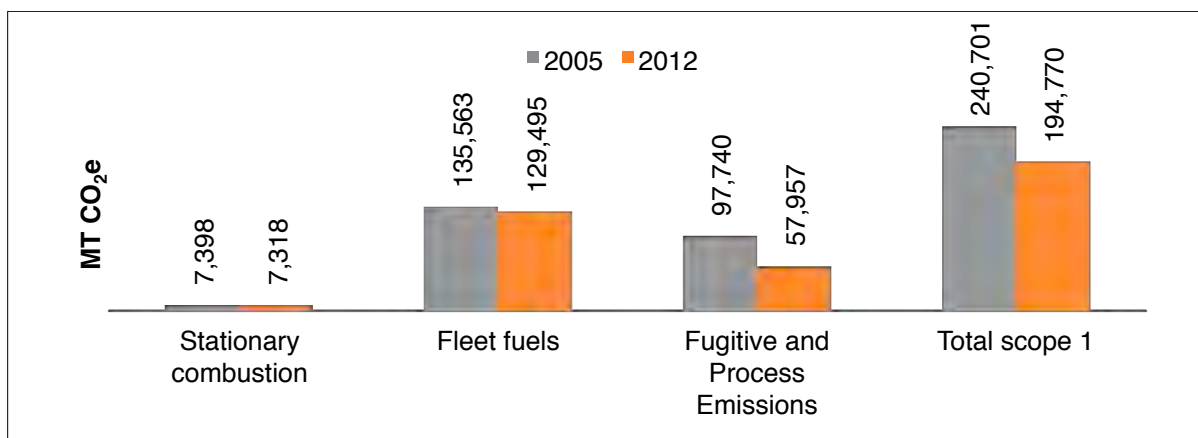


Figure 12: 2005 and 2012 Scope 1 Emissions

Stationary sources of Scope 1 emissions come from use at city buildings, use for water distribution, and use for wastewater treatment. The combustion of natural gas in buildings, and the resulting emissions, decreased by 6% between 2005 and 2012, while natural gas combustion for water distribution and wastewater treatment decreased by 72% and 43%, respectively.

The city's fleet fuels portfolio changed dramatically between 2005 and 2012 with the addition of B20 biodiesel vehicles and E85 flex fuel vehicles. Overall, emissions from the city's vehicle fleet decreased by 4.5% from 2005 to 2012. The incorporation of biofuels into the fleet fuel portfolio helped to reduce Scope 1 emissions between 2005 and 2012. For example, converting to B20 biodiesel prevented the emission of approximately 6,400 MT CO₂e. Reduced diesel consumption further reduced Scope 1 emissions along with B20 biodiesel.

Phoenix reduced fugitive and process emissions more than any other emissions category. Fugitive methane emissions from landfills were reduced by 45%, due to the installation of advanced landfill gas capture systems at the Skunk Creek and the new

SR-85 landfills. Fugitive and process emissions from wastewater treatment decreased slightly as city WWTPs treated less effluent in 2012 than in 2005.

Scope 2

Scope 2 emissions account for 60% of the city's total emissions with a total of 377,576 MT CO₂e. From 2005 to 2012, emissions from Scope 2 decreased 1.0% (Figure 13). Scope 2 is comprised of the indirect emissions from the off-site generation of electricity used in municipal buildings, street lighting, traffic signals and wastewater treatment. Scope 2 emissions from electricity generation are calculated from billed electricity, so the benefits of on-site generation of electricity from solar energy projects are not directly accounted for and buildings may consume more electricity than what is billed.

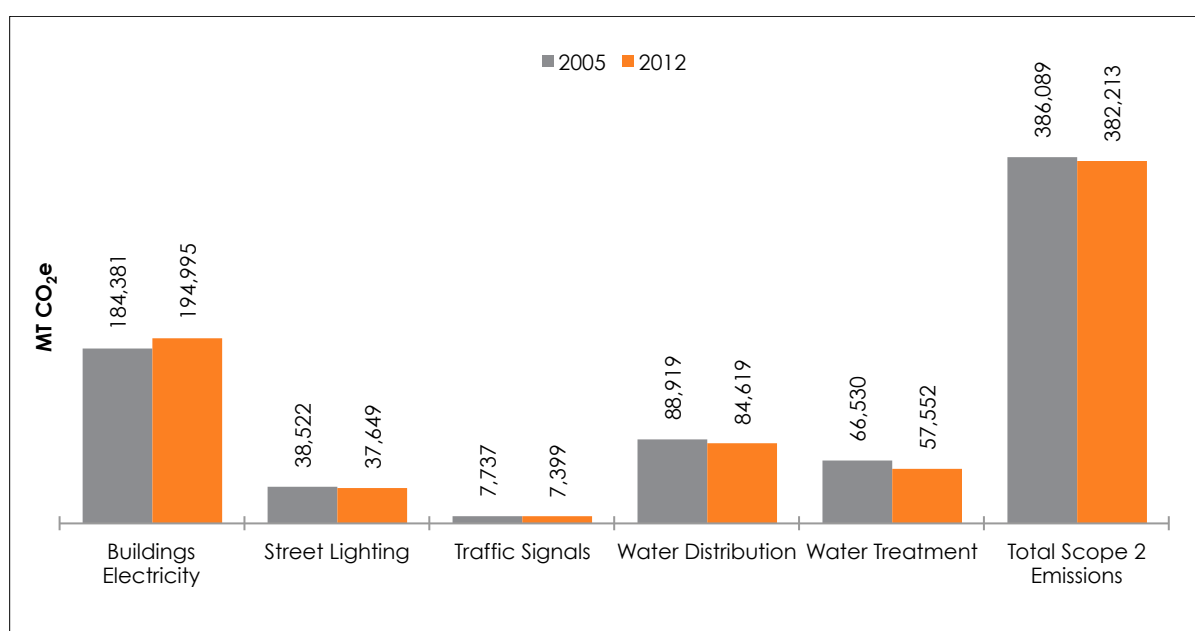


Figure 13: 2005 and 2012 Scope 2 Emissions

While Scope 2 emissions decreased between 2005 and 2012, the kilowatt-hours of electricity purchased increased by 9% overall. City buildings consumed 16% more purchased electricity; street lighting consumed 8% more purchased electricity; and traffic signals and water distribution consumed 5% more purchased electricity each. Wastewater treatment consumed 5% less purchased electricity.

Over the same period, however, the carbon intensity (eGRID factor) of the purchased electricity in Arizona, measured in MT CO₂e per generated kWh decreased by 9%. Additionally, Phoenix expanded its building footprint by 4,676,009 square feet, an 18% increase from 2005. Between 2005 and 2012, GHG emissions per square foot of city operated building space decreased 12% from 7.6 to 6.7 kg CO₂e per square foot.

Scope 3

Scope 3 emissions account for 9% of the city’s total emissions with a total of 57,158 MT CO₂e. From 2005 to 2012, emissions from Scope 3 increased 16%. Scope 3 is comprised of fuel emissions from employee commute, GAC Hauling and Regeneration, and the total T&D loss in the electricity grid associated with electricity purchased by the city. Although the city does not operationally control Scope 3 emissions, the LGOP encourages the reporting of activities relevant to a city’s GHG programs and goals. Phoenix chose to report emissions from these sectors because Phoenix has some ability to impact those activities through various policies, programs, and contracts.

Emissions from employee commuting are the largest component (60%) of Scope 3 emissions (Figure 14). Between 2005 and 2012 total employee commuting miles increased by 22%. The increase in commuting miles is a result of multiple factors. First, the 2005 commuting data did not include data regarding commuting by bus. The 2012 commuting data also includes information regarding light rail commuting, which did not exist in 2005. Both bus miles and light rail miles are included in 2012 totals. The 2005 employee commute data did include volunteer sites, which are city of Phoenix work sites that have less than 50 employees. Employee commuting to and from volunteer sites was estimated for 2005 using the average annual commuting statistics for city employees in that year. Thirdly, alternative fuel vehicle commuting miles by fuel type was estimated for 2005, while 2012 used actual AFV ownership data.

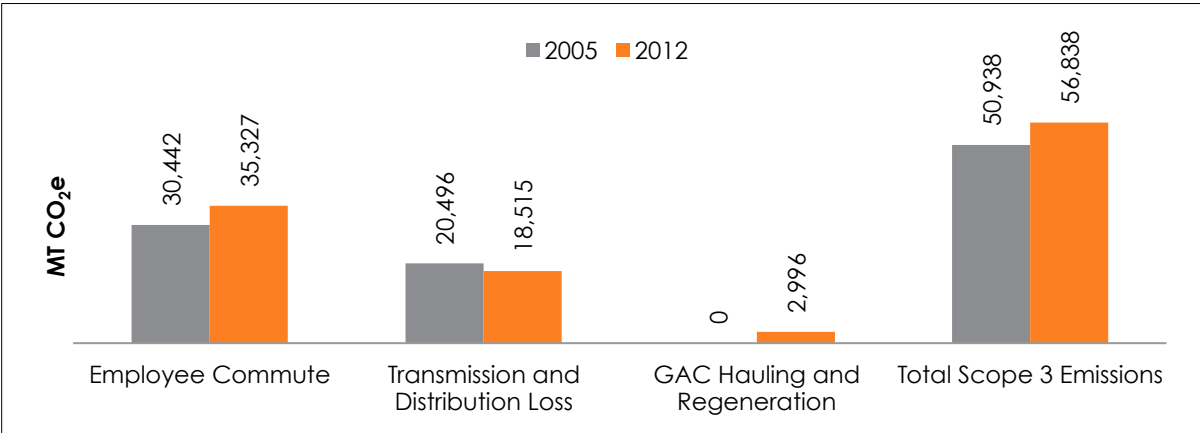


Figure 14: 2005 and 2012 Scope 3 Emissions

T&D loss from the electricity grid decreased by 1% between 2005 and 2012. Data for 2012 data was not yet available so the 10-year average T&D loss rate was used as a proxy. GAC hauling and regeneration is a new activity for Phoenix in the 2012 emissions inventory.