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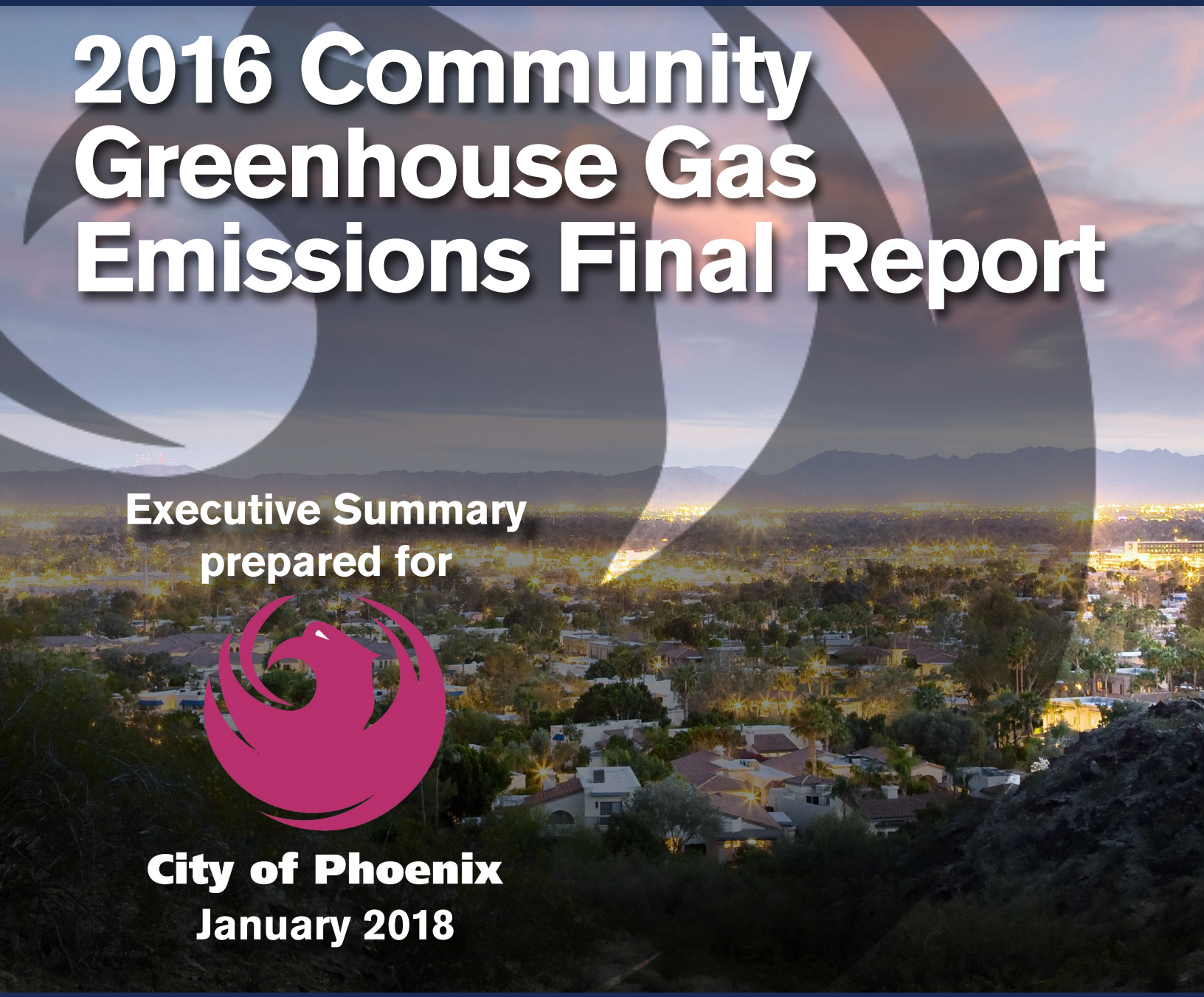
# 2016 Community Greenhouse Gas Emissions Final Report



Executive Summary
prepared for

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## Executive Summary

The City of Phoenix (Phoenix) has completed a community-scale greenhouse gas (GHG) emission inventories for calendar year 2016, a follow up to its first community-scale GHG emissions inventory for calendar year 2012. The community-scale GHG emission inventory was conducted using the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC Protocol).

The GPC Protocol is a worldwide standard for inventorying city-induced GHG emissions developed by the World Resources Institute, C40 Cities Climate Leadership Group, and ICLEI[1]. The GPC is also the standard supported by the Global Covenant of Mayors for Climate and Energy, of which Phoenix is a member.

The GPC Protocol categorizes direct and indirect GHG emissions into three sectors: Stationary energy, Transportation and Waste. Direct GHG emissions occur within Phoenix boundaries, such as gasoline consumption or natural gas combustion, and indirect GHG emissions are induced by activity within the Phoenix boundary, such as electricity consumption.

- Stationary Energy Sector GHG emission sources include energy utilized in residential buildings; commercial buildings and facilities; manufacturing industries; agriculture, forestry and fishing energy use; and electricity transmission and distribution energy losses.
- Transportation Sector GHG emissions include emissions from commercial air travel, civil aviation, on-road transportation, non-road vehicle use, light rail, and freight rail
- Waste Sector GHG emissions result from solid waste disposal, composting, and wastewater treatment.

The 2016 Community-Scale GHG Emission Inventory shows citywide emissions to be 15,684,329 metric tons of carbon dioxide equivalents (MT $CO_2e$), a 7.2% reduction in the overall GHG emissions compared to the 2012 levels of 16,897,600 MT $CO_2e$, and a positive change in the city's effort to mitigate climate change. The Transportation Sector is the largest source of GHG emissions in Phoenix and, in 2016, emitted 9,344,245 MT $CO_2e$. The Stationary Energy Sector is the second largest source of GHG emissions and emitted 5,958,302 MT $CO_2e$. The Waste Sector was the smallest source of GHG emissions for the City of Phoenix and emitted 381,783 MT $CO_2e$.

## Methodology

The 2016 Community-Scale GHG Emission Inventory for the City of Phoenix was conducted using the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) methodology to inventory direct and indirect GHG emissions. The GPC Protocol provides a clear methodology for determining which emission sources to include in or exclude in a GHG inventory; defining and categorizing GHG emission sources; and identifying how transboundary emissions are treated. In doing so, the GPC Protocol improves the quality and transparency of GHG inventories, increases the credibility of comparisons across geographies and timescales, and creates a meaningful benchmark to identify strategies for community-scale GHG emission mitigation.

[1] Greenhouse Gas Protocol. (n.d.). GHG Protocol for Cities | Greenhouse Gas Protocol. Retrieved from http://www.ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

## Key Findings

The 2016 Community-Scale GHG Emission Inventory shows Phoenix-wide GHG emissions to be 15,684,329 MT $CO_2e$, a 7.2% reduction in the overall GHG emissions compared to the 2012 levels of 16,897,600 MT $CO_2e$. The distribution of GHG emissions between Stationary Energy, Transportation, and Waste Sectors for 2012 and 2016 is shown in Figure 1 and detailed in Table 1.

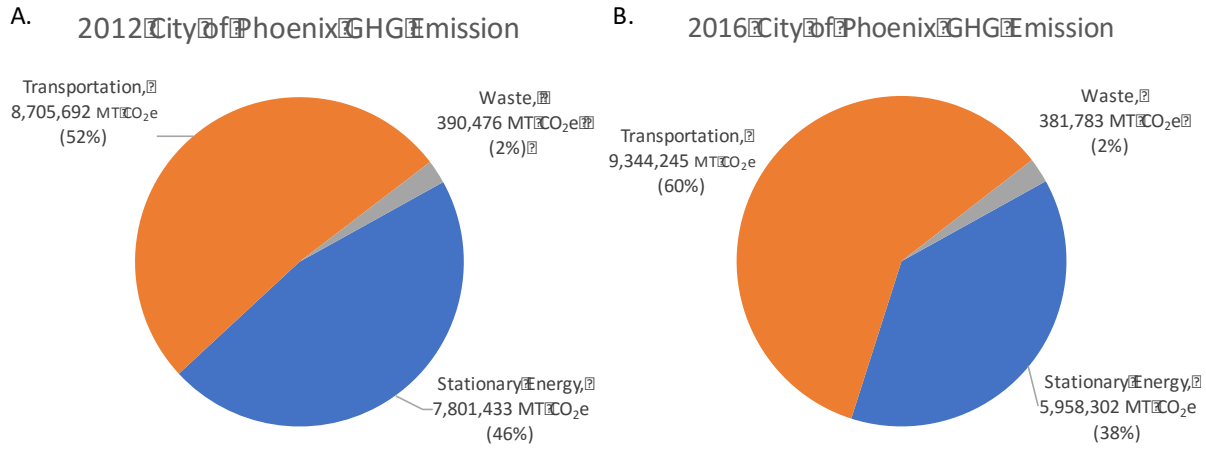


**Figure 1. (A) City of Phoenix GHG emissions by emission sector for 2012. (B) City of Phoenix GHG emissions by emission sector for 2016.**

**Table 1. Phoenix GHG emissions by Sector and Subsector (MT $CO_2e$)**

| Sector | 2012 Emission | 2016 Emission | Change in Emission | % Change |
|---|---|---|---|---|
| **Stationary Energy** | | | | |
| Residential buildings | 3,679,189 | 2,796,904 | -882,285 | -24% |
| Commercial & institutional buildings | 3,936,896 | 2,925,368 | -1,011,528 | -26% |
| Manufacturing industries and construction | 180,999 | 179,750 | -1,249 | -1% |
| Agriculture, forestry and fishing activities | 4,273 | 56,188 | 51,916 | 1215% |
| Non-specified sources | 75 | 92 | 16 | 22% |
| **Stationary Energy Sector Total** | **7,801,433** | **5,958,302** | **-1,843,131** | **-23.6%** |
| **Transportation** | | | | |
| On-road transport | 5,954,202 | 6,443,139 | 488,938 | 8.2% |
| Railways | 30,309 | 29,455 | -854 | -2.8% |
| Commercial Aviation | 698,263 | 705,643 | 7,380 | 1.1% |
| Civil Aviation (Aviation Gasoline) | 13,394 | 15,067 | 1,673 | 12.5% |
| Off-road transport | 2,009,524 | 2,150,940 | 141,416 | 7.0% |
| **Transportation Sector Total** | **8,705,692** | **9,344,245** | **638,553** | **7.3%** |
| **Waste** | | | | |
| Solid waste disposal | 365,749 | 356,623 | -9,127 | -2% |
| Wastewater treatment and discharge | 10,066 | 10,840 | 775 | 8% |
| Biological treatment of waste (composting) | 14,661 | 14,320 | -341 | -2% |
| **Waste Sector Total** | **390,476** | **381,783** | **-8,693** | **-2.2%** |
| **GHG Emission Total** | **16,897,600** | **15,684,329** | **-1,213,271** | **-7.2%** |

## Stationary Energy

The Stationary Energy Sector is the second largest source of GHG emissions in the City of Phoenix. Stationary Energy GHG emission results from the direct combustion of natural gas and indirectly from electricity consumption. Stationary energy GHG emission sources include energy utilized in residential buildings; commercial buildings and facilities; manufacturing industries; agriculture, forestry and fishing energy use; and electricity transmission and distribution energy losses. GHG emissions from natural gas leakages were not included for reporting in 2012 and 2016 due to a lack of data on leakage rates.

Stationary Energy GHG emissions for 2016 were 5,958,302 MT $CO_2e$, which is a 23.6% decrease in emissions from 2012. The driving force behind the large reduction in Stationary Energy GHG emissions resulted from a regional increase in clean energy production, which decreased the carbon intensity of what Phoenix consumes, as reflected in the EPA eGRID GHG emission factor. Data to calculate Stationary Energy GHG emissions were obtained from Arizona Public Service (electricity), the Salt River Project (electricity), Southwest Gas (natural gas), and the Energy Information Administration (electricity transmission and distribution loss).

Figure 2 shows the distribution of GHG emissions between different sub-sectors in the Stationary Energy Sectory for 2012 and 2016 and Table 2 details the GHG emissions by subsector.

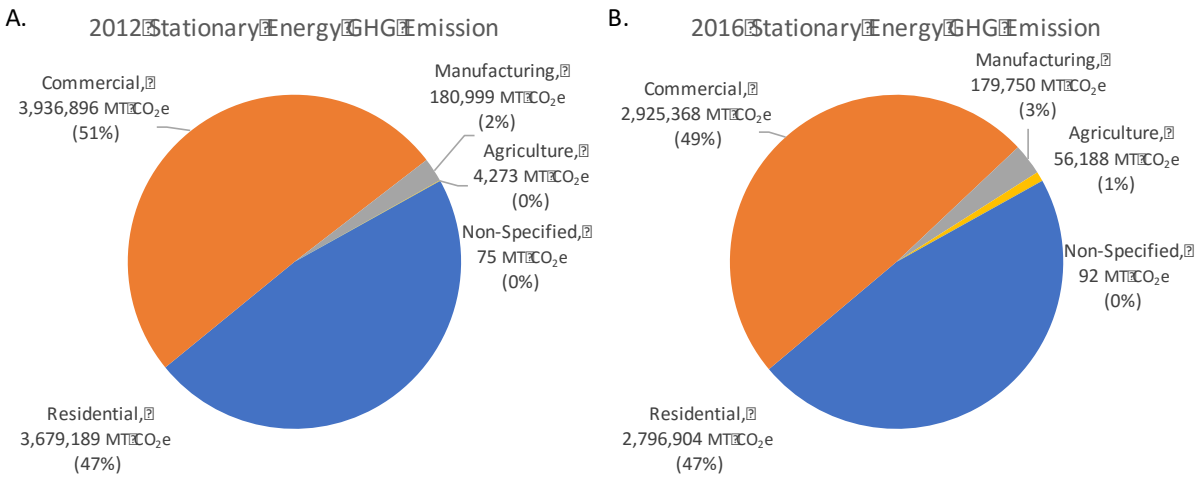


**Figure 2. (A) Stationary Energy GHG emissions by emission sector for 2012. (B) Stationary Energy GHG emissions by emission sector for 2016.**

**Table 2. Subsector Stationary Energy GHG Emission (MT $CO_2e$)**

| Stationary Energy | 2012 Emission | 2016 Emission | Change in Emission | % Change |
|---|---|---|---|---|
| Residential buildings | 3,679,189 | 2,796,904 | -882,285 | -24% |
| Commercial & institutional buildings | 3,936,896 | 2,925,368 | -1,011,528 | -26% |
| Manufacturing industries and construction | 180,999 | 179,750 | -1,249 | -1% |
| Agriculture, forestry and fishing activities | 4,273 | 56,188 | 51,916 | 1215% |
| Non-specified sources | 75 | 92 | 16 | 22% |
| **Stationary Energy Emission Total** | **7,801,433** | **5,958,302** | **-1,843,131** | **-23.6%** |

## Transportation

Transportation Sector GHG emissions include emissions from commercial air travel, civil aviation, on-road transportation, non-road vehicle use, light rail, and freight rail. Transportation GHG emissions result from the combustion of fossil fuels (gasoline, diesel, CNG, LNG, LPG, aviation gasoline, jet fuel A), blended alternative fuels (B20 biodiesel, E85 Ethanol, E54 Ethanol), or indirectly from the consumption of electricity to charge electric vehicles. The Transportation Sector is the largest source of GHG emission in the City of Phoenix.

Total Transportation Sector GHG emission for 2016 was 9,344,245 MT $CO_2e$, which is a 7.3% increase in GHG emission from the 2012 level of 8,705,692 MT$CO_2e$. Increased on-road and off-road transportation activity was responsible for the increased Transportation Sector GHG emissions. Data were obtained from the City of Phoenix, Arizona Department of Transportation, the Weights and Measures Division of the Arizona Department of Agriculture, the Valley of the Sun Clean Cities Coalition, the Federal Aviation Administration, and Southwest Gas.

Figure 3 shows the distribution of GHG emissions between different sub-sectors of transportation sources for the years 2012 and 2016 and Table 3 details the emissions by subsector.

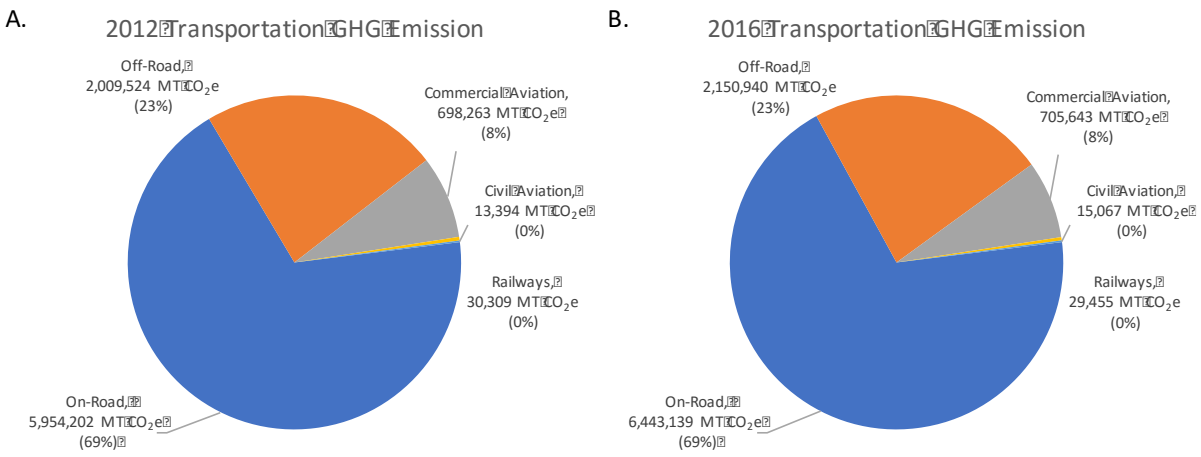


**Figure 3. (A) Transportation GHG emissions by emission sector for 2012. (B) Transportation GHG emissions by emission sector for 2016.**

**Table 3. Subsector Transportation GHG Emission (MT $CO_2e$)**

| Transportation | 2012 Emission | 2016 Emission | Change in Emission | % Change |
|---|---|---|---|---|
| On-road transport | 5,954,202 | 6,443,139 | 488,938 | 8.2% |
| Railways | 30,309 | 29,455 | -854 | -2.8% |
| Commercial Aviation | 698,263 | 705,643 | 7,380 | 1.1% |
| Civil Aviation (Aviation Gasoline) | 13,394 | 15,067 | 1,673 | 12.5% |
| Off-road transport | 2,009,524 | 2,150,940 | 141,416 | 7.0% |
| **Transportation Sector Total** | **8,705,692** | **9,344,245** | **638,553** | **7.3%** |

## Waste

Waste Sector GHG emissions, are a comparatively small component of GHG emissions that occur in the City of Phoenix. The Waste Sector includes emissions from the current and historic disposal of solid waste generated and treated in Phoenix, the current disposal of solid waste generated in Phoenix that is disposed outside the city at the SR-85 Landfill, wastewater treated at the 91st Avenue and 23rd Avenue wastewater treatment plants in Phoenix, and the biological treatment (composting) of waste generated and treated in Phoenix.

Between 2012 and 2016 there has been a 2.2% decrease in Waste Sector GHG emissions. While GHG emissions from solid waste disposal and composting decreased by approximately 2%, similar to the Waste Sector overall, GHG emissions from wastewater treatment increased by 8%. The total GHG emissions from the Waste Sector were 381,783 MT $CO_2e$ in 2016 as compared to 390,476 MT $CO_2e$ reported in the 2012. Waste Sector GHG emission reductions were driven by solid waste disposal, which is greater than 90% of the sector. While new Solid Waste GHG emissions occur from the ongoing disposal of solid waste, historic, closed landfills within the City of Phoenix would produce less GHG emissions over time due, as the waste decays.

Figure 4 provides the breakdown of GHG emissions between different sub-sectors of the waste sector for the years 2012 and 2016 and Table 4 details these emissions.

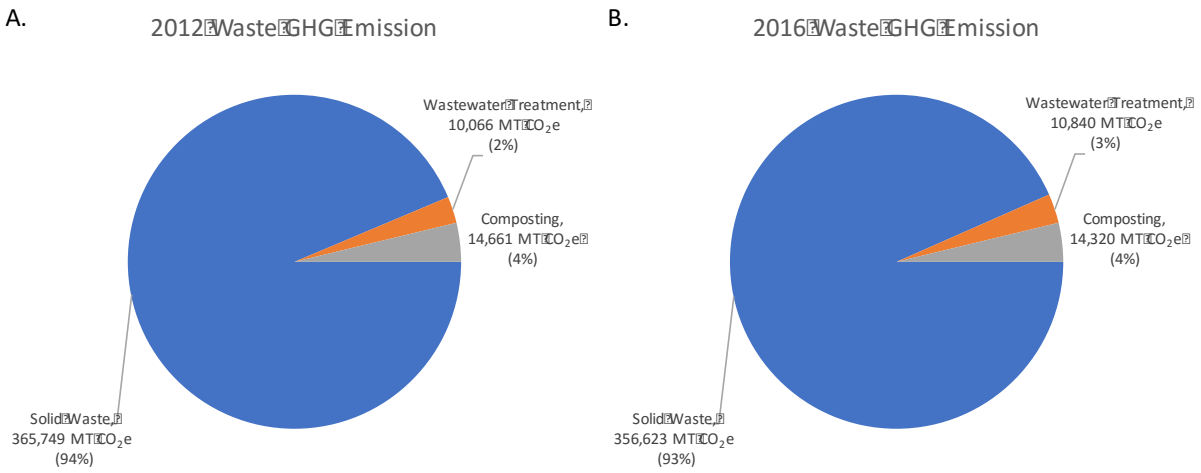


**Figure 4. (A) Waste Sector GHG emissions by emission sector for 2012. (B) Waste Sector GHG emissions by emission sector for 2016.**

**Table 4. Subsector Waste Sector GHG Emission (MT $CO_2e$)**

| Waste | 2012 Emission | 2016 Emission | Change in Emission | % Change |
|---|---|---|---|---|
| Solid waste disposal | 365,749 | 356,623 | -9,127 | -2% |
| Wastewater treatment and discharge | 10,066 | 10,840 | 775 | 8% |
| Biological treatment of waste (composting) | 14,661 | 14,320 | -341 | -2% |
| **Waste Sector Total** | **390,476** | **381,783** | **-8,693** | **-2.2%** |

## Conclusion

In 2016, citywide GHG emissions by Phoenix were 15,684,329 MT $CO_2e$ – a 7.2% reduction in GHG emission compared to the 2012 level of 16,897,600 MT $CO_2e$.

Phoenix's GHG emission reduction was driven by the Stationary Energy Sector, which saw a 22% reduction in GHG emission between 2012 and 2016. The Stationary Energy Sector GHG emission reduction was driven by a decrease in the regional EPA eGRID GHG emission factor, which occurred due to an increase in regional clean energy production. Waste Sector GHG emission decreased by 2.2% between 2012 and 2016. One possibility for the decrease may be that while new Solid Waste GHG emissions occur from the ongoing disposal of solid waste, historic, closed landfills within the City of Phoenix would produce less GHG emissions over time, as the waste decays.

The Transportation Sector is the largest source of GHG emissions in Phoenix. In addition to being the largest source of GHG emissions, Transportation Sector GHG emission increased by 7% between 2012 and 2016. This increase occurred as a direct result of increased on-road transportation activity and the concomitant increase in gasoline consumption. Measures to reduce transportation GHG emissions may help Phoenix further reduce overall GHG emissions.

Gasoline-powered motor vehicles used for on-road transportation is the largest single source of transportation-related GHG emissions. An increased adoption of battery electric vehicles (BEVs), such as the Nissan Leaf, or plugin electric hybrid vehicles (PEHV), such as the Chevy Volt, is one avenue to reduce transportation-related GHG emission. Given current tailpipe emissions of gasoline-powered motor vehicles and current carbon intensity levels of the electric grid[2], replacing 1% of gasoline-powered motor vehicles for BEVs could result in an annual GHG emission reduction of 24,701 MT $CO_2e$. Therefore, there is potential for a 2,470,000 MT $CO_2e$ reduction in GHG emission from converting all existing gasoline-powered motor vehicles to BEVs, and this reduction will only increase as the regional electricity mix becomes cleaner and less carbon intensive (Figure 5).

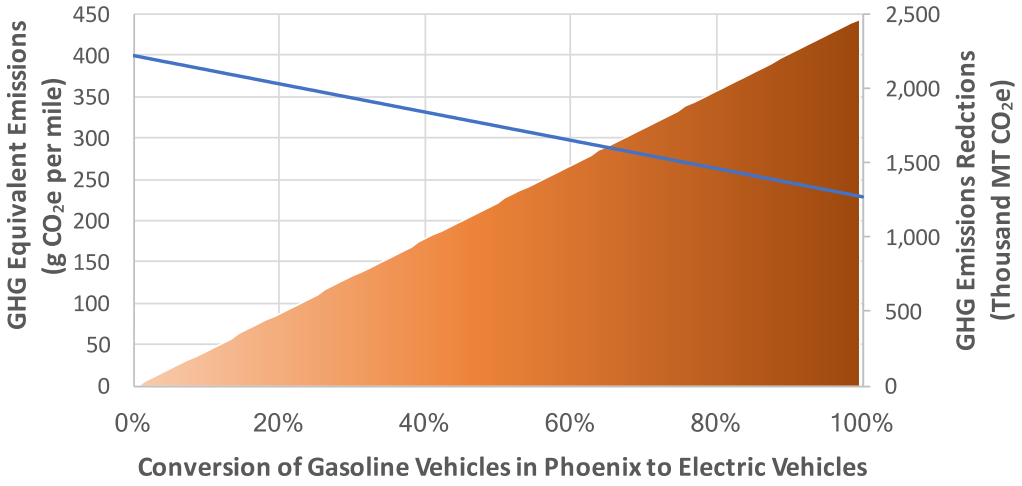


**Figure 5. The potential for GHG emission reduction from the conversion of existing gasoline-powered motor vehicles to battery electric vehicles.**

[2] Salisbury, Mike (2013). Air Quality and Economic Benefits of Electric Vehicles in Arizona. Report by the Southwest Energy Efficiency Project. URL: http://www.swenergy.org/data/sites/1/media/documents/publications/documents/AZ EV AirQuality.EconAnalysis.9.26.13.pdf