City of Phoenix

Agenda
Community and Cultural Investment Subcommittee

Meeting Location:
City Council Chambers
200 W. Jefferson St.
Phoenix, Arizona 85003

Wednesday, September 7, 2022 **10:00 AM** **phoenix.gov**

OPTIONS TO ACCESS THIS MEETING

Virtual Request to speak at a meeting:

- Register online *by visiting the City Council Meetings page on phoenix.gov* ***at least 2 hours prior to the start of this meeting****. Then, click on this link at the time of the meeting and join the Webex to speak:*

https://phoenixcitycouncil.webex.com/phoenixcitycouncil/onstage/g.php?MTID=e118b57adeefc9185496555efb99b9067

- Register via telephone at 602-262-6001 **at least 2 hours prior to the start of this meeting,** noting the item number. Then, use the Call-in phone number and Meeting ID listed below at the time of the meeting to call-in and speak.

In-Person Requests to speak at a meeting:

- Register in person at a kiosk located at the City Council Chambers, 200 W. Jefferson St., Phoenix, Arizona, 85003. Arrive **1 hour prior to the start of this meeting**. Depending on seating availability, residents will attend and speak from the Upper Chambers, Lower Chambers or City Hall location.

- Individuals should arrive early, 1 hour prior to the start of the meeting to submit an in-person request to speak before the item is called. After the item is called, requests to speak for that item will not be accepted.

At the time of the meeting:

- Watch the meeting live streamed on phoenix.gov or Phoenix Channel 11 on Cox Cable, or using the Webex link provided above.

- Call-in to listen to the meeting. Dial 602-666-0783 and Enter Meeting ID 2557 819 4277# (for English) or 2550 768 1782# (for Spanish). Press # again when prompted for attendee ID.

- Watch the meeting in-person from the Upper Chambers, Lower Chambers or City Hall depending on seating availability.

Para nuestros residentes de habla hispana:

- Para registrarse para hablar en español, llame al 602-262-6001 **al menos 2 horas antes del inicio de esta reunión** e indique el número del tema. El día de la reunión, llame al 602-666-0783 e ingrese el número de identificación de la reunión 2550 768 1782#. El intérprete le indicará cuando sea su turno de hablar.

- Para solamente escuchar la reunión en español, llame a este mismo número el día de la reunión (602-666-0783; ingrese el número de identificación de la reunión 2550 768 1782#). Se proporciona interpretación simultánea para nuestros residentes durante todas las reuniones.

- Para asistir a la reunión en persona, vaya a las Cámaras del Concejo Municipal de Phoenix ubicadas en 200 W. Jefferson Street, Phoenix, AZ 85003. Llegue 1 hora antes del comienzo de la reunión. Si desea hablar, regístrese electrónicamente en uno de los quioscos, antes de que comience el tema. Una vez que se comience a discutir el tema, no se aceptarán nuevas solicitudes para hablar. Dependiendo de cuantos asientos haya disponibles, usted podría ser sentado en la parte superior de las cámaras, en el piso de abajo de las cámaras, o en el edificio municipal.

CALL TO ORDER

000 CALL TO THE PUBLIC

MINUTES OF MEETINGS

1 **Minutes of the Community and Cultural Investment Subcommittee Meeting** Page 7

This item transmits the minutes of the Community and Cultural Investment Subcommittee meeting on June 1, 2022, for review, correction or approval by the Community and Cultural Investment Subcommittee.

THIS ITEM IS FOR POSSIBLE ACTION.

Responsible Department
This item is submitted by Deputy City Manager Inger Erickson and the City Manager's Office.

CONSENT ACTION (ITEM 2)

2 **Abandoned Shopping Cart Retrieval Services Contract Award Recommendation** Page 17

Request the Community and Cultural Investment Subcommittee recommend City Council approval to enter into an agreement with Arizona Cart Services for abandoned shopping cart retrieval services. The aggregate contract value will not exceed $300,000.

THIS ITEM IS FOR CONSENT ACTION.

Responsible Department
This item is submitted by Deputy City Manager Alan Stephenson and the Neighborhood Services Department.

INFORMATION ONLY (ITEM 3)

3 **Head Start Birth to Five Monthly Report - July 2022** Page 19

This report provides the Community and Cultural Investment Subcommittee, which serves as the City of Phoenix Head Start Birth to Five Governing Board, with an updated summary of the Head Start Birth to Five Program's financial and programmatic status.

THIS ITEM IS FOR INFORMATION ONLY.

Responsible Department
This item is submitted by Deputy City Manager Gina Montes and the Human Services Department.

INFORMATION AND DISCUSSION (ITEMS 4-5)

4 **2020 Greenhouse Gas Emissions and Climate Action Plan Update** Page 25

This report presents the results of the City of Phoenix 2020 Local Government Operations Greenhouse Gas (GHG) Emissions Inventory Report and the 2020 Community-Scale Greenhouse Gas Emissions Inventory Report (Reports) as well as an updated status on actions to address climate. The GHG Reports update the City's 2018 Local Government Operations GHG Inventory and 2018 Community-Scale GHG Inventory reports. The Reports present the status of the City's progress toward meeting its current greenhouse gas reduction targets for government operations of 40 percent by 2025 and 50 percent by 2030 for Community-Scale.

THIS ITEM IS FOR INFORMATION AND DISCUSSION.

Responsible Department
This item is submitted by Deputy City Manager Karen Peters and the Office of Environmental Programs.

5 **Update on Drought Management Plan and Water Conservation Efforts** Page 143

This report provides the Community and Cultural Investment Subcommittee an update on implementation of the City of Phoenix Drought Management Plan, Conservation and Outreach efforts, in response to anticipated further shortages on the Colorado River.

THIS ITEM IS FOR INFORMATION AND DISCUSSION

Responsible Department
This item is submitted by Deputy City Managers Karen Peters and Alan Stephenson and the Water Services and Planning and Development departments.

000 CALL TO THE PUBLIC

FUTURE AGENDA ITEMS

ADJOURN

For further information or reasonable accommodations, please call the City Council Meeting Request line at 602-262-6001. 7-1-1 Friendly.

Persons paid to lobby on behalf of persons or organizations other than themselves must register with the City Clerk prior to lobbying or within five business days thereafter, and must register annually to continue lobbying. If you have any questions about registration or whether or not you must register, please contact the City Clerk's Office at 602-534-0490.

Members:
Councilwoman Betty Guardado, Chair
Councilwoman Yassamin Ansari
Councilmember Carlos Garcia
Councilwoman Debra Stark

City of Phoenix

Report

Agenda Date: 9/7/2022, **Item No.** 1

Minutes of the Community and Cultural Investment Subcommittee Meeting

This item transmits the minutes of the Community and Cultural Investment Subcommittee meeting on June 1, 2022, for review, correction or approval by the Community and Cultural Investment Subcommittee.

THIS ITEM IS FOR POSSIBLE ACTION.

Summary

The minutes are included for review as **Attachment A**.

Responsible Department

This item is submitted by Deputy City Manager Inger Erickson and the City Manager's Office.

Attachment A

Phoenix City Council
Community and Cultural Investment Subcommittee
Summary Minutes
Wednesday, June 1, 2022

City Council Chambers
200 W. Jefferson St.
Phoenix, Ariz.

Subcommittee Members Present	Subcommittee Members Absent
Councilwoman Betty Guardado, Chair	
Councilmember Carlos Garcia	
Councilwoman Debra Stark	
Councilwoman Yassamin Ansari	

CALL TO ORDER

Chairwoman Guardado called the Community and Cultural Investment Subcommittee to order at 10:06 a.m. with Councilwoman Stark, Councilwoman Ansari, and Councilmember Garcia present.

CALL TO THE PUBLIC

No call to the public

MINUTES OF MEETINGS

1. Minutes of the Community and Cultural Investment Subcommittee Meeting
Councilwoman Stark made a motion to approve the minutes of Community and Cultural Investment Subcommittee meeting. Councilmember Garcia seconded the motion, which passed unanimously 4-0.

CONSENT ACTION (ITEMS 2-4)

2. Request Approval of the Head Start Birth to Five ERSEA Plan Updates

3. Artist Fabrication, Construction Oversight and Installation Contract for Eastlake Park Streetscape Arts Project

4. 2015-20 Consolidated Plan's 2019 Annual Action Plan CARES Act Amendment
Councilwoman Ansari made a motion to approve consent action items. Councilwoman Stark seconded the motion, which passed unanimously 4-0.

DRAFT

INFORMATION ONLY (ITEM 5)

5. Head Start Birth to Five Monthly Report – April 2022

No questions were asked.

DISCUSSION AND POSSIBLE ACTION (ITEM 10)

Chairwoman Guardado made a motion to hear Item 10 to be heard as the first discussion item. Councilmember Garcia seconded the motion, which passed unanimously 4-0.

10. Annual Neighborhood Services Code Enforcement Policy Review

Neighborhood Services Director Spencer Self and Deputy Director Bob Lozier gave a staff presentation regarding the annual neighborhood services code enforcement policy review.

Mr. Lozier provided a brief review of the code enforcement policy, which provides enforcement guidelines for neighborhood preservation, zoning, animal, and businesses ordinances. He also gave an overview of the standard code enforcement process and proposed an additional process that addresses code compliance issues with recidivist persons or properties. Mr. Lozier discussed other policy updates related to the department mission statement and code violation reporting.

Mr. Self requested the Subcommittee recommend City Council approval of the Neighborhood Services Department Code Enforcement Policy as revised.

Councilwoman Ansari asked if there would be updates to code enforcement policy related to individuals experiencing homelessness.

Mr. Self replied that homelessness was not a crime and noted the Neighborhood Services Department would seek partnerships with people housing homeless individuals. He stated that staff would work through the year to address this issue through department policy.

Councilwoman Ansari asked if staff could create short term guidelines for the department related to individuals experiencing homelessness before the policy was completed at the end of the year.

Mr. Self replied the department would develop written guidelines and training for code enforcement inspectors related to homeless individuals.

Councilwoman Ansari asked about code enforcement related to animal neglect and tethering. She noted the Arizona Humane Society would respond to those issues but asked if the Neighborhood Services Department would need to create policies to address those issues if the Humane Society contract ends on June 15.

DRAFT

Mr. Self replied the Neighborhood Services Department would not need to update the policy before the expiration of the Human Society contract. He stated the department could continue to enhance its outreach efforts and noted the enforcement policy would not need to be changed.

Councilmember Garcia asked about language barriers related to Neighborhood Services Department citations and inquired about the current translation services the department had to offer.

Mr. Self replied that staff provided translation services related to some documents and in person services and noted that the department was in the process of reviewing all documentation and services to provide translation.

Mr. Lozier noted the department placed an emphasis on bilingual applicants throughout the hiring process and stated that staff had access to a translator application on their cell phones for in person interactions.

Mr. Self highlighted the language access plan, which allows for the translation of multiple language for different department forms.

Councilmember Garcia noted translation services for citations was critical.

Chairwoman Guardado asked how the department addresses citations that were received by residents who may speak a different language and not understand the citation language.

Mr. Self replied the department maintained above 95 percent voluntary code compliance rate because staff connects with all residents to overcome language barriers.

Chairwoman Guardado asked if there were enough department inspectors to work with residents to avoid compliance citations.

Mr. Self replied that staffing requirements related to citations were being evaluated but that the department received 50,000 compliance cases each year with 50 inspectors. He stated the department will ensure that resources were distributed equitably throughout the City.

Councilwoman Guardado stated the department should continue to evaluate staffing efforts to ensure services were provided fairly.

Councilwoman Ansari made a motion to approve the staff recommendation. Councilmember Garcia seconded the motion, which passed unanimously 4-0.

DRAFT

INFORMATION AND DISCUSSION (ITEMS 6-9)

6. Solid Waste Contained Collections Citywide Reroute

Public Works Director Joe Giudice, Assistant Director Felipe Moreno, and Solid Waste Administrator Lorizelda Stoeller provided a staff presentation on the solid waste contained collection citywide reroute.

Mr. Moreno gave a brief operational overview of the current solid waste collection route, noting the City served 418,000 homes with 271 solid waste equipment operators. He stated the reroute was due to growing population in the city, and he described benefits of the reroute, including redistributed workloads, operational efficiencies, continued customer service, and matching service demands. Mr. Moreno said that 80 percent of customers would experience day of collection change, but there would be no impact to bulk trash or household hazardous waste pickup.

Ms. Stoeller spoke about community outreach efforts made by the department, including door hangers, social media, newsletters, and websites in both English and Spanish. She described the timeline of the reroute plan including the launch date of October 3, 2022.

7. Parks and Recreation Summer Programs Update

Parks and Recreation Director Cynthia Aguilar and Assistant Directors Tracee Hall and Martin Whitfield gave a staff update on the Parks and Recreation summer programs.

Mr. Whitfield discussed the City-sponsored all day summer camp programs that occur Monday through Friday from May to July. He noted there were 24 summer camp sites throughout the City and stated the program was for youth ages six to 12 and cost $0 to $80 per week. Mr. Whitfield discussed the various programming efforts at the summer camp which included field trips, themed weeks, and onsite events such as carnivals and water days. He also spoke about the outreach efforts on social media, flyers shared at park events and schools, and email.

Ms. Hall spoke about the 2022 aquatics season, which started in June and ends in September. She highlighted the 14 pool locations throughout the City and discussed swim lessons offered. Ms. Hall noted the marketing outreach for swim lessons, including social media, flyers, and interviews with local media.

Chairwoman Guardado asked if there was a lifeguard and pool supervisor recruitment plan for the 2023 pool season.

DRAFT

Ms. Hall replied staff was continuously recruiting for lifeguards and promoting the Phoenix junior lifeguard academy. She noted the department was focused on rebuilding the lifeguard academy program at the City.

Chairwoman Guardado asked if staff had considered promoting lifeguards as pool supervisors to address the two-year requirement for pool supervisors.

Ms. Hall replied yes.

Chairwoman Guardado asked staff to create a recruitment plan and share it with the committee in the fall. She stated that the department should open 80 percent to 90 percent of all City Pools next swim season. Chairwoman Guardado asked if the pools were operating at full capacity for the 2022 swim season.

Ms. Hall replied that was correct, and there was no longer a reservation system to use City pools.

Chairwoman Guardado asked if the department was promoting reduced summer camp prices for families.

Mr. Whitfield stated the department goal was to not turn any youth away and staff would work with families to find payment solutions.

Chairwoman Guardado asked if the summer camps were at full capacity for 2022.

Mr. Whitfield noted that summer camps were currently at 47 percent capacity.

Ms. Aguilar stated the department would begin advertising half day summer camp options at a reduced cost.

8. Update on Supply Shortages in the Colorado River

9. Water Conservation Update

Items 8 and 9 were heard together.

Deputy City Manager Karen Peters, Water Services Director Troy Hayes, Water Resources Management Advisor Cynthia Campbell, and Principal Planner Maxwell Wilson gave a staff update of the supply shortages in the Colorado River and a water conservation update.

Ms. Campbell discussed the long-term water resource planning efforts related to Colorado River shortages. She stated the City received 58 percent of water from the Salt and Verde Rivers, 40 percent from the Colorado River, and two percent from groundwater. Ms. Campbell noted the Colorado River was experiencing the driest conditions in over 1,200 years and the Bureau of Reclamation would take extraordinary measures to protect water delivery capability and hydropower generation.

DRAFT

Mr. Hayes discussed prior City responses to drought, noting the establishment of the Colorado River Resiliency Fund by the City Council in 2014. Mr. Hayes declared a Stage 1 Water Alert. He stated that Phoenix did not have a water shortage and noted the Stage 1 alert would not mandate water restrictions but focus on sustainable growth and increase water conservation efforts. Mr. Hayes outlined multiple Stage 1 strategies, including marketing efforts in a Phoenix news release, paid advertising, public meetings, and community outreach events. He stated the City was prepared and committed to water efficiency.

Mr. Wilson began the water conservation update and spoke about population growth and its impact on water usage. He presented multiple examples of how the City had taken action to conserve water and noted the Phoenix conservation plan included three phases. Mr. Wilson spoke about projects included in the Phase 1, such as the landscape contract pilot project, water education from the cloud, and the water wranglers program. He discussed Phase 2 programs, such as the smart irrigation controller subsidy, expansion of the Homeowner Association (HOA) efficiency checkup program, and the commercial cooling tower program. Mr. Wilson highlighted programs in Phase 3, including the expanded toilet program, improved youth education, and updated building codes program.

Councilwoman Stark asked if the smart irrigation controller subsidy was available for HOAs.

Mr. Wilson stated it was not available for HOAs but would be in the future.

Councilwoman Stark asked if the City had worked with Maricopa County or the State government to install cooling towers.

Mr. Wilson stated the City had not communicated with Maricopa County or the State government regarding the installation of cooling towers and noted the program was still small and in need of pilot programs before expanding.

Councilwoman Stark encouraged staff to form partners with the County and State governments as the program expanded.

Councilmember Garcia asked about the factors that move the City between the four stages of the drought management plan.

Mr. Hayes replied that rising water levels in Lake Mead would move the City out of the Stage 1 water alert. He stated that if the City had to begin utilizing drought resources, it would push the City to a Stage 2 water warning. Mr. Hayes mentioned the 2026 stakeholder water reconciliation meeting and was hopeful that regional partners would create long term solutions.

Councilmember Garcia asked how other cities in Arizona compare to Phoenix as it relates to water conservation.

DRAFT

Mr. Hayes replied that drought impacted cities differently due to area and availability of resources.

Ms. Campbell stated Phoenix was one of the most robust cities in Arizona and noted that other cities may be worse off and begin to utilize groundwater reserves.

Councilmember Garcia asked if there were other cities more dependent on Colorado River water.

Ms. Campbell replied many central cities utilize Salt River Project (SRP) and Arizona Public Service (APS) water, whereas the City of Tucson utilizes only Colorado River water and groundwater.

Councilmember Garcia asked if staff could speak to water usage in residential areas versus commercial spaces.

Mr. Hayes replied that five percent to six percent of City water was used for industrial purposes, or 250 industrial customers total. He noted that interior plumbing and cooling towers were the major uses of industrial water.

Councilmember Garcia asked the impact of new business growth on water usage.

Mr. Hayes replied it was important to establish sustainable growth and growing in a way that does not put the greatly impact the City water portfolio.

Councilmember Garcia asked if the City had any progress related to sustainable water technologies and turning waste water into drinking water.

Mr. Hayes replied waste water was currently being used in efficient ways like cooling the Palo Verde Nuclear Plant or irrigation. He stated the department was actively trying to turn waste water into drinking water and noted the Cave Creek Water Reclamation Plant would begin operations in 2025. Mr. Hayes also stated the City was working with the State government to create regulations related to turning waste water into drinking water.

Councilmember Garcia asked how the City could take Tres Rios Wetlands water and turn it into tap water.

Mr. Hayes replied the technology to turn waste water into drinking water existed but was expensive and energy intensive. He noted it would create another layer in the City water portfolio.

Councilmember Garcia asked staff to discuss regional partnerships related to water conservation.

DRAFT

Ms. Campbell replied there were a number of agreements between Phoenix and additional cities and communities such as Avondale, Tucson, and the Gila River Native American Community.

Chairwoman Guardado noted the importance of water conservation and asked staff to curate a meeting in Fall 2022 to discuss conservation efforts.

Ms. Erickson replied staff would return in the fall to coordinate that discussion.

Councilwoman Ansari asked if staff could speak to why the City was not taking more significant action on water conservation similar to the City of Las Vegas ban on grass lawns.

Mr. Hayes replied that each city had a unique water portfolio and noted that the City would continue to store water even in a Tier 2a or Tier 2b drought scenario. He stated the City could not consider a Stage 2 water warning while still storing water.

Councilwoman Ansari asked how quickly the City could move to higher stages of a water emergency.

Mr. Hayes noted the City could enter into a Tier 2a or Tier 2b in 2023 and, based on projections made by the Bureau of Reclamation, the City could enter into a Tier 3 shortage in 2024.

Ms. Peters clarified the tier levels Mr. Hayes referred too concerned the regional drought contingency plan related to Lake Mead water levels and stated the stages of the drought management plan was specific to the City.

Councilwoman Ansari asked if the Stage 3 water emergency was projected to happen in 2024.

Mr. Hayes replied no, but that the water tiers as determined by the federal government signal which stage of the drought management plan the City should enact.

Councilwoman Ansari asked staff to analyze potential enforcement of water usage by industrial facilities.

Ms. Peters replied staff was considering strategic industrial water usage as the City continues to grow.

Councilwoman Ansari asked staff to discuss the timeline of the Phase 3 building code update.

Mr. Wilson replied the program was in the early stages of development but noted staff would begin to meet with the Planning and Development Department to identify a timeline.

DRAFT

Ms. Peters stated that staff had identified the year 2025 as a potential Phase 3 building code update.

Councilwoman Ansari asked if the Phase 3 building code would include a sustainability package update.

Ms. Peters replied she would need to confirm with the Planning and Development Department.

Councilwoman Stark replied that the Maricopa Association of Governments would analyze regional building codes that address sustainability issues. She noted building code updates were released every three years.

CALL TO THE PUBLIC
No call to the public

FUTURE AGENDA ITEMS
No future agenda items

ADJOURNMENT
Chairwoman Guardado adjourned the meeting at 11:38 a.m.

Respectfully submitted,

Cooper Payne
Management Intern

DRAFT

City of Phoenix

Report

Agenda Date: 9/7/2022, **Item No.** 2

Abandoned Shopping Cart Retrieval Services Contract Award Recommendation

Request the Community and Cultural Investment Subcommittee recommend City Council approval to enter into an agreement with Arizona Cart Services for abandoned shopping cart retrieval services. The aggregate contract value will not exceed $300,000.

THIS ITEM IS FOR CONSENT ACTION.

Summary

The Neighborhood Services Department's (NSD) Abandoned Shopping Cart Retrieval Program picks up abandoned shopping carts throughout the city of Phoenix. The program was designed to address increasing resident concerns regarding hazards to pedestrians and motorists, and the visual blight created by abandoned shopping carts in neighborhoods. The program provides a timely response to community complaints regarding carts abandoned on sidewalks, along rights-of-way and in alleys. The current contract expires Nov. 1, 2022.

Procurement Information

The Finance Department issued a Request for Proposals (RFP 22-136) on June 24, 2022, to solicit a contract for abandoned shopping cart retrieval services. More than 150 vendors from NSD’s and the Finance Department’s distribution list or database were notified of the RFP. The RFP closed on July 15, 2022. One successful offer was received by the posted deadline. One offer was disqualified due the vendor’s late submittal.

An evaluation panel comprised of five City staff representing three different departments familiar with the program, evaluated the one responsive proposal based on the following criteria for a total of 1,000 points:

- Method of Approach - 400 points;
- Experience and Qualifications - 300 points;
- Capacity - 200 points; and
- Price - 100 points.

The result of the evaluation panel consensus score for the proposal is as follows:

Proposer	Total Points
Arizona Cart Services	725 points

The Assistant Finance Director recommends that the offer from Arizona Cart Services be accepted.

Contract Term
The contract will begin on or about Nov. 1, 2022. The initial term of the contract is for one-year with four one-year options to extend that may be exercised at the discretion of the City Manager or designee.

Financial Impact
The aggregate contract value will not exceed $300,000. Funds are available in the Neighborhood Services Department's budget.

Concurrence/Previous Council Action
On Nov. 3, 2021, the Community and Cultural Investment Subcommittee recommended City Council approval to issue an RFP to establish a new five-year Shopping Cart Retrieval services contract.

Responsible Department
This item is submitted by Deputy City Manager Alan Stephenson and the Neighborhood Services Department.

City of Phoenix

Report

Agenda Date: 9/7/2022, **Item No.** 3

Head Start Birth to Five Monthly Report - July 2022

This report provides the Community and Cultural Investment Subcommittee, which serves as the City of Phoenix Head Start Birth to Five Governing Board, with an updated summary of the Head Start Birth to Five Program's financial and programmatic status.

THIS ITEM IS FOR INFORMATION ONLY.

Summary

The Improving Head Start for School Readiness Act of 2007 requires each Head Start Grantee to share monthly information with the Governing Board and Policy Council on program planning, policies and operations. In compliance with the Act, the Head Start program provides a monthly report on the following areas:

- Fiscal expenditures;
- Enrollment reports;
- School attendance;
- Medical/dental exams; and
- Program information summaries.

Fiscal Expenditures

Attachment A shows year-to-date expenditures for the Fiscal Year 2022-23, which began July 1, 2022. The reports include a breakdown of each Education Service Provider, the Policy Council, Child Care Partnership, and administrative support budget. The current year's expenditures align with the approved budget.

Enrollment Reports

The Office of Head Start requires programs to report the total number of children enrolled on the last day of each month. At the end of July, overall enrollment for Early Head Start program was 271 out of 488 available slots. Preschool is not in session during the month of July; programming will resume in August when the new school year begins.

The Early Head Start Home-Based program provides year-round in-person home

visitation. At the end of July, 151 slots out of 300 were filled. Many vacancies are due to children turning three and becoming ineligible for the program. When children are no longer age eligible, Early Head Start Caseworkers assist parents in identifying preschool options, which can include Head Start for income-eligible families, private preschools, or local school district options.

The Early Head Start-Child Care Partners provide full-day, year-round in-person childcare. At the end of July, 120 slots out of 188 were filled. During the summer months, many parents opt to keep their younger children at home with older siblings who are on summer break.

Recruitment efforts continue through social media messaging, billboards, community events, and bus shelters. Currently, 58 percent of the preschool slots are filled with children who have been accepted for the 2022-2023 school year.

School Attendance

The annual target for attendance set by the Office of Head Start is 85 percent. **Attachment B** indicates year-to-date attendance through the end of July. The preschool program is not in session during July; therefore, no attendance data is available. The Child Care Partnership's year-to-date average was 44 percent at the end of July, which is below the target of 85 percent. The low percentage is due to families taking vacations, some parents leaving their children at home with older siblings on summer break, and children being sick with colds and COVID.

Medical/Dental Exams

Head Start regulations require all children to have medical and dental exams annually. Through the end of July, 257 medical and 244 dental exams were completed, totaling 501 exams, as illustrated in **Attachment C**.

Program Information Summaries

Please see **Attachment D**.

Responsible Department

This item is submitted by Deputy City Manager Gina Montes and the Human Services Department.

Attachment A

Fiscal Expenditures for Fiscal Year 2022-2023
Yr 4 FY 23 Head Start Financial Summary Grant 890167
Planned level of Expenditures
For the Month of July 2022

Fund Center	Program	FTE	Revised Budget 2021-2022	FY22 YEAR-TO-DATE Expenditures Federal Fund	FY22 YEAR-TO-DATE Expenditures General Purpose Fund	FY22 Remaining Balance	FY22 YEAR-TO-DATE % Spent
8940050001	HS Administration	12	$ 4,408,796.79	$ 464,603.84		$ 3,944,192.95	11%
8940050004	HS T&TA	-	$ 325,611.00	$ 3,945.00		$ 321,666.00	1%
8940050012	HS Policy Council	-	$ 33,050.00			$ 33,050.00	0%
8940050015	HS Mental Health	4	$ 434,056.33	$ 42,271.39		$ 391,784.94	10%
8940050016	HS Casework Support	67	$ 5,441,447.38	$ 501,535.00		$ 4,939,912.38	9%
8940050017	HS Classroom Support	16	$ 1,566,566.00	$ 103,708.35		$ 1,462,857.65	7%
	Total City of Phoenix	**99**	**$ 12,209,528**	**$ 1,116,064**	**$ -**	**$ 11,093,464**	**9%**
8940051001	Alhambra	-	$ 2,375,654			$ 2,375,654	0.0%
8940051003	Booker T Washington	-	$ 4,516,359	$ 376,363		$ 4,139,996	8%
8940051005	Washington	-	$ 3,892,314			$ 3,892,314	0%
8940051006	Deer Valley	-	$ 671,089			$ 671,089	0%
8940051010	Greater Phoenix Urban League	-	$ 7,414,500	$ 395,729		$ 7,018,771	5%
8940051116	Fowler	-	$ 872,415			$ 872,415	0%
	Total Education Service Providers	**-**	**$ 19,742,331**	**$ 772,092**	**$ -**	**$ 18,970,239**	4%
8940505021	Early Head Start Operations Support	54	$ 7,403,700	$ 428,161		$ 6,975,539	6%
8940505024	Early Head Start T&TA	-	$ 161,858	$ 6,202		$ 155,656	4%
	Total Early Head Start	**54**	**$ 7,565,558**	**$ 434,364**		**$ 7,131,194**	**6%**
	Subtotal		**$ 39,517,417**	**$ 2,322,519**		**$ 37,194,897**	**6%**
	Grand Total	**153**	**39,517,417**	**2,322,519**	**0**	**37,194,897**	**6%**

Attachment B

Percentage of Preschool Attendance	
Target: 85%	YTD Percent: N/A

Goal:

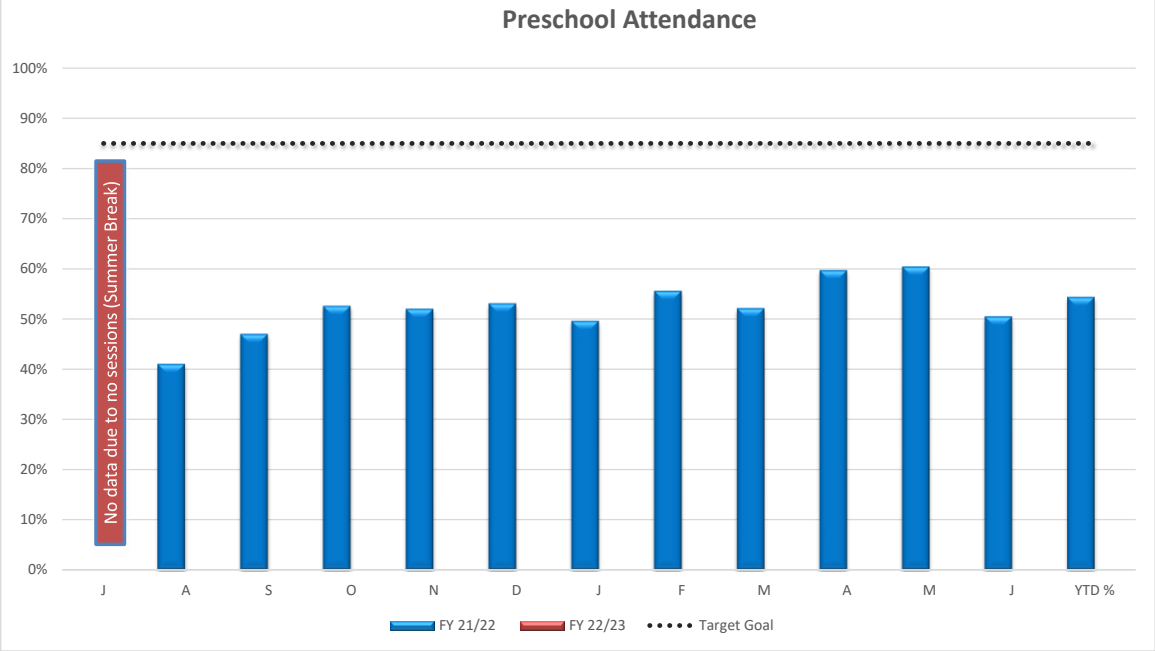
Increase attendance of Head Start Birth to Five children.

Target:

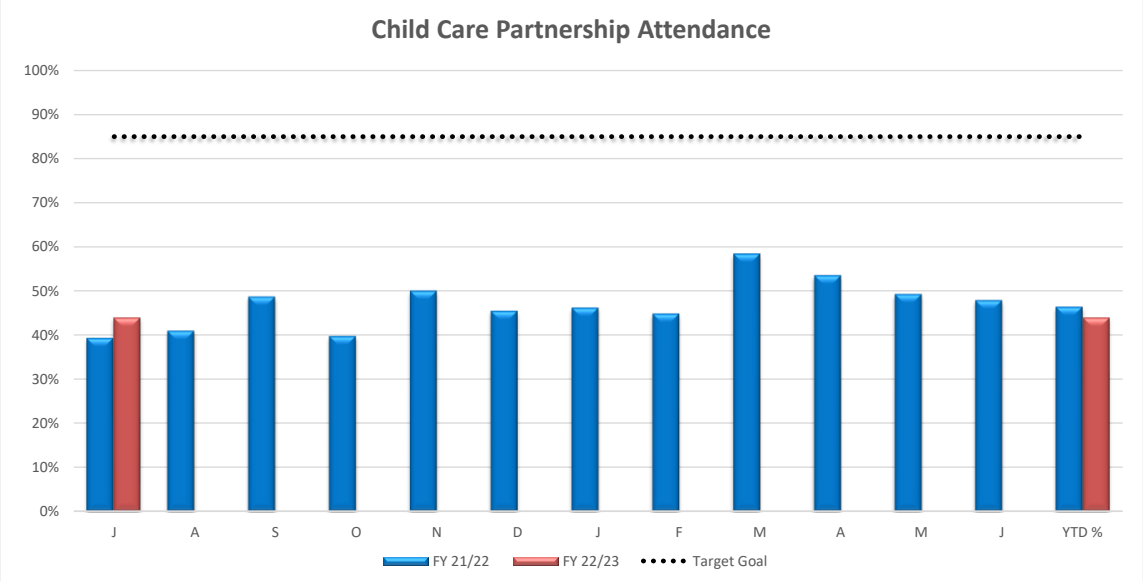
85% of children will attend each day.

Significance:

Attendance is a key factor in being able to get children ready to attend kindergarten.



Percentage of Child Care Partnership Attendance	
Target: 85%	YTD Percent: 44%



Attachment C

Head Start Birth to Five Medical Exams Completed	
Target: 3,451 exams	FY 22-23 Exams: 257

Goal:

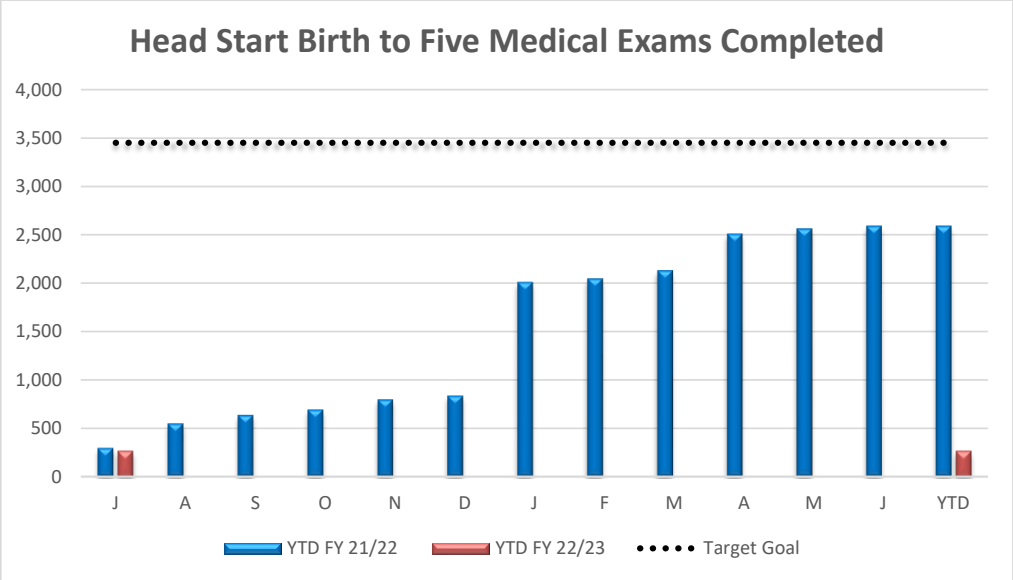
Ensure Head Start Birth to Five children receive necessary medical and dental exams.

Target:

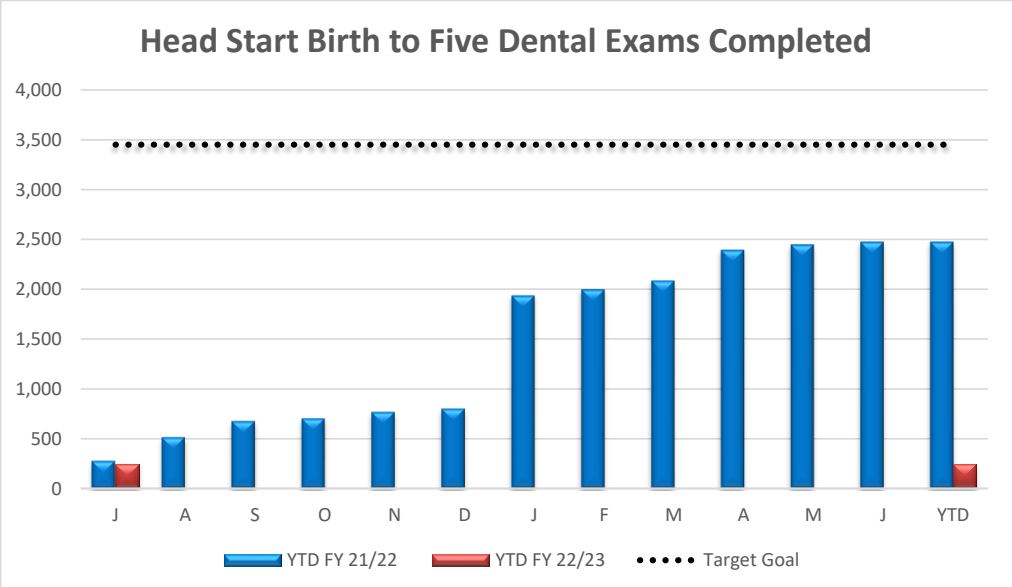
3,451 Medical Exams and 3,451 Dental Exams

Significance:

Head Start Birth to Five children are required to have medical and dental exams as part of the Head Start regulations.



Head Start Birth to Five Dental Exams Completed	
Target: 3,451 exams	FY 22-23 Exams: 244



Attachment D

Program Information Summaries

Community Outreach Events

Head Start Birth to Five Program staff participated in eight community events in July held by the City of Phoenix Council Districts 5 and 7, the City of Phoenix Parks and Recreation Department, and Maricopa County District 5. Residents were given backpacks, school supplies, and community resource information. Staff assisted over 50 families in filling out pre-applications and provided information to over 2,000 residents about Head Start.

Head Start Annual Pre-Service

The Head Start Birth to Five Annual Pre-Service was held at Desert Willow Conference Center for over 550 Head Start staff. This event is an annual kick-off to the new school year and provides teachers, instructional assistants, caseworkers, and other staff professional development relevant to their area of expertise. The sessions focused on various topics aimed at building relationships, the positive impact fathers have on a child's development, child and adult wellbeing, and teaching children about resiliency. Attendees will use this information to create nurturing learning environments for children and inclusive workplaces for adults.

Education and Training

A boot camp for children's social and emotional development was held at Desert Willow Conference Center for over 25 Education Service Providers and Child Care Partner administrators. The event's purpose was to ensure administrators understand and promote the evidence-based Pyramid Model, a conceptual framework of evidence-based practices for promoting young children's healthy social and emotional development. Administrators will support staff in using the strategies and techniques in the classroom to create a nurturing, caring, safe environment for children to learn.

Four Head Start Birth to Five staff presented at the annual First 1,000 Days Conference hosted by the Region 9 Head Start Association in Las Vegas, Nevada. The topics of the presentations focused on using data to enhance home visiting and parental nurturance.

City of Phoenix

Report

Agenda Date: 9/7/2022, **Item No.** 4

2020 Greenhouse Gas Emissions and Climate Action Plan Update

This report presents the results of the City of Phoenix 2020 Local Government Operations Greenhouse Gas (GHG) Emissions Inventory Report and the 2020 Community-Scale Greenhouse Gas Emissions Inventory Report (Reports) as well as an updated status on actions to address climate. The GHG Reports update the City's 2018 Local Government Operations GHG Inventory and 2018 Community-Scale GHG Inventory reports. The Reports present the status of the City's progress toward meeting its current greenhouse gas reduction targets for government operations of 40 percent by 2025 and 50 percent by 2030 for Community-Scale.

THIS ITEM IS FOR INFORMATION AND DISCUSSION.

Summary

Greenhouse gas emissions from human activity have increased dramatically over the past century and a half. These emissions, primarily resulting from burning of fossil fuels for electricity, heating, and transportation, are accelerating climate change. The City's 2021 Climate Action Plan, approved by City Council, reaffirms a long-term goal of becoming a carbon-neutral city by 2050, with interim goals along the way.

2020 Local Government Operations Greenhouse Gas Emissions Inventory

In 2016, the City Council adopted a goal to reduce GHG emissions from City operations to 40 percent below 2005 levels by the year 2025 after achieving previous emissions reductions goals. Since 2012, the Office of Environmental Programs (OEP) has been authorized by the City Council to enter into an intergovernmental agreement with Arizona State University (ASU) for consulting services to calculate GHG emissions inventories and check on the progress to the 2025 goal. The results show that in 2020, **GHG emissions from City operations were 25.2 percent lower than 2005 levels**.

The most significant City operations GHG reduction programs included:

- Savings from energy efficiency projects completed by facilities management;
- Additional solar power projects;
- Use of alternative fuels decreased the impact of the increase of Public Transit service miles in fulfillment of T2050;

- Continued construction of PHX Sky Train;
- Capture and reuse of biogas at 91st Ave Wastewater Treatment Plant;
- Increased waste diversion rates, including construction of 27th Compost Facility; and
- Increased implementation of the telework program.

The decrease in emissions can also be attributed to efforts by Salt River Project (SRP) and Arizona Public Service (APS) to reduce GHG emissions by using decreased carbon energy sources to produce power that has lowered the GHG intensity of the electricity the City purchases.

2020 Community-Scale Greenhouse Gas Emissions Inventory

A community-scale GHG emissions inventory was completed for 2020 as an update to the 2012, 2016 and 2018 inventories. The results show that in 2020, **GHG emissions on a community-scale were 14 percent lower than 2012 levels**. GHG emissions decreased during a period where the City's population grew 12 percent and the metro area economy grew 42 percent. Per capita emissions fell from the 2012 baseline of 11.8 Metric Tons (MT) Carbon Dioxide Equivalent Emissions (CO_2e) to 9.0 MT CO_2e in 2020.

The community-scale inventories are categorized into stationary energy, transportation, and waste sectors. Since 2012, the following GHG emissions decreases resulted in:

- A 21.5 percent decrease in the stationary energy sector due to a less GHG intensive electrical grid;
- A 4.6 percent decrease in transportation sector was observed due to decreased commuting and travel, including air travel, caused in part by the COVID-19 pandemic, while at the same time there was a marked increase in heavy truck delivery services; and
- A 21.8 percent decrease in the waste sector due to advanced methane capture systems and older landfills emitting less methane, along with capture and reuse of biogas at the 91st Avenue Wastewater Treatment Plant.

The actions are part of an overall strategy to reduce GHG emissions in the City. City staff completed a C40-compliant Climate Action Plan that provided a higher level of detail and scope for reducing GHG emissions that was approved by City Council on Oct. 12, 2021. Staff from all City departments were involved in the development of this plan and expect to begin work on updating this plan for Council for approval in fall 2023.

Attachments A, **B** and **C** provided are the reports prepared by the OEP in conjunction with ASU Walton Sustainability Solutions Initiative.

Responsible Department
This item is submitted by Deputy City Manager Karen Peters and the Office of Environmental Programs.

Rob and Melani Walton Sustainability Solutions Initiatives

Arizona State University

2020 Greenhouse Gas Emissions Inventory

An Executive Summary prepared for

City of Phoenix

May 2022

sustainabilitysolutions.asu.edu

Acknowledgements

This report is a joint effort by the city of Phoenix:
Nancy Allen, Environmental Programs Administrator
Rosanne Albright, Environmental Programs Coordinator
Dr. Matthew Potzler, Environmental Air Quality and Climate Specialist

And

Rob and Melani Walton Sustainability Solutions Initiatives
Arizona State University

William Campbell, Portfolio Manager
Lizzy Bruns, Graduate Student

And

NAU NORTHERN ARIZONA UNIVERSITY

Dr. Richard Rushforth, Assistant Research Professor, School of Informatics, Computing and Cyber Systems

We would like to recognize the financial support from the city of Phoenix's Office of Environmental Programs. In addition, we wish to acknowledge the numerous city staff for supplying the Office of Environmental Programs with data to tabulate the 2020 Government Operations & Community GHG emissions inventories.

Finally, we would like to thank city of Phoenix employees, residents, and business owners, who are on the ground supporting the city's efforts and who are working toward reducing their own greenhouse gas emissions.

Government Operations Findings

In 2020, city of Phoenix government operations emitted 25.2% fewer GHG emissions than the 2005 baseline level of 716,143 MT CO_2e. This is a decrease in annual emissions of 180,467 MT CO_2e.

Community-Wide Findings

In 2020, community-wide GHG emissions for the city of Phoenix were 14.0% less than the 2012 baseline level of 17,622,666 MT CO_2e. Community-wide GHG emissions have decreased by 2,466,616 MT CO_2e annually.

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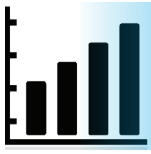
Background

City of Phoenix Climate Action Projects



Government Operations

Community Emissions

Recommended Actions

Background

The city of Phoenix set its first climate action goals 14 years ago in 2008 with the stated goal of reducing greenhouse gas (GHG) emissions from city operations 5% below 2005 levels by 2015.

In 2012, three years ahead of schedule, Phoenix exceeded its goal with a reduction of 7.2%. In response to this accelerated reduction and to continue to position itself as a national leader, the Phoenix City Council adopted a new goal to reduce GHG emissions to 15% below 2005 levels by 2015. The completion of the Phoenix 2015 Greenhouse Gas Emissions Inventory for Government Operations showed that Phoenix exceeded its 15% reduction goal. In 2017, Phoenix updated its government operations GHG emissions reduction goal to 40% below 2005 levels by 2025.

Phoenix's 2021 Climate Action Plan set an even more ambitious goals for reducing GHG emissions from government operations:

Achieve net-zero GHG emissions for municipal operations electricity use by 2030 through renewable energy projects, energy efficiency upgrades, and utility partnerships.

In addition to government operations, Phoenix conducts regular community-scale GHG emissions inventories according to the Global Protocol for Community-Scale GHG emissions Inventories (GPC). The GPC is a worldwide standard for inventorying city-induced GHG emissions and is the standard supported by the Global Covenant of Mayors for Climate and Energy. Phoenix is a member of the C40 Cities Climate Leadership Group and Global Covenant of Mayors for Climate and Energy. At the community scale, Phoenix has a stated goal to reduce community carbon emissions from buildings, transportation, and waste by 50% by 2030 and to move toward becoming a carbon neutral city by 2050.

2020 Overall Findings

- Phoenix government operations emitted 535,675 MT CO_2e, a 25.2% decrease below baseline 2005 levels;
- Community GHG emissions were 15,156,347 MT CO_2e, a 14.0% decrease below baseline 2012 levels.

City Action Highlights

- Phoenix government operations consume 8% less energy compared to 2005 while providing services for nearly 300,000 more residents;
- Electricity consumption by traffic signals and streetlights has fallen nearly 50% since 2005;
- Biogas capture at the 91st Ave Wastewater Treatment Plant decreased facility emissions by 28,949 MT CO_2e.

City of Phoenix Climate Action Projects

Buildings and Facilities

- Increasing renewable energy to city operations
- $30 million in building retrofits to increase building efficiency by 20%.
- First city to adopt International Energy Conservation Code's 2018 International Building Code

City Vehicle Fleet

- Alternative Fuel Programs:
  - City Vehicle Fleet continues to transition liquid natural gas and diesel to less GHG-intensive compressed natural gas and biogenic fuels.
  - Public Works, in partnership with Mr. Bults Inc. (MBI), were the recipients of a United States Environmental Protection Agency Diesel Emissions Reduction Act (DERA) grant to replace heavy duty diesel refuse trucks. This project will be implemented using $1,000,000 in DERA grant funding combined with $2,194,693 in cost-share funds from Public Works and MBI to replace diesel refuse trucks. This project will replace 9 Class 8 diesel refuse trucks, and 1 MBI long haul refuse truck, with model year 2019 Class 8 trucks powered by compressed natural gas engines certified to meet the California Air Resources Board's most stringent optional low NO_x emission standard.
- Construction of PHX Sky Train, electrically powered, at Phoenix Sky Harbor International Airport at an estimated cost of $1.5 billion is expected to be completed by 2022 is reducing the need for fleet powered by compressed natural gas.

Heat Ready City

- Walkable Urban Code is an urban and transit-oriented zoning code.
- Established first-of-its-kind Heat Ready Program that was recognized in the Bloomberg Philanthropies Mayors Challenge Champion City program.
  - Citizen Forester Program 2.0 – The Volunteer Office led the relaunch of the Citizen Forester Program certifying 20 Citizen Foresters and planting more than 200 trees this year. The program continues to grow with support from an AmeriCorps VISTA member working in the City Manager's Office and a $50,000 Phoenix IDA grant to fund community led heat-mitigation projects to support HeatReady Phoenix.
  - We're Cool 2019 – Volunteer Phoenix led the fourth annual We're Cool campaign, in partnership with the Human Services Department and the Office of Homeland Security and Emergency Management, to connect low-income communities to cooling centers, heat safety information and support during the summer months with the help of 400 youth volunteers.
- Planning and Development revised zoning code to ensure trees are planted and maintained.
- Cool Pavement Program to coat streets in a lighter color to reflect light to reduce temperatures locally.

Solid Waste

- Reimagine Phoenix:
  - Construction of state-of-the-art $15 million compost facility to divert organic waste.
  - Partnered with Stardust Building Supplies to pursue deconstruction rather than demolition to divert materials from the landfill.
  - 36% of solid waste diverted from landfills with goals of 50% by 2030 and of being a zero waste city by 2050.

Sustainable Food Systems

- Healthy food system goal adopted into the General Plan, PlanPHX.
- City Council approved the 2025 Phoenix Food Action Plan to promote a healthy, sustainable, equitable, and thriving local food system with healthy food for all.

Transportation Initiatives

- Transportation 2050
  - Added 2.4 million service miles
  - 16.5 miles of light rail have been constructed
  - 44 RAPID buses have been ordered for use in 6 routes
  - 349 transit shelters installed at bus stops that previously had no shade
  - 20,693 ADA ramps improved/installed through street maintenance
  - 567 solar lighting kits installed on new and existing transit shelters
  - Installed 32.2 miles of bicycle lanes, upgraded 1 mile of existing bike lane miles to protected bike lanes and upgraded 34.5 miles of existing bike lanes to buffered bike lanes
- New Bus and Dial-A-Ride Vehicles – Public Transit has ordered 403 new buses and 122 Dial-a-Ride vehicles to its fleet to replace aging buses. The department adds new vehicles each year to modernize the fleet, which in turn provides the region's bus passengers with an overall more efficient and dependable bus service, as well as vehicles that are more fuel efficient and include the latest clean fuel technology.
- eScooter Pilot Program Launch – The Street Transportation Department launched the Downtown Shared eScooter Pilot Program to provide a micro-mobility solution for our residents and visitors.
- Parking Protected Bicycle Lanes – The Street Transportation Department installed the City's first and second parking protected bicycle lanes through the Accelerated Pavement Maintenance Program.
- Street Landscape Improvements – 700 trees planted along with increased service levels and irrigation audits for street landscaping and irrigation maintenance, which will result in reduced water consumption, save money and help make Phoenix streets more walkable.
- Liberty Lane Street Improvements – A 4.5-foot buffer was added to the bike lanes on Liberty Lane, creating more space between motor vehicles and bicyclists/pedestrians, resulting in improved safety for all users of the roadway.
- The Grand Canalscape, a nearly 12-mile continuous multimodal trail system from Glendale to Tempe, was completed with additional expansion planned.

Water

- Colorado River Drought Contingency Plan: Phoenix Water Services effectively negotiated in the Arizona implementation of the Colorado River Drought Contingency Plan to maintain protection of existing priority system for Colorado River water in Central Arizona and system conservation in the plan.
- Water Loss Committee: The efforts of the Department's Water Loss Committee resulted in a reduction of our Lost and Unaccounted for Water reported to the Arizona Department of Water Resources of nearly one billion gallons year over year by city operations.
- Partnered with Ameresco to construct a $25 million facility to treat and sell biogas, which contains renewable natural gas, from 91st Wastewater Treatment Plant.

Programs planned or commenced since 2020

City Vehicle Fleet

- A policy will be developed to work toward procuring lower-GHG emissions vehicles where operationally feasible, including electric vehicles.

Heat Ready City

- Cool Corridors Program to plant trees citywide to provide shade to high pedestrian traffic areas with the first Cool Corridor established in 2022 and a goal of 100 by 2030.
- Established the Office of Heat Response and Mitigation, the nation's first municipally office of its kind.
- Heat Response Plan developed to help keep people safe in summer.

Solid Waste

- Phoenix is participating in C40 Cities Reinventing Cities Competition that seeks to transform underutilized sites through sustainability and community focused projects.

Sustainable Food Systems

- 2021 – Backyard Garden Program empowers residents to grow healthy food in their own backyards.
- 2022 – Urban Agriculture Fellowship Program designed to train next generation of growers.
- 2022 – Agri-Food Technology Innovation Programs will provide grants to advance projects to produce food in a manner sustainable in Phoenix.
- 2022 – Resilient and Sustainable Agriculture Program provides grants to Phoenix farms to reduce the climate impact of food production and enhance the resiliency of both the farm and local food system in the face of various shocks and disruptions.

Transportation Initiatives

- 2022 – Road Safety Action Plan Vision Zero approved by City Council.
- 2022 – Active Transportation Plan in development to increase walkability and bikeability.

Water

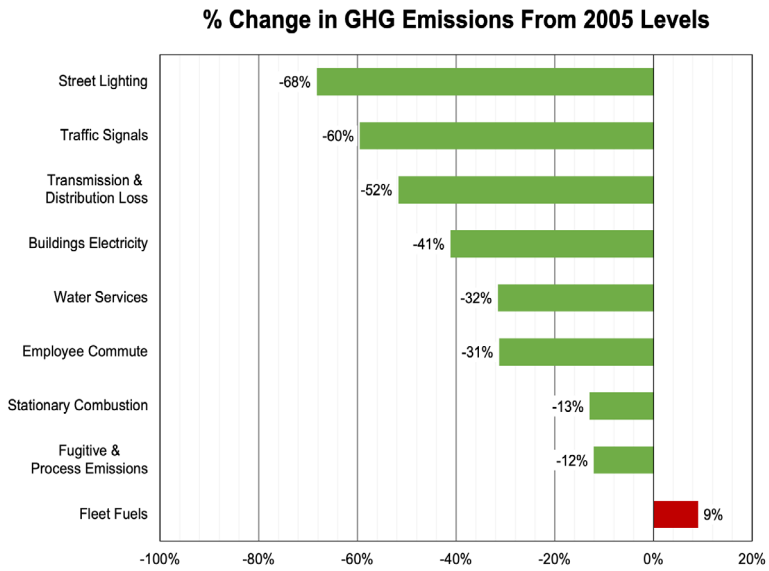
- The 2021 Water Resource Plan demonstrates Phoenix's robust and diverse water portfolio.
- Phoenix encourages residents to adopt a desert lifestyle that has reduced the number of gallons per capita per day (GPCD) it uses by nearly 30% over the last twenty years, despite an increase of almost 400,000 additional residents.

Government Operations

Significant Reductions

Since 2005, GHG emissions from Phoenix government operations have decreased from 716,143 MT CO_2e to 535,675 MT CO_2e, a 25.2% decrease in emissions.

The most substantial decrease in GHG emissions were associated with electricity consumption, where efficiency upgrades and changes to the regional energy mix have driven significant decreases. Fleet fuels have increased as service miles increased to meet T2050 goals. The use of alternative fuels, like CNG and biodiesel, decreased emissions (Right).



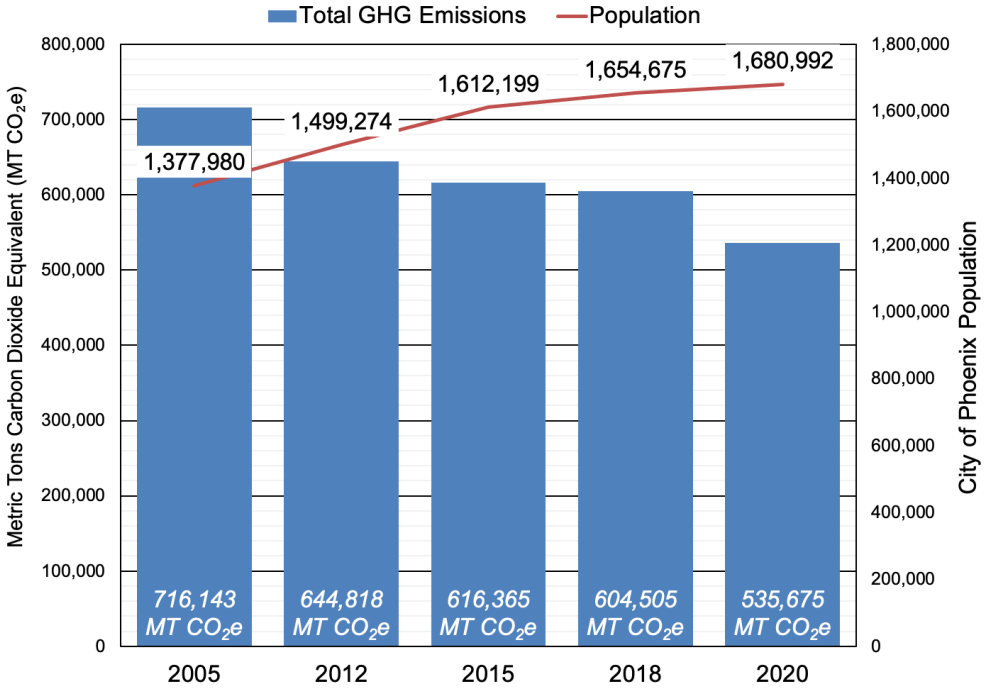
The 2020 inventory update enables Phoenix to evaluate its progress towards lowering emissions from its operations to reach the goals of 40% reduction by 2025 and net zero by 2050.

City of Phoenix government operations total GHG emissions have decreased despite significant population growth

In 2020, Phoenix government operations emitted 38.7% fewer GHG's per resident than in 2005.

GHG emissions from Phoenix government operations have decreased due to multiple factors:

- 40.6% fewer emissions from electricity consumption;
- 12.9% fewer emissions from natural gas combustion;
- 12.1% fewer emissions emissions from landfills and wastewater treatment.



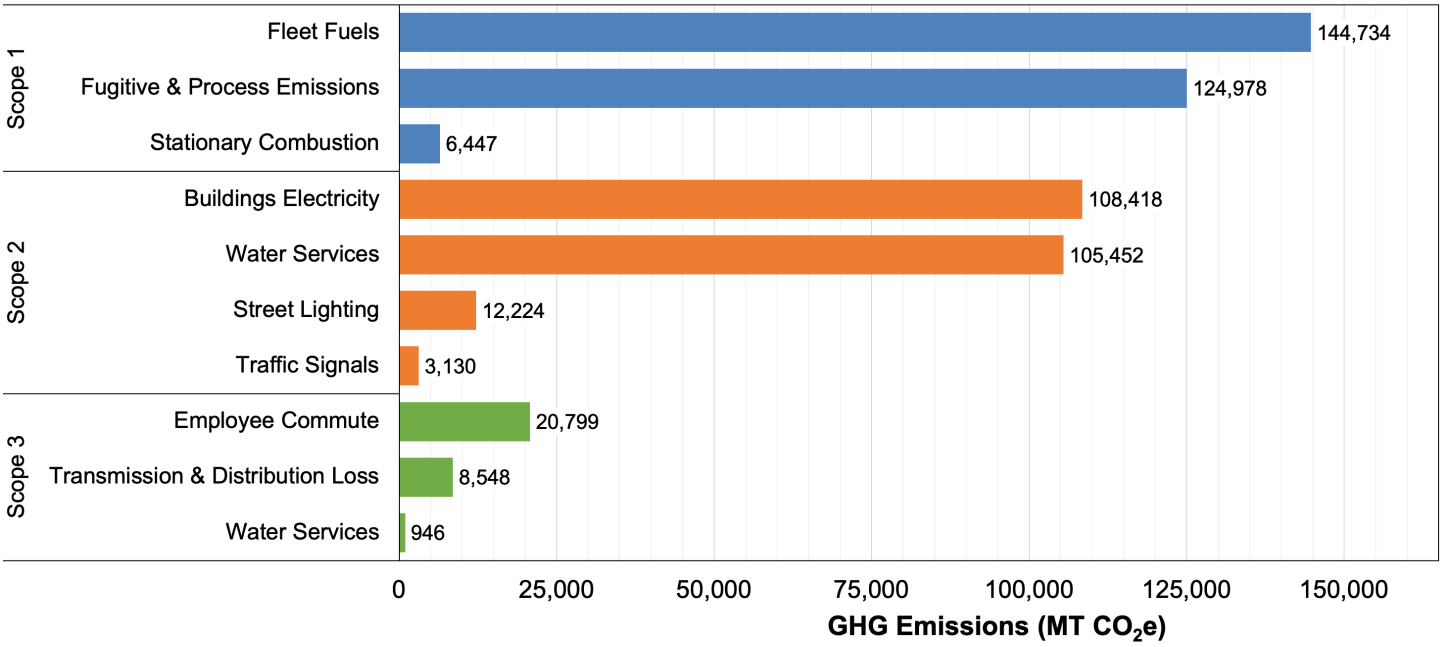
Government Operations

What's the source?

The Phoenix 2020 Greenhouse Gas Emissions Inventory for Government Operations identified sources of greenhouse gas emissions in city operations by both scope and sector:

- Scope 1 GHG emissions are those generated directly by city operations;
- Scope 2 GHG emissions are indirect sources of emissions from electricity consumption;
- Scope 3 GHG emissions are related to city operations but not owned or controlled by Phoenix.

The sectors—buildings and facilities, city vehicle fleet, water services, solid waste and employee commuting— were chosen to make the findings more relevant to Phoenix's policy making and project management.



Top Sectors

Wastewater Treatment

Biogas capture at the 91st Avenue Wastewater Treatment Plant reduced GHG emissions 28,949 MT CO_2e below 2018 levels.

Employee Commute

Telecommuting programs have contributed to a decrease in employee commuting emissions by 9,473 MT CO_2e since 2005.

Buildings and Facilties

GHG emissions from Buildings & Facilities have fallen 124,837 MT CO_2e due to a less carbon intensive electricity grid.

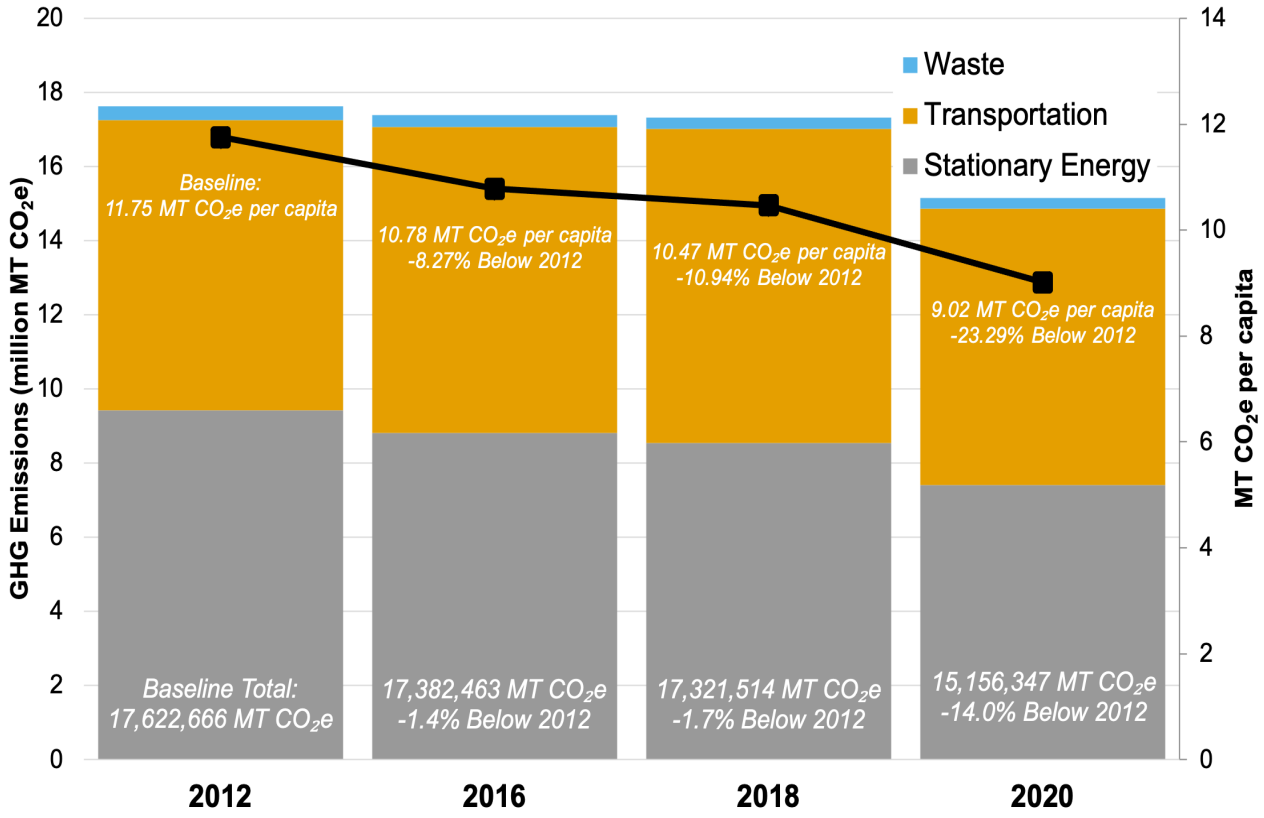
Solid Waste

The 27th Avenue Compost Facility will reduce future GHG emissions at the SR-85 Landfill.

Community Emissions

The city of Phoenix completed its fourth community greenhouse gas emissions inventory for calendar year 2020 using the Global Protocol for Community-Scale GHG Emission Inventories (GPC). Calendar year 2012 is the baseline for Phoenix-wide GHG emissions. A community inventory estimates GHG emissions from the entire Phoenix community, not just government operations, for all stationary energy consumption, transportation activities and waste generation. The GPC is the international standard for conducting community GHG emissions inventories.

Phoenix community GHG emissions between 2012 and 2020



Key Findings:

- In 2020, community-scale GHG emissions were 15,156,347 MT CO_2e, representing a 14.0% decrease below the 2012 baseline level of 17,622,666 MT CO_2e.
- GHG emissions decreased across Phoenix while Phoenix's population grew 12.1% and the the metro area economy grew significantly, indicating that Phoenix can reduce emissions while experiencing economic growth.
- The Phoenix per capita GHG emissions rate fell 23.3% from 11.75 MT CO2e to 9.02 MT CO_2e between 2012 and 2020.
- For the first time since 2012, transportation-related activities became the largest source of GHG emissions across Phoenix, comprising 49.2% of emissions, and will likely increasingly be the dominant source of GHG emissions as the regional electricity grid becomes less carbon intensive.

Actions

Recommended Measures

We recommend that the city of Phoenix continue to take bold actions to identify and reduce GHG emissions, to update and evaluate the effectiveness of mitigation programs, and to take the necessary climate adaptation steps to ensure a resilient metropolitan region in a warmer, drier future. The following recommended measures can be accomplished in consultation with the City and its departments, under the leadership of the City Council and City Manager's Office.

1. Conduct a Consumption-Based GHG Emissions Inventory

GHG emissions are not contained by city boundaries. Phoenix should be cognizant of the GHG emissions impacts of its purchasing decisions to bolster and increase the impact of sustainable purchasing policies. By conducting this consumption-based inventory, the GHG emissions resulting from the production, shipping, use, and disposal of items and services purchased by the City can be included in resulting municipal operations emissions inventories to gain a better picture of the GHG emissions. This information can then be used to make decisions to reduce the financial and environmental costs of city purchasing.

2. Create a city of Phoenix GHG Emissions Dashboard

Transparency and accountability are critical in ensuring that emissions reduction efforts remain active. As the City continues to develop robust data on its GHG emissions, it should pursue developing an online GHG dashboard to be displayed on the City's Open Data portal to present the results of emissions inventories in an easily accessible way for city staff, other municipalities and the public.

3. Innovate Methods for Estimating the GHG Emissions Impact of Land Use

During the 2020 GHG emissions inventory cycle, Phoenix conducted its first GHG emissions inventory of Agriculture, Forestry, and Other Land Use (AFOLU) and city-wide food consumption. The initial AFOLU GHG emissions inventory process identified several shortcomings for tabulating these emissions for a city with Phoenix's climate. It is recommended to invest in efforts to develop new methods for tabulating AFOLU GHG emissions for cities in hot deserts, reinforcing Phoenix's leadership role in understanding and mitigating community-scale GHG emissions.

4. Coordinate the Development of a Regional GHG Emissions Inventory and Resiliency Plan

Develop a plan that will address greenhouse gas emissions and increase the resilience of the greater Phoenix metropolitan area through regional coordination under the Maricopa Association of Governments. Regional cooperation will lead to increased economic opportunities by leveraging public and private investments that can be used to ensure long-term economic growth. The plan will also build public awareness of climate-related risks and allow for improved collaboration to seek solutions.

5. Set the Standard for Comprehensive City GHG Emissions Inventorying

The Local Government Operations Protocol and GPC are internationally-recognized standards for conducting city-level GHG inventories. However, these standard protocols may inadequately inventory unique aspects of a city and its operations. To address this, we recommend the following actions. First, we recommend conducting a GHG inventory of Phoenix-specific systems, like Phoenix's water system from raw water sources to wastewater discharge. Second, we recommend evaluating technologies to increase the spatial and temporal resolution of GHG inventories. Finally, we recommend setting up a system for the third-party verification of the government operations and community-scale GHG inventories.

Rob and Melani Walton Sustainability Solutions Service

Arizona State University

2020 Greenhouse Gas Emissions Inventory for Government Operations

A comprehensive report prepared for

City of Phoenix

May 2022

sustainabilitysolutions.asu.edu

Acknowledgements

This report is a joint effort by the City of Phoenix:

Nancy Allen, Environmental Programs Manager
Rosanne Albright, Environmental Programs Coordinator
Dr. Matthew Potzler, Environmental Air Quality and Climate Specialist

And

Arizona State University's Walton Sustainability Solutions Initiatives:
William Campbell, Portfolio Manager
Lizzy Bruns, Graduate Student

And

Northern Arizona University's School of Informatics, Computing, and Cyber Systems
Dr. Richard Rushforth, Assistant Research Professor

We wish to acknowledge the numerous city departments' staff for supplying the data needed to produce the *2020 Greenhouse Gas Emissions Inventory for Government Operations*. We would also like to acknowledge the personnel of Avantpage Translation for their Spanish translation services.

Finally, we would like to thank City of Phoenix employees, residents, and business owners, who are on the ground supporting the City's efforts and who are working toward reducing their own greenhouse gas emissions.

Note: The data and calculations presented in this report may not be exact due to rounding errors within the GHG emissions template.

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Acronyms

AR	IPCC Assessment Report (Numbered 2 through 5)
ASU	Arizona State University
AZNM	Arizona and New Mexico eGRID Subregion
B20	A biodiesel blend consisting of 20% biodiesel and 80% diesel fuel
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_2e	Carbon Dioxide Equivalent Emissions
eGRID	EPA's Emissions and General Resource Integrated Database
EIA	U.S. Energy Information Administration
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FTE	Full-time equivalent
GGE	Gasoline Gallon Equivalent
GHG	Greenhouse Gas
GAC	Granular Activated Carbon
GWP	Global Warming Potential
ICLEI	International Council for Local Environmental Initiatives
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	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MT	Metric Tons
MWh	megawatt-hour
NAU	Northern Arizona University
NERC	North American Electric Reliability Corporation
N_2O	Nitrous Oxide
T&D	Transmission & Distribution
TRP	Trip Reduction Program
UNFCCC	United Nations Framework Convention on Climate Change
WWT	Wastewater Treatment
WWTP	Wastewater Treatment Plant

Executive Summary

The *City of Phoenix 2020 Greenhouse Gas Emissions Inventory for Government Operations* is the fifth update to the City of Phoenix (the City) government operations GHG emissions inventory. The initial GHG inventory of government operations covered calendar year 2005 and was published in 2009. This report provided both a baseline GHG inventory and technical support for the *City of Phoenix 2009 Climate Action Plan for Government Operations*. The climate action plan projected that GHG emissions from the City's government operations would increase by 14% over 2005 level if no actions were taken. As a result, the Phoenix City Council, in December 2008, adopted a mandate to reduce GHG emissions from government operations to 5% below the 2005 GHG emissions levels by 2015.

In 2013, the City conducted a GHG emissions inventory for calendar year 2012 to track progress toward the 2015 GHG emissions reduction goal. The *City of Phoenix 2012 Greenhouse Gas Emissions Inventory for Government Operations* found that GHG emissions from government operations had decreased 7.2%, exceeding the City's 2015 goal. Shortly thereafter, the Phoenix City Council adopted a new goal to reduce government operations GHG emissions to 15% below 2005 levels by 2015. The *City of Phoenix 2015 Greenhouse Gas Emissions Inventory for Government Operations* found that government operations GHG emissions were reduced by 15.6%, thus meeting the updated 2015 GHG emissions goal. In 2017, the City updated its government operations GHG emissions reduction goal to 40% below 2005 levels by 2025. The *City of Phoenix 2020 Greenhouse Gas Emissions Inventory for Government Operations* is the second inventory update since setting the 2025 GHG emissions reduction goal, and provides demonstrated progress towards the 2025 goal and a data-driven basis for developing climate actions to meet the 2025 goal.

The major findings of the *City of Phoenix 2020 Greenhouse Gas Emissions Inventory for Government Operations* are listed below.

- 2020 government operations GHG emissions were 68,829 MT CO_2e (11.4%) below 2018 levels and 180,467 MT CO_2e (25.2%) below 2005 levels.
- Between 2018 and 2020, the GHG intensity of the regional electricity grid fell by 17.3%. Over the same period, GHG emissions from purchased electricity fell by 23.0% (68,636 MT CO_2e), indicating additional reductions due to City actions. Through energy retrofits, energy use has declined in City buildings every year since 2016.
- Buildings and Facilities GHG emissions from purchased electricity fell 31,296 MT CO_2e between 2018 and 2020. Facilities managed by the

Public Works, Street Transportation and the Phoenix Convention Center departments, realized a 19 percent electricity use savings since 2016.
- GHG emissions from Traffic Signals and Streetlights decreased 66.8% below 2005 levels and 57.5% below 2018 levels.
- Water Services GHG emissions from purchased electricity decreased 16,550 MT CO_2e (13.6%) between 2018 and 2020 despite electricity consumption increasing by 11,725 MWh.
- GHG emissions from the City's vehicle fleet has increased 14,985 MT CO_2e since 2018. Increased Vehicle Fleet emissions is attributed to higher levels of CNG and B20 consumption.
- GHG emissions from landfills was similar between 2018 and 2020, increasing by 362 MT CO_2e.
- GHG emissions from wastewater treatment decreased 20.6% (28,949 MT CO_2e) between 2018 and 2020 and were 4.1% (345 MT CO_2e) below 2005 levels due to the capture and reuse of methane biogas at the 91st Avenue Wastewater Treatment Plant (WWTP).
- The 27th Avenue Compost Facility emitted 6,360 MT CO_2e in 2020, 21.7% decrease below 2018 levels. The facility will save GHG emissions over its lifetime by reducing green-organic waste disposal at the SR-85 landfill.

Since 2015 Phoenix has implemented, or is in the process of implementing, several projects in order to meet and surpass its original emissions reduction goal. These projects include:

- $16.9 million in the 27th Avenue Compost Facility.
- $30 million in LED Streetlight project replacing 100,000 streetlights
- $25 million in a biogas facility at the 91st Avenue WWTP
- $30 million in retrofits underway to reduce energy use in city buildings
- $530 million in transit since 2016 under the Phoenix Transportation Plan (T2050) for extended bus and paratransit operating hours, and increased local bus frequency to every 30 minutes or less citywide.

The City has achieved significant GHG emissions reductions despite growing by approximately 300,000 people since 2005 (Figure ES-1). Accordingly, the per capita GHG intensity of the City's government operations have fallen from 0.48 to 0.30 MT CO_2e per resident between 2005 and 2020. For more information on City of Phoenix actions to reduce GHG emissions, please read the City of Phoenix Climate Action Plan 2021 Edition.

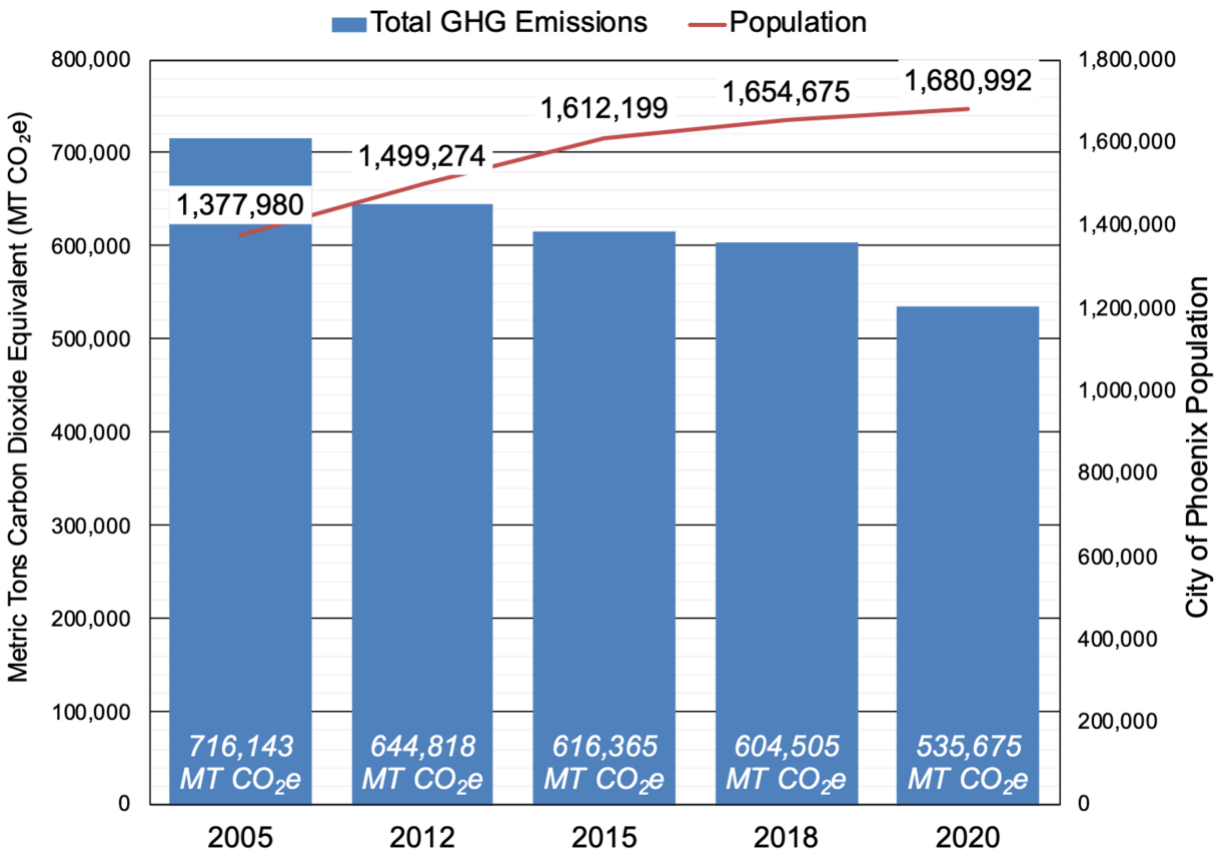


Figure ES-1. City of Phoenix Government Operations GHG Emissions and Population Between 2005 and 2020.

1 Introduction

In December 2008, the Phoenix City Council adopted a goal to reduce GHG emissions from government operations to 5% below reported 2005 levels by 2015. To achieve this goal, the City of Phoenix (City) established a baseline GHG emissions level for City operations and developed *The City of Phoenix 2009 Climate Action Plan for Government Operations*. The report forecasted a 14% increase in GHG emissions by 2015 if Phoenix maintained a business-as-usual approach and did not take efforts to curb GHG emissions.

In 2013, the City commissioned Arizona State University's Rob and Melani Walton Sustainability Solutions Service to conduct a local government operations GHG emissions inventory for 2012 to track progress toward the 2015 goal. The 2012 government operations GHG emissions inventory found that the City had already reduced GHG emissions by 7.2%, meeting the 5% reduction goal. As a result, Phoenix City Council adopted a new goal to reduce government operations GHG emissions 15% below 2005 levels by 2015. The 2015 government operations GHG emissions inventory found that the City achieved its 15% GHG emissions reduction goal. In 2017, the City updated its government operations GHG emissions reduction goal to 40% below 2005 levels by 2025.

The *City of Phoenix 2020 Greenhouse Gas Emissions Inventory for Government Operations* summarizes the City's progress toward reducing GHG emissions from government operations 40% below 2005 levels by 2025.

The report structure is as follows:

- Section 2 provides an overview of the major findings of the GHG emissions inventory of government operations.
- Section 3 describes the GHG emissions inventory boundary along with methodological background and updates for the GHG Emissions reports.
- Section 4 summarizes results by reporting sector: Buildings and Facilities, City Vehicle Fleet, Water Distribution and Wastewater Treatment Processes, Solid Waste, and Employee Commute.
- Section 5 provides internal and external benchmarks for Phoenix operations.
- Section 6 summarizes biogenic CO_2 emissions, which are non-fossil CO_2 emissions that are not included in Phoenix's total emissions.

2 Major Findings

In 2020, GHG emissions from City government operations were 535,675 MT CO_2e, which is 25.2% below 2005 levels and 11.4% below 2018 levels (Figure 1).

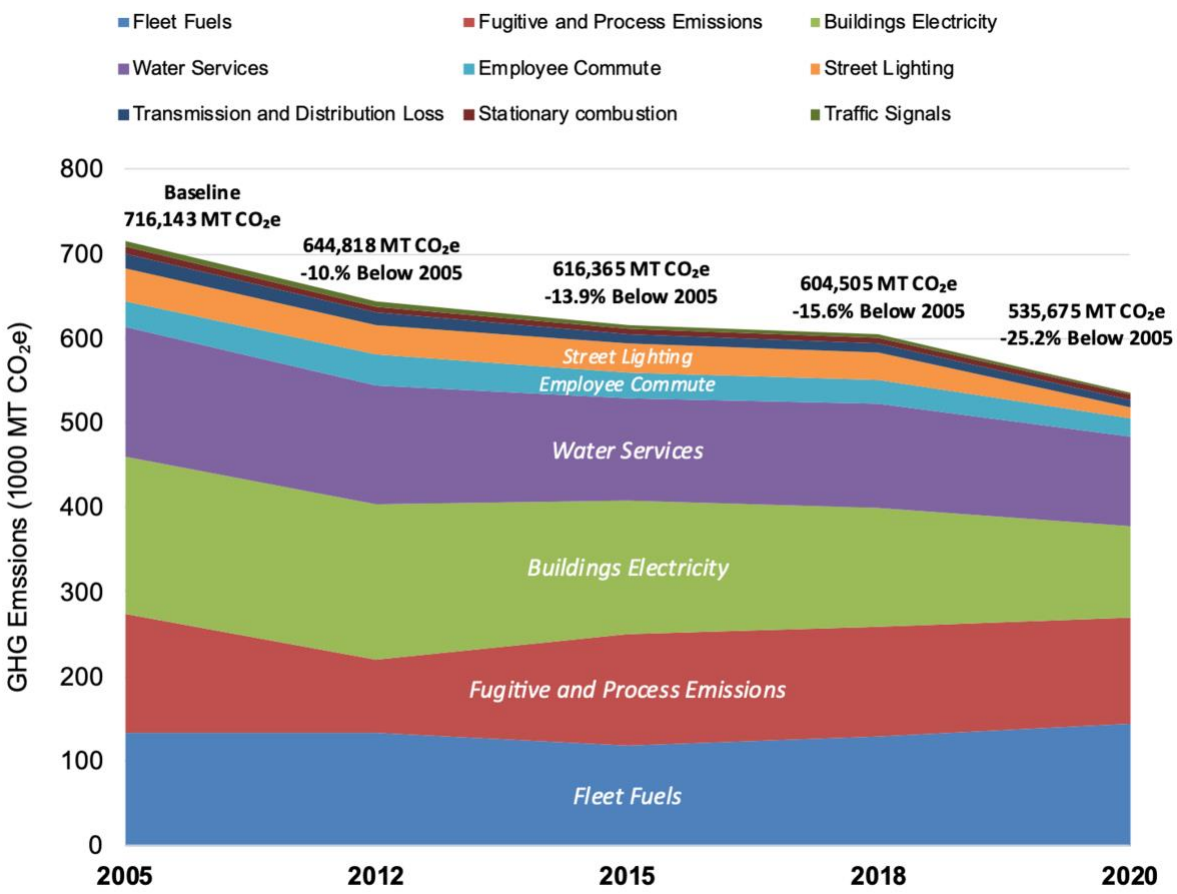


Figure 1. City of Phoenix GHG Emissions from 2005 to 2020.

The City reduced GHG emissions through a combination of internal and external measures. Internal measures include energy efficiency upgrades, the incorporation of alternative fuels into the vehicle fleet fuel portfolio, and upgrades to landfill gas capture systems. For additional internal measures, please refer to the City of Phoenix Climate Action Plan for 2021. External measures include a decrease in the EPA's Emissions & Generation Resource Integrated Database (eGRID) regional factor[1]. Between 2005 and 2020, the GHG intensity of the Arizona-New Mexico (AZNM) subregion fell by approximately 35%, from 1,316 lb. CO_2e emitted per MWh of electricity generated (lb.

[1] 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.

CO_2e/MWh) to 850 lb. CO_2e/MWh. The 2019 closure of the Navajo Generation Station, operated by Salt River Project, substantially reduced the GHG intensity of electricity in the Arizona-New Mexico subregion.

Between 2018 and 2020, GHG emissions from City government operations decreased in every subsector except Fleet Fuels, which increased 14,985 MT CO_2e (11.5%) as shown in Table 1. The increase in Fleet Fuels GHG emissions were driven by increased CNG consumption (1,404,331 GGE) and B20 fuel consumption (1,281,289 gallons), which resulted in 8,880 MT CO_2e and 10,440 MT CO_2e additional GHG emissions, respectively. However, over the same period, gasoline consumption remained relatively unchanged (3% increase) and diesel consumption decreased by 12%. In the Water Services sector, GHG emissions from electricity usage decreased by 16,650 MT CO_2e (13.6%) despite an increase in electricity consumption of 11,725 (4%). Water Services natural gas consumption increased by 25% between 2018 and 2020. GHG emissions from employee commuting decreased in 2020 most likely due to the COVID-19 pandemic as some employees were able to telework to perform their duties; the change in commuting patterns caused by the pandemic reduced commuting-related GHG emissions by 22% compared to 2018.

2.1 Revisions

Minor revisions were made to the GHG emissions totals from City government operations. These revisions are detailed below.

- 2005: No revisions were made to the 2005 inventory.
- 2012: 644,819 MT CO_2e revised upwards from 644,723 MT CO_2e.
  - Audit found incorrect Excel formula that omitted 96 MT CO_2e from liquified natural gas consumption.
- 2015: 616,351 MT CO_2e revised downwards from 616,415 MT CO_2e
  - Audit found incorrect Excel formula that overestimated N_2O emissions from the 91st Avenue wastewater treatment plant by 64 MT CO_2e.
- 2018: 604,505 MT CO_2e revised downwards from 605,701 MT CO_2e.
  - Audit found incorrect Excel formulas that overestimated emissions from Fugitive and Process Emissions by 61 MT CO_2e.
  - Updated state-level Transmission and Distribution loss data, which decreased emissions by 1,135 MT CO_2e.

Table 1 shows changes GHG emissions for City government operations and population between 2005 and 2020.

Table 1. GHG Emissions by Scope and Sector Between 2005 and 2020

Scope 1	2005	2012	2015	2018	2020	2005-2020 Change	2005-2020 % Change
Stationary Combustion	7,404	7,329	6,377	6,085	6,447	-957	-12.9%
Fleet Fuels	132,709	133,521	118,706	129,748	144,734	12,025	9.1%
Fugitive and Process Emissions	142,165	87,073	131,868	129,646	124,798	-17,187	-12.1%
Scope 1 Total Emissions	282,277	227,923	256,951	265,479	276,158	-6,119	-2.2%

Scope 2	2005	2012	2015	2018	2020	2005-2020 Change	2005-2020 % Change
Buildings Electricity	184,285	183,851	156,646	139,714	108,418	-75,867	-41.2%
Street Lighting	38,502	36,416	33,935	32,069	12,224	-26,278	-68.3%
Traffic Signals	7,733	7,157	4,755	4,075	3,130	-4,602	-59.5%
Water Services	155,368	137,793	121,158	122,002	105,452	-49,916	-32.1%
Scope 2 Total Emissions	**385,888**	**365,217**	**316,494**	**297,860**	**229,225**	**-156,664**	**-40.6%**

Scope 3	2005	2012	2015	2018	2020	2005-2020 Change	2005-2020 % Change
Employee Commute	30,272	35,042	31,350	29,518	20,799	-9,473	-31.3%
Transmission and Distribution Loss	17,705	13,640	10,810	10,766	8,548	-9,158	-51.7%
Water Services	0	2,996	760	881	946	946	-
Scope 3 Total Emissions	**47,977**	**51,679**	**42,920**	**41,165**	**30,293**	**-17,685**	**-36.9%**

GHG Inventory	2005	2012	2015	2018	2020	2005-2020 Change	2005-2020 % Change
Total Scope 1 and 2 Emissions	668,165	593,140	573,445	563,339	505,383	-162,782	-24.4%
Total Scope 1, 2, & 3 Emissions	**716,143**	**644,818**	**616,365**	**604,505**	**535,675**	**-180,467**	**-25.2%**
City of Phoenix Population	**1,377,980**	**1,499,274**	**1,612,199**	**1,654,675**	**1,680,992**	**303,012**	**22.0%**

3 Methodology

3.1 Local Government Operations Protocol

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, the ASU and NAU team has used the 2010 version (Version 1.1) of the protocol for the previous GHG emissions inventories.

The LGOP provides a methodology for the calculation of GHG emissions from numerous sources and for the development of a comprehensive inventory report. Activity data are collected from a GHG emissions source and multiplied by an emission factor (e.g., metric tons CO_2 emitted per kWh) to calculate the total emissions. Where activity data are not available, they are modeled. The LGOP provides emission factors for most calculation methodologies used in the report. Measured or calculated emissions are then converted to carbon dioxide equivalent emissions (CO_2e) using the IPCC AR5 GWP factors[2] shown in Appendix A.

3.2 Scope Classifications and Sectors

GHG emissions from government operations are categorized as Scope 1, 2, or 3 emissions. Scope categories indicate whether GHG emissions are direct or indirect in order to improve transparency and to inform different types of climate policies and goals. The Scope categories are illustrated in Figure 2.

- Scope 1: Direct emissions from City owned or controlled operations.
- 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 the City.
- 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 other outsourced activities. This report includes employee commuting

[2] Greenhouse Gas Protocol, 2016. Global Warming Potential Values. URL: https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

and outsourced granular activated carbon (GAC) hauling and regeneration activity as Scope 3 emissions.

This report is organized into five sectors to make it more compatible for policy making and project management teams.

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

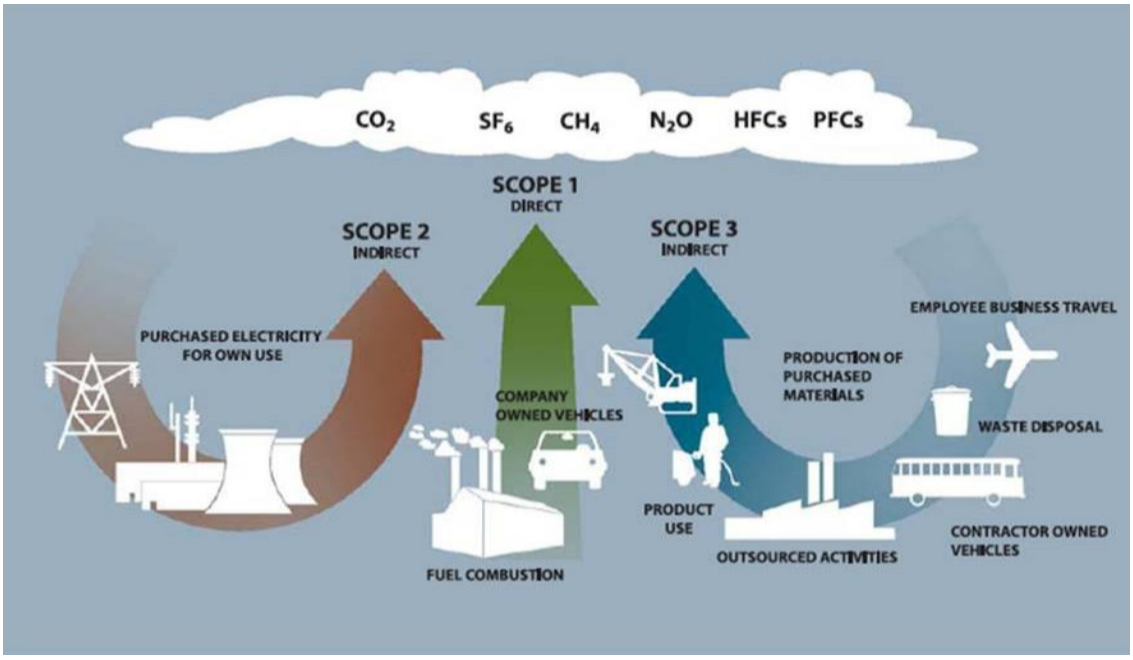


Figure 2. Overview of LGOP Scopes and Emissions Sources.[3]

3.3 City of Phoenix Government Operations Boundary

The LGOP provides two approaches for defining the boundaries of what to include in the government operations GHG 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[4].

[3] 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.
[4] ICLEI USA, 2020. Greenhouse Gas Protocols. URL: https://icleiusa.org/ghg-protocols/

This inventory uses the *operational control* approach as it most accurately represents GHG emissions sources within the City's control. The boundaries of the City operations GHG inventory follow the same guidelines as the 2005 baseline inventory. However, Scope 3 GHG emissions – emissions resulting granular activated carbon (GAC) hauling and regeneration and electricity transmissions and distribution (T&D) loss – and biogenic emissions were added into the 2012 inventory, and have been included in each inventory since. The 27th Avenue Compost Facility GHG emissions source was added in the 2018 inventory. A detailed description of considerations of the City's operational control boundary is located in Appendix B.

3.4 Inventory Changes Since 2005

The 2020 GHG emissions inventory methodology generally follows that of the 2005 inventory. With each emissions inventory, technical improvements are made to more accurately quantify emissions. In 2010, ICLEI and partners released the latest LGOP Version 1.1. This update included several changes to figures, methods, and other factors. Additionally, the 2005 and 2012 GHG emissions inventory utilized Intergovernmental Panel on Climate Change (IPCC) AR2 Global Warming Potential (GWP) emissions factors; the 2015 GHG emissions inventory utilized IPCC AR4 GWP emissions factors; the 2018 and 2020 GHG emissions inventory utilizes IPCC AR5 GWP; and the 2020 GHG emissions inventory utilizes IPCC AR6 GWP. This procedure of updated GWP factors, found in the EPA U.S. Greenhouse Gas Inventory Report, complies with the United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines for national inventories, requiring the use of the latest GWPs for national GHG emissions inventories[5].

The following changes have been made to the City government operations GHG emissions inventory since the baseline inventory:

- Estes Landfill was added to all inventory years;
- Employee commuting emissions at sites with more than 50 employees added to the 2005 inventory year;
- In 2005, wastewater treatment emissions were estimated using population-based data. Site-specific data were used where applicable in 2012, 2015, 2018, and 2020;
- Inventory-year specific T&D loss rates are used;
- Biogenic emissions are calculated for all inventory years;
- The 2020 inventory year utilizes eGRID 2020, which is the most up-to-date eGRID data available; and

[5] UNFCCC Secretariat, 2014. Report of the Conference of the Parties on its nineteenth session, held in Warsaw from 11 to 23 November 2013. Decision 24/CP.19, paragraph 2. URL: http://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf.

- The 2020 GHG emissions inventory includes emissions from the 27th Avenue Compost Facility.

3.4.1 Estimating Tailpipe Emissions of Methane and Nitrous Oxide

The methodology used to estimate tailpipe methane (CH_4) and nitrous oxide (N_2O) emissions changed between the 2005 and 2015 GHG emissions inventories. In 2005, the Clean Air-Cool Planet's GHG modeling software was used to estimate fleet emissions of CH_4 and N_2O. The 2020 inventory uses the Climate Registry's simple estimation method for tailpipe CH_4 and N_2O emissions based upon fuel carbon dioxide content, providing a standard estimation of these emissions across fuel and vehicle types. Using this method, CH_4 and N_2O emissions factors were developed for the previous inventories using the EPA *Inventory of U.S. Greenhouse Gas Emissions and Sinks*[6]*.* This method avoids the need to track vehicle mileage.

3.4.2 2005 Wastewater Treatment Methane and Nitrous Oxide Emissions

Wastewater treatment CH_4 and N_2O emissions for 2005 were obtained from the *City of Phoenix 2015 Greenhouse Gas Emissions Inventory for Government Operations.* Please refer to that report for an explanation for the backcasting methodology to estimate 2005 emissions levels.

3.4.3 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 commuting throughout the work week. Alternative fuel combustion data were obtained Energy Information Administration (EIA) *Annual Energy Outlook* to estimate alternative fuel employee commuting. It was assumed that national alternative fuel combustion levels provided a proxy for alternative fuel combustion patterns for City employees[7].

3.4.4 Estimating Compost Emissions

In 2017, the City began operating the 27th Avenue Compost Facility. While a compost operation did exist within City boundaries prior to 2018, this facility was neither owned nor operated by the City. GHG emissions from composting were calculated according to EPA methodology for estimating national-level emissions from composting in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019*[8]*.*

[6] U.S. EPA (2019). Inventory of U.S. Greenhouse Gas Emissions and Sinks. URL: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks 2.
[7] U.S. Energy Information Administration (2013). Annual Energy Outlook. URL: https://www.eia.gov/outlooks/aeo/
[8] U.S. EPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017. URL: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2017

3.4.5 Estimating Aviation GHG Emissions for 2020

The 2018 levels Jet Fuel A and Aviation Gasoline consumption for Police Department Aircraft were assumed for 2020. This assumption was made due to incomplete reporting, which showed the reduction of fuel consumption by multiple orders of magnitude, related to the consumption of these fuels. If the reported 2020 data are proven to be correct, these emissions will be revised in a future GHG emissions inventory.

4 Results

4.1 Summary

2020 Overall Findings

GHG emissions from City of Phoenix government operations have decreased 25.2% below 2005 levels.

Emissions Sources*

- Buildings and Facilities** — 129,264 MT CO_2e
- City Vehicle Fleet — 144,734 MT CO_2e
- Employee Commute — 20,799 MT CO_2e
- Solid Waste — 116,884 MT CO_2e
- Water Services — 115,447 MT CO_2e

*Above GHG emissions represent all emissions within a sector across all emissions scopes but excludes Transmission and Distribution Loss in the regional electricity grid, which was 8,458 MT CO_2e in 2020.
** Excludes Water Services.

4.1.1 2005 to 2020: What has Changed?

The 2020 GHG emissions inventory of City operations is an additional data point in support of the City's 15-year track record of reducing GHG emissions (Figure 3). Numerous projects and activities undertaken by the City since 2005 have significantly reduced the GHG intensity of City operations. Projects and activities, and how they have affected the 2020 City government operations GHG emissions, are listed below.

- The installation of advanced methane capture systems at landfills reduced fugitive methane emissions from City landfills.
- Transitioning City Fleet to B20 and CNG from diesel has reduced the GHG intensity of Public Works activities.
- Public Transit has transitioned all its diesel consumption to B20 and increased use of LNG, reducing GHG intensity, while fuel consumption has increased since 2015 in order to meet T2050 goals.
- Energy efficiency upgrades to buildings, facilities, streetlights, traffic signals, water treatment and distribution, and wastewater treatment have reduced 2020 electricity consumption 8% below 2005 and 4% below 2015 levels.

- The 27th Avenue Compost Facility diverts material from the SR-85 landfill, reducing landfill GHG emissions while producing an environmentally beneficial commercial product.

Beyond projects and activities undertaken by the City, the GHG intensity of the regional electricity grid – the Arizona-New Mexico (AZNM) eGRID subregion – has fallen 35.4% over the last fifteen years. The 2019 retirement of the Navajo Generation Station, among other factors, reduced the GHG intensity of the regional electricity grid by 11.2% between 2018 and 2020.The planned retirement of additional regional coal power plants over the next decade will further reduce the GHG intensity of the regional electricity grid.

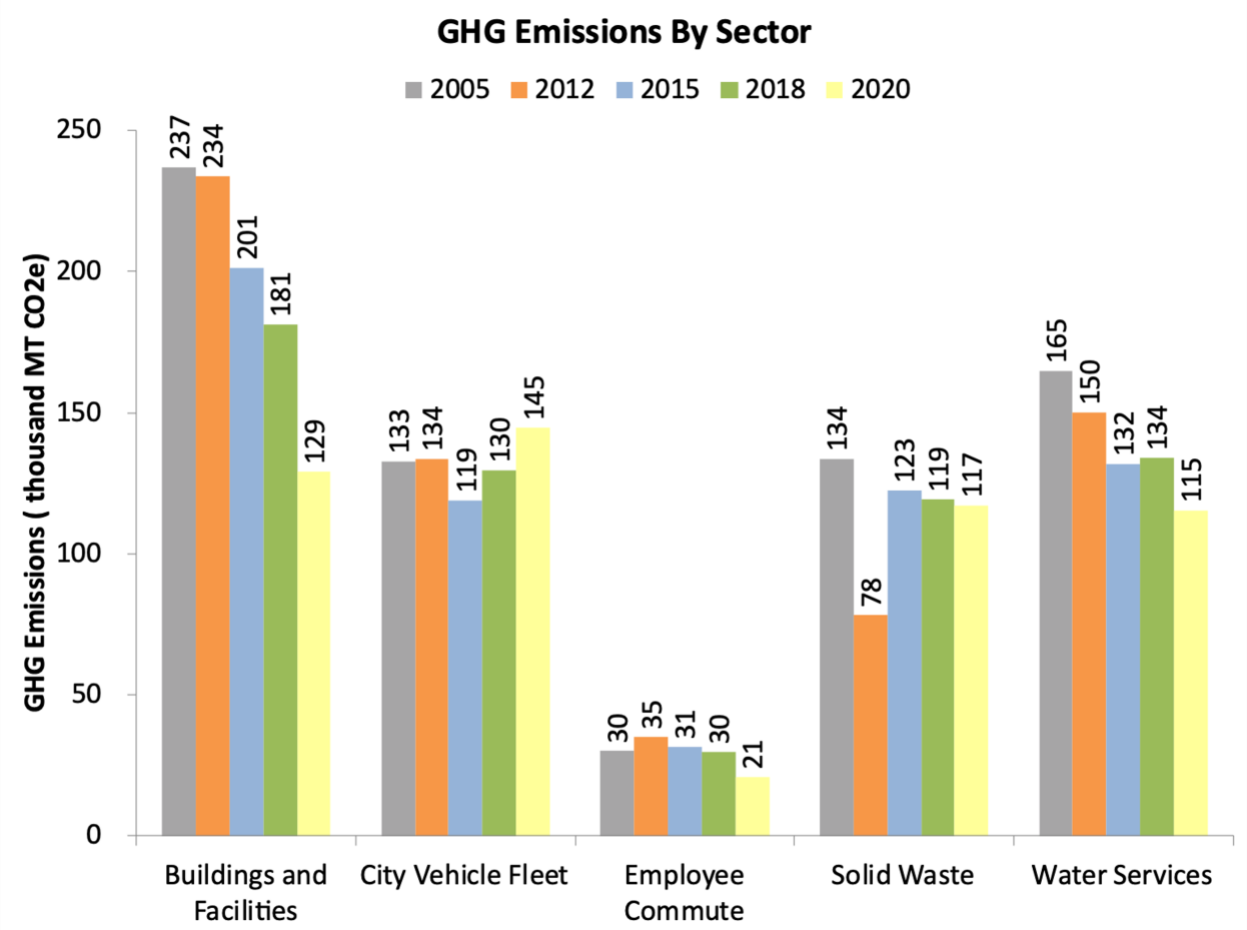


Figure 3. GHG Emissions by City Sector

Between 2005 and 2020, the City's population increased by 22% from 1,377,980[9] to 1,680,992[10] residents. While some government operations are population dependent – e.g., solid waste generation and water distribution and wastewater treatment – the City's GHG emissions are largely electricity-dependent. The significant decarbonization of the regional electricity grid has effectively decoupled population growth from GHG emissions from City government operations. Had the regional electricity grid not decarbonized, GHG emissions from City operations would have decreased by only 7.0% between 2005 and 2020. Instead, GHG emissions decreased by over 25%.

4.1.2 Emissions Sources and Distribution

City government operations GHG emissions are largely attributed to four sectors: Buildings and Facilities, Vehicle Fleet, Water Services, and Fugitive and Process Emissions. Figure 4 provides an overview of the relative magnitude of GHG emissions by Scope and Subsector.

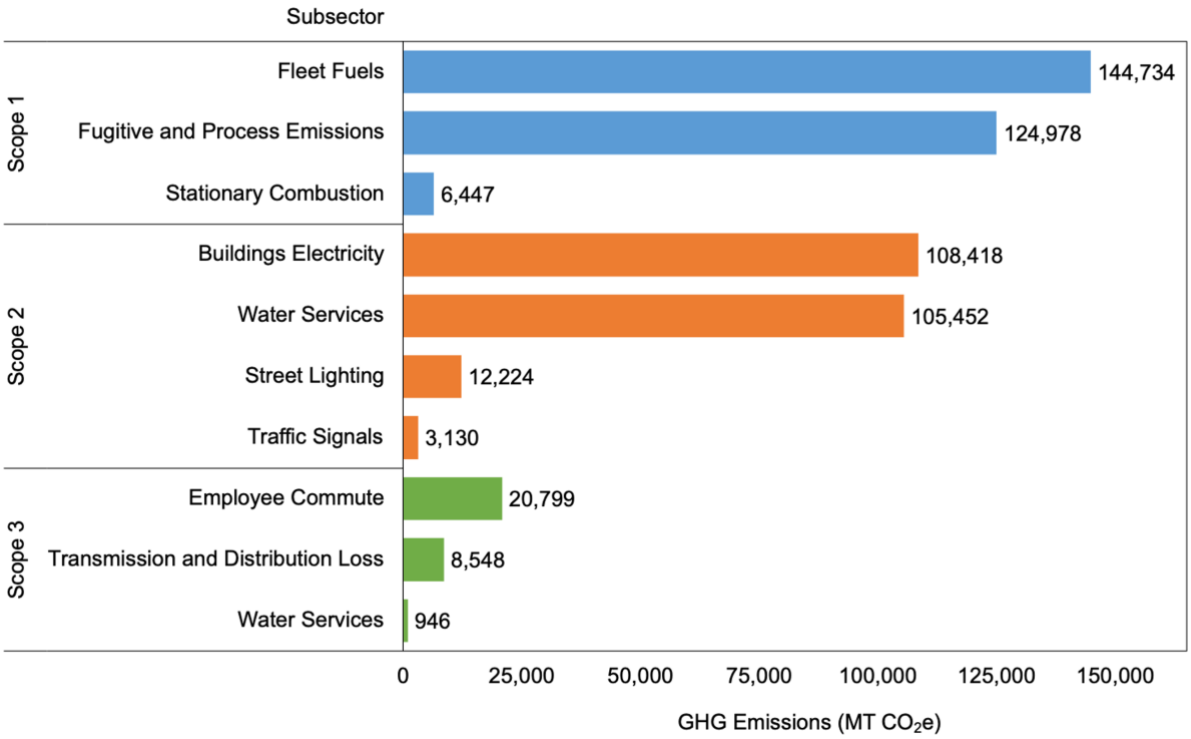


Figure 4. Total Emissions by Scope and Subsector

[9] U.S. Census Bureau (2005). American Community Survey. URL: https://factfinder.census.gov/bkmk/table/1.0/en/ACS/05_EST/S0101/1600000US0455000
[10] U.S. Census (2022). City and Town Population Totals: 2010-2019. URL: https://www.census.gov/data/tables/time-series/demo/popest/2010s-total-cities-and-towns.html

Scope 1 and Scope 2 GHG emissions account for 94% of GHG emissions from City government operations. Scope 1 emissions account for more than 50% of City government operations GHG emissions (Figure 5) and, more specifically, Fleet Fuels and Fugitive and Process Emissions represents 27.0% and 23.3% of total GHG emissions, respectively. Scope 2 GHG emissions from Buildings Electricity and Water Services each account for approximately 20% of total GHG emissions. Combined, these four sectors comprise over 90% of GHG emissions from City government operations. As the regional electricity grid becomes less GHG-intensive, Scope 2 GHG emissions will comprise a smaller proportion of the City government operations GHG emissions inventory.

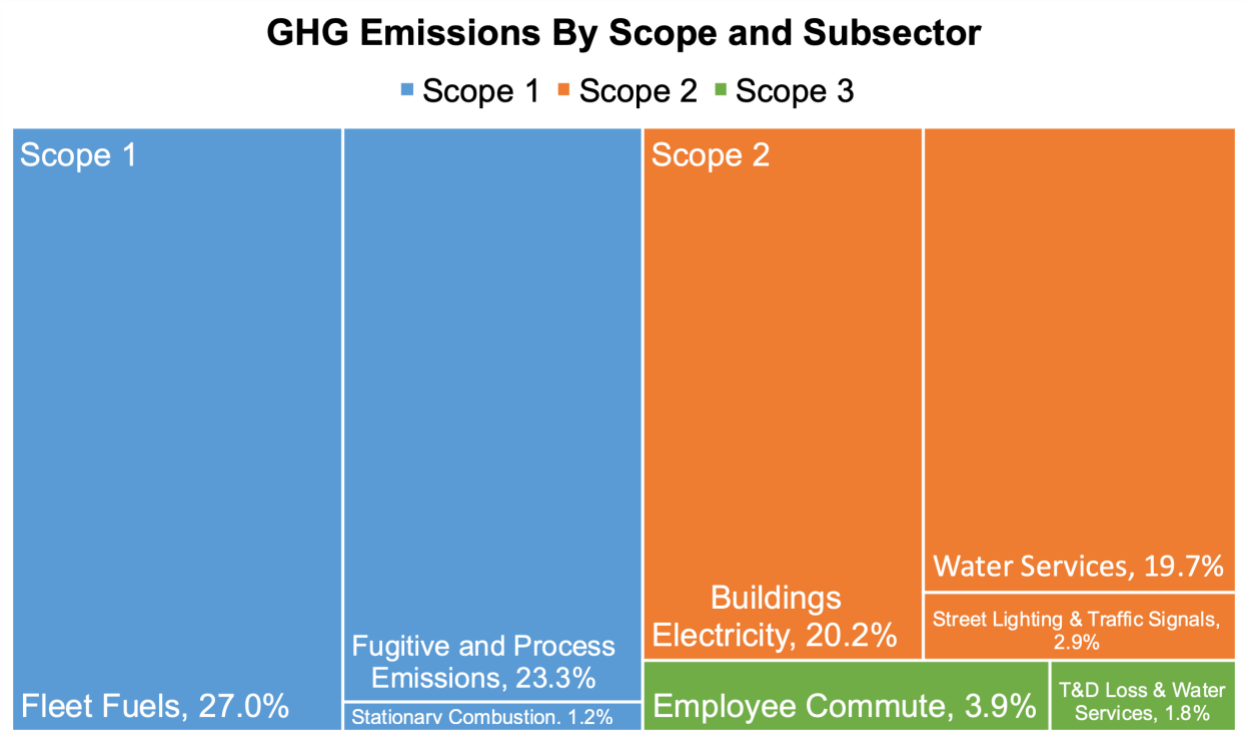


Figure 5. Percent of Total Emissions by Scope and Subsector

4.1.3 GHG Emissions Reductions Since 2005

Each GHG emissions subsectors have decreased emissions since 2005, except Fleet Fuels, which increased due to increased service needs (Figure 6).

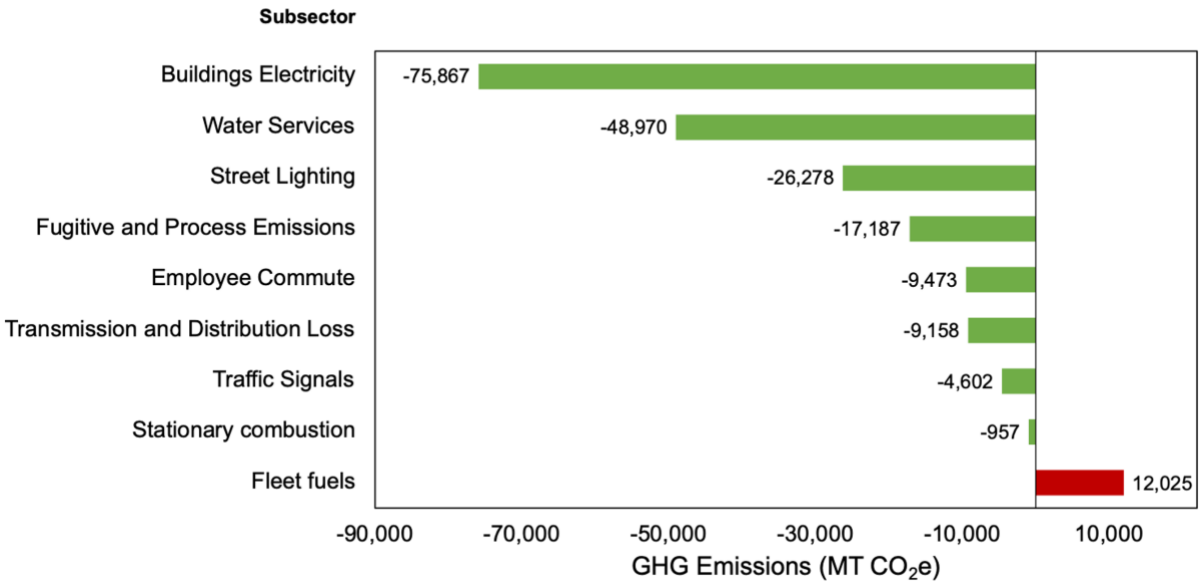


Figure 6. Emissions Changes between 2005 and 2020.

The Buildings Electricity and Water Services subsectors and have had the largest observed decreases in GHG emissions between 2005 and 2020; GHG emissions from Buildings Electricity fell by 41% and Water Services by 32%. The observed GHG emissions reductions in these subsectors were driven by several factors. First, the regional electricity grid became less GHG intensive. A less GHG intensive regional electricity grid has led to the reduction of 156,664 MT CO_2e below 2005 levels. Finally, energy efficiency projects have led to GHG emissions reductions, but exact emissions reductions are difficult to quantify.

Additional factors that contribute to the observed GHG emissions reduction include:

- Decreased emissions from closed City landfills;
- Capturing generated biogas at the 91st Avenue Wastewater Treatment Plant;
- A change in commuting patterns (increased teleworking) compared to previous inventory years.

5 Findings by Sector for 2020

5.1 Buildings and Facilities

Building and Facilities Findings

Total Emissions: 235,671 MT CO_2e
44.0% of government operations emissions
40.1% decrease from 2005 levels

Emissions Sources

- Building Electricity Consumption
- Building Natural Gas Consumption
- Streetlights Electricity Consumption
- Traffic Signals Electricity Consumption
- Water Services Electricity and Natural Gas Consumption*

City Action Highlights

- To date, the City has installed:
  - 94,875 LED Street Lights
  - 63,324 LED Signal Indications
  - 9,320 LED Pedestrian Indications

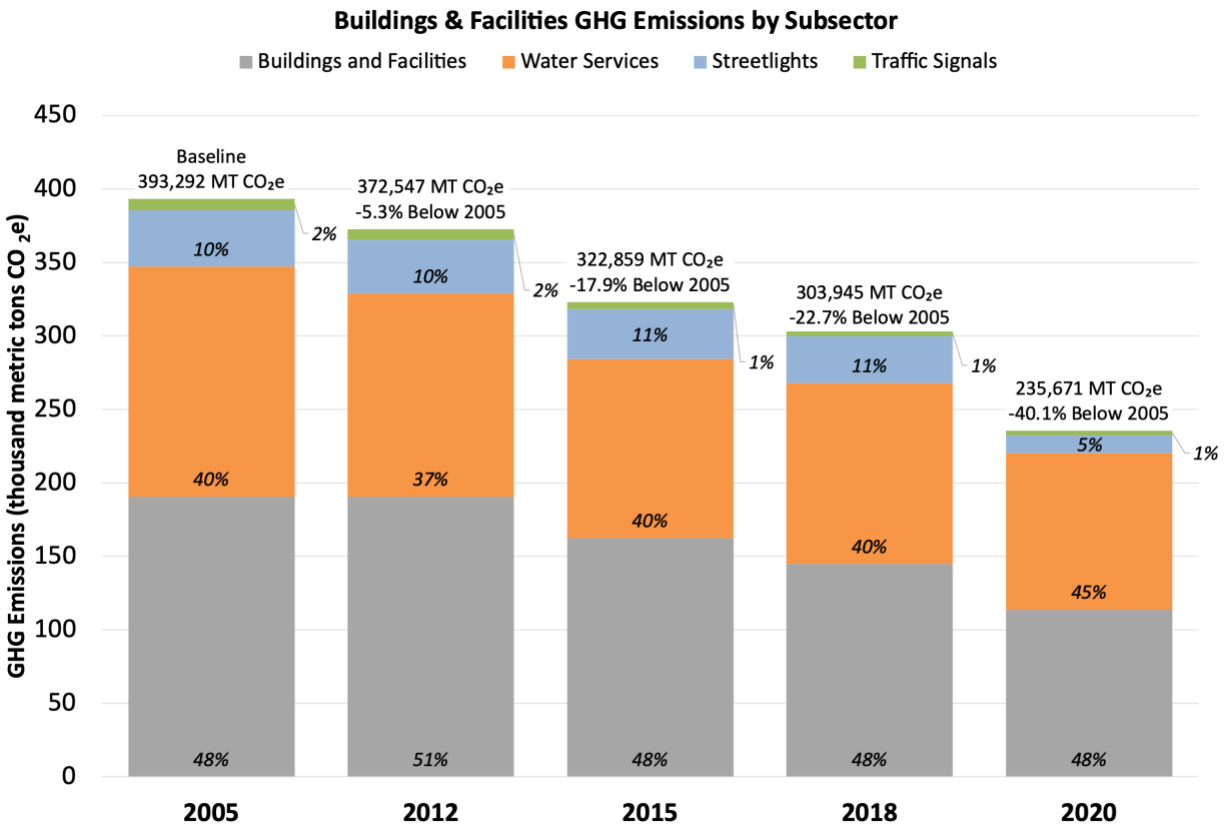
*Water Services electricity and natural gas consumption are included because this section describes trends for all electricity and natural gas consumption.

5.1.1 2005 to 2020: What has Changed?

- Between 2005 and 2020, the GHG emissions intensity of the AZNM subregion of the U.S. electricity grid fell by 35%.

5.1.2 Emissions Sources and Distribution

GHG emissions in the Buildings and Facilities sector occur directly from the combustion of natural gas purchased from a natural gas utility and indirectly from the purchase of electricity (Figure 7).



*Percentages may not add to 100% due to rounding.

Figure 7. Buildings and Facilities GHG Emissions Between 2005 and 2020

GHG emissions from natural gas combustion fell by 14% between 2005 and 2020 and 4.9% between 2018 and 2020. Additionally, GHG purchased electricity emissions decreased 40.6% below 2005 levels and 27.6% below 2018 levels. Table 2 shows 2020 summary data. The steep decline in Buildings and Facilities GHG emissions is primarily due to a significant reduction in the GHG intensity of the regional electricity grid. City efforts to build and purchase solar power are located Appendix C. Further development of the city's renewable energy portfolio is necessary to continue to decrease emissions from Buildings and Facilities.

Streetlights electricity consumption peaked in 2015 at 71,316,538 kWh and has since fallen 46% to 31,705,340 kWh. In 2020, Traffic Signals electricity consumption was 27% lower than reported consumption in 2005 and 7% lower than 2018. The decrease in electricity consumption has occurred over a period during which the City has invested heavily in LED retrofits of Streetlights and Traffics Signals. Energy efficiency upgrades, along with a less GHG intensive electricity grid, have reduced GHG emissions from traffic signals and streetlights by 62%.

Table 2. 2020 Buildings and Facilities Emissions by Subsector

Subsector	Electricity Consumption (kWh)	Natural Gas Consumption (therms)	GHG Emissions (MT CO_2e)
Buildings and Facilities	281,207,257	1,033,173	113,910
Street Lighting	31,705,340	--	12,224
Traffic Signals	8,119,517	--	3,130
Water Services	273,513,529	179,591	106,407
Total	**594,545,642**	**1,212,764**	**235,671**

5.1.3 GHG Metrics: Buildings and Facilities

Table 3 provides a list GHG metrics for City buildings and facilities.

Table 3. Buildings and Facilities Emissions Indicators

Indicator	2005	2012	2015	2018	2020
Building Space (sq. ft.)	25,948,884	30,624,893	12,599,324	11,495,864	15,047,461
Building Space GHG Emissions Intensity (kg CO_2e per sq. ft)	7.35	6.22	12.89	12.62	7.57
Per Capita GHG Emissions Intensity (kg CO_2e per resident)	138.4	127.1	100.7	87.7	67.8
Electricity GHG Emissions per CDD (kg CO_2e per CDD)	39.1	36.3	30.9	28.3	19.3
FTE GHG Emissions Intensity (kg CO_2e per FTE)	13.00	12.64	11.08	9.92	9.92

5.2 City Vehicle Fleet

City Vehicle Fleet Findings

Total Emissions: 144,734 MT CO_2e
27% of government operations emissions
9.1% increase from 2005 levels

Emissions Sources

- Gasoline
- Diesel
- Compressed Natural Gas (CNG)
- Biodiesel
- Liquefied Natural Gas (LNG)
- 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
- Adoption of CNG in Public Transit

5.2.1 2005 to 2020: What has Changed?

- The size of Public Works fleet peaked in 2015 with 7,389 vehicles and has since dropped to 7,340 vehicles.
- Public Works and Aviation have converted the majority of the diesel vehicle fleet to B20 and CNG. However, Ultra Low Sulfur diesel fuel continues to be used in specific situations, such as emergency generators and fueling sites with low throughput. Aviation has plans to convert to electric-powered ground equipment.
- The completion of the PHX SkyTrain in 2021 will decrease emissions as the CNG-powered passenger fleet is used less frequently.
- GHG emissions from B20 and CNG have increased since 2018 due to added service miles as part of the City's Transportation 2050 (T2050) Plan to increase local bus frequency, build out the existing city bus network, increase service hours of bus operations, and introduce new bus routes.

5.2.2 Emissions Sources and Distribution

CNG, gasoline, B20 vehicles were the largest source Vehicle Fleet GHG emissions in 2020, respectively. CNG and B20 consumption has increased as diesel consumption has decreased; 2020 diesel consumption was 41% of the 2005 levels. However, diesel consumption has increased since 2015 due to an increase in public transit service miles to meet T2050 goals. GHG emissions from gasoline and E85 ethanol has remained largely flat since 2012. Jet Fuel A and Aviation GHG emissions Gasoline, a small percentage of Vehicle Fleet emissions, have also remained flat. Jet Fuel A and Aviation Gas consumption levels were carried over from the 2018 inventory to account for incomplete reporting. Figure 8 shows Vehicle Fleet GHG emissions by fuel type. Only the fossil fuel component of biofuel GHG emissions – 80% of each gallon of B20 and 15% of each gallon of E85 ethanol – is counted towards the GHG emissions.

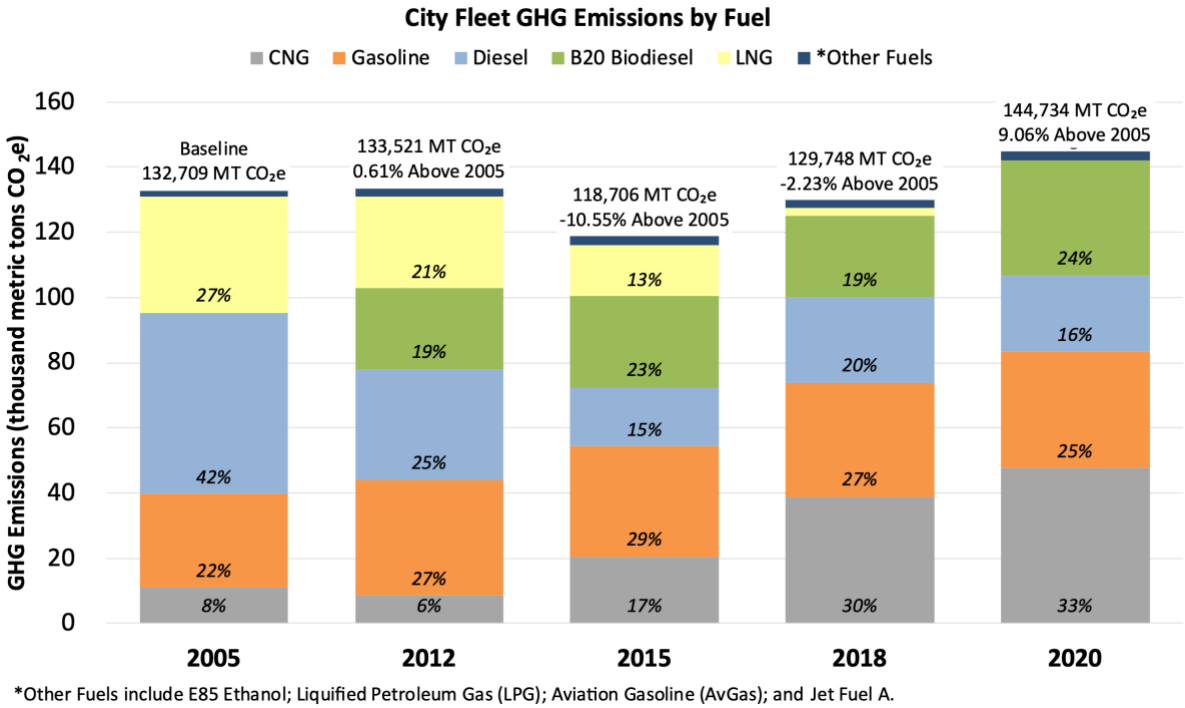


Figure 8. Vehicle Fleet Emissions by Fuel Between 2005 and 2020

Table 4 shows fuel consumption levels by fuel type and inventory year. The major changes to the levels of CNG, B20, and LNG fuel consumption is driven by Public Transit vehicle fleet and service levels. The City began replacing LNG buses with more efficient CNG busses in 2013; all LNG buses are retired. The LNG that is used by the Public Transit vehicle fleet is converted to CNG. No other major changes in fuel consumption were observed between 2015 and 2020.

Table 4. City Fleet Fuel Consumption By Type By Year

Fuel Type	Unit	2005	2012	2015	2018	2020
Gasoline	gallon	3,172,441	3,976,124	3,813,990	3,936,224	4,064,327
Diesel	gallon	5,452,613	3,324,829	1,777,341	2,579,301	2,282,301
B20	gallon	0	3,034,345	3,394,710	3,027,969	4,309,358
Compressed Natural Gas (CNG)	GGE*	1,744,813	1,349,993	3,239,129	6,151,022	7,555,353
Liquefied Natural Gas (LNG)	gallon	7,917,008	6,222,272	3,528,633	543,296	38,866
E85 Ethanol	gallon	0	287,438	340,753	311,460	335,145
Liquified Petroleum Gas (LPG)^	gallon	14,392	0	0	0	0
Aviation Gasoline (AvGas) ^	gallon	2,401	5,975	4,961	4,875	4,875
Jet Fuel A^	gallon	163,160	222,283	202,119	192,739	192,739

* GGE – Gasoline Gallon Equivalent
^ Jet Fuel A and Aviation Gas consumption levels were carried over from the 2018 inventory to account for incomplete reporting

5.2.3 GHG Metrics: Vehicle Fleet

Emissions per vehicle maintained by Public Works fell from approximately 9.2 to 6.7 MT CO_2e per vehicle, despite an increase to the number of vehicles (Table 5). The data shown in Table 5 are for Public Works vehicles only.

Table 5. City Fleet Indicators Change

Indicator	2005	2012	2015	2018	2020
Number of Vehicles	6,090	7,387	7,389	7,340	7,548
MT CO_2e per Vehicle	9.2	7.1	6.6	6.7	6.3

5.3 Water Services

Water Services Findings

Total Emissions: 115,447 MT CO_2e
21.6% of government operations emissions
25% decrease from 2005 levels

Emissions Sources

- Water distribution stationary & process emissions
- 23rd Avenue and 91st Avenue wastewater treatment plants stationary & process emissions
- Granular activated carbon (GAC) hauling and regeneration
- Electricity and natural gas use

City Action Highlights

- The onsite harvesting of biogas at the 91St Avenue Wastewater Treatment plant has reduced GHG emissions from wastewater treatment.

5.3.1 2005 to 2020: What has 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 2007, the Lake Pleasant Water Treatment Plant (WTP) came online. The Verde WTP was closed in December 2011 and the lease with the Salt River Pima Maricopa Indian Community for the use of the site was extended.
- In 2018, the Water Services department treated 102.6 billion gallons of water and 41.1 billion gallons of wastewater. The volume of water treated has increased 4% since 2005 while the volume of wastewater treated has decreased 6%.
- The emissions from the hauling and regeneration of granular activated carbon (GAC) for water treatment did not occur in 2005, but have been included in the GHG inventory since 2012.

5.3.2 Emissions Sources and Distribution

GHG emissions can occur from natural gas combustion, electricity consumption, CH_4 generation during wastewater treatment, and N_2O emissions from wastewater effluent discharge. Scope 3 GHG emissions also occur during GAC filter regeneration. Between

2005 and 2020, Water Services GHG emissions have decreased 30% (Figure 9). The overwhelming majority of Water Services GHG emissions occur from electricity consumption, and benefit from the decarbonization of the regional electricity grid. Most wastewater treatment GHG emissions – methane flaring and wastewater discharge – are population-driven. Projected population increases over the next decade will potentially increase GHG emissions in this sector unless further mitigation efforts are undertaken. However, the capture and reuse of methane generated during wastewater treatment (biogas) will substantially reduce GHG emission from methane flaring.

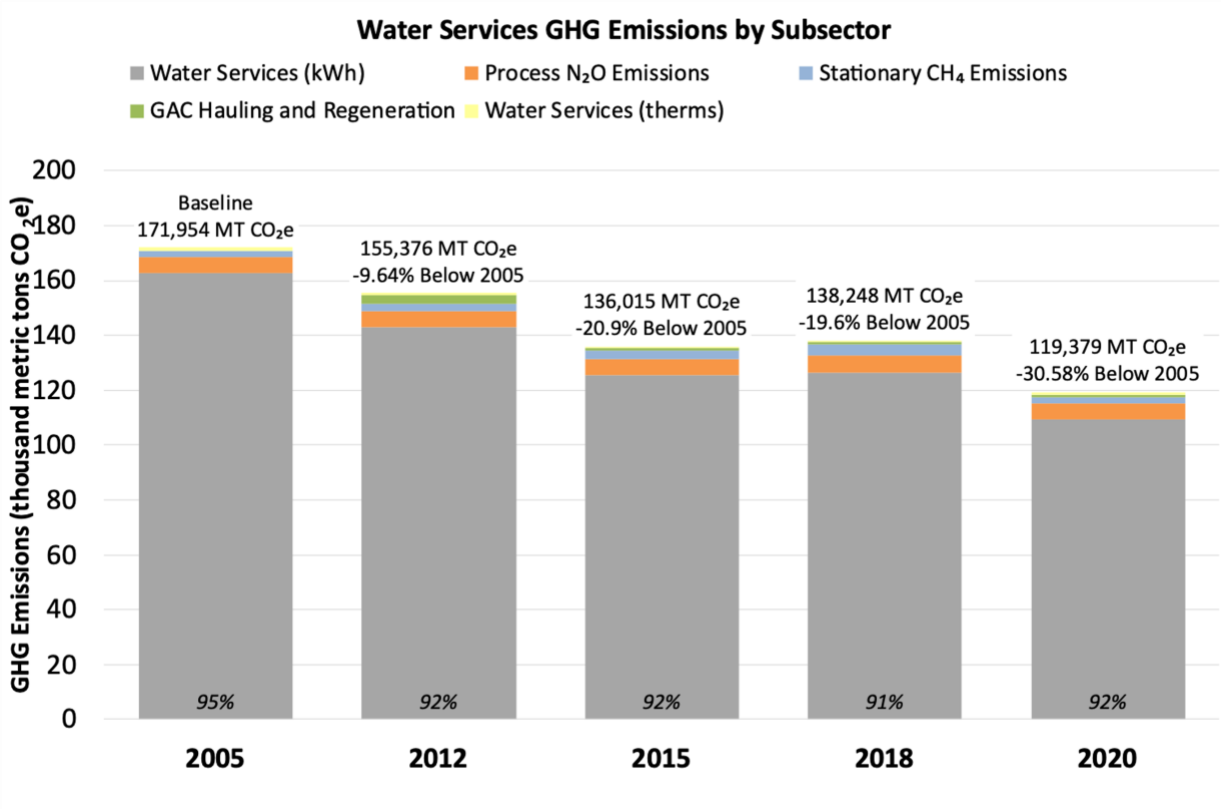


Figure 9. Water Services Emissions Changes Between 2005 and 2020

The changes in the GHG emissions observed at the 23rd Avenue and 91st Avenue WWTPs are due to a combination of population change as well as the changes in operation at the WWTPs, such as biogas capture. Wastewater treatment GHG are shown in Figure 10.

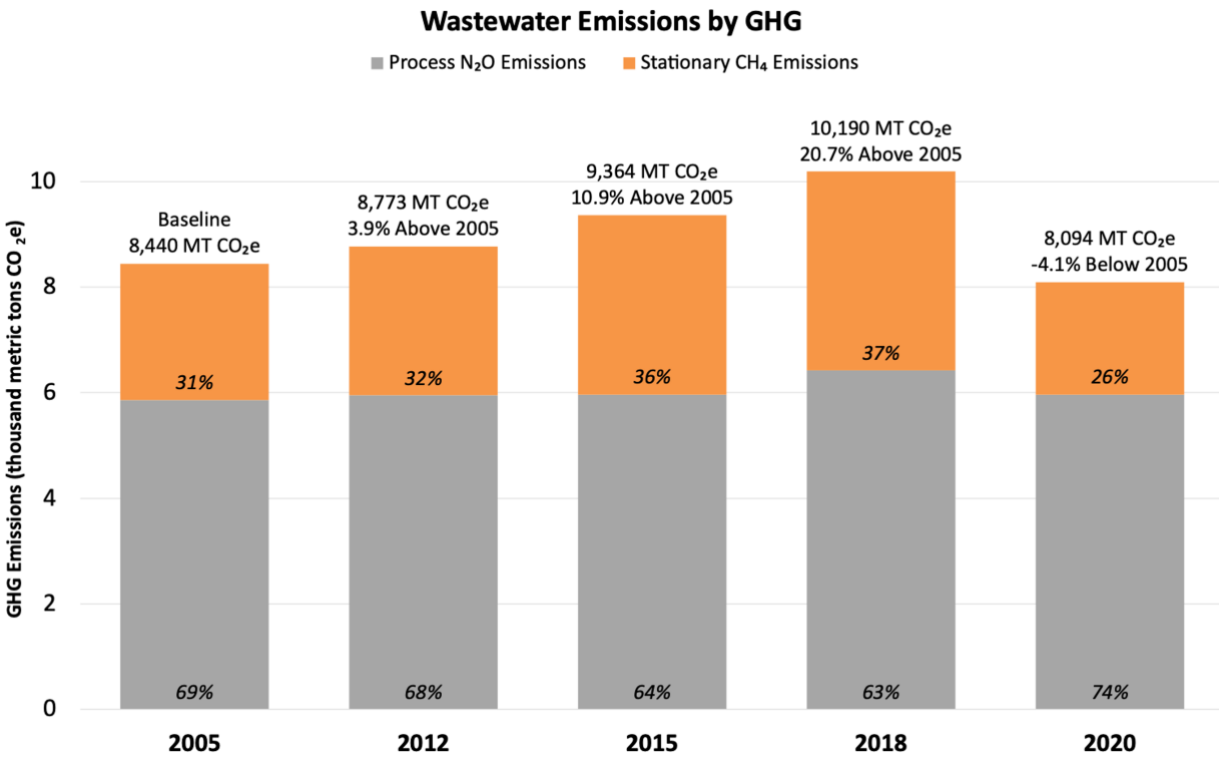


Figure 10. Wastewater Treatment GHG Emissions Between 2005 and 2020

GHG emissions at the 23rd Avenue and 91st Avenue WWTPS are shown in Table 6. During 2020, the 91st Avenue WWTP, which is the larger of the two WWTPs, emitted roughly the same amount of GHGs as the 23rd Avenue WWTP. The 91st Avenue WWTP accepts wastewater from Glendale, Mesa, Scottsdale, and Tempe. In previous inventory years, the 91st Avenue WWTP emitted more than double the 23rd Avenue WWTP. The reduction in GHG emissions at the 91s Avenue WWTP observed in 2020 occurred because of the reuse of captured methane emissions (biogas). Currently, the City accounts for all GHG emissions at the 91st Avenue WWTP because the plant is under the City's operational control.

Table 6. GHG emissions at the 23rd Avenue and 91st Avenue WWTPs

Wastewater GHG Emissions Source		Wastewater Treatment Plant		Total
		23rd Avenue	91st Avenue	
Stationary CH_4 Emissions	Incomplete Digester Gas Combustion	1,933	194	2,126
Process N_2O Emissions	Effluent Discharge	386	1,341	1,726
	Nitrification/Denitrification	1,083	3,159	4,242
Total		**3,322**	**3,402**	**4,693**

5.3.3 GHG Metrics: Water Services

Water Services indicators in Table 7 below shows that the GHG intensity of drinking water served by the City has consistently decreased since 2005.

Table 7. Water Services Emissions Indicators

Indicator	2005	2012	2015	2018	2020
Gallons of Drinking Water Treated (billion gallons)	105.9	98.9	95.4	99.2	102.6
MT CO_2e per Billion Gallons Treated	1,624	1,571	1,426	1,394	1,164
Water Treatment Plants	6	5	5	5	5
MT CO_2e per WTP	28,659	31,075	27,203	27,650	23,876
Million Gallons of Wastewater Treated	69.5	42.2	40.3	40.8	41.1
MT CO_2e per Million Gallons Wastewater Treated	2,473	3,682	3,375	3,388	2,905

5.4 Solid Waste

Solid Waste Findings

Total Emissions: 116,884 MT CO_2e
21.8% of government operations emissions
13% decrease from 2005 levels

Emissions Sources

- City landfills emitted 110,523 MT CO_2e
- The 27th Avenue Compost Facility emitted 6,360 MT CO_2e

City Action Highlights

- 27th Avenue Compost Facility will help avoid future GHG emissions

5.4.1 2005 to 2020: What has Changed?

- In 2006, the State Route 85 (SR-85) landfill was opened and features an ongoing installation of a landfill gas collection system, which includes horizontal wells that can capture gas while waste is still being placed in the landfill.
- In 2017, the City opened the 27th Avenue Compost Facility. This facility will reduce long-term GHG emissions associated with the hauling and disposal of green & organic solid waste at the SR-85 Landfill.

5.4.2 Emissions Sources and Distribution

The SR-85 landfill, which opened in 2006, is the only operational landfill managed by the City. The SR-85 landfill has an active landfill gas collection system which has a 65% collection efficiency. Collection efficiencies at City landfills ranged from 50-85%. The Del Rio Landfill is the only City landfill that does not have a landfill gas collection system. Methane emissions are expected to increase at the SR-85 landfill as it is the only active landfill in the City, while methane emissions from the other City landfills will decrease as they are now closed (Figure 11).

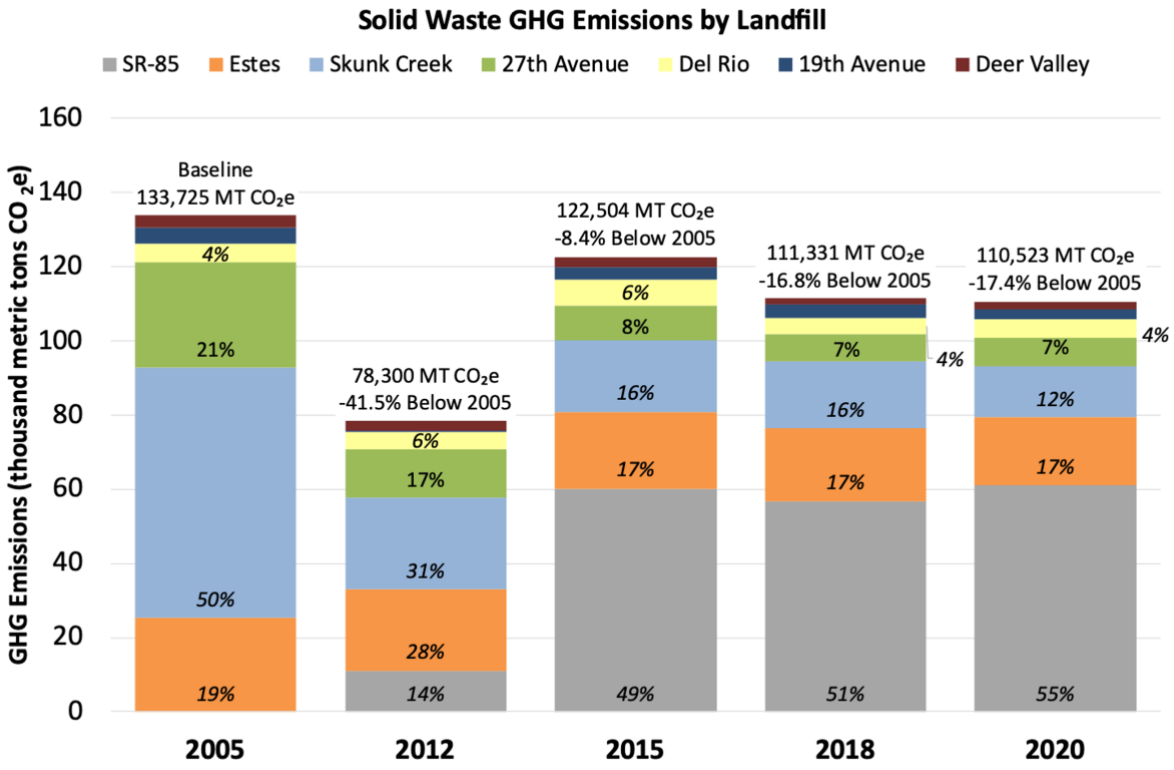


Figure 11. Phoenix Landfills Emissions Changes between 2005 and 2020

Table 8 provides an overview of the amount of methane (CH_4) collected and flared, the resulting methane released after flaring, and the MT CO_2e emissions produced from the released methane at each facility.

Table 8. 2020 Solid Waste Emissions by Landfill

Facility	2005	2012	2015	2018	2020
Skunk Creek	67,375	24,589	19,400	18,047	13,803
27th Avenue	28,476	13,013	9,257	7,403	7,643
Del Rio	4,902	4,760	6,986	4,367	4,859
Deer Valley	3,394	2,548	2,641	1,664	2,241
19th Avenue	4,377	429	3,468	3,598	2,676
Estes	25,200	21,896	20,636	19,432	18,284
SR-85	0	11,064	60,116	56,820	61,016
Total	**133,725**	**78,300**	**122,504**	**111,331**	**110,523**

Landfill GHG emissions in this report will differ from data reported to the EPA Greenhouse Gas Reporting Program. The City operations GHG emissions inventory utilizes landfill methane flaring formulas contained in the LGOP methodology, while EPA

utilizes a different methodology for both GHG emissions and estimated gas collection system capture rates. EPA specifies use of a capture rate formula which relies on cover type and area, this GHG update estimates capture rates at city landfills using operational indicators, such as status of ongoing gas well installation at SR-85, which includes horizontal wells, surface monitoring, flare data, and landfill cover maintenance.

5.4.3 27th Avenue Compost Facility

In 2017, the City opened the 27th Avenue Compost Facility. The facility processed 33,213 tons of compost in CY 2020, resulting in the emission of 133 MT CH_4 and 10 MT N_2O. Total GHG emissions from the compost facility were 6,360 MT CO_2e.

Over its lifetime, the 27th Avenue Compost Facility will have a net negative effect on GHG emissions from City government operations. Though the facility does emit GHG emissions, composting green organic solid waste will emit fewer GHG emissions than disposal at the SR-85 Landfill. Since methane is the primary GHG emitted from composting and landfilling, any GHG reduction will have a multiplier effect (Table A1). Additionally, composting at the 27th Avenue Compost Facility reduces the number of trips necessary to haul waste to the SR-85 Landfill, which in turn reduces Vehicle Fleet emissions. For these reasons, GHG emissions reductions from the 27th Avenue Compost Facility will be tangible and measurable in the future.

5.4.4 GHG Metrics: Solid Waste

Table 9 shows Solid Waste sector GHG indicators for the City.

Table 9. GHG Emissions Indicators for Solid Waste

Indicator	2005	2012	2015	2018	2020
Amount of Waste in Place (short tons)	44,030,052	50,257,923	52,405,666	54,666,679	56,335,520
Kg CO_2e Per Ton of Solid Waste in Landfills	3.04	1.56	2.34	2.19	2.07
Compost Processed (short tons)	—	—	—	46,768	33,213

5.5 Employee Commute

Employee Commute Findings

Total Emissions: 20,799 MT CO_2e
3.9% of government operations emissions
31.3% decrease from 2005 levels

Emissions Sources

- Gasoline
- Compressed Natural Gas (CNG)
- Electric and Hybrid Electric Vehicles
- Liquefied Petroleum Gas (LPG)
- Ethanol – E85

City Action Highlights

- Construction of light rail
- Employee Rideshare Program

5.5.1 2005 to 2020: What has Changed?

- City employees fill out surveys as part of the Trip Reduction Program (TRP) overseen by Maricopa County Air Quality Department.
- Employee commuting from 2005 did not include miles by bus or light rail as this data was not available. Bus and light rail commuting data were available for the previous GHG emissions inventories.
- Employee commuting using city vehicles is counted in the City Vehicle Fleet sector to avoid double counting.
- The ongoing SARS-CoV2 (COVID-19) pandemic facilitated the City's development and implementation of the City's Telework Program, which reduced the 2020 Employee Commuting GHG emissions.

5.5.2 Emissions Sources and Distribution

Employee commuting GHG emissions occur from the fuel use for personal vehicles, vanpools, bus transit, and light rail is used to account for commuting emissions (Table 10). Alternative fuel use was estimated using annual transportation fuel usage data EIA Annual Energy Outlook. Emissions from bus commuting are reported in the Public Transit sector. Instances of employees commuting in city vehicles are counted as City Vehicle Fleet emissions. The employee commuting data show that there was an increase in hybrid-electric and plug-in electric vehicle employee commuting miles.

Table 10. Employee Commute Emissions by Fuel Type/Mode

Year	Commuting Miles	GHG Emissions (MT CO_2e)
2005	84,325,745	30,272
2012	99,937,270	35,042
2015	88,496,426	31,350
2018	87,386,610	29,518
2020	60,556,831	20,799

5.5.3 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, flex-work schedules, bicycle facilities and other incentives. However, given the structure of the current commuting data it is difficult to estimate GHG emissions from commuting alternatives. Nonetheless, the City can encourage employees to seek alternative modes of travel to commute to work. In addition, unnecessary travel should be avoided, when possible, potentially by increasing telecommuting opportunities.

6 City of Phoenix GHG Metrics

Table 11 details GHG Indicators for City of Phoenix government operations.

Table 11. Internal Government operations Indicators

Government Operations Indicators	2005	2012	2015	2018	2020	Unit
Population	1,377,980	1,473,405	1,537,058	1,660,272	1,680,992	People
Employees	14,667	12,849	14,664	14,615	14,261	Employees
Building Area	25,948,884	30,624,893	12,599,324	11,495,864	15,047,761	Sq. ft.
Cooling Degree Day (CDD)	4,709	5,065	5,065	4,943	5,618	CDD
Building Area GHG Intensity	7.35	6.22	12.89	12.62	7.57	kg CO_2e per sq. ft
Per Capita GHG Intensity	138.4	129.3	105.7	87.4	67.8	kg CO_2e per resident
CDD Electricity GHG Intensity	39.1	36.3	30.9	28.3	19.3	kg CO_2e per CDD
FTE GHG Intensity	13.00	12.64	11.08	9.92	9.92	kg CO_2e per FTE
Drinking Water Treated	105.9	98.9	95.4	99.2	102.6	billion gallons
Drinking Water GHG Intensity	1,624	1,571	1,426	1,394	1,164	MT CO_2e per billion gallons
Water Treatment Plants (WTP)	6	5	5	5	5	number
WTP GHG Intensity	28,659	31,075	27,203	27,650	23,876	MT CO_2e per WTP
Wastewater Treated	69.5	42.2	40.3	40.8	41.1	million gallons
Wastewater GHG Intensity	2,473	3,682	3,375	3,388	2,905	MT CO_2e per million gallons
Solid Waste in Place (WIP)	44,030,052	50,257,923	52,405,666	54,666,679	56,335,520	tons
Solid Waste GHG Intensity	3.04	1.56	2.34	2.19	2.07	kg CO_2e per Ton WIP
Fleet Size	6,090	7,387	7,389	7,340	7,548	Number of Vehicles
Fleet Vehicle GHG Intensity	9.2	7.1	6.6	6.7	6.3	MT CO_2e per Fleet Vehicle
Vehicle Miles Traveled (VMT)	52,825,683	48,022,781	—	35,990,125	29,238,298	VMT
VMT GHG Intensity	1.06	1.09	—	1.36	1.62	kg CO_2e per VMT
Gasoline Consumption	3,172,441	3,976,124	3,813,990	3,936,224	4,064,327	gallons
Diesel Consumption	5,452,613	3,324,829	1,777,341	2,579,301	2,282,301	gallons
Diesel + B20 Consumption	5,452,613	6,359,174	5,172,051	5,607,270	6,591,659	gallons
CNG Consumption	1,744,813	1,349,993	3,239,129	6,151,022	7,555,353	GGE
Commuting Gasoline Miles Traveled	80,555,678	93,917,068	83,504,307	82,130,508	57,275,929	miles
Commuting Gasoline Miles Per Employee	5,576	7,167	5,711	5,772	4,045	mile per FTE
% Single Occupancy Vehicle	73.8%	74.1%	75.8%	72.1%	67.88%	%
Alternative Fuel Vehicle Miles	891,044	1,140,705	1,402,897	3,354,038	3,013,192	mile

Appendix A: Greenhouse Gas Equivalents

Table A1. IPCC AR2, AR4, and AR5 Global Warming Potential (GWP) Values

Greenhouse Gas*	AR2 GWP Values[1]	AR4 GWP Values[2]	AR5 GWP Values[3]
Carbon Dioxide (CO_2)	1	1	1
Methane (CH_4)	21	25	28
Nitrous Oxide (N_2O)	310	298	265

*Only carbon dioxide, methane and nitrous oxide were included in the 2005 and 2015 inventories

[1]GWP values used in the previous City of Phoenix 2005 and 2012 local government operations GHG emissions inventories.

[2]GWP values used in the City of Phoenix 2015 local government operations GHG emissions inventories.

[3]GWP values used in *2018 and 2020 City of Phoenix GHG Emissions from Government Operations*.

Appendix B: City of Phoenix's Government Operations Boundary

Wastewater Facilities

For the 2012 government operations GHG emissions inventory, the City considered whether the 91st Avenue wastewater treatment plant (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 the City 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 has continued in the current GHG emissions inventory of government operations.

Solid Waste Facilities

The 2020 inventory includes estimated emissions from the 27th Avenue Compost Facility. As this facility was opened in 2017, the 2018 inventory is the first inventory where city-owned compost operations are included.

Biogenic CO_2 Emissions

Biogenic CO_2 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. According to LGOP, biogenic CO_2 emissions do not add carbon into the atmosphere as these sources of CO_2 are part of the natural carbon cycle and do not count toward local government operations GHG emissions total. The City can shift fossil CO_2 emissions to biogenic CO_2 emissions through the continued conversion of diesel fleet vehicles to biodiesel blends in addition to the development of biomass-based sources of electricity.

Leased Facilities

The City 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. The City 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.

Scope 3 Emissions

The City has chosen to report Employee Commute and GAC hauling and regeneration emissions because it does not maintain direct operational control and therefore is not required to report these 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 are explained below). It also chose to report emissions from outsourced GAC hauling and regeneration as Scope 3 emissions in the Water Services sector because the city holds financial control and considers it an area over which it has influence. Both sludge and solid waste hauling were included as Scope 1 emissions as those contracts are considered more integral to government operations and control.

Appendix C: Solar Projects & Partnerships

Table C1. Completed Solar Projects and Partnerships

Solar Projects/Partnerships			
Description	**Completed**	**kW**	**Projected kWh/year**
Aviation HQ	2020	580	917,126
SRP Solar Sleeve	2020	10,700	18,350,500

Appendix D: Findings by Scope

Appendix C presents City government operations GHG emissions by GHG emissions scope (Scope). GHG emissions by Scope are shown in Figures D1 and D2.

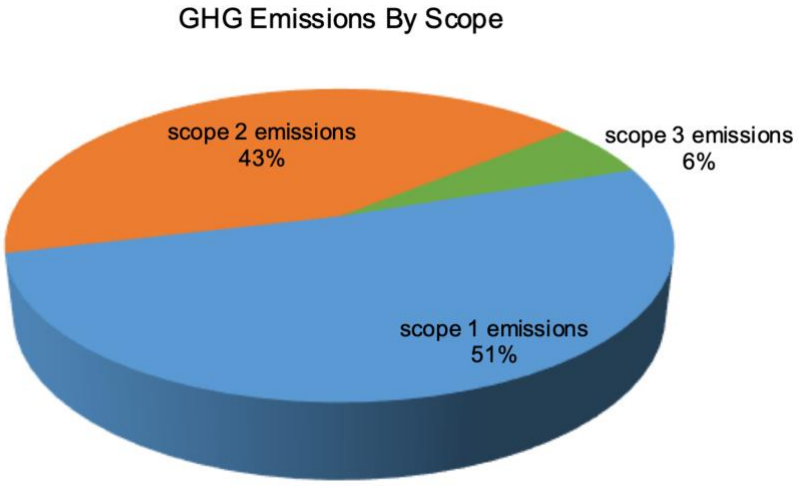


Figure D1. GHG Emissions by Scope

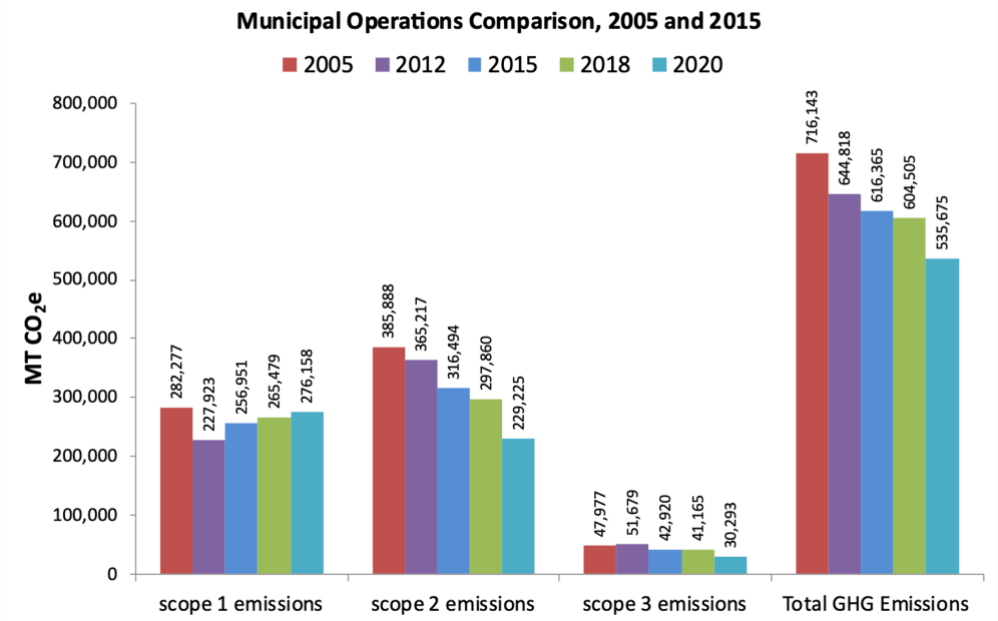


Figure D2. Government operations comparison, 2005 through 2020

Scope 1

Scope 1 emissions contribute 51% of the city's total emissions accounting for 276,158 MT CO_2e. From 2005 to 2020, Scope 1 emissions decreased 2.2%. Scope 1 is comprised of stationary combustion, fleet fuels, and fugitive and process emissions from landfills and wastewater treatment plants (Figure D3). The combustion of natural gas in buildings, and the resulting emissions, decreased 12.9% between 2005 and 2020, while natural gas combustion for water distribution treatment decreased 25%. The City's fugitive and process GHG emissions decreased 12.1% between 2005 and 2020. Fugitive methane emissions from landfills were reduced by 17%. Fugitive and process emissions from wastewater treatment decreased by 4.1% because of the capture and reuse of flared methane at the 91st Avenue WWTP. The 27th Avenue Compost Facility was a new source of fugitive and process emissions in 2018.

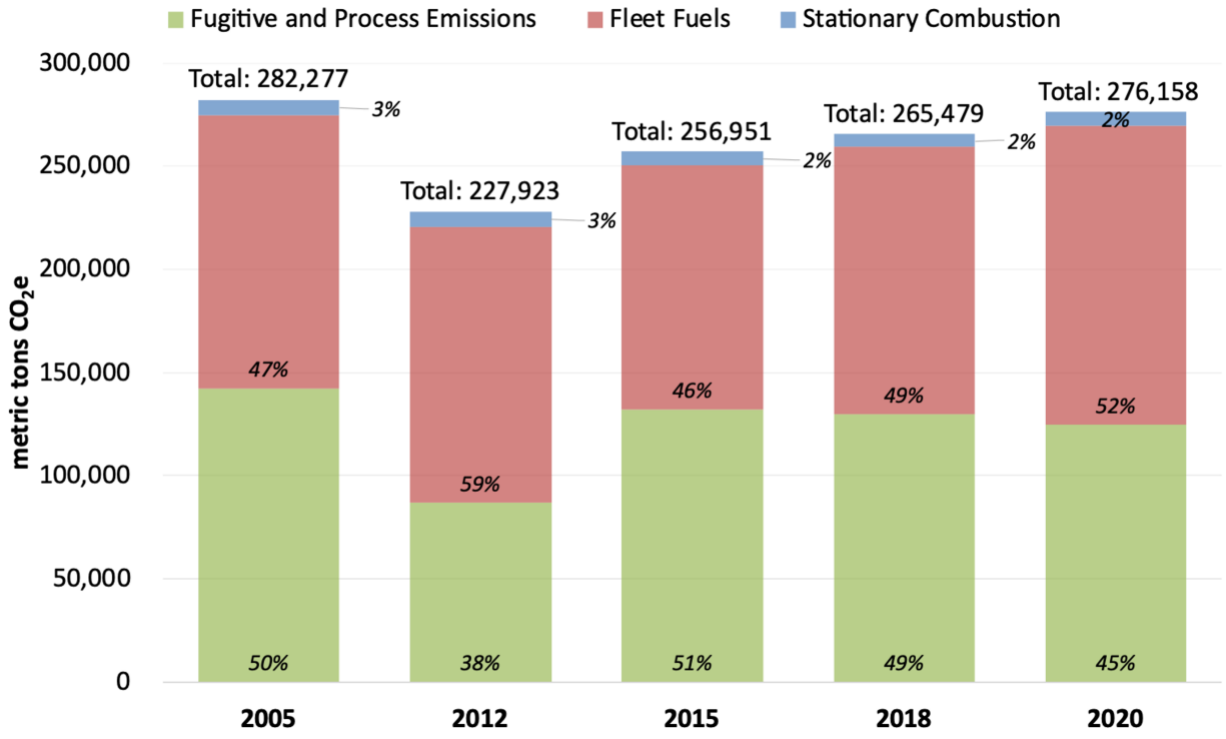


Figure D3. Breakdown of 2020 Scope 1 Emissions

The City's fuel portfolio has changed dramatically between 2005 and 2020 with the addition of B20 vehicles, CNG, and E85 flex fuel vehicles; B20 vehicles are primarily used in Public Transit. However, an increase in service miles has caused an increase in Fleet Fules (Public Transity) emissions between 2015 and 2020.

Scope 2

Scope 2 GHG emissions are indirect GHG 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. On-site generation of electricity from solar energy projects are not incorporated into the GHG inventory total and buildings may consume more electricity (both solar and grid-based generated) than what is billed (grid-based only).

Scope 2 emissions account for 43% of the City's total emissions and totaled 229,225 MT CO_2e in 2020. Between 2005 to 2020, Scope 2 GHG emissions decreased 40.6% (Figure D4) while purchased electricity decreased only 8%. Between 2005 and 2020, the carbon intensity of purchased electricity in Arizona decreased 35.4% due to increased natural gas generation and decreased coal generation in the region electricity grid in combination with increased renewable energy genration.

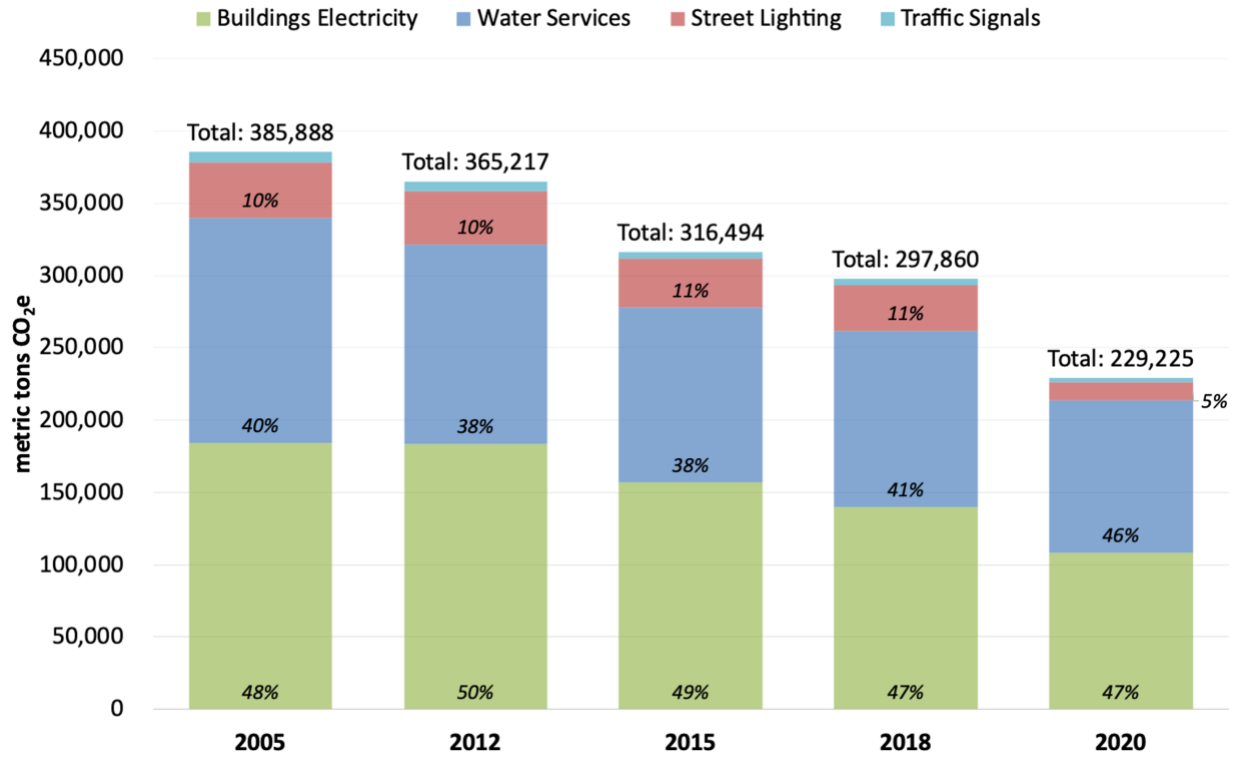


Figure D4. Breakdown of 2020 Scope 2 Emissions

Scope 3

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. The City chose to report emissions from these sectors because it has some ability to impact those activities through various policies, programs, and contracts.

Scope 3 emissions account for 6% of the City's total emissions with a total of 42,301 MT CO_2e. From 2005 to 2020, emissions from Scope 3 decreased 37%. GHG emissions from employee commuting are the largest component (69%) of Scope 3 emissions (Figure D5).

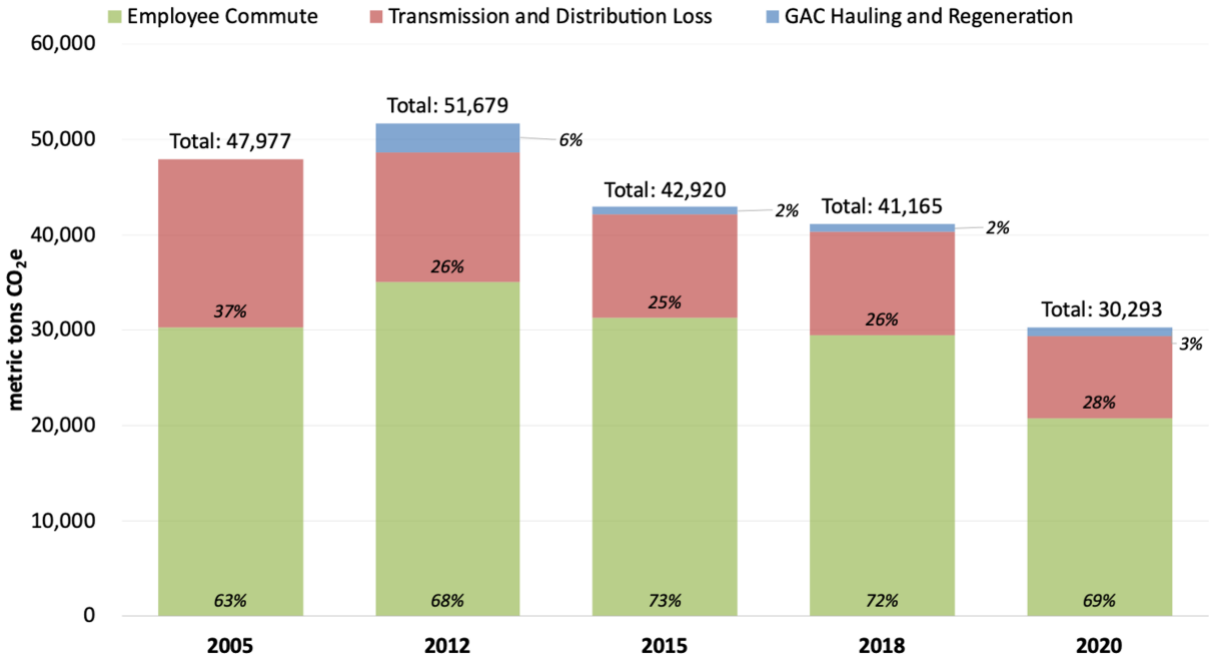


Figure D5. Breakdown of 2020 Scope 3 Emissions

Rob and Melani Walton Sustainability Solutions Service

Arizona State University

2020 Community-Scale Greenhouse Gas Emissions Inventory

A comprehensive report prepared for

City of Phoenix

May 2022

sustainabilitysolutions.asu.edu

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Finally, we would like to thank City of Phoenix employees, residents, and business owners, who are on the ground supporting the city's efforts and who are working toward reducing their own greenhouse gas emissions.

Note: The data and calculations presented in this report may not be exact due to rounding errors within the GHG emissions template.

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Acronym List

AFFA	Agriculture, Forestry, and Fishing Activities
AFOLU	Agriculture, Forestry, and Land Use
APS	Arizona Public Service
AR	IPCC Assessment Report (Numbered 2 through 5)
ASU	Arizona State University
AZNM	Arizona and New Mexico eGRID Subregion
B20 Biodiesel	Contains up to 20% biodiesel
BEV	Battery Electric Vehicle
BPEV	Batter Plugin Electric Vehicle
CH_4	Methane
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent Emissions
E54	Fuel containing 54% ethanol
E85	Fuel containing 85% ethanol
eGRID	EPA's Emissions and General Resource Integrated Database
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
FERC	Federal Energy Regulatory Commission
FTE	Full-time equivalent
GGE	Gasoline Gallon Equivalent
GHG	Greenhouse Gas
GPC	Global Protocol for Community-Scale GHG Emission Inventories
GWP	Global Warming Potential
ICLEI	International Council for Local Environmental Initiatives,
IE	Included Elsewhere
IPPU	Industrial Processes and Product Use
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MPST	Mining, Processing, Storage, and Transport of Coal
MT	Metric Tons
MWh	megawatt-hour
NAU	Northern Arizona University
NE	Not Estimated
NERC	North American Electric Reliability Corporation
NO	Not Occurring
N_2O	Nitrous Oxide
ONGS	Oil and Natural Gas Systems
PNM	Public Service Company of New Mexico
SRP	Salt River Project
T&D	Transmission & Distribution
TRP	Trip Reduction Program
WECC	Western Electricity Coordinating Council
WWT	Wastewater Treatment
WWTP	Wastewater Treatment Plant

Executive Summary

The city of Phoenix (City) has completed a community-scale greenhouse gas (GHG) emissions inventory for calendar year 2020 using the Global Protocol for Community-Scale GHG Emission Inventories (GPC). The GPC 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. The City of Phoenix is a member of both the C40 Cities Climate Leadership Group and Global Covenant of Mayors for Climate and Energy.

The GPC categorizes direct and indirect GHG emissions into three sectors: Stationary Energy, Transportation and Waste. Direct GHG emissions occur within City boundaries, while indirect GHG emissions are induced by activity within the City boundary.

- The Stationary Energy Sector includes GHG emissions that occur from energy utilized in residential buildings, commercial buildings and facilities, manufacturing industries, agriculture, forestry and fishing energy use, and electricity transmission and distribution energy losses.
- The Transportation Sector includes GHG emissions from commercial and civil aviation, on-road transportation, non-road vehicle use, freight and light rail.
- The Waste Sector includes GHG emissions from solid waste disposal, the biological treatment of waste (composting), and wastewater treatment.

The 2020 community-scale GHG inventory is the fourth completed by the City following the 2012, 2016, and 2018 community-scale GHG inventories. While each of the community-scale GHG inventories completed by the City have followed the GPC, during each inventory process the previous year(s) GHG inventory have been recalculated to reflect updates to source data, data collection and processing methods, GHG global warming potentials, and GHG emissions estimation methods. Changes to GHG emissions totals for the 2012, 2016, and 2018 calendar years are reported along with the 2020 GHG emissions totals.

Key Findings

- In 2020, community-scale GHG emissions were 15,156,347 metric tons of carbon dioxide equivalents (MT CO_2e).
- 2020 community-scale GHG emissions were 14.0% lower than the 2012 levels of 17,622,666 MT CO_2e (Figure ES-1).
- Stationary Energy Sector GHG emissions totaled 7,406,849 MT CO_2e.
- Transportation Sector GHG emissions totaled 7,461,649 MT CO_2e.
- Waste Sector GHG emissions totaled 287,850 MT CO_2e.
- GHG emissions decreased 14% during a period when the City's population grew 12.1% and the metro area economy grew 41.6%.

[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

- GHG emissions per capita fell 23.3% from the 2012 baseline of 11.75 MT CO_2e to 9.02 MT CO_2e in 2020.

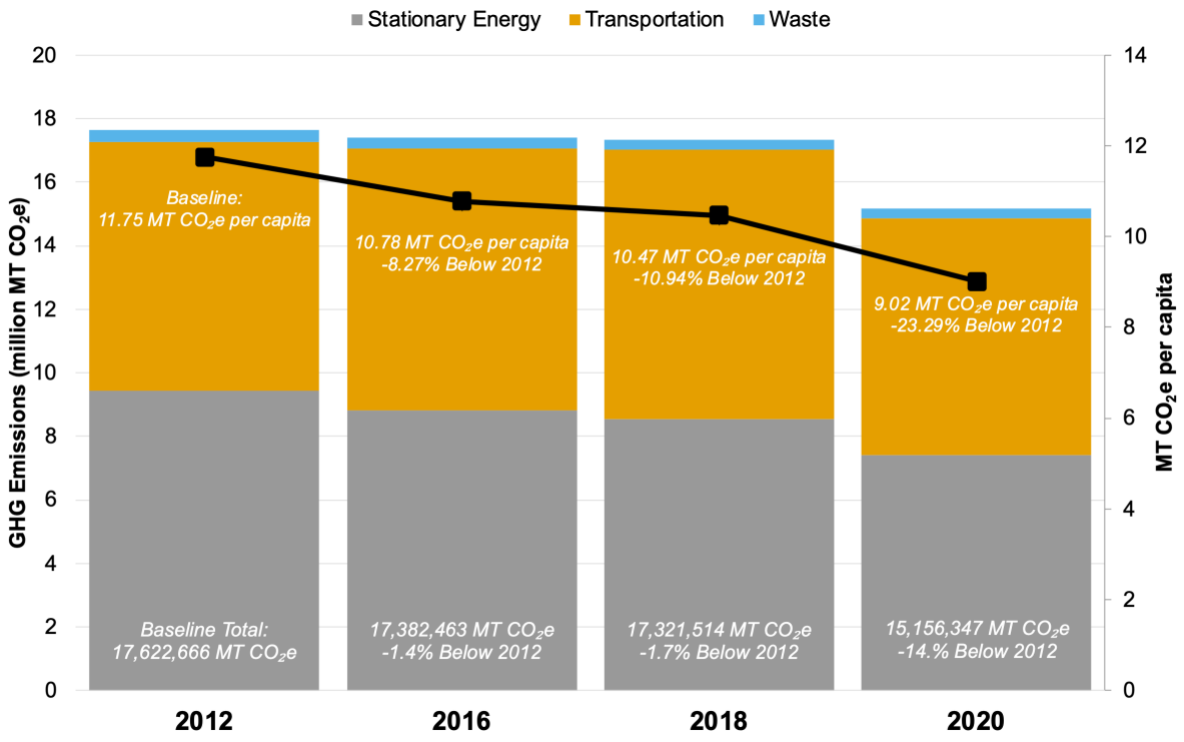

Figure ES-1. GHG emissions by emissions sector for 2012, 2016, 2018, and 2020.

The distribution of GHG emissions between Stationary Energy, Transportation, and Waste Sectors for four community GHG inventories is detailed in Table ES-1.

Table ES-1. Phoenix GHG emissions by Sector (MT CO_2e)

Sector	2012	2016	2018	2020	% Change 2012 -2020
Stationary Energy	9,431,639	8,810,561	8,552,674	7,406,849	**-21.5%**
Transportation	7,823,097	8,255,732	8,464,774	7,461,649	**-4.6%**
Waste	367,931	316,170	304,066	287,850	**-21.8%**
Total	**17,622,666**	**17,382,463**	**17,321,514**	**15,156,347**	**-14.0%**

Stationary Energy

Stationary Energy is the second largest source of GHG emissions in Phoenix. These GHG emissions occur from energy utilized in residential buildings; commercial buildings and facilities; manufacturing industries; agriculture, forestry and fishing energy use; and electricity transmission and distribution energy losses.

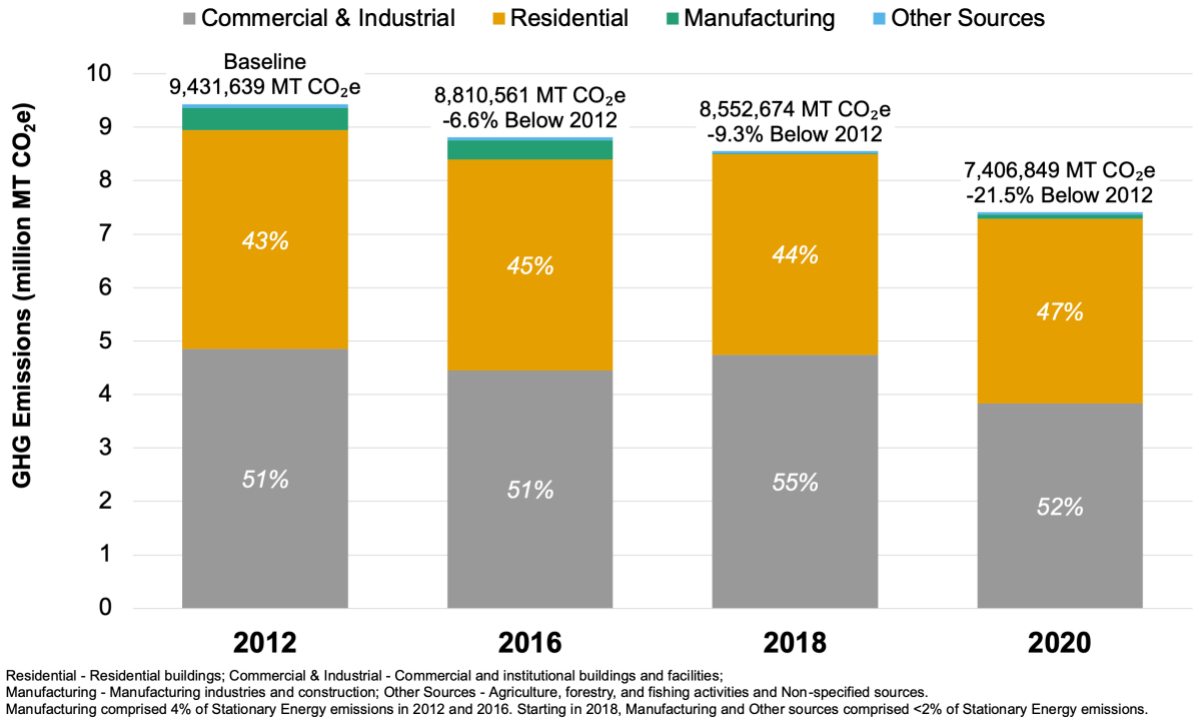

Figure ES-2. Stationary Energy GHG emissions for 2012, 2016, 2018, and 2020.

In 2020, Stationary Energy GHG emissions were 7,406,849 MT CO_2e; a 21.5% decrease below 2012 levels. Electricity-based GHG emissions decreased significantly mainly due to the retirement of the Navajo Generating Station, which decreased the carbon intensity of electricity consumed in Phoenix. Data to calculate Stationary Energy GHG emissions were obtained from Arizona Public Service (electricity), Salt River Project (electricity), Southwest Gas (natural gas), and the Energy Information Administration (electricity transmission and distribution loss). Figure ES-2 shows the distribution of GHG emissions between different sub-sectors in the Stationary Energy Sector and Table ES-2 details the GHG emissions by subsector.

Table ES-2. Subsector Stationary Energy GHG Emissions (MT CO_2e)

Stationary Energy	2012	2016	2018	2020
Residential Buildings	4,093,323	3,939,273	3,752,152	3,457,002
Commercial & Institutional Buildings	4,853,598	4,454,805	4,745,669	3,831,741
Manufacturing Industries & Construction	415,704	364,647	8,303	72,459
Agriculture, Forestry & Fishing Activities	68,954	51,758	46,477	45,523
Non-Specified Sources	60	78	74	123
Total	9,431,639	8,810,561	8,552,674	7,406,849

Transportation

In 2020, the Transportation Sector was the largest source of GHG emissions in Phoenix. Transportation GHG emissions sources occur from commercial air travel, civil aviation, on-road transportation, non-road vehicle use, light rail, and freight rail. 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 through the consumption of electricity to charge electric vehicles. Transportation GHG emissions for 2020 were 7,461,649 MT CO_2e, a 4.6% decrease in GHG emissions from the 2012 level of 7,823,097 MTCO_2e (Figure ES-3).

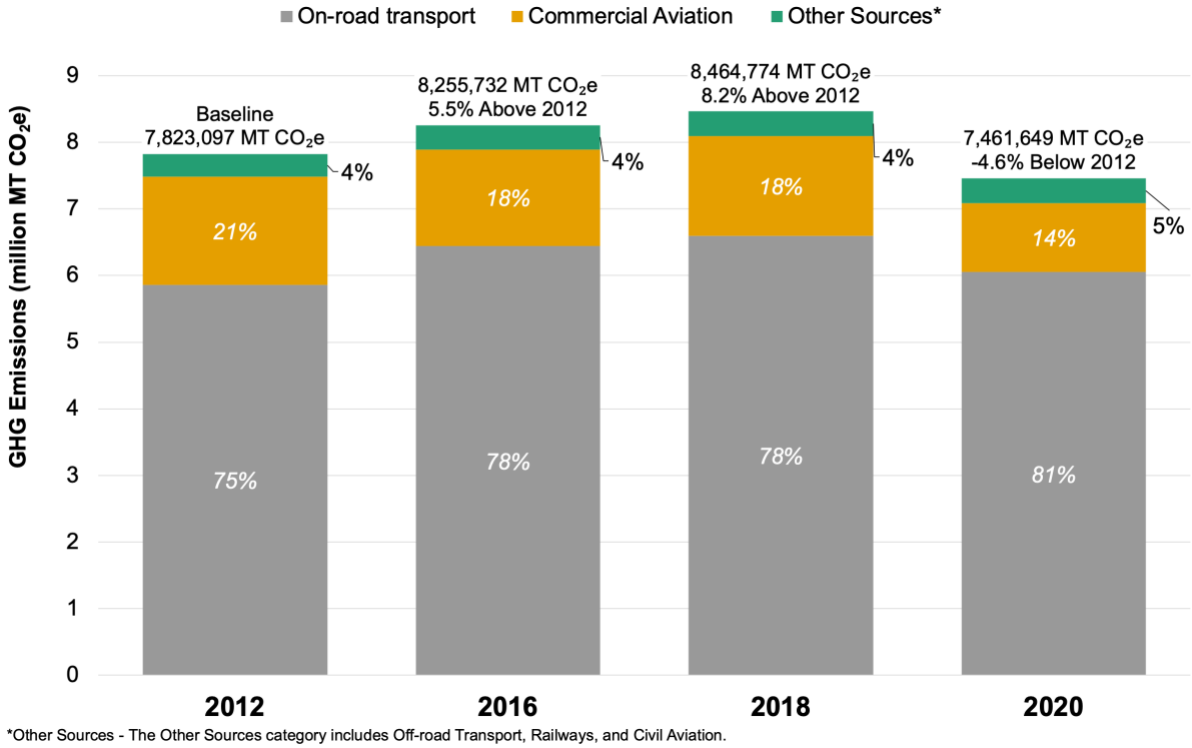

Figure ES-3.Transportation GHG emissions for 2012, 2016, and 2018.

Transportation emissions decreased in 2020 due to decreased commuting and travel, including air travel, caused in part by the COVID-19 pandemic, while at the same time there was a marked increase in heavy truck delivery services. Data were obtained from the City of Phoenix, Arizona Department of Transportation, the Weights and Measures Division of the Arizona Department of Agriculture, the Federal Aviation Administration, and the Energy Information Administration. Table ES-3 details GHG emissions among Transportation sub-sectors for the years 2012, 2016, 2018, and 2020.

Table ES-3. Subsector Transportation GHG Emissions (MT CO_2e)

Transportation	2012	2016	2018	2020
On-road transport	5,855,958	6,446,392	6,595,753	6,050,418
Railways	29,113	29,300	31,541	28,792
Commercial Aviation	1,626,397	1,448,210	1,494,963	1,039,280
Civil Aviation (Aviation Gasoline)	13,392	11,708	16,164	16,801
Off-road transport	298,237	320,122	326,353	326,353
Total	**7,823,097**	**8,255,732**	**8,464,774**	**7,461,649**

Waste

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, wastewater treated at the 91st Avenue and 23rd Avenue wastewater treatment plants in Phoenix, and the composting of waste generated in Phoenix. The total GHG emissions from the Waste Sector was 287,850 MT CO_2e in 2020 as compared to 367,931 MT CO_2e reported in 2012 (Table ES-4). Waste Sector GHG emission reductions were driven by multiple factors. First, while Solid Waste GHG emissions will 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. Second, the capture and reuse of flared methane biogas at the 91st Avenue Wastewater Treatment Plant led to a decrease in wastewater treatment GHG emissions despite Phoenix's population growing significantly between 2012 and 2020.

Table ES-4. Subsector Waste Sector GHG Emissions (MT CO_2e)

Waste	2012	2016	2018	2020
Solid Waste Disposal	353,689	302,773	285,742	273,395
Wastewater Treatment & Discharge	8,440	9,428	10,199	8,094
Biological Waste Treatment (Composting)	5,802	3,968	8,125	6,360
Total	**367,931**	**316,170**	**304,066**	**287,850**

Conclusion

In 2020, citywide GHG emissions in Phoenix were 15,133,075 metric tons CO_2e – 14.1% below the 2012 levels of 17,622,666 MT CO_2e. Stationary Energy GHG emissions decreased 2,051,816 MT CO_2e below 2012 levels due to decarbonization of the regional electricity grid. Transportation Sector GHG emissions decreased to 4.7% below 2012 levels possibly due to the travel and commuting impacts of the COVID-19 pandemic. Waste Sector GHG emissions decreased by 21.8% between 2012 and 2020, but are small compared to the Stationary Energy and Transportation sectors. While Solid Waste GHG emissions will occur from the ongoing disposal of solid waste, closed landfills within the City will produce less GHG emissions as the waste decays.

Despite falling below 2012 levels, the Transportation Sector was the largest source of GHG emissions in Phoenix in 2020. The largest source of Transportation Sector GHG emissions is gasoline and diesel use in private vehicles. The COVID-19 pandemic greatly affected transportation behavior, causing a decrease in gasoline consumption and an increase in diesel consumption between 2018 and 2020. The decrease in Transportation Sector GHG emissions in 2020 will likely be temporary and measures to reduce transportation-related GHG emissions will drive future community-scale GHG emissions. An increased adoption of battery electric vehicles (BEVs), fuel cell electric vehicles (FCEVs), plugin electric hybrid vehicles (PEHVs), or hydrogen vehicles can reduce transportation-related GHG emissions. Another is higher adoption rate of mass transit options.

Introduction

City of Phoenix community-scale GHG emissions were inventoried according to the Greenhouse Gas Protocol for Cities (GPC). The GPC has five GHG emissions sectors – Stationary Energy, Transportation, Waste, Industrial Processes and Product Use (IPPU), and Agriculture, Forestry, and Land Use (AFOLU). The city of Phoenix Community-scale GHG emissions inventory is a BASIC-level inventory. A BASIC-level community GHG emissions inventory includes: all scope 1 emissions from Stationary Energy sources (excluding energy production supplied to the grid, which shall be reported in the scope 1 total); all scope 1 emissions from Transportation sources; all scope 1 emissions from Waste sources (excluding emissions from imported waste, which shall be reported in the scope 1 total); all scope 2 emissions from Stationary Energy sources and transportation; scope 3 emissions from treatment of exported waste. IPPU and AFOLU are not required to be inventoried for BASIC-level reporting under the GPC.

In 2020, community-scale emissions totaled 15,160,180 MT CO_2e, 14.0% decrease below the baseline 2012 level of 17,622,666 MT CO_2e (Table 1). Appendix A contains a detailed breakdown of GPC sector and subsector GHG emissions for the 2012, 2016, 2018, and 2020 inventories. Stationary Energy and Transportation Sectors account for approximately 99% of community-scale GHG emissions. On-road motor gasoline combustion is the single largest source of GHG emissions, and comprises 71% Transportation emissions and 35% of total emissions. The next largest source of GHG emissions is commercial and industrial electricity consumption, which makes up 23% of total emissions. Moreover, the top three emitting sources – on-road motor gasoline consumption, commercial and industrial electricity consumption, and residential electricity consumption – are 78.6% of total emissions. Since GHG emissions from electricity consumption will likely decrease into the future due to the increased decarbonization of the regional electricity grid, GHG emissions from on-road motor gasoline consumption will likely remain the single largest source of GHG emissions for the City. Policies to reduce gasoline consumption across Phoenix are critical to meeting future GHG emissions targets and goals.

Table 1. Community- Level GHG Emissions by Sector for 2012, 2016, and 2018

Sector	GHG Emissions (MT CO_2e)				% Change 2012-20
	2012	2016	2018	2020	
Stationary Energy	9,431,639	8,810,561	8,552,674	7,406,849	**-21.5%**
Transportation	7,823,097	8,255,732	8,464,774	7,461,649	**-4.6%**
Waste	367,931	316,170	304,066	287,850	**-21.8%**
Total	**17,622,666**	**17,382,463**	**17,321,514**	**15,156,347**	**-14.0%**

The observed decreases in community-scale GHG emissions were driven by the regional electricity grid becoming less GHG-intensive. GHG emissions from electricity production fell by 2,024,790 MT CO_2e (21.5%) between 2012 and 2020. Transportation

Sector GHG emissions decreased by 357,614 MT CO_2e (4.6%). Waste GHG emissions, which are approximately 2% of community-scale GHG emissions, decreased by 80,081 MT CO_2e (21.8%) between 2012 and 2020. Per capita GHG emissions fell by 23.3% from 11.75 to 9.02 MT CO_2e per resident between 2012 and 2020 (Figure 1).

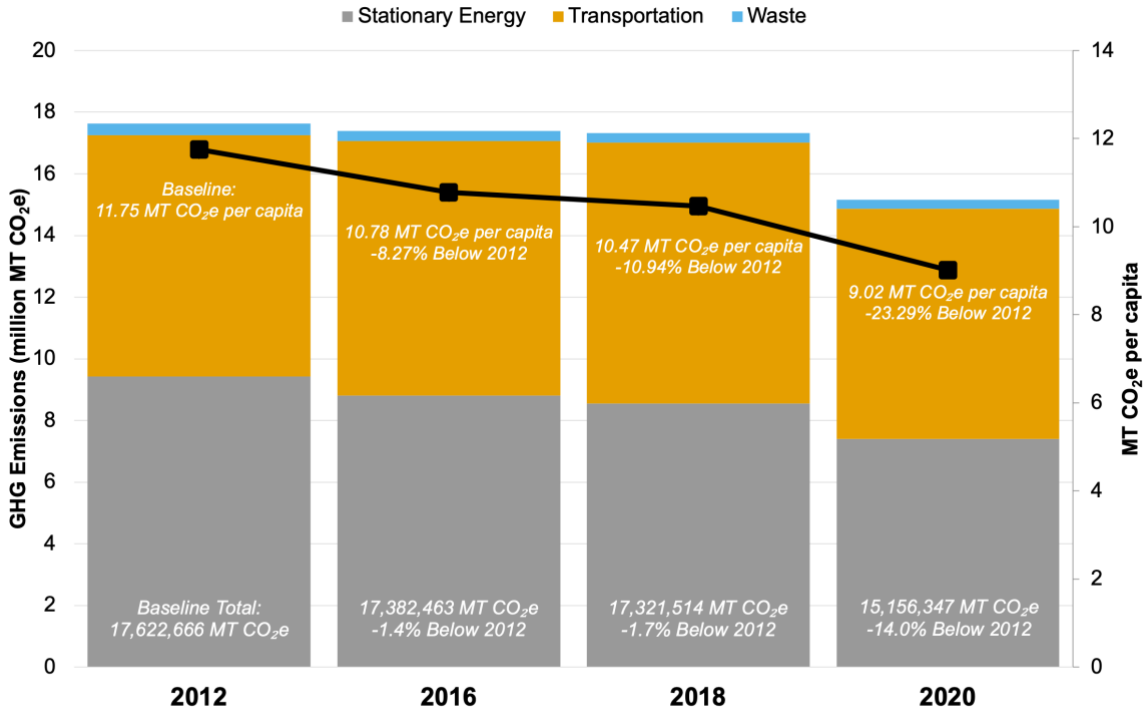

Figure 1. Total GHG Emissions and Per Capita GHG Emissions Since 2012

GHG emissions are assigned to scopes based on where the emitting activity occurs. Scope 1 GHG emissions occur directly within city boundaries from transportation activities, natural gas combustion, and waste disposal. Scope 2 GHG emissions are indirect GHG emissions through the purchase of grid-supplied energy, such as electricity and do not necessarily occur within city boundaries. Scope 3 GHG emissions are other indirect emissions from waste disposed of outside the city boundary. In 2020, 55% of GHG emissions occurred directly within the city boundary as Scope 1 emissions; 44% occurred indirectly as Scope 2 emissions through the purchase of electricity; and approximately 1% occurred indirectly as Scope 3 emissions from waste disposed of outside the city boundary (Table 2)

Table 2. 2018 Community-Level GHG Emissions by Sector and Scope

Sector	GHG Emissions (MT CO_2e)			
	Scope 1	Scope 2	Scope 3	Total
Stationary Energy	788,752	6,618,097	264,434	**7,406,849**
Transportation	7,448,545	13,104	548	**7,461,649**
Waste	139,649	0	148,200	**287,850**
Total	**8,376,946**	**6,631,201**	**148,200**	**15,156,347**

**Scope 3 Stationary Energy and Transportation GHG emissions do not count toward the BASIC-level GHG emissions total.*

In 2020, Stationary Energy activities – GHG emissions resulting from natural gas combustion and electricity consumption – accounted for approximately 48.8% of community-scale GHG emissions. Transportation activities comprise approximately 49.3%. Community-scale Transportation Sector GHG emissions have increased relative to Stationary Energy Sector GHG emissions since 2012. Gasoline combustion produced 71% of Transportation GHG Sector emissions within city boundaries. The two largest sources of GHG emissions produced 78.6% of total community-scale GHG emissions – electricity consumption (43.6%) and gasoline combustion (35.0%). Community-level GHG mitigation efforts should prioritize these two sources of GHG emissions to achieve material GHG emissions reductions.

Recent plant closures and announcements by Arizona Public Service[2] (APS), Salt River Project[3] (SRP) and the Public Service Company of New Mexico[4] (PNM) to retire and replace coal-fired power plants with generation sources that are less carbon intensive will result in significant reductions to community-scale GHG emissions. The single largest GHG emissions source in the regional electricity grid – the Navajo Generating Station operated by SRP – closed in 2019. In fact, the measure of the carbon intensity of the electricity grid – fell by 17.3% between 2018 and 2020.

Motor gasoline consumed for on-road transportation is the single largest GHG emitting activity in Phoenix. These emissions grew between 2012 and 2018, but fell back to 2012 levels in 2020 largely due to the COVID-19 pandemic. GHG emissions from gasoline consumption will likely rebound as activities return to pre-pandemic levels. Therefore, the viability and cost effectiveness of strategies to reduce GHG emissions from Transportation activities, specifically on-road motor gasoline consumption, will drive future community-scale GHG emissions and the ability to meet GHG emissions reductions goals.

[2] Arizona Public Service (2020). Stakeholder Perspectives. URL: https://www.aps.com/en/About/Our-Company/Clean-Energy/Stakeholder-Perspectives
[3] Salt River Project (2019). Navajo Generating Station Permanently Shuts Down. URL: https://media.srpnet.com/navajo-generating-station-permanently-shuts-down/
[4] PNM (2020). Our Commitment. URL: https://www.pnm.com/our-commitment

1. Stationary Energy Sector

Stationary Energy GHG emissions are predominantly Scope 2 emissions, which occur from electricity consumption (Figure 2). These emissions occur due to the combustion of natural gas (Scope 1) and the consumption of purchased electricity (Scope 2). Scope 2 Stationary Energy GHG emissions are the second largest of Phoenix's GHG emissions sources, comprising 48.9% of community-scale emissions in 2012; 46.1% in 2016; 44.9% in 2018; and 43.7% in 2020. However, because the carbon intensity of the regional electricity grid decreased significantly, electricity-related GHG emissions decreased 23% between 2012 and 2020 despite electricity consumption increasing 4.7%.

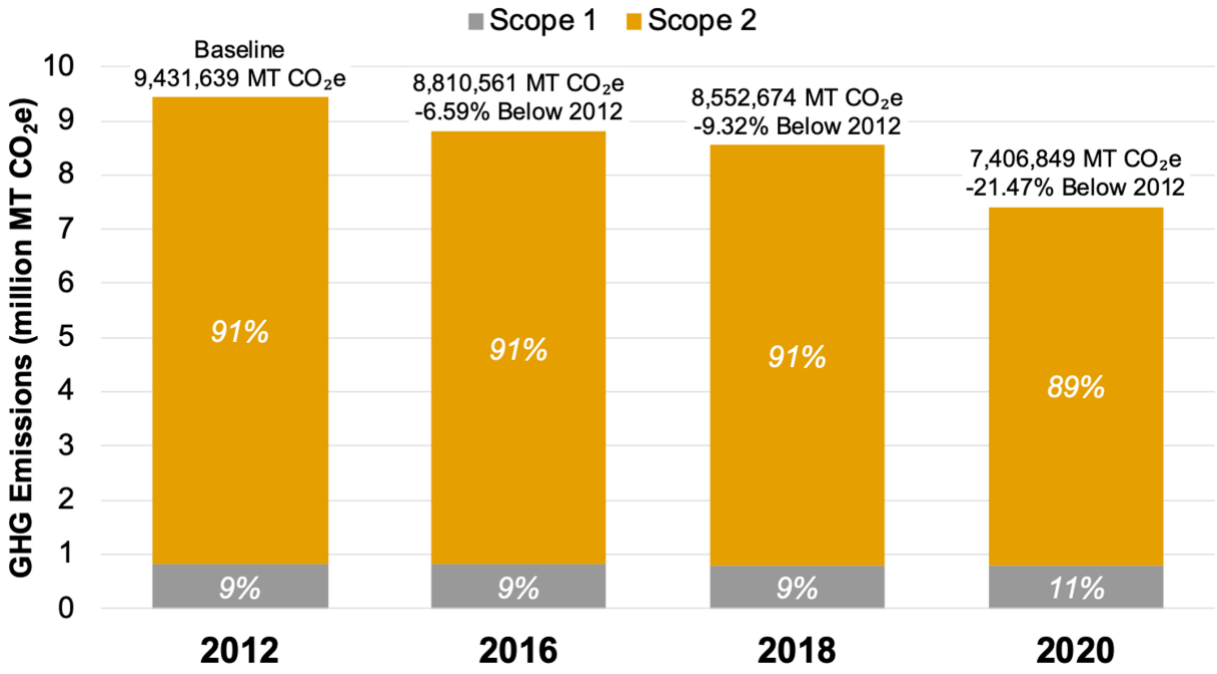

Figure 2. Stationary Energy GHG Emissions by Scope Since 2012

Electricity GHG emissions are calculated using electricity consumption data (activity data) and GHG emissions factors published by the EPA in the eGRID.[5] The Arizona-New Mexico (AZNM) subregion GHG emissions factor is used to calculate electricity GHG emissions. An eGRID subregion emissions factor is not utility-specific, and characterizes the typical GHG profile of electricity generation in that area in CO_2e emissions per MWh of net generation. The AZNM subregion includes power plants in Arizona, Western and Central New Mexico, Southern Nevada, and parts of

[5] The eGRID database inventories plant-level 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 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.

southwestern California. Since 2012, the AZNM subregion GHG emissions factor has decreased 26.6% due to increased natural gas and renewable electricity generation, and most importantly, a decrease in coal-fired electricity generation. The largest source of GHG emissions in the AZNM subregion, SRP's coal-fired Navajo Generating Station, closed in 2019.[6] Between 2018 and 2020, the AZNM subregion GHG emissions factor dropped 17.3%, contributing to a substantial decrease in Phoenix's GHG emissions. Two factors were largely responsible for the observed decrease in the AZNM subregion GHG emissions factor: (1) the closure of the Navajo Generating Station (NGS) coal-fired plant and (2) new generation brought online between 2018 and 2020 were mostly carbon-neutral electricity sources.[7,8] Looking to the future, SRP has a long-term goal of reducing the GHG-intensity of electricity production 65% below 2005 levels by 2035 and 90% by 2050[9]; APS has stated it will cease using coal to generate electricity by 2031[10] and has a carbon neutrality goal for 2050[11]; PNM plans to generate 100% carbon free electricity by 2040.[12] Utility plans to reduce the GHG-intensity of electricity generation will significantly reduce Phoenix's GHG emissions even further.

1.1 Scope 1 Stationary Energy

Scope 1 Stationary Energy GHG emissions occur, in part, from natural gas combustion within the city boundary. In 2020, citywide natural gas consumption was 2.9% greater than 2012 levels and 13.6% greater than 2018 levels (Table 3).

Table 3. Summary of Scope 1 Stationary Energy GHG Emissions

Scope 1 Activity Data (kilotherms)	**2012**	**2016**	**2018**	**2020**
Residential Buildings	58,796	58,946	53,241	60,479
Commercial & Industrial Buildings	63,802	69,036	83,367	65,688
Manufacturing Industries & Construction	16,289	13,850	1,562	13,632
Agriculture, Fishing, and Forestry Activities	12,982	9,737	8,744	8,564
Non-specified	11	15	14	23
Total	**151,881**	**151,584**	**146,927**	**148,386**

Scope 1 GHG Emissions (MT CO_2e)	**2012**	**2016**	**2018**	**2020**
Residential Buildings	312,298	313,330	283,007	321,480
Commercial & Industrial Buildings	338,887	366,966	443,139	349,167
Manufacturing Industries & Construction	86,522	73,622	8,303	72,459

[6] Salt River Project (2019). Navajo Generating Station Permanently Shuts Down. URL: https://media.srpnet.com/navajo-generating-station-permanently-shuts-down/
[7] Environmental Protection Agency (2020). eGRID2018 Unit, Generator, Plant, State, Balancing Authority Area, eGRID Subregion, NERC Region, U.S., and Grid Gross Loss (%) Data Files.
[8] Environmental Protection Agency (2022). eGRID2020 Unit, Generator, Plant, State, Balancing Authority Area, eGRID Subregion, NERC Region, U.S., and Grid Gross Loss (%) Data Files
[9] Salt River Project (2022). 2035 Sustainability Goals Delivering today, shaping tomorrow. URL: https://www.srpnet.com/environment/sustainability/2035-goals.aspx. Accessed 10 March 2022.
[10] Arizona Public Service (2020). Clean Energy. URL: https://www.aps.com/en/About/Our-Company/Clean-Energy
[11] Arizona Public Service (2020). Stakeholder Perspectives. URL: https://www.aps.com/en/About/Our-Company/Clean-Energy/Stakeholder-Perspectives
[12] PNM (2020). Our Commitment. URL: https://www.pnm.com/our-commitment

Agriculture, Fishing, and Forestry Activities	68,954	51,758	46,477	45,523
Non-specified	60	78	74	123
Total	**806,722**	**805,753**	**781,000**	**788,752**

Scope 1 Stationary Energy GHG emissions fell by 25,722 MT CO_2e below 2012 levels (Figure 3). Natural gas consumption at commercial and institutional buildings are the largest source of Scope 1 Stationary Energy GHG emissions. In 2012, Scope 1 Stationary Energy GHG emissions from commercial and institutional buildings and facilities subsector were only slightly higher than the residential buildings subsector, 42% and 39% respectively. In 2018, the commercial and institutional buildings and facilities subsector comprised 57% of Scope 1 Stationary Energy GHG emissions.

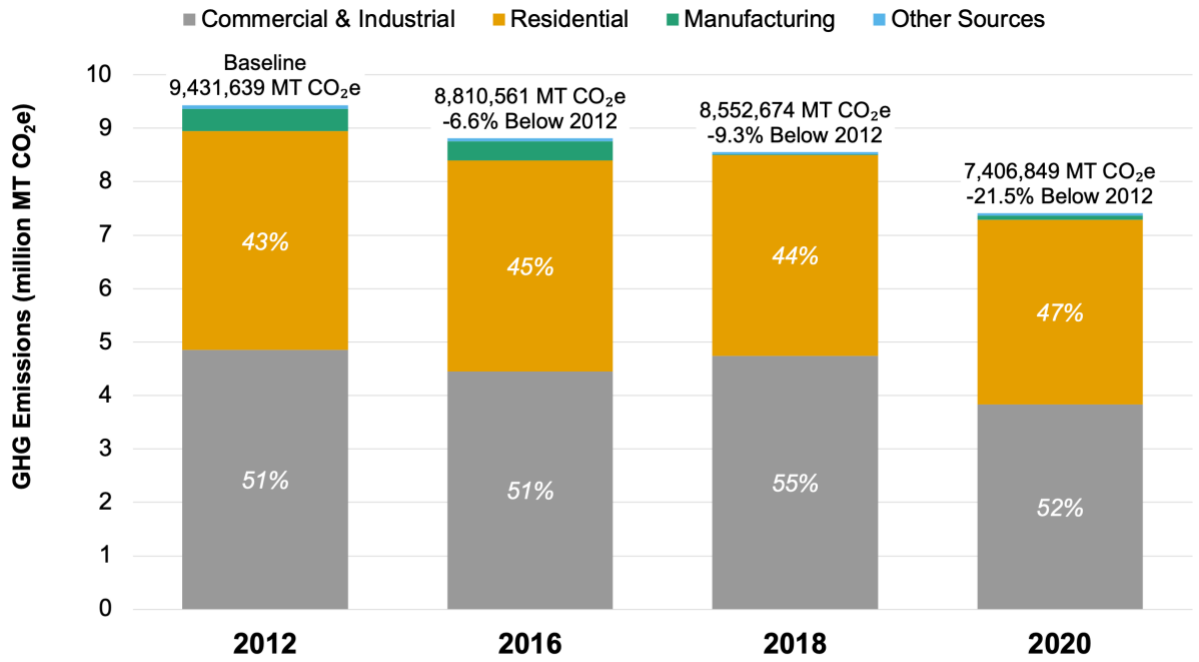

Figure 3. Scope 1 Stationary GHG Emissions Since 2012

1.2 Scope 2 Stationary Energy

Scope 2 Stationary Energy GHG emissions occur from the consumption of electricity purchased from APS and SRP within the city boundary. Between 2012 and 2020, electricity increased 4.7% (809,198 MWh) and between 2018 and 2020, electricity increased 2.9% (508,825 MWh) (Table 4). In 2020, Scope 2 Stationary Energy GHG emissions were 6,618,097 MT CO_2e, which was 23.3% below 2012 levels (Figure 4). Stationary Energy GHG emissions decreased due to the regional electricity grid becoming 35.4% less GHG-intensive between 2012 and 2020 from the retirement and replacement of coal-fired power plants with natural gas and renewable (wind and solar)

electricity generation.[13] Additionally, between 2012 and 2020, commercial and industrial electricity consumption only grew 5.1% during a period in which GDP grew approximately 41.6%. The decreased growth in electricity consumption relative to economic growth could have occurred for numerous reasons, including energy efficiency retrofits, energy efficient new construction, and commercial solar adoption. Further work is recommended to explore the extent each of these factors contributed to the decreased growth in electricity consumption.

Table 4. Summary of Scope 2 Stationary Energy GHG Emissions

Scope 2 Activity Data (GWh)	**2012**	**2016**	**2018**	**2020**
Residential Buildings	7,202	7,620	7,444	8,132
Commercial & Industrial Buildings	8,599	8,579	9,220	9,046
Manufacturing Industries & Construction	627	612	IE	IE
Total	**16,428**	**16,815**	**16,671**	**17,199**

Scope 2 GHG Emissions (MT CO_2e)	**2012**	**2016**	**2018**	**2020**
Residential Buildings	3,781,025	3,625,943	3,469,145	3,135,523
Commercial & Industrial Buildings	4,514,711	4,087,840	4,302,529	3,482,574
Manufacturing Industries & Construction	329,182	291,025	IE	IE
Total	**8,624,917**	**8,004,808**	**7,771,674**	**6,618,097**

**In 2018, Manufacturing industries and construction were IE in Commercial and institutional buildings. Scope 2 Stationary Energy GHG emissions from Energy Industries; AFFA; and Non-Specified Sources were assumed to be included elsewhere (IE) and, therefore, not included in this table. Scope 2 Stationary Energy GHG emissions Fugitive Emissions from MPST; and Fugitive Emissions from ONGS were NE and, therefore, not included in this table*

[13] 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. The 11.2% reduction in the GHG intensity of the regional electricity was calculated comparing the 2012 and 2018 emissions factor for the Arizona-New Mexico subregion.

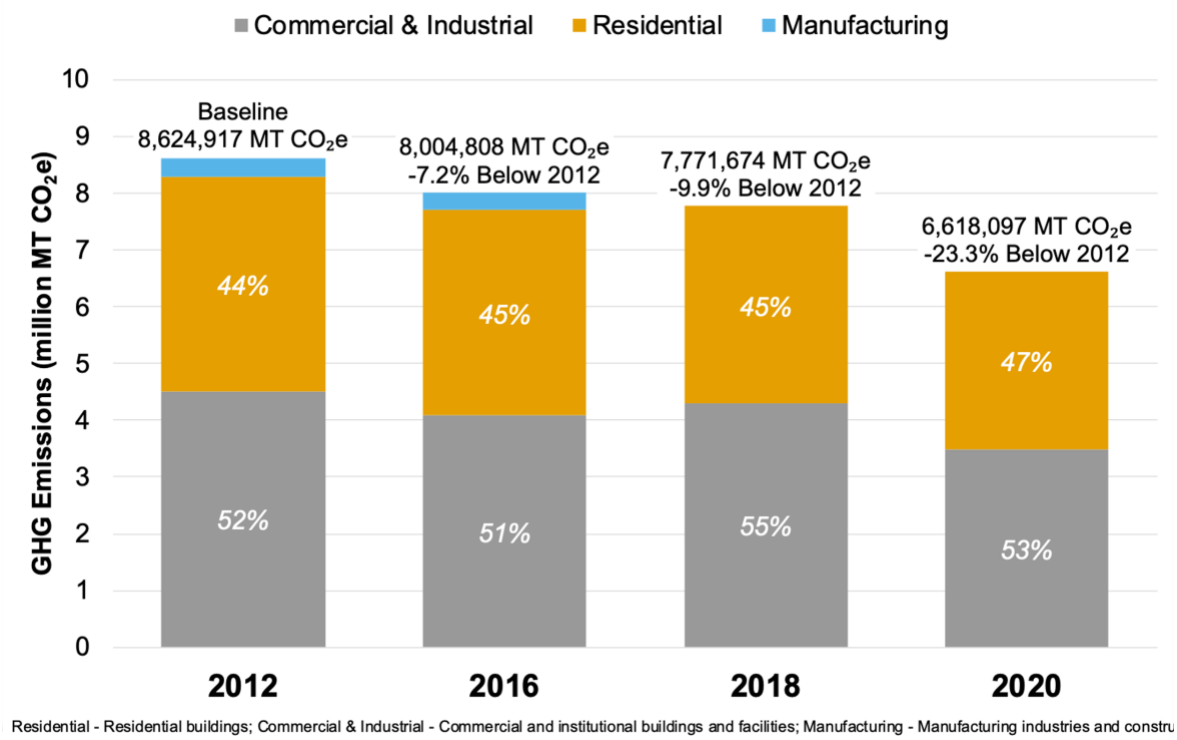

Figure 4. Scope 2 Stationary GHG Emissions Since 2012

1.3 Scope 3 Stationary Energy

Scope 3 Stationary Energy GHG emissions occur from transmission and distribution loss in the state's electricity grid and fluctuates from year-to-year (Table 5). Between 1990 and 2020, transmission and distribution (T&D) loss in the State of Arizona has averaged 4.5% ± 0.7% of electricity consumption and has ranged between 3.4% in 2015 up to 5.7% in 1996.[14] Scope 3 Stationary Energy GHG emissions are not within the scope of GPC BASIC-level reporting. Nonetheless, these GHG emissions are calculated to show the full extent of GHG emissions from electricity consumption.

Table 5. Summary of Scope 3 Stationary Energy GHG Emissions

Scope 3 Activity Data	**2012**	**2016**	**2018**	**2020**
Transmission & Distribution Loss (MWh)	613,573	631,792	666,138	685,863
Natural Gas Leakage (therms)	NE	NE	NE	NE
Total	**613,573**	**631,792**	**666,138**	**685,863**

Scope 3 GHG Emissions (MT CO_2e)	**2012**	**2016**	**2018**	**2020**
Transmission & Distribution Loss (MWh)	322,125	300,632	310,345	264,434
Natural Gas Leakage (therms)	NE	NE	NE	NE
Total	**322,125**	**300,632**	**310,345**	**264,434**

**NE – Not Estimated*

[14] U.S. Energy Information Administration, Form EIA-923, Power Plant Operations Report and predecessor forms. U.S. Energy Information Administration, Form EIA-860, Annual Electric Generator Report. U.S. Energy Information Administration, Form EIA-861, Annual Electric Power Industry Report. Form EIA-111, Quarterly Imports and Exports Report.

2. Transportation Sector

Transportation Sector GHG emissions have Scope 1, 2, and 3 components. Scope 1 Transportation Sector GHG emissions occur due to the combustion of fossil fuels – gasoline, diesel, CNG, LNG, LPG – and biofuel blends – B20 biodiesel and E85 ethanol. Scope 2 Transportation Sector GHG emissions occur from the consumption of electricity to charge plug-in electric vehicles and power electric light rail; and Scope 3 emissions occur from the T&D loss associated with Scope 2 transportation. In 2020, community-scale Transportation sector GHG emissions totaled 7,461,649 MT CO_2e and were 4.6% less than the 2012 levels of 7,823,097 MT CO_2e.

Motor gasoline is the largest source of community-scale Transportation Sector GHG emissions at 71.0% and 35% of all community-scale GHG emissions (Figure 5). Community-level gasoline consumption encompasses all gasoline end uses. While some end uses may not be for transportation purposes (e.g., gasoline lawnmowers), emissions from these end uses were assumed to be insignificant compared to gasoline consumption for motor vehicles.[15] GHG emissions from Jet Fuel A (13.9%) and on-road diesel fuel (8.8%) are the next largest sources of transportation GHG emissions. While Transportation Sector GHG emissions showed a decrease between 2012 and 2020, this may be a result of the COVID-19 pandemic. In previous inventories, GHG emissions from gasoline combustion has grown with population. As growth occurs, viable solutions to reduce gasoline consumption – from EVs and increased mass transit to creating walkable communities – are critical for meeting GHG emissions reductions goals.

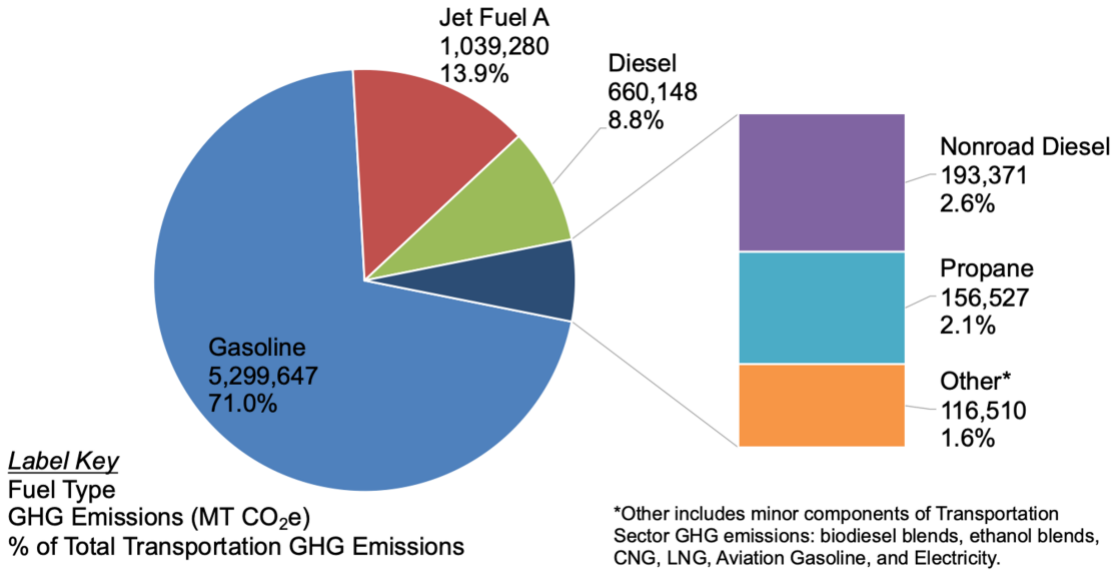

Figure 5. Summary of Transportation Sector GHG Emissions by Fuel Type

[15] The U.S. Energy Information Administration estimates light-duty vehicles account for 92% of gasoline consumption in the United States. Source: U.S. Energy Information Administration, 2019. Use of Gasoline. URL: https://www.eia.gov/energyexplained/gasoline/use-of-gasoline.php

2.1 Scope 1 Transportation GHG Emissions

Scope 1 Transportation GHG emissions occur from the combustion of fossil fuels and biofuel blends in on-road motor vehicles, commercial and civil aircrafts, freight rail, and nonroad vehicles such as tractors and construction equipment (Table 6). Before 2020, on-road transport GHG emissions growth (12.7%) had largely followed population growth (12.7%). The second largest source of community-scale Transportation sector GHG emissions comes from Commercial Aviation, which is almost primarily from the Phoenix Sky Harbor International Airport. In 2020, Commercial Aviation GHG emissions were revised upwards for all inventory years due to revised source data from the EIA. Community-level GHG emissions from off-road transport, which is the third largest source of community-scale Transportation sector GHG emissions, result from construction equipment, agricultural equipment and mining equipment.

Table 6. Summary of Scope 1 Transportation GHG Emissions (MT CO_2e)

Scope 1 Sources	2012	2016	2018	2020
On-road transport	5,855,292	6,441,344	6,586,630	6,042,566
Railways*	23,545	23,545	23,545	23,545
Commercial Aviation	1,626,397	1,448,210	1,494,963	1,039,280
Civil Aviation	13,392	11,708	16,164	16,801
Nonroad transport	298,237	320,122	326,353	326,353
Total	**7,816,863**	**8,244,929**	**8,447,655**	**7,448,545**

*Freight rail GHG emissions have not been re-estimated since the 2012 community inventory due to constraints with source data.

Gasoline consumption is the major driver of Scope 1 Transportation GHG Emissions (Additionally, the further development and marketability and adoption of hydrogen vehicles will further reduce on-road GHG emissions and should explored as a strategy to displace fossil fuels.

Table 7). Between 2012 and 2020, fuel consumption increased across every fuel type except LNG and B20 biodiesel. The city of Phoenix vehicle fleet – e.g., buses and garbage and recycling trucks – is the primary consumer of LNG and B20 biodiesel. Additionally, the further development and marketability and adoption of hydrogen vehicles will further reduce on-road GHG emissions and should explored as a strategy to displace fossil fuels.

Table 7. Scope 1 Transportation Activity Data and GHG Emissions by Fuel

Scope 1 GHG Emissions (MT CO_2e)	2012	2016	2018	2020
Gasoline [1]	5,250,540	5,797,934	5,917,671	5,299,647
On-Road Diesel[1]	529,242	591,063	617,575	660,148
B20 Biodiesel[1]	24,785	22,062	24,732	35,199
E85 Ethanol[1]	379	207	410	441
E54 Ethanol [1]	0	441	0	0
CNG[1] – *therms*	22,595	18,293	33,391	27,484
LNG[1] – *GGE*	27,751	11,345	2,423	19,647
Jet Fuel A (Commercial Aviation)[2]	698,263	705,643	779,113	1,039,280
Aviation Gasoline (Civil Aviation)[2]	13,394	15,067	10,043	16,801
Railways**	23,545	23,545	23,545	23,545
Nonroad Diesel[3]	148,488	163,595	169,826	169,826
Nonroad LPG[3]	149,749	156,527	156,527	156,527

Total	**6,888,732**	**7,505,722**	**7,735,257**	**7,448,545**

**Activity Data are reported in gallons unless otherwise noted; NE – Not Estimated. Emissions estimated from EPA National Emissions Inventory; Italicized entries denote Activity Data estimated from EPA National Emissions Inventory; **Emissions estimated from the EPA National Emissions Inventory and not activity data; Transportation Sector: [1]On-Road Sector; [2]Aviation; [2]Off-Road.*

2.2 Scope 2 Transportation GHG Emissions

The 2020 levels of Scope 2 Transportation sector GHG emissions are 172% higher than 2012, but 1.1% lower 2018 levels (Table 8). The growth of Scope 2 Transportation sector GHG emissions is primarily from the increased adoption of plug-in electric vehicles. The estimated electricity consumption by EVs has increased 16-fold since 2012, but EVs are currently a small fraction of the on-road vehicle fleet. GHG emissions related to the Valley Metro light rail system increased 33% due to the expansion of the light rail system since 2012. GHG emissions from electric transport are a small percentage of overall transportation-related GHG emissions (~0.2%). As the regional electricity grid becomes less GHG-intensive over the coming decades, the use of electric personal transport – plugin EVs and plugin hybrid EVs – and electric mass transit – light rail and battery electric buses – will become GHG-saving alternatives to traditional gasoline-powered personal vehicles. Increasing electric-powered transit will require investment in electric mass transit, which is underway through T2050, battery technology improvements, installing a regional charging station network, and consumer-friendly market conditions.

Table 8. Summary of Scope 2 Transportation GHG Emissions

Scope 2 Activity Data (MWh)	**2012**	**2016**	**2018**	**2020**
On-road transport	1,269	10,608	19,576	20,368
Railways (Light Rail)	10,605	12,095	17,157	13,624
Total	**11,874**	**22,703**	**36,733**	**33,991**

Scope 2 GHG Emissions (MT CO_2e)	**2012**	**2016**	**2018**	**2020**
On-road transport	666	5,048	9,123	9,490
Railways (Light Rail)	5,568	5,755	7,996	7,447
Total	**6,234**	**10,803**	**17,119**	**16,937**

2.3 Scope 3 Transportation GHG Emissions

Scope 3 Transportation GHG emissions occur from transmission and distribution loss in the state's electricity grid (Table 9). Scope 3 Transportation GHG emissions are not within the scope of GPC BASIC-level reporting and presented for informational purposes. Refer to the ***Scope 3 Stationary Energy*** section for a more detailed discussion on T&D loss in the State of Arizona.

Table 9. Summary of Scope 3 Transportation GHG Emissions

Scope 3 Activity Data (MWh)	**2012**	**2016**	**2018**	**2020**
On-road transport	47	399	708	852
Railways (Light Rail)	396	454	620	570
Total	**443**	**853**	**1,328**	**1,422**

Scope 3 GHG Emissions (MT CO_2e)	**2012**	**2016**	**2018**	**2020**
On-road transport	25	190	330	397

Railways (Light Rail)	208	216	289	266
Total	**233**	**406**	**619**	**663**

3. Waste Sector

Waste Sector GHG emissions have both Scope 1 and Scope 3 components (Table 11). Unlike Scope 3 emissions in the Stationary Energy and Transportation sectors, Scope 3 Waste emissions are included within the GPC BASIC-level reporting. Overall, Waste Sector GHG emissions decreased 21.8% (80,081 MT CO2e) between 2012 and 2020.

Table 10. Summary of Waste Sector GHG Emissions

Waste Sector GHG Emissions (MT CO_2e)	**2012**	**2016**	**2018**	**2020**
Scope 1 Waste Emissions	250,130	156,167	150,118	139,649
Scope 3 Waste Emissions	117,800	160,003	153,948	148,200
Total	**367,931**	**316,170**	**304,066**	**287,850**

Scope 1 Waste Sector GHG emissions include emissions from municipal solid waste and wastewater generated and treated within the city boundary in addition to waste imported into the city and treated (Table 11). Scope 1 Waste Sector sources include the following facilities:

- The 23rd Avenue and 91st Avenue wastewater treatment plants.
- Emissions from composting– the biological treatment of waste –at the 27th Avenue Compost Facility. Prior to 2018, a different facility operated at the 27th Avenue Landfill.
- Closed landfills within in the city of Phoenix boundary. Over time, these emissions will decrease as the biological processes that generate methane decrease. The last city-owned landfill to accept waste within the City boundary closed in 2006 and the last privately-owned landfill to accept waste within the city boundary – the Waste Management Lone Cactus Landfill – closed in 2019.

Table 11. Summary of Scope 1 Waste GHG Emissions

Scope 1 Sources Activity Data (MT CH_4)	**2012**	**2016**	**2018**	**2020**
Disposal of Solid Waste Generated in the City	8,425	5,099	4,707	4,471
Biological Treatment of Waste Generated in the City	121	83	170	133
Wastewater Generated Inside the City	92	121	135	76
Total	**8,638**	**5,303**	**5,011**	**4,680**

Scope 1 Sources Activity Data (MT N_2O)	**2012**	**2016**	**2018**	**2020**
Biological Treatment of Waste Generated in the City	9	6	13	10
Wastewater Generated Inside the City	22	23	24	23
Total	**31**	**29**	**37**	**32**

Scope 1 GHG Emissions (MT CO_2e)	**2012**	**2016**	**2018**	**2020**
Disposal of Solid Waste Generated in the City	235,889	142,771	131,794	125,195
Biological Treatment of Waste Generated in the City	5,802	3,968	8,125	6,360
Wastewater Generated Inside the City	8,440	9,428	10,199	8,094
Total	**250,130**	**156,167**	**150,118**	**139,649**

Scope 3 Waste GHG emissions occur from the disposal of waste generated within the city but disposed outside the city (Table 12). As GHG emissions are expected to increase at the SR-85 landfill, methane capture and reuse programs may become a viable way to reduce waste-related emissions, and offset Scope 1 Stationary Energy GHG emissions from natural gas combustion. Organic waste diversion to the compost facility at 27th Avenue is a viable way to reduce future Waste Sector GHG emissions. Similarly, the capture of digester gas at the 91st Avenue Wastewater Treatment Plant (WWTP) for processing and sale as renewable natural gas (RNG) by Ameresco, Inc. will reduce Waste Sector GHG emissions from wastewater treatment.

Table 12. Summary of Scope 3 Waste GHG Emissions

Scope 3 Sources Activity Data (MT CH_4 Emissions)	**2012**	**2016**	**2018**	**2020**
Disposal of Solid Waste Generated in the City but Disposed Outside the City at SR-85	295	2,147	2,029	2,301
Disposal of Solid Waste Generated in the City but Disposed Outside the City by Private Haulers	3,912	3,567	3,469	2,992
Total	**4,207**	**5,714**	**5,498**	**5,293**

Scope 3 GHG Emissions (MT CO_2e)	**2012**	**2016**	**2018**	**2020**
Disposal of Solid Waste Generated in the City but Disposed Outside the City at SR-85	8,260	60,116	56,820	64,416
Disposal of Solid Waste Generated in the City but Disposed Outside the City by Private Haulers	109,540	99,887	97,128	83,784
Total	**117,800**	**160,003**	**153,948**	**148,200**

Appendix A. Detailed GHG Emissions Summary

Appendix A contains tables detailing City of Phoenix community-scale GHG emissions by each GPC sector and subsector.

Table A1. Year-to-Year Comparison of Stationary Energy GHG Emissions

GPC ref No.	Scope	GHG Emissions Source (By Sector and Sub-sector)	Greenhouse Gas Emissions (metric tons CO_2e)			
			2012	2016	2018	2020
I		Stationary Energy				
I.1		**Residential Buildings**				
I.1.1	1	Emissions from fuel combustion within the city boundary	312,298	313,330	283,007	321,480
I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary	3,781,025	3,625,943	3,469,145	3,135,523
I.1.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	141,216	136,245	138,614	125,284
I.2		**Commercial and institutional buildings and facilities**				
I.2.1	1	Emissions from fuel combustion within the city boundary	338,887	366,966	443,139	349,167
I.2.2	2	Emissions from grid-supplied energy consumed within the city boundary	4,514,711	4,087,840	4,302,529	3,482,574
I.2.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	168,618	153,600	171,913	139,151
I.3		**Manufacturing industries and construction**				
I.1.1	1	Emissions from fuel combustion within the city boundary	86,522	73,622	8,303	72,459
I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary	329,182	291,025	IE	IE
I.2.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	12,294	10,935	IE	IE
I.4		**Energy Industries**				
I.4.1	1	Emissions from energy used in power plant auxiliary operations within the city boundary	NE	NE	NE	NE
I.4.2	2	Emissions from grid-supplied energy consumed in power plant auxiliary operations within the city boundary	NE	NE	NE	NE
I.4.3	3	Emissions from transmissions and distribution losses from grid-supplied energy consumption in power plant auxiliary operations	NE	NE	NE	NE
I.4.4	1	*Emissions from energy generation supplied to the grid*	986,289	1,200,633	1,391,552	1,659,111
I.5		**Agriculture, forestry and fishing activities**				
I.5.1	1	Emissions from fuel combustion within the city boundary	68,954	51,758	46,477	45,523
I.5.2	2	Emissions from grid-supplied energy consumed within the city boundary	IE	IE	IE	IE

GPC ref No.	Scope	GHG Emissions Source (By Sector and Sub-sector)	Greenhouse Gas Emissions (metric tons CO_2e)			
			2012	2016	2018	2020
I.5.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	IE	IE	IE	—
I.6		**Non-specified sources**				
I.1.1	1	Emissions from fuel combustion within the city boundary	60	78	74	123
I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary	IE	IE	IE	IE
I.1.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	NO	NO	NO	NO
I.7		**Fugitive emissions from mining, processing, storage, and transportation of coal**				
I.7.1	1	Emissions from fugitive emissions within the city boundary	NO	NO	NO	NO
I.8		**Fugitive emissions from oil and natural gas systems**				
I.8.1	1	Emissions from fugitive emissions within the city boundary	NE	NE	NE	NE

Notation Key	Definition	Explanation
IE	Included Elsewhere	GHG emissions for this activity are estimated and presented in another category of the inventory. The category shall be noted in the explanation.
NE	Not Estimated	Emissions occur but have not been estimated or reported; justification for exclusion shall be noted in the explanation.
NO	Not Occurring	An activity or process does not occur or exist within the city.
C	Confidential	GHG emissions which could lead to the disclosure of confidential information and can therefore not be reported.

Color Key
Sources required for BASIC reporting
Sources required for BASIC+ reporting
Sources included in Other Scope 3
Sources required for territorial reporting
Non-applicable emissions

Scope	Definition
Scope 1	GHG emissions from sources within the city boundary.
Scope 2	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.
Scope 3	All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

Table A2. Year-to-Year Comparison of Transportation GHG Emissions

GPC ref No.	Scope	GHG Emissions Source (By Sector and Sub-sector)	Greenhouse Gas Emissions (metric tons CO_2e)			
			2012	2016	2018	2020
II		Transportation				
II.1		**On-road Transportation**				
II.1.1	1	Emissions from fuel combustion for on-road transportation occurring within the city boundary	5,855,292	6,441,344	6,586,630	6,042,566
II.1.2	2	Emissions from grid-supplied energy consumed within the city boundary for on-road transportation	666	5,048	9,123	7,852
II.1.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmissions and distribution losses from grid-supplied energy consumption	25	190	330	329
II.2		**Railways**				
II.2.1	1	Emissions from fuel combustion for railway transportation occurring within the city boundary	23,545	23,545	23,545	23,545
II.2.2	2	Emissions from grid-supplied energy consumed within the city boundary for railways	5,568	5,755	7,996	5,253
II.2.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmissions and distribution losses from grid-supplied energy consumption	208	216	289	220
II.3		**Waterborne navigation**				
II.3.1	1	Emissions from fuel combustion for waterborne navigation occurring within the city boundary	NO	NO	NO	NO
II.3.2	2	Emissions from grid-supplied energy consumed within the city boundary for waterborne navigation	NO	NO	NO	NO
II.3.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmissions and distribution losses from grid-supplied energy consumption	NO	NO	NO	NO
II.4		**Aviation**				
II.4.1	1	Emissions from fuel combustion for aviation occurring within the city boundary	1,639,788	1,459,918	1,511,127	1,056,081
II.4.2	2	Emissions from grid-supplied energy consumed within the city boundary for aviation	NE	NE	NE	NE

GPC ref No.	Scope	GHG Emissions Source (By Sector and Sub-sector)	Greenhouse Gas Emissions (metric tons CO_2e)			
			2012	2016	2018	2020
II.4.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmissions and distribution losses from grid-supplied energy consumption	NE	NE	NE	NE
II.5		**Off-road transportation**				
II.5.1	1	Emissions from fuel combustion for off-road transportation occurring within the city boundary	298,237	320,122	326,353	326,353
II.5.2	2	Emissions from grid-supplied energy consumed within the city boundary for off-road transportation	IE	IE	IE	IE

Notation Key	Definition	Explanation
IE	Included Elsewhere	GHG emissions for this activity are estimated and presented in another category of the inventory. The category shall be noted in the explanation.
NE	Not Estimated	Emissions occur but have not been estimated or reported; justification for exclusion shall be noted in the explanation.
NO	Not Occurring	An activity or process does not occur or exist within the city.
C	Confidential	GHG emissions which could lead to the disclosure of confidential information and can therefore not be reported.

Color Key
Sources required for BASIC reporting
Sources required for BASIC+ reporting
Sources included in Other Scope 3
Sources required for territorial reporting
Non-applicable emissions

Scope	Definition
Scope 1	GHG emissions from sources within the city boundary.
Scope 2	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.
Scope 3	All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

Table A3. Year-to-Year Comparison of Waste GHG Emissions

GPC ref No.	Scope	GHG Emissions Source (By Sector and Sub-sector)	Greenhouse Gas Emissions (metric tons CO_2e)			
			2012	2016	2018	2020
III		**Waste**				
III.1		**Solid waste disposal**				
III.1.1	1	Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps within the city boundary	131,794	131,794	131,794	125,195
III.1.2	3	Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps outside the city boundary	117,800	160,003	153,948	148,200
III.1.3	1	*Emissions from waste generated outside the city boundary and disposed in landfills or open dumps within the city boundary*	NO	NO	NO	NO
III.2		**Biological treatment of waste**				
III.2.1	1	Emissions from solid waste generated within the city boundary that is treated biologically within the city boundary	5,802	3,968	8,125	6,360
III.2.2	3	Emissions from solid waste generated within the city boundary but treated biologically outside of the city boundary	NO	NO	NO	NO
III.2.3	1	*Emissions from waste generated outside the city boundary but treated biologically within the city boundary*	NO	NO	NO	NO
III.3		**Incineration and open burning**				
III.3.1	1	Emissions from solid waste generated treated within the city boundary	NO	NO	NO	NO
III.3.2	3	Emissions from solid waste generated within the city boundary but treated outside of the city boundary	NO	NO	NO	NO
III.3.3	1	*Emissions from waste generated outside the city boundary but treated within the city boundary*	NO	NO	NO	NO
III.4		**Wastewater treatment and discharge**				
III.4.1	1	Emissions from wastewater generated and treated within the city boundary	8,440	9,428	10,199	8,094
III.4.2	3	Emissions from wastewater generated within the city boundary but treated outside of the city boundary	NO	NO	NO	NO
III.4.3	1	*Emissions from wastewater generated outside the city boundary but treated within the city boundary*	NO	NO	IE	IE
IV		**Industrial Processes and Product Uses (IPPU)**				
IV.1	1	Emissions from industrial processes occurring within the city boundary	NE	NE	NE	NE
IV.2	1	Emissions from product use occurring within the city boundary	NE	NE	NE	NE
V		**Agriculture, Forestry, and Other Land Use (AFOLU)**				
V.1	1	Emissions from livestock within the city boundary	NE	NE	NE	NE

GPC ref No.	Scope	GHG Emissions Source (By Sector and Sub-sector)	Greenhouse Gas Emissions (metric tons CO_2e)			
			2012	2016	2018	2020
V.2	1	Emissions from land within the city boundary	NE	NE	NE	NE
V.3	1	Emissions from aggregate sources and non-CO_2 emissions sources on land within the city boundary	NE	NE	NE	NE
VI		**Other Scope 3**				
VI.1	3	Other Scope 3	3,001	483	564	800

Notation Key	Definition	Explanation
IE	Included Elsewhere	GHG emissions for this activity are estimated and presented in another category of the inventory. The category shall be noted in the explanation.
NE	Not Estimated	Emissions occur but have not been estimated or reported; justification for exclusion shall be noted in the explanation.
NO	Not Occurring	An activity or process does not occur or exist within the city.
C	Confidential	GHG emissions which could lead to the disclosure of confidential information and can therefore not be reported.

Color Key
Sources required for BASIC reporting
Sources required for BASIC+ reporting
Sources included in Other Scope 3
Sources required for territorial reporting
Non-applicable emissions

Scope	Definition
Scope 1	GHG emissions from sources within the city boundary.
Scope 2	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.
Scope 3	All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

Appendix B. DRAFT GHG Emissions from Agriculture, Forestry, and Land Use (AFOLU) and Food Systems

The 2020 community GHG emissions inventory represents the first attempt at cataloging GHG emissions for the AFOLU sector (Figure 1). AFOLU GHG emissions are required for BASIC+ GHG inventory reporting, but optional for the current BASIC-level GHG inventory reporting undertaken by the City of Phoenix and most cities. However, as AFOLU emissions will be required for future GHG C40 reporting, these initial efforts lay groundwork for comprehensive AFOLU emissions reporting for the 2022 community GHG emissions report and beyond.

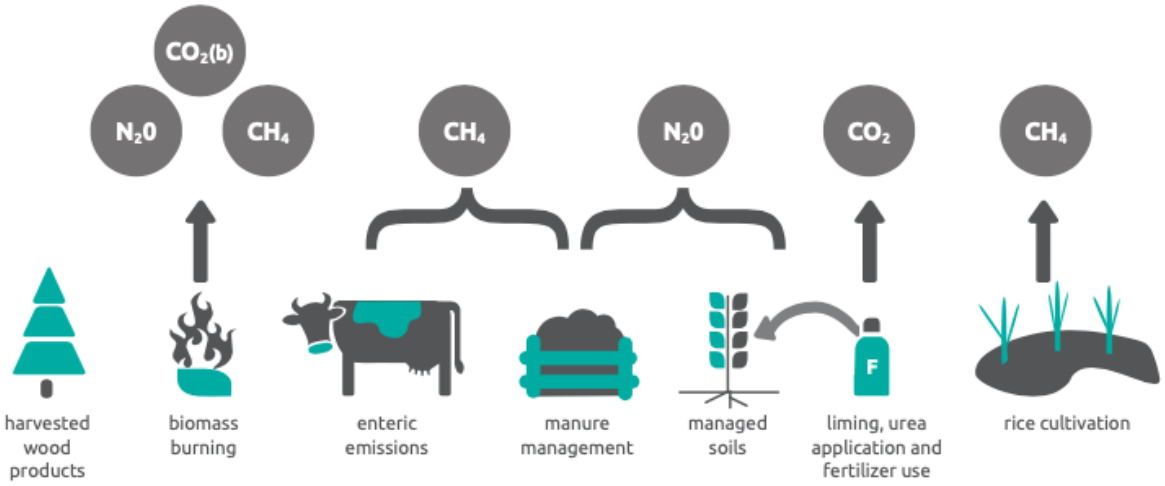

Figure B6. Sources of AFOLU GHG Emissions[16].

AFOLU emissions broadly fall into three categories: livestock; land; and aggregate sources and non-CO_2 emissions sources on land. As shown in Figure 1, some AFOLU emissions are relevant to the City of Phoenix and some are not. For example, changes in GHG emissions resulting from harvested wood products and rice cultivation are not relevant to the City of Phoenix. Biomass burning, through the combustion residential firewood; livestock emissions from enteric digestion and manure management; and CO_2 and non-CO_2 GHG emissions from agricultural soil management are relevant to the City of Phoenix. Additionally, changes in carbon stocks from land types and land use change are another highly relevant component of the City of Phoenix's AFOLU sector. This initial attempt at inventorying AFOLU GHG emissions will present estimation methods and results for livestock GHG emissions and a framework for calculating GHG

[16] Image Source: 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

emissions from land and land use change and aggregate sources and non-CO_2 emissions sources on land.

B.1 Livestock

Livestock GHG emissions fall into two categories: enteric fermentation and manure management. Livestock populations drive the estimation of these GHG emissions. Variations in livestock population estimation methods can create large ranges of potential GHG emissions. Summary city-level livestock GHG emissions reflect the uncertainty inherent to estimated livestock population levels. In 2020, total livestock GHG emissions occurring in the City of Phoenix were estimated to be 3,368 to 94,702 MT CO_2e. GHG Emissions from enteric fermentation were estimated to be 2,965 to 77,176 MT CO_2e and the emissions from manure management estimated to be 674 to 17,526 MT CO_2e.

Enteric fermentation by livestock – cattle, horses, sheep, swine, goats, American bison, and the non-horse equines (mules and asses) – results in the emissions of methane (CH_4). While numerous animals contribute to livestock-related GHG emissions, cattle are the primary source of livestock GHG emissions. In 2019 at the state-level, cattle were responsible for the emission of 82,378 MT CH_4 via enteric fermentation while all other livestock types emitted 2,935 MT CH_4[17]. Similarly, cattle, and moreover dairy cattle, were responsible for the vast majority of CH_4 emissions from manure management. In 2019 at the state-level, cattle were responsible for emitting 24,183 MT CH_4 of the state's total 28,632 MT CH_4 resulting from livestock manure management[18]. Likewise, cattle were responsible for emitting 1,176 MT N_2O the state's total 1,218 MT N_2O resulting from livestock manure management[19].

Estimates on the number of livestock head per livestock type – cattle, horses, sheep, swine, goats, American bison, and the non-horse equines (mules and asses) – are required to estimate livestock GHG emissions from the City of Phoenix. These data were obtained from the United States Department of Agriculture's Census of Agriculture. However, the Census of Agriculture is published every 5-years for years ending in 2 and 7, and not published yearly[20]. For this, reason the 2017 Census of Agriculture was used to estimate livestock GHG emissions.

Census of Agriculture data on the number of livestock (head) are available at the state and county geographic scales, but not at the city geographic scale. However, data on the number and size of livestock operations are available at the zip code level. Using these constraints, a scaling factor was developed for each livestock category; the ratio of livestock operations in City of Phoenix zip codes to livestock operation in the county.

[17] U.S. EPA. 2022. Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020. Appendix 3, Part B. U.S. Environmental Protection Agency, EPA 430-P-22-001. https://www.epa.gov/ghgemissions/draft-inventory-us-greenhouse-gas-emissions-and-sinks-1990-2020.
[18] Ibid.
[19] Ibid.
[20] United States Department of Agriculture. National Agricultural Statistics Service - Census of Agriculture. URL: https://www.nass.usda.gov/AgCensus/.

This analysis found 151 cattle operations related with City of Phoenix zip codes and 610 cattle operations county-wide; 33 sheep operations related with City of Phoenix zip codes and 96 county-wide; and 20 swine operations associated with City of Phoenix zip codes and 104 hog operations county-wide[21]. It should be noted that these estimates provide an upper bound on livestock estimates for the City of Phoenix because they take into account the full zip code area, and zip codes located on the periphery of the city boundary, which are more likely to contain livestock operations, may contain a livestock operation though the livestock operation is not physically within the city boundary. Additionally, this analysis revealed numerous livestock operations associated with zip codes in the city center. Therefore, Census of Agriculture zip code level data may be associated with the physical address of the company owning the livestock operation, but not the physical location of the operation itself. Further, City of Phoenix code specifies which animals are allowed to be owned within the city boundary and city code currently forbids swine ownership within city limits except for certain types of pet pigs. Taking these factors into account, zip codes on the periphery of the city with livestock operations and city code, a more realistic upper bound estimated is 2-52 cattle operations, 0-19 sheep operations, and 0 swine operations. It should be noted that a satellite imagery evaluation of the Census of Agriculture data could only located two dairy facilities physically within the City of Phoenix boundary, while most were located adjacent to the city boundary in unincorporated county islands.

In the 2017 Census of Agriculture, Maricopa County had an estimated 210,980 cattle; 2,575 sheep and lamb; and 1,124 hogs and pigs[22]. Using the scaling factors described in the previous paragraph, the estimated City of Phoenix cattle population was 692-17,985 cattle; 0-510 sheep, and 0 swine. It should be noted that the horse population of the City of Phoenix was not estimated as these data were not available in the Census of Agriculture. Livestock emissions from enteric fermentation and manure management are calculated by multiplying livestock population by animal type by animal type emissions factors[23]. Animal type emissions factors were obtained and derived from the U.S. EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020*[24]*.* Table B1 shows estimated GHG emissions from enteric termination.

Table B13. Estimated CH_4 Emissions from Enteric Fermentation in the City of Phoenix

Livestock	Head	CH_4 Emissions Factor (kg CH_4 per head per year)	CH_4 Emissions (MT CH_4)	CH_4 Emissions (MT CO_2e)
Cattle	692 – 17,985	153.00	106 – 2,752	2,965 – 77,048
Sheep and Lamb	0 – 510	9.00	0 – 459	0 – 128.43
Swine	0	1.50	0	0
Total	**–**	**–**	**106 – 3,211**	**2,965 – 77,176**

[21] USDA National Agricultural Statistics Service. (2017). NASS - Quick Stats. USDA National Agricultural Statistics Service. https://data.nal.usda.gov/dataset/nass-quick-stats. Accessed 2022-02-18.
[22] Ibid.
[23] 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
[24] EPA. 2022. Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020. Appendix 3, Part B. U.S. Environmental Protection Agency, EPA 430-P-22-001. https://www.epa.gov/ghgemissions/draft-inventory-us-greenhouse-gas-emissions-and-sinks-1990-2020.

Table B2 shows estimated GHG emissions from manure management, which is several times lower than the emissions from enteric fermentation.

Table B14. Estimated CH_4 Emissions from Manure Management in the City of Phoenix

Livestock	Head	CH_4 Emissions Factor (kg CH_4 per head per year)	CH_4 Emissions (MT CH_4)	CH_4 Emissions (MT CO_2e)
Cattle	692 – 17,985	23.82	16 – 428	462 – 11,995
Sheep and Lamb	0 – 510	0.21	0 – 0.11	0 – 3.00
Swine	0	416.73	0.00	0.00
Total	**–**	**–**	**16 – 428.11**	**462 – 11,998**

Table B3 shows estimated N_2O emissions from manure management. This is the smallest component of the GHG emissions emitted from the livestock sector.

Table B15. Estimated N_2O Emissions from Manure Management in the City of Phoenix

Livestock	Head	N_2O Emissions Factor (kg N_2O per head)	N_2O Emissions (MT N_2O)	N_2O Emissions (MT CO_2e)
Cattle	692-17,985	1.16	0.80-21	212-5,519
Sheep and Lamb	0-510	0.07	0-0.03	0-8.83
Swine	0	0.00	0.00	0.00
Total	**–**	**–**	**0.80 – 21.03**	**215 – 5,271**

Finally, Table B4 shows = total estimated GHG emissions by livestock type for both enteric fermentation and manure management.

Table B16. Estimated GHG Emissions from Manure Management in the City of Phoenix

Livestock	Head	CH_4 Emissions (MT CO_2e)	N_2O Emissions (MT CO_2e)	Total Emissions (MT CO_2e)
Cattle	692 – 17,985	3,426 – 89,043	212 – 5,519	3,368 – 94,562
Sheep and Lamb	0 – 510	0 – 131	0 – 9	0 – 140
Swine	0	0	0	0
Total	**–**	**3,426 - 89,174**	**212 – 5,528**	**3,368 - 94,702**

B.2 Land Use & Land Use Change

Land sector GHG emissions fall into two broad categories: GHG emissions from the changes in carbon stocks from land use and from changes in carbon stocks resulting from land use change. Changes in carbon stock from both land use and land use change requires in depth analysis on carbon stock by land use type in the City of Phoenix. This section contains a reproducible method for creating the land use and land use change data required for calculating the change in carbon stocks to calculate Land Use GHG emissions.

There are multiple comprehensive land cover databases that are open source and free to download. However, two provide a long history of comparable data for this analysis. First, the USDA Cropland Data Layer (CDL), which dates to 2008, is a satellite imagery data product that contains information on crop types under cultivation at 30-to-56-meter resolution for the continental United States[25]. The Cropland Data Layer provides high resolution of land cover type by crop, natural landcover, and type of urban settlement. Second, is the National Land Cover Database (NLCD) produced by the United States Geological Survey, provides land cover data on 16 land cover classes at a 30-meter resolution[26]. Since NLCD data date to 2001 and have a consistent resolution over time, these data were used to develop the method. However, CDL data could be used in the future to provide greater resolution for crop-specific carbon stock and soil management GHG emissions estimations.

A detailed summary of land use types by area, and changes between 2001 and 2019, within current City of Phoenix boundaries is shown below in Table B5. Definitions of these land use types can be found at the Multi-Resolution Land Characteristics Consortium website.[27]

Table B17. Estimated Land Use by Type in the City of Phoenix Between 2001 and 2019

Land Cover (sq mi.)	Year								
	2001	2004	2006	2008	2011	2013	2016	2019	Change 2001-19
Open Water	1.1	1.1	1.1	1.2	1.4	1.4	1.1	1.1	-0.1
Developed, Open Space	26.4	26.6	28.7	30.1	31.9	30.7	30.9	30.9	4.5
Developed, Low Intensity	69.1	70.6	75.7	80.3	81.3	81.2	81.3	81.1	12.0
Developed, Medium Intensity	128.5	130.4	137.6	144.0	145.7	147.4	148.9	151.8	23.3
Developed, High Intensity	46.5	47.9	50.7	53.3	54.1	55.4	56.2	58.3	11.8
Barren Land	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0
Shrub, Scrub	224.3	222.5	211.8	199.3	194.6	193.3	191.5	186.6	-37.7
Grassland/Herbaceous	2.3	2.3	2.3	2.3	2.3	2.4	2.6	4.1	1.8

[25] USDA National Agricultural Statistics Service Cropland Data Layer. 2019. Published crop-specific data layer [Online]. Available at https://nassgeodata.gmu.edu/CropScape/ (accessed 14 February 2022; verified 18 February 2022). USDA-NASS, Washington, DC.
[26] Dewitz, J., and U.S. Geological Survey, 2021, National Land Cover Database (NLCD) 2019 Products (ver. 2.0, June 2021): U.S. Geological Survey data release, https://doi.org/10.5066/P9KZCM54
[27] Multi-Resolution Land Characteristics Consortium (n.d.). National Land Cover Database Class Legend and Description [Online]. Available at: https://www.mrlc.gov/data/legends/national-land-cover-database-class-legend-and-description (accessed 22 March 2022; verified 22 March 2022). MRLC, Washington D.C.

Pasture/Hay	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Cultivated Crops	30.9	27.7	21.2	18.6	17.9	17.4	16.8	15.3	-15.7
Woody Wetlands	1.0	1.0	0.8	0.8	0.8	0.8	0.8	0.8	-0.2
Emergent Herbaceous Wetlands	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Total	**530.5**	**530.5**	**530.5**	**530.5**	**530.5**	**530.5**	**530.5**	**530.5**	**0.0**

A simplified version of Table B5 is shown in Table B6. The Land Cover categories in Table B5 have been condensed to four major categories: open water, developed land, open space/desert, and cropland. Table B6 shows that the growth in developed area has come about from the conversion of cropland and open space/desert land covers.

Table B18. Simplified Table of Land Use by Type in the City of Phoenix Between 2001 and 2019

Land Cover (sq mi.)	Year								
	2001	2004	2006	2008	2011	2013	2016	2019	Change 2001-19
Open Water	1.1	1.1	1.1	1.2	1.4	1.4	1.1	1.1	-0.1
Developed Land	270.4	275.5	292.7	307.8	313.0	314.8	317.3	322.2	51.7
Open Space/Desert	227.9	226.1	215.3	202.8	198.1	196.8	195.3	191.9	-36.0
Cropland	31.0	27.8	21.3	18.7	18.0	17.5	16.8	15.3	-15.7
Total	**530.5**	**530.5**	**530.5**	**530.5**	**530.5**	**530.5**	**530.5**	**530.5**	**0.0**

As shown in Tables B5 and B6, the growth of developed areas in the City of Phoenix has resulted from the conversion of open space/desert and cropland. Calculating year-over-year changes in carbon stocks from land use and land use types has two major considerations. Land that remains in specified land use category and land that changes between land use categories. Per GPC and IPCC guidance, land use changes that occur within 20 years of the current inventory year need to be accounted for as land use changes, and land use changes that occur more than 20 years before the inventory year are not counted as land use changes.[28] For the 2022 inventory year, the NLCD will provide 20+ year of land cover data to accurately account for this cutoff. However, the fundamental challenge to calculating the change in carbon stocks from land use change within Phoenix boundaries is that established methods do not explicitly consider desert land use types. This first estimate was calculated assuming the grassland land use type.[29] Additional research studies are required to accurately tabulate the change in carbon stocks from land use changes in the City of Phoenix as it is a desert climate.

[28] 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

[29] U.S. EPA. 2022. Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020. Appendix 3, Part B. U.S. Environmental Protection Agency, EPA 430-P-22-001. https://www.epa.gov/ghgemissions/draft-inventory-us-greenhouse-gas-emissions-and-sinks-1990-2020.

B.3 Aggregate Sources And Non-CO_2 Emissions Sources On Land

GHG emission from aggregate sources and non-CO_2 emissions sources on land were not inventoried in 2022. However, estimates will be co-developed along with the development of Land Use and Land Use Change GHG emissions.

B.4 Food System GHG Emissions

The Food System GHG emissions inventory captures GHG emissions from the production, manufacturing, distribution, and consumption of food products at restaurants and retail establishments. It is a full life cycle GHG emissions inventory of the food consumption patterns of City of Phoenix residents. For 2020, food system GHG emissions were estimated to be approximately 5,591,820 MT CO_2e with a minimum/maximum range of 4,080,490 to 8,511,300 MT CO_2e. In 2020, overall food system GHG emissions for the City of Phoenix resident population, across the lifecycle of food from farm to table, are approximately 37% of total community-scale GHG emissions and may range from 27%-56% of total community-scale GHG emissions.

Numerous methodologies exist to conduct a food system GHG emissions inventory, including consumption-based emissions inventory methods and life cycle analysis (LCA) based methods. The food system GHG emissions estimate for the City of Phoenix uses published average per capita emissions numbers for the entire U.S. food supply chain[30]. Mohareb et al. (2018) conducted a meta-analysis of food system LCAs to establish, "representative carbon footprint values for a diversity of food commodities" for U.S. food consumption that includes "processing, packaging, transportation, distribution, retail, household preparation, and waste disposal[31]." Per capita GHG emissions factors are shown in Table B7.

Table B19. Per Capita Food System U.S. GHG Emissions Intensities for Food Supply Chain Steps[32]

Food System GHG Category	Average	Min	Max
Production & Primary Processing	**1935.8**	**1158**	**3366.1**
Nuts	*8.2*	*5.7*	*10.8*
Fresh Fruit	*33.2*	*13.7*	*68.5*
Added Sugar and Sweeteners	*39.5*	*39.5*	*39.5*
Processed Fruit	*40.4*	*32.8*	*54*
Fish and Seafood	*45.8*	*10*	*84.8*
Fresh Vegetables	*46.9*	*12.6*	*231.6*
Eggs	*47.4*	*20.4*	*100.7*
Processed Vegetables	*53.8*	*34.8*	*82.1*
Grain Products	*57.6*	*35.2*	*75.6*
Fluid Milk	*104.4*	*74.5*	*136.8*
Added Fats and Oils	*115.5*	*68.7*	*262*
Other Dairy Products	*246.6*	*202.7*	*301.6*
Meat	*1096.5*	*607.4*	*1918.1*

[30] Mohareb, E. A., Heller, M. C., & Guthrie, P. M. (2018). Cities' role in mitigating United States food system greenhouse gas emissions. Environmental science & technology, 52(10), 5545-5554.
[31] Ibid.
[32] Mohareb, E. A., Heller, M. C., & Guthrie, P. M. (2018). Cities' role in mitigating United States food system greenhouse gas emissions. Supporting Information. Environmental science & technology, 52(10), 5545-5554.

Secondary Processing	**109.03**	**109.03**	**109.03**
Packaging Materials	**114.12**	**77.97**	**131.22**
Distribution	**238.5**	**214.55**	**264.5**
Retail	**390.6**	**370.79**	**410.41**
Food Service	**179.39**	**179.39**	**179.39**
Grocery Trips	**49.41**	**8.05**	**292.96**
Household	**309.65**	**309.65**	**309.65**
Landfill - Food	**445.04**	**164.71**	**745.12**
Landfill - Sludge	**26.32**	**18.24**	**36.72**
Wastewater	**59.16**	**59.16**	**59.16**
Composting	**3.24**	**0.2**	**4.4**
Emissions	*4.75*	*0.4*	*9.51*
Fertilizer Offset from Composting	*-0.66*	*-0.08*	*-1.72*
Carbon Stored in Land Application	*-0.85*	*-0.12*	*-3.39*
Anaerobic Digesting	**-0.09**	**0.05**	**-0.25**
Emissions	*0.15*	*0.11*	*0.22*
Fertilizer Offset from Composting	*-0.14*	*-0.03*	*-0.28*
Carbon Stored in Land Application	*-0.07*	*-0.03*	*-0.12*
Offset from Electricity	*-0.03*	*0*	*-0.07*
Total Emissions (kg CO2e/cap)	**3860.17**	**2669.79**	**5908.41**

While Table B7 shows all GHG emissions factors developed by Mohareb et al. (2018), the City of Phoenix government operations and community GHG emissions inventories, contain GHG emissions totals from landfilling, composting, and wastewater. In order to avoid double counting within the system, the food system GHG emissions inventory only includes GHG emissions factors from production & primary processing to household use categories (farm-to-table), yield an average per capita emissions total of 3,326 kg CO_2e per capita, a minimum per capita emissions rate of 2,427 kg CO_2e per capita, and a maximum per capita emissions rate of 5,063 kg CO_2e per capita. However, it should be noted GHG emissions from local food production and processing will occur by default.

Given these emissions factors, the estimated food system GHG emissions is 5,591,820 MT CO2e with range of 4,080,490-8,511,300 MT CO_2e (Table B8). As these lifecycle inventory emissions factors are on a per capita basis, they scale with population.

Table B20. Estimated Farm-to-Table GHG Emissions of the City of Phoenix Food System

Inventory Boundary	2012	2016	2018	2020
Resident Population	1,499,274	1,612,199	1,654,675	1,680,992
Food System Minimum GHG Emissions (MT CO_2e)	3,639,383	3,913,500	4,016,608	4,080,490
Food System Average GHG Emissions (MT CO_2e)	4,987,335	5,362,980	5,504,276	5,591,820
Food System Maximum GHG Emissions (MT CO_2e)	7,591,214	8,162,983	8,378,050	8,511,300

A detailed breakdown of 2020 food system GHG emissions by component is shown in Table B9. As shown in numerous studies, meat production, processing, and consumption is the single largest contributor to the City Phoenix's farm-to-table food system GHG emissions total.

Table B21. Estimated Farm-to-Table GHG Emissions of the City of Phoenix Food System

Food System GHG Category	Average	Min	Max
Production & Primary Processing	**3,254,064**	**1,946,589**	**5,658,387**
Nuts	13,784	9,582	18,155
Fresh Fruit	55,809	23,030	115,148
Added Sugar and Sweeteners	66,399	66,399	66,399
Processed Fruit	67,912	55,137	90,774
Fish and Seafood	76,989	16,810	142,548
Fresh Vegetables	78,839	21,180	389,318
Eggs	79,679	34,292	169,276
Processed Vegetables	90,437	58,499	138,009
Grain Products	96,825	59,171	127,083
Fluid Milk	175,496	125,234	229,960
Added Fats and Oils	194,155	115,484	440,420
Other Dairy Products	414,533	340,737	506,987
Meat	1,843,208	1,021,035	3,224,311
Secondary Processing	**183,279**	**183,279**	**183,279**
Packaging Materials	**191,835**	**131,067**	**220,580**
Distribution	**400,917**	**360,657**	**444,622**
Retail	**656,595**	**623,295**	**689,896**
Food Service	**301,553**	**301,553**	**301,553**
Grocery Trips	**83,058**	**13,532**	**492,463**
Household	**520,519**	**520,519**	**520,519**
Total Emissions (MT CO_2e)	**5,591,820**	**4,080,490**	**8,511,300**

Appendix C. Stationary Energy – Natural Gas Documentation

Appendix C describes the data collection and data processing for obtaining natural gas consumption data and calculating GHG emissions from natural gas combustion. Appendix C also describes any changes to data sources and methodologies in the 2018 community-scale GHG emissions inventory.

C.1 Natural Gas Data Collection

Stationary Energy GHG emissions from the combustion of natural gas occur at residential buildings, commercial and institutional buildings and facilities, manufacturing industries and construction, energy industries, agriculture, forestry, and fishing activities, non-specified sources, fugitive emissions from mining, processing, storage, and transport of coal, and fugitive emissions from oil and natural gas systems. Natural gas consumption data were obtained from the Southwest Gas Corporation (Southwest Gas), which is the only natural gas utility that services the city. Natural gas data were obtained for each GHG emissions inventory as the inventory was being compiled.

A similar data request process was followed for each of the GHG emissions inventory years. For 2012 and 2016, Southwest Gas provided consumption data at the zip code resolution for residential buildings, commercial and institutional buildings and facilities, manufacturing industries and construction, energy industries, agriculture, forestry, and fishing activities, and non-specified sources. For 2018 and 2020, Southwest Gas did not provide zip code level data. Southwest Gas provided total annual consumption data for residential buildings, commercial and institutional buildings and facilities, manufacturing industries and construction, energy industries; agriculture, forestry, and fishing activities, and non-specified sources.

C.2 Natural Gas Data Processing

For 2012 and 2016, zip code level data were scaled to the percentage of land area in a zip code that was within the city. Natural gas consumption data were scaled only for zip codes which contained a fraction of land within and outside the city boundary. Upon follow up evaluation of the natural gas data previously provided by Southwest Gas; it was found that this scaling of natural gas data by the percent area of a zip code with the City of Phoenix was not necessary. Previously, zip code level natural gas consumption was scaled by percent land area within the City boundary. However, a review of the previous 2012 and 2016 datasets found that if a zip code was associated with more than one Phoenix metropolitan area city the consumption was reported for each city associated with that zip code. To avoid under-reporting natural gas consumption, the zip code scaling factors which were used previously were no longer used. For this reason, 2012 and 2016 community-scale GHG emissions from natural gas combustion were revised upwards (See Section Appendix A.3).

Using the data provided by Southwest Gas, the following equation was used to calculate GHG emissions from Stationary Energy natural gas consumption.

$$GHG_{NG,i,j,y} = NG_{i,y} \times CF \times EF_{NG,j}$$

Where, $GHG_{NG,i,j,y}$ = The GHG emissions in metric tons from natural gas (NG) consumption from a Stationary Energy sector (*i*) for a GHG (*j*) for a GHG emissions inventory year (*y*).

$NG_{i,y}$ = Natural gas (NG) consumption from a Stationary Energy sector (*i*) for a GHG emissions inventory year (*y*) in therms.

CF = Conversion factor for converting data reported in therms to million British thermal units (mmBTU).

$EF_{NG,j}$ = The natural gas consumption GHG emissions factor for CO_2, CH_4, N_2O (*j*).

Finally, natural gas consumption GHG emissions were converted to metric tons of carbon dioxide equivalent (MT CO_2e) by multiplying $GHG_{NG,i,j,y}$ by global warming potential $GWP_{AR5,j}$ and summed across GHGs (*j*).

C.3 Changes between inventory years

As mentioned in Section Appendix B.1, the natural gas consumption data for 2012 and 2016 in the 2018 GHG emissions inventory were not scaled unlike the previous 2012 and 2016 GHG emissions inventories. A comparison between the scaled (previously reported) and unscaled natural gas consumption for 2012 and 2016 is shown below in Table C1.

Table C1. Changes to Natural Gas GHG Emissions Due to Updated Scaling Methods

Year	Scaled Natural Gas Use (kilotherms)	Scaled GHG Emissions (MT CO_2e)	Unscaled Natural Gas Use (kilotherms)	Unscaled GHG Emissions (MT CO_2e)	ΔGHG Emissions (MT CO_2e)	% Change
2012	122,983	650,267	151,881	806,722	156,455	24%
2016	128,256	678,147	151,584	805,753	127,606	19%

The result of using unscaled natural gas consumption data increases total Stationary Energy GHG emissions by approximately 2% over reported 2012 and 2016 levels.

Appendix D. Stationary Energy – Electricity Documentation

Appendix C describes the data collection and data processing for obtaining electricity consumption data and calculating GHG emissions from electricity consumption. This appendix also describes any changes to data sources and methodologies in the 2018 community-scale GHG emissions Inventory.

D.1 Electricity Data Collection

Stationary Energy GHG emissions from the consumption of purchased electricity can occur at residential buildings, commercial and institutional buildings and facilities, manufacturing industries and construction facilities, energy industry facilities, agriculture, forestry, and fishing activities, and non-specified sources.

Electricity consumption data for the Community GHG Emissions Inventory were obtained from Arizona Public Service (APS) and the Salt River Project (SRP). APS and SRP are the only electric utilities that provide electricity to consumers within the city boundary. Electricity data were obtained from APS and SRP for each GHG emissions inventory as the inventory was being compiled – i.e., 2012 data were collected while conducting the 2012 community-scale inventory, 2016 data were collected while conducting the 2016 community-scale inventory, and 2018 data were collected while conducting the 2018 community-scale inventory, and 2020 data were collected while conducting the 2020 community-scale inventory.

Both APS and SRP have electricity generation facilities located within the Phoenix metropolitan area, but only APS has an electricity generation facility within city boundaries – the APS West Phoenix Power Plant. The APS West Phoenix Power Plant is a 997 MW natural gas facility located in southwest Phoenix.[33] The APS West Phoenix Power Plant is included in the 2020 community-scale inventory as emissions from energy generation supplied to the grid (eGRID). Emissions from the APS West Phoenix Power Plant are included in this inventory as an information item (Appendix A, GPC ref. no I.4.4), and are not tabulated as part of the community-scale inventory per GPC guidelines. APS West Phoenix Power Plant emissions for 2012, 2016, 2018, and 2020 were obtained from the EPA Greenhouse Gas Reporting Program through the Facility Level Information on GreenHouse gases Tool (FLIGHT).[34]

A similar data request process was followed for each of the GHG emissions inventory years. For 2012 and 2020, APS provided consumption data at the zip code resolution for residential, commercial, and industrial consumers. However, for 2016 and 2018, APS only provided total consumption data for residential, commercial, and industrial

[33] Pinnacle West Capital Corporation (2019). 2018 Annual Report. URL: http://s22.q4cdn.com/464697698/files/doc_financials/annual/2018/Annual-Report_2018_Web.pdf
[34] U.S. Environmental Protection Agency (2019). EPA Greenhouse Gas Reporting Program through the Facility Level Information on GreenHouse gases Tool URL: https://ghgdata.epa.gov/ghgp/main.do

consumers for zip codes associated with the City of Phoenix. Unlike APS, SRP only provided total consumption for residential and commercial consumers within the City of Phoenix.

D.2 Electricity Data Processing

D.2.1 APS Electricity Data Processing

Using the data provided by APS, the following equation was used to calculate GHG emissions from Stationary Energy electricity consumption in 2012 and 2020.

$$GHG_{APS,i,j,scaled,y} = \sum_z EC_{APS,i,z,y} \times SF_{i,z,y} \times CF \times EF_{AZNM,j,y}$$

Where, $GHG_{APS,i,j,scaled,2012}$ = The scaled GHG emissions in metric tons from purchased electricity from APS for a Stationary Energy subsector (*i*) for a GHG (*j*) for inventory year (y) 2012 and 2020.

$EC_{APS,i,z,2012}$ = Purchased electricity from APS for a Stationary Energy subsector (*i*) in zip code (z) for inventory year (y) 2012 and 2020.

$SF_{i,z,y}$ = Scaling factor for zip code (*z*) for inventory year (y) 2012 and 2020.. The scaling factor the % of land area in *z* that is within the city boundary. $SF_{i,z,y}$ ranges from near 0 to 1.

CF = Conversion factor to convert kWh to MWh. If data were reported in the MWh, *CF = 1*. If data were reported in kWh than CF = 0.001.

$EF_{AZNM,j,y}$ = The eGRID[35] emissions factor for the AZNM subregion for GHG emissions factor for CO_2, CH_4, N_2O (*j*) for eGRID reporting year (*y)*.

Zip code level data from APS were not available for calendar years 2016 and 2018. Therefore, the 2012 data (SF_{2012}) were used to develop the scaling factors for 2016 and 2018:

$$SF_{APS,2012} = \sum_{i,z} EC_{APS,i,z,2012} \times SF_{i,z,2012} \Big/ \sum_{i,z} EC_{APS,i,z,2012}$$

Where, $SF_{APS,2012}$ = Is the overall scaling factor for APS data in calendar year 2012. It is the ratio of the total purchased electricity from APS within the city scaled by zip code specific scaling factors to the reported total unscaled purchased electricity from APS within the city.

[35] The eGRID database inventories plant-level 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 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.

$EC_{APS,i,z,2012}$ = Purchased electricity from APS for a Stationary Energy subsector (*i*) in zip code (z) for an inventory year 2012.

$SF_{i,z,2012}$ = Scaling factor for zip code (*z*). The scaling factor the % of land area in *z* that is within the city boundary. $SF_{i,z,2012}$ ranges from near 0 to 1.

Therefore,

$$GHG_{APS,scaled,i,j,y} = \sum_z EC_{APS,i,z,y} \times SF_{APS,2012} \times EF_{AZNM,j,y}$$

.

Where, $GHG_{APS,scaled,i,j,y}$ = The scaled GHG emissions in metric tons from purchased electricity from APSY for a Stationary Energy subsector (*i*) for a GHG (*j*) for an inventory year 2016 or 2018 (*y*).

$SF_{APS,2012}$ = Is the overall scaling factor for APS data in calendar year 2012. It is the ratio of the total purchased electricity from APS within the city scaled by zip code specific scaling factors to the reported total unscaled purchased electricity from APS within the city.

$EF_{AZNM,j,y}$ = The eGRID emissions factor for the AZNM subregion for GHG emissions factor for CO_2, CH_4, N_2O (*j*) for eGRID reporting year (*y)*.

Next, electricity consumption for the Lake Pleasant Water Treatment Plant (obtained from the City of Phoenix Government Operations GHG Emissions Inventory) was added to the APS electricity total to account its removal during the scaling process. Finally, GHG emissions from APS electricity consumption were converted to metric tons of carbon dioxide equivalent (MT CO_2e) by multiplying $GHG_{i,j}$ by the GHG-specific global warming potential found in the IPCC AR5 report ($GWP_{AR5,j}$).

D.2.2 SRP Data Processing

For each inventory, SRP provided total residential, commercial, and industrial electricity consumption for accounts within the city boundary. As this data consisted of account holders only within the city boundary, no scaling factor was applied to the data.

Using the data provided by SRP, the following equation was used to calculate GHG emissions from Stationary Energy natural gas consumption.

$$GHG_{SRPi,j,y} = EC_{SRP,i,y} \times CF \times EF_{AZNM,j,y}$$

Where, $GHG_{SRP,i,j,y}$ = The GHG emissions in metric tons from purchased electricity from SRP for a Stationary Energy subsector (*i*) for a GHG (*j*) for an inventory year (*y*).

$EC_{SRP,i,y}$ = Purchased electricity from SRP for a Stationary Energy subsector (*i*) for an inventory year (*y*).

CF = Conversion factor to convert kWh to MWh. If data were reported in the MWh, *CF = 1*. If data were reported in kWH than CF = 0.001.

$EF_{AZNM,j,y}$ = The eGRID emissions factor for the AZNM subregion for GHG emissions factor for CO_2, CH_4, N_2O (*j*) for eGRID reporting year (*y*)..

Finally, GHG emissions from SRP electricity consumption were converted to metric tons of carbon dioxide equivalent (MT CO_2e) by multiplying $GHG_{i,j,y}$ by the GHG-specific global warming potential found in the IPCC AR5 report ($GWP_{AR5,j}$).

D.2.3 Total GHG Emissions from Electricity Consumption

After the GHG emissions from electricity consumption (*EC*) in the SRP and APS service territories were calculated, the following equation was summed across inventory sectors (*i*) and GHGs (*j*) to calculate total GHG emissions from electricity consumption within city boundaries.

$$GHG_{EC,i,j,y} = GHG_{APS,i,j,y} + GHG_{SRP,i,j,y}$$

D.3 Transmission and Distribution Loss (T&D Loss)

GHG emissions from T&D loss were estimated using data obtained from the EIA on Arizona's supply and disposition of electricity from 1990 through 2020.[36] For each inventory year, T&D loss is calculated as the ratio between estimated electricity system losses and the difference between total electricity disposition minus direct use of electricity at power plants.

D.4 Changes between inventory years

For each of the inventory years – 2012, 2016, 2018, and 2020 – electricity consumption has been provided by APS and SRP. SRP data has been provided as an overall total electricity consumption for commercial and residential sectors within City boundaries. For the 2012 community-scale inventory, APS provided zip code level consumption data for commercial, industrial, and residential sectors for zip codes associated with the City. An analysis of this data showed that some of the zip codes with highest reported consumption only had minor portion of the zip code within the City. For example, in the 2012 data the zip code with the highest reported total consumption had less than 1% land area within City boundaries and the zip code with highest reported residential consumption had only 30% land area within City boundaries.

To account for this aspect of the data, a scaling factor was developed to scale reported electricity consumption to City electricity consumption using land area as indicator of electricity consumption. For 2012, a single scaling factor was used, which was a simple ratio of the total area of the City compared to the total area of all zip code for which data was provided. For the 2016 community-scale inventory, the same scaling factor methodology was used because the reported electricity consumption was within 0.5% of 2012 levels. For 2018 community-scale inventory, the scaling methodology was

[36] U.S. Energy Information Administration, Form EIA-923, Power Plant Operations Report and predecessor forms. U.S. Energy Information Administration, Form EIA-860, Annual Electric Generator Report. U.S. Energy Information Administration, Form EIA-861, Annual Electric Power Industry Report. Form EIA-111, Quarterly Imports and Exports Report.

updated for the 2012 data and then applied to 2016 and 2018 data. In the updated method, consumption for each zip code is scaled by the percent land area within the City; electricity consumption for some zip codes are scaled, others are not because those zip codes are entirely within City boundaries. Use of this scaling factor assumes that electricity consumption by customer-type within each zip code is constant through the reporting time period from 2012 to 2018. This assumption and scaling approach may need to be revisited in future community-scale GHG emissions inventories. After data from each zip code are scaled, they are summed to arrive at electricity consumption for the City. The result of this methodological change was to increase GHG emissions from electricity consumption in 2012 and 2016 (Table D1). The 2020 inventory was able to follow the approach of the 2012 inventory because zip-code level data were available.

Table D1. Changes to Scaling Methodologies for Electricity Data

Year	Old Scaling Method		New Scaling Method		ΔGHG Emissions (MT CO_2e)	% Change
	APS Electricity Consumption	GHG Emissions (MT CO_2e)	APS Electricity Consumption	GHG Emissions (MT CO_2e)		
2012 (kWh)*	6,429,328,231	3,102,482	9,873,891,733	4,764,661	1,662,179	54%
2016 (MWh)	5,677,762	2,413,206	9,875,762	4,197,472	1,784,266	74%

**kWh data were provided in 2012; MWh data were provided in 2016 and 2018.*

Appendix E. Transportation Sector Documentation

Transportation Sector GHG emissions are generated by a number of different sources and types of fuel. GHG emissions sources include on-road transport, railways, commercial aviation, civil aviation, and off-road transport. Fuel types consumed gasoline, diesel, B20 biodiesel, E85 ethanol, compressed natural gas (CNG), liquified natural gas (LNG), propane (LPG), aviation gasoline, and jet fuel A. Transportation sector GHG emissions also includes the consumption of purchased electricity to charge electric vehicles and to power electric light rail. Appendix D describes data sources and methods by fuel type.

E.1 Transportation Sector Data Processing

Transportation sector GHG emissions are calculated using a generalized formula.

$$GHG_{i,j,y} = FC_{i,y} \times CF \times EF_{i,j,y}$$

Where, $GHG_{i,j,y}$ = The GHG emissions in metric tons from a transportation fuel (*i*) for a GHG (*j*) for an inventory year (*y*).

$EC_{SRP,i,y}$ = Fuel consumption of a transportation fuel (*i*) for an inventory year (*y*).

CF = Conversion factor to convert fuel consumption data to the units of the emissions factor. A CF is only used when necessary and is equal to 1 when not necessary.

$EF_{i,j,y}$ = The GHG emissions factor in metric tons from a transportation fuel (*i*) for a GHG (*j*) for an inventory year (*y*).

Finally, GHG emissions from transportation fuel consumption were converted to metric tons of carbon dioxide equivalent (MT CO_2e) by multiplying $GHG_{i,j,y}$ by the GHG-specific global warming potential found in the IPCC AR5 report ($GWP_{AR5,j}$).

E.2 On-Road Transport

E.2.1 Gasoline and Diesel

Gasoline and diesel consumption for Maricopa County were obtained from the Arizona Department of Transportation (ADOT) via a public records request. Gasoline and diesel gallonage data are reported to the ADOT in order to obtain funds through the Highway User Revenue Fund (HURF). Historic HURF monthly distribution reports are available through ADOT. ADOT HURF reports contain county-level monthly gasoline and use oil (diesel) sales data.[37] As these data were for the entirety of Maricopa County, gasoline and diesel sales data were scaled using a ratio of City of Phoenix and Maricopa County populations. Per GPC guidance, population is an acceptable scaling factor for

[37] Arizona Department of Transportation. Archived Audits and Reports. *Highway User Revenue Fund (HURF).* URL: https://azdot.gov/node/5069.

population-dependent activity data. A future study would be needed to determine if and how driving behaviors differ by Phoenix metropolitan area city.

E.2.2 Alternative Fuel Vehicles – B20 Biodiesel, E85 Ethanol, CNG, LNG

The *City of Phoenix 2018 GHG Emissions Inventory of Local Government Operations* is the primary source of data for alternative fuel consumption and the resulting GHG emissions within the city boundary. It was assumed that local government operations were the largest consumer of these fuels for transportation within the city boundary and other alternative fuel uses were *de minimis*.

E.2.3 Electric Vehicles

GHG emissions from electric vehicles for 2012, 2016 and 2018 haven been added to the community-scale inventory. National data were used to estimate electric vehicle consumption as local data were not available for estimating these GHG emissions. National-level statistics for annual gasoline consumption and electricity use for mobile transportation were obtained from the EIA Annual Energy Outlook. The ratio between electric energy for transportation and the energy in gasoline usage in the U.S. was used as a proxy to estimate citywide residential electric vehicle usage. GHG emissions from electricity consumption from electric vehicles were calculated according to the method in Appendix C, Section C.2.2.

E.3 Railways

E.3.1 Valley Metro Light Rail

Valley Metro light rail electricity consumption data were obtained from two sources. The National Transit Database[38] used for inventory years 2012 and 2016. The National Transit Database is published by the U.S. Department of Transportation and contains various statistics about public transit systems across the United States, including fuel usage. Electricity usage by Valley Metro is reported to the National Transit Database as Valley Metro Rail, Inc. The National Transit Database had not been published for calendar year 2018 during the time in which the 2018 inventory was compiled. Therefore, 2018 electricity consumption by the Valley Metro light rail system was obtained via a public records request of Valley Metro.

For each inventory year, total Valley Metro electricity usage for rail operations were scaled based on ratio of the length of light rail track within the city compared to the overall length of Valley Metro light rail track. GHG emissions from electricity consumption from the Valley Metro light rail were calculated according to the method in Appendix C, Section C.2.2.

[38] U.S. Department of Transportation. The National Transit Database. URL: https://www.transit.dot.gov/ntd.

E.3.1 Freight Rail

The National Emissions Inventory (NEI)[39] published by U.S. EPA was used to gather data on GHG emissions from freight rail activity in Maricopa County. The 2011 NEI was used as a proxy for 2012, 2016, 2018, and 2020. Please refer to the 2016 community-scale GHG emissions inventory report for a summary of methods to estimate Freight Rail GHG emissions.

E.4 Aviation

E.4.1 Commercial Aviation

The Energy Information Administration (EIA) State Energy Data System (SEDS) was used to gather annual data on Jet Fuel A consumption in the State of Arizona. Next, airport operations data were obtained from the Federal Aviation Administration's (FAA) Operations Network (OPSNET) database for the State of Arizona, Phoenix Sky Harbor Airport, and the Phoenix Deer Valley. The FAA OPSNET data were used to calculate the proportion of commercial airport operations that occurred at the Phoenix Sky Harbor and Phoenix Deer Valley airports relative the State of Arizona. Once this annual scaling factors were calculated, they were multiplied by the annual state-level Jet Fuel A consumption to arrive at estimated Jet Fuel A consumption at the two Phoenix airports. This number was then divided by two to only account for takeoffs. It should be noted that EIA SEDS data are subject to revision from year-to-year.

E.4.2 Civil Aviation

The Energy Information Administration (EIA) State Energy Data System (SEDS) was used to gather annual data on Aviation Gasoline consumption in the State of Arizona. Next, airport operations data were obtained from the Federal Aviation Administration's (FAA) Operations Network (OPSNET) database for the State of Arizona, Phoenix Sky Harbor Airport, and the Phoenix Deer Valley. The FAA OPSNET data were used to calculate the proportion of non-commercial airport operations that occurred at the Phoenix Sky Harbor and Phoenix Deer Valley airports relative the State of Arizona. Once this annual scaling factors were calculated, they were multiplied by the annual state-level Aviation Gasoline consumption to arrive at estimated Aviation Gasoline consumption at the two Phoenix airports. This number was then divided by two to only account for takeoffs. It should be noted that EIA SEDS data are subject to revision from year-to-year.

E.5 Off-Road Transportation

E.5.1 Nonroad Diesel

Consumption data for nonroad diesel (dyed diesel) were obtained via a public records request of the Arizona Department of Transportation for dyed diesel sales in Maricopa County. Nonroad (dyed) diesel is only permitted for use in "vehicles and equipment

[39] U.S. Environmental Protection Agency. National Emissions Inventory (NEI). URL: https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei.

used in agriculture (farming and ranching), mining and roadway construction"[40] and illegal for on-road transportation uses. Public records requests were submitted for two different points in time. The public records request for nonroad diesel consumption for calendar year 2016 was submitted in 2017 and data were obtained in 2017. These data had contained origin-destination flows of dyed diesel sales – from the terminal to point of sale – at the city level for Maricopa County. The second public records request for dyed diesel sales in Maricopa County for 2012 and 2018 (submitted as one public records request) yielded aggregate sales in Maricopa County for each calendar year requested. Therefore, the ratio of dyed diesel sales in Phoenix compared to Maricopa County was used as scaling factor for 2012 and 2018 data.

GHG emissions for dyed diesel were calculated using the following equation.

$$GHG_{NonRoadDiesel,Phoenix,j,y} = \begin{cases} DyedDiesel_{Gallons,Phoenix,y} \times EF_{diesel,j} & if\ y = 2016 \\ DyedDiesel_{Gallons,MaricopaCounty,y} \times SF_{Phoenix,2016} \times EF_{diesel,j} & if\ y = 2012, 2018 \end{cases}$$

Where, $GHG_{NonRoadDiesel,Phoenix,j,y}$ = the GHG emissions from red-dyed diesel sold within the city for a GHG (*j*) and an inventory year (*y*).

$DyedDiesel_{Gallons,Phoenix,y}$ = The gallons of red-dyed diesel sold at pumps located within the city in an inventory year (*y*).

$EF_{diesel,j}$ = The diesel emissions factor (*EF*) for a GHG (*j*).

$DyedDiesel_{Gallons,MaricopaCounty,y}$ The gallons of red-dyed diesel sold at pumps located within the Maricopa County in an inventory year (*y*).

$SF_{Phoenix,2016}$ = The ratio between total red-dyed diesel gallons sold at pumps located in the city to the total red-dyed diesel gallons sold in pumps located in Maricopa County for year 2016.

For 2012 and 2016, the 2011 and 2014 US EPA National Emissions Inventory (NEI) were the sources of nonroad diesel GHG emissions, respectively. However, a follow up analysis showed that the amount of CO_2 emissions associated within nonroad diesel use reported in the NEI was equivalent to the volume diesel sold in both 2012 and 2016 in Maricopa County as reported by ADOT. Therefore, it was concluded there was double counting of diesel no. 2 sales for nonroad purposes included in the nonroad diesel GHG emissions in the 2012 and 2016 community-scale GHG emissions inventories (Table E1). To correct for this double-counting, red-dye diesel consumption data for the City (2016) and Maricopa County (2012, 2018) were obtained from ADOT. Red-dye diesel consumption was used as a proxy for nonroad diesel emissions because it is illegal for purchase for on-road transportation. ADOT provided city-specific data for Maricopa County for 2016 and county-level data for 2012 and 2018, so 2016 data was used to scale 2012 and 2018 county-level data to the city-level. Additionally, 2018 data was used as a proxy for 2020 data. With this updated method for estimating

[40] Arizona Department of Transportation (2019). Red-Dyed Diesel Fuel in Arizona. URL: https://azdot.gov/motor-vehicles/professional-services/fuel-tax-information/red-dyed-diesel-fuel-arizona.

non-road diesel consumption, on-road diesel GHG emissions may contain diesel purchased for nonroad purposes, but nonroad diesel GHG emissions only contains GHG emissions for nonroad purposes.

Table E1. Changes to Non-Road Diesel Consumption and GHG Emissions

Year	NEI Data Nonroad Diesel	ADOT Dyed Diesel Sales	ΔGHG Emissions (MT CO_2e)	% Change in GHG Emissions
	GHG Emissions (MT CO_2e)	GHG Emissions (MT CO_2e)		
2012	1,864,570	148,488	-1,716,082	-92%
2016	1,992,217	149,749	-1,842,468	-92%

E.5.2 Other Nonroad GHG Emissions

The NEI was used to gather data on GHG emissions from other nonroad fuel consumption in Maricopa County. The 2011 NEI was used as a proxy for 2012 and the 2014 NEI was used as a proxy for 2016, 2018, and 2020. Other nonroad fuel consumption data were scaled from Maricopa County to the city boundary. These data primarily cover the combustion of propane for nonroad uses.

Appendix F. Waste Sector Documentation

Waste Sector GHG emissions occur from numerous sources: solid waste, wastewater treatment, compost processing, and granulated activated carbon (GAC) hauling and regeneration. Much of these GHG emissions occur due to city's local government operations and as such a description of the methods to calculate these GHG emissions are found in the *City of Phoenix 2018 GHG Emissions Inventory of Local Government Operations*.

F.1 Solid Waste

Solid Waste GHG emissions occur at landfills owned and operated by the city within city boundary, a landfill owned and operated by the city outside city boundary, a privately-owned landfill within the city boundary, and privately-owned landfills outside the city boundary.

GHG emissions from landfills owned and operated by the city were obtained from the *City of Phoenix 2018 GHG Emissions Inventory of Local Government Operations*. Of the seven landfills owned and operated by the city, six are located within the city boundaries – these landfills are closed and no longer accept waste – and the only open landfill is located outside city boundaries. The names of these landfills, the data source, method of GHG emissions calculation, and GPC subsector are described in Table F1.

Table F1. Data and Method Documentation for City-Owned Landfills

Landfill	Activity Data	Source	Method	Active?	GPC Subsector
Skunk Creek	CH_4 Monitoring	City of Phoenix	ICLEI LGOP	No	Disposal of solid waste generated in the city
27th Avenue	CH_4 Monitoring	City of Phoenix	ICLEI LGOP	No	Disposal of solid waste generated in the city
Del Rio	CH_4 Monitoring	City of Phoenix	ICLEI LGOP	No	Disposal of solid waste generated in the city
Deer Valley	CH_4 Monitoring	City of Phoenix	ICLEI LGOP	No	Disposal of solid waste generated in the city
19th Avenue	CH_4 Monitoring	City of Phoenix	ICLEI LGOP	No	Disposal of solid waste generated in the city
Estes	EPA LandGEM Model	City of Phoenix	First Oder Decay	No	Disposal of solid waste generated in the city
SR-85	CH_4 Monitoring	City of Phoenix	ICLEI LGOP	Yes	Disposal of solid waste generated in the city but disposed outside the city

The City of Phoenix only collects municipal solid waste from single family residences within city boundaries. Residents in the city that live in multi-family housing in addition to commercial and industrial establishments are serviced by private haulers. There is one landfill within the city boundary – the Lone Cactus Landfill – owned by a private waste management company. GHG emissions from the Lone Cactus Landfill are reported by Waste Management, Inc. to the EPA Greenhouse Gas Reporting Program. Therefore, GHG emissions from the Lone Cactus Landfill were obtained from the EPA Facility-Level Information on Greenhouse Gas Emissions Tool (Table F2).

Table F2. Data Documentation for Privately-Owned Landfills

Landfill	Activity Data	Owner	Active?	GPC Subsector
Lone Cactus	EPA GHGRP	Waste Management	Yes	Disposal of solid waste generated in the city
Private Haulers	EPA GHGRP/Population	Multiple	Yes	Disposal of solid waste generated in the city but disposed outside the city

Since solid waste is also collected by private haulers and disposed of in privately-owned landfills outside of the city boundary, an additional estimation method was employed to estimate GHG emissions from the landfills attributable to solid waste generated within the City of Phoenix. First, a per capita GHG emissions from solid waste calculated for Maricopa County. To do this, all landfill emissions data reported to the EPA GHGRP within Maricopa County was pulled from EPA FLIGHT for 2012, 2016, and 2018 and converted to a per capita metric using population data obtained from the U.S. Census and City of Phoenix. Next, the number of residents living in multi-family housing in city was estimated using data obtained from the U.S. Census American Housing Survey. Finally, the population data were converted to GHG emissions using the per capita GHG emissions rate, as shown in the equation below.

$$GHG_{PrivateMSW,y} = \frac{\sum_l GHG_{SW,l,Maricopa,y}}{Pop_{Maricopa,y}} \times \left[\left(1 - \frac{\#\ Single\ Family\ Detached\ Housing}{All\ Dwellings}\right)_{PHX\ MSA,y} \times Pop_{Phoenix,y}\right]$$

Where, $GHG_{PivateMSW,y}$ = the GHG emissions from solid waste picked up by private haulers (PrivateHaulers) in an inventory year (*y*).

$\Sigma_l GHG_{SW,l,Maricopa,y}$ = The total reported GHG emissions by all landfills in Maricopa County, Arizona.

$Pop_{Maricopa,y}$ = The population of Maricopa County, Arizona in an inventory year (*y*).

 # Single Family Detach Housing = The number of single-family detached housing units in the Phoenix metropolitan area in an inventory year (*y*).

 # All Dwellings = The number of housing units in the Phoenix metropolitan area in an inventory year (*y*).

$Pop_{Phoenix,y}$ = the population of Phoenix, Arizona in an inventory year (*y*).

F.2 Wastewater Treatment

GHG emissions from wastewater treatment were obtained from the *City of Phoenix 2018 GHG Emissions Inventory of Local Government Operations*. Please refer to the *City of Phoenix 2018 GHG Emissions Inventory of Local Government Operations* for details about monitoring data and method. A summary table is presented below (Table F3).

Table F3. Data Documentation for Wastewater Treatment Plants

Wastewater Treatment Plant	Service Area	GHG Emissions	Data Source	GHG Emissions Methodology	GPC Subsector
23rd Avenue	City of Phoenix	CH_4, N_2O	City of Phoenix CH_4 and effluent monitoring data	ICLEI LGOP	Wastewater generated in the city
91st Avenue	All or Portions of Glendale, Mesa, Phoenix, Scottsdale and Tempe	CH_4, N_2O	City of Phoenix CH_4 and effluent monitoring data	ICLEI LGOP	Wastewater generated in the city

F.3 Compost Processing

GHG emissions from compost processing were obtained from the *City of Phoenix 2018 GHG Emissions Inventory of Local Government Operations*. The city provided data on the total tons of green organic waste diverted to be processed as compost from FY 2005-2006 to FY 2018-19. Using these data, GHG emissions from composting were calculated according to the methodology employed by the EPA to estimate national-level emissions from composting in Section 7.3 of the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017*.[41]

F.4 GAC Hauling and Regeneration

GHG emissions from GAC hauling and regeneration were obtained from the *City of Phoenix 2018 GHG Emissions Inventory of Local Government Operations*. The city provided data on the vehicle miles driven to the GAC recharging facility and the amount and type of energy used at the recharging facility. GHG emissions from GAC Hauling and Regeneration are included as Other Scope 3 GHG emissions.

[41] U.S. EPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017. URL: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2017

City of Phoenix

Report

Agenda Date: 9/7/2022, **Item No.** 5

Update on Drought Management Plan and Water Conservation Efforts

This report provides the Community and Cultural Investment Subcommittee an update on implementation of the City of Phoenix Drought Management Plan, Conservation and Outreach efforts, in response to anticipated further shortages on the Colorado River.

THIS ITEM IS FOR INFORMATION AND DISCUSSION

Summary

Water supply conditions on the Colorado River continue to decline. The two major Lower Basin reservoirs, Lake Mead and Lake Powell, have dropped to storage levels not seen since they were constructed. On Aug. 16, 2022, the U.S. Bureau of Reclamation ("Reclamation") announced a Tier 2a shortage condition on the Colorado River for 2023. This means Phoenix supplies will be cut slightly, but not at a level that will impact customer deliveries. Reclamation announced in June the need to make more significant cuts to deliveries in order to save Lake Mead and Lake Powell; however, no plan has been forthcoming.

Since the Stage 1 Water Alert was declared on June 1, 2022, the Phoenix Water Services Department has increased public education and outreach, along with water conservation efforts, to help educate customers and City of Phoenix residents on why voluntary water conservation is essential to ensure a sustainable future for everyone. Below is a list of some of the work completed:

Outreach and Education

- Following the Stage 1 Alert declaration, a news release was issued which resulted in extensive coverage by local media;
- On June 6, 2022, Water Conservation Media Day was held in which reporters were invited to meet with the City's subject matter experts in a model home to see simple conservation tools that help the average person use less water;
- The Stage 1 Water Alert and water conservation messaging has appeared consistently in the City Services Bill newsletter, along with messaging that promotes the Be Water Smart website, which features easy-to-understand water conservation strategies;

- Media campaigns were implemented using print, digital, radio, outdoor and Grocery TV;
- Water conservation signage was added at Burton Barr Library;
- Water Department staff attended two community events in July 2022 to engage with the public and teach them importance of water conservation; and
- The City's Green Team and Water Services Department are presenting a series that focuses on outdoor water use and conservation for City of Phoenix employees.

Conservation Efforts

- Completed Water Waste Door Hanger pilot (100 distributed), preparing for full launch in fall 2022;
- Coordinated with procurement staff to include landscape watering guidelines as an enforceable standard in City-wide landscaping contract;
- Hosted the second cohort of the citizens' Water Wranglers Conservation Institute with more than 20 participants; and
- Identified more than 10 million additional gallons of annual potential water savings for local homeowners associations.

Phoenix will continue to plan, invest, and conserve to ensure a sustainable future while providing safe, clean, and reliable water to its customers without interruption. Additionally, the City will continue to take proactive actions to prepare for even deeper shortages on the Colorado River as we strive to be the most sustainable desert city in the world. As part of this initiative the Water Services and Planning & Development departments are working to develop policy guidelines for new development to ensure that newly-built projects use water in a sustainable manner. Addressing these issues now helps the City ensure that continued growth can better address future community needs for housing and jobs in Phoenix.

The Planning and Development and Water Services Department worked with homebuilders this past year on stipulations for two rezoning cases to successfully integrate water efficiency standards into all homes along with enhanced standards for landscaping and open space preservation. The focal point in this agreement was the use of EPA WaterSense Certification as a requirement for all new homes and common areas to make them as water efficient as possible. This certification includes WaterSense-compliant landscaping and irrigation design, plumbing fixtures, leak detection audits, as well as a formal review and endorsement by an authorized third-party certification organization for water efficiency. The rezoning stipulations also included limits on turf areas, limiting it to only a certain percentage of backyards and banning it in front yards and in many common areas and right-of-way landscaping zones.

Staff are evaluating how EPA WaterSense or some other kind of third-party water efficiency certification, as well as new standards for turf areas and landscaping, can be incorporated into future development throughout the city. The policy will address all development types (i.e., residential, commercial, industrial) aimed at incorporating drought resilience into developments. In addition, the policy will also address annexation of new land for water service and business expansion of large water users. Staff will also engage stakeholders to review and provide feedback on the draft policies prior to bringing them back to City Council for adoption.

Concurrence/Previous Council Action

- The Water Conservation Ad Hoc Committee was established on Feb. 28, 2019, and presented to City Council in the March 14, 2019, General Information Packet; and
- The Water Conservation Ad Hoc Committee Report was reviewed and approved at the Dec. 10, 2019, City Council Policy Session.
- The Community and Cultural Investment Subcommittee received Drought Management and Water Conservation Ad Hoc Committee updates on June 1, 2022.
- The Transportation, Infrastructure and Planning Subcommittee received an Update on Supply Shortages in the Colorado River on June 15, 2022.

Responsible Department

This item is submitted by Deputy City Managers Karen Peters and Alan Stephenson and the Water Services and Planning and Development departments.