DENVER
PUBLIC HEALTH &
ENVIRONMENT

Electric Vehicle Emissions Analysis

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Introduction

In 2017, the City and County of Denver released, "Opportunities for Vehicle Electrification in the Denver Metro area and Across Colorado"[1] a major report covering a number of critical areas for electric vehicle (EV) adoption. In addition to a focus on fast charging stations and the challenges around multi-family properties, the report provided a detailed analysis of the emissions impact of electric vehicles in the Denver metro area served by Xcel Energy in Colorado.

That analysis found that in the baseline year of 2016, electric vehicles reduced emissions compared to gasoline vehicles and that these reductions became more significant by 2025 as the electricity mix became cleaner.

However, since the publication of the report, there have been major changes in Xcel Energy's trajectory towards reducing emissions in its electricity supply. In August of 2018, Xcel Energy's Colorado Energy Plan was approved by the Colorado Public Utilities Commission. This plan will retire coal fired units and add large amounts of wind, solar and battery storage, making Denver's electricity mix significantly cleaner by 2026.[2] In December of 2018, Xcel Energy also announced their intention to reduce carbon emissions 80% by 2030 compared to 2005 levels across their entire service territory.[3]

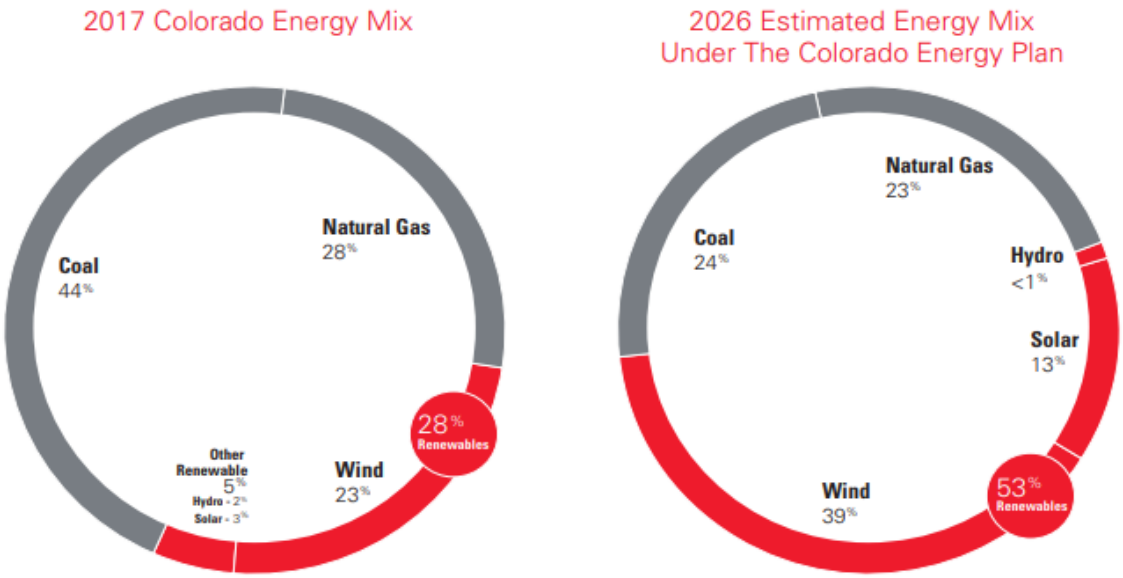

Figure 1. Comparison of Xcel Energy's Colorado Electricity Mix, 2017 and 2026[4]

[1] Denver Department of Public Health and Environment. 2017. Opportunities for Vehicle Electrification in the Denver Metro area and across Colorado. https://www.denvergov.org/content/dam/denvergov/Portals/771/documents/EQ/EV/EVFinalReport.pdf

[2] Xcel Energy. 2018. CO Energy Plan Fact Sheet. https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Resource%20Plans/CO-Energy-Plan-Fact-Sheet.pdf

[3] Xcel Energy. 2018. Xcel Energy aims for zero-carbon electricity by 2050. https://www.xcelenergy.com/company/media_room/news_releases/xcel_energy_aims_for_zero-carbon_electricity_by_2050

[4] Xcel Energy. 2018. CO Energy Plan Fact Sheet. https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Resource%20Plans/CO-Energy-Plan-Fact-Sheet.pdf

The City and County of Denver has also made aggressive commitments to clean energy. As part of its 80x50 Climate Action Plan, released in July of 2018, Denver set a goal to achieve 100% renewable electricity community-wide by 2030.[5] Other municipalities in Xcel Energy's service territory, such as Lafayette, Nederland, Longmont and the City of Boulder, have made similar pledges to achieve 100% renewable electricity in their communities by 2030. If these cities meet this renewable electricity goals, this will make electric vehicles zero emission vehicles.

These advances toward a much cleaner electricity mix in the Denver metro area warranted an update of the electric vehicle emissions analysis to better understand the impacts on emissions from the transportation sector.

Denver and the surrounding areas face serious air quality challenges, and mobile source emissions are the leading cause of ground-level ozone in the region.[6] Supporting widespread adoption of EVs is an important strategy for addressing air quality in the region and improving the health of the area's residents.

[5] Denver Department of Public Health and Environment. 2018. 80x50 Climate Action Plan. https://www.denvergov.org/content/dam/denvergov/Portals/771/documents/EQ/80x50/DDPHE_80x50_ClimateActionPlan.pdf

[6] Environmental Protection Agency. 2019. 2014 National Emissions Inventory Report. https://gispub.epa.gov/neireport/2014/

Findings

A well-to-wheels emissions analysis shows that in the Denver metro area, electric vehicles reduce emissions of pollutants compared to a similar gasoline-fueled vehicle. This analysis uses the average power mix in the Denver metropolitan area.

Table 1. 2018 Lifecycle Emissions Profile, mg/mile

Pollutant	New Gasoline Car	New Electric Vehicle	% Reduction
NOx	108	31	71%
VOC	135	2	99%
GHG	323,060	213,270	34%

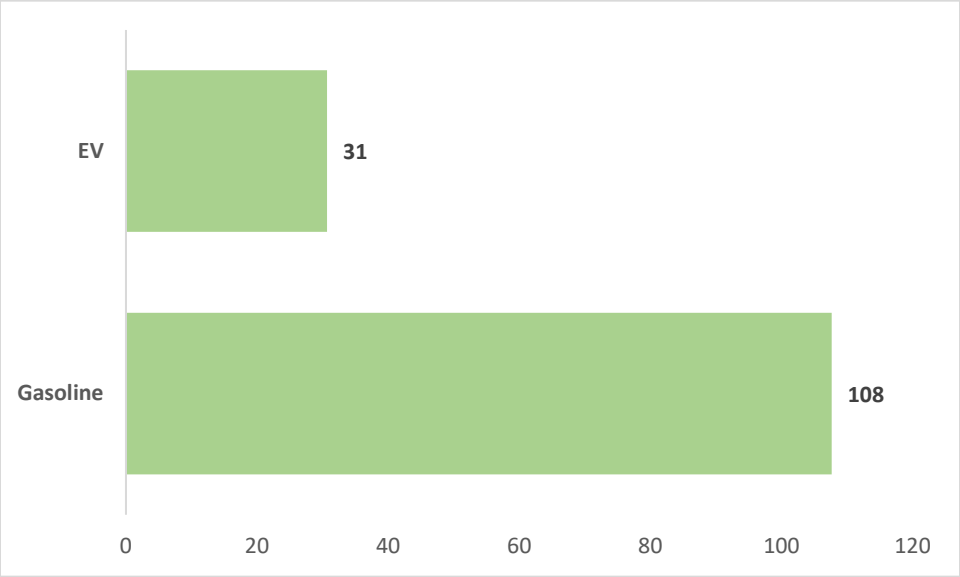

Figure 2. NOx Emissions in Denver by Vehicle Type in 2018, mg/mile

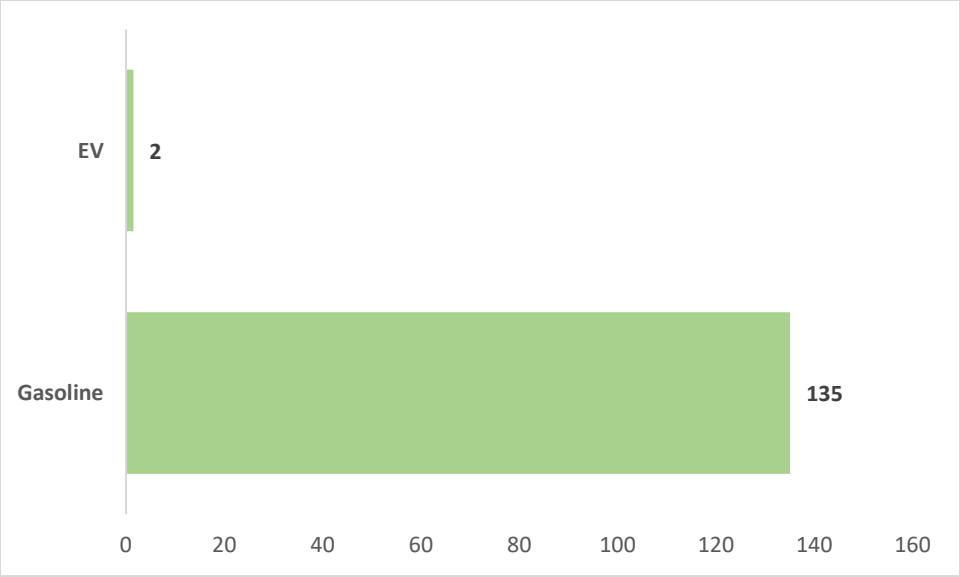

Figure 3. VOC Emissions in Denver by Vehicle Type in 2018, mg/mile

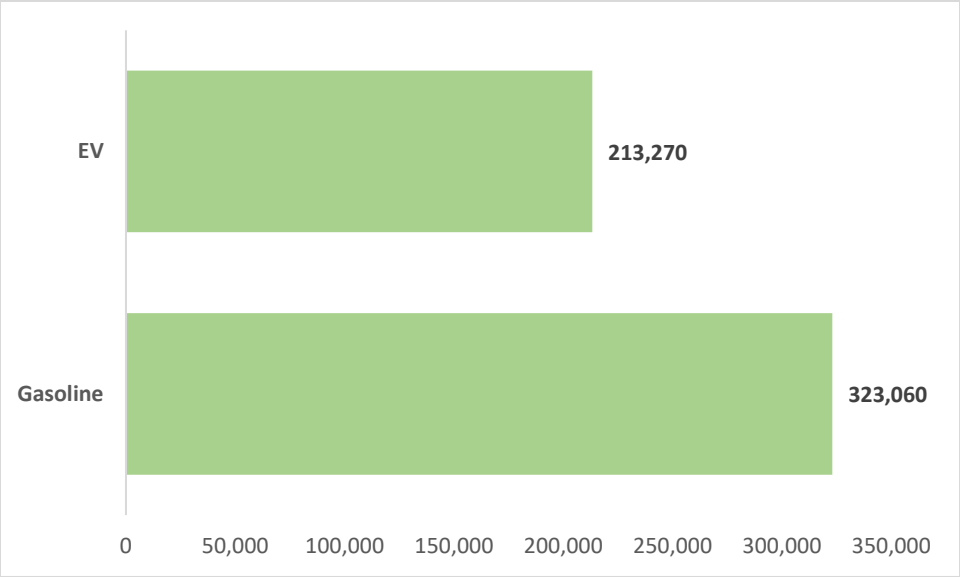

Figure 4. GHG Emissions in Denver by Vehicle Type in 2018, mg/mile

Based on the GHG emissions of an EV in 2018, it would be the equivalent of a gasoline vehicle with an on-road fuel economy of 52 mpg.

2026 Results

This analysis used the projected electricity mix for 2026 based on the Colorado Energy Plan and the projected fuel economy of new gasoline vehicles based on Colorado's adoption of the Low Emission Vehicle Standard.

Table 2. 2026 Projected Lifecycle Emissions Profile, mg/mile

Pollutant	New Gasoline Car	New Electric Vehicle	% Reduction
NOx	69	11	83%
VOC	95	1	98%
GHG	256,420	106,240	59%

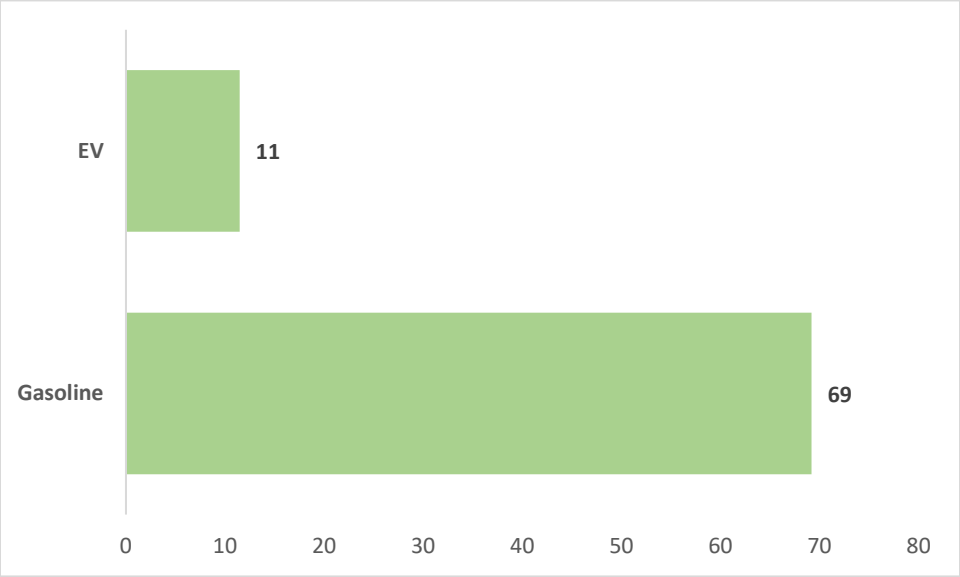

Figure 5. NOx Emissions in Denver by Vehicle Type in 2026, mg/mile

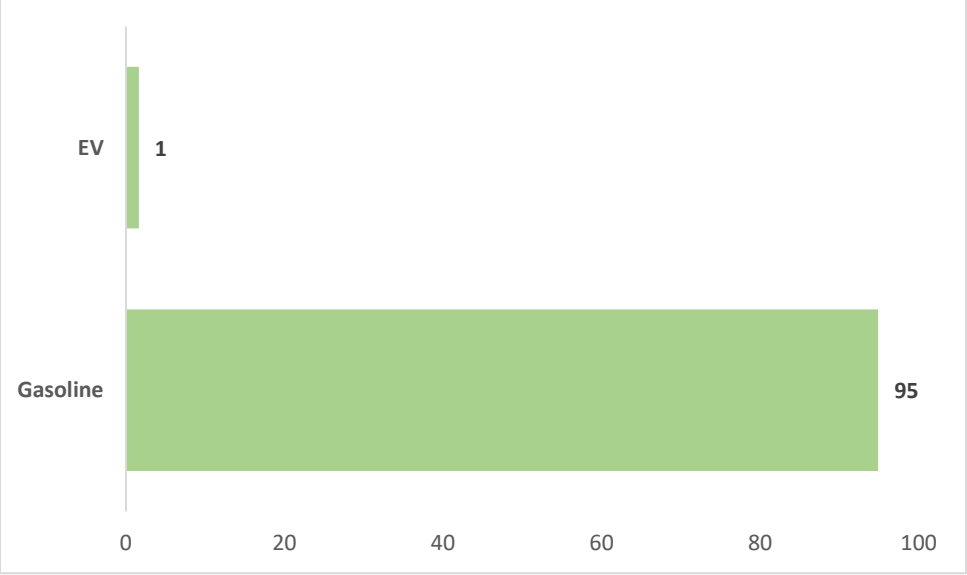

Figure 6. VOC Emissions in Denver by Vehicle Type in 2026, mg/mile

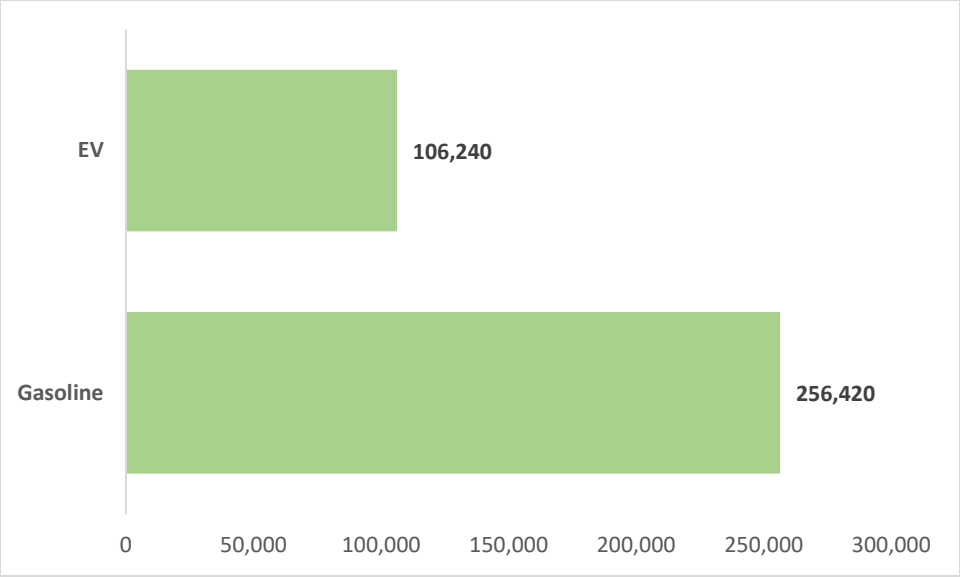

Figure 7. GHG Emissions in Denver by Vehicle Type in 2026, mg/mile

Based on the projected GHG emissions of an EV in 2026, it would be the equivalent of a gasoline vehicle with an on-road fuel economy of 105 mpg.

In addition to the years 2018 and 2026 where Xcel has provided actual or forecast electricity mix data, an attempt was made to estimate the GHG emissions for electric vehicles in 2030 based on Xcel Energy's recent pledge to reduce carbon emissions by 80% by 2030.

As Xcel's decarbonization goal uses the year 2005 as a baseline, we used the GREET model to calculate the greenhouse gas emissions from a hypothetical electric vehicle based on Xcel Energy's electricity mix in that year.

In 2005, this hypothetical EV would have produced lifecycle GHG emissions of 373 grams/mile. To reduce emissions by 80 percent compared to this level would require an emissions rate of 75 grams/mile. Therefore, we assume that this is the emissions level of electric vehicles in 2030 based on Xcel Energy's average electricity mix. Based on the GHG emissions of an EV in 2030, it would be the equivalent of a gasoline vehicle with an on-road fuel economy of 150 mpg.

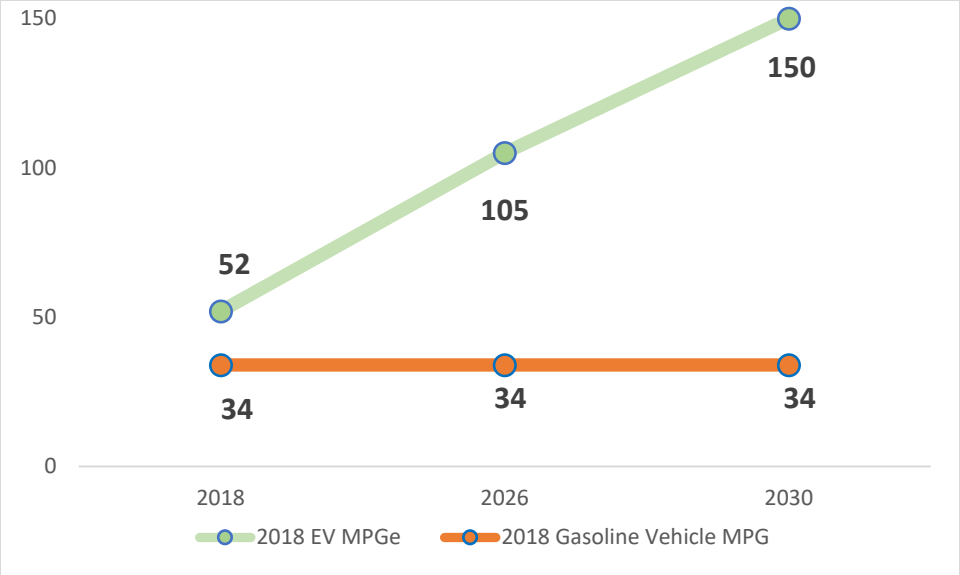

Figure 8. Mile per Gallon Comparison for 2018 EV and 2018 Gasoline Vehicle by Year

An important point of comparison is that because their fuel supply, electricity, becomes cleaner each year, existing EVs will also reduce their emissions every year. In Figure 8, the same 2018 Nissan LEAF, if on the road in 2030, would have improved its mpge from 52 to 150 mpge, while a comparable new gasoline vehicle bought in 2018 would at best maintain its original fuel economy of 34 mpg.

Assumptions and Data

Table 3. Xcel Energy's Electricity Mixes used in Calculations[7]

Year	Coal	Natural Gas	Wind	Solar	Hydro	Other
2005[8]	66%	30%	3%	0%	1%	
2018	39.1%	32.7%	23.5%	3.2%	1.3%	<1%
2026	24%	23%	39%	13%	1%	<1%

Table 4. On Road Fuel Efficiencies (mpg) of New Vehicles[9]

2018	2026	2030
33.9	42.7	43.5

In Table 4, the 2018 number reflects the fuel efficiencies of new passenger vehicles as most electric vehicles fall into this vehicle category. By 2026 and 2030, it is anticipated that electric vehicles will be widely available in both the passenger vehicle and light truck sectors, so the fuel efficiency in those years is based on the combined fuel efficiency of all new vehicles.

The author performed an analysis comparing the emissions associated with several vehicles: a new gasoline vehicle in 2018 and 2026, and a new EV in 2018 and 2026. This analysis focused on air quality emissions around the Denver metropolitan area.

The analysis focuses on the following pollutants: ground-level ozone precursors, such as VOCs, NOx, and GHG. The NOx and VOC emissions are particularly important as the region is currently in non-attainment for permissible levels of ground level ozone which is formed by the combination of NOx, VOCs and sunlight. The authors performed analysis using the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) fuel-cycle model developed by the Argonne National Laboratory.[10] The GREET model was used to make a comparison between the lifecycle emissions of two light-duty vehicle fuels: gasoline (with 10 percent ethanol) and electricity.

New vehicles purchased in 2018 and 2026 are analyzed. It is assumed new gasoline vehicles purchased in 2026 will meet the fuel economy standards set by the state of California running through 2026 as Colorado elected to follow the LEV standard in 2018.

[7] Xcel Energy. 2018. CO Energy Plan Fact Sheet. https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Resource%20Plans/CO-Energy-Plan-Fact-Sheet.pdf
[8] Xcel Energy. 2016. Energy and Carbon Emissions Reporting. https://www.xcelenergy.com/staticfiles/xe-responsive/Environment/Carbon/Carbon-Reduction-2016-Energy-and-Carbon-Summary.pdf
[9] Energy Information Administration. 2019. Annual Energy Outlook. Light-Duty Vehicle Miles per Gallon by Technology Type. https://www.eia.gov/outlooks/aeo/data/browser/#/?id=50-AEO2019&cases=ref2019&sourcekey=0
[10] The GREET model was developed by the Argonne National Laboratory, using version: V1.3.013395 available at https://greet.es.anl.gov/. Edits were made to reflect the different electricity mixes and vehicle fuel efficiency scenarios detailed above.

Electricity generation mixes were estimated using data provided by Xcel Energy (the utility serving the majority of the Denver metropolitan area).

The GREET model calculates the amount of emissions occurring in urban areas to show which emissions would be most likely to contribute to air quality issues. To better represent the impact that electric and gasoline vehicles will have on air quality, the transportation energy system around Denver was characterized to show exactly what emissions are likely to contribute to the Denver metro area airshed.

Regarding relevant upstream emissions from electricity, the author calculated that in 2018, 21 percent of Xcel Energy's coal plant emissions and 93% of natural gas plant emissions take place in the area around Denver and therefore contribute emissions into the region's airshed.[11] Due to the global impact of greenhouse gas emissions, all upstream emissions are included in the calculations. In 2026, due to the planned retirement of the area's remaining coal plants, zero percent of Xcel Energy's coal plant emissions would take place in this area and 93 percent of natural gas emissions would come from this region. For upstream emissions for gasoline vehicles, 35 percent of the emissions associated with gasoline refining take place in the Denver metro area due to the Suncor refineries located in Adams County which process approximately 35 percent of the gasoline used in the state.

Regarding the extraction of fuel (mining and drilling): it is estimated that 94 percent of the state's oil drilling and 36 percent of natural gas extraction take place in the Denver metro and North Front Range area (the vast majority of which takes place in Weld County).[12] In addition, it was assumed that 0 percent of coal mining contributes to urban emissions.

[11] Environmental Protection Agency. 2016. eGRID2012 Version 1.0. Retrieved from http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html

[12] Colorado Oil and Gas Conservation Commission. 2019. COGIS – Production Data Inquiry. Retrieved from http://cogcc.state.co.us/