TRANSPORTATION GREENHOUSE GAS EMISSIONS BASELINE FOR THE DETROIT 2030 DISTRICT

2022

DETROIT 2030 DISTRICT®

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Faculty Advisor:

Dr. Geoffrey Lewis

Client:

Detroit 2030 District - Connie Lilley

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By

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Contents

Abbreviations

ACEEE	American Council for an Energy-Efficient Economy
BEV	Battery Electric Vehicle
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalents
DCS	Detroit Climate Strategy
DDOT	Detroit Department of Transportation
EPA	Environmental Protection Agency
GREET	Greenhouse gasses, Regulated Emissions, and Energy use in Technologies Model
GHG	Greenhouse Gas
GWP	Global Warming Potential
HEV	Hybrid Electric Vehicle
IRB-HSBS	Health Sciences and Behavioral Sciences Institutional Review Board
N_2O	Nitrous Oxide
OECD	The Organization for Economic Co-operation and Development
SAA	Sustainability Action Agenda
SMART	Suburban Mobility Authority for Regional Transportation
U.S.	United States
WTW	Well-To-Wheels

Executive Summary

This report discusses the findings from the Detroit 2030 District Transportation Emissions Baseline Survey that was conducted in 2022. The goal of this survey was to collect data on people who commute into the Detroit 2030 District for work. Data on commute distance, mode(s) of travel, vehicle fuel type, and distance traveled were all collected and used to calculate a GHG emissions baseline in kg CO_2e. This survey also considered the recent COVID-19 pandemic, and the implications this has had on work commuting patterns. Data were collected during both pre-COVID and post-COVID timeframes, and the results were compared. The survey also contained a policy questions section, in which commuter behavior was assessed based on potential policy implementation.

Based on our calculation, the baseline emissions in the Detroit 2030 District were estimated to be 2,546 kg CO_2e per commuter before the pandemic, and 1,368 kg CO_2e per commuter after the pandemic. The baseline emissions for Bedrock were estimated to be 338 kg CO_2e per commuter before the pandemic, and 619 kg CO_2e per commuter after the pandemic. These values were calculated using emissions factors from the GREET 2021 model, in combination with the ASIF framework for emission calculation. Some conclusions can be drawn from this survey analysis. As the Detroit 2030 post-COVID emission baseline is lower than the pre-COVID baseline, we can determine that this is likely impacted by the increase in remote work. This is a potential tool to lower transportation emissions: 49% of respondents thought that formal or expanded work from home policies would likely change their commuting behavior. Other emission reduction policies that respondents selected as likely to change commuting behavior include a driving alone tax, and a subsidized company rideshare program. Detroit 2030 District building managers should consider these policies when aiming to reduce commuter emissions

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Introduction

Currently, in the United States (U.S.), transportation makes up the largest part of carbon emissions. In 2019, 29% of greenhouse gas (GHG) emissions in the U.S. were attributed to transportation (U.S. EPA 2021). About 70% of Detroit residents commute to suburban and metropolitan job centers during the week (City of Detroit 2018). Currently, there are no affordable options in place to reliably provide alternative transportation options, as the city is incredibly large and widespread. Detroit's public transit system is severely lacking in funds and using public transportation in metro Detroit hasn't been simple or convenient in decades (Gifford 2019). There are several reasons for measuring transportation emissions baseline in cities: to better understand the choices of urban commuters and why they make them; to track transportation systems to identify which low-carbon transportation choice are working and which can be improved; and to share findings with local stakeholders, other cities, and beyond to make impacts on reducing transportation emissions.

The 2030 Districts Network is a U.S.-registered nonprofit organization that currently has twenty-three member Districts across the country. The goal for all Districts is to estimate baselines and then commit its members to 50% reductions in energy, water, and transportation emissions by 2030. For this project, we want to help the Detroit 2030 District to calculate the transportation emissions baseline in Detroit and give recommendations accordingly. Many other 2030 District cities including Seattle, Ithaca, Pittsburg, and Philadelphia have established their transportation emissions baseline. For Detroit, a project in 2019 calculated transportation emissions in downtown Detroit using SEMCOG household travel data and EPA MOVES software for the calculation (EPA MOVES 2022). They recommended that future researchers survey District commuters to better calculate the emission baseline, as surveys can be more specific on questions and bring a clearer image (Li et al. 2019). If a transportation emission baseline can be developed for specific buildings, it can provide more specific strategies for Detroit 2030 District members to clearly understand what improvements would be the most cost-effective for emission reductions. It will also attract more Detroit building owners to join the Detroit 2030 District.

The benefits of an accurate transportation emissions baseline go beyond the members of Detroit 2030 District, and can be used by the City of Detroit and local environmental nonprofits, and could also provide a template for other 2030 Districts to adapt to their own cities. Learning from all previous experiences on calculating emission baselines, we established the transportation emissions baseline through surveying specific building members and making calculations accordingly through the Greenhouse gasses, Regulated Emissions, and Energy use in Technologies Model (GREET).

Detroit 2030 District Background

The goal of the 2030 Districts Network is to connect Districts, businesses, and communities and to work together toward initiatives that achieve sustainability in energy, water and transportation. All Districts share the same goal of creating high-performance buildings, reducing the environmental impact of construction and renovation of commercial buildings, as well as promoting economic development and environmental justice. Over 1,400 organizations have agreed to be a part of the 2030 Districts Networks, with over 2,100 buildings and 540 million ft^2 of commercial building space committed (2030 District Network).

The Detroit 2030 District is primarily focused on promoting high-performance building operations. The Detroit 2030 District, composed of 34 million square feet of commercial space, is committed to reducing the environmental impacts of buildings while guaranteeing the promotion of economic growth as goals are being pursued. The building members are diverse in type, including office spaces, convention venues, museums, multifamily housing, and houses of worship (Detroit 2030 District).

As shown in Figure 1 below, the District boundaries extend from just past West Grand Boulevard on the north to the Detroit River on the south, encompassing iconic locations such as the Detroit Opera House, Wayne State University, Detroit School of Arts, and the Children's Hospital of Michigan. People commute to this part of Detroit using a variety of transportation modes and transportation distances. These commuters are likely to react differently to carbon reduction transportation policies, making it necessary to survey specific building members to better understand their preferences for commuting and give suggestions accordingly (Detroit 2030 District interactive map).

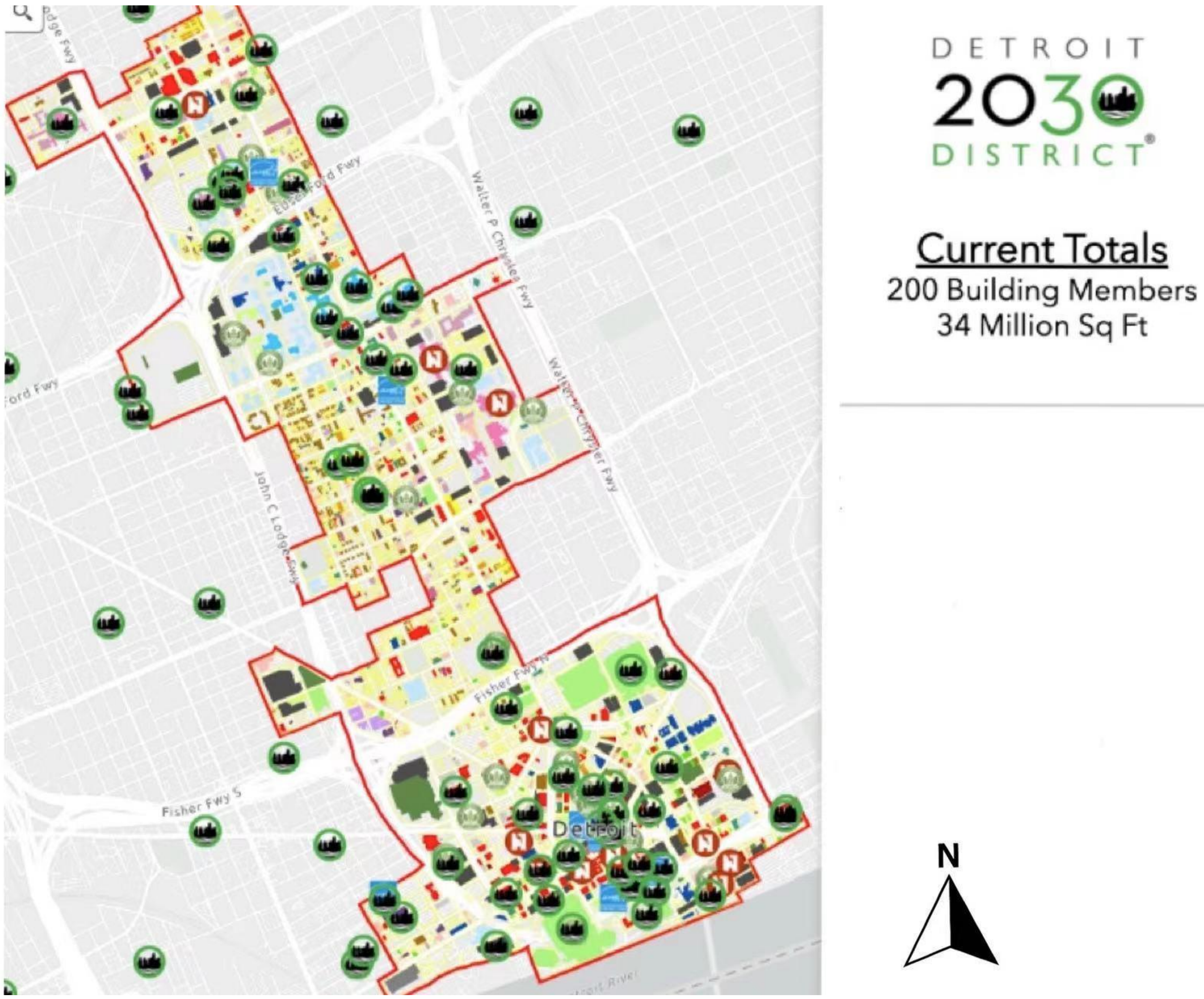


Figure 1: Detroit 2030 District map (Detroit 2030 District interactive map)

Other 2030 District Baseline Methods

Calculating the transportation baseline has two steps. The first step is to split the commuter transportation modes based on type (i.e., walking, bus, or drive to work). The second step is to then calculate the GHG emissions of daily commutes in the Detroit 2030 District. Some 2030 Districts have estimated transportation baselines and we will review the methods they used.

The Seattle 2030 District, which expanded to 58.9 million square feet in 2019, was the first District to complete the calculation of the transportation baseline. Commute Seattle completed the 2010 Center City Commuter Mode Split Survey as a commuter mode split within the 2030 Seattle District. They used the Seattle Climate Partnership's Carbon Calculator, where CO_2 emissions per commuter per mile is calculated by the targeted commute mode; as a result, each commuter emits about 900 kg CO_2 each year (Wickwire 2017).

The Ithaca 2030 District developed its transportation baseline using survey responses, the number of buildings, the average square foot per worker, and emissions factors from the EPA. Based on the average floor area per worker, they were able to estimate the total number of commuters within the District. They then applied the survey statistics to this estimation to calculate the annual baseline emission value for single-occupancy vehicles at 1,875 kg CO_2e, carpool at 494 kg CO_2e, and bus at 437 kg CO_2e (Ithaca 2030 District 2017).

The Pittsburgh 2030 District, supported by the Green Building Alliance, committed to a 50% reduction in transportation in 2030 and conducted the transportation baseline work in 2015. They used the "Regional Travel Demand Model" from the Southwestern Pennsylvania Commission. In the Pittsburgh 2030 District baseline model, people's trips are associated with the commuting modes they choose, meanwhile, those commuting modes were given specific CO_2 emission per person per trip (Pittsburgh 2030 District 2015). Combined with the Make My Trip Count (MMTC) commuter survey as a tracking method, Pittsburgh 2030 District determined the transportation baseline for Downtown in 2015. According to the 2019 progress report, the District has received over 2000 MMTC responses, identifying a 26% reduction in transportation emissions, and is currently at 1,386 kg CO_2 per person trip annually (Pittsburgh 2030 District 2020).

The Philadelphia 2030 District, which covers 49 million square feet, expects a 50% reduction in gas emissions in 2030 (Philadelphia 2030 District 2020). Philadelphia published that the transportation baseline was 1,181 kg CO_2 using data from the 5-year American Community Survey, meaning the transportation emissions are predicted to drop to 591 kg CO_2 in 2030.

At 5 million square feet, the Ann Arbor 2030 District estimated a transportation emission baseline as well in 2021 (Fields et al 2021). They used the ASIF framework to calculate transportation emissions. ASIF stands for Activity, modal Share, energy Intensity, and carbon intensity of Fuel, which are the minimum variables needed to calculate the transportation emissions of an individual for a given timeframe. From the ASIF framework, they designed surveys to collect data. Meanwhile, they proposed some policy measurements based on the A2Zero Carbon neutrality plan. Differing from the other 2030 Districts, Ann Arbor 2030 split the tracking survey into pre-COVID and during-COVID in face of pandemic impacts. They got results from 21 buildings out of more than 90 buildings in the District and found there was a 73%

reduction from pre-COVID (1724 kg CO_2e per commuter) compared to that during COVID (472 kg CO_2e per commuter per year).

Along with the reports and experiences of the other 2030 Districts, past research, plans, and reports can be used to better guide and understand the data within this study. The city of Detroit has some current and past strategies to reduce emissions, as well as strategies for creating an emission baseline.

One of the more comprehensive plans began in 2017, in which a Master Plan of Policies for Detroit was created by the City Council, and listed some key transportation policies to be implemented within the next 10 years (Duggan 2018). These policies focus on increasing equity, mobility, safety, and sustainability of transit systems within Detroit. The Detroit Climate Resilience Ordinance was created around this same time, and calls for the reduction of gasoline engine usage, and an increase in public and shared transit usage (Detroit Climate Resilience Ordinance 2017). The City Council also established the Green Task Force, which contains the Transportation and Mobility committee. This committee was created in 2020 and is working to improve the sustainability of transportation within Detroit through policy (Green Task Force 2020).

The City of Detroit's Office of Sustainability is currently working on a Detroit Climate Strategy (DCS) to replace/improve the Sustainability Action Agenda (SAA) that was established in 2019 (Colvin 2021). The Greenhouse Gas Ordinance was established at the same time and builds off the SAA to set specific goals for emission reduction. This Ordinance targets a 35% GHG reduction by 2024 (Mondry 2019), 75 percent by 2043, and 100 percent by 2050, based on the GHG Inventory that was published in 2012 (Carlson et al. 2014).

The Sustainability Action Agenda goes into depth regarding methods to reduce transportation emissions across Detroit. These strategies include a plan to reduce emissions from city vehicles, improvements to electric vehicle infrastructure, GHG assessments, and changes to truck routing systems for example. Although the Detroit Climate Strategy is still in the works, the published overview mentions that a GHG assessment will be a key component of this plan.

The American Council for an Energy-Efficient Economy (ACEEE) is a nonprofit research organization that has analyzed the energy efficiency of large cities across the U.S. for comparison. ACEEE has analyzed components of Detroit's transportation, including aspects like Sustainable Transportation Planning, Location Efficiency, Mode Shift, Public Transit, Efficient

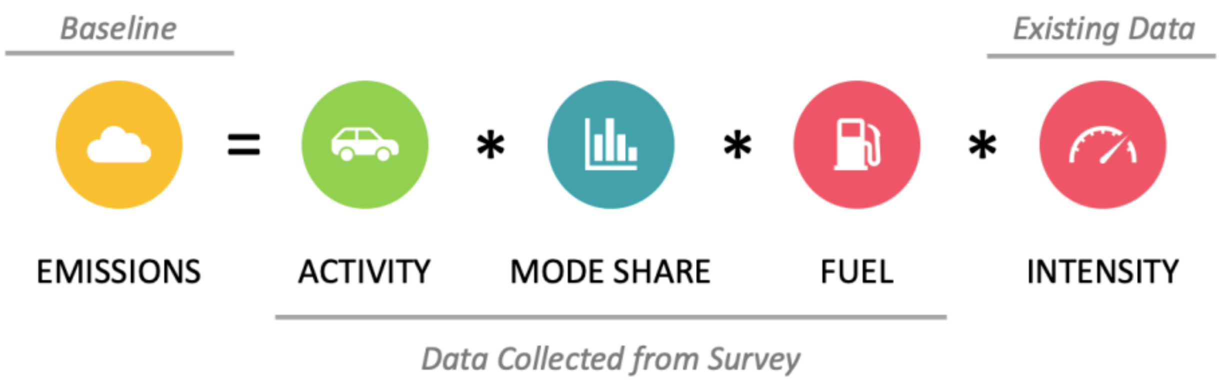
Vehicles, Freight System efficiency, and Clean, Efficient Transportation for Low-Income Communities (Appendix B). ACEEE awarded the city of Detroit 7.5 stars out of 30 (ACEEE 2020) and also noted that, although Detroit has a Strategic Plan for Transportation already in place, there is no existing emissions reduction target baseline (City of Detroit 2018).

Detroit currently has three main modes of public transportation. These include the Suburban Mobility Authority for Regional Transportation (SMART) and Detroit Department of Transportation (DDOT) bus systems, the QLine, and the Detroit People Mover. Individual transportation modes are also available, including a shared bike system called MoGo, as well as electric scooters like Bird, Lime, and Spin (Gifford 2019).

Taking notes from other 2030 Districts and the current situation of the Detroit 2030 District, we designed our research questions for this project to capture Detroit 2030 District buildings' commuting behavior through both pre and post-COVID timelines, calculating their transportation emission baselines, and giving them these results to set targets for future reductions. In addition, we wanted this process to be easily replicable for future buildings in the District and across the region to use.

Research Methods

The Detroit 2030 emission baseline was calculated using the ASIF framework (Equation 1) (Fong & Doust 2014). This framework was created in 2000 with the goal of making transportation baselines from which reduction goals can be set (Schipper 2000). Using the ASIF framework in our project, we have a combination of existing data and data calculated from commuters within the Detroit 2030 District.



Equation 1. The term Emissions includes the total GHG emissions that result from transportation. Activity regards both the distance and the number of trips taken within the District. Modal share references the vehicle type and transportation mode. Fuel refers to the source of energy used for the trip, and Intensity includes the energy requirement by mode and fuel per mile (Fields et al. 2021).

The ASIF framework requires data from commuters, including their commute time, fuel type, and mode share, or what transportation type(s) they utilize (i.e., what percentage of their commute is done by bike, and what percent from bus). These data were collected by a survey that was distributed to the Detroit 2030 District commuters. This survey was split into a pre-COVID (2019 commuting patterns) and post-COVID (expected 2022 commuting patterns) section, based on the Ann Arbor 2030 District's transportation emission baseline report (Fields et al. 2021). More specifics of the survey design can be found below in the survey design section.

Detroit 2030 District Survey Design

We decided that our survey would collect and aggregate data from Detroit 2030 District members and sort it by building, as it could then be distributed and used by the Detroit 2030 District, as well as the member buildings. We believe that these by-building results offer the most insight, as they show a transportation emission baseline for individual member buildings in both pre- and post-COVID to see where their transportation emissions currently stand, and to find ways to improve upon it. As a result of this method of data collection, we were also able to ask questions about policies that could potentially shift employee transportation behavior, should these policies be put into action in the future.

The design of our survey adopted the Ann Arbor 2030 District's survey. Ann Arbor 2030 District's survey used Google Forms, but our team created the Detroit 2030 District survey in Qualtrics, as this platform gave more opportunities to add logic, question type specifics, and had a more robust data collection interface. Once the data were collected, Qualtrics created a well-organized Excel sheet of results based on the question, mode share, or organized based on certain cells, such as building address (Fields et al. 2021).

The survey was split into sections. The first asked basic questions, including the address at which the employee worked so that we could aggregate individual responses by building. The second and third sections were labeled as pre-COVID and post-COVID, respectively. These sections consisted of commuting questions and were the primary data for calculating transportation emission baselines:

- The number of days the employee commutes to work
- The round-trip mileage (to and from) commute for work
- The number of days the employee telecommutes for work
- The mode share percentage (the percentage use of each transportation type listed in a given time) of the employee's commute in both fair and cold weather months
- The fuel type and efficiency of the employee's vehicle, based on their answer to the mode share question

These questions were asked twice, once regarding the employee's pre-COVID commuting behavior, which was dated in 2019, approximately a year before the pandemic began. They were again asked the same questions regarding their post-COVID transportation behavior, which we define as their current 2022 transportation behavior. We believe it is useful for both the District and the member buildings to compare transportation emissions before and after the pandemic.

Regarding the mode share question, we created a list that consisted of common modes of transportation:

- Walking
- Bicycle
- Drive Alone (automobile, motorcycle, moped)
- Carpool
- Detroit Public Transit
- Ride-Hail (Uber, Lyft)
- I did not work for the employer/organization at this time

The question is formatted for employees so their mode share totals to 100%. For example, if a commuter selected that they biked for 50% of their commute, and drove alone for the other 50% of their commute, their mode share would sum to 100%. One of the reasons Qualtrics is preferred over Google Forms is that we could require the question to add up to 100% before the employee could move forward so that human error is reduced. Commuters were asked about their mode share percentage for both cold and fair weather months to account for potential differences in what transportation employees use. For example, some employees may walk and bike to work during fair weather months, and drive alone during cold weather months. We expect shifts in seasonal mode share to be more likely for lower mileage commutes, where modes like biking and walking are more feasible. With longer commuting distances, we expect fewer seasonal differences in mode.

Our team acknowledges that asking survey respondents to respond to questions regarding their transportation behavior prior to the COVID-19 pandemic almost two years earlier is subject to human error. Regardless of the potential for error, potential insights from a pre-COVID and post-COVID analysis of transportation behavior make these questions worth asking.

The final section was dedicated to a question regarding access to parking, followed by behavioral questions regarding possible policy enactments. The first policy focused on implementing more secure bike rack parking/storage at the workplace, and was added to the survey based on the idea that more accessible bike storage might incentivize commuters to bike to work more often, without worrying about their bike being stolen or damaged (Runyan 2017).

The second policy asked commuters what the impact of having closer bus stops to work might have on their commute patterns, since this will reduce the time it takes to walk from the bus stop to work (Litman 2021). The third policy question asked respondents if a free or subsidized public transportation pass might impact their behavior. This policy was based on free fare programs in U.S. cities like Olympia and Kansas City, in which ridership increased as a result of free public transit (Hess 2020). A policy that increases workers' ability to work from home or remotely was also asked about. This policy was added based on the Ann Arbor 2030 District's report, as well as the recent increase workers have experienced in working from home regulations as a result of COVID-19. There were also two policies regarding EVs; one asked about dedicated carpool lanes, and the other asked about EV charging at the workplace. These questions were included in the survey because the adoption of EVs depends on many different factors, but is overall projected to grow within the U.S. (Archsmith 2022).

A policy in which the respondent's company subsidizes a rideshare program for employees was asked, based on the impacts rideshare and carpooling can have on emissions reduction (U.S. EPA 2001). This question was included to help understand current commuter perception of ridesharing options, and if there was potential for this option to be implemented in an effective manner. A tax for driving alone was another policy asked about in this survey. Taxes are an effective disincentive, with examples like fuel taxes and carbon taxes reducing emissions (Singh 2018). While this policy would be more complex to implement, it could also be one of the most promising and effective. The last two policies focused on how having dedicated bike lanes on existing roads and increased access and reduced costs for inner-city parking might impact commuting behavior. The former was included due to the evidence supporting the idea that an increase in bike lanes and bike infrastructure can have on increasing bike users (Mitra 2021). The latter was included in the survey based on the idea that more accessible city parking will increase commuter vehicle usage (Knott 2019).

For each policy, the possible behavioral responses were asked on a qualitative scale:

- This will not change my commuting behavior
- This is not likely to change my commuting behavior
- Undecided
- This is likely to change my commuting behavior
- This will change my commuting behavior

- I already have access to this service
- Not applicable

Detroit 2030 District Emission Factors

In order to calculate the emission baseline, the survey results need to be combined with emission factors (i.e., the emissions per mile traveled using a given mode). The Greenhouse gases, Regulated Emissions, and Energy use in Technologies model (GREET) is an analytical tool used to gain an understanding of energy and environmental impacts of technology by considering "well to wheels" impacts, including fuel production and combustion (the fuel cycle) and raw materials mining to vehicle disposal for automobiles (the vehicle cycle) (U.S. DOE 2022). Our team used the 2021 GREET version that contained 2020 data, which was the most recent and relevant emissions data available. This model was used in the transportation emission baseline calculation of the Ann Arbor 2030 District, and is used in a similar method for the Detroit 2030 District calculation. We chose GREET as it offers national emission averages that are updated annually and can be applied across the country, should our calculation model be used beyond the Detroit 2030 District. Emissions factors by modes are collected in Table 1 below.

Table 1: Emissions Factors for Detroit 2030 District Modes of Transportation

Transportation Mode	Emissions Factor	Units
Walking	0	g CO_2e/mile
Bicycle	0	g CO_2e/mile
Gasoline	408	g CO_2e/mile
Diesel	339	g CO_2e/mile
PHEV & HEV	227	g CO_2e/mile
EV	163	g CO_2e/mile
Bus	235	g CO_2e/passenger mile
Ride-hail	291	g CO_2e/passenger mile

Walking, Bicycling and Telecommuting

We assume that individuals who either walk, bike or telecommute produce no emissions. While telecommuting does contribute to electricity usage and emission rates, home emission rates are outside the scope of this project.

Driving Alone and Carpooling

For individuals who drove alone or carpooled in a gasoline or diesel-powered vehicle, the GREET model's Life Cycle Assessments were used to calculate the impacts of these emissions. These life cycle assessments use CO_2, CH_4, N_2O, and well-to-wheels (WTW) emissions factor values from GREET. WTW values include emissions from extraction, processing, and combustion of fuels.

For people who drive alone or carpool in electric and hybrid vehicles, respondents could select their vehicle as a plug-in gas-electric, non-plug-in hybrid gas-electric, or battery electric vehicle charged primarily at their home, work, or public charging station. The location in which the vehicle was charged was originally collected in survey responses, as a way to better identify the charging energy source. However, the ReliabilityFirst (RFC mix) values from GREET were used to calculate emission factors from all electric vehicles, regardless of charging location. For carpooling, we divided the total emissions by the number of passengers in the vehicle.

Public Transit

For individuals that used public transportation for any portion of their commute, emissions were calculated using GREET EFs based on g CO_2e per passenger mile.

Ride-Hailing

We have made the assumption that all ride-hailing services use light-duty gasoline-powered vehicles. We are adjusting the emissions factor by assuming an average of 1.4 passengers (vehicle emission factor divided by average Uber/Lyft # of passengers) (Henao and Wesley 2019).

Bedrock MyCommute Data

In our preliminary Detroit 2030 District meetings with building managers, Bedrock Detroit, a real estate firm that has a portfolio of over 100 properties within Detroit, made us aware that they were already tracking commuting patterns among their employees. They utilized a badge swipe method for calculating emissions from their commuters through a program known as MyCommute. This method allowed a user to swipe their parking badge on their way into the parking lot, and a system automatically calculated their total commute distance.

Bedrock Detroit shared the data on more than 10,000 trips collected through the MyCommute program so we could use it to calculate their baseline emissions from. They tracked the commutes of their employees within both our pre-COVID (2019) and post-COVID (2022) time periods, so we were able to apply a similar model to their data that we used for Detroit 2030 District's baseline calculations. However, the MyCommute pre-COVID captured data between January 11th, 2019, and February 28th, 2020. The post-pandemic data covered October 1st, 2021 through February 1st, 2022. Because the data did not perfectly capture annual commuting patterns, we annualized the data, assuming that transportation behavior remained consistent throughout the two time periods.

Bedrock's MyCommute data tracked the commuting distance of employees and then totaled the number of trips (and mileage) each employee made. The following modes of transportation were tracked:

1. Bike Miles
2. Bus Miles
3. Carpool Miles
4. Vanpool Miles
5. Commuter Shuttle Miles
6. Walk Miles
7. Light Rail Miles
8. Commuter Rail Miles
9. Telecommute Trips
10. Ride-Hail Miles
11. Single-Occupancy Vehicle Miles
12. Parking Miles

For modes of transportation that were also covered in the Detroit 2030 District survey, our calculation methods and emissions factors were the same. Table 2 shows the emissions factors for the Bedrock transportation modes. Since MyCommute tracked more modes of transportation than the Detroit 2030 District survey, we will explain the additional modes and how we treated them in the analysis.

Table 2: Emissions Factors for Bedrock Detroit Modes of Transportation

Transportation Mode	Emissions Factors	Units
Walking	0	g CO2e/mile
Bicycle	0	g CO_2e/mile
Gasoline	408	g CO_2e/mile
Carpool	204	g CO_2e/passenger mile
Vanpool/Shuttle	136	g CO_2e/mile
Light/commuter rail	377	g CO_2e/mile
Bus	235	g CO_2e/passenger mile
Ride Hailing	291	g CO_2e/passenger mile

Assumptions regarding the number of average passengers and fuel type were made for the following modes, and we acknowledge that our results depend on these assumptions and may result in estimates that differ from Bedrock's actual transportation emissions.

Carpool Miles:

Carpool Miles used the light duty vehicle gasoline emissions factor found in GREET 2021, assuming that one passenger was always present on each trip (based on discussions with Bedrock) the emissions were divided by two to get per person emissions.

Vanpool/Commuter Shuttle Miles:

Both of these are services offered by Bedrock to encourage alternative modes of travel rather than driving alone. We assume that these modes use the same type of vehicle. Both use

GREET's gasoline emissions factor, and we conservatively assumed that the average ridership per trip is two passengers. So the emissions factor for these modes is GREET's emissions factor for gasoline divided by three (a driver plus two passengers).

Light/Commuter Rail Miles:

We assumed that these modes use similar fuel types, and so we used a single emissions factor. From GREET, we found that the emissions factor for this mode of transportation is 377 g CO_2e/mile.

Single-Occupancy Vehicle Miles/Parking Miles:

Both of these refer to employees who drive alone to work. Single-occupancy vehicle mileage refers to commuters who do not use the Bedrock parking garages, while parking miles refers to those who do. These modes use the GREET gasoline light duty vehicle emissions factor.

Incentives

The survey respondents were prompted with an incentive to increase feedback numbers. A short paragraph on the first page of the survey explained the purpose of the study and informed the respondent that, through the completion and submission of the survey, their name would be entered into a drawing in which they may win a $25.00 Visa gift card.

IRB Approval

For this survey work to be conducted, a review process was required to obtain exemption status. This was completed by The University of Michigan's Health Sciences and Behavioral Sciences Institutional Review Board (IRB-HSBS), and this survey was given IRB exempt status per the federal exemption category EXEMPTION 2(i) and/or 2(ii) at 45 CFR 46.104(d).

Quantitative Analysis

After gathering the data from Qualtrics, our team performed the same data analysis separately using two different software tools, Excel and Python. This was to both use project members' areas of expertise and build confidence in our results.

We used Excel and Python to calculate the emissions baseline for the Detroit 2030 District data. Our team used both to double check the results of the calculations. In addition, select team members had interests in trying different software to conduct the analysis. The two methods are described in the appendices: Python Model (Appendix A) and Spreadsheet Model (Appendix C). Both methods follow the same ASIF framework highlighted above (Equation 1).

Survey responses were gathered within Qualtrics, allowing us to import the data to Excel. The survey respondents were organized in their own individual rows, while the questions and question answers were placed in their own columns. Data cleaning had to be performed (e.g., clearing out those who put text within solely numeric responses) to ensure all of the data fit into our equations. Unfinished surveys required us to reach out to individuals to ask the remaining questions. After cleaning and removing some responses due to them being incomplete and not responding to follow-up emails, we had 71 commuters from four buildings with analyzable information.

We began by calculating GHG emissions for each respondent. Fair weather (April-September) and cold weather (October-March) categories were each half a year in length. The calculation method for each of these categories was identical. This includes pre-COVID fair and cold weather and post-COVID fair and cold weather sections. For each mode, the mode percentage was multiplied by the number of commuting days per week, round trip distance, and associated emission factor, which resulted in weekly emissions per mode per passenger. To capture the entire season within each category, we multiplied these weekly emissions per mode per passenger by the average working weeks in a half year (22.9 weeks) (OECD 2020; 2021). Upon completing these steps for each category, we then summed pre-COVID fair and cold weather emissions to get annual pre-COVID emissions per commuter and the same steps to get annual post-COVID emissions per commuter. We then calculated total change in emissions, as well as percent change in annual emissions per commuter between pre-COVID and post-COVID. The individual emissions per commuter were aggregated by building and annual emissions per commuter for each building was calculated.

Assumptions for Quantitative Analysis

The research team made assumptions throughout the quantitative analysis about potential error sources. These assumptions should be reviewed before conducting a similar analysis, as some may need to be updated or altered based on specific needs.

Detroit 2030 District and Bedrock Data Assumptions

We have made a number of assumptions throughout the project, which we will highlight and note in this section. First, the Detroit 2030 District survey asked about pre-COVID and post-COVID commuting patterns throughout the fair and cold weather seasons to get a more detailed look at annual commuting patterns. We assumed that people work 45.6 weeks per year, based on the OECD 2020 Average Annual Hours Worked per Worker (1,767 hours) and Average Usual Weekly Hours Worked per Worker (38.7 hours) (OECD 2020; 2021). These 45.6 weeks are split into 22.8 weeks respectively for the fair and cold weather seasons. We assume that a respondent's commuting patterns are seasonally constant. In other words, the survey does not explicitly account for a person who might only have to come to work a handful of times per month or a person who might have to travel to various locations for work. We also assumed that mode share across the District (see Results section) was not weighted by trip distance but rather considered all respondents equally in calculating the average.

To find and use emissions factors to fit into the ASIF framework we based our calculations on, this project used a 100-year global warming potential (GWP) for converting methane (CH_4) (GWP = 30) and nitrous oxide (N_2O) (GWP = 265) fossil fuel emissions into carbon dioxide equivalents (CO_2e). This is the assumption used in GREET. An important assumption we made was that telecommuting was a zero-emission mode, when in reality it is not as heating/cooling, lighting, and IT energy demand at home will likely increase. This assumption will likely artificially support many post-COVID working scenarios for businesses that have expanded work from home activities.

For mode share, the research team assumed ride-hailing involves 1.4 passengers per trip (Henao and Wesley 2019). Based on discussion with Bedrock Detroit, we assumed that the Carpool transportation mode averaged one passenger on the commute to work. In addition to the carpool mode, we also assumed that gasoline was the fuel used for all carpool vehicles. To be conservative, we assumed that the Bedrock Vanpool/Commuter Shuttle transportation modes averaged two passengers while the service was active. Finally, gasoline was assumed to be the fuel used for all vehicles that fell into the Single-Occupancy Vehicle Miles and Parking Miles section in the Bedrock data.

Results

Baseline Emissions

Detroit 2030 District

Our survey collected 71 complete responses from four buildings. Our building types included a convention center, an office building, a museum, and a house of worship (Table 3). Aggregating all of the responses, we calculated both the pre-COVID (2019 period) and post-COVID (Q1, 2022) annual GHG emissions per individual. For the pre-COVID period, the average emissions were 2,546 kg CO_2e per commuter, and 1,368 kg CO_2e per commuter in the post-COVID period (Figure 2), a 46% reduction impacted by the pandemic.

Table 3: Building Type and Number of respondents

Name/Building Type:	**Number of Respondents**
Building A - Museum	11
Building B - Office	29
Building C - Convention Center	23
Building D - House of Worship	8
Total:	71

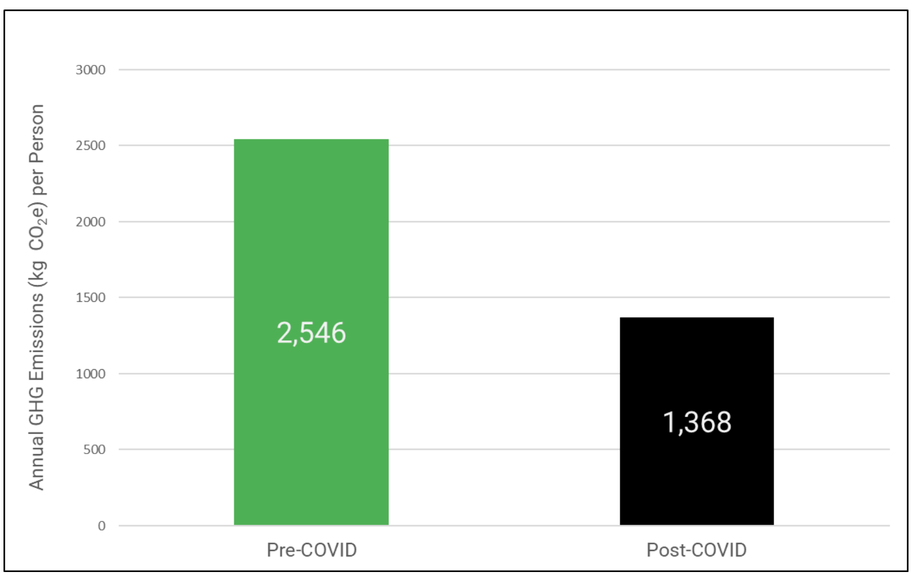


Figure 2: Detroit 2030 District Pre- and Post-COVID Annual Commuting Baselines

Results of calculating the annual GHG emissions per individual per building are summarized in Table 4 and Figure 3.

Table 4: Average Annual Emissions Per Person Per Building, pre- and post-covid

	kg CO_2e Per Person (Pre-COVID)	kg CO_2e Per Person (Post-COVID)	% Change
Building A - Museum	1,249	601	-52%
Building B - Office	3,027	154	-95%
Building C - Convention Center	3,040	3,315	9%
Building D - House of Worship	1,162	1,174	1%

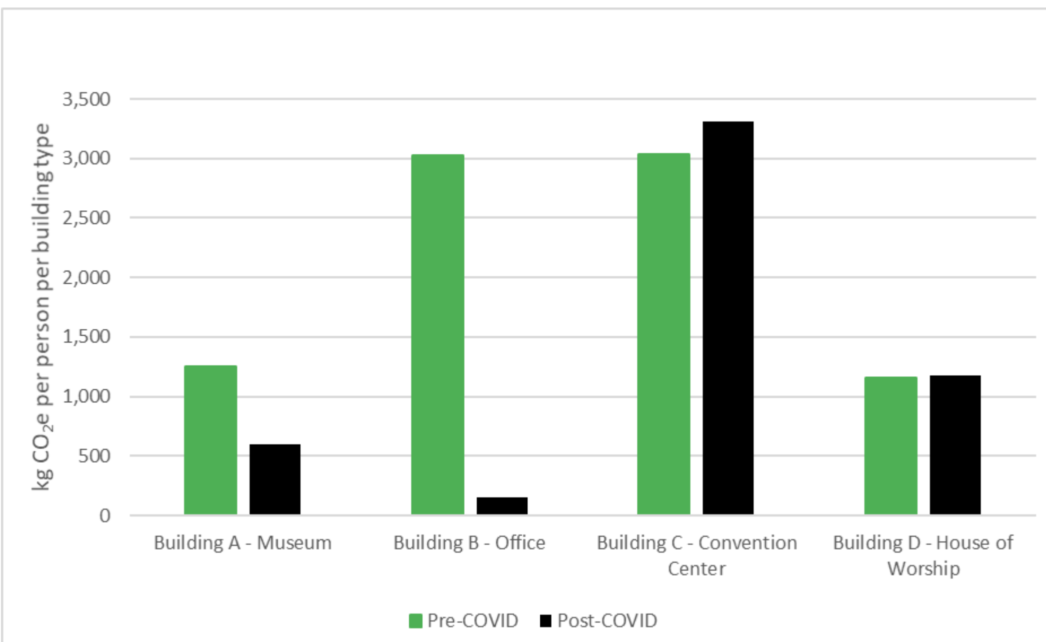


Figure 3: Detroit 2030 District Average Annual Emissions Per Person Per Building

The office building type accounted for the largest decrease in emissions from a pre-COVID to a post-COVID setting, where we see a 95% decrease in emissions per person. We can infer that this is due to the rise of telecommuting, even after in-person work started to become normalized. Regarding the slight increases in emissions for the venue and house of worship building types, a few of the survey respondents weren't working during the pre-COVID timeline and were working during the post-COVID timeline, which has increased the emissions per commuter. However, these changes are minimal compared to the decreases we see in the museum and office building types. Comparing the results in Figure 3, we have found the average among four buildings pre-COVID was close to 2,100 kg CO_2e per person and falling to around 1,300 kg CO_2e per person during post-COVID.

We then analyzed the distribution of mode share for the 71 commuters. Figure 4 below shows both the percentage of mode share between the pre-COVID and post-COVID data, matched against the results from the Bureau of Transportation 2020 commuter mode share data for the state of Michigan (Bureau of Transportation Statistics 2020). In terms of mode share percentage, driving alone is still the most common mode of transportation, rising above 70% in both the pre-COVID and post-COVID timelines, above the average from the Bureau of Transportation mode share data for Michigan. The rest of the transportation modes, collectively, reached 10%. Carpooling during post-COVID became more common than pre-COVID, but still lower than the Michigan average. The percentage of public transportation dropped a little due to the popularity of remote work, and ride hailing was rarely used.

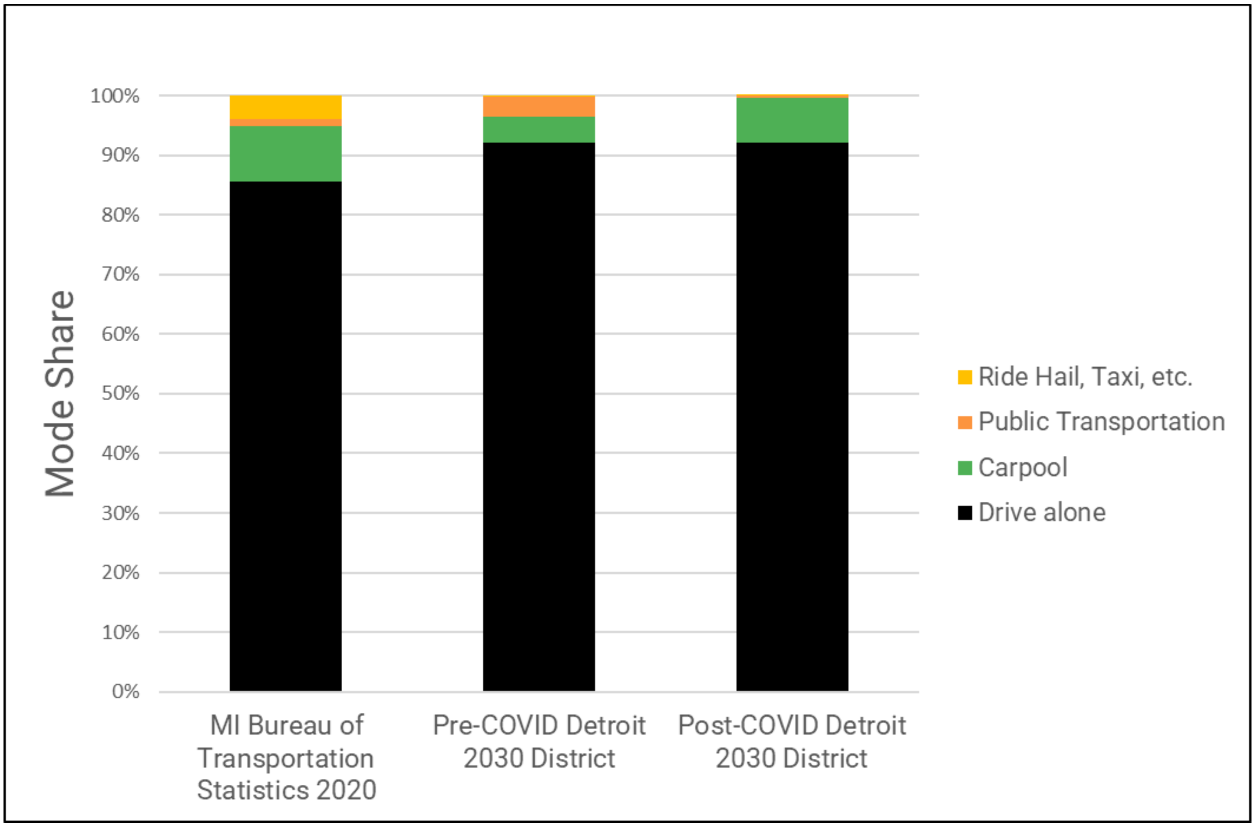


Figure 4: Detroit 2030 District Mode Share Comparison

Vehicle Type Breakdown

As seen in Figure 4 above, close to 90% of the respondents selected that they drive alone or carpool during their daily commute. Out of these respondents, their vehicle type breakdown is shown in Figure 5. Gasoline-powered vehicles make up the large majority, at 89%, and the remaining portion is split evenly with 5% of driving commuters using a battery electric vehicle primarily charged at their home (BEV), and the other 5% using a non-plug-in hybrid gas electric vehicle (HEV).

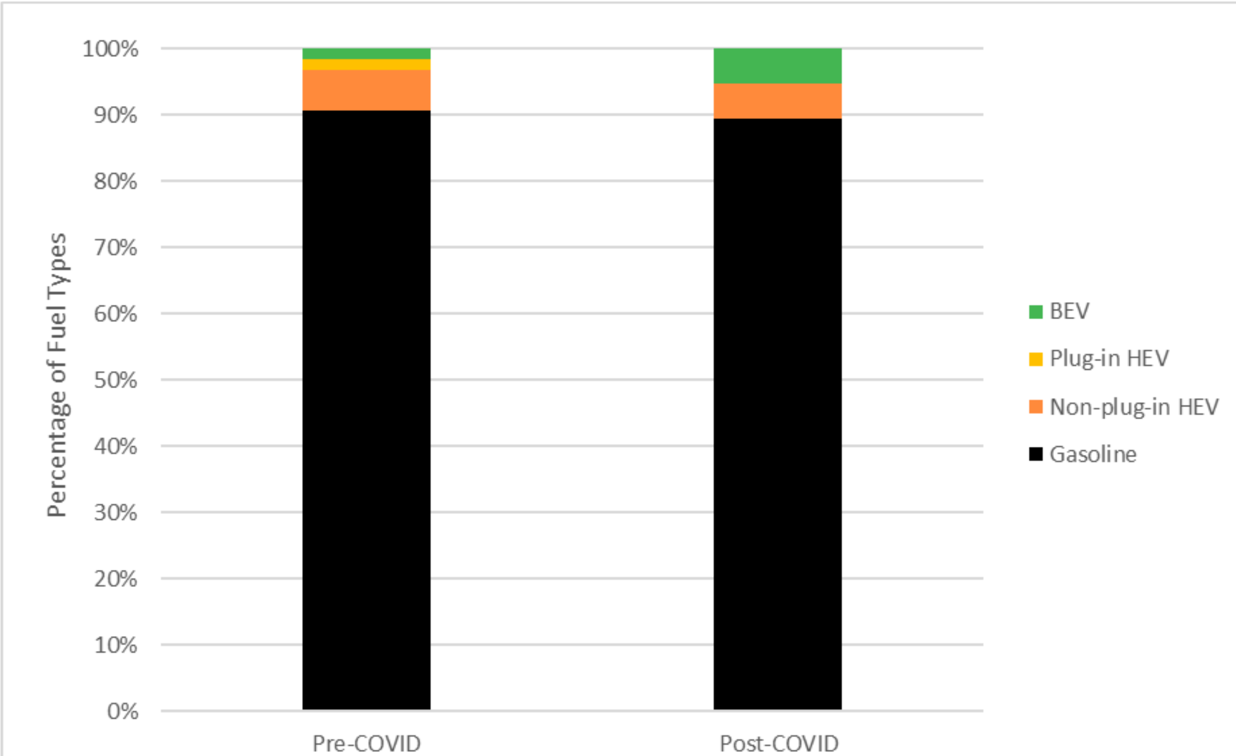


Figure 5: Detroit 2030 District Pre- and Post-COVID Fuel Type Breakdown (For Drive Alone and Carpool Modes)

Detroit 2030 District Future Commuting Behaviors + Policy Preferences

Figure 8 depicts survey respondent's predictions on whether or not their commuting behavior is likely to return to the same routine as pre-COVID, or to remain the same as post-COVID. These findings show that 32% of survey respondents believe that their patterns will remain the same, 15% believe that their commuting routines will return to how they were before the pandemic, and 28% believe that they will be somewhere in between.

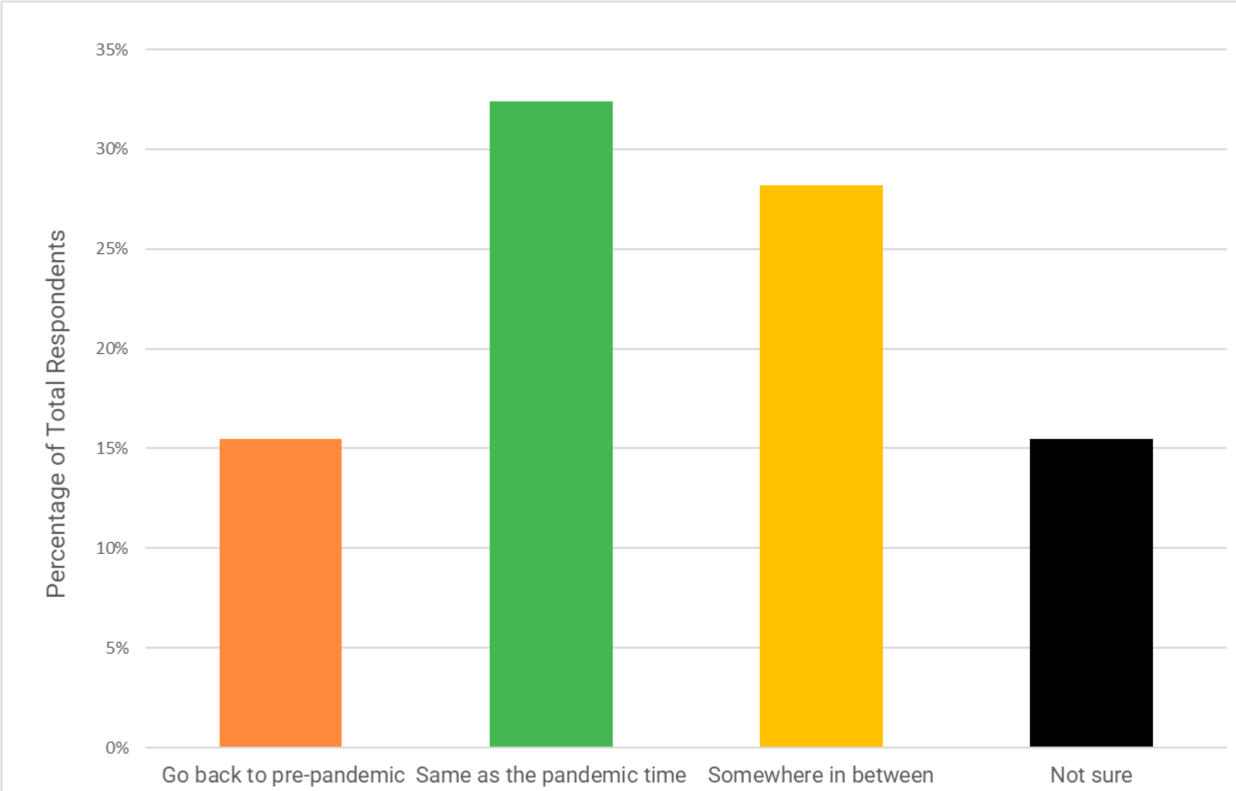


Figure 8: Detroit 2030 District Percentage Breakdown of Predicted Future Commuting Behavior.

Survey respondents were asked questions regarding potential transportation policies. All of these policies were based on potential motivators for commuters to choose less emitting transportation modes. Their answers are represented in Figure 9 and Table B1 (Appendix B). Ten questions were asked regarding these potential policies. The first question, titled "Bike Storage" in Figure 9, asked how increased secure bike rack parking or bike storage at the workplace would impact their personal commuting behavior. The second and third questions focused on how an increase in bus stop proximity to their work might change commuting behavior, as well as free or subsidized public transportation. Other policies, such as expanded work from home, were asked to see what sort of effect COVID-19 had on remote vs. in-person working preferences. The remaining policies are dedicated carpool or EV lanes, EV charging in the workforce, a public transportation subsidy, a tax for driving alone, a company subsidized rideshare program, dedicated bike lanes, and increased access and reduced costs for inner-city parking.

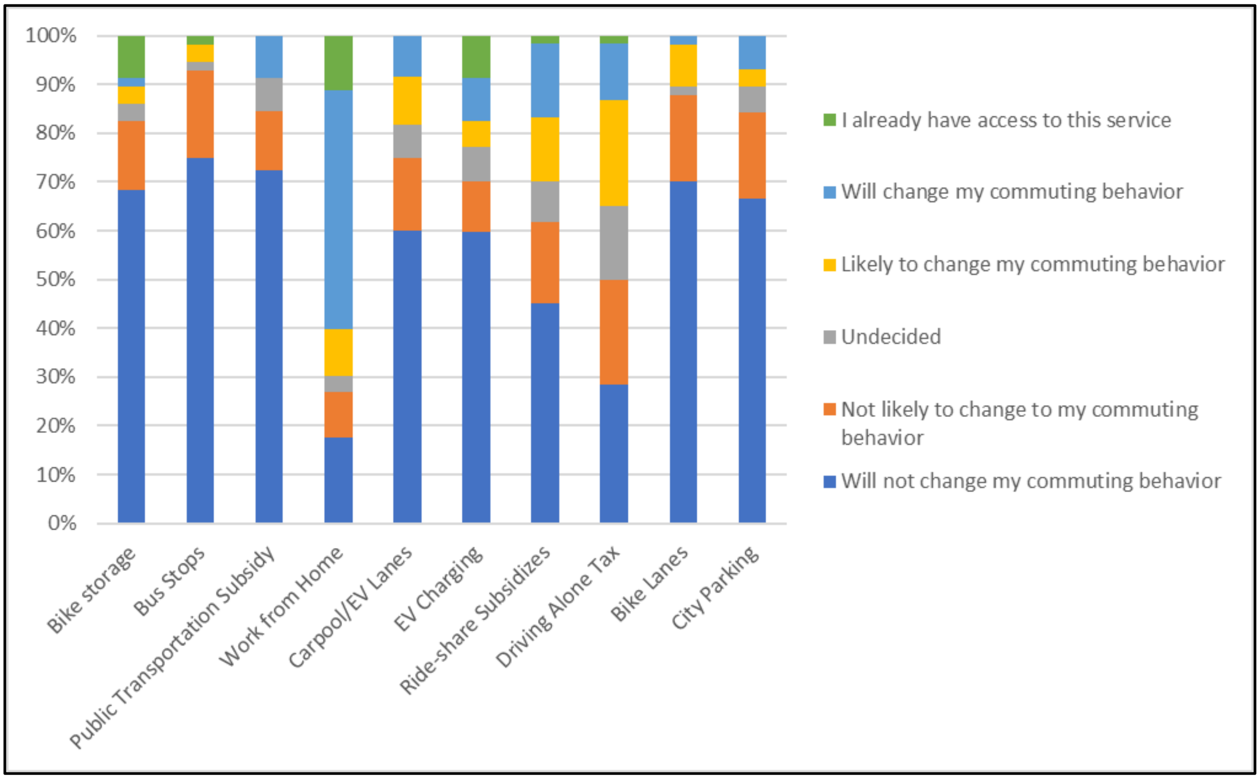


Figure 9: Detroit 2030 District Percentage Breakdown of Policy Preferences

As seen in Figure 9 and Table B1 (Appendix B), a large amount of survey respondents (49%) agree that expanded work from home policies will or are likely to change their commuting behavior. This is probably due to the familiarity respondents have with working from home as a result of the pandemic. The possibility of a drive-alone tax was also selected by 34% as a policy that would change or is likely to change commuting behavior. This question also had the largest percentage of respondents who selected that they were undecided, at 15%. This is likely due to the range in possible tax amounts (that this question did not specify). Some people may be more likely to continue their commuting habits if the potential driving alone tax was within their budget. When asked if a company subsidized rideshare program would impact commuting behavior, 28% of respondents said that this would or would be likely to change their behavior.

These three questions had the largest percentages of respondents agreeing that the implementation of such policies would change or is likely to change their commuting behavior. From this, we can draw some conclusions as to what policy proposals are likely to be the most impactful in influencing commuter behavior within the District. We can also conclude that the other policy proposals are less likely to be impactful since respondents selected that those policies would not, or were not likely to change their behavior. The full implications of these results are discussed in the Policy Proposal section below.

<u>Bedrock MyCommute Data</u>

Bedrock MyCommute tracked and produced 10,625 usable commuter data points from 27 buildings in the pre-COVID timeline, while the post-COVID timeline produced 10,770 commuter data points from 26 buildings. The pre-COVID section summarized data captured between January 11th, 2019, and February 28th, 2020. The post-COVID data was covered between October 1st, 2021, and February 1st, 2022. Because the data did not perfectly capture annual commuting patterns, we annualized the data, assuming that transportation behavior remained consistent throughout the two time periods.

With these assumptions in mind, we calculated the annual emissions per commuter for both time periods. For pre-COVID, the average annual commuting emissions were 338 kg CO_2e per commuter, and 619 kg CO_2e per commuter in the post-COVID timeline (Figure 7), with the increasing trend being an opposite result compared to the Detroit 2030 District.

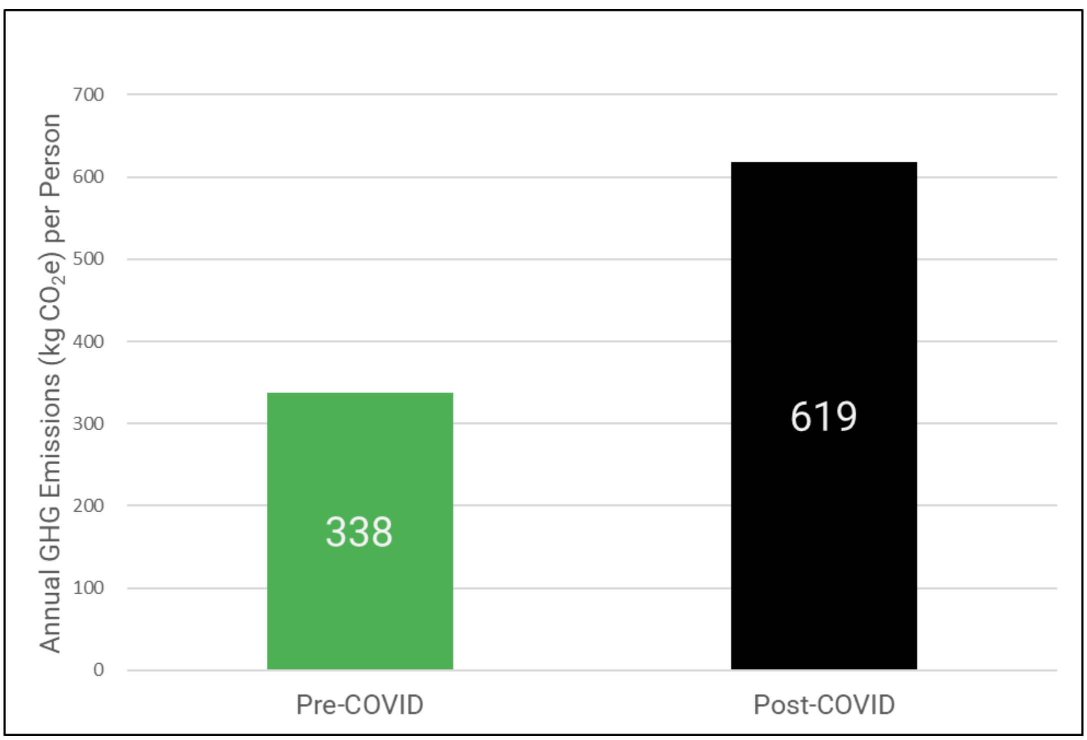


Figure 6: Bedrock Detroit Pre- and Post-Pandemic Annual Commuting Baselines

Numerically, the annual emissions per person are significantly lower in both pre- and post-COVID periods than those from Detroit 2030 District buildings analyzed in this report. The primary reason for this was the high percentage of individuals who walked to Bedrock Detroit operations, which emits nothing. Many commuters who did drive usually had less than a mile commute. It should be noted that the Bedrock data did not perfectly cover annual emissions. The post-COVID data covered only the cold weather months, and we made the assumption this commuting behavior was constant throughout the year. This could have influenced the annual post-COVID emissions per person average. In addition to the annualization assumptions we made, there are other factors that could have also influenced the increase in emissions per person from pre- to post-COVID. From discussions with Bedrock Detroit, we found out that the monetary benefits that were awarded for taking alternative modes of transportation during pre-COVID were discontinued during the pandemic. This cutoff could have motivated less workers to actively seek these transportation alternatives.

The total kg CO_2e per mode per year of the different modes of transportation within the MyCommute database are shown in Figure 7. Please note that these totals are high due to the graph representing over 10,000 individual’s commuting activity annualized within pre- and post-COVID.

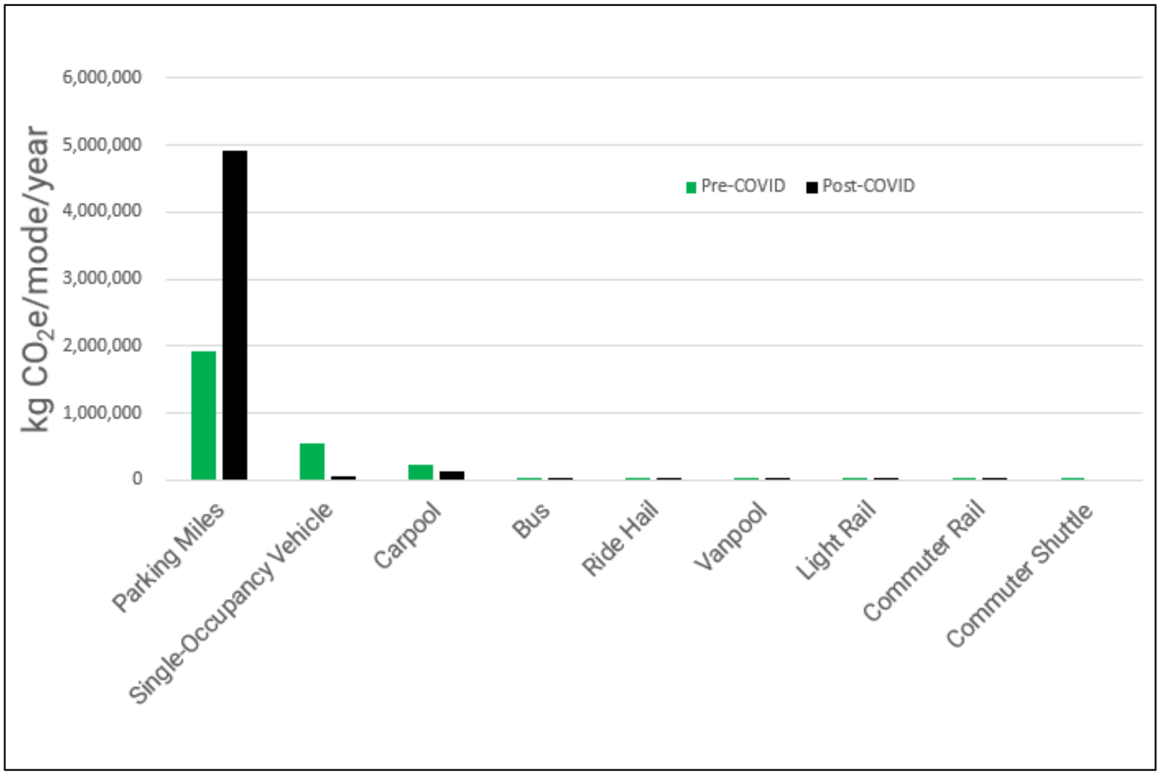


Figure 7: Bedrock Deroit Total GHG Emissions per Mode per Year for 10,625 Employees pre-COVID and 10,770 post-COVID

Parking miles, single-occupancy vehicle miles, and carpooling dominate the GHG emissions, as they were the most common forms of transportation. These were all the transportation modes that involved the use of personal vehicles. To note is the fact that, when the pandemic began, many employees telecommuted to work instead of commuting, which was tracked and assumed to be a zero-emission mode. If the emissions from working from home were tracked in this study, it would have most likely increased the annual emissions per commuter during the post-COVID timeframe.

Conclusion & Recommendations

COVID-19 Pandemic Considerations

Since this survey was completed two years after the start of the COVID-19 pandemic, the number of commuters within the Detroit 2030 District was likely to be influenced by the increased prevalence of working from home. This can be seen in the Detroit 2030 District results specifically, in which the post-COVID emissions baseline is notably lower than the pre-COVID emissions baseline per commuter.

Detroit 2030 District Policy Proposals

Based on the policy preferences of the survey respondents, shown in Figure 9, the majority of survey respondents would or would be likely to change their commuting behavior due to expanded work from home policies. An increase in the accessibility of work from home opportunities through policy would likely be the most impactful policy proposal for reducing emissions within the Detroit 2030 District. Remote work would not only reduce transportation emissions but also may reduce office building emissions through a decrease of daily building workers. If building owners establish policies that encourage work from home for at least two or more weekdays it would reduce emissions by up to 40% from the pre-covid baseline.

The policy preferences from the survey results also show that a driving alone tax may show some potential in reducing transportation emissions. Since people who drive alone or carpool to work make up the largest proportion of commuters, this potential tax could effectively reduce the number of drivers within the District. This policy is likely to be more controversial and will vary in effectiveness depending on how large the tax is. This policy would also likely need to be implemented at the municipal level, rather than the level of a business, organization, or building level and more research conducted to determine the appropriate tax percentage for reducing emissions.

The third policy with the most potential to reduce emissions is a company subsidized rideshare program. This program could be implemented at the building or company level, which makes this policy more feasible than a drive-alone tax. It can be recommended that business owners consider providing rideshare subsidies for employees. This might include company vehicles that can routinely pick up multiple riders on a daily route, and could potentially reduce emissions by over 50%, depending on how many workers choose to utilize the program.

Future Commuting Surveys and Potential Improvements to the Research Methods

We calculated both the pre-COVID and post-COVID emissions per commuter among the aggregated buildings (Figure 2). The pre-COVID emissions were 2,546 kg CO_2e per commuter, and the post-COVID emissions were 1,368 kg CO_2e per commuter. This is a 46% decrease in emissions between pre- and post-COVID. If we compare our findings with the 2021 Ann Arbor 2030 District survey results, which analyzed the difference in emissions within the height of the pandemic, they saw a 73% decrease in emissions between pre-COVID and during-COVID (Fields et al 2021). This means that we are starting to see a shift back to commuting patterns seen before the pandemic. However, we expect that remote work will become more common for many workers, and will most likely keep the emissions in future years lower than the 2019 baseline.

Because we only analyzed four out of the hundreds of member buildings within Detroit 2030 District, we don't recommend using our results as a baseline for the entire District. However, we believe that a new baseline beyond 2019 commuting patterns may be needed to effectively account for the new normalizing working patterns, mainly to account for the appearance of remote work. Serious considerations should be made as to which baseline, pre-COVID or post-COVID, will be used to estimate future commuting reductions. We believe that commuting patterns have not yet reached a new equilibrium since the pandemic started, and that we will continue to see changes in future years. We also believe that they are unlikely to return to 2019 commuting patterns, so it may be inappropriate to compare commuting emissions to a pre-COVID scenario.

Overall, we believe a post-COVID baseline provides a better representation of what future commuting behavior will be like, and should be used as the baseline for setting reduction targets. It also may be a useful endeavor in future years to compare whatever the current commuter behavior is to a 2022 baseline, if only to see how the commuting patterns have changed. If it's seen that little to no change has taken place, it would support the claim that commuting patterns have reached a new normalization, and that improvements should be set from a post-COVID baseline.

Our team designed the survey and analysis process to be replicable, so that Detroit 2030 District member buildings can use the tools provided to calculate their own transportation baseline. We have compiled tools, guides, and a pre-filled Excel sheet to calculate an emissions baseline (Appendix C: Spreadsheet Model and Appendix D: Toolkit). It should be noted that the emissions factors will need to be updated with the most recent GREET values, or, if using local emission data, input those data into the correct cells.

In terms of recommendations for future researchers on survey design, many 2030 Districts, including our team, chose to send surveys to specific building members to calculate the transportation emissions baselines (Reinheimer 2018). We would still recommend future researchers to do this as surveys can provide data on various specific research questions. We would also recommend that future researchers send surveys to more buildings to more comprehensively represent the whole District. For survey designs, as mentioned above, we asked COVID-19 specific questions as we are still in the pandemic period while conducting the research and we would like to know the patterns. Future researchers could remove COVID-19 specific questions if COVID-19 is not a prevalent concern for commuting behaviors at the time they are seeking data. This would reduce the number of questions in the survey, which might increase the response rate.

Finally, we believe it would be interesting to include a question regarding EV infrastructure investment vs. public transportation investment in future studies. Within the mode share split (Figure 4), public transportation was one of the least used modes of transportation, and within the policy section (Figure 9), a policy that offered the possibility of more accessible public transportation access had most respondents say that it wouldn't change their commuting behavior. For EVs on the other hand, we saw an increase in respondents who drove EVs in post-COVID as opposed to pre-COVID (Figure 5), likely due to the cost improvements and more accommodating charging infrastructure available now than before the pandemic. This could give insight into whether a company, if they do plan to promote alternative modes of transportation, should offer a company subsidized public transportation pass or make investments in at-work charging stations, based on the preferences of their employees.

In regards to Bedrock Detroit, for pre-COVID, the average annual commuting emissions were 338 kg CO_2e per commuter, and 619 kg CO_2e per commuter in the post-COVID timeline (Figure 7). Overall, Bedrock's emissions were incredibly low, so we think their efforts should be focused around pinpointing and strengthening what programs are currently effective rather than trying to push new initiatives. If future studies are to be done on Bedrock, we believe there are a few ways to improve upon data collection and analysis when using data from their MyCommute program. First, collecting and comparing two full year's worth of commuting data would eliminate the need to annualize the results. The post-COVID data we were given, for example, tracked less than half a year's worth of commuting trips, and were purely during cold weather months. We believe that annualizing the data impacts the results and should be avoided in the future. Second, it may be beneficial to send a survey asking if their employee's commuting behavior changed as a result of the stoppage of monetary benefits for taking alternative transportation during the pandemic. This would give valuable insight into whether monetary incentives were the reason why Bedrock's pre-COVID emissions were less than their post-COVID emissions.

Final Takeaways

This project aims at calculating Transportation Emissions Baseline for Detroit 2030 District. We considered pre-COVID and post-COVID cases and ended up surveying building members from four building types within the Detroit 2030 District. For the pre-COVID period, the average emissions were 2,546 kg CO_2e per commuter. For the post-COVID period, the average emissions were 1,368 kg CO_2e per commuter (Figure 2). There is a 46% reduction in commuting emissions impacted by the pandemic. Baseline emissions for Bedrock were estimated to be 338 kg CO_2e per commuter before the pandemic, and 619 kg CO_2e per commuter after the pandemic.

Based on the response patterns we observed in the survey, we recommend three policies that have the largest potential for reducing transportation emissions. The policies include policies that increase the accessibility of work from home opportunities, a driving alone tax policy, and company rideshare programs. These policies have the potential to reduce nearly 40%-50% of transportation emissions.

We would recommend that future researchers survey more buildings to better estimate the baseline emissions for the District. Future researchers should still consider the COVID situation because we believe that commuting patterns have not yet reached a new equilibrium since the pandemic started. Our team designed the survey and analysis process to be replicable, so that Detroit 2030 District member buildings can use the tools provided to calculate their own transportation baseline.

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Appendix A: Python Model

The Python Model is conducted in the Jupyter Notebook and mainly uses pandas (library) to analyze the data. Before using this model, it is important to delete any responses where responders did not complete survey questions and to sort the data grouped by building type. The python model is divided into 3 parts: pre-process, baseline calculation and policy analysis.

During pre-process, delete unessential columns including; longitude, latitude, IP Address and so on, and adjust the .csv table to be convenient for analysis. Using a function to find data unconforming to the calculation format, fill the null values with 0 for the next operation.

Use Equation 1 to calculate the transport emissions baseline in the Detroit 2030 District. Based on the mode of transportation, calculate the corresponding emissions during fair weather months and cold weather months considering pre-COVID and post-COVID. Then sum up emissions by transportation mode to get the pre-COVID and post-COVID baseline respectively.

For the policy question calculations, organize the data by policy question to get the count of answers. Arrange these based on response (likely to change my commuting behavior, not sure, etc). Use the answer counts to calculate the proportion of each response type per question by using the percentage function in excel.

The jupyter ipython notebook is also a part of the toolkit, contact Detroit 2030 to get the full python script. Following flowchart (Figure 11) shows the steps in the Python Model.

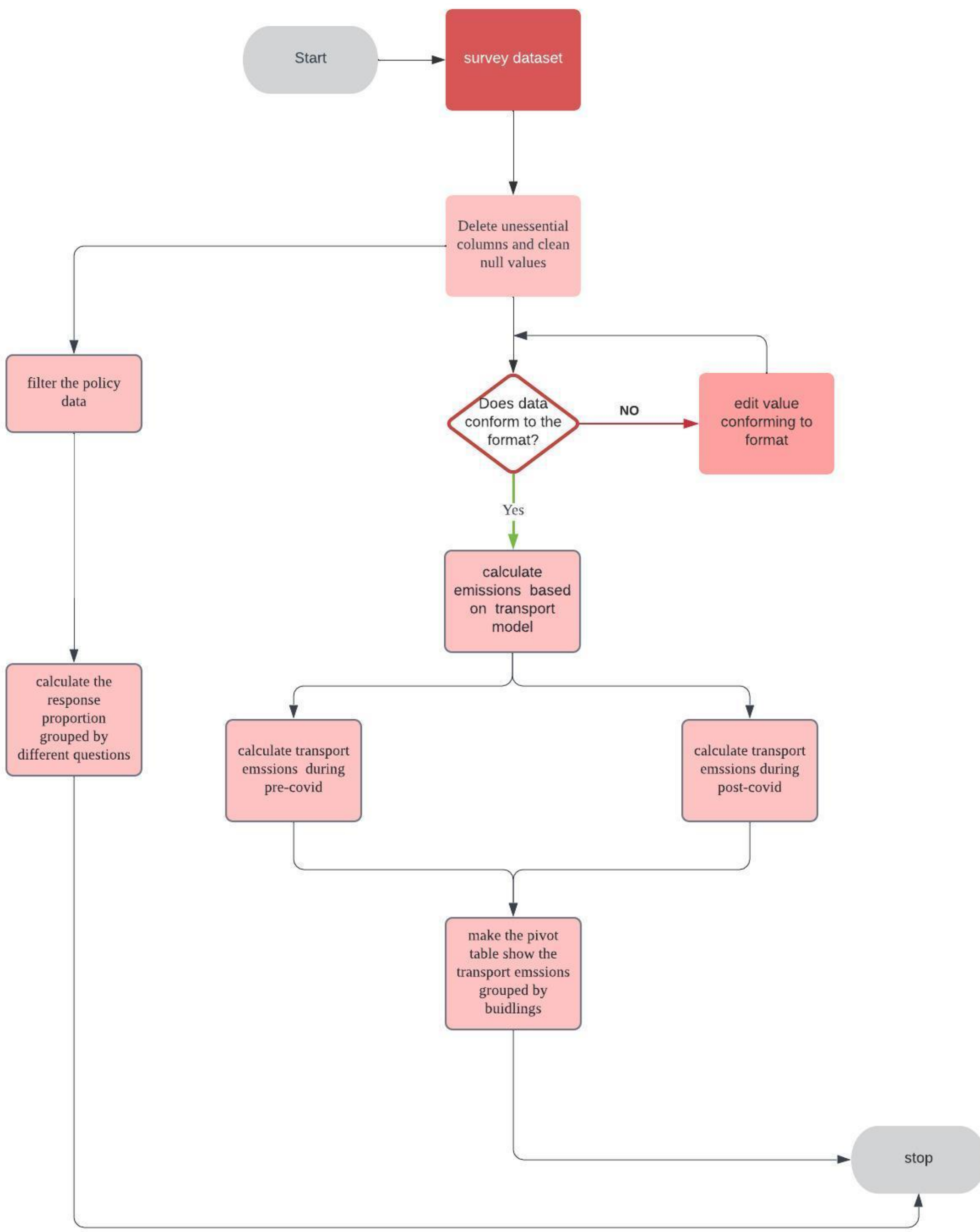

Figure 11: Flowchart of Python Model

Appendix B: Policy Table Results

Table B1: Percentage Breakdown of Policy Preferences

	Bike storage	Bus Stops	Public Transpo-rtation Subsidy	Work from Home	Carpool Lanes	EV Charging	Subsidizes Rideshare	Driving Alone Tax	Bike Lanes	City Parking
Will not change my commuting behavior	55%	59%	59%	15%	51%	48%	38%	24%	56%	54%
Not likely to change to my commuting behavior	11%	14%	10%	8%	13%	8%	14%	18%	14%	14%
Undecided	3%	1%	6%	3%	6%	6%	7%	13%	1%	4%
Likely to change my commuting behavior	3%	3%	0%	8%	8%	4%	11%	18%	7%	3%
Will change my commuting behavior	1%	0%	7%	44%	7%	7%	13%	10%	1%	6%
I already have access to this service	7%	1%	0%	10%	0%	7%	1%	1%	0%	0%

Appendix C: The Excel Model

Raw_Data

The "Raw_Data" tab is where Qualtrics imported the data to. As the name implies, this is purely the data that Qualtrics collected from respondents. We wanted to ensure that there was a fallback to work from, should there be a mistake in the data cleaning, cutting unfinished responses, etc. Each row populates a separate respondent, and due to our survey questions, will have their name, email, and place of employment. For privacy reasons, these have been anonymized. It should also be noted that the "Progress" (Column A) and "Finished"(Column B) columns are an easy summary of which respondents finished the survey, and if they did not, what percentage they left unfinished. We used this as a reference to reach out and help fill unfinished surveys.

Parameters

The "Parameters" tab is located at the very end of the excel tabs. This tab holds the assumptions and inputs used in the calculations. The emissions factors table includes all of the values for the modes of transportation asked within the survey. Make note of the relevant emitting units, which are all g CO_2e/mile, except for the "Bus" option, which was measured in g CO_2e/passenger mile. We also added the assumptions for each transportation mode to help assist in understanding the emissions factor value. This tab also includes miscellaneous parameters for reference, such as the number of working weeks, seasonal weeks, average ridership for ride-hailing, and average ridership for vanpool/commuter shuttle.

Other tables include the potential answers to questions regarding access to parking, future commuting pattern changes as a result of COVID, and the possible rankings for the policies asked within the survey. These were placed as a reference for the "Policy_Analysis" tab.

Emissions_Calculations, Building_Emissions

The analysis for the Detroit 2030 District survey data was performed in the "Emissions_Calculations" tab. We placed all of the quantitative data from "Raw_Data" into the cells, eliminating any unnecessary variables. We then cleaned the data we could (removing text from numeric responses, emailing and completing unfinished surveys) and deleted whatever unusable responses were left. The rows above the responses serve as identifying tools which help explain the description of the column, whether a formula was used, and the units used in the column.

After the first four columns, which were dedicated to the name, email, and building address of the respondent, we move onto quantitative answers. Columns "E" through "Z" are dedicated to the answers made by the respondent. For more information regarding what questions were asked, refer to the *Survey Design* section in our report. One column to note is column "X", which asks for the fuel type for whatever vehicle the respondent uses. This question, along with columns "Y" and "Z" are only asked if the respondent answered that they drove alone or carpooled in any capacity. If they did not, these sections remain blank.

Columns "AA" through "AI" are dedicated to the commuting emissions calculations for pre-COVID fair weather months. The following equation was the basic formula used for calculating emissions:

$$\text{g } CO_2\text{e per person} = (\text{\# commuting days}) * (\text{round trip miles}) * (\%\text{ mode}) * (\text{g } CO_2\text{e per mi emission factor})$$

Equation 2: Formula for Calculating the Emissions Baseline Within the Excel Template

The emissions factor variable was taken from the "Parameters" tab. The “Drive Alone” and “Carpool” columns use IF statements to refer to vehicle fuel type. The “Carpool” column divides by the number of people in the vehicle. The “ride-hail” column is divided by 1.4 people. Column "AH" sums the total emissions from each mode for each respondent. Column "AI" multiplies the values in "AH" by the seasonal working weeks (22.9). This step is continued through columns "AJ" through "AR" for the cold weather months, before being totaled in column "AS" to show total pre-COVID emissions. The exact same process is done on later columns for the post-COVID timeline.

The last couple of columns do basic analysis of the results. Columns "CL" and "CM" compare the emissions between the pre-COVID and post-COVID timelines. Within "CM", the text response "No Change" means that the pre-COVID and post-COVID commuting patterns of that individual didn't change whatsoever. "Had Zero Pre-COVID Emissions" explains that this individual didn't emit in pre-COVID, but did post-COVID. This would provide an error (we would be dividing by 0) and was noted by the formula.

Columns "CO" through "CR" were used to calculate annual emissions per person during pre and post-COVID. The answers are shown in both g CO_2e and kg CO_2e.

The "Building_Emissions" Tab merely splits the respondents by the building address they chose in Qualtrics. We then analyzed each building's emissions per person in columns "CO" through "CR."

Policy_Data_Raw, Policy_Analysis

The "Policy_Data_Raw" tab, much like the "Raw_Data" tab, only houses the raw data of each respondent's policy answers from the Qualtrics Survey. The "Policy_Analysis" tab simply shows a list of the buildings who took the survey, and counts how many of their employees chose what answer for each question. This is done through a series of IF statements. Below the initial count shows the percentage breakdown of each building respondents choices.

Results

The "Results" tab, as the name implies, displays the results of the calculations. After the data has been calculated, it will show up in the appropriate table within the "Results" tab.

Appendix D: Toolkit

The toolkit is in the form of a Google folder, to be "owned" and distributed as needed by Connie Lilley of the Detroit 2030 District. It includes:

1. A link to the Qualtrics Survey
2. An associated Microsoft Excel spreadsheet model from which our team performed our quantitative analysis
3. An associated Python model from which our team performed our quantitative analysis
4. The final presentation of this research team, recorded on Friday, April 14, 2022;
5. And this final report.

If you would like to access the toolkit, please reach out to the Detroit 2030 District at connielilley@2030districts.org. In addition, if you would like further information regarding GREET tutorial videos or the Ann Arbor 2030 District Toolkit, please reach out to the Ann Arbor 2030 District directly at annarbor@2030districts.org

Appendix E: Detroit 2030 District Survey

Email address

Please enter your name. Information provided will only be used for follow-up correspondence, if needed.

Please select which building/organization about which you are answering these questions.

The following questions should be answered based on your **pre COVID-19 pandemic** transportation behavior.

Pre-pandemic: How many days per week did you typically commute to work?

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7

Pre-pandemic: How many miles is your ***round trip*** (to AND from work) commute for work?

Pre-pandemic: How much ***time in minutes***, on average, does it take to commute to and from work?

Pre-pandemic: How many days per week did you typically telecommute (i.e., worked from home) to work?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7

Pre-pandemic: Which form of transportation did you use to get to work during **fair weather months** (approx. April -- September)? Choose an estimated percentage, **based on round trip mileage**, for each transportation option as shown below. **Please make sure all options add to 100%**.

Walking	0
Bicycle	0
Drive Alone (automobile, motorcycle, moped)	0
Carpool	0
Detroit Public Transit (bus, rail)	0
Ride Hailing (Uber, Lyft)	0
I did not work for the employer/organization at this time (write 100%)	0
Total	0

Pre-pandemic: Which form of transportation did you use to get to work during **cold weather months** (approx. October -- March)? Choose an estimated percentage, **based on round trip mileage**, for each transportation option as shown below. **Please make sure all options add to 100%**.

Walking	0
Bicycle	0
Drive Alone (automobile, motorcycle, moped)	0
Carpool	0
Detroit Public Transit (bus, rail)	0
Ride Hailing (Uber, Lyft)	0
I did not work for the employer/organization at this time (write 100%)	0
Total	0

Pre-pandemic: What is the fuel type for your vehicle?

- ◯ Gasoline
- ◯ Diesel
- ◯ Plug-in gas-electric
- ◯ Non-plug-in hybrid gas-electric
- ◯ Fully battery electric vehicle primarily charged at my home
- ◯ Fully battery electric vehicle primarily charged at my work
- ◯ Fully battery electric vehicle primarily charged at a public charging station
- ◯ I did not select "drive alone" or "carpool"

Pre-pandemic: What is the approximate fuel efficiency of your vehicle? (Miles Per Gallon (**MPG**) for gasoline vehicle. If you own a fully electric vehicle, write **N/A**)

Pre-pandemic: If you drive an electric vehicle, how many kilowatt-hours does your vehicle consume during your commute? (If you do not have an electric or hybrid vehicle, write N/A)

The following questions should be answered based on your **Post COVID-19 pandemic (Post-pandemic in this context being present day or Q1 2022)** transportation behavior.

Post-pandemic: How many days per week do you typically commute to work?

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7

Post-pandemic: How many miles is your ***round trip*** (to AND from work) commute for work?

Post-pandemic: How much **time in minutes**, on average, does it take to commute to and from work?

Post-pandemic: How many days per week do you typically telecommute (i.e., worked from home) to work?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7

Post-pandemic: Which form of transportation did you use to get to work during **fair weather months** (approx. April -- September)? Choose an estimated percentage, **based on round trip mileage**, for each transportation option as shown below. **Please make sure all options add to 100%**.

Walking	0
Bicycle	0
Drive Alone (automobile, motorcycle, moped)	0
Carpool	0
Detroit Public Transit (bus, rail)	0
Ride Hailing (Uber, Lyft)	0
I did not work for the employer/organization at this time (write 100%)	0
Total	0

Post-pandemic: Which form of transportation did you use to get to work during **cold weather months** (approx. October -- March)? Choose an estimated percentage, **based on round trip mileage**, for each transportation option as shown below. **Please make sure all options add to 100%**.

Walking	0
Bicycle	0
Drive Alone (automobile, motorcycle, moped)	0
Carpool	0
Detroit Public Transit (bus, rail)	0
Ride Hailing (Uber, Lyft)	0
I did not work for the employer/organization at this time (write 100%)	0
Total	0

Post-pandemic: What is the fuel type for your vehicle?

- ○ Gasoline
- ○ Diesel
- ○ Plug-in gas-electric
- ○ Non-plug-in hybrid gas-electric
- ○ Fully battery electric vehicle primarily charged at my home
- ○ Fully battery electric vehicle primarily charged at my work
- ○ Fully battery electric vehicle primarily charged at a public charging station
- ○ I did not select "drive alone" or "carpool"

Post-pandemic: What is the approximate fuel efficiency of your vehicle? (If you own a fully electric vehicle, write NA)

Post-pandemic: If you drive an electric vehicle, how many kilowatt-hours does your vehicle consume during your commute? (If you do not have an electric or hybrid vehicle, write NA)

The final section is asking you to consider potential shifts to your overall commuting patterns.

Do you have access to parking at work?

- ○ Yes, its free or reimbursed in a lot/garage
- ○ Yes, I have to pay for a lot/garage
- ○ Yes, I park on the street
- ○ No

If your commuting patterns changed because of the COVID-19 pandemic, how do you anticipate they will change after the pandemic?

- ○ I think my commuting patterns will go back to the way they were before the pandemic
- ○ I think my commuting patterns will remain as they are during the pandemic
- ○ I think my commuting patterns will be somewhere in between
- ○ I'm not sure

Consider the following policy proposals and respond with how you think each would impact your commuting decisions if implemented.

How likely would the following policies change your commuting behavior?

	Will not change my commuting behavior	Not likely to change my commuting behavior	Undecided	Likely to change my commuting behavior	Will change my commuting behavior	I already have access to this service	Not applicable
Increased secure bike rack parking / storage at workplace	◯	◯	◯	◯	◯	◯	◯
Closer bus stops to work	◯	◯	◯	◯	◯	◯	◯
Free or subsidized public transportation pass	◯	◯	◯	◯	◯	◯	◯
Expanded work from home policies	◯	◯	◯	◯	◯	◯	◯
Dedicated carpool/EV lanes	◯	◯	◯	◯	◯	◯	◯
Installed EV charging at my workplace	◯	◯	◯	◯	◯	◯	◯
Company fully subsidizes a rideshare program for employees to carpool	◯	◯	◯	◯	◯	◯	◯
A tax for driving alone	◯	◯	◯	◯	◯	◯	◯
Dedicated bike lanes on existing roads	◯	◯	◯	◯	◯	◯	◯
Increased access and reduced costs for inner city parking	◯	◯	◯	◯	◯	◯	◯

Please provide feedback on this survey (e.g., any questions you found confusing; questions regarding our assumptions/methods; etc.)