Measuring the Mitigating Transportation Emissions in Downtown Detroit

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Abstract

This project was designed to assist Detroit 2030 District to reduce greenhouse gas emissions associated with transportation by 50% by 2030. This project utilizes a variety of research methods to create meaningful deliverables for the client. These research methods include data collection, surveys, interviews, modeling, literature review and analysis.

We obtained data from SEMCOG household travel survey, which tracks travel movements around southeast Michigan. We were able to obtain information about traffic patterns as well as individual traveler characteristics and household demographics. We identified the area of interest by comparing the boundary of the District to the boundaries of SEMCOG's traffic analysis zones. After, we used EPA MOVES software to calculate emission factors and created a baseline estimate of the District's transportation emissions.

The ultimate goal of this project is to develop a strategy to engage building owners, managers, and tenants, in the process of measuring and reducing GHG emissions generated by the occupants of their buildings associated with transportation. An emission reduction model utilize to evaluate the possibility of hitting the organizations target reduction and to better understand the barriers to hitting that goal. According to the two scenarios, and adjusting the VMT based on Mode, Distance, and Purpose, we propose reduction strategies. Several recommendations are offered including Commuter Incentives, Cycling Program, Pedestrian Development, etc. From another aspect, Detroit is one city where green infrastructure has emerged as a planning priority. Green Infrastructure will have a positive impact on GHG reduction.

Chapter 1: Introduction

Jessica Robbins

Motivation: Urban Transportation Emissions

The transportation sector is one the largest emitters of greenhouse gas emissions in the United States, responsible for 28% of emissions produced in 2016 (Environmental Protection Agency, 2018). Cities, with their ability to bring together local businesses, community groups, and government agencies, are able to influence local decision-making pertaining to land use and transportation investment, are positioned to help reduce transportation emissions.

The motivations for measuring transportation emissions in urban areas are several: by gathering metrics pertaining to mode share, travel distance, and travel purpose, to better understand the choices that urban commuters make and why they make them; by tracking progress over time, to identify which low-carbon transportation initiatives are working, and which can be improved; and, by sharing findings with local stakeholders, peer cities, and beyond, to hold ourselves accountable, to make visible both the impact that our transportation has on our climate and our commitment to creating a more sustainable world.

History and Purpose of the Detroit 2030 District

The Detroit 2030 District is a private-public partnership , established with the goal of bringing together business owners, property managers, and developers to reduce downtown Detroit's energy use, water consumption, and transportation-related greenhouse gas emissions 50% by 2030 (Council, 2017). Launched in June 2017, the Detroit 2030 District currently comprises over 36 participating property owners and managers and 28 supporters, including such local institutions as The Detroit Lions, the DTE Energy Foundation, and the Michigan Energy Office (2030 Districts Network, n.d.-c). The District's membership is diverse, consisting of commercial and multifamily buildings, as well as houses of worship (Hicks, 2017).

Detroit's 2030 District consists of about two-thirds of a square mile (2030 Districts Network, n.d.-a) of property at the heart of downtown Detroit. As seen in the image below, the District boundary runs from just past West Grand Boulevard to the bank of the Detroit River, encapsulating such Detroit landmarks as the Detroit Opera House, Wayne State University, and Children's Hospital of Michigan. The reasons individuals have for visiting this section of Detroit are diverse, as are their modes and distance of travel. It is likely that these different groups of travelers will respond differently to whichever suite of carbon-reducing transportation programs are introduced. However, a successful package of emissions reduction strategies has the potential to create ripples that extend throughout the community, far beyond the 2030 District boundary.

Figure 1: Boundaries of the Detroit 2030 District (Hicks, 2017)

The Detroit 2030 District is one of many municipal-level greenhouse gas tracking and sustainability initiatives taking place in Detroit. In 2014, a citywide greenhouse gas inventory for the City of Detroit found that transportation within the City produces 3.2 metric tons of CO_2 equivalents per year, representing about 30% of the City's greenhouse gas emissions (Carlson, J., Cooper, J., Neale, M., & Ragland, 2014). This report found that approximately 98% of the transportation emissions produced within Detroit are attributable to private vehicle traffic, including private cars, trucks, and on-road freight transit.

The Detroit 2030 District represents both a complement to and continuation of Detroit's eco-D initiative, a part of the national EcoDistricts program. Founded in 2014, Eco-D aims to be a collaborative and community-driven enterprise, leveraging planning, technical expertise, and information sharing to facilitate the creation of neighborhood-scale sustainability projects throughout Detroit (Ricchiuto, 2015). Eco-D's purview is expansive both in terms of geography—the program offers services to a variety of neighborhoods—and scope. Projects associated with the Eco-D initiative have included community gardens and urban agriculture, energy efficiency, community solar, alternative transportation, and green infrastructure (EcoDistricts, n.d., 2017) (EcoDistricts, n.d.).

In 2017, the City of Detroit created the Office of Sustainability. In addition to serving as a 2030 District Partner, the Office has tackled several large-scale sustainability initiatives, including creating the City's Sustainability Action Agenda and improving the energy efficiency of municipal operations (Mondry, 2018; Nonko, 2018). The Office of Sustainability has made resident engagement a high priority, holding focus groups with diverse segments of the community and administering a large-scale survey among Detroit residents (Nagl, 2018; Nonko, 2018).

These sustainability initiatives represent the variety of approaches that can address urban sustainability and equity issues. The 2030 District is unique in its focus on people employed and managing buildings downtown, and as such represents a valuable piece of Detroit's sustainability policy landscape.

Efforts to Estimate Traffic-Related CO_2 Emissions in Other 2030 Districts

The Detroit 2030 District is one member of a network of similar 2030 Districts across the country. Established in Seattle in 2006, the 2030 Districts Network has united over 15 cities across the world under the banner of achieving dramatic reductions in resource consumption and traffic emissions by 2030. The formation of the 2030 Districts Network was catalyzed by the Architecture 2030 Challenge (2030 Districts Network, n.d.-a), which in 2006 issued the following environmental challenges to the global architecture and building community:

- All new buildings, developments, and major renovations shall be designed to meet a fossil fuel, GHG emissions, and energy consumption performance standard of 70% below the country or regional average/median for that building type.
- At a minimum, an equal amount of existing building area shall be renovated annually to meet a fossil fuel, GHG emissions, and energy consumption performance standard of 70% of the country or regional average/median for that building type.
- The fossil fuel reduction standard for all new buildings and major renovations shall be increased to 80% in 2020 and 90% in 2025. By 2030, new buildings and major renovations shall be carbon-neutral (Architecture 2030, n.d.)

The mission of the 2030 Districts Network is ambitious and expansive: to forge partnerships between business owners, building owners and managers, local government, and the local community, proving "a business model for urban sustainability" (Reinheimer, 2018). In order to facilitate the adoption of best practices in urban sustainability, the 2030 Districts Network offers technical resources, networking, and information exchange opportunities for member cities, including guidance on how to form a 2030 District, analytical tools to assist with modeling energy and water use, and case studies and resource libraries developed by District members (2030 Districts Network, n.d.-b).

2030 Districts that have attempted to establish a baseline for traffic-related greenhouse gas emissions have found that the process is complicated by a lack of such universally applicable monitoring tools. Unlike water and energy consumption, traffic emissions are generated largely by activities that take place outside of the member buildings, and potentially outside of the District boundary. This disjunction between District jurisdiction and emission source raises questions both with regards to the feasibility of establishing a consistent emission inventory methodology across Districts, and with regards to a given District's ability to independently impact transportation emissions.

In 2018, graduate student Sarah Reinheimer completed an assessment of efforts to measure traffic emissions across the 2030 Districts Network (Reinheimer, 2018). Reinheimer's work identified both best practices in traffic estimation methodologies for 2030 Districts, and highlighted some of the barriers that impede attempts to establish a consistent emissions monitoring strategy.

According to Reinheimer, each District's methodology for creating a baseline estimate of traffic emissions falls into one of three categories: use of the National Household Travel Survey, Public-Private Partnerships, and Metropolitan Planning Organization (MPO) Partnerships. Use of figures from the National Household Travel Survey involves using travel data collected every eight years by the Federal Highway Administration and U.S. Department of Transportation, with summary statistics reported at the level of census region or division. The public-private partnership approach can look different for each District that elects to take that route, as it depends on the type of transportation monitoring and survey efforts already taking place in the City, the availability of appropriate data and survey instruments, and the types of relationships that the District has formed with partner organizations. Working with local partner organization opens up the possibility of obtaining very granular local transportation data, but is also somewhat of an idiosyncratic process, and it is unlikely that any particular District's approach will be fully replicable in another location. MPO partnerships involve working with the local metropolitan planning organization, which are responsible for monitoring local traffic patterns and emissions.

Reinheimer's work identifies several best practices for 2030 Districts looking to conduct an estimate of transportation-related greenhouse gas emissions. Reinheimer emphasizes the importance of fostering partnerships with local transportation agencies and District members as a valuable part of the transportation emissions estimation process. One of the key barriers to obtaining an accurate emissions estimate is lack of local travel data. The earlier District officials can form meaningful partnerships with the agencies that possess these data, the easier the emissions estimation process will be.

Reinheimer discusses surveys as valuable tools for estimating mode share, travel distance, and other components of travel behavior. However, given the large amount of time and institutional capacity necessary to administer a statistically robust survey, Reinheimer recommends that Districts conducting a baseline emissions estimate use pre-existing local transportation data, then branch out to incorporating survey data in emissions updates as the institutional capacity of the District increases. With regards to writing and administering surveys, Reinheimer recommends recruiting local stakeholders to help with survey recruitment and advertising, coordinating with other local survey efforts in order to avoid survey fatigue, translating surveys into the predominant languages of the area, offering incentives for survey completion, and allowing respondents to identify multiple modes of travel in their survey responses.

When conducting a travel survey specific to the City of Detroit, it is important to keep the concept of "mode loyalty" in mind. Results from the 2015 Michigan Travel Characteristics Survey demonstrate a higher degree of mode loyalty among automobile drivers, compared to those take public transit or rely on active transportation. The survey results showed that respondents who identified automobile as their primary mode of transit to work took a car to work 94.8% of the time. In contrast, workers who identified transit as their primary mode of transit drove a car about 15% of the time, carpooled about 15% of the time, and walked 27.3% of the time (McGuckin, N., Casas, J., & Willaby, 2016). This high incidence of multimodality, especially among those who rely on public and active transportation, highlights the importance of crafting a survey instrument that is sensitive to these variations in travel behavior.

Many factors can complicate a District's effort to produce a robust survey. These include the writing of the survey itself, which must be detailed enough to produce meaningful data, but short enough to minimize the risk of non-participation. All survey efforts run the risk of low participation. 2030 District officials should also be aware of the possibility that those organizations that are able to generate high levels of survey engagement may produce fewer emissions than organizations that are not as actively engaged in the 2030 District's activities. Finally, survey preparation and administration represents a significant commitment of time and staff resources.

More generally, the process of obtaining travel data, establishing collaborations with local transportation agencies, and administering surveys is time consuming and resource intensive. This process can be impeded by a lack of up-to-date and locally relevant travel data. Ideally, transportation data should be local enough to reflect the local transportation environment, granular enough to enable identification of transportation going in and out of the District, and should contain information pertaining to travel mode, party size, travel purpose, and distance. Districts have adopted different approaches for meeting their data needs, and have consequently introduced different assumptions into their transportation emission baseline. These methodological differences undermine the Districts Network's goal of facilitating inter-District resource sharing and make it difficult to compare emissions reductions across Districts.

The following table summarizes the baseline transportation emissions produced by other 2030 Districts.

District Location	**CO2 Emissions Baseline**	**Source**
Cleveland	2,901.4 kg CO_2/commuter/ year	(McKnight, n.d.; Reinheimer, 2018)
Denver	6 kg CO_2/commuter/day	(Reinheimer, 2018)
Ithaca	1,501 CO_2/commuter/ year	(Namnum, A., & Briana, 2017)
Philadelphia	9.4 kg CO_2/commuter/day	(Reinheimer, 2018)
Pittsburgh	1,794 kg CO_2/commuter/year	(Reinheimer, 2018)
San Francisco	2.9 kg CO_2/commuter/day	(Reinheimer, 2018)
Seattle	900 kg CO_2/commuter/year	(Reinheimer, 2018)

Table 1: Baseline Transportation Emissions of 2030 Districts

Chapter 2: Creating a Transportation Emissions Baseline for Downtown Detroit

Jessica Robbins

Detroit and Southeast Michigan: Overarching Travel Trends

Detroit travelers have been subject to shifts in travel behavior that are taking place across the region, as well as the country as a whole. In Southeast Michigan, women have overtaken men as the more frequent travelers--with working women becoming the demographic responsible for the highest number of trips (McGuckin, N., Casas, J., & Wilaby, 2016) and young people have gradually begun to delay the age at which they obtain a driver's license (McGuckin, N., Casas, J., & Willaby, 2016). Statewide, the most frequently used mode of transportation is the private automobile, accounting for 88.2% of trips. Shopping and personal business are the most frequently weekday travel purposes; work trips account for about 12% of all weekday trips statewide , and less than 10% of all trips in Southeast Michigan. Household size and income are both positively correlated with number of trips taken; however, larger households also tend to show increased diversity of travel mode, including carpooling, walking, and biking (McGuckin, N., Casas, J., & Willaby, 2016).

Employment status has been shown to influence travel behavior, with workers making more trips per person and more vehicle trips than the unemployed. About 82% of Michigan workers commute to a regular workplace on weekdays, with the remainder either working from home (6%), or citing no fixed place of employment (12%). Where telecommuting is available, the average worker telecommutes 1.3 days per week. In 2015, the average commute time for the Detroit region was 25.4 minutes, which is about two minutes longer than the statewide average (McGuckin, N., Casas, J., & Wilaby, 2016; McGuckin, N., Casas, J., & Willaby, 2016).

Within the Metro Detroit Area, the average person makes 3.8 trips per day, 2.4 of which are vehicle-based (McGuckin, N., Casas, J., & Willaby, 2016). Sixty-nine percent of Detroit commuters drive alone to work, 13% carpool, 9% take public transit, 4% walk, 3% telecommute , and 1% bicycle (Detroit Future City, 2017). Average auto occupancy for work trips is 1.1 people, which is the lowest average party size for all travel purposes (McGuckin, N., Casas, J., & Wilaby, 2016). Within the past year, the City of Detroit has undergone significant demographic shifts, which have resulted in changes in travel behavior. Specifically, the proportion of residents who both live and work within the City has declined; currently, about 30% of employed Detroit residents work within city limits. This trend is significant in that it implies that the 2030 District could benefit from forming partnerships across the entire Detroit Metro Region, as well as promoting employment opportunities within the City. It is also important to note that this increasing distance between residence and workplace has a disproportionate impact on the commutes of low-income workers, with the lowest-wage workers now typically having the longest commutes. Detroit Future City, the reporter of these metrics, believes that the paucity of entry-level jobs within the City contributes to these patterns (Detroit Future City, 2017).

Measuring the District's Transportation Emissions: Methodology

Methods: Data Sources

Travel Behavior Data: Travel behavior for the Detroit metro region was obtained from the Southeast Michigan Council of Governments (SEMCOG), Southeast Michigan's MPO. In 2015, SEMCOG conducted a household travel survey in order to provide travel behavior information for state and regional transportation models. SEMCOG's surveying effort resulted in the collection of travel data from 12,394 households across the SEMCOG service area, including East Wayne, West Wayne, Oakland, Macomb, Washtenaw, Monroe, St. Clair, and Livingston (Wilaby, M., & Casas, 2016). The travel survey reports information on travel mode and purpose, travel time and distance, and the origins and destinations of trip segments. Individual- and household-level information includes household income, age, and employment status.

Emissions Rates Data: Emissions rates were calculated using EPA MOVES, a software program created by the United States Environmental Protection Agency to model emissions of criteria air pollutants, greenhouse gases, and air toxics associated with the operation of both on- and off-road vehicles. MOVES was run with vehicle makeup and age and fuel composition data provided by SEMCOG, created for the 2017 National Emissions Inventory.

Estimated Trip Occupancy: Estimates for typical party size (trip occupancy) were obtained from the MI Travel Counts III Travel Characteristics Technical Report published in 2016 (McGuckin, N., Casas, J., & Willaby, 2016). The MI Travel Counts Technical Report reports average occupancy for auto trips by trip purpose. Average party size was averaged across travel purposes in order to obtain an overall estimate of average trip size. For work-related trips, the average trips size reported for work and volunteer activities was used. As average trip size was available for automobile trips only, the estimate of average trip size used does not take into account the party size for walking or bicycle trips, or trips completed on public transportation.

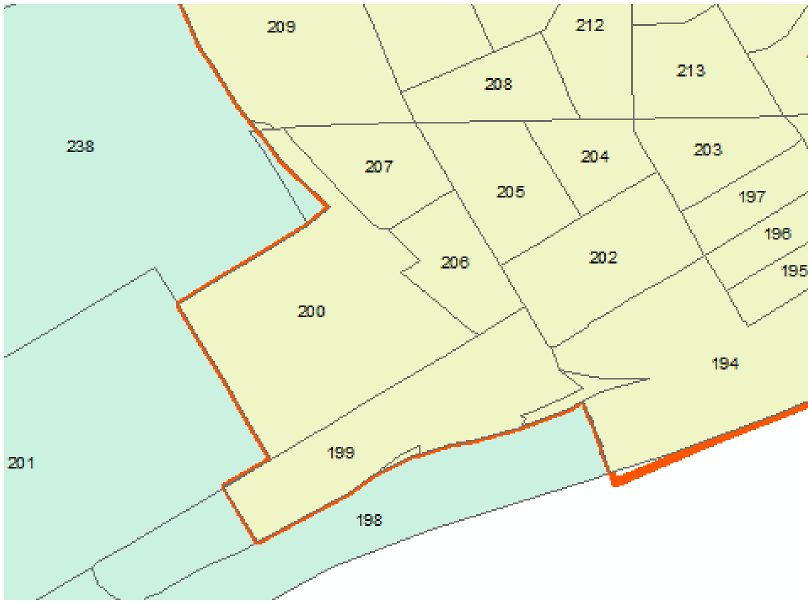
Trip Purpose	**Mean Auto Occupancy**
Work/Volunteer	1.1
Social and recreation	1.7
Shop and errands	1.4
Pick-up/Drop-off	1.7

Table 2. Mean auto occupancy by trip purpose, as reported in the MI Travel Counts III Travel Characteristics Technical Report.

District Boundary and Traffic Analysis Zone (TAZ) Data: A GIS map of the District boundary was provided by District partner Michael Cousins. This map was overlaid with a map of TAZ boundaries produced by SEMCOG in 2010, in order to determine which TAZs fall within the District.

Figure 2: The 2030 District in relation to TAZ boundaries. TAZs colored dark green are those that were included in the analysis.

In general, all TAZs that fell at least in part within the District boundary were included in the greenhouse gas emissions calculations. Exceptions to this rule were TAZs 134, 135, 142, 143, 148, 150, 153, 157, 161, 169, 198, 231, 238, and 261, as visual inspection revealed that these TAZs shared very little area with the 2030 District.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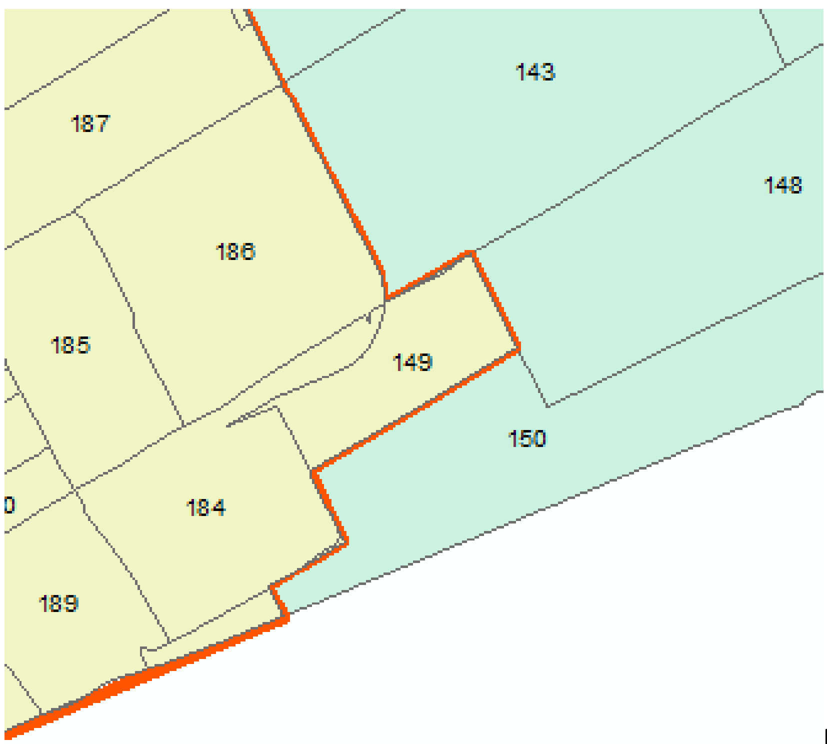
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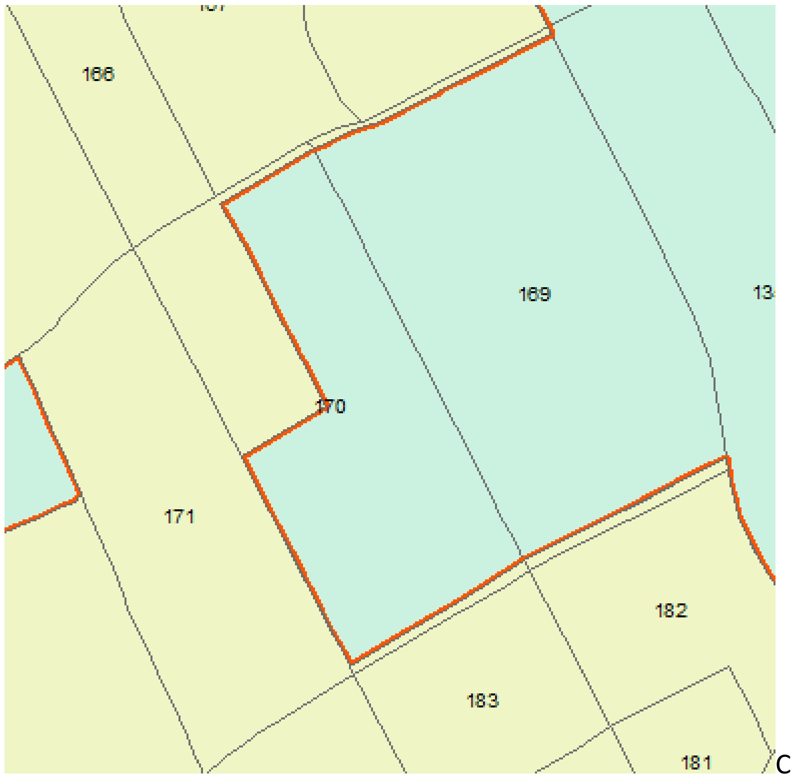


Figure 3 A-C: Depictions of TAZs 198, 238, 169, and 150, and their position relative to the 2030 District Boundary, indicative of the types of TAZs that were excluded from analysis.

Methods: Calculations

Identification of District-related trip segments, District travelers, and work-related travel: Using the data describing the relationship between the District and TAZ boundaries, a list of TAZs that fall within the District was generated. SEMCOG's travel data provide origin and destination TAZ information for each trip segment. This information was used to identify trip segments that either originate or terminate within the District. An individual is considered a District traveler if their travel data shows that they made at least one trip that began or ended within the District over the course of the survey period.

Work-related trips are identified by SEMCOG as trip segments whose destinations are locations that are associated with working from home, working at a fixed work location, working at a non-fixed work location, and working at an on-site meeting. An individual is considered a District work-related commuter if they make at least one trip in or out of the District for work-related purposes, and a household is considered a work-related household if it contains at least one member who has made at least one such trip. In keeping with the 2030 District Network's practice of counting both morning and evening commutes (which originate at a workplace and end at home) towards a District's total work-related transportation CO_2 emissions, estimates for work-related travel emissions calculated using SEMCOG's definition of work-related travel are doubled.

Emissions rates: Emissions rates were calculated using EPA MOVES software, and emissions are reported in kilogram of CO2 emitted per mile traveled, based on travel mode used. Travel mode is recorded by SEMCOG's household travel survey. However, EPA and SEMCOG identify different potential travel modes. A comparison of the possible travel modes provided by each of the transportation agencies, as well as the emissions rates that were ultimately used, is provided in the table below. Emission rates for Train/Amtrak and the Detroit People Mover were estimated based on national emission estimates for intercity rail and transit rail, respectively (EPA Center for Corporate Climate Leadership, 2018).

Travel Mode, SEMCOG	Travel Mode, EPA MOVES	Emissions Rate (kg CO_2/mile)
Walk	N/A	0
Bicycle	N/A	0
Motorcycle	Motorcycle	0.371907
Auto/van/truck (as the driver)	Passenger car, passenger truck	0.423002
Auto/van/truck (as the passenger)	Passenger car, passenger truck	0.423002
Carpool/vanpool	Passenger car, passenger truck	0.423002
School bus	School bus	1.00205
Public transit local bus	Transit bus	1.290701
Dial-a-ride/paratransit	Passenger car, passenger truck	0.423002
Private bus or shuttle	Passenger car, passenger truck, transit bus	0.712235
Taxi/limo	Passenger car, passenger truck	0.423002
Train/Amtrak	N/A	0.14
Detroit People Movers	N/A	0.119
Something else	N/A	0.442377

Table 3: Emission rates for the modes of transportation identified by the SEMCOG travel survey, as well as the EPA MOVES mode-based emissions rates that were used to estimate the emission rate for each mode identified in the SEMCOG survey

CO_2 emissions per trip: Kilograms of CO_2 emitted for each segment were calculated as follows:

$$Emissions(kgCO_2) = distance(miles)_i \times emissionrate(kgCO_2/mile)_i$$

Where *i* is each trip segment that either begins or ends within the District.

Annual person trips: The annual person-trips metric is obtained by multiplying three values: the number of individuals identified as District travels via the SEMCOG travel survey, average party size, and the average annual number of trips taken per person.

$$Annual person trips = number of District travelers (person) \times average party size (person) \times annual number of trips (\frac{trip}{person})$$

The number of District travelers is obtained by summing the sample weights associated with each individual who is identified as a District traveler.

When calculating annual number of trips associated with all travel purposes, the averaged daily number of trips is multiplied by 365. When calculating annual number of trips associated with work, the daily average number of work-related trips—as defined by SEMCOG—is multiplied by 250 and then by 2.

Total CO_2 emissions: Annual CO2 emissions are calculated by multiplying the number of annual person-trips by the average emissions produced per trip per person:

$$Annual CO_2 Emissions \left(\frac{kgCO_2}{year}\right) = number of person trips \left(\frac{person trip}{year}\right) \times \frac{kgCO_2}{trip person}$$

Measuring the District's Transportation Emissions: Results

Metric	Value	Unit
Number of District Travelers, all purposes	477,310	people
Number of District Travelers, work-related travel	169,491	people
Annual Person-trips, all travel	465,776,143	person-trip / year
Annual Person-trips, work-related travel	101,672,315	person-trip / year
Total CO_2 emissions, all travel purposes	1,842,533,268	kg CO_2 / year
Total CO_2 emissions, work-related travel	690,464,552	kg CO_2 / year
CO_2 emissions/ person-trip, all travel purposes	3.96	kg CO_2 / person-trip
CO_2 emissions / person-trip, work-related travel	6.79	kg CO_2 / person-trip
CO_2 emissions / person, all travel purposes	3,860	kg CO_2 / person / year
CO_2 emissions / person, work-related travel	4,074	kg CO_2 / person / year

Table 4: Summary statistics for District travel

Annual per-person CO_2 emission estimates are comparable to those obtained in other 2030 Districts, albeit slightly higher than has been reported by other Districts thus far.

Profile of District Traffic

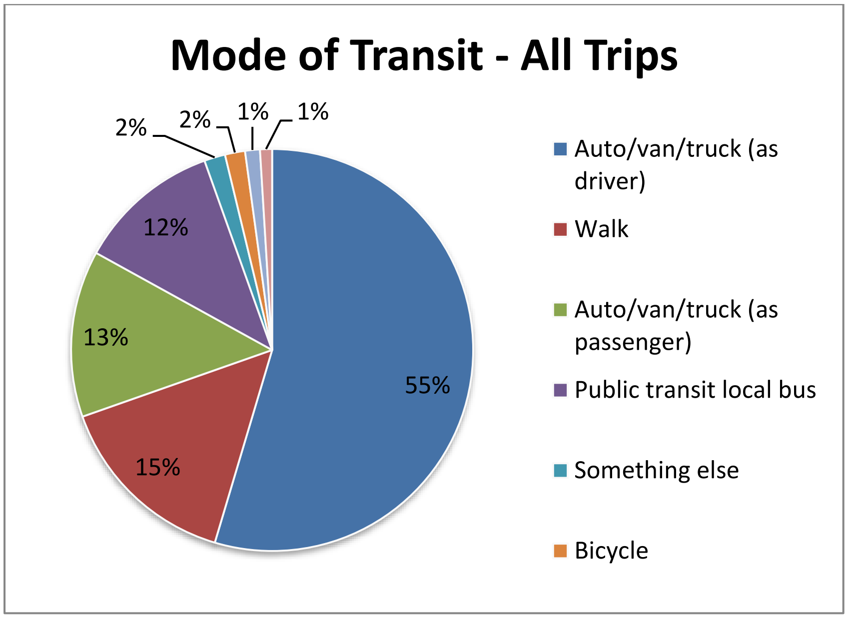
The SEMCOG Travel Counts Household Survey reports trip-level information pertaining to travel mode, trip purpose, trip distance, and trip occupancy. Summary statistics for these variables are reported below, considering both all trips that go in or out of the District and trips that SEMCOG has identified as work-related.

Twenty-three percent of traffic going into or out of the District can be directly attributed to work. As discussed, SEMCOG's definition of work-related travel means that only trips whose destination is a workplace are considered to be work-related. The most common travel purpose was general household activities, which constitutes 25% of the traffic going in or out of the District, and may include trips that District commuters take from their workplace to their home. Other common travel purposes include school, shopping, and reaching health care services.

Travel Purpose	**% of Responses**
Typical home activities	25%
Work at fixed work location	19%
Change travel mode/transfer	11%
Drop off/pick up passengers	7%
Routine shopping	5%
Health care visit	5%
Non-shopping errands	5%
School/studying	4%
Eat out	4%
Socialize with friends	3%
Exercise or recreation	3%
Work related (off-site meeting)	2%
Other	7%

Table 5: Travel Purpose. Note that responses have not been statistically calibrated

The most common mode of transport in or out of the District is private automobile, including cars, vans, and trucks. This mode of transit constitutes 68% of all traffic going in or out of the District, and 80% of the travel that takes place for work. Other commonly reported modes of transportation include walking, bicycling, carpool, and public transit.



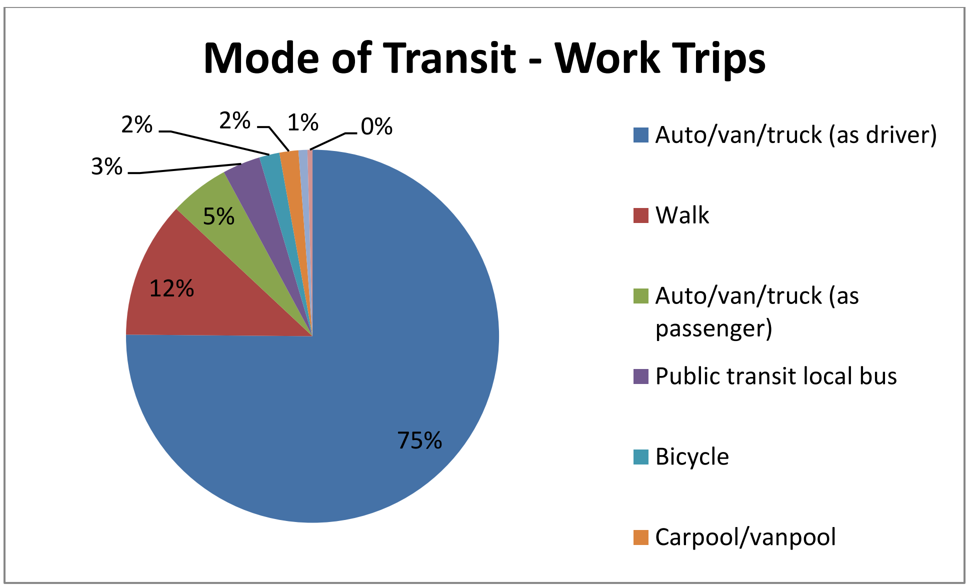


Figure 4 A-B: Travel mode into or out of the District, as observed in the general District commuter population, and for explicitly defined work-related trips only. Responses have not been statistically weighted

Work-related trips tend to be longer than trips made for other purposes. The average work related trip is 17 miles, whereas the average trip overall is 12 miles. Work-related trips also tend to have smaller party sizes than general District traffic. The average observed trip occupancy for all trips was 2, whereas for work-related trips the average party size was 1.4.

Profile of District Commuters

The SEMCOG Travel Counts Household Survey collects information on individual commuters within the SEMCOG service area. Key demographic information for people who travel in and out of the District is presented below.

Age and Gender

The types of people who travel in out of the District are diverse. Forty-nine percent of the individuals who travel in or out of the District are classified as full time workers. This is true for 83% of those whose District travel was work-related.

Person Type	% of Responses, All Travelers	% of Responses, Work-Related Travelers
Full time worker	49%	83%
Non-worker	15%	12%
University student	13%	0%
Retiree	8%	0%
Pre-driving age child	7%	0%
Preschool child	4%	0%
Driving age child	2%	1%
Not ascertained	2%	3%

Table 6: Personal characteristics of individuals who travel in and out of the District

The average age of people who travel in or out of the District, for both work-related travel and all travel in general, is between 43 and 44. Thirty-eight percent of all travelers fall within the age range of 26 to 45; 53% of work-related travelers fall within this age category. The majority of the people who travel in or out of the District are women: women represent 52% of all travelers, and 51% who travel for work.

Employment Status and Employment-Related Transportation

Sixty-six percent of all people who travel in or out of the District identify as currently employed. This is true for 94% of work-related travelers. Among those who travel to the District for work, 87% said that they have a fixed work location.

Work Location	% of Responses
Same place every day	87%
No fixed workplace	10%

Work from home	1%
Don't know/Declined to state	1%
Table 7: Typical workplace location for those whose District travel is work-related	

In the SEMCOG Travel Counts Household Survey, 85% of individuals whose District travel was work-related said that their primary mode of transit to work was automobile (including cars, vans, and trucks). Other reported modes of transit included walking, bicycling, and public transit.

Typical Mode of Transit to Work	% of Responses
Auto/van/truck (as driver)	80%
Public transit	9%
Auto/van/truck (as passenger)	5%
Walk	2%
Bicycle	2%
Carpool/vanpool	1%
Table 8: Most common mode of transit to work, as reported by individuals who travel in or out of the District for work.	

Twenty-seven percent of those whose District travel is work-related said that their workplace offers telecommuting. Of those who are able to telecommute, 46% telecommute at least one day per week. Five percent typically telecommute five days per week.

Household Income and Lifecycle

The SEMCOG Travel Counts Survey also collects household-level data. Key demographic characteristics of households whose members travel to or from the District are summarized below, both for all travelers and for travelers whose travel is work-related.

In general, the annual household income associated with people who commute to or from the District for work is higher than the household income of the general District commuter. Sixty-three percent of individuals whose District-related travel is for work reported having an annual household of $50,000 or more. This is true for 50% for the general population of District commuters.

Income	% of Responses, All Travelers	% of Responses, Work-Related Travelers
Less than $15,000	13%	3%
$15,000 to $24,999	8%	4%
$25,000 to $34,999	8%	7%
$35,000 to $49,999	9%	10%

$50,000 to $74,999	15%	18%
$75,000 to $99,999	11%	14%
$100,000 to $124,999	9%	11%
$125,000 to $149,999	5%	7%
$150,000 or more	11%	14%
Don’t know/Declined	12%	13%

Table 9: Annual household income for households whose members travel in or out of the District, both for general purposes and for work-related reasons only

The plurality of households whose members travel into or out of the District contain no children or retired persons. However, District commuters who travel for work-related purposes are slightly more likely to belong to households that contain children than the general population (39% vs. 35%), and slightly less likely to come from households that contain retired persons (5% vs. 1%).

Household Type	% of Responses, All Travelers	% of Responses, Work-Related Travelers
Household has 1 adult, no children and no retired persons	23%	20%
Household has 2 or more adults, no children and no retired persons	21%	23%
Household has 1 adult and the youngest child is 0 to 4 years old	2%	2%
Household has 2 or more adults and the youngest child is 0 to 4 years old	12%	14%
Household has one adult and the youngest child is 5 to 17 years old	4%	2%
Household has 2 or more adults and the youngest child is 5 to 17 years old	18%	21%
Household has 2 adults and the age gap is 15 years or more	5%	5%
Household has 2 or more adults and the age gap for any two members is 15 years or more	10%	12%

Household has 1 or more adults with no children and all adults are retired	4%	0%
Not ascertained	1%	1%

Table 10: Household type of District commuters, both the general District commuting population and households whose members commute to the District for work purposes

Discussion: Interpretations of Findings

Analysis of the results of SEMCOG's Household Travel Survey reveals the diversity of the 2030 District traveler population. While work-related travel is the single biggest contributor to District traffic, the reported reasons for visiting the District are various. Generally, those who travel to or from the District are quite diverse in terms of age, employment status, and income; the subpopulation of those who travel to the District for work is less diverse in these regards, especially with regards to employment status. Those who travel to the District for work are also generally wealthier than those who travel to the District for personal or recreational reasons alone.

While the modes used to get in or out of the District are also diverse, work-related travel is notably private automobile dependent. However, an interesting phenomenon is revealed when comparing the work-related travel behavior reported by individuals in response to the Household Travel Survey and the observed behavior of work-related travels. That is, 85% of survey respondents reported that their typical mode of transportation to work was via private automobile, while observed travel patterns indicate that private automobile was the mode of choice 80% of the time.

Travel Mode	**% of Responses, as Reported in Survey**	**% of Responses, as Observed**
Auto/van/truck (as driver)	80%	75%
Walk	2%	12%
Auto/van/truck (as passenger)	5%	5%
Public transit local bus	9%	3%
Bicycle	2%	2%
Carpool/vanpool	1%	2%
Private shuttle or bus	<1%	1%
Other	<1%	<1%

Table 11: Comparison of typical travel mode to work, as voluntarily reported and as observed via traffic data

The phenomenon of mode loyalty, as observed at the statewide level, would predict that survey respondents would underreport their reliance on private automobiles. This does not seem to be the case here, indicating that mode loyalty to private automobiles may be not as strong as a detriment of travel behavior in the Detroit metro region as it is in Michigan as a whole. Mode loyalty to public transit, in contrast, appears to be relatively low. Respondents also seem to have under-reported their frequency of walking to work. While willingness to walk to work may be determined at least in part by seasonal factors, these observations indicate that promoting a shift in mode from private automobile to walking may be more successful than encouraging use of public transportation.

Discussion: Underlying Assumptions and Data Limitations

Several assumptions were made in the course of completing this analysis in order to address limitations of the available traffic and emissions data.

This analysis is concerned only with trips with that either originate or end within the District; trips that pass through the District without stopping are not counted towards the District's emissions. Additionally, emissions associated with the manufacture of vehicles or vehicle fuel, and trips associated with inter-business travel, are not taken into account.

This analysis drew on traffic and emissions data produced by different entities, which is produced and updated at different rates. As such, this analysis relies on the assumption that traffic patterns of the Detroit Metro Region did not change significantly between 2015 and 2017, and that TAZ boundaries have not changed significantly since 2010.

There is some ambiguity in defining the physical boundary of the analysis zone. While the 2030 District boundary does coincide with TAZ boundaries in many cases, there were also several instances where a TAZ fell partially, but not completely, within the District boundary. Generally, a TAZ was included within the analysis area even if it fell only partially within the District boundary, except in the case of the four TAZs discussed in the Methods section above. In cases where TAZs were included within the analysis zone, it was assumed that a significant majority of the traffic occurring within the TAZ could be attributed to the 2030 District. Additionally, District members located outside of the official District boundary were not included in the analysis.

A certain degree of ambiguity was introduced into the analysis by the structure of the SEMCOG household travel data. First, the fact that SEMCOG and EPA MOVES define different sets of possible modes of transportation mean that emissions rates returned by MOVES had to be adjusted in order to accommodate the travel mode information provided by SEMCOG. A similar issue arises with SEMCOG's definition of work-related travel, which only identifies a trip as work-related if it terminates at a work location. Doubling the emissions associated with nonbusiness-to-business location trips in order to obtain an estimate for the emissions associated with all work-related travel assumes that there is a high degree of symmetry between nonbusiness-to-business location and business-to-nonbusiness location trips.

Finally, the SEMCOG household travel data is calibrated to report individual and household-level characteristics with a high degree of statistical accuracy. Trip-level data is not calibrated in this way, which makes it difficult to perform a precise or in-depth traffic pattern analysis. To address this issue, this analysis drew from state-level statistics of average trip occupancy in order to compute the number of District commuters. However, this solution is itself fraught—complicated by the fact that average occupancy rates are only reported for automobile use and reported in terms of average occupancy by travel purpose, where there is limited capacity to confirm the relative frequency of different travel purposes, or to compare travel purposes defined at the state level with those defined by SEMCOG.

Discussion: Recommended Next Steps

Taken together, these findings regarding travel behavior and demographic characteristics of 2030 District travelers suggest several strategies for reducing travel emissions, as well as for obtaining reliable emissions estimates in the future.

First, while the purview of the 2030 District has historically been restricted to work-related travel, the high percentage of District travel that occurs for recreational purposes suggests that there may be an advantage in taking a more holistic approach to emissions reduction.

Several 2030 Districts have incorporated survey efforts into their approach for measuring traffic emissions (Reinheimer, 2018). Including a survey in future years offers several advantages. A survey can be distributed specifically to those buildings that fall within the Detroit 2030 District boundary, as opposed to relying on TAZs as a proxy for the District boundary. Additionally, a survey tailored to the research questions of the 2030 District could provide a more accurate picture of the volume of traffic that occur for work-related purposes, typical party size, and seasonal travel patterns; could help ascertain why commuters choose to walk, drive, or take public transit to work; and could better distinguish between trips taken in cars, trucks, and vans. However, as noted above, comprehensive survey distribution can be a time- and resource-intensive process, and would require the development of a personalized statistical weighting mechanism to compensate for possible biases in sampling and survey response.

Responses to SEMCOG's Household Travel Survey and analysis of work-related travel patterns suggest that work-related emissions could be reduced by reducing trip length, increasing average party size, shifting mode, and reducing number of trips made. Party size increases could be obtained by running or promoting carpooling programs. Substantial mode shift may not be possible without sustained investment in public transportation programs. However, as the discussion of mode loyalty above demonstrates, 2030 commuters may be amenable to adopting active transportation. Reduction in trip number could be achieved by promoting telecommuting, as survey results indicate that many will choose to telecommute at least occasionally when given the option. The final strategy, reducing trip length, is unlikely to be achieved without a more substantial overhaul of Detroit's workplace opportunity landscape.

Analysis of commuting and demographic trends occurring within the city of Detroit reveal that travel behavior is intertwined with age, gender, household income, and job access. While the District itself may be largely unable to independently influence the demographic shifts taking place in the Detroit region, it can recognize the trends unfolding and help support strategies for reducing regional transportation emissions. For instance, in recognition of the observation that the commutes of lower-income individuals tend to be longer than those of their higher-earning counterparts, the District can help reduce the traffic emissions attributable to this group by advocating for a greater diversity of employment types, as well as increased housing affordability, within downtown Detroit.

Chapter 3: Emissions Reduction Model

James Wooldridge

Purpose

The purpose of the emission reduction model was to evaluate the possibility of hitting Detroit 2030's goal of a 50% reduction in transportation emissions and better understand the barriers in the way of that goal. The model worked by decreasing the vehicle miles traveled (VMT) based on Mode, Distance, and/or Purpose. VMT has been shown to strongly relate go CO2 emissions; therefore, reductions in VMT to result in reductions in CO_2 (Dierkers, Silsbe, Stott, Winkelman, & Wubben, 2006).

Model & Method

The reduction model relies on the same assumptions as the baseline model along with five additional assumptions. First, the same number of trips are assumed to occur. Reductions in VMT were able to account for changes in the number of trips. For instance, if an employee were to work several days from home, this would result in a measurable change in their VMT per year.

Second, there is no shift in trip Purpose. Third, there is no direct shift in mode. This means that a data point for auto was not changed to public transit. Changes in VMT were able to account for changes in mode by reducing the travel associated with a particular mode.

Fourth, increases in the use of public transit, carpooling, and vanpooling were assumed to be increases in ridership, not increases in the number of trips and therefore VMT. This works well with the structure of the model because it is hard to evaluate changes to carpool, vanpool, or public transit numbers. Conceptually, the same number of vanpools and public busses are running but with more people in them.

Fifth, there were no diminishing returns in the policy strategies. This means the potential to change VMT from one strategy did not positively or negatively affect any of the other strategies ability to change VMT.

Seven strategies were chosen to reduce CO_2 emissions thought reductions in VMT. The strategies were selected based on the ability for the 2030 district to implement them, their relevance to the regional context of metro Detroit, and acceptability within the model. The outcomes of each strategy should not be seen as hard and true rules.

The model's calculation work by evaluating the criteria of each trip and strategy, then applying the VMT reduction when relevant. The relevant criteria of the trips were mode, distance, and purpose. If a trip only reduced VMT of trips by the mode "auto/ van/ truck (as driver)", then the trip data was filtered to only apply that strategies reduction to trips by the mode auto. Some strategies had more than one criterion. A strategy could apply to reducing VMT of all trips by mode "auto/ van/ truck (as driver)", and only apply to a distance less than 15 miles.

Strategy 1: Commuter Incentives

Commuter incentives refers to actions taken by employers to reduce the VMT of their employees traveling to work, between different work locations, and back home (Dierkers et al., 2006). There are a number of different methods employers can use listed by the Center for Clean Air Policy (CCAP) and the EPA's Best Workplaces for Commuters program, including:

- *Tax-free transit benefits/ pre-tax dollars to promote transit option* – These methods are based around subsidizing the cost of commuting in more a sustainable such as public transportation tickets or vanpool costs (US EPA, 2005e).

- *Tele-work and alternative work schedule programs* – These methods are based around promoting the opportunity to work from home or shift schedules to allow commutes during non-rush hour traffic (US EPA, 2005d).

- *Programs & incentives for carpool, vanpool, bicycle, or walking* – These methods are based around providing carpool or vanpool programs that connect employees and infrastructure necessary for cycling and walking (*Developing Successful Bicycle / Pedestrian Commuter Programs A Handbook For Employers*, 1996; US EPA, 2001, 2005a). This could include showers, locker rooms, and bike lockers. Incentives must be provided to encourage participation in these programs. Cycling events and competitions can be a great way to start.

- *Target Parking: parking cash-out, preferential carpool, vanpool parking* – A parking cash-out program is where an employee can choose a taxable cash income or a subsidized parking space (US EPA, 2005c). Preferential carpool and vanpool spaces are more conveniently located parking spaces only for those who carpool.

- *Guaranteed Ride Home Programs* – These are guaranteed rides in unpredictable emergency situations for those who use modes such as public transit, vanpool, carpool, or cyclists (Menczer, 2015). It is meant to give employees an expedient method of leaving work when there is an illness, school emergency, or other event that would require their immediate and unexpected attention. The rides are often provided by taxi companies, rental car companies, ride share services, or reimbursement packages for a Lyft or Uber.

- *Marketing Program* – It is important to market the initial launch of these programs (US EPA, 2005b). This can include but is not limited to promotional events, competitions, flyers, newsletters, and inserts into paychecks. Potential themes can be around saving money, improving health, and encouragement to try something once.

The possible strategies seem to align nicely with a preliminary survey of 2030 district employees. A lightning survey of the barriers and desirability of multimodal transit was conducted from late-March and though mid-April. It received 234 responses during this time period while the potential survey pool size is unknown. The results were mixed but showed a strong potential for the embracement of multimodal transit.

Table 12: Response Rate by Mode

Mode	Bike	Walk	Public Transit	Carpool	Vanpool	Telecommute	Cumulative
Response Rate	201	116	534	294	265	569	1170
% work days	17%	10%	45%	25%	23%	49%	N/a

Average	0.86	0.50	2.24	1.26	1.13	2.43	8.41
S. Dev	1.63	1.3	2.08	1.77	1.81	1.97	5.97

Response rate = summation of days selected by respondents

% of work days = Response Rate / (5 days x 234 responses)

The average cumulative willingness to use alternative transportation in days per week was 8.41 with a standard deviation of 6.97. The result is encouraging because 8.41 days is not only larger than the number of work days per week but larger than the number of days per week. The number is larger than the available days per week because the survey asked about the willingness to use each mode per week. Someone could respond 4 days for biking, 3 for carpool and 2 for transit, resulting in 9 days of alternative transportation. This method of measurement acknowledges flexibility in mode choice. An individual may choose to carpool instead of bike on a day with rain.

The results are encouraging. With an average of 8.41 and a standard deviation of 6.97, more than half of the respondents were willing to use a low carbon mode of transit more than 5 days a week and 84% of the respondents were willing to use a low carbon transit mode more than 2.4 days a week. This is promising, as 1.25 days is 25% of a 5-day work week. The most popular methods were public transportation and telecommuting. It is unclear if this will result in a 25% reduction in VMT, but it does show a promising interest for embracing low carbon transit.

The CCAP predicts an VMT reductions to be between 5% to 25% (Dierkers et al., 2006). These values were placed on all trips with a purpose related to work except for the category "work at home." The mode selected was "auto/ van/ truck (as driver)." There were no restrictions to distance put in place.

Strategy 2: Cycling Program

The regional cycling strategy is based around various programs to improve conditions for cyclists (Dierkers et al., 2006). The strategy focuses on both the built environment and increasing awareness about local cycling and safety. Encouraging cycling throughout the city to increase the accessibility to alternative transportation options (Litman, 2018). There are a number of different approaches the 2030 district can employ on behalf of this endeavor.

- *Infrastructure Investments* – The district should support endeavors that increase the abundance of cycling-related infrastructure in the city. This relates to increasing the number of bicycle lanes, bridges, signage, and signals (Dierkers et al., 2006). Bike paths that take more direct routes than streets are particularly effective (Litman, 2018).

- *Multi-Modal Connectivity* – This can be endeavors to increase the number of bike racks on busses and other forms of public transit. The purpose is to provide increased connectivity between different modes of transit (Dierkers et al., 2006).

- *Employer Facilities* – Some of the methods include adding secure bicycle parking, storage, and locker/ shower facilities (*Developing Successful Bicycle / Pedestrian Commuter Programs A Handbook For Employers*, 1996).

- *Incentives & Deals* – Provide incentives and reduce the cost of beginning or attempting to travel by cycling.(*Developing Successful Bicycle / Pedestrian Commuter Programs A Handbook For Employers*, 1996; Dierkers et al., 2006; US EPA, 2005b). Employees can benefit from discounts with local bike shops for rentals and purchases. The district can benefit through supporting bikeshare programs like Mogo. Local shops could offer discounts or coupons to those who cycle.

- *Cycling Events* – Events are aimed at increasing public awareness of cycling connectivity, health benefits, and safety awareness (US EPA, 2005b).

- *Events & Safety Programs* – These safety program can work on increasing awareness of routes, creating a cycling culture, and provide an education space on pedestrian and cycling safety.

The CCAP predicts a reduction in area VMT of 1% to 5% (Dierkers et al., 2006). The emissions reduction model applied for this strategy applied to all purposes and all trips with a distance of 5 miles or less. This distance was selected because work from the Louis Harris Organization established that 5-miles is easily bike-able for most people within 25 minutes (*Developing Successful Bicycle / Pedestrian Commuter Programs A Handbook For Employers*, 1996).

Strategy 3: Pedestrian Oriented Development

The aim of pedestrian oriented development strategies is to increase the walkability of an area. Just as with the cycling program, many of the specific strategies are aimed around urban planning level decisions and should be encouraged throughout the city. This should increase the accessibility to alternative transportation options especially within the district as it has the Detroit People Mover, Detroit Department of Transportation busses, and the Q-line.

- *Mixed-use zoning* – This refers to zoning areas for more than one kind of use.

- *Short to medium length blocks on a gridded network* – Allows for multiple paths and more direct routes (Dierkers et al., 2006; Litman, 2018).

- *Ample sidewalk space* – Accommodates more people for walking and other sidewalk activities (Dierkers et al., 2006).

- *Narrower roadways & road dieting techniques* – These strategies aim to increase pedestrian safety using the build environment (Dierkers et al., 2006; Litman, 2018; Randolph, 2012). Narrower roadways result in reduced traffic speeds and increased pedestrian safety. Many road dieting techniques include pedestrian islands that allow pedestrians to safely cross a street half way and stand in an island in the middle if they need to. This is especially useful multi-lane streets.

- *Trees and Green Infrastructure* – Provide shade and help to reduce the heat island effect which can make walking more unpleasant during warmer months (Gill, Handley, Ennos, & Pauleit, 2007).

- *Events & Safety Programs* – These safety program can work on increasing awareness of routes, creating a cycling culture, and provide an education space on pedestrian and cycling safety

(*Developing Successful Bicycle / Pedestrian Commuter Programs A Handbook For Employers*, 1996; Litman, 2018; US EPA, 2005b).

The CCAP predicts a 1% - 10% regional reduction in VMT (Dierkers et al., 2006). The reduction was applied to all trips, regardless of mode or purpose, under 0.5 miles. A distance of .5 miles was selected as 61% of a length of .5 miles in the US were by walking (Litman, 2017).

Strategy 4: Pay as you Drive Insurance

Pay as you drive insurance is a form of car insurance that bases cost on the amount of time spent driving (Dierkers et al., 2006).

- Awareness: The primary strategy for the 2030 district is to promote awareness of this money saving option for employees and residents of the area.

The CCAP predicts a maximum 10% reduction in VMT for all those who participate in the program (Dierkers et al., 2006). A 10% reduction to VMT was applied to all trips with the mode "auto/ van/ truck (as driver)", regardless of distance or purpose.

Strategy 5: Smart-Oriented Growth

The purpose of smart-oriented growth is to curtail development away from sprawl and towards denser, more sustainable development patterns (Dierkers et al., 2006; Litman, 2018). This strategy is heavily focused on urban planning strategies and will require various political and educational involvements. Some of the desired features include:

- *Comprehensive Regional Planning* – This addresses land use and transportation planning. The area currently has the South Eastern Michigan Council of Governments (SEMCOG), the Ann Arbor Area Transit Authority (AAA), the Suburban Mobility Authority for Regional Transit (SMART), and the Regional Transit Authority (RTA). SEMCOG can plan but does not have any legal zoning authority. The RTA provides a few regional bus routes, but an integration and expansion of the different transit systems has been denied in recent years (Lawrence, 2018).

- *Funding for Transportation Alternatives* – The district should advocate for increased funding of regional and local public transportation (Dierkers et al., 2006; Litman, 2018; Randolph, 2012). This includes SMART, RTA, DDOT, AAA, Q-line, Detroit People Mover, and the systems of pedestrian and cycling infrastructures.

- *Increase Density* – Through redeveloping the city center with incentives, infill and Transit Oriented Development (TOD) (Dierkers et al., 2006; Litman, 2018; Randolph, 2012; Stevens, 2017). Increasing density should be accompanied by anti-gentrification policies that prevent a swap in the demographic that results in long commutes.

- *Synthesize Disincentives to prevent Sprawl* – Such methods include urban growth boundaries, in lieu fees, impact fees, linkage fees, and mitigation fees (Juergensmeyer, Robers, Salkin, & Rowberry, 2018; Randolph, 2012). Urban growth boundaries set a limit to where development is allowed. In lieu fees are charges placed on developers for things like new schools or parks. Impact fees are also charges placed on developers but for hard infrastructure improvements.

Linkage fees are for soft infrastructure improvements and additions. Mitigation fees are to compensate for environmental harm like wetland destruction or tree removal.

The CCAP predicts a regional reduction in VMT of 3% to 20% (Dierkers et al., 2006). The reduction was applied to trips of any all purposes and distance with the mode “auto/ van/ truck (as driver)”.

Strategy 6: Road Pricing

The purpose of road pricing is to disincentivize auto usage and make alternative transportation more appealing (Dierkers et al., 2006). This is a regional urban level change in policy that can include the following:

- *Variable Tolls* – Fees for using certain roads that can be adjust based on the time of day and congestion levels (*Congestion Pricing A Primer*, 2006). They often occur in highways and interstates.

- *High Occupancy Toll Lanes (HOC)* – A high occupancy toll lane is only for vehicles with more than one passenger (*Congestion Pricing A Primer*, 2006). Those who drive in the HOC without more than one passenger have to pay a fee.

- *Cordon Pricing* – This is a fee for driving or entering areas with high levels of congestion or where driving is to be discouraged (*Congestion Pricing A Primer*, 2006).

CCAP estimates a reduction in VMT of 1% to 3% (Dierkers et al., 2006). The VMT reduction was applied to all purposes and distances with the mode of “auto/ van/ truck (as driver)”.

Strategy 7: Municipal Parking Restrictions

Municipal parking restrictions are intended to reduce VMT by decreasing the abundance and convenience of parking (Dierkers et al., 2006). This is achieved though parking pricing or targeting the parking supply. Some of the specific tactics are as follows:

- *Updated Parking Codes* (Dierkers et al., 2006) – Adding codes like maximum parking requirements and reducing minimum parking requirements. Code maximums prevent an oversupply that is only meant for the peak of holiday season. Code minimums give developers more flexibility in and room for development

- *Parking Pricing* (Dierkers et al., 2006) – Increasing the cost of parking for both employees and non-employees especially in transit accessible areas. One method to achieve this is to increase the taxes on those who provide parking.

- *Incentivize redevelopment* (Dierkers et al., 2006) – Building codes and parking codes should align with one another to allow for developers to redevelop parking lots when they have an excessive parking supply.

The CCAP estimates a 15% to 30% reduction in VMT with the implementation of these strategies (Dierkers et al., 2006). The VMT reduction was applied to all VMT with the mode “auto/ van/ truck (as driver)” regardless of purpose or distance.

Strategy 8: Electric Vehicles

Electric vehicles (EV) use electricity to partially or completely provide energy for the movement of a vehicle. There are three main kinds: hybrid, plug-in hybrid, and all electric (Mclaren et al., 2016). Hybrid vehicles rely on a battery that recharges when the car uses its internal combustion engine (ICE) or by collecting energy from braking. Plug-in hybrids have an ICE but allow for their batteries to be recharged when plugged into a source of electricity. All electric vehicles rely primarily on their electric motors and must be plugged in to be charged. Some current models have an ICE with a small gas tank to extend the range of the car. Only all electric vehicles were assessed by this model, and the strategy is focused on infrastructure:

- *EV Infrastructure* – Adding EV infrastructure in the district should help to reduce barriers to its usage. This can take the form of specialized charging stations throughout the district.

The emission reduction calculation took two parts. The first, an estimation of the market penetration of EV. Second, an estimation of the composition of electrical supply in Michigan and therefore the emissions associated with reduction.

Two estimates for market penetration were found. The International Energy Agency set its goal for a global adoption rate of 14% (International Energy Agency, 2018). A 2018 report from the Edison Foundation believed that the US fleet would comprise of 7% electric vehicles (Cooper & Schefter, 2018). Both estimations were used.

Estimations on grid composition and EV emissions was provided by the US Department of Energy (US Department of Energy, n.d.). Estimations from both the state of Michigan and Nationally were compared. Emissions for EV on a national grid were lower than those on a Michigan grid because of a lower usage of coal and a higher usage of lower carbon fossil fuels (natural gas) and alternative energy sources (wind, solar, hydro, etc). The MI estimates should be viewed as a baseline while the US Average estimations can be viewed as a potential with the movement away from fossil fuels. The US grid resulted in an 80% reduction in Kg CO_2 / mile while the MI grid resulted in a 56% reduction in CO_2 mile.

Chapter 4: Mitigation through Reduction - Green Infrastructure

Muyao Li

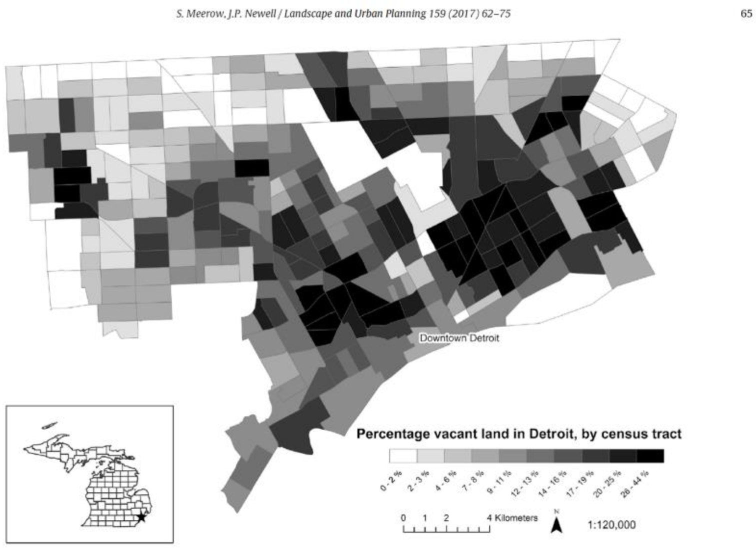
GI in Detroit and Southeast Michigan

The City of Detroit is exploring ways to expand the implementation of district-scale green infrastructure to develop large-scale, publicly-accessible green spaces. Green infrastructure refers to the development of urban green spaces, such as parks, rain gardens, and greenways, that provide a variety of social and ecological benefits, from improved public health to stormwater abatement (Jim, Yo, & Byrne, 2015; Young, 2011). These benefits are often classified using the ecosystem services framework, which includes four major categories of services: provisioning, regulating, supporting, and cultural (Ahern, 2007; Andersson et al., 2014; Elmqvist, Gomez-Baggethun, & Langemeyer, 2016). Researchers, government agencies, and organizations are actively promoting the expansion of green infrastructure. Cities such as Detroit, New York City, and London have ambitious policies to implement it on a large scale (Berkooz, 2011; Mell, 2016).

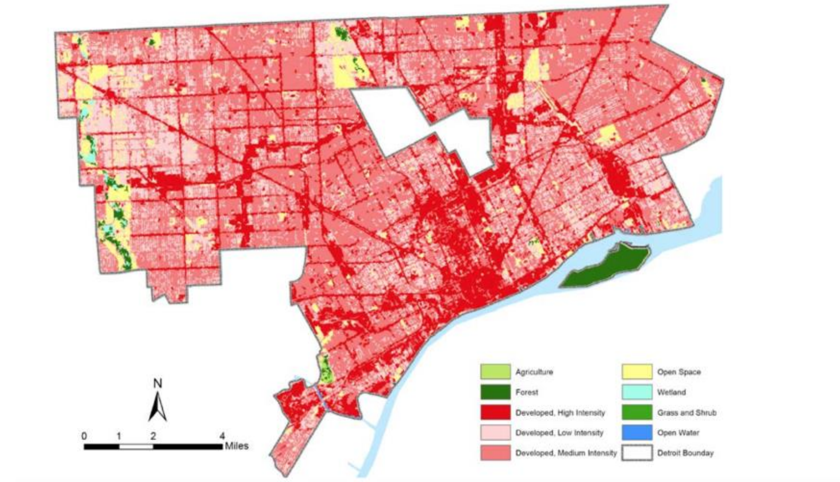
Area	Total Land Cover Area(Acres)	Percent Green Infrastructure	Percent Tree Canopy of Total GI
Livingston	374,633	61%	63%
Macomb	309,977	45%	53%
Monroe	359,557	67%	28%
Oakland	580501	45%	86%
St.Clair	467,236	67%	45%
Washtenaw	462,342	62%	51%
Wayne	395,303	30%	81%
Detroit	89,187	19%	85%
Region	2,949,548	54%	56%

Detroit is one city where green infrastructure has emerged as a planning priority, making it an interesting, timely, and appropriate case study city to examine and improve these processes (Schilling & Logan, 2008). For decades, the loss of manufacturing, population decline, weak tax revenue base, and social strife have plagued the city. It has one of the nation's highest rates of property vacancy, with over 105,000 vacant parcels and over 40 square miles of vacant residential, commercial, and industrial land.

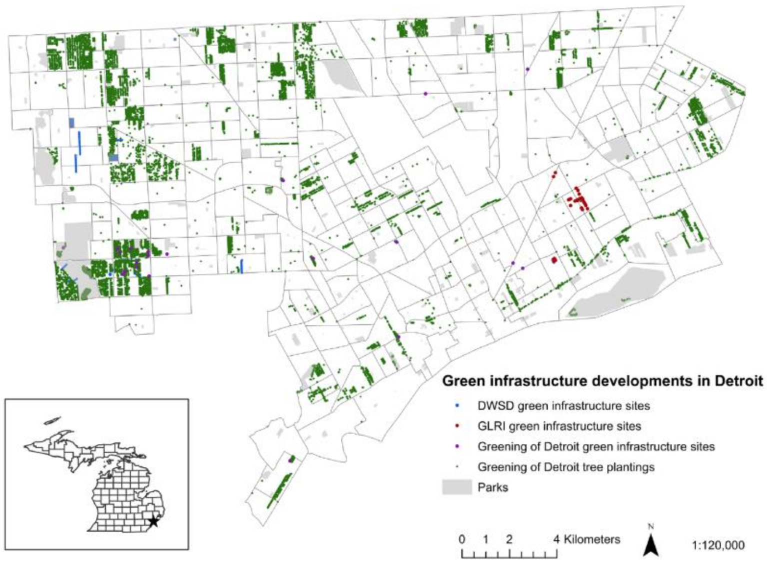
Large areas of vacant land in Detroit make it hypothetically easier to implement new green infrastructure and blight removal provides an added incentive (Nassauer,J, 2018).



Detroit Land Use & Vacancy.
It was created by a research team at the University of Michigan led by Sara Meerow (sameerow@umich.edu).



Green infrastructure projects are being planned and implemented by city and regional agencies, non-profit organizations (NGO), and private entities. The most significant player thus far is the Detroit Water and Sewerage Department (DWSD), a public utility that provides services to the city and administers a sprawling water-sewage infrastructure to communities across seven counties. Facing increasingly strict EPA water regulations and the need to reduce flows into its combined sewer system, DWSD has invested in bioretention, green streets, and tree planting projects (DWSD, 2015). The NGO Greening of Detroit is planting trees in many parts of the city, often in partnership with DWSD. DWSD's green infrastructure program is specifically designed to reduce runoff to the combined sewer system in the Upper Rogue River Tributary area, so it is logical that projects are clustered in that area.(DWSD, 2015).



It was created by a research team at the University of Michigan led by Sara Meerow (sameerow@umich.edu).

Green Infrastructure Mitigation Strategies

Land use change plays a major role in GHG emissions, causing significant changes in carbon pools, leading to large-scale emission or storage of CO_2 Globally, deforestation alone accounts for 11% of anthropogenic GHG emissions (Van der Werf et al 2009). Smaller-scale techniques can be used on vacant property for neighborhood stabilization or to manage roadway runoff. Larger techniques include buffers along major highways, in addition to assembling large parcels of land to convert to natural green infrastructure, which includes reducing and eliminating the roadway network in areas of high vacancy.(SEMCOGG) The change in impervious cover is primarily occurring through City of Detroit actions to reduce blight and demolish vacant properties. (DWSD)

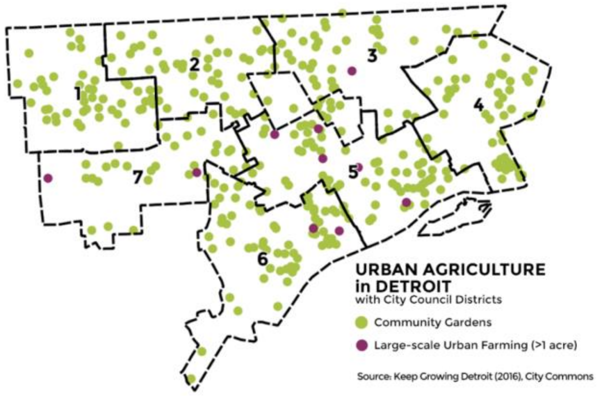
While agriculture contributes to GHG emissions, agriculture and forestry currently help to reduce a portion of total U.S. GHG emissions. Land use, land use change, and forestry (which, as a category, includes forests, trees in urban areas, agricultural soils, and landfilled yard trimmings and food scraps) represented a small but significant sink of 780 Tg CO_2 eq. (USEPA, 2006).

Soils also have a capacity to store carbon. Economic analyses suggest that soil carbon sequestration is among the most beneficial and cost effective options available for reducing GHG, particularly over the next 30 years (Calderia et al., 2004).

Tree Canopy

As of 2010, the City of Detroit had 48,580 acres of impervious surface (54.5 percent of all land cover) and 14,646 acres of tree canopy (16.4 percent). Plants and soil around the world absorb roughly a quarter of the greenhouse gases that humans release into the atmosphere, helping the Earth avoid some of the worst effects of climate change. Trees reduce street noise - psychological & health benefits. Trees cause streets to appear more narrow reducing traffic speeds & increasing safety. Tree makes walking and biking more inviting.

Urban Farming



It was created by Detroit Food Policy Council and the Detroit Health Department

The urban farm program has been used by Detroit residents to improve community food qualities and security. Today there are 432 community gardens and 834 backyard garden and 92 market gardens. (Detroit Food Policy Council and the Detroit Health Department)

The urban farm program help increase Public Awareness, Build Community Support and Empowerment. Innovative alternatives can be created by the urban farm program, and maintaining green infrastructure can include using volunteers within the community.

Transportation: Green & Smart

These are a relatively low-cost, easily implementable approach to achieving better balance for all users of the street. Those facilities encourage people to choose biking as a primary transportation mode. Developing more activities within neighborhood, create more efficient transit for automobiles, pedestrians and cyclists.

Chapter 5: Reduction Model Results

James Wooldridge

Results

The results are first separated into two scenarios: low VMT reduction and a high VMT reduction (see Table 13). The low VMT reduction values resulted in a 16% decrease in emissions while the higher reduction values resulted in a 55% decrease in emissions. It should be reinforced that the results of this estimation are a loose prediction of possibilities.

Reduction Strategies					Reduction Values		
Strategy	Mode	Purpose	Range	low/high	% of total	kg CO_2/ year	% of total
No Strategy	-	-	-	-	-	-	-
Strategy 1 Commuter Incentives	Auto	Work Related	Regional	5%	2.59%	45,718,830.92	2.31%
				25%	13.00%	228,594,154.62	11.54%
Strategy 2 Cycling Program	All	All	< 5 mi	1%	0.04%	1,146,336.30	0.06%
				5%	0.22%	5,731,681.52	0.29%
Strategy 3 Pedestrian Oriented Development	All	All	< 0.5 mi	1%	0.0004%	9,518.79	0.0005%
				10%	0.004%	95,187.86	0.005%
Strategy 4 Pay as you Drive Insurance	Auto	All	Regional	1%	0.77%	13,629,412.23	0.69%
				10%	7.70%	136,294,112.31	6.88%
Strategy 5 Smart Oriented Growth	Auto	All	Regional	3%	2.32%	40,888,236.69	2.06%
				20%	15.50%	272,588,244.63	13.76%
Strategy 6 Road Pricing	Auto	All	Regional	1%	0.77%	13,629,412.23	0.69%
				3%	2.32%	40,888,236.69	2.06%
Strategy 7 Municipal Parking Restrictions	Auto	All	Regional	15%	11.59%	204,441,183.47	10.32%
				30%	23.18%	408,882,366.94	20.64%
			Total	low	18.09%	319,462,930.63	16.12%
				high	61.92%	1,093,073,984.57	55.19%

TABLE 13: Reduction of VMT and Kg CO_2 by Strategy

The three highest preforming strategies were the commuter incentives, smart-oriented growth, and the municipal parking program. This is likely because they targeted the primary mode of transit, the automobile. The automobile was used for 55% of all trips and accounted for 74% of all VMT.

The two worst preforming strategies were the cycling programs and pedestrian oriented development. These strategies had the least impact under this analysis because less than 5% of all trips are a distance of 5-miles or less. The pursuit of strategies may create unaccounted emissions as cycling use could increases throughout the city. This could include travel external to the 2030 district, travel not included in the current model parameters. Likewise, increased walkability could make various transit services more accessible. Future increases in Detroit's population could increase the importance of an established cycling culture and system of infrastructure.

	Grid Type	Market Penetration	No VMT Reduction			Low VMT Reduction			High VMT Reduction		
			kg CO2 / year	%	Change	kg CO2/ year	%	Change	kg CO2/ year	%	Change
Baseline	na	na	-	-		319,462,930.63	16.12%		1,093,073,984.57	55.19%	
Auto	MI	low 7%	53,822,769.40	2.72%		360,701,627.63	18.21%		1,103,889,979.93	55.73%	
		high 14%	107,645,538.81	5.43%	2.72%	401,940,324.62	20.29%	2.08%	1,123,716,040.92	56.74%	1.00%
	US	low 7%	76,249,618.60	3.85%		377,884,950.76	19.08%		1,108,396,780.21	55.96%	
		high 14%	152,499,237.20	7.70%	3.85%	436,306,970.88	22.03%	2.95%	1,123,719,565.84	56.74%	0.77%
Bus	MI	low 7%	13,019,378.39	0.66%		332,459,939.86	16.79%		1,105,976,926.91	55.84%	
		high 14%	26,038,756.78	1.31%	0.66%	345,456,949.08	17.44%	0.66%	1,118,883,828.26	56.49%	0.65%
	US	low 7%	18,444,287.57	0.93%		337,875,528.26	17.06%		1,111,354,969.20	56.11%	
		high 14%	36,888,575.13	1.86%	0.93%	356,288,125.88	17.99%	0.93%	1,129,639,912.84	57.03%	0.92%
Auto & Bus	US	low 7%	94,693,906.16	4.78%		396,297,548.38	20.01%		1,126,681,723.85	56.89%	
		high 14%	189,387,812.33	9.56%	4.78%	473,132,166.12	23.89%	3.88%	1,160,289,453.12	58.58%	1.70%

TABLE 14: CO2 Reduction by Grid, Market Penetration, and Strategy Implementation

EVs offered various levels of reduction depending on the market penetration, grid composition, and strategy effectiveness. The latter resulted in the biggest decrease in EV's effectiveness towards reducing transportation emissions. This is because the strategies target personal vehicle usage by decreasing VMT. With fewer VMT, there are less reducible emissions though this method.

EV busses kept their effectiveness regardless of which strategy was implemented because VMT by bus did not see a meaningful decrease. The adoption of a complete fleet of electric busses would reduce by emissions by 3.3% on their own under a max VMT reduction scenario. Additionally, electric busses could benefit the city due to their lower lifetime costs (Casale & Mahoney, 2018).

There are multiple reasons that this model may overestimate the reduction of emissions. First, diminishing returns were not taken into account. For instance, the strategies of commuter incentives, smart growth, and municipal parking restrictions all contain methods to decrease the availability of parking. The reduction in parking from one strategy may make the reductions from another less effective. For instance, an employer may successfully make an effort to reduce the parking provided to employees, thus encouraging other forms of transit. Detroit may then adopt new parking codes that decrease the maximum parking an employer can provide to employees. In this case however, there would be no further reductions in the amount of employer provided parking as the parking was already decreased. This would mean the policy had no effect on parking and therefor no effect on the VMT of employees. In such a case, this model overestimates the reductions in emissions.

Second, these strategies use of the maximum reduction values is ambitious considering the regional context. The Detroit metropolitan area is heavily dependent on the automobile with 85% of all trips using this mode of transit (McGuckin, Casas, & Wilaby, 2016). Strategies such as the commuter incentives, smart growth, and municipal parking restrictions rely on reliable and abundant public transportation to serve as an alternative to using an automobile. Employees may be able to rely on vanpooling and carpooling but work-related trips only accounts for 27.8% of the miles traveled to the district. Without alternatives modes of transportation for other purposes of traveling to the 2030 district, people will either use a personal vehicle, ride-share (which still results in a trip by an automobile) or decide against traveling to the 2030 district. The first two outcomes result in no change of emissions while the final outcome hurts the business in the 2030 district.

Third, additional emissions were not taken into account for new vanpool lines or the expansion of transit routes and frequencies. Vanpools would likely result in an overall decrease in emission because the addition of one vanpool bus is less than the emissions of multiple cars. Public transit would be trickier. The best way to measure the total emissions from transit would be to multiply an emissions factor by the number of miles by the number of busses each day. More busses would increase the total emissions while potentially decreasing the emissions per person.

Fourth, this model doesn't take into account future population growth in the region. SEMCOG predicts an additional 195,348 people to live in the region by 2030 and the majority to live move in outside of Detroit (*Population and Housing Estimates for Southeast Michigan*, 2018; "Population Estimates," 2018; "SEMCOG 2045 Regional Development Forecast," n.d.). With the goal of a 50% reduction in emissions, an increasing population will make this even more difficult if they live outside of Detroit.

Implications for Future Analysis

A layered analysis will provide improvements to 2030 Transit understanding of their metrics and goals but won't directly improve reductions without informed action. A layered analysis could have two or more layers but at least two; one layer to look at the regional transportation trends, and another layer to look at the transit to and from the 2030 district. Transportation patterns are the result of various cultural, economic, and political factors. Looking at transportation patterns at the regional level would allow for VMT substitution from an automobile to walking, cycling, and public transit to matter to 2030 districts in a data driven manor. Such a scope would encompass the unaccounted-for emissions reduction and look at the bigger pictures, for instance how equity and transportation are interconnected. On the other end, the smaller level of monitoring the 2030 districts in and out travel allows the businesses and residents of that district to work towards their goal and lead by example.

Reaching the Goal

In order to hit the goal for a 50% reduction in transportation emissions, the Detroit 2030 District will have to use all the strategies presented in this document. With these strategies, and scenarios, the district could see a 16% to 59% reduction in emissions. The population of the region will continue to grow, making the task more difficult. If the district is to hit the goal, they must be proactive in engaging with their employees, government officials of the region, NGOs, and the community with the implementation and improvement of these strategies. The district should prioritize engagement with the surrounding communities as to not further the inequities in the region. The status as a 501c makes interacting with local government officials tricky. The district should consider expressing support, need, expertise, and possibly partial funding for some projects or policies. The district may have the most power to reduce its own employee's transportation emissions. The EPA released a document titled "Marketing Commuter Benefits to Employees" by their Best Workplace for Commuters division (US EPA, 2005b). This is an excellent set of information the district can use to market commuter programs to employees.

Conclusion

Detroit 2030 District was estimated to produce 1,842,533,268 kg of CO_2 per year from transportation. This included trips to, from, and within its boundaries but did not include trips that merely passed through its boundaries. Nine reduction strategies (commuter incentives, cycling program, pedestrian oriented design, pay as you drive insurance, smart growth, municipal parking restrictions, and electric vehicles) were used to reduce VMT. Reducing VMT translates into reduction in CO_2 emissions. If all strategies are implemented, the District could expect between a 16% and 59% reduction in transportation emissions. The reduction model was simplistic as it didn't transfer VMT to other modes, required maximum estimation values to achieve its goal, didn't include diminishing returns, and doesn't account for regional population growth. A tenth strategy, green infrastructure, can help the district sequester emissions. However, the extent to which this is possible is unclear. In the future, 2030 Districts should track both the transportation of the region and transportation specific to the District. Transportation is a regional issue, therefore monitoring progress and the solutions proposed should acknowledge the regional nature of this topic.

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