

The Philadelphia 2030 District: Measuring Transportation Emissions Now and in the Future

A Quantitative and Qualitative Review

Prepared for: The Philadelphia 2030 District

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EXECUTIVE SUMMARY

Cities are only two percent of the world's landmass. Despite this, they “account for more than 70% of global CO₂ emissions” (C40 Cities, n.d.). Cities are also anticipated to grow—66 percent of the world's population is projected to live in urban areas by 2050 (UN DESA, 2014).

This Master's Project (MP) focuses on one American city, Philadelphia, but is meant to be applicable to American cities across the country. City governments are “more directly accountable to their constituents than national leaders on quality-of-life issues” and tend to have close relationships with local businesses, residents, non-profits and other stakeholders (Lane, 2012). Local governments also enable possible solutions to be implemented on an experimental basis, allowing for small-scale solutions to be developed before implementation at the state or federal level.

Several city, non-profit and state-led transportation greenhouse gas (GHG) reduction initiatives have emerged. This MP will focus on the work of one: the 2030 District in Philadelphia, which formed in October 2017 and is one of the 18 2030 Districts nationwide. 2030 Districts are “private/public partnerships in designated urban areas across North America committed to reducing energy use, water use and transportation emissions” (Districts 2030 Background, pg. 2, n.d.).

This MP primarily focuses on the challenges surrounding measurement of Philadelphia's 2030 District transportation emissions. While in the past, policy makers have primarily focused on electric power generation and industry to limit the growth of GHG emissions, transportation emissions today account for 27 percent of U.S. GHG emissions (EPA, 2015). Transportation is also now the fastest-growing source of GHG emissions, and there are 1/3 more vehicles on the road than there were in 1990 (Sorrel, 2016). Transportation infrastructure lasts decades, and the decisions surrounding urban development comes not just from national, but local and city governments. This is where cities, in partnership with businesses and other stakeholders, can play a substantial role in limiting the growth of these emissions, both now and in the future.

In Chapter 1, I provide a frame of reference regarding cities, climate change and how 2030 Districts can develop a solution. I begin by explaining the general challenge and problem that all cities and researchers face is a lack of standardization regarding how to measure transportation GHG emissions on a city and regional planning level. In addition, out of the 18 Districts, only San Francisco, Denver, Cleveland, Seattle and Pittsburgh have started to track their transportation emissions. An additional challenge with this is that each 2030 District is using its own methods, and the approaches have varied considerably.

The Project and Its Importance

The MP has three parts. The first part was the development of a transportation GHG emissions baseline for the Philadelphia 2030 District. The baseline will enable the District to track its progress towards the 2030 Challenge Architecture 2030 set for all Districts.

The second part of the project was to create a proposed survey for the District to better track transportation GHG emissions moving forward. As a note of clarification, I will not administer the survey, but have designed it for the District.

The third part of the project was to create case studies comparing the 2030 Districts already measuring their transportation emissions. There is currently no document that summarizes how each District has approached tracking transportation emissions. This project considered some of the best-practice methodologies of the five other 2030 Districts and suggested which of their methods (both survey and baseline) can be incorporated and used moving forward.

By helping the Philadelphia 2030 District create a transportation GHG emissions baseline and a survey to measure its GHG emissions, not only will it enable the Philadelphia 2030 District to accurately measure progress on reducing its transportation emissions 50 percent by 2030, but it will also serve as an example for other 2030 Districts and add to the literature for standardizing a method all Districts can use, regardless of their size or location in the U.S. This will enable Districts to better measure progress against one another, contribute to the best-practice literature and determine which policies have an impact.

In the first part of Chapter 2, I focus on the current practices and key takeaways and lessons learned from how the other 2030 Districts have created a transportation GHG emissions baseline, as well as tracked their progress moving forward. Table 2 lists the transportation carbon dioxide emission baselines of each District, along with how they have measured their carbon dioxide emissions since the completion of their baselines.

I divided their approaches into three buckets: 1. National Household Travel Survey (NHTS): Cleveland; 2. Public-Private Partnerships: Denver and Seattle; 3. Metropolitan Planning Organization (MPO) Partnership: Pittsburgh and San Francisco.

Methodology for Philadelphia 2030

The second part of this section reviews how I decided which data to use for the Philadelphia 2030 baseline, as well as its key assumptions.

There were five different methodologies considered throughout the process of determining the best way to develop a baseline: 1. The Delaware Valley Regional Planning Commission (DVRPC) 2012-2013 Household Travel Survey (HTS), 2. Develop and Distribute a Survey, 3. Longitudinal Employer-Household Dynamics (LEHD) Origin-Destination Employment Statistics (LODES) data with the American Community Survey (ACS), 4. On the Map (OTM) with ACS, 5. Census Transportation Planning Products (CTPP) with the DVRPC Distance Matrix Data.

Based on discussions with my advisor and client, I decided to use methodology five, CTPP with the DVRPC Distance Matrix Data. Table 4 compares the potential baseline methods, as according to data availability, age of data, replicability/fit the project timeline, and risk of error.

Philadelphia 2030 Baseline Result

I used methodology five in an Excel Workbook Baseline Calculator and found that the Philadelphia 2030 District had a transportation GHG emissions baseline of 9.4 kg

CO2/commuter/day. Table 6 is the Excel Workbook methodology justification, Table 7 contains the MPO and CTPP data assumptions and Table 8 the data sources for the Excel Workbook.

Survey Design

As previously stated, I recommend that the Philadelphia 2030 District pursue a survey methodology to measure transportation GHG emission moving forward. The proposed survey is in this section.

In Chapter 3, I cover what other initiatives have done to track city transportation GHG emissions, along with the role of transit agencies in data collection, challenges agencies have faced with measuring transportation GHG emissions at the metropolitan level, along with how MPOs and the Clean Air Act (CAA) offer opportunities to address the data standardization challenge.

Chapter 4 is a discussion on where Philadelphia's GHG emissions fall relative to the other Districts and how geography, along with city and state policies, influence the baseline. I also discuss the lack of standardization when it comes tracking transportation GHG emissions.

Next, I explain that the methodology I use to establish the 2030 Philadelphia baseline is a methodology that should and can be replicated by Districts moving forward. First, the Excel Workbook Calculator is easy and inexpensive to use. Most importantly, its inputs are easy to change and are customizable to the location. As MPOs are already required to collect emission factors because of the CAA, this data is already available.

Finally, I conclude that the baseline calculator is an important first step, but is only a first step. A survey methodology will enable Districts to see the current travel habits of their 2030 District commuters, as well as the nuances of multi-modality travel that is not available through the CTPP data. In addition, survey questions will allow the District to understand some of the rationale behind transit choices, as well as options commuters have.

In Chapter 5, I divide my recommendations into two buckets: one set specifically for Philadelphia and one set for 2030 Districts in general. I recommend 2030 Districts focus on using their local MPO, develop strong relationships and partnerships, standardize their communication and survey methodology, and in the long term, develop a centralized office for obtaining information on the various 2030 Districts, as well as decide if the 2030 District focus is on adding new buildings or decreasing emissions.

For Philadelphia specifically, I recommend that it continue its partner and stakeholder outreach, develop specific ambassadorial roles for committee members, and fold its survey into the MPO data tracking efforts.

My appendix includes an index of terms, the Excel Workbook Baseline Calculator and related documents, as well as other important primary documents used in this research.

DEDICATION

This thesis is dedicated to my mom, who has always supported and encouraged me in my endeavors. I would not be where I am today without you.

ACKNOWLEDGEMENTS

I wish to express my thanks to the following people for their support through the process of creating, developing and analyzing the data and information that made this project possible.

Dr. Tim Johnson, thank you for your willingness to meet with me and provide guidance throughout this process.

The DVRPC Office for their feedback and data, without which my baseline calculations would not exist. Thank you to Robert Graff, Shawn Megill Legendre, and Benjamin Gruswitz.

The SEPTA staff, who also enabled me to complete my baseline. Thank you to Geoffrey Philips and Rebecca Collins.

District 2030 staff and volunteers, which include Matthew Combe, Isabella McKnight, Isaac Smith, and Tom Hootman.

Many thanks to Eleanor Johnstone, who connected me with my client and has been an invaluable resource throughout the entire process.

My client contact Katie Bartolotta from the Philadelphia District 2030, who has connected me with everyone I have needed to speak with during this process.

The Duke Energy Initiative and Sanford for providing funding, which allowed me to meet my client and DVRPC staff, among others, in person.

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CHAPTER 1: INTRODUCTION

CITIES AND CLIMATE CHANGE: CHALLENGES AND OPPORTUNITIES

Globally, cities are only two percent of the world's landmass. Despite this, they consume more than two-thirds of the world's energy and "account for more than 70% of global CO₂ emissions" (C40 Cities, n.d.). Cities are also projected to grow—66 percent of the world's population is projected to live in urban areas by 2050 (UN DESA, 2014).

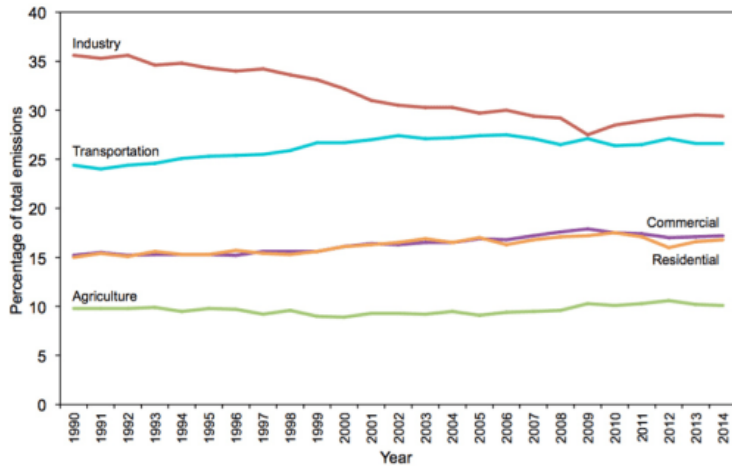
This Master's Project (MP) will focus on one American city, Philadelphia, but is meant to be applicable to American cities across the country. American cities' transportation and land use planning has been uncoordinated, especially at the regional level, as well as have underdeveloped infrastructure and sprawling limits. As a result, American cities are major contributors to climate change. This is both a challenge and an opportunity. Cities, through legislation, regulations and other policy directives, can influence most greenhouse gas (GHG) emissions outside of agriculture and industry. Major sectors include transportation, buildings and waste, to name a few. Ensuring that urban areas are being built or managed in a sustainable way is essential to preventing the explosive growth of GHG emissions.

Even before President Trump withdrew the U.S. from the Paris Agreement and proposed to repeal the Clean Power Plan, cities had begun to take the lead on limiting emissions. City governments are "more directly accountable to their constituents than national leaders on quality-of-life issues" and tend to have close relationships with local businesses, residents, non-profits and other stakeholders (Lane, 2012). Local governments also enable possible solutions to be implemented on an experimental basis, allowing for small-scale solutions to be developed before implementation at the state or federal level.

Several city, non-profit and state-led transportation GHG reduction initiatives have emerged: the C40 Cities Climate Leadership Group, Architecture 2030 Districts, the Greenhouse Gas Protocol (GPC), and the Under 2 Coalition, to name just a few. This MP will focus on the work of one: the 2030 District in Philadelphia, which formed in October 2017 and is one of the 18 2030 Districts nationwide.

This MP will primarily focus on the challenges surrounding measurement of the city's 2030 District transportation emissions. While in the past, policy makers have primarily focused on electric power generation and industry to limit the growth of GHG emissions, transportation emissions account for 27 percent of U.S. GHG emissions, and light-duty vehicles are 60 percent of these emissions (EPA, 2015). The only sector that contributes more to GHG emissions in the U.S. is the electricity sector, at 29 percent. Worryingly, transportation is now the fastest-growing cause of GHG emissions, and there are 1/3 more vehicles on the road as there were in 1990 (Sorrel, 2016). Between 1990 and 2006, transportation emissions increased by more than 25 percent, almost half the "total national growth in GHG emissions during this period" (APTA, 2008, pg. 2).

Table 1: Percentages of Total U.S. GHG Emissions by Sector from 1990-2014



Source: Sorrell, 2016

Transportation infrastructure lasts decades, and the decisions surrounding urban development comes not just from national, but local and city governments. This is where cities, in partnership with businesses and other stakeholders, can play a substantial role in limiting the growth of these emissions, both now and in the future.

By having our cities and regions standardize how they measure their transportation emissions, they can understand what affects transportation emissions and devise effective reduction strategies. These methodologies can be best practices and an exemplar to inspire other cities to develop solutions to climate change.

As cities are a major contributor to climate change, they also can be part of the solution.

2030 DISTRICTS

The Philadelphia 2030 District is part of a network of 18 other cities in the U.S. that is overseen by Architecture 2030, a non-profit research organization.

2030 Districts are “private/public partnerships in designated urban areas across North America committed to reducing energy use, water use and transportation emissions” (Districts 2030 Background, pg. 2, n.d.). 2030 District organizations are unique in that they connect property owners and their managers with the local government, the businesses in the District, along with the community to “provide a business model for urban sustainability” (Districts 2030 Background, pg. 2, n.d.). The goal is to brainstorm, design and implement strategies that will fulfill the 2030 Architecture goals. Each District will “support peer exchange across Districts, store and share data...create national partnership relationships, and influence national policy on transportation infrastructure and building, water and energy efficiency” (2030 Districts, 2017).

The goals are divided into three buckets: energy, water, and transportation, with different benchmarks depending on whether the buildings and infrastructure are new or existing. This MP focuses on the transportation emissions.

For existing buildings, each District has the goal to reduce transportation emissions by 50% by 2030. For new buildings and major renovations, the goal is “an immediate 50% reduction below the District average” (2030 Districts, 2018).

Philadelphia 2030 District

The Delaware Valley Green Building Council (DVGBC) is leading the development of Philadelphia’s 2030 District, which incorporates Philadelphia’s Center City and University City (Bartolotta, 2017). Its approximate boundaries are: from the North: Spring Garden Street and Powelton Avenue, from the South: Walnut Street, the West: 40th Street, and from the East: Interstate 95.

Three maps are below: a map of the District, as well as two of how the District fits into the surrounding commuter region.

Figure 1: Philadelphia 2030 District



Source: Bartolotta, 2018

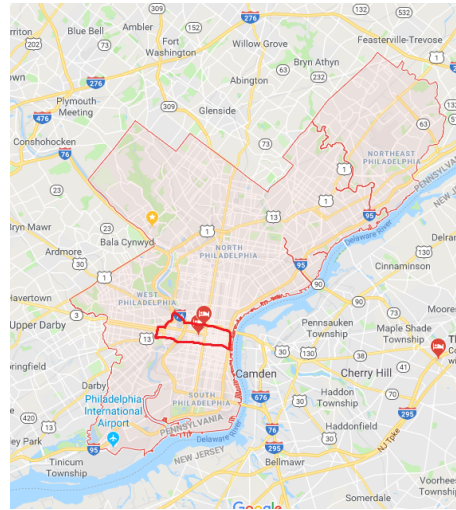
Note: The red dots indicate buildings committed to the 2030 District

Figure 2: Map of Philadelphia and the Surrounding Commuter Region



Source: Gottlieb, 2015

Figure 3: Map of Philadelphia with District 2030 drawn in red



Source: Bartolotta, 2018

As stated, Philadelphia’s 2030 District launched October 2017, and its goal is to have private, public, government and community leaders work together and share best practices (Bartolotta, 2017). The focus until now has been on finding buildings to commit to the initiative, and there has been minimal focus on how to calculate the transportation GHG emissions of the District’s residents and commuters.

The Problem Facing Philadelphia and 2030 Districts in General

A general challenge and problem that all cities and researchers face is a lack of standardization regarding measuring transportation GHG emissions on a city and regional planning level. Aware of this, Architecture 2030, the umbrella organization of the Districts, simply mandated that each 2030 District create a transportation baseline that “establishes an average mode split and associated carbon dioxide emissions from commuter transportation to and from the 2030 District’s boundary” (Smart Cities Dive, 2015, pg. 1).

In addition, out of the 18 Districts, only San Francisco, Denver, Cleveland, Seattle and Pittsburgh have started to track their transportation emissions. An additional challenge with this is that each 2030 District is using its own methods, and the approaches have varied considerably, an issue that will be explained in more depth in the Methodology section. After researching their methodologies, my goal was to provide an inexpensive and easy-to-use methodology for Districts to both create a baseline, as well as measure their emissions moving forward. Currently, each District’s methodology is either unavailable or not collected in the same manner, and thus cannot be replicated. Best-practice exchange and meaningful comparisons will only be possible with standardization.

THE PROJECT AND ITS IMPORTANCE

The MP has three parts. The first part was the development of a transportation GHG emissions baseline for the Philadelphia 2030 District. The baseline will enable the District to track its progress towards the 2030 Challenge Architecture 2030 set for all Districts.

The second part of the project was to create a proposed survey for the District to better track transportation GHG emissions moving forward. As a note of clarification, I will not administer the survey, but design it for the District.

The third part of the project was to create case studies comparing the 2030 Districts already measuring their transportation emissions. The Districts already measuring their transportation emissions, as stated, are San Francisco, Denver, Seattle, Cleveland and Pittsburgh. Each District measures its emissions slightly differently, and there is currently no document that summarizes how each District has approached tracking transportation emissions. This project considered some of the best-practice methodologies of the five other 2030 Districts and suggested which of their methods (both survey and baseline) can be incorporated and used moving forward.

Importance of the Project for Philadelphia

As previously stated, the focus until now has been on finding buildings to commit to the initiative, and there has been minimal focus on how to calculate the transportation GHG emissions of the District's residents and commuters. Creating a transportation baseline was an important focus however, not only because the 2030 District goal is to reduce transportation emissions 50 percent by 2030, but also because transportation emissions constitute Philadelphia's second-biggest source of GHG emissions (Drexel, 2015, pg. 4).

Importance of the Project for 2030 Districts in General

By helping the Philadelphia 2030 District create a transportation GHG emissions baseline and a survey to measure its GHG emissions, not only will it enable the Philadelphia 2030 District to accurately measure progress on reducing its transportation emissions 50 percent by 2030, but will also serve as an example for other 2030 Districts and help add to the literature for standardizing a method all Districts can use, regardless of their size or location in the U.S. This will enable Districts to better measure progress against one another, contribute to the best-practice literature and determine which policies have an impact.

Definitions

A list of the various definitions, terms and acronyms can be found in Appendix 1.

Limitations

The limitations of the data used to create the baseline is explained in more depth in Chapter Two, the Methodology section. However, an important point to remember is that the data from the baseline includes buildings that are not in the District, and that the majority of it is from 2010. The data used will be updated in 2018/2019, and the District will be able to easily update the Excel workbook I created to calculate the transportation emissions baseline once it is available.

In addition, the survey was not administered as part of the purview of this project. The District plans on presenting a final transportation emissions baseline and tracking method at a full District meeting in February 2019.

ORGANIZATION OF THE CHAPTERS

This project is divided into five chapters plus Appendices. Chapter 1 is the introduction to the project, and contains a description of the 2030 Districts, the Philadelphia 2030 District, the challenges that both face, a description of the project, the importance of the project for Philadelphia, and the importance of the project for the 2030 Districts in general.

Chapter 2 is the methodology section. In the first part of this section, I focus on the current practices and key takeaways and lessons learned from how the other 2030 Districts have created a transportation GHG emissions baseline, as well as tracked their progress moving forward. The second part of the section reviews how I decided which data to use for the Philadelphia 2030 baseline, as well as its key assumptions. The third part of the chapter includes the proposed survey.

Chapter 3 is the literature review. It covers what other initiatives have done to track city transportation GHG emissions, along with the role of transit agencies in data collection, challenges agencies have faced with measuring transportation GHG emissions at the metropolitan level, along with how metropolitan planning organizations (MPOs) and the Clean Air Act (CAA) offer opportunities to address the data standardization challenge.

Chapter 4 is a discussion on where Philadelphia's GHG emissions fall relative to the other Districts and how geography, along with city and state policies, influence the baseline. I also discuss the lack of standardization when it comes to establishing baseline transportation GHG emissions, and the importance of a survey methodology when moving forward.

Chapter 5 is where I offer conclusions and recommendations for the Philadelphia 2030 District as well as 2030 Districts in general moving forward.

The Appendix includes definitions and terms, the Excel workbook used for establishing the baseline, along with explanations of how to use it, as well as 2030 District primary documents.

CHAPTER 2: METHODOLOGY

A few notes in this section. First, below is a table that lists the transportation carbon dioxide emission baselines of each District, along with how they have measured their carbon dioxide emissions since the completion of their baselines. Each District has measured their emissions slightly differently, from using survey methodologies in the beginning, to using data already collected by various regional and local organizations, and then transitioning to a survey methodology moving forward.

In addition, to calculate transportation emission factors, some 2030 Districts have only used MOVES data (an EPA-developed transportation emissions modeling system), while others have used MOVES in conjunction with local regional data and others have not used MOVES at all. MOVES data allows the local MPO and the 2030 Districts to “estimate emissions for mobile sources at the national, country, and project level for criteria air pollutants, greenhouse gases, and air toxics” (EPA, 2016a). MOVES is useful because it “incorporates analysis of millions of emission test results...for all types of on-road vehicles across multiple geographic scales for any part of the country, except California” (EPA Moves, 2016, pg. 6). Hence, that is why the SF 2030 District uses a variety of emission factors, none of which are from the EPA.

MOVES is also useful because, if a region has the corresponding data, it can be input to produce a more accurate analysis on transportation GHG emissions in a particular state or metropolitan area (EPA Moves 2016, pg. 6). However, some MPOs have calculated for their specific region their own emission factors using different modeling tools. This can be due to two opposing reasons. First, some MPOs (especially those with access to higher levels of funding) have the resources to calculate (or have a consultant calculate) emission factors specific to their region. Then, they do not need the MOVES data. However, on the other hand, other MPOs might be unable to use the MOVES data. This is because some MPOs, due to limited personnel, funds and/or the time for retraining, do not collect the necessary regional data needed for MOVES, do not know how to use the system, or have their own methodology for emission factors, as in the case of California (Matute, 2011 and Miquel, 2012). In general, without a standardization of modeling emission factors, this can present challenges to the consistency of data across regions. This must be considered when analyzing the different emissions and emission factors across the 2030 Districts.

CURRENT PRACTICES OF THE 2030 DISTRICTS

Table 2: Transportation Emissions of 2030 Districts

Location	Emissions Baseline	Baseline Data Source	Survey Emissions	Survey Data Source
Cleveland	2,901.4 kg CO2/commuter/year	NHTS 2001/EPA Emissions Data 2001	2,479 total kg CO2/commuter/year	Partnered with University Circle Inc 2016
	11.6 kg CO2/commuter/day		9.9 kg CO2/commuter/day	

Denver	13.2 pounds CO2/commuter/day	2013 DDP Commuter Survey/EPA Emission Factors	14.4 pounds CO2/ commuter/day	2015-2016 DDP Commuter Survey/EPA Emission Factors
	6 kg CO2/commuter/day		6.5 kg CO2/commuter/day	
Philadelphia	9.4 kg CO2/commuter/day	2006-2010 CTPP, TAZ Network Distance (DVRPC), SETPA/EPA Emission Factors	-----	-----
Pittsburgh	1,794 kg CO2/commuter/year	SPC, 2013 Emission Factors from EPA and SPC	1,359.6 kg CO2/commuter/year	MMTC Survey with 11 stakeholders, 2015 *these results only include committed 2030 buildings
	7.2 kg CO2/commuter/day		5.4 kg CO2/commuter/day	
San Francisco	2.9 kg CO2/Commuter/day	SFCTA's SF- CHAMP 5.0 Data, 2012/Emission Factors variety	N/A	2016 Performance Assessment, March 2017
Seattle	900 kg CO2/commuter/year	Commute Seattle/City of Seattle's Seattle Climate Partnership, 2011	3.204 CO2/commuter/day	2015 Seattle 2030 Annual Report
	3.6 kg CO2/commuter/day		*Note: this was derived from the 2015 report which indicated an 11% decrease in CO2 transportation emissions	

**Note: A full year is 52 weeks, with an average of 5 days a week working. Accounting for 10 federal holidays, I put this at 50 weeks. To have the commuter/day (if a District measured its emissions by year), I divided the original number by 50, and divided by 5, assuming most employees work 5 days a week on average.*

As stated, there are five other Districts that have started to measure their transportation GHG emissions. These are the 2030 Districts of Cleveland, Denver, Pittsburgh, Seattle and San

Francisco (Smart Cities Dive, 2015, pg. 3). I have two goals with these five Districts. First, I want to create a robust transportation survey and emissions baseline that also considers the best practices of the Districts that have already completed transportation surveys. Second, I want to see if their approach to data collection could be replicated in Philadelphia.

Through my research and interviews with District representatives, I found that each 2030 District that has data, has acquired it through a different approach.

I divided their approaches into three buckets:

1. National Household Travel Survey (NHTS): Cleveland
2. Public-Private Partnerships: Denver and Seattle
3. MPO Partnership: Pittsburgh and San Francisco

Understanding their different approaches is important, as it highlights why Districts have measured what they have measured, where there is room for improvement, especially in relation to standardizing the current methodology and approach, as well as how Districts can improve their data collection moving forward. The goal in this section is to enable Districts to learn about their different approaches and how their approaches can be standardized moving forward.

This analysis would not be possible without the time and help of the District representatives with whom I spoke: Matthew Combe from Seattle (1/11/2018), Isabella McKnight from Cleveland (1/11/2018 and 10/10/2017), Isaac Smith from Pittsburgh (1/17/2018), Eleanor Johnstone from San Francisco (1/11/2018), and Tom Hootman from Denver (1/15/2018).

Approach 1: NHTS: Cleveland

Isabella McKnight, the Program Manager from the 2030 District of Cleveland, explained that they met with their local MPO, the Northeast Ohio Areawide Coordinating Agency (NOACA) and the Greater Cleveland Regional Transit Authority (GCRTA) and were informed that the best local data was the NOACA's 2012 Regional Household survey. It set the GHG transportation baseline at 2,157 kg CO₂/occupant per year (McKnight, 2017, pg. 2).

In 2016, the Cleveland 2030 District developed a transportation survey, partnering with University Circle Inc., a non-profit that focuses on the economic development of a District in Cleveland called University Circle. "Their goal was to make the "survey as short as possible to capture largest participation rate while getting only the data" they needed (McKnight, 2017, pg. 3). Survey results calculated a baseline of 2,479 kg CO₂/occupant per year.

Because of the difference in numbers between the MPO and their survey (2,157 vs. 2,479 kg CO₂/occupant/year) the District decided to not use the MPO's numbers. Concerns McKnight highlighted in our conversation about the MPO's survey included a small number of respondents surveyed (1,600), issues with the mode split (it indicated that around 15% of Clevelanders walked to work), and the fact that this was the only time the MPO had performed this survey.

Instead, the Cleveland 2030 District settled on using the NHTS, which is "disbursed every eight years by the U.S. Department of Transportation (DoT) and Federal Highway Administration (FHWA)" (McKnight, 2017, pg. 2). To calculate the kg CO₂/mile, they used 2001 EPA

emissions data. The new Cleveland baseline became 2,901 kg CO₂/commuter year. Their rationale for the NHTS over other measures was because citizens' "commute in the Midwest is the worst, and it has the most single drive-alone vehicles" (McKnight, 10/10/2017) and the 2030 District was concerned about "setting a baseline that was too lenient" and would not show the District's success on transportation emissions reductions (McKnight, 10/10/2017).

Looking ahead, the Cleveland 2030 District plans on partnering with UCI again to update their survey on a bi-annual basis.

Moving Forward and Thoughts:

- Cleveland 2030 indicated an interest in partnering with the MPO when releasing their bi-annual commuter survey, so that it would include more respondents.
- The survey was quick to take. However, this also meant the survey did not ask about people's primary, secondary or tertiary modes, ridesharing (such as Uber), what public transit they took, or if they varied in their transit methods during the week.
 - A survey issue the Cleveland 2030 District had was connecting with building owners and working with them to ensure that the tenants and by extension, employees received the surveys. In addition, some offices blocked Google forms, which is how the survey was distributed.

Initial Recommendations:

- Follow up with the MPO: Under the CAA, MPOs are required to track emissions. More accurate data is available, and this could have simply been the wrong baseline to use for the District, as it appears to not have accounted for commuters coming into the District, and only those who live in the District, as indicated by the large percentage of walkers.
- Work with the MPO on developing a survey distribution method so that it reaches a wider audience.

Approach 2: Public-Private Partnerships: Denver and Seattle

In the 2030 Districts of Seattle and Denver, Matthew Combe (Seattle) and Tom Hootman (Denver) worked with local non-profit organizations to acquire the data needed to establish their baseline and survey.

Seattle

The District has access to a city survey, a close relationship with a city non-profit organization (Commute Seattle) and the city's emission's factors (Combe, 1/11/2018). Commute Seattle's goals align with the 2030 District, whose mission is to "foster mobility partnerships and services" to "create a transit-supportive business culture" (Commute Seattle, n.d.).

The data for the baseline and survey that the District 2030 uses comes from two surveys that Commute Seattle aggregates for them. These surveys happen every two years.

1. The commute trip reduction survey. This survey, mandated by the city of Seattle and administered by Commute Seattle, is required for any employer with over 100 employees, but only surveys those offices in the downtown core.
2. The transportation management plan survey. The city of Seattle also mandates that employees in buildings over a certain size complete. It is administered by the Seattle Department of Transit.

The mode split, number of trips, and distance of both surveys is combined and averaged out. One of the useful aspects of the surveys is that the District can break the survey down by building and give each property manager their transportation emissions, as well as the average of all the buildings surveyed.

Challenges

- If a building in the 2030 District is not surveyed, the 2030 District applies the city average to the building. The problem with this, according to Combe, is that most buildings not included in the transportation emissions survey do not perform as well as the average, and their transportation emissions tend to be higher. This ends up benefiting the 2030 District, but inaccurately deflates the CO2 emissions (Combe, 1/11/2018).
- The two surveys combined only include about 30 percent of the Districts' buildings.
- Some office buildings have many tenants, and although the property manager sends the survey to the tenants, follow up is a challenge.
- The baseline and the follow up between the 2013 and 2015 Annual Reports on their CO2 emissions differ, which makes comparisons difficult.

Note: The 2013 Annual Report states that the District emitted 21.78% less emissions (but doesn't specify the original number, or indicate whether the reduction is district-wide or only from buildings). The 2013 Annual Report does include that the District has 133 buildings and a total of 38 million square feet (Geller, 2013). In the 2015 Annual Report, the District has about 46 million square feet committed, but the 2015 report does not mention the number of buildings. In addition, CO2 emissions have decreased by 11%, but it does not explain what the District is measuring this number against—the original baseline, or the 2013 Annual Report. The report does note that this number includes the "Total District Performance," but this unfortunately is still unclear (Wickwire, 2015).

Looking ahead

- The Washington State Department of Transit tried to reduce the survey length and combine it into one survey. Although the first iteration came out two years ago, distribution was a challenge. The District wants to work with Commute Seattle to combine the two surveys into one. The challenge is that neither has the time or money, so progress has been slow.
- Explaining the difference between the 2013 and 2015 Annual Reports and the baseline is important for checking if transportation emissions have really decreased.

- The survey currently does not distinguish between rail related questions—so District 2030 cannot measure the different emission factors between the commuter rail train (which runs on diesel) or light rail (which will be carbon neutral starting in 2019) (Fesler, 2017).
- Although there is a local MPO, no strong relationship exists. Developing a partnership with it will help with their data needs moving forward.

Denver

Tom Hootman, as a volunteer 2030 board member, works with the Denver Downtown Partnership (DDP), a “non-profit business organization” that is “the leading voice for private sector businesses in Downtown Denver” (Downtown Denver Partnership, n.d.).

The DDP was already performing transportation data collection (Bernhardt, 2016, pg. 8) and it tracks responses on an annual basis. As it constitutes the central business district, the DDP overlaps with the Denver 2030 District. The 2030 District decided to use the 2013 survey as their baseline (this was an arbitrary decision). Because of their close partnership, the DDP sends Hootman general data on transportation modes and distances from surveyed occupants. Hootman then uses the EPA MOVES data for the emission factors, and he uses a combined weighted average to calculate the emissions for trucks and cars, which is rolled into one.

Challenges:

- The Denver 2030 District has a very small number of staff, and the baseline is calculated by a volunteer, rather than a dedicated employee.
- The District, like in Seattle, is missing buildings in the District, as the survey is administered by an outside organization.
- The survey is administered differently than in Seattle or other Districts—the survey is only sent to companies that are DDP members.
- There is no question that distinguishes between bus and rail.

Looking Ahead

When I asked why the District uses the DDP rather than the local MPO, Hootman was uncertain of the answer—but he said the District had already established a good relationship with the DDP.

Approach 3: Government Partnership: Pittsburgh and San Francisco

In approach three, Pittsburgh and San Francisco established close relationships with their MPOs, which were already measuring transportation emissions (Lew, 2016, pg. 8; Ciranni, 2016, pg. 12).

Pittsburgh

Pittsburgh’s 2030 District is “facilitated by the Green Building Alliance (GBA)” (Ciranni, 2016, pg. 2). Starting in 2013, the GBA collaborated with the Southwestern Pennsylvania Commission (SPC), their local MPO to develop a 2013 “average mode split by person trips and associated emissions from commuter transportation to and from Downtown,” using “SPC’s

“Regional Travel Demand Model” (Ciranni, 2016, pg. 12). Their emission factors were a combination of factors specific to Pittsburgh and the EPA.

The SPC software “approximated geographic areas in traffic analysis zones (TAZs)” and for each mode calculated the “associated carbon dioxide emissions” (Ciranni, 2016, pg. 12). In 2015, in partnership with 10 “regional transportation stakeholders” the 2030 District developed a survey (MMTC) to measure current transportation emissions against the 2013 baseline (Ciranni, 2016, pg. 12). They had over 20,000 responses, of which almost 8,000 came from individuals who worked in 2030 District Committed Downtown buildings. To incentivize survey responses, the 2030 District also gave away Penguin hockey and Pirate baseball tickets. Unfortunately, it is hard to judge whether it increased survey participation, although Smith noted that 75 percent of participants did include their name and contact information. In addition, to ensure a variety of responses, the District also had people stand in front of buildings to ask employees to fill out the surveys.

As a note, the final emissions from the survey represent only the committed Pittsburgh 2030 District “Downtown Buildings.” The 2030 District pulled out the final survey emissions if the individuals worked in buildings that were not committed, to ensure as accurate a baseline as possible.

Challenges

- They used Survey Monkey, but some financial institutions blocked access.
- They tracked various modes, but allowed respondents to mathematically calculate their mode split percentages, which meant Smith had to take extra time to clean the data set from calculation errors.

Successes

- Because the 2030 District worked with the MPO, they made sure their survey questions matched the baseline questions regarding modes, or if not, made those changes consciously (such as not distinguishing between how many individuals were in a carpool).
- They added telecommuting to show avoided trips.
- They allowed respondents to detail their mode split weekly and daily. This is very important, because 45 percent of respondents use multiple modes throughout the week, and many individuals use multiple modes in their one trip.
- Because they used a stakeholder approach, they had a variety of methods to get individuals to answer survey questions—the city did a press statement, buses had advertisements, individuals were in front of buildings with iPads, etc.
- Avoided survey fatigue: they knew, for instance, that a building was being recertified under LEED version four. They coordinated the LEED transportation survey questions so they could be folded into the MMTC survey results.

San Francisco

The San Francisco 2030 District developed a transportation baseline through the work of Eleanor Johnstone's Duke University Master's Project: San Francisco's 2030 District: Performance and Implications for Urban Energy Efficiency and partnership with the San Francisco County Transportation Authority (SFCTA), which, among its various duties, "approves funding for transportation projects that directly benefit air quality, through reduced motor vehicle emissions" (SFCTA, 2018 and Johnstone, 2017). To create a baseline, Johnstone developed a calculator "from data provided by SFCTA's SF-CHAMP 5.0 model calibrated to 2012 to evaluate a baseline for the target TAZ" (Johnstone, 2017, pg. 26). It used three inputs, which include carbon emissions factors, mode splits and trip data, which are then weighted.

To measure the change in emissions moving forward, she developed an annual survey titled the "Commuter Behavior Survey" in March 2017.

Challenges:

- There was limited incentive for building managers, owners and tenants to complete the survey.
- The 2030 District had a low level of access to building tenants to track and encourage participation.
- Respondents experienced survey fatigue, which decreased participation.

Successes

- The survey was translated into Spanish and Mandarin, as well as distributed via paper copies to reach those without a computer or English skills.
- The inputs Johnstone used tend to be available through state and local databases.
- The survey was coordinated with member building owners, but some managers were more proactive than others. Unfortunately, 90 percent of the responses came from one building—a concern to be addressed moving forward.

OVERALL IMPLICATIONS AND TAKEAWAYS

As I move forward, there are several challenges to simply following these five District's past practices regarding their survey methodology. Each District established their transportation emissions baseline differently, which means the information they are missing and want to collect via a survey will be different than in Philadelphia. The surveys and baselines I have reviewed have been designed and distributed using different methodologies, lengths, level of detail, number of members reached, and partner organizations involved (which ranged from MPOs to private organizations).

It is important to take these differences into consideration, because it influences the Districts' baselines and how they check whether they are achieving their transportation GHG emission reduction goals. By better understanding the differences in methodologies, the Districts can seek to standardize their methodologies and better compare across Districts. This will not only help

them better track their transportation GHG emissions moving forward, but also eventually enable them to compare what strategies are contributing to their success, or challenges hindering their goals.

MPO Takeaways

- Many Districts already have existing partnerships, but due to a variety of factors, have not realized that their MPOs can solve many of their data challenges. Setting up a strong relationship with their MPO is one of the most important keys to developing an accurate and strong baseline moving forward.
 - In addition, most MPOs have more clout, money, and resources to ensure the survey is filled out.

Survey Takeaways

- Connect with the city and MPO to learn what surveys are already being distributed and when and if there are opportunities to work together.
- Focus on getting buy in first, then focus on what the District's goals are. This means focusing on relationships with the District members, the key quantitative questions, and then expand out to qualitative questions, depending on District priorities.
- Standardize how to communicate with tenants/companies—each method of outreach is different (Denver with the tenants vs. others that are with the property manager).
- Include a survey question that distinguishes between the different types of transit modes, especially in relation to various types of public transit.
- Have a prize to incentivize tenants to complete the survey.
- Review survey results with each building (Pittsburgh does this).
- Have the survey be administered regularly, at least every 2 years.
- Include questions that allow for multi-modality (daily and weekly).
- Include an open comments question box.

Data Takeaways

- Standardize data collection, both in regards to the baseline and follow up—for example, Seattle and Denver collect their data via third parties and Pittsburgh used other city stakeholders to help in the collection methodology.
- Standardization of emission factors—if Districts should only use MOVES data or if their emission factors are rigorous enough, explaining their data choice and why.
 - Standardize how to calculate the mode emissions factors. i.e., Denver does a weighted average of a car and truck, which changes their baseline slightly.
- Establish a consistent methodology measuring the final average GHG emission's, i.e., kilograms instead of pounds, occupant instead of commuter, actual CO2 reduction instead of percentage decrease, and daily instead of yearly.
- Establish best-practice data transparency methods. As in the example of Seattle, because it appears that the boundaries of the District shifted, the buildings included and

calculations most probably also changed. This could have been due to external factors as they work with a local organization, but explaining the changes and being consistent in how they explain the transportation goals (with the number of buildings, square feet, and whether CO2 decreases were district-wide or only include participating buildings) is important for understanding emission reductions and changes moving forward.

2030 District Takeaways

- Every 2030 District is structured slightly differently, and some offices are volunteer-led. Despite this, each 2030 District should have a dedicated staff member responsible for the data rather than a volunteer.
- Standardize interactions with property owners, (such as how they will ensure the survey is completed), lines of communication with tenants and property owners, as well as a methodology for getting past company firewalls.

Data Collection Decisions to Establish a Transportation Baseline

There were five different methodologies considered throughout the process of determining the best way to develop a baseline: 1. The Delaware Valley Regional Planning Commission (DVRPC) 2012-2013 Household Travel Survey (HTS), 2. Develop and Distribute a Survey, 3. Longitudinal Employer-Household Dynamics (LEHD) Origin-Destination Employment Statistics (LODES) data with the American Community Survey (ACS), 4. On the Map (OTM) with ACS, 5. Census Transportation Planning Products (CTPP) with the DVRPC Distance Matrix Data. (These terms are all described in Appendix 1).

Based on discussions with my advisor and client regarding these five methods, I ultimately decided to use methodology five, CTPP with the DVRPC Distance Matrix Data.

Table 4 compares the potential baseline methods, as according to data availability, age of data, replicability/fit the project timeline, and risk of error. This table was inspired by the table Johnstone created in her MP when she was also considering the various options available to develop a transportation baseline (Johnstone, 2017, pg. 28). Table attributes are explained in the table below.

Table 3: Explanation of Methodology

Method	Data Available	Age of the Data	Replicability/Fits Project Timeline	Risk of Error	Notes
The Data Source	Ranked from low – which meant difficult to acquire – to high – easy to acquire	Ranked from low – which meant old (5 years or more) – to high – new or current data (less than five years old)	If the methodology and data could fit the project easily and if it could be completed in the time allocated for the MP (low meant it would be difficult, to high meant easier to fit to project and timeline)	Ranked from high – which meant high risk of errors or mistakes – to low – which meant lower risk of error	Information that explained the preceding five boxes

Table 4: Evaluation of Potential Baseline Methods for Philadelphia District 2030

Method	Data Available	Age of Data	Replicability/Fits Project Timeline	Risk of Error	Notes
2012-2013 DVRPC: HTS	High	Low	Low	High	HTS every 10 to 15 years. Household and population was fit to county-level attributes from the ACS (to account for some under-reporting of trips), had a small sample size and was weighted, which means it would need to be reweighted for my desired Districts (Gruswitz, 10/4/017).
Survey to Create Baseline	Low	High	Mid-Low	High	As the District is new, the challenge would be avoiding bias, as well as ability to design and distribute survey in timeline of MP.
CTTP with DVRPC TAZ Data	High	Mid	Mid	Low	CTTP data includes mode. CTTP data was collected between 2006-2010 and released in 2010. Next release will be late 2018/early 2019 (AASHTO-CTTP, 2017). DVRPC provided a TAZ to TAZ matrix showing commuting distance.
OTM with ACS	High	High	High	High	Census Tract/Block Challenge: depending on the definition, the borders and thus tracts/blocks change. OTM: I can only see the top destinations (i.e., cities) commuters travel to. I can only see distances in segments of 0 to less than 10,

					<p>10-24, 25-50 and over 50, which makes mode calculations a challenge.</p> <p>The data is for employment and does not specify if they actually commute.</p> <p>ACS: it is only possible to calculate the mode of transit and distance based off of the place of residence in this dataset, which means commuters to the District I would need to estimate myself.</p>
LEHD LODES Data with ACS	High	High	Low	High	<p>Census Tract/Block Challenge: depending on the definition, the borders and thus tracts /blocks change.</p> <p>Must download LODES data for the entire states of Pennsylvania, Delaware and New Jersey. Must be joined to an xwalk file.</p> <p>Challenge of joining datasets—need familiarity with technical software, data cleaning and high computing power.</p> <p>The data is also for employment only and does not specify if they actually commute.</p> <p>Same issue with ACS and assumptions regarding mode of transit.</p>

Narrative of Decision Making Process

1. The DVRPC 2012-2013 HTS

Originally, I wanted to use the DVRPC 2012-2013 HTS (DVRPC Data Sources, 2017). However, this survey is only administered every 10 to 15 years. In addition, household and population data was fit to county-level attributes from the ACS (to account for some under-reporting of trips), which means the data collected would need to be reweighted for my desired District. In addition, it had a small sample size (Gruswitz, 10/4/2017). Finally, additional calculations would have still have been necessary, as the “survey itself never collected information on emissions, but...the information on household vehicles (make, model, year) could be used to derive...info related to emissions” (Gruswitz, 10/4/2017).

2. Survey

I briefly considered a survey methodology for establishing the transportation baseline, but decided against this early in the process. First, I wanted to review past 2030 District surveys to develop a survey that would consider the best practices of other 2030 Districts, which I knew would take additional time. In addition, Johnstone has a survey in her MP work, and from her experience, it took several months to create and distribute a survey, as well as follow up with reminders. By the time she acquired the data, it was a challenge to analyze the data in the remaining time. In addition, the Philadelphia 2030 District is newly formed, and the client was concerned that the data collected would be biased due to poor data collection methodology.

3. LEHD-LODES data with the ACS

Originally, I thought the best method would be to use raw data files from the LEHD and the ACS, data that is collected on a national level by the Census Bureau (LEHD, 2018; ACS, 2018). LEHD “makes available several data products that may be used to research workforce dynamics”, which includes LEHD Origin- Destination Employment Statistics (LODES) data (United States Census, 2017).

I downloaded the LODES data and joined it to a schema crosswalk file (which is a table that shows equivalent elements across various databases, so that the various data sources can be joined together) for Pennsylvania, Delaware and New Jersey. Doing this gave me work block id, home block id and linear distance (in the form of longitude and latitude). In addition, as this methodology incorporated measuring GHG emissions at the District level, I also requested a map of all the census tracts and blocks of Center and University City in Philadelphia to sort out which census tracts/blocks I would need to use. The challenge was depending on the definition, the borders (and thus census tracts/blocks) of these Districts could change. In addition, the use of this data would have required extensive cleaning and other pre-processing.

I also still lacked the travel modes. As a result, I planned to use ACS data. The ACS provides the most detailed and unbiased results regarding mode of travel in the U.S. (United States Census, 2017). Unfortunately, it is only possible to calculate the mode of transit and distance based off of the place of residence. As a result, I would have had to assume that those who live in the District and commute out would most probably have similar commuting patterns as those that commute into the District. Therefore, I would have had to use the ACS to make a rough transportation mode prediction based off the information calculated from the LODES data.

An advantage was that there are one year and five year ACS—geographies with 65,000 and more residents have 1-year estimates, so I could have relied on the one-year data available that correlates to the most recent LODES data, which would have been 2015 (Quinterno, 2014, pg. 107).

A final assumption was the LODES data was for employment, and I could not say with certainty if the individuals were actual commuters. For instance, it could be the case that an individual lived in New Jersey and worked remotely for a company in Philadelphia, or that they only went to the office four days a week and not five.

Because of the many assumptions I had to make, and challenges associated with modeling, I decided against using this methodology.

4. OTM with ACS

As a result of the complications with the LODES data, after speaking with an analyst from the Census Bureau, I was informed that the LODES data was also available through a platform called OTM, which shows where “people work and where workers live” (United States Census, 2011, pg. 1).

OTM allows the user to break the city into census tracts or blocks, and to query the database on questions such as the number of workers who commute to a census tract or block through an inflow/outflow analysis (On the Map, 2015). However, as this was still LODES data, I could not say with certainty if the individuals were actual commuters. In addition, I could only compute distance by 0 to less than 10 miles, 10-24 miles, 25 to 50 miles and greater than 50 miles.

I could also only calculate percentages of commuters to top destinations, which meant I lost many of the details of where individuals commuted beyond these top destinations. Finally, I faced the same issue that I could not compute from this platform commuters’ mode of transit, which meant I would still need to use the ACS data.

5. CTPP with the DVRPC TAZ-TAZ Data

I explained my methodology choices to Robert Graff, a manager from the Office of Energy and Climate Change Initiatives from the DVRPC. He had several suggestions he sent to me in an email on November 30, 2017.

First, he suggested I use the CTPP, something I had originally considered, but dismissed because the most recent version of the data was released in 2010 (and collected between 2006-2010). The next release is not scheduled until sometime late 2018 or early 2019 (AASHTO-CTPP, 2017). As the currently available data could be as old as 11 years, initially, I decided it would not provide enough of an accurate baseline. Mr. Graff disagreed. As transportation and land use patterns have not changed in Philadelphia, he said it would still be largely accurate.

In addition, as I would be using an Excel calculator tool, once the data is updated, it will not be hard to input the update in 2018/2019. The biggest advantage of the CTPP is that it provides mode between any two TAZs. Using TAZs versus census tracts/blocks also presented an

advantage, because the majority of MPOs and planning agencies use TAZs as a basis for their modeling process. As I want to use a methodology other MPOs could easily copy, this was an important factor for me. Mr. Graff continued that the DVRPC had developed and could provide a TAZ to TAZ matrix showing commuting distances.

As a result, after discussions with Mr. Graff and other individuals from his office, I received two Excel files—one with the relevant 2030 District CTPP mode data (specifically the A302103 Table of the 2006-2010 CTPP) and another with the commuting distances by TAZ. This enabled me to create a baseline calculator, which I will go into more detail in the next section.

Main Advantages of the DVRPC Methodology

- We know the mode between any two TAZs.
- The Columns o_dvrpc (origin-home) and d_dvrpc (destination-work) in A302103 Table of the 2006-2010 CTPP have the origin and destination zones that match the DVRPC model (so they can be tied to distances in the matrix) (Gruswitz, 2/5/2018).
- The flow column has EI (external to District going internal to District), IE (internal to District going external to District), or II (internal to District going internal to District) (Gruswitz, 2/5/2018).

PHILADELPHIA 2030 DISTRICT BASELINE RESULT

The Excel Workbook Baseline Calculator found that the Philadelphia 2030 District had a transportation GHG emissions baseline of 9.4 kg CO2/commuter/day. This finding will be reviewed in relation to the other Districts in Section Four, Discussion.

The baseline calculator was, as mentioned, inspired by the work of Johnstone. The calculator is designed to measure kilograms of carbon dioxide emitted per commuter per day. My data sources are below. The Excel workbook and additional documents that detail the method of my calculations are in Appendix 2.

In addition, please find below the mode split for each transit option in the District.

Table 5: Mode Split in District 2030

Mode	Split (%)
Auto (Drive Alone)	40.12
Carpool	7.17
Bus	17.98
Streetcar	0.97
Subway	10.08
Railroad	12.94

Ferry	0.02
Bike	1.55
Walk	7.70
Taxi	0.26
Motorcycle	0.13
Other	0.48
Worked from Home	0.55

Initial Takeaways from the Excel Workbook Calculations

As mentioned in the introduction, an important point to remember from the baseline is that the data includes buildings that are not in the District, and that the majority of it is from 2010. The data used will be updated in 2018/2019, and the District will be able to easily update it once it is available.

Table 6: Excel Workbook Methodology Defense
(with many thanks and based off the methodology from Johnstone's MP)

Comments	Accept/Reject	Justification	Action Response
Goal: total CO2/commuter	Accept	Only looked at those individuals who are workers	
Segment trips by purpose	Accept	Pittsburgh, Denver, Cleveland, San Francisco and Seattle only measure work travel	Only analyzed work-based PMT
List number of people making the trips (rather than the total number of trips)	Accept	We want the emissions/commuter/day to track emissions, especially in relation to density	
Motorcycle emission factors are a combination of DVRPC data and MOVES. They are also in VMT and from 2017, rather than 2010.	Accept	The emissions factors were given to me by DVRPC, as SEPTA did not have this data. In addition, most motorcycle trips only have one passenger. Finally, motorcycles make up a very small	Use motorcycle emission factors provided to me by Legendre from 2017.

		proportion of the fleet, and according to Shawn Legrendre from DVRPC, any differences in emission factors between 2010 and 2017 could be within the margin of error and/or due to methodological changes between MOVES 2010b and MOVES 2014a (Legrendre, 4/2/2018)	
Include travel to outside zone if home is in zone	Accept	As people are commuting in and out of the District, this is important to take into consideration	
DVRPC data is transit VMT, divide by number of commuters for PMT per Mode	Accept	Adviser says this is accurate	Received from SEPTA occupancy averages for other transit options
Measure mode specific transit options	Accept	This will enable 2030 to help make policy recommendations regarding mode options moving forward	
Emission Factors from SETPA rather than MOVES	Accept	As the data is from a local organization (SEPTA), and DVRPC (the local MPO) also agreed with this, confidence level is high.	
Ferry Not Included in Calculations	Accept	Ferry travel is ignored, as only .02% of commuters (or 50 people) use it to get to work. If ferry use should increase significantly in the future, this method will allow the user to incorporate this travel in the baseline.	Not included in the baseline

Carpool Data from CTPP is averaged out—for 5 or 6 in a carpool, I divided by 5.5 for PMT, and 7 or more I divided by 7	Accept	It is doubtful there are many more than 7 in a carpool. In addition, I did not want to favor the “5 or 6” over another and so averaged it out.	Divide by 5.5 and 7 for PMT per carpool mode
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Table 7: MPO and CTPP Data Assumptions

Assumptions	Justifications
Only one work location (based on where an individual “worked most” (ACS form, question 30) (Gruswitz, 2/5/2018).	ACS has the most robust data on work location, until a survey specific to the District is established.
Only one mode can be chosen, and it is based on the greatest distance “rather than time.” (ACS form, question 31) (Gruswitz, 2/5/2018).	Same as above.
Spreadsheet lists highway network distance (in miles) between TAZs for each of the origin-destination pairs in the spreadsheet	Auto was easier to come by, as it is a standard matrix in the model. Transit would have needed additional computation from the DVRPC modeling staff.
“Taxi PMT does not account for the driver” (Johnstone, Excel Calculator, 2017).	“Taxi driver is not traveling to or from the area for a fixed number of trips each day, every day, for site-specific work purposes. The demand lies with the traveler, and for traditional taxis we do not have evidence to suggest that these vehicles carry more than one passenger per commute trip” (Johnstone, Excel Calculator, 2017).

Table 8: Data Sources for Excel Workbook

Input	Sources
Emissions Per Passenger Per Mode for NHSL/MFL/BSL, Regional Rail, Trolley, Buses, Single Occupancy Vehicle	GHG by NTD Mode, Geoffrey Philips, SEPTA (2010)

Emissions Per VMT, Motorcycle	Shawn Megill Legendre, DVRPC Travel Demand Model and U.S. EPA's MOVES software (2017)
Average Occupancy	Geoffrey Philips, SEPTA Unique Trips Data (2010)
TAZ to TAZ Highway (Auto) Network Distances in Miles	Robert Graff, DVRPC (2015)
Origin and Destination Zones with Modes	A302103 Table of the 2006-2010 CTPP (from Benjamin Gruswitz)

SURVEY DESIGN

Moving forward, as stated, I recommend that the Philadelphia 2030 District pursue a survey methodology to measure transportation emission moving forward. The following outlines my proposed survey.

This survey would not be possible without the help of Johnstone and her MP (Johnstone, 2017), and Isaac Smith from the Pittsburgh 2030 District and their “Make My Trip Count (MMTC) Commuter Survey” (Smith, 2015). I also reviewed the 2016 Commute Seattle Center City Mode Split Survey (Commute Seattle, 2016), the 2015-2016 Downtown Denver Commuter Survey Questions (DDP, 2015), and the 2030 Cleveland District Transportation Survey (McKnight, 2017).

I recommend that the survey is administered on a bi-annual basis. Transportation trends tend to change more slowly as compared to energy and water usage, as they are based on major and long-term infrastructure decisions. This survey is divided into two parts. The first part is the core set of recommended questions that the Philadelphia 2030 District should ask its members. The second part is supplementary questions that the District could either ask as an optional “Part II,” or in another iteration of the survey.

Survey fatigue is an issue that all 2030 Districts face. As a result, I have two recommendations the 2030 District of Philadelphia, as well as the other Districts could consider, depending on the context of the District and the information they are looking to collect.

Strategy One: The District focus on the core set of questions, and consider the more qualitative questions the next time the survey is administered.

Strategy Two: The more qualitative or supplementary questions be added as a Part II, and be optional. This would follow the experience of the Pittsburgh 2030 District, where it divided its survey into a Part I and Part II, with part two being optional.

Survey Questionnaire

You are taking this survey as either an employee, a resident, or an employee and a resident of a property that is enrolled in the Philadelphia 2030 District program. When filling out this survey please consider a typical workday from your last 12 months of commuting in Philadelphia.

1. Which 2030 District address below is your origin or destination?

(list of 2030 Buildings, divided by place of employment, place of residence)

If you neither live nor work at any of these addresses, please do not take this survey.

2. What is your home zip code?
3. What is your work zip code?
4. How many days per week do you commute for work?
(break down into 7 boxes:7 days a week, down to 0, and have an Other:_____)
5. How many miles is your typical one-way commute?
<2 miles, 2-5 miles, 5-10 miles, 10-20 miles, >20 miles
6. Indicate the number of days per week you typically work from home (“telecommute”)
0,1,2,3....
7. Please indicate the typical time you arrive/leave work below:

	Time you Arrive at Work	Time you Leave Work
12 am- 5:59 am		
6 am-8:59 am		
9 am-11:59 am		
12 pm-2:59 pm		
.....		

8. Please indicate on this table, on average, what type of transportation you use (for longest distance) each day over the course of a week. If you do not work that day, please select the option “I did not work that day.”

M	T	W	Th	F	Sat	Su	(transit options all listed in each row below, ex below)
							Drive Alone (Parked at or near work)

							Park and Ride
							Bus/Trolley Bus
							Street Car/Trolley Car
							Subway/Elevated
							Railroad
							Etc (full list below)

Transit Options Full List Will include: Drive Alone (Parked at or near Work), Park and Ride, Bus/Trolley Bus, Street Car/Trolley Car, Subway/Elevated, Railroad, Carpool, Van-Pool, Walk, Bike, Dropped Off/Picked Up, Taxi/Uber, Motorcycle, Ferry, Telecommute, Other, I did not work that day

9. This next question refers to multi-modality in one trip. You can chose up to three transit options, with the first your primary or longest distance in that mode, to second longest, to third longest.

Longest Distance	Second Longest	Third Longest
Drop Down Menu of Transit Options here		
Percentages of distance average here (must automatically add up)		

Transit Options Will include: Drive Alone, Bus/Trolley Bus, Street Car/Trolley Car, Subway/Elevated, Railroad, Light Rail, Carpool, Vanpool, Walk, Bike, Telecommute, Taxi/Uber, Ferry, Motorcycle, Other, I did not use an additional mode

10. In the past year, have you changed your mode(s) of transportation? Y/N

11. If yes, please indicate below

Transit Options Below	Added to daily Commute	Stopped using for commute

12. What was the reason for making the changes indicated above to your daily commute? Select all that apply.

Reason	Added because	Stopped because

Reasons: New job site, new living location, save money, save time, employer subsidized benefits became available, were removed, comfort and safety, social or environmental values, other

13. What type of fuel does your vehicle use?
14. What is your vehicle's gas mileage?
15. How many people are in your carpool?
16. How many people are in your vanpool?
17. Is there anything else you would like to share about your commute?

Demographic Questions:

1. What industry do you work in?
Construction/Real Estate, Education, Finance/Insurance, Government, Healthcare, Hospitality, Information/Media, Manufacturing, Professional and Business Services Retail Trade, Software/Engineering, Transportation/Warehousing, Utilities, Wholesale Trade, Other_____
2. To which gender do you identify?
3. What is your age?
4. What is your estimated average household income before taxes?
0-\$9,999, \$10,000-\$19,999, \$20,000-\$29,999.....
5. What is your work/student status?
Full Time, Part Time Worker, Full Time Student, Part Time Student
6. What is your ethnicity?

If you would like to be entered into the prize drawing, please provide your name and an email address or phone number. No contact information will be associated with survey responses or used for any other purpose other than to contact prize winners.

Secondary Questions

Parking Questions

1. Where do you typically park at work? If you shared a vehicle, indicate where that vehicle is typically parked for your car/vanpool(have a dropdown list)
2. How much does it typically cost you out of pocket per day to park at work?

3. Does your employer offer any of the following?
Parking space, secure bike parking space, carshare, does not offer any of the following
4. Do you use any of the following?
Parking space, secure bike parking space, carshare, carpool data service, do not use any of the following

Employer and Transit Benefit Questions

5. Does your employer offer transit passes?
6. If yes, do you use the passes offered by your employer?
7. Does your employer offer tax-free transit options (i.e., commuter benefits program?)
8. If yes, do you use this benefit?
9. Does your employer offer flextime or flexplace work options? (if so, how many days a week)
10. Does your office have a telework policy?
11. Does your office have one person to answer transportation-related questions?

General

12. If you used to use public transportation, why did you stop?

Drop down: change in employment, change in job location, transit service/route change, change in living location, felt uncomfortable or had a bad experience, change in scheduling, never used public transit, other ____

13. What is the primary reason you would avoid driving?
Convenience, financial, necessity, accessibility, environmental, social, safety, other

14. What are your main reasons for driving alone?
Drop Down: Faster, Cheaper, Safety concerns about transit/bike, travel during work hours for personal/company business, drop off/pick up kids or spouse, public transit is not available, irregular work schedule, no one to ride with, less stressful, parking provided by employer, unpredictable work hours, comfort, I do not drive alone, other

15. If you currently drive alone, but that no longer became an option what would your next viable choice to commute be?
Options: Park and Ride, Bus, Light Rail, Carpool, Walk, Bike, Telecommute, Taxi/Uber, Ferry, Other

16. Are you familiar with the bike sharing program in Philadelphia?
17. Are you familiar with the DVRPC resources?
(list different resources here)

CHAPTER 3: THE ROLE OF TRANSIT AGENCIES AND TRACKING TRANSPORTATION GHG EMISSIONS

EFFORTS TO ADDRESS URBAN TRANSPORTATION GHG EMISSIONS

There are several other agencies and stakeholders working to collect transportation data, as well as share best practices to limit urban transportation GHG emissions. Below is a table that outlines a few of the major initiatives. These initiatives all either began in the U.S. or have significant U.S. city regional participation.

Table 9: A Brief Overview of Major Transportation Initiatives in the U.S.

Program	Est.	Description	Adapting Cities
Clean Cities (through the DOE)	1993	The DOE “supports local actions to cut petroleum use in transportation” (DOE, n.d.). Coalitions include “businesses, fuel providers, vehicle fleets, state and local government agencies, and community organizations” (DOE, n.d.). Activities include developing “information resources, data-driven online tools, technical assistance” among other activities (DOE, n.d.).	Clean Cities (through the DOE)
The Office of Sustainable Communities/ Interagency Partnership for Sustainable Communities (DoT, EPA and HUD)	2009	The DoT, EPA and HUD partnered in 2009 to “help communities...make transportation systems more efficient and reliable” as well as “provide more transportation options and lower transportation costs, while protecting the environment” (FTA Livable, 2015 and EPA, 2014).	The Office of Sustainable Communities has worked with more than 400 tribal, state, regional and local governments (EPA Community Stories, 2015). With the new administration and budget cuts, this initiative no longer appears to be active.

Greenhouse Gas Protocol (GPC)	2014	<p>An initiative developed by the World Resources Institute (WRI), the C40 Cities Climate Leadership Group and ICLEI-Local Governments for Sustainability. The goal is to standardize global data on “city performance,” which includes transportation emissions (Swope, 2014, pg. 1).</p> <p>GPC measures a range of emissions, from Scope 1 and 2, “which originate from households or businesses located within the city’s borders” as well as indirect emissions, “known as Scope 3” (Swope, 2014, pg. 2).</p>	At least 70 participating cities world wide
The Under 2 Coalition	2015	<p>Originating from a partnership between California and Baden-Württemberg (a German state), subnational governments (including cities) commit to “either reducing their GHG emissions 80 to 95 percent below 1990 levels or...to less than 2 metric tons per capita by 2050” (Under 2, 2018). This initiative has three “work streams”, which include “decarbonization pathway planning, scaling... policy solutions and mainstreaming transparency and reporting” (Under 2, 2018). The focus of the work is to create opportunities for subnational governments to learn from each other’s initiatives and to create scale for various local projects that have been successful.</p>	205 jurisdictions, representing 43 countries, have joined.

Smart City Challenge (US DoT)	December 2015-2017	A competitive grant the DoT offered for a city to develop an “integrated, first-of-its-kind smart transportation system that would use data, applications, and technology to help people and goods move more quickly, cheaply and efficiently” (Snow, 2017). 78 cities applied.	Columbus, OH won. In 2016, the DoT awarded an additional \$65 million in grants to support 19 additional projects, such as in Pittsburgh, SF, Denver and Portland (DoT, 2016). Unfortunately, the grant does not seem to have been continued under the new administration.
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Takeaways from Table 9

As has been stated, measuring transportation GHG emissions is a difficult endeavor, due to the myriad of actors and stakeholders, especially as compared to measuring water usage or building GHG emissions. The focus on measuring (and decreasing) transportation GHG emissions is also a relatively new focus—all except one of the initiatives listed above, are less than 10 years old (and most even less than that).

In addition, continuity, especially on a federal level, is a struggle. Two of these initiatives (the Smart City Challenge and the Interagency Partnership for Sustainable Communities) no longer appear to be active.

The 2030 District initiative has found a niche where there is still a lack of uniformity regarding measuring transportation emissions. The 2030 Districts have an opportunity to help standardize the measurement and tracking of transportation GHG emissions, especially as other actors look to develop transparent and replicable data collection tracking methods across the regions. This is where the importance of local government transit agencies and partnerships comes into play.

THE ROLE OF TRANSIT AGENCIES IN DATA TRACKING

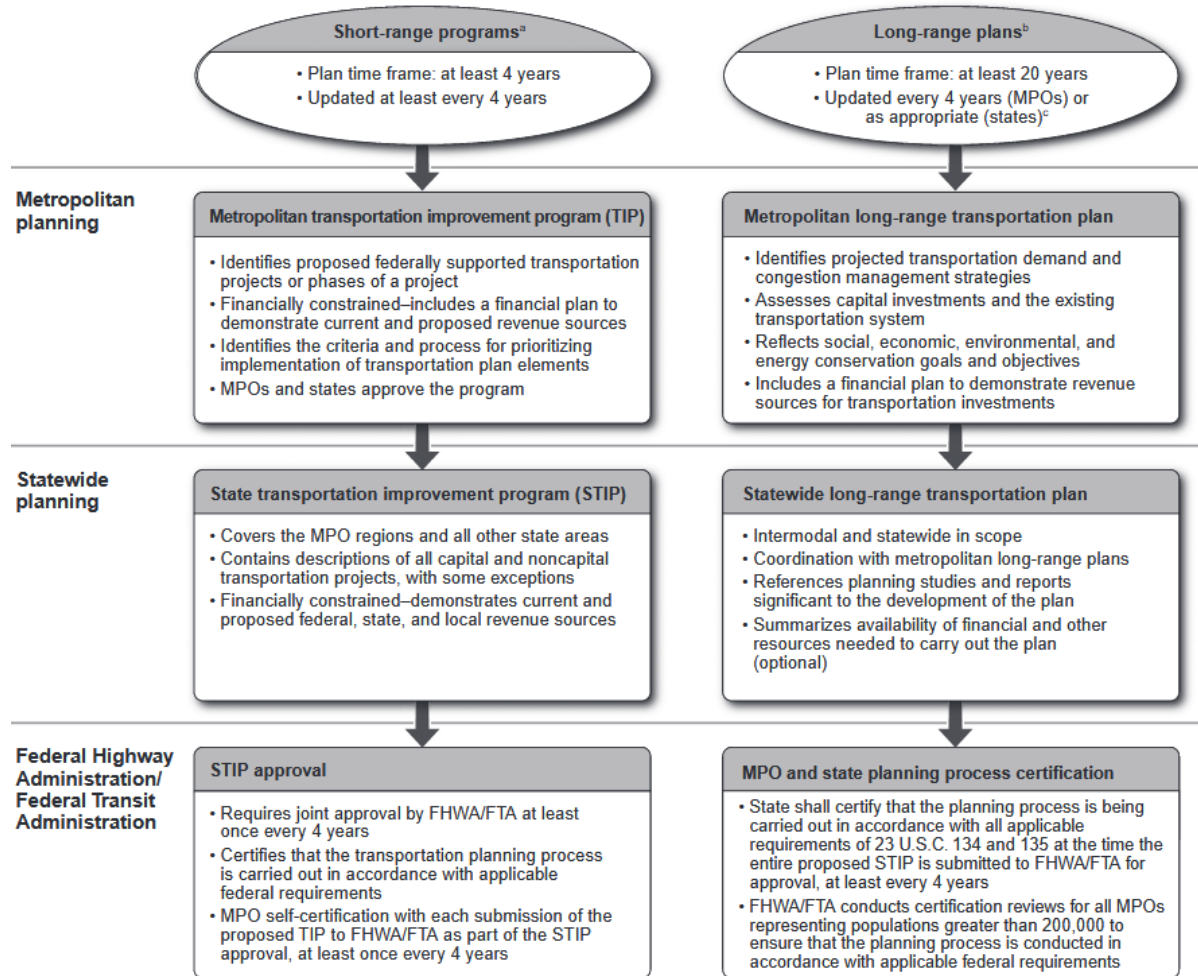
Transportation, as stated below, has a myriad of actors involved. There are many governmental actors involved in transportation, from the federal level, such as the DoT, the FHWA, the Federal Transit Authority (FTA), to state level DoTs and city planning departments. This MP, however, focuses on the role of MPOs in providing modeling expertise for measuring GHG emissions in the 2030 Districts.

Currently, at the state level, DoTs are “required to develop statewide transportation plans.” However, these plans do not have to be quantitative, and instead “they can be policy-based plans, with goals for meeting transportation needs” (Houk, n.d., pg. 2).

MPO’s, on the other hand, as part of their planning process, must track emissions, as required by the CAA (and which will be explained in further depth in this literature review). MPOs are “a transportation policy-making body made up of representatives from local government and transportation agencies” (Houk, n.d., pg. 2). MPOs were created in the 1970’s by legislation from the federal government that mandated an MPO for any urban area that had a population larger than 50,000 inhabitants.

They are specifically “responsible for conducting transportation conformity analysis and reporting.” In addition, MPOs “are the primary agency responsible for considering the combined effects of transportation strategies over large, multi-jurisdictional areas” (FTA, Air Quality, 2017). As a result, MPOs are also a natural agency to lead a consistent data collection across the regions because they interact and work with all transportation agencies, from the FTA and FHWA (who oversee MPOs) to working with the state DoTs to develop the STIP (a statewide transportation improvement plan mandated by the federal government). MPOs “represent local governments and work in coordination with state departments of transportation and major providers of transportation services,” as well as have an important role in the “regional transportation decision-making process” as determined by the Federal-Aid Highway Act of 1973, which established MPOs and their mandate to “carry out a continuing, cooperative and comprehensive planning process” (GAO, 2009, pg.1,3). Most importantly, for a project to receive federal funding, “any project in an urbanized area must emerge from the relevant MPO” (GAO, 2009, pg. 4). As part of the interdisciplinary role of an MPO, they tend to have a board which includes elected officials, state and public transportation officials, as well as a technical advisory committee, which includes engineers, planners, as well as citizen, bike and pedestrian committees (GAO, 2009, pg. 4).

Figure 4: Transportation Planning Process



Source: GAO, 2009

Challenges with Measuring Transportation GHG Emissions at a Metropolitan Level

Yet, when researching this topic, an unexpected challenge was the lack of clear, data-driven best practices regarding measuring transportation energy use and transportation GHG emissions. This was evidenced by research from Drexel University in its report called, “Options for Achieving Deep Reductions in Carbon Emissions in Philadelphia by 2050,” (2015) and the article from the *Journal of the American Planning Association*, “Does Accessibility Require Density or Speed?” by Levine et al. (2012).

For instance, Levine et al. struggled with ensuring the transportation data and methodology was consistent when comparing accessibility in metropolitan cities. Although transportation data is developed by all major U.S. MPOs, the data is collected through a variety of methods and with different definitions (Levine et al., 2012, pg. 169). Levine et al. advised, moving forward, that

there should be a “consistent definition of these model outputs across regions...the development of a nationwide repository of this information” (Levine et al., 2012, pg. 169). Drexel University researchers cited similar concerns. In addition, Drexel University found, when advising next steps for Philadelphia, that there was a lack of information regarding the actual performance of different cities regarding achieving their GHG reduction goals (Drexel, 2015, pg. 59).

When I researched what other cities have done to measure their emissions, I found that this is something that agencies and organizations across the board struggle to effectively address. Collecting transportation GHG emissions data is more difficult than estimating building energy use and GHG emissions. This is due to several factors, ranging from many more commuters and vehicles than buildings, to the fact that there are more stakeholders involved in transportation, such as federal, state, and local governments, plus the local MPOs, environmental groups, along with commuters, public transit and residents, among various others.

The Florida DoT, Public Transit Office authored a report on “best practices for urban fixed route systems in evaluating transit performance in the United States” (FDOT, 2014, pg. 3). It found that, “there is no uniformity in conducting transit performance evaluation among transit agencies. Each agency, depending on their capabilities and needs, adopts different methodologies in the collection, measurement, analysis, and assessment of transit performance data” (FDOT, 2014, pg. 3). There is also no central repository where agencies can collect and review information on their and other’s performance evaluation methodologies. This results in the inability of transit agencies to learn from each other’s best-practices. The challenge, according to the magazine *Governing*, is that “cities use all kinds of different methods of measuring and reporting their emissions” (Swope, 2014, pg. 1). While the various accounting measures make sense locally, it makes it extremely difficult to compare cities from across the country.

Additional decisions cities must make when trying to measure transportation emissions include how to treat transboundary emissions, which criteria pollutants to count (all of them, which would be particulate matter, ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides and lead) and what data to track (commuters, deliveries, among other things) (Swope, 2014, pg. 2). This encourages the diversity of approaches cities take today and creates additional challenges regarding the standardization of transportation baselines and benchmarking.

The CAA

To learn about what methods of data standardization might be available, I began to look into the CAA. The CAA “mandates controls on air pollution from mobile sources by regulating both the composition of fuels and emission-control components on motor vehicles” (EPA Regulatory Information, 2013). There are six pollutants the CAA mandates be measured: Ozone, Nitrogen Dioxide, Carbon Monoxide, Lead, Particulate Matter and Sulfur Dioxide (FHWA, 2017).

Metropolitan Planning Organizations (MPOs)

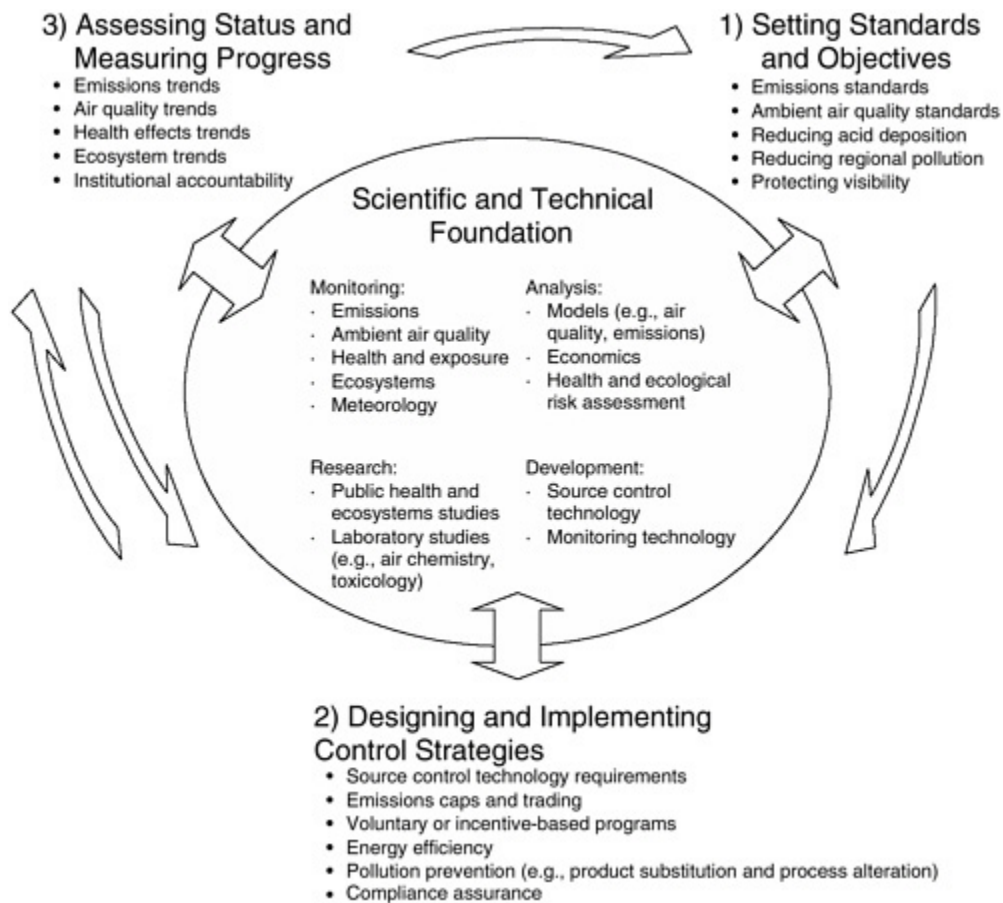
The next question I had, was who did the CAA mandate to measure these emissions? This responsibility, unsurprisingly, is housed primarily with MPOs.

States, MPOs and the CAA

The CAA requires that states, MPOs and cities comply with the CAA through a process called transportation conformity. Required under the CAA Section 176(c), it “establishes the framework for improving air quality to protect public health and environment” (FHWA, 2017).

MPOs must develop metropolitan transportation improvement plans (TIPs) and states design state implementation plans (SIP). A SIP is both “a general plan to attain and maintain the National Ambient Air Quality Standards (NAAQS)... and a specific plan to attain the standards for each area designated nonattainment for a NAAQS” (EPA, 2016b). The SIP ensures that any new activities, especially as they relate to infrastructure or transportation, will not “cause or contribute to any new violations of the NAAQS” (FHWA, 2017).

Figure 5: SIP Diagram



Source: EPA: Basics of SIP Requirements, 2016b

A TIP (which is what an MPO develops), is a capital improvement program that “lists all regionally significant and federally-funded transportation projects and services in the MPO

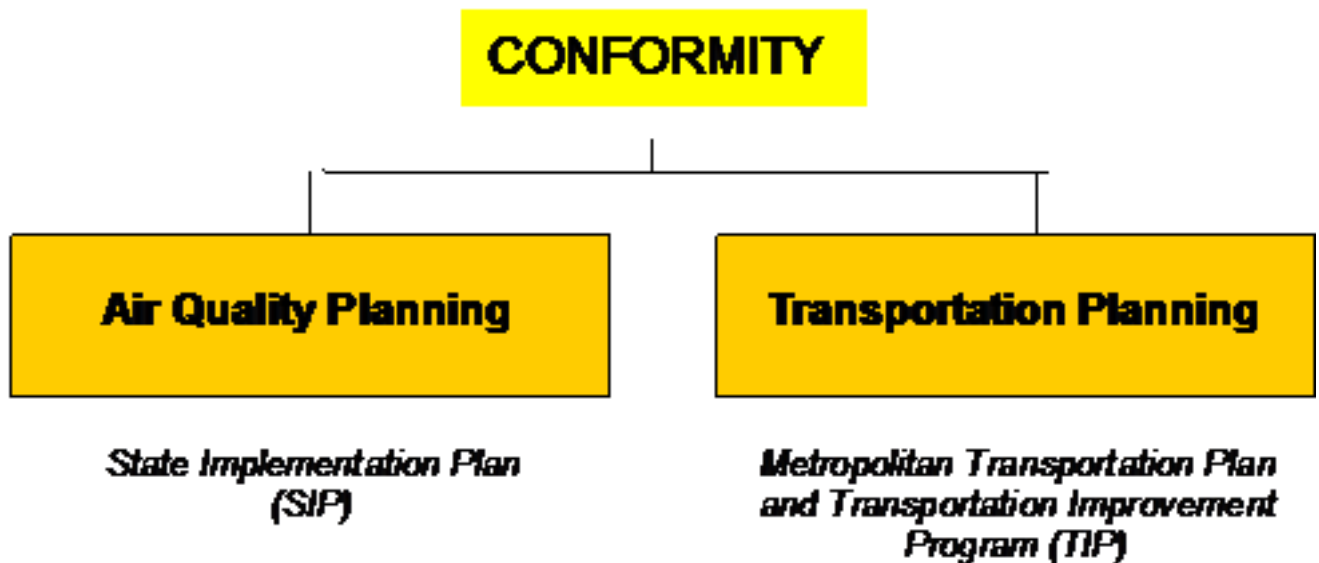
planning area” (Nashville MPO, 2018). Both the TIP and SIP must follow conformity, “which is how the MPO shows that the total emissions projected for that... TIP are within the on-road mobile source emissions limits (“budgets”) established by the SIP to protect public health for the NAAQs.” (FHWA, 2017).

This is done through “transportation control measures” (TCMs). TCMs are “specific programs (within the SIP) designed to reduce emissions from transportation sources by reducing vehicle use or changing traffic flow or congestion conditions” (FHWA, 2017). They must be implemented in a “timely” fashion and for regional projects, local agencies are “consulted on data, modeling and other issues related to the determination” (FHWA, 2017).

To respond to conformity requirements, MPOs must “estimate regional emissions and compare to the SIP budget, use the latest planning assumptions and latest emissions model and ensure timely implementation of TCMs in approved SIP” (FHWA, 2017).

MPOs are a crucial part to ensuring the SIP follows these regulations. The MPO “routinely performs air quality conformity determination...as required by...federal regulations” (Boston MPO, n.d.). In close partnership with the EPA, they “also implement...programs to further reduce emissions of criteria air pollutants from sources such as cars...” (EPA Regulatory Information, 2013).

Figure 6: The Connection between Air Quality and Transit: Transportation Conformity



Source: FHWA, 2017

Consistent Data in Regard to GHG Emission Data

If this is the case, why has transportation GHG emissions data collection been such a challenge? I believe this is due to several factors. The role of an MPO has greatly expanded since the Intermodal Surface Transportation Efficiency Act of 1991. In the time-period following its enactment, “subsequent federal laws and policies, along with various state and local initiatives, have tasked MPOs with many new challenges...some...have taken on these challenges and thrived, while others have frankly struggled to meet the most basic requirements” (TRB: Plumeau, 2006, pg. 3). The number of MPOs has also grown—and there are now 400 in the U.S. This has created a variety of MPO structures, sizes, budgets and varying degrees of closeness and partnership to their DoTs (TRB: McKenzie, 2006). I believe this has created challenges in accessing the data they collect, as well as even knowing who within the MPO to approach to request this data.

Neil Pedersen, from the Maryland State Highway Administration, at a conference hosted in conjunction with the Transportation Research Board titled “The Metropolitan Planning Organization, Present and Future,” acknowledged MPOs face several challenges moving forward, especially as it relates to working with outside stakeholders (TRB, 2006). Future transportation decision making, he stated, needs to include stakeholders not currently part of the MPO process, especially as these outside groups “typically operate in decision-making processes that are separate from those of MPOs, and many may not be aware of the MPO transportation planning process” (TRB, 2006, pg. 27). Adding to the challenge of forming partnerships will be their different timeframes and access to different funding streams (TRB: Pedersen, 2006).

With the development of 2030 Districts, I see this happening—and the continuing struggle these outside groups have in accessing each other’s data and expertise.

MPOs and Carbon Dioxide Measurements

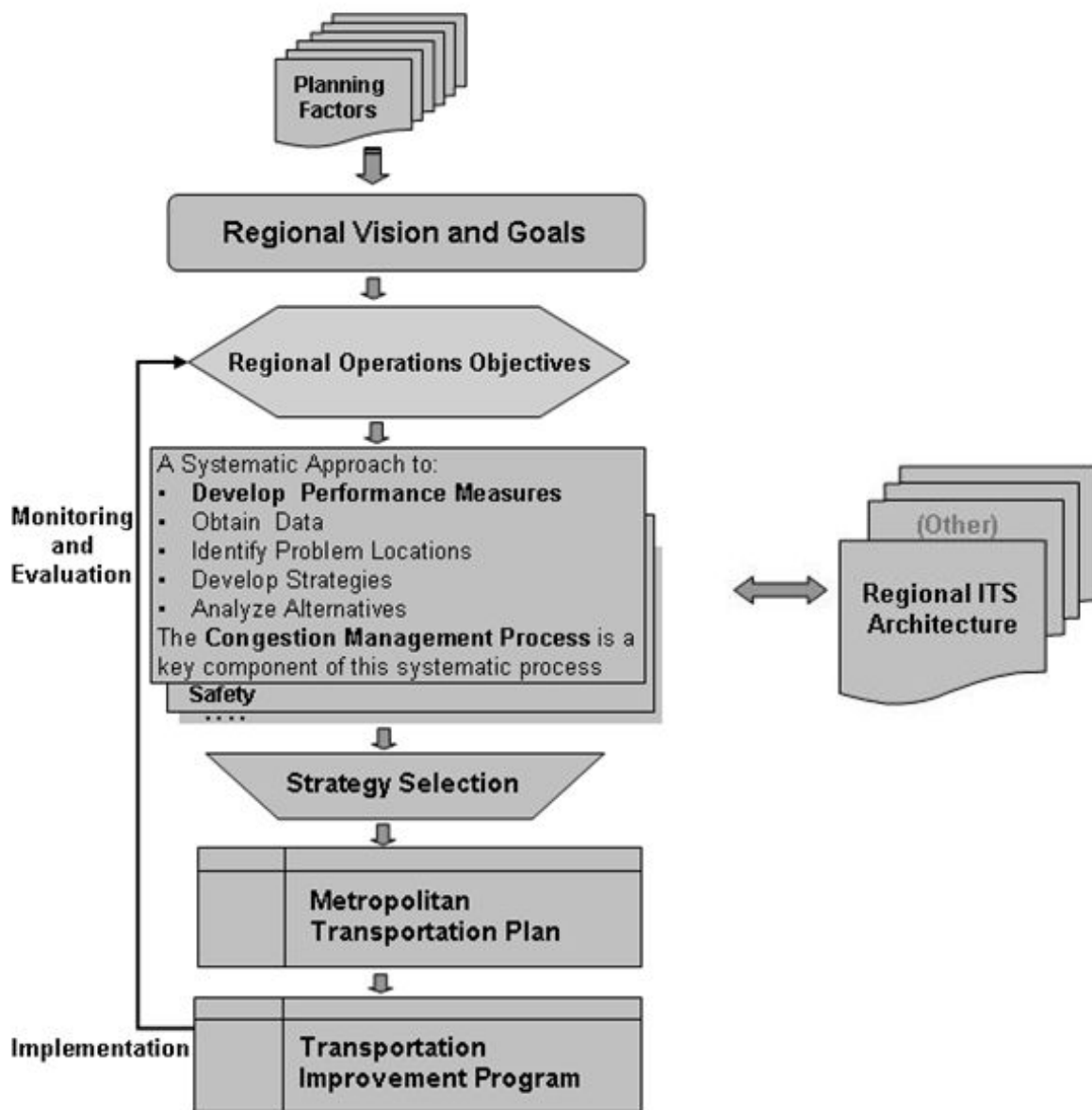
The MPOs have access to a wealth of data. For instance, as stated, all MPOs are required to create long range transportation plans, short-range TIPs, annual statements of planning priorities and activities and public participation plans (GAO, 2009, pg. 5). In order to create these programs, MPOs “consider...local travel forecasts...with the assistance of computerized travel-demand models” (GAO, 2009, pg. 8). However, an issue is that the “technical capacity of MPOs to develop travel demand forecasts—a crucial component of the long-range plans—also varies” (GAO, 2009, pg. 12). While a GAO report from 2009 found that almost 50% of MPOs use their own models, about 50% (especially the small MPOs) rely on outside consultants or their state DoT. Adding to the complexity, MPOs are allowed to “choose their own transportation models without being subject to minimum standards or guidelines” (GAO, 2009, pg. 12).

Changes as a Result of the Final Rule on Statewide and Nonmetropolitan Transportation Planning and Metropolitan Planning

However, since 2012, with the passage of the Moving Ahead for Progress in the 21st Century Act (MAP-21) and continued with the Fixing America’s Surface Transportation (FAST) Act, the federal government has started to mandate performance-based requirements. Performance-based

approach (PBPP) to planning is a “strategic approach that uses performance data to inform decisions in order to help achieve desired performance outcomes” (FTA-APTA PBPP, 2017, pg. 4). The FHWA and FTA have been issuing rules on the goals, and in May 2016, they issued the final rule. The federal government’s goal, among others, with performance-based requirements is to improve MPO and transportation projects, and provide “greater transparency and accountability” (FTA,-APTA PBPP 2017, pg. 4). PBPP “ties the funding of projects and programs to improving measured performance and achieving targets set for future performance” (MWCOG, 2017a).

Figure 7: Performance-Based MPO Planning Framework



Source: FHWA Operations, 2017

The mandated performance-based plans include the “Congestion Mitigation and Air Quality Improvement (CMAQ) Program” (which is under the CAA)...and “highway and transit asset management,” among others. Most importantly, the “Final Rule requires MPOs...to integrate their goals, objectives, performance measures and targets ...into their planning process” (FTA-APTA PBPP, 2017, pg. 5). By May 2018, each MPO needs to work with their highway department and their public service transportation agencies to have a coordination process for the “collection of performance data, performance targets for the metropolitan area, reporting of metropolitan area targets and reporting of actual system performance” (MWCOG, 2017b). Part of the goal of this new rule is to help the government “more reliably access the impacts of federal funding investments” (Final Rule, FTA, 2016).

One can think of the federal performance requirements going into three buckets: safety, maintenance and performance (MWCOG, Feb 2017b). The performance side looks at “highway congestion and reliability, freight movement and economic vitality, and environmental sustainability, including air quality.” (MWCOG, Feb 2017b). MPOs must count “person-miles” rather than “vehicle miles,” and take more into account lower emission transit options that move citizens, as well as measure hours of peak-hour excessive delay and the percent of non-single occupancy vehicle travel.

Some MPOs already have implemented performance-based projects and plans. However, this new rule will help “create a set of common national goals for all states and metropolitan areas to work toward, achieve more consistency in the data nationwide, and to improve transparency by establishing a formal reporting system” (MWCOG, Feb 2017b).

Unfortunately, under current regulations, the federal government does not mandate that MPOs, or any other government agency, measure CO₂ transportation emissions. However, even under the current models the MPOs use, it is very easy for MPOs to include in their models CO₂ emissions. As one employee said, “Measuring carbon emissions from transportation “is not very far outside the normal MPO mandate...you can do a lot of things on the back on the envelope and that will get you close to the right answer” (Beer, 2016). This point will be explored in more depth in my recommendation section.

CHAPTER 4: DISCUSSION AND REVIEW

Where does Philadelphia's Baseline Fall between the five 2030 Districts?

Based on my calculations and the data provided by SEPTA, the DVRPC and CTPP pulled data, the 2030 District of Philadelphia's transportation GHG emissions fall between Cleveland and Pittsburgh.

I estimate that Philadelphia has 9.4 kg CO₂ per commuter per day. Cleveland's baseline is around 11.6 kg CO₂ per commuter per day, and Pittsburgh is 7.2 kg CO₂ per commuter per day.

The order of emissions from lowest to highest in kilograms of CO₂ per commuter per day is as follows:

Table 10: City CO₂ Baseline Transportation Rankings (Lowest to Highest)

Ranking	City	Kilograms CO ₂ per commuter per day
1	San Francisco	2.9
2	Seattle	3.6
3	Denver	6
4	Pittsburgh	7.2
5	Philadelphia	9.4
6	Cleveland	11.6

Comparison of Baselines

First, it is difficult to accurately compare the five baselines. Each District approached the measurement of its baseline from a different methodological perspective, as highlighted in the methodology section. Some communicated directly with tenants, others through the building managers and owners. Others used the data another non-profit had already collected, while others pulled data from their MPO. Some used MOVES data, while others used their own emission factors. In the case of Cleveland, the baseline is an average of transportation emissions in the U.S.

Yet, some comparisons and conclusions can be drawn from the data. First, one sees that the West Coast 2030 Districts that have measured their transportation emissions have lower transportation emissions as compared to the east coast cities. I postulate that this is due to several factors, which range from geography, to city and state policy that has encouraged public transit, as well as a cleaner energy grid.

Geography

San Francisco and Seattle are constrained by their geography, which has historically limited sprawl. San Francisco is a peninsula, and Seattle is located on an isthmus between Puget Sound

on the west and on its east, Lake Washington. Denver, also called the “Mile High City,” has the Rocky Mountains in the west and the Great Plains in the east. Although Cleveland borders Lake Erie, its population has been shrinking, while city policies have encouraged sprawl. Both Pittsburgh and Philadelphia have no geography to discourage sprawl and have only recently started to focus on the role of transportation in their GHG reduction goals.

City and State Policy

An important component of the difference in emissions, beyond geography, are policies the city and state government have put into place regarding transportation and the energy grid. San Francisco is in California, a very progressive state regarding energy and transportation policy. California has stricter CAFE standards, a cleaner grid, and is promoting the transition to EVs. Washington state also has a cleaner grid, and Seattle has, since the 1970’s, been working to improve their public transportation system. Most recently, Seattle passed a \$50 billion rail expansion, and added additional bus and bike infrastructure (Sisson, 2017). Denver has been pursuing public-private partnerships to build commuter rail, and later this year, additional stations will be opening (Sisson, 2017).

Pittsburgh, Philadelphia and Cleveland have historically struggled with sprawl and dirtier grids, a result of the energy resources historically available and policy choices these cities have pursued. However, this too seems to be changing. Pittsburgh in 2016 announced they would be launching a new mobility and infrastructure department in 2017 (Caruso, 2016).

Philadelphia has been working to promote more sustainable transportation options as well, and in 2015, Philadelphia began an Indego bikeshare system. As my data is from 2006-2010, it will be fascinating to see if emissions have shifted as a result.

Cleveland unfortunately continues to struggle, and a recent editorial highlighted that the state government continues to underfund mass transit. State funding from Ohio’s General Revenue Fund has decreased from 2002 to today by \$39.1 million dollars (Editorial Board, 2017).

Baseline and Standardization

From my research, and as highlighted earlier in this MP, there is a severe lack of standardization when comparing transportation emissions between cities. Methodologies varied according to location, data availability and expertise of the local actor collecting the data. This makes District to District comparisons difficult, as Johnstone also found in her MP (Johnstone, 2017). In addition, as more Districts seek to measure their emissions, it is even more important that there is some form of standardization. Otherwise, not only will comparisons between Districts be inaccurate, but it will be difficult to judge which policies cities and Districts should pursue.

The methodology I use to establish the 2030 Philadelphia baseline is a methodology that should and can be replicated by Districts moving forward. First, the Excel workbook calculator is easy and inexpensive to use. As 2030 Districts and cities are under-resourced, the methodology I developed allows any user with Excel and a connection to their MPO the ability to calculate an emissions baseline. Most importantly, its inputs are easy to change and are customizable to the location. Each city can easily input their average occupancy rates on public transit and their

emissions per passenger mile, in connection with data from the CTPP and the MPO. As MPOs are already required to collect transportation pollutant data because of the CAA, this information is available and only needs to be pulled. Even if a city does not collect occupancy rates, national averages can be used, and MOVES data would allow a District to calculate emission factors.

Limitations

Despite this, the baseline has limitations, as highlighted in the methodology section. First, the calculations will only be as good as the data used. If the emission factors are incorrect, or if the data is unduly old, then the baseline will not accurately reflect the transportation habits of its commuters. In addition, the CTPP is based off the ACS, which means that multi-modality is lost, along with only one work location being measured. Finally, the spreadsheet matrix measuring distance is measured in highway distance, which means it reflects auto travel, rather than transit. In addition, the spreadsheet matrix is from 2015, while most of the other data is from 2010. However, as there have been no major infrastructure projects in the ensuring time period, this should not fundamentally alter the calculations.

In addition, ferry travel is ignored, as only .02% of commuters (or 50 people) use it to get to work. If ferry use should increase significantly in the future, this method will allow the user to incorporate this travel in the baseline. Carpool data is also averaged out for the PMT per mode. For the carpool section of “5 or 6,” I divided by 5.5 and for “7 or more,” I divided by 7, as it is doubtful there are many more than 7 in a carpool.

I used VMT and 2017 data for motorcycles, as this was the data that Legrendre from the DVRPC recommended. As justification, motorcycles only have one passenger. According to Legrendre from DVRPC, any differences in emission factors between 2010 and 2017 could be within the margin of error and/or due to methodological changes between MOVES 2010b and MOVES 2014a (Legrendre, 4/2/2018).

Finally, as mentioned in the introduction, an important point to remember with this calculated baseline is that the data includes buildings that are not in the District, and that the majority of it is from 2010. The data used will be updated in 2018/2019, and the District will be able to easily update it once it is available.

All of these assumptions can limit the accuracy of my results, but still provide a robust baseline that will enable the District to have a basis off of which to measure emissions moving forward.

Importance of a Survey in Moving Forward

As a result, the baseline calculator is an important first step, but is only a first step. A survey methodology will enable Districts to see the current travel habits of their 2030 District commuters, as well as the nuances of multi-modality travel that is not available through the CTPP data. In addition, survey questions will also allow the District to understand some of the rationale behind transit choices, as well as options commuters have, such as if employers offer transit passes, tax free transit options or flexplace work options.

If the District forms a close relationship with their MPO and other city actors, such as in the case of Pittsburgh, this can help with survey distribution. This is also, however, where a District should only do a survey when it knows it has the ability and manpower to pursue this option. A survey is useful, for all the reasons listed above. However, if a District does not have strong relationships, then it will struggle with response rates. This crucially includes strong relationships with the building manager or owner (the heart of a District regardless). This is because it is the building manager or owner that will communicate with the tenants, and will distribute the surveys to the companies in the building. In addition, strong relationships will ensure that the District is aware if there are firewalls blocking survey distribution (as in the case of certain law or tech firms) as well as other surveys being distributed, that could decrease the response rate due to survey fatigue.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

Recommendations in General for 2030 Districts

The MPO as a Data Source

Many Districts already have existing partnerships, but due to a variety of factors, have not realized that their MPO can solve many of their data challenges. In addition, although MPOs are not federally mandated to measure CO2 emissions, with the data MPOs are already required to collect, it is easy for MPOs to calculate this information. Setting up a strong relationship with the local MPO is one of the most important keys to developing an accurate and strong baseline as well as aiding with the survey rollout.

Finally, as I learned through my literature review, MPOs are also aware of the importance of branching out to meet other stakeholders involved in transportation, and many are eager to help and be involved.

The Importance of Strong Relationships and Partnerships

This relates to the effectiveness of a 2030 District, ranging from data collection, survey distribution and achieving the 2030 long-term goals of GHG reductions. Buy-in from stakeholders (ranging from the building owners and managers, to understanding what drives the tenants), to the various local non-profits, business and governmental organizations that work on transportation will be essential for being effective in this space.

In addition, seeking out new relationships is critical to fulfilling 2030 goals. Seattle and Denver had existing relationships with non-profits, thus that is where their data came from. However, better data is available through their MPO. Branching out, as well as utilizing existing relationships, will be crucial for 2030 District effectiveness.

Including these actors in the discussions early on ensures their perspectives are heard, are taken into account, helps with buy-in, and avoids redundancy of effort.

Standardization of Communication and Survey Methodology

Some Districts communicate with the tenants, others with the managers and owners. Some surveys, as they have been conducted by outside organizations, include a minority of 2030 buildings. In addition, each survey has asked slightly different questions. This has made comparisons difficult. Standardizing survey methodology and communication with the managers/tenants will allow Districts to better understand how their initiatives and work can be compared across cities.

In addition, as more Districts seek to measure their emissions, it is even more important that there is some form of standardization. Otherwise, not only will comparisons between Districts be inaccurate, but it will be difficult to judge which policies cities and Districts should pursue.

Need for Centralization of 2030 District Strategy and Goals

The 2030 District partnership provides a forum for cities to learn from each other as they try to decrease GHG emissions. However, the 2030 model is extremely decentralized. As a result, for me to find Districts' Annual Reports, GHG data and methodology involved a combination of outreach, research, and follow up. As a goal of the 2030 Districts is to be a resource for each other, a centralized repository for this information should be considered moving forward.

In addition, 2030 Architecture should standardize which data 2030 Districts should publicize (such as square footage, number of buildings in a District, if the CO2 emission reductions are district-wide or only include participating buildings, or if a District's means of calculating emissions have changed). I would suggest this is included in Districts' Annual Reports, as well as in one document available to all Districts, as these details are important for understanding the work of a District.

Finally, the 2030 District lacks a full time Executive Director. As the number of Districts grow, having a dedicated department and staff members responsible for the above information will become more and more important. This ensures unnecessary duplication is avoided, best-practices are shared, and baselining and surveying efforts are standardized.

Establishing a Strategic Plan: Focus on Adding New Buildings and/or Decreasing Emissions

2030 Districts have two important, but diametrically opposed goals. The districts have an impetus to add more member buildings to their District. However, at the same time, they have a goal to decrease emissions 50% by 2030. If the new buildings signing on have high emissions, that will make achieving this goal more difficult. 2030 Architecture (and its members) must decide how to address this moving forward, whether by loosening the standards as new members join, or focusing on the original members and the original goal. Regardless, clarifying the strategic plan will be important to ensuring 2030 Districts have an achievable goal as they move forward. This will also ensure they know where they should direct the majority of their focus, whether that be outreach or best-practice sharing.

Recommendations for the Philadelphia Specifically

Although the above all relate to Philadelphia, below are some recommendations tailored specifically to the 2030 Philadelphia District, after conversations with my client and other stakeholders.

Continuing Partner and Stakeholder Outreach

Philadelphia 2030 is already doing this through its transportation committee and outreach efforts to other governmental, business and non-profit organizations. Continuing to build relationships and devising a strategy about which ones to focus on as it determines its transportation survey distribution will be crucial to the District's success.

Ambassadorial Roles for Committee Members

Committee group members are excited to help with the work of the 2030 District. However, technical work (such as establishing a baseline or developing a survey) is difficult for them to do effectively, as they are involved on a volunteer basis. Utilizing their skillset as one as an advisee,

enables them to be involved, take advantage of their knowledge and expertise, and allows the dedicated staff member to do a deep dive into the technical.

In addition, as these are leaders and experts in their field, they can also help publicize and advance the work of the District, helping raise awareness and get buy in from other possible stakeholders and partners. Developing roles and materials for them will help advance the 2030 District moving forward.

Folding the Survey into Other Data Tracking Efforts

DVRPC does roughly every decade a household tracking survey. As Philadelphia 2030 decides how to release its survey, thinking about how to do it in connection with the MPO will be important to getting a robust response and data points.

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APPENDIX

APPENDIX 1: INDEX OF TERMS

Term	Full Term	Description
ACS	American Community Survey	Detailed survey data collected by the US Census Bureau
CAA	Clean Air Act	The CAA mandates controls on air pollution by regulating fuels and pollutants
Census Block		The smallest geographical unit as established by the US Census Bureau
Census Tract	""	An area about the size of a neighborhood, as decided upon by the Census Bureau
CMAQ Program	Congestion Mitigation and Air Quality Program	The CMAQ program supports surface transportation projects (among others) that improve air quality and decrease traffic
CTPP	Census Transportation Planning Products	ACS data specifically tabulated for transportation planning
DDP	Denver Downtown Partnership	Non-profit business organization that collects transportation data in downtown Denver
DoT	Department of Transportation	State level transportation agency
DVRPC	Delaware Valley Regional Planning Commission	DVRPC is the MPO for the greater Philadelphia area

FHWA	Federal Highway Administration	
FTA	Federal Transit Administration	
GBA	Green Building Alliance	A chapter of the USGBC based in Western Pennsylvania
GHG	Greenhouse Gas	
HTS	Household Travel Survey	DVRPC's Travel Survey
LEED	Leadership in Energy and Environmental Design	National green building standards and certification program
LEHD	Longitudinal Employer-Household Dynamics	Data collected by the Census Bureau used to research workforce dynamics
LODES	LEHD Origin-Destination Employment Statistics	Data product from LEHD to research workforce dynamics
MMTC	Make My Trip Count	2030 District of Pittsburgh 2015 Survey
Mode Split	""	The division of trips according to the travel mode
MOVES	Motor Vehicle Emission Simulator	An EPA-developed transportation emissions modeling system

MPO	Metropolitan Planning Organization	MPOs are “a transportation policy-making body made up of representatives from local government and transportation agencies” (Houk, n.d., pg. 2).
NHTS	National Household Travel Survey	A periodically disbursed, nationally representative FHWA survey that analyzes mobility trends of the US
NOACA	Northeast Ohio Areawide Coordinating Agency	Local MPO in Cleveland region
NAAQS	National Ambient Air Quality Standards	The CAA requires specific pollutants that decrease air quality to be monitored through the NAAQS standards.
OTM	On the Map	Data collected by the US Census Bureau that is displayed visually (specifically based off the LEHD LODES data)
PBPP	Performance Based Planning and Programming	A “strategic approach that uses performance data to inform decisions in order to help achieve desired performance outcomes” (FTA-APTA PBPP, 2017).
PMT	Person miles traveled	The number of miles traveled by an individual

SEPTA	Southeastern Pennsylvania Transportation Authority	A regional public transportation authority that operates bus, subway, commuter and light rail systems, among other transit lines in the greater Philadelphia area
SFCTA	San Francisco County Transportation Authority	Local SF MPO
SIP	State Implementation Plan	A SIP is both “a general plan to attain and maintain the NAAQS.... and a specific plan to attain the standards for each area designated nonattainment for a NAAQS” (EPA, 2016b).
SPC	Southwestern Pennsylvania Commission	The local MPO for the Pittsburgh area
STIP	State Transportation Improvement Program	A state-wide transportation improvement plan mandated by the federal government
TAZ	Traffic analysis zone	Land is divided into units based on the number of people in a zone

TCM	Transportation Control Measures	“Specific programs (within the SIP) designed to reduce emissions from transportation sources by reducing vehicle use or changing traffic flow or congestion conditions” (FHA, 2017).
TIP	Transportation Improvement Plan	TIP (which is what an MPO develops), is a capital improvement program that “lists all regionally significant and federally-funded transportation projects and services in the MPO planning area” (Nashville MPO, 2018).
VMT	vehicle miles traveled	The number of miles traveled by a vehicle
US(GBC)	United States Green Buildings Council	"Private, member-based non-profit promoting sustainability in building design, construction and operation" (Johnstone, 2017, pg. 3).
xwalk file	schema crosswalk	A table that shows equivalent elements across various databases

APPENDIX 2: TRANSPORTATION EXCEL WORKBOOK

For the Excel File, please email Sarah Reinheimer at sreinheimer@gmail.com

APPENDIX 3: DISTRICT 2030 TRANSPORTATION SURVEYS AND ANNUAL REPORTS

Please email Sarah Reinheimer at sreinheimer@gmail.com if you would like to review one of these primary sources. The vast majority of these documents are also available online.