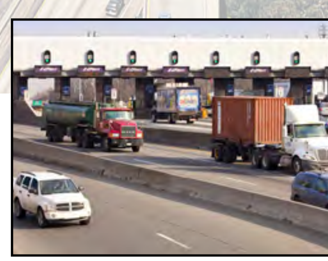
Applying TEAM in Regional Sketch Planning:

Four Case Studies in:

PUGET SOUND, WASHINGTON
CHAMPAIGN, ILLINOIS
LAKE CHARLES, LOUISIANA
STATE OF CONNECTICUT



United States Environmental Protection Agency

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Transportation and Climate Division
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- Champaign-Urbana Urban Area Transportation Study
- Imperial Calcasieu Regional Planning and Development Commission
- Northeast States for Coordinated Air Use Management
- Puget Sound Clean Air Agency

ICF International provided technical support to the U.S. Environmental Protection Agency in the development of the methodologies and analysis employed to develop the emission inventories and other tasks related to this assessment.

Acronyms and Abbreviations

BAU	business as usual
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CTDEEP	Connecticut Department of Energy and Environmental Protection
CTDOT	Connecticut Department of Transportation
CTR	Commute Trip Reduction
CUUATS	Champaign Urbana Urbanized Area Transportation Study
EPA	U.S. Environmental Protection Agency
GHG	greenhouse gas
IMCAL	Imperial Calcasieu Regional Planning and Development Commission
LCMPO	Lake Charles Metropolitan Planning Organization
LRTP	Long Range Transportation Plan
MOVES	Motor Vehicle Emission Simulator (EPA's motor vehicle emissions model)
MPO	Metropolitan Planning Organization
NESCAUM	Northeast States for Coordinated Air Use Management
NOx	nitrogen oxides
PM	particulate matter
PSCAA	Puget Sound Clean Air Agency
PSRC	Puget Sound Regional Council
TAZ	traffic analysis zone
TDM	Transportation Demand Management
TEAM	Travel Efficiency Assessment Method
TE	travel efficiency
TRIMMS	Trip Reduction Impacts of Mobility Management Strategies
VMT	vehicle miles traveled
VOC	volatile organic compound

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Executive Summary

Despite significant improvements in vehicle technologies and fuels, the transportation sector continues to be one of the largest sources of criteria pollutants and GHG emissions in the country.[1] While emissions per mile traveled have decreased, growth in travel activity has partially offset those gains, and presents a challenge to achieving and maintaining healthy air quality in many areas. For air quality and transportation planners that are interested in reducing transportation emissions in their regions, the ability to estimate the emission reduction potential of a given strategy aimed at reducing travel activity is critical to long range planning and programmatic investment. Over the past several years, the U.S. Environmental Protection Agency (EPA) has supported air quality and transportation planning activities by developing methods to quantify the potential emission reductions from travel efficiency strategies, and has worked with various state and local agencies to apply these methods in a series of case studies.

The term “travel efficiency” (TE) strategies refers to a broad range of strategies designed to reduce travel activity, especially single-occupancy travel. TE strategies build on the traditional Transportation Control Measures (TCMs), such as employer-based transportation management programs and transit improvements, listed in Section 108(f)(1)(A) of the Clean Air Act by adding smart growth and related land use strategies, road and parking pricing, and other strategies aimed at reducing mobile source emissions by reducing vehicle travel activity.

EPA has developed the Travel Efficiency Assessment Method (TEAM), an approach to quantify the potential emission benefits of travel efficiency strategies. TEAM uses available travel data and a transportation sketch model analysis to quantify the change in VMT resulting from TE strategies. In a TEAM analysis, a future analysis year is chosen. VMT and emissions are estimated in the future “Business as Usual” (BAU) case that does not include the TE strategies. Then VMT and emissions estimated in future TE strategy scenarios are compared against the BAU case. Emission factors are developed using the current version of EPA’s MOVES (Motor Vehicle Emission Simulator). TEAM allows for the analysis of potential travel efficiency strategies to reduce emissions without having to run an area’s travel demand model, saving time and resources.

The case studies in this report are EPA’s latest in this field of study. With this latest round of case studies, EPA has worked with ten areas to assess the impact of travel efficiency strategies using the TEAM approach. In 2010, EPA conducted a national scale TEAM assessment of potential emission reductions that could be achieved if travel efficiency strategies were adopted in all the urban areas of the country.[2] EPA furthered this work in 2014 through a series of case studies featuring Tucson, AZ, Kansas City, MO-KS, and Boston, MA.[3] In 2016, EPA completed a second round of case studies, highlighting St. Louis, MO-IL, Atlanta, GA, and Orlando, FL, which further refined TEAM to include two

[1] EPA, *Our Nation’s Air: Status and Trends Through 2016,* available at https://www.epa.gov/air-trends. This interactive report includes a table showing the contribution of various source sectors to air pollution at: https://gispub.epa.gov/air/trendsreport/2017/#sources.
[2] EPA, Potential Changes in Emissions Due to Improvements in Travel Efficiency, EPA-420-R-11-003, March 2011, available on the web at: https://nepis.epa.gov/Exe/ZyPdf.cgi/P100AGMT.pdf?Dockey=P100AGMT.pdf
[3] EPA, Estimating Emission Reductions from Travel Efficiency Strategies: Three Sketch Modeling Case Studies, EPA-420-R014-003a, June 2014, available on the web at: https://nepis.epa.gov/Exe/ZyPDF.cgi/P100JWK8.PDF?Dockey=P100JWK8.PDF.

alternative approaches for estimating effects of land use strategies, and began accounting for additional VMT and transit emissions when calculating the overall emission reductions.[4]

As with the previous case studies, for this latest round, EPA solicited letters of interest from agencies interested in applying TEAM in their local context and evaluating their selected strategies. Four agencies were selected from the submitted letters:

- Champaign-Urbana Urban Area Transportation Study (CUUATS), the MPO for the Champaign-Urbana area in Illinois;
- Imperial Calcasieu Regional Planning and Development Commission (IMCAL), the MPO for the Lake Charles area in Louisiana;
- Northeast States for Coordinated Air Use Management (NESCAUM), an association of air quality agencies in eight Northeast states: CT, ME, MA, NH, RI, VT, NJ, and NY; and
- Puget Sound Clean Air Agency (PSCAA), which covers the Seattle, Washington region.

Figure ES-1 shows the locations of the case studies completed to date, including those discussed in this report.

Figure ES-1 TEAM Case Study Sites

In addition to the two MPO participants, this round of TEAM case studies involved agencies that are specifically responsible for air quality decision making rather than transportation planning. NESCAUM's purpose is to provide scientific, technical, analytical, and policy support to the air quality programs of

[4] EPA, Applying TEAM in Regional Sketch Planning: Three Case Studies in Atlanta, Orlando, St. Louis, EPA-420-R-16-009, July 2016, available on the web at: https://www.epa.gov/state-and-local-transportation/applying-team-regional-sketch-planning-three-case-studies-atlanta.

the states it represents. NESCAUM, in coordination with Connecticut Department of Transportation (CTDOT) and Connecticut Department of Energy and Environmental Protection (CTDEEP), used Connecticut as the basis for this analysis, with an interest in applying to other states in the consortium in the future. Puget Sound represents the first TEAM partnership with a local agency responsible for air quality planning. Participants also vary considerably in the complexity of their travel demand models and resources available. Some areas had all the data necessary to conduct an analysis, while others needed to seek data from other sources.

In this round of case studies, the analysis year used was 2040. In each case study, four different scenarios of travel efficiency strategies were compared to the BAU case. For these scenarios, the partner agencies chose the combination of travel efficiency strategies of most interest to them. The results of each case study are included in Sections 2 through 5 in this report.

Analysis

This report is specific to the analysis task of the study, and covers data collection, VMT analysis, and emissions analysis. Each case study is reported independently with a focus on the technical attributes of the analysis and the lessons learned.

Analysis Tools

This round of TEAM case studies used the Trip Reduction Impacts of Mobility Management Strategies (TRIMMS) sketch model developed by the Center for Urban Transportation Research (CUTR) at the University of South Florida as part of the TEAM approach.[5] TRIMMS offers a variety of features making it suitable for this type of analysis. However, the land use component of TRIMMS was not employed in this study as described later in this document. The regional analysis was conducted with TRIMMS 3.0, the latest version of this sketch model available at the time the case studies were undertaken.

MOVES2014a was used to determine appropriate, regional average emission rates for all regions. MOVES was run in Inventory mode based on regionally provided inputs to produce activity-weighted average emission rates for the four primary pollutants considered in this analysis: CO_2-Equivalent (CO_2e), NOx, $PM_{2.5}$, and VOC.

Land Use Analysis

Land use strategies are one of the most important, and most complex, means by which regions can reduce VMT. Land use patterns affect how people travel, and therefore an area's geographic size and density have an impact on emissions. Areas that are more compact will have shorter average trip lengths and fewer vehicle trips. Supportive land use policies can provide for the commercial and residential densities to enable transit to be viable and cost effective. Land use strategies in these case studies were analyzed using the Multivariate Approach developed in previous TEAM case studies.

[5] The TRIMMS model can be found at http://trimms.com/.

Selected Strategies

The selection of travel efficiency strategies makes the TEAM analysis unique to that region by representing what is important to understand about how a strategy works and what can be defined by regionally applicable data. The combination of strategies in this report represents a broad range of strategies, and application to specific geographies and populations, including the statewide level. The agencies, in consultation with EPA, chose the strategies they were interested in. The agencies explored available data to support their strategy selection, and in the case of land use strategies, conducted additional analysis to provide required data. Table ES-1 provides an overview of the selected strategies and their individual geographical and population application.

Table ES-1. Summary of Travel Efficiency Strategies Selected

Case Study Area	Strategies	Geographic Area Covered	Applied to
Champaign-Urbana, Illinois	Restructure transit network to reduce wait times and travel times. Expand bicycle lanes and sidewalk coverage.	Urbanized area	161,000 residents of urbanized area
	Increase the cost that University employees pay for parking	University of Illinois	24,300 employees
	Increase densities, land use mixing, and job accessibility	Champaign County	246,000 county residents
	Upgrade existing rail corridor to Chicago to high speed rail	Champaign-Chicago corridor	775,000 daily riders
Lake Charles, Louisiana	TDM program for petrochemical employees	Petrochemical employment cluster	7,500 employees
	Transit improvement in North Lake Charles	North Lake Charles residential neighborhood	13,500 residents
	Parking pricing in downtown area	Downtown Lake Charles	13,000 daily travelers
	Smart growth land use	MPO area	260,000 residents
State of Connecticut	Commuter rail improvements	New York-New Haven corridor	1.35 million residents
	Local bus improvements	New York-New Haven corridor	1.35 million residents
	Smart growth land use	New York-New Haven corridor	1.35 million residents
	VMT pricing	State of CT	4.01 million residents
Puget Sound, Washington	Expand Commute Trip Reduction (CTR) Program	Puget Sound region	156,000 additional employees
	Expand access to free transit within EJ/low-income populations	Puget Sound region	169,000 EJ/low-income residents
	VMT pricing	Puget Sound region	4.85 million residents
	Smart growth land use	Puget Sound region	4.85 million residents

Results

Table ES-2 shows the percent VMT and emission reductions for the scenarios analyzed for each area. The values represent the percent change from the BAU 2040 future case, and are cumulative (i.e., Scenario 2 results include the impacts of both Scenario 1 and 2, Scenario 3 includes the impacts of Scenarios 1, 2, 3, etc.).

The range of estimated regional VMT and emission changes resulting from the various scenarios analyzed reflect the variety of strategies and strength of implementation envisioned by the partner agencies. As expected, the greatest reductions result from scenarios that represent a combination of strategies that are mutually supportive and apply to a significant portion of the regional population. Where strategies affect only a small subset of the regional population or only apply in a designated subarea of the region, the impacts are limited.

It is important to note that the percent change in VMT and emissions shown in Table ES-2 are relative to the future year BAU case. If a strong program of travel efficiency strategies is already included in the LRTP for the region, the incremental addition or strengthening of strategies will result in modest changes compared to the BAU. Where a scenario represents an aggressive departure from the BAU and is applied broadly across the region, the reductions can be significant.

Table ES-2. Percent Regional VMT and Emissions Changes

Percent Regional Emissions Changes for Future Year Business as Usual compared to Future Year Scenario					
Scenario	**Light-Duty VMT**	**CO_2e**	**$PM_{2.5}$**	**NOx**	**VOC**
Champaign Urbana Urban Area Transportation Study					
Scenario 1: Local Transit Hubs and Bus Improvements + Bicycle and Pedestrian Improvements	−2.96%	−3.39%	−4.35%	−5.59%	−7.48%
Scenario 2: Scenario 1 + Parking Pricing at the University	−3.23%	−3.66%	−4.63%	−5.87%	−7.77%
Scenario 3: Scenario 2 + Smart Growth Land Use	−7.87%	−8.18%	−8.86%	−9.74%	−11.09%
Scenario 4: Scenario 3 + High Speed Rail	−8.09%	−8.38%	−9.04%	−9.88%	−11.16%
Imperial Calcasieu Regional Planning and Development Commission					
Scenario 1: TDM Program for Petrochemical Employees	−0.07%	−0.07%	−0.07%	−0.07%	−0.07%
Scenario 2: Scenario 1 + Transit Improvement in North Lake Charles	−0.10%	−0.10%	−0.10%	−0.10%	−0.10%
Scenario 3: Scenario 2 + Parking Pricing in Downtown Lake Charles	−0.24%	−0.24%	−0.24%	−0.23%	−0.22%
Scenario 4: Scenario 3 + Smart Growth Land Use	−1.05%	−1.04%	−1.04%	−1.01%	−0.97%

Percent Regional Emissions Changes for Future Year Business as Usual compared to Future Year Scenario					
Scenario	**Light-Duty VMT**	**CO_2e**	**$PM_{2.5}$**	**NOx**	**VOC**
Northeast States for Coordinated Air Use Management					
Scenario 1: Commuter Rail Improvements	−0.40%	−0.40%	−0.40%	−0.41%	−0.42%
Scenario 2: Scenario 1 + Local Bus Improvements	−0.95%	−0.95%	−0.95%	−0.98%	−1.00%
Scenario 3: Scenario 2 + Smart Growth Land Use	−1.18%	−1.18%	−1.17%	−1.16%	−1.14%
Scenario 4: Scenario 3 + VMT Pricing	−5.42%	−5.44%	−5.45%	−5.54%	−5.64%
Puget Sound Clean Air Agency					
Scenario 1: Expand Commute Trip Reduction Program	−0.09%	−0.10%	−0.10%	−0.10%	−0.10%
Scenario 2: Scenario 1 + Expand access to free transit within EJ/low-income populations	−1.87%	−1.89%	−1.91%	−2.00%	−2.17%
Scenario 3: Scenario 2 + VMT Pricing	−5.11%	−5.16%	−5.21%	−5.44%	−5.86%
Scenario 4: Scenario 3 + Smart growth land use	−11.91%	−11.82%	−11.71%	−11.28%	−10.49%

With this third round of case studies that are described in this report, EPA has worked with ten areas to assess the impact of travel efficiency strategies using the TEAM approach. Throughout the rounds of case studies, TEAM has proved to be accessible to a wide variety of organizations with varying degrees of topical and technical expertise. TEAM is also unique in its flexibility to explore an array of different travel efficiency strategies. For example, TEAM has been used to explore hypothetical "what-if" exercises, evaluate program-level decisions, and been tested on numerous new strategy applications, and has produced useful results in each case. TEAM has also proven to be scalable, as it has been used successfully to evaluate the VMT and emission reduction benefits of strategies applied to a specific corridor, city or county, or entire state. EPA believes that these case studies provide a valuable resource to encourage agencies not only to conduct these analyses, but ultimately, to adopt effective travel efficiency strategies to improve local air quality and reduce emissions.

1. Background on Travel Efficiency Assessment Methodology Analysis

1.1. Introduction

Over the past several years, the U.S. Environmental Protection Agency (EPA) has supported research on the potential to lower emissions by reducing single-occupancy vehicle travel and, correspondingly, vehicle miles traveled (VMT). This research led to an approach that used regional data to quantify the potential emission reductions from several travel efficiency strategies. Travel efficiency strategies represent the broad range of strategies designed to reduce travel activity, especially travel that involved one individual per vehicle (i.e., single-occupancy travel). The term "travel efficiency strategies" builds on the traditional Transportation Control Measures (TCMs) listed in Clean Air Act section 108(f)(1)(A) such as employer-based transportation management programs and transit improvements, by adding smart growth and related land use strategies, road and parking pricing, and other strategies aimed at reducing mobile source emissions by reducing vehicle travel activity.

EPA has developed an approach to quantify the potential emission benefits of travel efficiency strategies and this approach is the Travel Efficiency Assessment Method (TEAM). TEAM uses available travel data and a transportation sketch model analysis to quantify the change in VMT resulting from the strategies. In a TEAM analysis, a future analysis year is chosen, and the VMT in the future analysis year assuming the travel efficiency strategy in place is compared to the VMT in same future year without it. In a TEAM analysis, the future year without any additional travel efficiency strategies is known as the "Business as Usual" (BAU) case. The difference in VMT and number of trips that results from each strategy compared to the BAU are then combined with emission factors for the chosen analysis year from the current version of EPA's MOVES (Motor Vehicle Emission Simulator) model to calculate reasonably expected emission reductions. The TEAM approach allows for the analysis of potential travel efficiency strategies to reduce emissions without having to run an area's travel demand model, saving time and resources.

The case studies in this report are EPA's latest in this field of study. In 2010, EPA conducted a national scale TEAM assessment of potential emission reductions that could be achieved if travel efficiency strategies were adopted in all the urban areas of the country.[6] EPA furthered this work in 2014 through a series of case studies featuring Tucson, AZ, Kansas City, MO-KS, and Boston, MA.[7] In 2016, EPA completed a second round of case studies, highlighting St. Louis, MO-IL, Atlanta, GA, and Orlando, FL, which further refined TEAM to include two alternative approaches for estimating effects of land use strategies, and began accounting for additional VMT and transit emissions when calculating the overall emission reductions.[8]

[6] EPA, Potential Changes in Emissions Due to Improvements in Travel Efficiency, EPA-420-R-11-003, March 2011, available on the web at: https://nepis.epa.gov/Exe/ZyPdf.cgi/P100AGMT.pdf?Dockey=P100AGMT.pdf.
[7] EPA, Estimating Emission Reductions from Travel Efficiency Strategies: Three Sketch Modeling Case Studies, EPA-420-R014-003a, June 2014, available on the web at: https://nepis.epa.gov/Exe/ZyPDF.cgi/P100JWK8.PDF?Dockey=P100JWK8.PDF
[8] EPA, Applying TEAM in Regional Sketch Planning: Three Case Studies in Atlanta, Orlando, St. Louis, EPA-420-R-16-009, July 2016, available on the web at: https://www.epa.gov/state-and-local-transportation/applying-team-regional-sketch-planning-three-case-studies-atlanta.

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In this round of case studies, the analysis year used was 2040. In each case study, four different scenarios of travel efficiency strategies were compared to the BAU case. For these scenarios, the partner agencies chose the combination of travel efficiency strategies of most interest to them.

1.2. Analysis Tools

TEAM is based on a transportation sketch planning analysis which relies on spreadsheet tools and calculations to determine the potential VMT reductions of various strategies. Although there are many sketch planning models, they are often developed for specific uses with varying capabilities and data requirements. Individual transportation agencies may also develop their own unique models for this purpose.

The Trip Reduction Impacts of Mobility Management Strategies (TRIMMS) model, developed by the Center for Urban Transportation Research at the University of South Florida, has been used in the TEAM approach in identifying changes in VMT for several types of strategies.[9] TRIMMS is a sketch planning model that estimates mode shift, VMT, and trip reductions. The TRIMMS model offers a variety of features and because it is spreadsheet based, once inputs are determined it is easy to use, making it suitable for this type of analysis. The principal input factors for strategies in TRIMMS are changes in travel time and travel cost. TRIMMS 3.0 was used for most of the regional VMT analysis, similar to the previous TEAM case studies.

Several 'off-model' approaches for analyzing VMT have been developed to fill gaps in the capabilities of TRIMMS for specific strategies:

- Bicycle and pedestrian infrastructure investment
- Smart growth land use
- High-speed rail

[9] The TRIMMS model can be found at http://trimms.com/. The latest version of TRIMMS is version 4.0. These case studies used TRIMMS 3.0, the latest version available at the time the case studies were undertaken.

First, the approach for bicycle and pedestrian infrastructure applies elasticities drawn from the literature that explain the relationship between availability of infrastructure and bicycle and pedestrian mode share. Next, for land use, two approaches have been developed in previous TEAM case studies: the neighborhood approach and the multivariate approach. Both land use approaches derive from literature on the relationship between land use and VMT and can be used interchangeably. When land use strategies are selected, the case study area chooses a preferred approach based on the land use data and any previous, available scenario work. Lastly, high-speed rail was introduced for the first time in this group of TEAM case studies. The approach used was an off-model analysis based on expectations within the Champaign-Urbana region. For more detail on this strategy, refer to Section 3.

Emissions estimates are performed in TEAM through a separate analysis step using EPA's Motor Vehicle Emission Simulator (MOVES). MOVES is EPA's state-of-the-science emission modeling system that estimates emissions for mobile sources at the national, county, and project scales for criteria pollutants, GHGs, and air toxics under a wide range of user-defined conditions.[10] Four pollutants are considered in this TEAM analysis: CO_2 equivalent (CO_2e), NOx, $PM_{2.5}$, and VOC.

MOVES2014a, the version of EPA's mobile source emissions model at the time of this analysis, was used for all emissions analyses in this study. MOVES was run in Inventory mode based on the regionally provided inputs. In TEAM, the MOVES analysis is focused on generating activity-weighted, regional-average emission rates for each case study region. Details of the calculation method for these emission rates are discussed in Section 1.5.2.

1.3. Strategy Selection, Scenario Development, and Baselines

A scenario in the TEAM analysis framework is a group of one or more travel efficiency strategies tested for an overall combined benefit. The development of scenarios using TEAM has consistently combined strategies, through sequential application and modeling, to help identify how benefits might increase with additional actions over time. This report presents the specific strategies selected for each scenario and the data needed to model them.

TEAM results provide a comparison of potential future year emission reductions from selected strategies with the potential emissions from a future year business as usual (BAU) scenario. The BAU scenario represents likely emissions based on the existing and planned transportation infrastructure with future-year demographic changes. The results are presented as percent reduction based on this comparison. For this reason, establishing the BAU baseline is a critical component of this approach.

1.3.1. Strategy Selection

Strategies of interest generally fall into the five categories. Table 1-1 provides information about the strategies that are routinely analyzed in TEAM, including data needs for each. Additional strategies of interest, such as high-speed rail, are analyzed off model (outside of a sketch model like TRIMMS), with individual methodologies based on available data. The strategies that are chosen for analysis are influenced by the capabilities of the model selected and the data available. For example, to model an improvement to the transit system in TRIMMS, the user must have available and input the changes in typical travel times for transit trips. For the off-model approaches, the data is used directly to estimate changes in VMT.

[10] User Guide for MOVES2014, EPA-420-B-14-055, July 2014.

Table 1-1. TEAM Analysis Options

Strategy Categories	Data Needs	TRIMMS Options
TRIMMS Analysis Options		
Transportation Demand Management or Employer Incentives	• Share of regional employees covered • Average subsidy offered to employees (by mode) • Guaranteed ride home, ride match, telework, and flexible work schedules program availability	• Financial and pricing strategy entries: parking cost and trip cost • Program subsidy radio buttons • Guaranteed ride home, ride match, telework, and flexible work schedules radio buttons
Transit	• Share of regional population affected • Average decrease in transit trip cost Transit travel time and access time	• Financial and pricing strategy entries: access time and travel time
Pricing	• Share of all parking (public and private) that is priced • Average increase in parking cost per trip • Average increase in trip cost	• Financial and pricing strategy entries: parking cost and trip cost
Off Model (Non-TRIMMS) Analysis Options		
Land Use	• Share of regional population in affected areas • Neighborhood approach: • Percent population by neighborhood type • Multivariate approach: • Increase in weighted average residential density (persons per square mile) • Increase in job accessibility by car • Increase in job accessibility by transit • Average decrease in distance to transit • Average increase in land use mixing	Not Applicable
Bicycle and Pedestrian Infrastructure Improvements	• Increase in density of bicycle facilities (facility miles/square mile) • Increase in sidewalk coverage	Not Applicable

1.3.2. Strategy Scope: Geographies and Subpopulations

A travel efficiency strategy can target different geographies and subpopulations. Often, TEAM case study agencies want to apply different strategies to different sub-regions or sub-populations. For analysis purposes, a sub-region is a division of the larger geographical region, and a subpopulation is a subset of the larger regional population. For example, a region might want to assess the following combination of strategies:

1. Provide transit subsidies to an additional 50,000 workers who currently do not have them;
2. Improve transit travel times on three primary transit corridors; and
3. Price parking only in the downtown area.

Such analyses can be done with TEAM. However, a sketch model such as TRIMMS cannot account for multiple geographies and populations in a single run. Therefore, for these strategies, the analysis must:

- Define and gather data for each strategy geography or subpopulation separately. For example, a strategy that applies a VMT charge to the entire region can use regional averages for inputs, but a strategy that applies to only the employed population should use inputs specific to employed persons.

- Consider where strategy geographies and subpopulations overlap. For example, Strategy A may apply to the entire region, while Strategy B applies to employed persons and Strategy C applies to persons living in a certain neighborhood. In this case, inputs are needed for 4 different subpopulations:
    - The population subject to Strategy A only;
    - The population subject to Strategies A and B only;
    - The population subject to Strategies A and C only;
    - The population subject to Strategies A, B, and C.

- Run the sketch model once for each analysis geography and sum VMT reductions across each sketch model run. The analysis would produce reductions in daily VMT for each subpopulation. Summing these results would produce the total VMT reduction for the region.

TEAM is easiest to use when all strategies apply equally to the same geography and the same population. For example, if the region of interest has a population of 1 million and transit subsidies and parking pricing strategies apply to the entire region, then 1 million people would have equal access to transit subsidies and every parking space in the region would be priced equally.

1.4. Data Collection and Validation

TEAM requires two types of data inputs:

- Regional base-year and future-year BAU inputs – These are used to establish an understanding of regional travel patterns in the base year and future year (BAU) and are required, regardless of the strategies selected. They include total population, total jobs, and trip characteristics for VMT reductions as well as MOVES required inputs.

- Strategy-specific inputs – These vary depending on the type and scope of the strategies selected. Strategy-specific inputs are discussed further in each Scenario Development section.

One advantage of TEAM is its use of readily available data inputs. Many of the regional base-year and future-year BAU inputs are data that MPOs already have on-hand as inputs to the regional travel demand model or as outputs from pre-existing runs of the travel demand model. As the primary analysis tool at the regional scale, travel demand model inputs and outputs are the best source of information to maintain consistency with other regional planning analysis. However, regions vary considerably in the complexity of their travel demand models and resources available. Some regions will have all the data necessary to conduct an analysis, while others will need to seek data from other sources.

When a region does not have readily available local data, they can often use surrogates or data points from publicly available national datasets. Because a TEAM analysis compares emissions with and without specific strategies to estimate percentage differences, the input data applies to both cases. This limits any concern about whether, for example, national average data adequately represents local conditions. Furthermore, since a TEAM analysis cannot be used to meet regulatory requirements, using data surrogates instead of local data is an acceptable approach here. This series and previous TEAM case studies have used national datasets such as highlighted in Table 1-2.

Table 1-2. Example of National Datasets for Use in TEAM

Dataset	Provider	Example Data Points Available
American Community Survey (ACS)	U.S. Census Bureau	Trip length Trip time
National Household Travel Survey (NHTS)	Federal Highway Administration (FHWA)	Vehicle occupancy Mode split Vehicle miles traveled Average trip length Trip purpose
Your Driving Costs	American Automobile Association (AAA)	Trip cost
National Transit Database (NTD)	Federal Transit Administration (FTA)	Transit vehicle miles traveled (VMT)

The MOVES portion of the TEAM analysis uses regional data to determine regional average emission rates. One advantage of TEAM is the ability to use MOVES data developed for other purposes, such as Clean Air Act requirements, if available. The emissions factors are applied to the VMT estimates from the BAU and the travel efficiency scenarios to estimate potential emission reductions.

Regardless of the data sources, the TEAM process always includes a step of validating, and sometimes refining, data inputs collected. Local data sources are preferred when available, but national datasets and default inputs available in some sketch models can help fill gaps in local data.

1.5. Analysis

This section describes the analytical tools and processes used for all TEAM case studies. Sections 2 through 5 discuss the specific analytical choices and processes that apply to individual case studies.

1.5.1. VMT Analysis

To calculate emissions resulting from travel efficiency scenarios, VMT and vehicle trips must first be calculated for each scenario. Several methods can be used based on the types of strategies selected for analysis and the data available.

1.5.1.1. TRIMMS Analysis

For the strategies analyzed in TRIMMS, each strategy generally represents an individual TRIMMS model run. The population input to TRIMMS is the population uniformly affected by that strategy. If a single strategy affects different parts of the population in different ways, the population would be split and analyzed in separate TRIMMS runs. For example, a strategy might both increase the dollar value of an existing transit subsidy and expand the number of people who have access to the subsidy. The analysis would treat people who already had access to the subsidy separately from people who did not.

Reduction of VMT and trips output from the TRIMMS model are used to represent the impact of the strategy in subsequent calculations in most cases. However, there are cases where adjustments need to be made, as discussed below and in Sections 2 through 5, where they apply.

One such case is when a TRIMMS analysis indicates an increase in VMT in response to a travel efficiency strategy. For example, TRIMMS might estimate a strategy that increases carpooling also increases total VMT because it does not account for a corresponding reduction in drive-alone trips. TRIMMS provides no mechanism to account for interactions or tradeoffs across strategy categories (further discussed in Section 1.5.1.4.). To ensure that the total number of passenger trips remains consistent, the analysis must consider whether TRIMMS is appropriately estimating the change in the total number of passenger trips, and subtract the appropriate number of drive-alone trips.

Another case where output should be considered is where a strategy would result in additional transit vehicle trips. TRIMMS may not accurately account for change in transit vehicle travel. Because it assumes the average passenger load on transit vehicles is unchanged, TRIMMS projects an increase in transit vehicle mileage proportional to the increase in transit ridership. This assumption would not be true in cases where additional ridership can be accommodated by the existing transit vehicles and routes. To predict the impacts of increased transit service more accurately, an alternative approach is used, based on data from the National Transit Database, and described in the Section 1.5.3

TRIMMS underestimates light-duty VMT due to the intrinsic assumption that each person makes just two trips per day: one trip from home to work, and a second trip from work to home. To correct for this assumption, a scaling factor is applied during post-processing. The scaling factor is the ratio of VMT from the regional travel demand model to TRIMMS-modeled VMT, for the same future year. The scaling factor is applied to the trip and VMT results for all TRIMMS runs conducted for that future year. For example, with a TRIMMS-modeled daily VMT of 2 million and an agency-provided daily VMT of 3 million for the year 2030, a scaling factor of 3/2 = 1.5 would be applied to all the results in 2030.

1.5.1.2. Land Use Analysis

To analyze smart growth land use, an approach based on elasticities found in academic research was used.[11] This approach, called the "multivariate approach," calculates the change in VMT from land use strategies by comparing the following variables for the BAU and scenarios assessed:

- Household/population density (sourced from inputs to the travel demand model)
- Job access by auto (an output from some travel demand models)
- Job access by transit (an output from some travel demand models)
- Distance to nearest transit stop (sourced from inputs to the travel demand model)
- Land use diversity (calculated from inputs to the travel demand model)

[11] Ewing and Cervero, "Travel and the Built Environment: A Meta-Analysis," Journal of American Planning Association, 2010. For more detail on how this information is used in TEAM, see www.epa.gov/sites/production/files/2016-07/documents/420r16009.pdf

This approach is based on research that relates changes in each of these variables to changes in VMT using elasticities, which quantify the percent change in VMT associated with a 1% change in each variable. To apply this approach, the percent change in each variable between the BAU and strategy is calculated at the level of the traffic analysis zone (TAZ) and then at the regional level. Elasticities are applied to the percent change in each variable at the regional level to determine the corresponding percent change in VMT which is then summed to determine a total percent change in VMT.

The elasticity values from the Ewing and Cervero study are calculated as a weighted average of results from more than 50 studies, including both national and regional studies. This approach fits well with the TEAM approach, which is intended to be applicable to all U.S. regions. The weighted averages provided allow for immediate application to all regions. These values are presented in Table 1-3.

Table 1 3. Ewing and Cervero (2010) Elasticity Values for the Multivariate Land Use Analysis[12]

D" Category	Variable	Elasticity Value
Density	Household/ population density	−0.04
	Job density	0
Diversity	Land use mix (entropy)	−0.09
	Jobs−housing balance	−0.02
Design	Intersection/ street density	−0.12
	% 4−way intersections	−0.12
Destinations	Job access by auto	−0.2
	Job access by transit	−0.05
	Distance to downtown	−0.22
Distance to Transit	Distance to nearest transit stop	0.05

1.5.1.3. Bicycle and Pedestrian Analysis

TEAM has also been used to anticipate the potential for VMT reduction based on expanded bicycle and pedestrian infrastructure. The analysis approach is based on a method used by the San Diego Association of Governments (SANDAG) for their 2050 Regional Transportation Plan that has been recognized as an acceptable analysis method for SANDAG's Sustainable Communities Strategy as required under California law.[13] SANDAG's approach assumes:

- A 1% increase in bicycle mode share for every additional mile of bicycle facilities per square mile of land area, based on academic research by Dill and Carr.[14]

[12] Ibid

[13] Technical Appendix 15: SANDAG Travel Demand Model Documentation." 2050 Regional Transportation Plan, San Diego Association of Governments (SANDAG), www.sandag.org/index.asp?projectid=360&fuseaction=projects.detail

[14] Bicycle Commuting and Facilities in Major U.S. Cities: If You Build Them, Commuters Will Use Them – Another Look. Dill, J., T. Carr. 2003. Transportation Research Board 1828, National Academy of Sciences, Washington, D.C.

- The increase in the walk mode share is equal to the percent increase in sidewalk miles after applying an elasticity value of 0.27 (from Ewing et al. 2009).[15]

1.5.1.4. Combining Strategies into Scenarios

After obtaining the VMT reductions from each strategy separately, the strategies are combined to estimate VMT reductions from scenarios. This step is performed in a post-processing spreadsheet. VMT from a set of strategies cannot just be summed together because it is likely that this would double-count reductions. Therefore, this part of the analysis process involves:

- Calculating the percent VMT reduction for each strategy at the regional level
- Isolating the strategies that make up a given scenario
- Calculating the percent VMT reduction for each scenario as the cumulative reduction from its component strategies; for example, combining Strategy 1 (with a 2% regional VMT reduction) and Strategy 2 (with a 5% regional VMT reduction) would yield a scenario VMT reduction of $1 - (1 - 0.02) * (1 - 0.05) = 6.9\%$

1.5.2. MOVES Analysis and Emission Rates

The TEAM approach uses regionally specific current and future emission rates from MOVES applied to the VMT and trips from the sketch model (e.g., TRIMMS) to calculate emission reductions outside of these models. For TEAM, MOVES is run in “Inventory” mode to obtain total emissions, using regional data when available and default data when necessary as appropriate. The resulting emissions are divided by activity to produce activity-weighted, regional average gram per start and gram per mile emission rates for the specified year. These starting and driving emission rates then are applied to the changes in the number of starts (representing trips) and VMT from the sketch model to estimate the change in emissions. This method is an efficient approach to determining impacts of the strategies with the given resolution of the input data.

Emissions analyses were conducted with MOVES2014a, which was the most recent MOVES version as of the date of the analyses. The choices made for the run specification file are consistent with EPA guidance.[16] Run specifications included the following selections:

- The geographic scale selected for MOVES modeling was the county scale. For case study areas made up of several counties, MOVES was run for each individual county and the results from all of them used to create activity-weighted emissions factors.
- All MOVES runs for TEAM obtained annual emissions and were conducted without pre-aggregation, (i.e., emissions estimated on an hourly basis).
- All available MOVES vehicle types were included in the MOVES runs, and all possible fuel types for a given vehicle type were included.
- All road types were included.

[15] Ewing, R., Greenwald, M. J., Zhang, M., Walters, J., Feldman, M., Cervero, R., Thomas, J. (2009). Measuring the impact of urban form and transit access on mixed use site trip generation rates—Portland pilot study. Washington, DC: U.S. Environmental Protection Agency.

[16] Analysis for scale and other parameters adhered to EPA’s current guidance for estimating on-road greenhouse gas emissions: Using MOVES for Estimating State and Local Inventories of On-Road Greenhouse Gas Emissions and Energy Consumption – Final (EPA-420-B-16-059, June 2016).

- Four primary pollutants were considered in this analysis: CO_2-equivalent (CO_2e), NOx, $PM_{2.5,}$ and VOC.[17]
- All the starting and running emission processes were chosen (start exhaust, crankcase start exhaust, running exhaust, crankcase running exhaust, brake wear, and tire wear).

For input databases, local information was included in the MOVES runs whenever available. Details about the collection, processing, sources, and quality assurance of these data items appear in the following sections.

MOVES output was post-processed into average emission rates. While all vehicles types were included, TEAM focuses on strategies affecting light-duty and transit vehicles. To be consistent with TRIMMS, emission rates were produced by combining MOVES vehicle and fuel types to match the TRIMMS composite definitions. For example, in TRIMMS, “auto drive alone” and “auto rideshare” represent trips with any light-duty vehicles, therefore the emission rates included the MOVES motorcycle, passenger car, and passenger truck vehicle types. Similarly, the TRIMMS “vanpool mode” corresponds to MOVES passenger truck and light commercial truck vehicle types. These composite emission rate calculations are made off-model. The resulting emission rates are listed in a simple table in each of the case studies, Sections 2 through 5.

Finally, total emissions were calculated by multiplying the emission rates by activity. Emission rates for starts were multiplied by the number of trips reduced, and emission rates for driving by the VMT reduced.

For future year emission rates, MOVES incorporates new emissions and fuel economy standards consistent with EPA regulations, thus emission rates for the future years analyzed in this study decrease. For criteria pollutants ($PM_{2.5}$, NOx, and VOC), region-specific future-year emission rates for each agency were developed using the MOVES model using the same method described above. For GHGs, future-year emission rates were adjusted using outputs from the MOVES model. MOVES can be used to estimate current-year and future-year CO_2 emission rates. These two rates were used to calculate a reduction factor, and this reduction factor was multiplied by the base-year CO_2 emission rate to estimate a future-year rate. These future-year emission rates may not account for possible significant emissions improvements in vehicle technology (e.g., shift to electric hybrid or fully electric options).

1.5.3. Transit VMT and Emissions

The preceding discussion is focused on the data and procedures used to estimate the impact of travel efficiency strategies on light-duty passenger vehicle trips, VMT and emissions. When a transit improvement strategy causes a shift in travel from light-duty passenger vehicle to transit, the potential for an increase in transit trips, VMT and emissions should be considered. Where the increase in transit travel can be accommodated on the existing routes and service area, it can be assumed that no additional transit trips, VMT or emissions occur. However, if additional transit trips or VMT would be required, further analysis on the impacts of the additional transit travel activity is needed to provide a more complete understanding of the impact of the strategy. The analysis is discussed below and additional region-specific details are presented in Sections 2 through 5.

[17] Other pollutants necessary for the model to compute these four were also included. In MOVES, some pollutants require the selection of other pollutants as prerequisites

The transit improvement strategies in these case studies (for both buses and commuter rail) were specified through reduced headways and trip times, and thus assumed to increase the number of transit vehicles and route miles traveled. For example, a reduction in headways from 20 minutes to 10 minutes implies that twice as many transit vehicles would be required and that total route miles would be doubled. The area-specific increase in transit VMT is based on baseline data from the 2016 National Transit Database. Using this approach, transit VMT can be estimated for the BAU and for the transit strategy envisioned for the scenario.

Transit emission rates were derived from two different sources:

1. For criteria pollutants ($PM_{2.5}$, NOx, and VOC), region-specific base-year and future year emission rates were developed using the EPA MOVES model.
2. For GHGs, CO_2 emission rates were estimated using the fuel consumption data collected from the National Transit Database or sourced directly from the relevant transit agency, and fuel emission rates from EPA's Mandatory Reporting of Greenhouse Gases Final Rule documentation.[18] Total fuel consumed by fuel type was multiplied by the emission rate for that fuel type to estimate the total CO_2 emitted consuming that fuel. The total CO2 emissions were divided by the transit VMT to estimate an average base-year CO2 emission rate (kg CO_2/mile). Standard fuel emission rates (kg CO_2e per unit of fuel consumed) were then applied to the miles-per-gallon figures to estimate grams of CO_2e per mile.

1.5.4. Comparison with Previous Results

To put the individual results in context, results were compared to those from previous TEAM case studies of six other regions. Previous case studies have analyzed strategies similar to those selected by the participating agencies. Key factors that affect the range of results for each strategy include the percentage of the regional population to which it was applied and the aggressiveness of the policy implementation:

1. in the case of TDM programs, the dollar amount of any subsidy;
2. for transit improvements, the improvement in travel times;
3. for land use, the percent increase in the 'D' variables; and
4. for parking pricing, the dollar value of the charge.

See individual case study comparisons to the range of VMT reductions in Sections 2 through 5.

[18] *Mandatory Reporting of Greenhouse Gases; Final Rule*, 74 FR 56259, October 30, 2009, Tables C-1 and C-2. Table of Final 2013 Revisions to the Greenhouse Gas LNG sourced from: EPA (2008) *Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance – Direct Emissions from Mobile Combustion Sources,* Table B-5.

2. Champaign-Urbana, Illinois – Champaign-Urbana Urbanized Area Transportation Study

2.1. Background

The Champaign-Urbana Urbanized Area is located in east-central Illinois and has a population of approximately 148,000 based on 2016 information. The urbanized area includes the University of Illinois primary campus with approximately 44,000 students, located between the cities of Champaign and Urbana. The Champaign Urbana Urbanized Area Transportation Study (CUUATS) is the metropolitan planning organization (MPO) for the Champaign Urbana Urbanized Area. The members of CUUATS are the University of Illinois, City of Champaign, City of Urbana, Village of Savoy, Champaign County, Champaign Urbana Mass Transit District, Champaign County Regional Planning Commission, and Illinois Department of Transportation. CUUATS submitted a letter of interest seeking to use TEAM to consider multiple future scenarios in the next Long Range Transportation Plan (LRTP) update.

CUUATS is incorporating sustainability into the planning and programming activities of the MPO. The LRTP, Sustainable Choices 2040, was approved in December 2014. The plan places sustainability at the core of the transportation planning activities in the urbanized area. For the development of the LRTP, CUUATS evaluated two alternative scenarios: Traditional Development 2040 and Sustainable Choices 2040. A set of interconnected models was used to analyze potential impacts of future planning decisions on the community through 2040 for the two scenarios. The MPO would like these future conditions and strategies to inform the public and stakeholders during public outreach and to support more detailed analysis for the next LRTP update.

At the local level, the cities of Champaign and Urbana and the University of Illinois have initiated aggressive plans to address GHG emissions. These plans provide a basis for some of the strategies that CUUATS proposed for analysis using TEAM, and the CUUATS staff used this opportunity to explore travel efficiency strategies that could be included in the next LRTP. CUUATS staff view the TEAM analysis as a way to build evidence for strategies that is consistent with the goals and expectations of their partner agencies. Agency staff supported all data needs for the analysis from internal resources or through partner input.

For several years, CUUATS has closely considered regional mobile source emissions and their potential impacts on the health, safety, and welfare of local populations and the environment and on the local economies. The Champaign-Urbana area is experiencing growth in population, total number of households, and VMT, and expects continued growth in the future.

The MPO is proactive in considering emissions in their transportation planning processes. For this case study, CUUATS staff developed a localized database of inputs for MOVES to generate existing emissions inventories and emission rates to conduct community-wide analyses for the 2040 LRTP in 2014, with 2010 as the base year. These existing condition inventories included 2010 hourly meteorological data obtained from the National Climate Data Center, 2010 vehicle registration data obtained from the Illinois Secretary of State, road type distribution aggregated from the Highway Performance Monitoring

System, MOVES default fuel table, and VMT outputs from the travel demand model.[19] These inputs are the basis of all emissions modeling conducted for this analysis.

2.2. Scenario Development

CUUATS was interested in evaluating many strategies and narrowed their four selections to:

- Local Transit Hubs, Bus Improvements and Bicycle and Pedestrian Improvements
- Parking Pricing at the University of Illinois
- Smart Growth Land Use; and
- High Speed Rail to Chicago

The selected strategies were combined to develop the following scenarios. This approach allows the agency to observe the cumulative effect of the individual strategies over time. The details of each strategy within the scenarios are provided below.

2.2.1. Scenario 1 – Local Transit Hubs and Bus Improvements + Bicycle and Pedestrian Improvements

The transit, bicycle, and pedestrian improvement policies analyzed in this scenario represent potential changes at both the county and MPO scales. First, local transit hubs and bus improvements envisioned in this scenario would involve an extensive restructuring of bus routes within the Champaign Urbana Urbanized Area. By creating neighborhood-based bus hubs with efficient transfers between routes and relying less on individual routes to cross the urban area, CUUATS and Champaign-Urbana Mass Transit District predict they could reduce overall trip times.

To establish the BAU and strategy scenario, CUUATS estimated a reduction in average wait time for buses from 9.9 minutes in the 2010 base year to 9.4 minutes in the 2040 BAU scenario. However, worsening traffic congestion threatens to double the average bus passenger in-vehicle travel time from 22.9 minutes per trip in 2010 to 52 minutes per trip in 2040. This transit hub/bus improvement policy would slightly reduce average bus in-vehicle travel time from 2010 to 2040 to just 20.4 minutes. In addition, this policy would reduce average bus wait times from 9.4 minutes in the BAU scenario to 7.4 minutes in the future strategy scenario. This information is summarized in Table 2-1.

Table 2-1 CUUATS Access and Travel Time by Scenario

Scenario	Access Time (min)	In Vehicle Travel Time (min)
2010 (Base Year)	9.90	22.90
2040 BAU Forecast	9.40	52.00
2040 Transit Hub Strategy	7.40	20.40

The decreased wait times were estimated to require a 26.3% increase in bus VMT from the BAU scenario. This is discussed further in Section 2.6 below. Table 2-2 shows how these improvements were input to TRIMMS. For the individual TRIMMS runs, CUUATS provided separate trip characteristics and population figures.

[19] EPA recommends using the default fuel information in its MOVES guidance. The MOVES default fuel information represents EPA's best information about the fuels used in every county in the United States.

Table 2-2. CUUATS TRIMMS Input: Access and Travel Time (minutes)

Mode	BAU Access Time	Strategy Access Time	BAU Travel Time	Strategy Travel Time
Public Transport (2040)	9.40	7.40	52.00	20.40

Next, the bicycle and pedestrian improvements strategy would increase miles of bicycle lanes in Champaign County from roughly 230 under the BAU to roughly 410, and would also provide sidewalks on both sides of all streets, except interstate highways and expressways.

As previously stated, a literature-based method was used to model the impact of the bicycle and pedestrian improvements on travel patterns. The increase in bicycle facilities in the Champaign Urbana Urbanized Area was calculated as 4.24 lane miles of additional bike facilities per square mile resulting in a 4.24 % bicycle mode share increase (2.95% to 7.19%) within the Champaign Urbana Urbanized Area. The new cycling trips are assumed to replace driving trips equal in length to the average cycling trip.

For pedestrian facilities, an elasticity of walk trips with respect to sidewalk coverage of 0.27 is used.[20] CUUATS provided an estimated sidewalk coverage of 58.9% in the BAU scenario. An increase to 100% coverage (sidewalks on both sides of all streets except highways and expressways) for this scenario would represent a 69.8% increase in sidewalk coverage. Walking mode share is thus projected to increase from 26.69% to 31.7% (26.69% x (1 + 0.27 x 0.698)) under this scenario. The new walking trips are assumed to replace driving trips equal in length to the average walking trip.

2.2.2. Scenario 2 – Scenario 1 + Parking Pricing at the University

This scenario would increase parking fees for employees at the University of Illinois by 50%. Approximately 24,000 employees are eligible to purchase a parking pass at the University. CUUATS staff estimated the BAU driving costs per person based on information from:

- the Commute Cost Calculator developed by the Washington State Department of Transportation,
- an assumed 30% increase in the price of gasoline as projected by the U.S. Energy Information Administration to 2040, and
- a monthly parking fee at the University of Illinois of $55.

The parking pricing strategy under this scenario would increase the monthly parking fee by 50% to $82.50 per month. This resulting increase in parking fees would increase this population's driving trip costs (including gas, basic vehicle maintenance, and parking) roughly 20%.

The methodology for this scenario compared the differences in trip cost between individuals driving and parking alone versus those using rideshare options. Daily parking costs per vehicle in the BAU scenario were assumed to be equal to $55 per month / 21 working days per month = $2.62 per day. The strategy parking cost is then assumed to increase by 50% (+$1.31 per day) resulting in $3.93 daily cost per vehicle. For auto-rideshare, costs are halved, assuming 2 people split the cost of each vehicle trip. Table 2-3 shows how the values were input to TRIMMS. The values shown are the sum of gasoline and parking costs.

[20] Ewing et al, (2009), "Measuring the impact of urban form and transit access on mixed use site trip generation rates—Portland pilot study". Washington, DC: U.S. Environmental Protection Agency.

Table 2-3. CUUATS TRIMMS Input: Financial and Pricing Strategies (costs per person)

Mode	BAU Trip Cost	Strategy Trip Cost
Auto-Drive Alone	$6.32	$7.63
Auto-Rideshare	$3.16	$3.81

2.2.3. Scenario 3 – Scenario 2 + Smart Growth Land Use

Scenario 3 adds a policy that would increase densities and land use mixing in Champaign County. CUUATS provided the following data for the roughly 300 traffic analysis zones (TAZ) in the county:

- Land area
- Population under 2040 BAU and scenario
- Jobs accessible within 30 minutes by auto under 2040 BAU and scenario
- Jobs accessible within 30 minutes by transit under 2040 BAU and scenario
- Average distance to nearest transit for residents (current transit network)
- Employment by retail, office, and other under 2040 BAU and scenario

These inputs were used to calculate TAZ-level values for each of 4 'D' variables:

- Density (of population)
- Diversity (of land uses)
- Destinations via auto (accessibility of jobs)
- Destinations via transit (accessibility of jobs)

Note: A fifth 'D' variable, Distance to transit, was not used in this analysis because the future locations of bus stops could not be projected with confidence.

County-wide averages for each "D" variable were calculated according to the following steps (using Density as a representative example):

- Calculate Density of each TAZ as population divided by land area
- Calculate the % of regional population resident in each TAZ
- Assign the % of regional population as the weighting factor for each TAZ. The sum of all weighting factors should equal 1.
- Multiply the Density value for each TAZ by its weighting factor
- Sum the results of Step 3 across all TAZs to calculate population-weighted average Density—a single value for the County

Repeating Steps 1-5 above for all 4 'D' variables for both the BAU and Scenario 3 allows for the calculation of % changes in each 'D' variable at the county level, and application of the following elasticities of VMT with respect to each of the variables:

1. Density (Household/ population density): −0.04
2. Diversity (Land use mix): −0.09
3. Destinations (Job access by auto): −0.2
4. Destinations (Job access by transit): −0.05

Note: See Section 1.5.1.2 for more information about elasticities for 'D' variables.

2.2.4. Scenario 4 – Scenario 3 + High Speed Rail to Chicago

The CUUATS final scenario adds high speed rail on the Amtrak corridor from Champaign to Chicago. This strategy is based on a feasibility study sponsored by the Illinois Department of Transportation.[21] EPA's analysis assumed that high speed rail on the Champaign-Chicago corridor would be implemented as described in the feasibility study. For example, this scenario involves the introduction of a 220-mph train running every 30 minutes during peak periods from Champaign's Union Station to Downtown Chicago and the O'Hare airport. The upgraded facility would cut travel time from Champaign to Chicago by nearly 75%. Although high speed rail would affect travel patterns and emissions along the entire corridor between Champaign and Chicago, this analysis considers only VMT and emission reductions within Champaign County.

To estimate the travel impacts of this strategy, increased ridership on the corridor was calculated based on forecasts provided by CUUATS (and based on forecasts by Amtrak). The increase is the difference between the forecast high speed rail ridership (775,000 riders per year) and the forecast Amtrak ridership on the same corridor, without high speed rail (365,500). Of the additional 409,500 annual rail riders, a standard assumption is that roughly half would be driving in the absence of high speed rail.[22] Therefore, this strategy was assumed to eliminate 204,750 annual car trips between Champaign and Chicago. Approximately 22 miles of each of those driving trips would occur within the study boundary of Champaign County. Therefore, under this scenario, VMT would be reduced annually by 4,504,400 vehicle miles.

2.3. Scenario Summary

Input parameters were provided in Table 2-4 for current conditions in the 2010 baseline year, a 2040 BAU future year, and the four scenarios selected by CUUATS. Specific input values were provided for the scenarios.

[21] "220 MPH High Speed Rail Preliminary Feasibility Study - Executive Report." University of Illinois at Urbana-Champaign and University of Illinois at Chicago, 24 Sept. 2013, www.midwesthsr.org/sites/default/files/studies/IDOT_HSR_220_Executive_Report.pdf. Accessed 30 Apr. 2018.

[22] American Public Transportation Association, Recommended Practice for Quantifying Greenhouse Gas Emissions from Transit, 2009. www.apta.com/resources/hottopics/sustainability/Documents/Quantifying-Greenhouse-Gas-Emissions-APTA-Recommended-Practices.pdf. See Figure 16.

Table 2-4. CUUATS Scenario Input Details

Scenario	Description	Data Inputs
Current Conditions	Existing conditions across all strategies in 2010	Region profile: • population – 201,688 • jobs – 101,597 Mode shares: • auto, drive alone – 47.7% • auto, rideshare – 23.3% • transit – 4.2% • bike – 2.6% • walk – 22.2% Average vehicle occupancy, auto rideshare – 2.38 Average vehicle trip lengths, one-way (miles): • auto, drive alone – 4.80 • auto, rideshare – 4.83 • transit – 1.94 • bike – 2.55 • walk – 1.24 Bike/pedestrian facilities: • bike lanes (Urbanized Area) - 60 lane miles • sidewalk coverage (Urbanized Area) - 47% of streets
Business as Usual (BAU)	2040 conditions with current levels of transit, parking pricing, land use, and regional rail	Region profile: • population – 245,827 • jobs – 149,177 Land use: • population density (pop/sq. mi) – 7,484 • job access by auto – 140,608 • job access by transit – 7,091 • land use mix – 0.37 Mode shares: • auto, drive alone – 50.3% • auto, rideshare – 24.6% • transit – 3.4% • bike – 2.4% • walk – 19.4% Average vehicle occupancy: auto, rideshare – 2.38 Average vehicle trip lengths, one-way (miles): • auto, drive alone – 5.03 • auto, rideshare – 5.08 • transit – 2.00 • bike – 2.76 • walk – 1.26 Trip Time (min) • transit, in-vehicle – 50 • transit, wait time – 9 • rail (to Chicago) – 165 Bike/pedestrian facilities: • bike lanes (Urbanized Area) - 227 lane miles

Scenario	Description	Data Inputs
		• sidewalk coverage (Urbanized Area) - 59% of streets Trip Cost • Average auto trip cost (University employees) – $6.32 Rail (to Chicago) 366,000 daily riders
Scenario 1: Local Transit Hubs and Bus Improvements + Bicycle and Pedestrian Improvements	Restructure transit network to reduce wait times and travel times. Expand bicycle lanes and sidewalk coverage.	Trip Time (min) • transit, in-vehicle – 20 • transit, wait time – 7 Bike/pedestrian facilities: • bike lanes (Urbanized Area) - 410 lane miles • sidewalk coverage (Urbanized Area) - 100% of streets
Scenario 2: Scenario 1 + Parking Pricing at the University	Increase the cost that University employees pay for parking	• Average car trip cost for University employees (gas, maintenance, parking) of $7.63
Scenario 3: Scenario 2 + Smart Growth Land Use	Increase densities, land use mixing, and job accessibility	Land use (Weighted average values for all TAZs from 2040 BAU): • population density (pop/sq. mi) – +4.5% • job access by auto – +0.3% • job access by transit – +70.4% • land use mix – +12.3%
Scenario 4: Scenario 3 + High Speed Rail to Chicago	Upgrade existing rail corridor to Chicago to achieve travel speeds of 220 mph	Trip Time (min) • 45 minutes by rail to Chicago Ridership (daily) • 775,000

2.4. Emissions Analysis

In TEAM, the MOVES analysis is focused on generating activity-weighted, regional average emission rates that represent the general parameters of the study region. All data used for this analysis was provided by CUUATS. MOVES inputs were originally generated for the entire county for the most recent LRTP analysis for use with MOVES2010b model. The input files for this analysis were converted for use in MOVES2014a.[23] Transit fuel consumption and VMT data were compiled from two databases in the National Transit Database, the 2016 Fuel and Energy Database, and 2016 Service Database, respectively, for bus service provided by the Champaign-Urbana Mass Transit District. The resulting emission rates are shown in Table 2-5.

[23] The MOVES2014a model has built-in tools that can be used to convert input databases created with MOVES2010b into a form that can be used within MOVES2014a.

Table 2-5. CUUATS Emission Rates

Emissions	g/mi		g/start	
	Base Year (2010)	Future Year (2040)	Base Year (2010)	Future Year (2040)
Auto (Motorcycles + Passenger Cars + Passenger Trucks)				
CO_2e	367.66	196.97	164.29	102.75
NOx	1.10	0.05	2.11	0.33
$PM_{2.5}$	0.02	0.01	0.07	0.01
VOC	0.26	0.01	3.69	0.61
Transit Vehicles (buses)				
CO_2e	1342.12	1208.31	141.72	153.47
NOx	14.74	1.19	0.05	0.01
$PM_{2.5}$	0.33	0.17	0.03	0.02
VOC	1.09	0.05	0.61	0.27
Vanpool (Passenger Trucks + Light-Duty Trucks)				
CO_2e	482.65	254.26	210.93	122.19
NOx	1.80	0.07	2.98	0.34
$PM_{2.5}$	0.03	0.01	0.09	0.02
VOC	0.43	0.01	5.01	0.60

2.5. CUUATS Scenario Results

Table 2-6 provides the regionwide cumulative percent VMT and emission changes from the BAU for light-duty vehicles.

Table 2-6. CUUATS Percent Change in VMT and Emissions for 2040 BAU Compared to 2040 Scenario

Scenario	Light Duty VMT	CO_2e	$PM_{2.5}$	NOx	VOC
Scenario 1: Local Transit Hubs and Bus Improvements + Bicycle and Pedestrian Improvements	−2.96%	−3.39%	−4.35%	−5.59%	−7.48%
Scenario 2: Scenario 1 + University Parking Pricing	−3.23%	−3.66%	−4.63%	−5.87%	−7.77%
Scenario 3: Scenario 2 + Smart Growth Land Use	−7.87%	−8.18%	−8.86%	−9.74%	−11.09%
Scenario 4: Scenario 3 + High Speed Rail	−8.09%	−8.38%	−9.04%	−9.88%	−11.16%

Tables 2-7 and 2-8 provide the regionwide cumulative reduction in light-duty passenger VMT and emissions from the 2040 BAU and 2010 Baseline.

Table 2-7. CUUATS VMT and Emission Changes by Scenario Relative to 2040 BAU

Scenario	2040 Scenario to 2040 BAU				
	Light Duty VMT	CO_2e (kg)	$PM_{2.5}$ (kg)	NOx (kg)	VOC (kg)
Scenario 1: Local transit hubs and bus improvements + bicycle and pedestrian improvements	-128,371	−27,867	−1	−15	−17
Scenario 2: Scenario 1 + University Parking Pricing	-143,386	−31,131	−1	−17	−19
Scenario 3: Scenario 2 + Smart Growth Land Use	-401,660	−85,235	−3	−42	−41
Scenario 4: Scenario 3 + High Speed Rail	-414,001	−87,723	−3	−43	−42

Table 2-8. CUAATS VMT and Emission Changes by Scenario Relative to 2010 Baseline

Scenario	2040 Scenario to 2010 Baseline				
	Light Duty VMT	CO_2e (kg)	$PM_{2.5}$ (kg)	NOx (kg)	VOC (kg)
Scenario 1: Local transit hubs and bus improvements + bicycle and pedestrian improvements	939,953	−621,101	−98	−6,082	−3,600
Scenario 2: Scenario 1 + University Parking Pricing	924,938	−624,365	−98	−6,084	−3,602
Scenario 3: Scenario 2 + Smart Growth Land Use	666,664	−678,468	−100	−6,108	−3,624
Scenario 4: Scenario 3 + High Speed Rail	654,323	−680,956	−100	−6,109	−3,625

As shown in Table 2-6, the most comprehensive scenario, Scenario 4, would reduce light-duty passenger VMT and GHG emissions by 8–9%. Most of those reductions are attributed to the smart growth land use strategy, which makes up the difference in performance between Scenarios 2 and 3.

Typically, in TEAM analyses, the percent reductions in VMT and each major pollutant are similar, and, for simplicity, EPA typically focuses on the VMT result from case study analyses. CUUATS' results are an exception to that approach, in that reductions of criteria pollutants are notably higher than reductions of VMT and GHG emissions. The discrepancy is explained by the impacts of the bicycle and pedestrian improvements strategy.

CUUATS' bicycle and pedestrian strategy reduces a larger share of regional driving trips than regional VMT. This is because the trips that can be shifted to cycling and walking are typically less than 3 miles, whereas the average length of all trips is closer to 5 miles. This is significant because emission rates are generally greatest when a trip has just started and the engine is cold. Emissions of certain criteria pollutants can be reduced by reducing vehicle starts. Therefore, eliminating short vehicle trips would reduce these pollutants more effectively than by reducing overall VMT. Note that the percentage of GHG emissions reduced is also greater than the percentage of VMT reduced, although not as much as percentage of criteria pollutants reduced. This is for the same reason, i.e., the bicycle and pedestrian strategy reduces more starts than VMT.

To contextualize the results in Table 2-6, the percent VMT reduction results from previous TEAM case studies of six other regions were examined for strategies like those selected by CUUATS. Table 2-9 presents the isolated effects of the individual strategies and compares the VMT reductions to the range of VMT reductions estimated for similar strategies in previous TEAM analyses.

Table 2-9. CUUATS Comparison of VMT Reductions with Previous Case Studies

Strategy	% Light Duty VMT Reduction CUUATS	Comparison Strategy Category	Previous Results for Comparison Category		
			Min.	Avg.	Max.
Local Transit Hubs and Bus Improvements + Bicycle and Pedestrian Improvements	−2.96%	Transit improvement	−0.02%	−0.41%	−1.42%
Parking Pricing at the University of Illinois	−0.27%	Parking pricing	−0.26%	−1.13%	−1.99%
Smart Growth Land Use	−4.64%	Land use	−0.16%	−2.70%	−6.43%
High Speed Rail from Champaign to Chicago	−0.22%	Transit improvement	−0.02%	−0.41%	−1.42%

For the combined transit and bicycle/pedestrian strategy, Transit Improvement was chosen as the comparison category. No previous examples of TEAM analyses combine transit and bicycle/pedestrian into a single strategy, so one of the two must be selected. Not surprisingly, the effect of CUUATS' combined strategy is well above the observed range for transit improvement only. Both the transit component and the bicycle/pedestrian component of this strategy are highly aggressive in comparison to previous TEAM strategies.

Parking pricing at the University of Illinois, produces results within the comparison range, although at the low end. The low impact of this strategy is attributed to the limited population to which it would apply (University employees only).

The Smart growth land use strategy produces reductions near the high end of the comparison range. Increases in population density, land use mixing, and job accessibility by auto all contribute to the VMT reduction, but the increase in job accessibility produces the bulk of the change. The dramatic improvement in the bus network under the transit strategy has the secondary effect of increasing the number of jobs that the average resident can reach in a 30-minute commute by bus by 70%.

For high speed rail, the transit improvement category is used for comparison. The reduction of VMT due to high speed rail is on the low end of the range and is commensurate with the volume of the county's daily traffic to or from Chicago—a relatively small part of the county's total traffic. The benefits of high speed rail would, of course, extend well beyond Champaign County, the area considered in this case study.

2.6. Transit VMT and Emissions

As discussed in Section 1.5.3, shifting travel from light-duty vehicles to transit can increase transit VMT and associated emissions. The results presented above in Table 2-5, Table 2-6, and Table 2-7 only include reductions in trips, VMT, and emissions for light-duty vehicles to retain consistency with and to allow comparison to previous TEAM analyses.

The bus improvements component of Scenario 1 is based on reduced wait and trip times. Headway and trip time reductions were assumed to be achieved by increasing the number of buses and thus route miles traveled along a given route. For example, halving the headway would require doubling the buses running that route. CUUATS modeled a reduction in average wait time for buses from 9.9 minutes in the base year to 9.4 minutes in the future BAU and 7.4 in the future scenario; CUUATS estimated that the decreased scenario wait times would require an increase in bus miles of 26.3% over BAU miles. Using this approach, future-year BAU and scenario VMT was estimated from base year VMT. Transit VMT estimates and emission rates were used to calculate the total annual emissions related to CUUATS' transit strategy in Scenario 1. The resultant increases in transit-related VMT and emissions are provided in Table 2-10.

Table 2 10. CUUATS Transit Vehicle Percent VMT and Emissions Increases from BAU

Strategies	Transit VMT	CO_2e kg/day	$PM_{2.5}$ (kg/day)	NOx (kg/day)	VOC (kg/day)
Local transit hubs and bus improvements	26.3%	5,002	0.4	3	0.1

3. Lake Charles, Louisiana – Imperial Calcasieu Regional Planning and Development Commission

3.1. Background

The Imperial Calcasieu Regional Planning and Development Commission (IMCAL) is a transportation planning, safety, and economic development organization representing the five parish Southwest Louisiana Lake Charles region. In addition, IMCAL staffs the Lake Charles Metropolitan Planning Organization (LCMPO).

Since 2014, the IMCAL region has experienced an unprecedented industrial boom from the revival of the country's liquefied natural gas sector. One hundred billion dollars' worth of new or proposed industrial plants is projected in the region over the next several years. Currently, 20 petrochemical-related facilities are under construction or pending. The new plants are projected to utilize 38,000 construction workers and generate 18,000 permanent jobs. This increased activity impacts local transportation demand and air quality. IMCAL wants to ensure the region continues to meet Clean Air Act requirements associated with mobile source emissions.

The Lake Charles MPO urban boundary covers most of Calcasieu Parish with a regional population of approximately 196,000 in 2015. Recent focus has been on a draft "Complete Streets" plan and collecting geographic information system data for sidewalks. The existing travel demand model will be updated within the next year, and therefore current model data is limited. The local transit agency is currently working to improve data collection in general, and shared information generated by their consultant to support data needs for this analysis. Downtown parking in Lake Charles is free and abundant. Although the anticipated growth is significant, land use planning in the region has not previously been explored as a potential solution.

3.2. Scenario Development

IMCAL was interested in many TE strategies and narrowed their four selections to:

- Travel Demand Management (TDM) for petrochemical industry employees
- Transit improvements in North Lake Charles
- Public parking pricing in Downtown Lake Charles; and
- Smart growth land use

As typical in the TEAM approach, selected strategies of interest are combined to develop the following scenarios. This approach allows the agency to observe the cumulative effect of strategies over time. The details of each strategy within the scenarios are provided below.

3.2.1. Scenario 1 – TDM Program for Petrochemical Employees

The TDM policy under this scenario would offer financial incentives for carpooling to workers in the region's petrochemical industry: roughly 7,500 of 119,000 projected workers in 2040. The policy would offer subsidies of $50 per month for ridesharing or vanpooling to each employee along with ridematch programs and guaranteed/emergency ride home programs. The number of employees assumed to accept the subsidy would be less than 7,500, and is implicitly calculated by the TRIMMS model used in the VMT part of this analysis.

The subsidy was modeled by estimating the change in the daily cost for rideshare trips when a savings of up to $50 per month was applied. To estimate the BAU rideshare trip cost, the following data was used:

- Average trip length – Current-year drive-alone trip length data were found in the 2009 National Household Travel Survey.[24] Average trip lengths for petrochemical employees in the Lake Charles region were assumed to be 10.8 miles which is equal to the average light-duty vehicle home-work trip length for individuals living in urbanized areas of fewer than 200,000 population. Using this trip length as the baseline, IMCAL estimated drive-alone trip length for the BAU 2040 analysis year by applying a trip length growth factor of 6% derived from the regional travel demand model. To estimate the 2040 rideshare trip length, the average length for home-based rideshare work trips was divided by the drive-alone work trips as reported in the 2009 National Household Travel Survey to calculate a rideshare trip length factor of 1.15. This factor was multiplied by the BAU 2040 drive-alone trip length provided by IMCAL to estimate rideshare trip length.

- Variable driving cost – The per-mile driving cost data were the American Auto Association's "2017 Your Driving Costs" publication, which provides a national average.[25] The American Auto Association annually publishes estimates for passenger vehicle ownership and variable costs. For this analysis, the operating cost for medium sedans was used as a representative commute vehicle.

- Average vehicle occupancy – Average occupancy for rideshare trips was estimated using data from the 2015 American Community Survey.[26] Future-year occupancy was assumed not to change without significant infrastructure or mobility changes.

The average roundtrip length was multiplied by the variable driving cost (i.e., cost per mile) and divided by the average occupancy to estimate the daily commute cost for rideshare trips in the Lake Charles area ($1.89). The daily trip cost was less than the daily $2.50 subsidy amount (assuming 21 work days per month), therefore, the cost of rideshare trips changing from $1.89 to $0 in TRIMMS. In addition to inputting the rideshare subsidy values described above, the ridematch and guaranteed ride home programs were analyzed using the yes/no radio buttons provided in TRIMMS to model those programs.

3.2.2. Scenario 2 – Scenario 1 + Transit Improvement in North Lake Charles

This scenario would add improved bus service to the neighborhood of North Lake Charles, with a population of roughly 13,500 people. The Lake Charles Transit System (LCTS) bus route #2 currently serves this neighborhood and connects it with Downtown Lake Charles. The baseline transit miles for LCTS bus route #2, which provides service between North Lake Charles and Downtown Lake Charles were 54,126 miles. IMCAL, with input from LCTS, developed an estimate of the baseline average transit travel time, in-vehicle time and out of vehicle time (wait and layover times), for typical bus trips to and

[24] U.S. Department of Transportation, Federal Highway Administration, 2009 National Household Travel Survey. https://nhts.ornl.gov.

[25] Your Driving Costs, American Auto Association, https://exchange.aaa.com/automotive/driving-costs/

[26] United Stats Census Bureau, www.census.gov/programs-surveys/acs/

from North Lake Charles and the transit center. They estimated that, with additional resources, this policy would improve the speed and frequency of service to reduce total average transit times (including in-vehicle and out-of-vehicle time) for residents of the neighborhood by 17%. This reduction in travel time via transit would require a 20% increase in bus service. Using this approach, future-year BAU and scenario VMT was estimated from base-year VMT. LCTS also provided fuel consumption and fuel efficiency data for their transit buses. LCTS reported that the average fuel efficiency for its bus fleet was 3.66 miles per gallon, and his information was used in the GHG calculations.

The transit improvement policy was analyzed by inputting the BAU trip time (66 minutes) and the strategy trip time (55 minutes) in TRIMMS and running the model for Scenario 2. Table 3-1 shows how these improvements were input to TRIMMS.

Table 3-1. IMCAL TRIMMS Scenario 2 Input: Access and Travel Time Improvements (minutes)

Mode	BAU Travel Time	Strategy Travel Time
Public Transport (2040)	66.00	55.40

3.2.3. Scenario 3 – Scenario 2 + Parking Pricing in Downtown Lake Charles

This scenario would add a charge for public parking used for non-work trips to Downtown Lake Charles, where all parking is currently free. The charge modeled was $0.50 per hour.

Like the TDM policy introduced in Scenario 1, the parking charge policy was modeled in TRIMMS as a change in travel cost. In this scenario, however, the change in cost was the additional cost of parking on top of the baseline cost for a vehicle trip to Downtown Lake Charles. As with the TDM program, the baseline trip cost was estimated by multiplying the average roundtrip distance by the variable driving cost and dividing by the average occupancy. IMCAL assumed average parking time to be 1.6 hours per trip based on their observations of travel patterns to downtown. With a parking cost of $0.50 per hour, the new cost would add an average of $0.80 per downtown trip.

Table 3-2 shows how these improvements were input to TRIMMS for trips with one passenger (auto-drive alone) versus trips with two people per vehicle (auto-rideshare). The values in the table represent the sum of both variable (gas and maintenance) and fixed (parking) trip costs. Variable cost for the BAU drive-alone was calculated as 17 cents per mile multiplied by the average one-way trip length of 13.04 miles * 2 = $4.43 per trip.[27, 28] Adding $0.80 in parking yields a total strategy trip cost of $5.23. The auto-rideshare costs used were per person, assuming 2 people per vehicle.

Table 3-2. IMCAL TRIMMS Scenario 3 Input: Financial and Pricing Strategies (costs per person)

Mode	BAU Trip Cost	Strategy Trip Cost
Auto-Drive Alone	$4.43	$5.23
Auto-Rideshare	$2.21	$2.61

[27] Your Driving Costs, "Operating a Medium Sedan". American Auto Association, https://exchange.aaa.com/automotive/driving-costs/

[28] A growth factor derived from IMCAL's travel demand model specifically for trips to downtown was used to estimate the 2040 BAU trip length to downtown.

3.2.4. Scenario 4 – Scenario 3 + Smart Growth Land Use

Scenario 4 adds a policy that would increase densities and land use mixing in the MPO area. IMCAL provided the following data for the 845 traffic analysis zones (TAZ) in the MPO area:

- Land area
- Population under 2040 BAU and scenario
- Jobs under 2040 BAU and scenario

A multivariate land use analysis was conducted outside of TRIMMS using these inputs.

The increase in the regionwide average that would result under the smart growth land use policy was calculated for the two 'D' variables identified below:

- Density (of population)
- Diversity (of land uses)

To calculate the regionwide average, density and diversity values for each TAZ were weighted by the population share in each TAZ. Using a weighted average allows calculation of a single value that summarizes the change in each variable across the entire area that would result from this policy.

The other three 'D' variables typically included in an analysis of smart growth land use—job accessibility by auto, job accessibility by transit, and distance to transit—were not calculated for this analysis because the required data were not available. Therefore, the VMT reduction for smart growth land use in this case study likely underestimates the potential reductions.

3.3. Scenario Summary

Table 3-3 provides input parameters for current conditions in the 2015 baseline year, a 2040 BAU future, and the four scenarios IMCAL selected. Specific input values are provided for the scenarios.

Table 3-3. IMCAL Scenario Details

Scenario	Description	Data Inputs
Current Conditions	Existing conditions across all strategies in 2015	Region profile: • population – 195,882 • jobs – 84,103 Mode shares: • auto, drive alone – 85.3% • auto, rideshare – 9.4% • transit – 0.4% • bike – 0.3% • walk – 1.4% • Other – 3.2% Average vehicle occupancy, auto rideshare – 2.37 Average vehicle trip lengths, one-way (miles): • auto, drive alone – 9.60 • auto, rideshare – 11.1
Business as Usual (BAU)	2040 conditions with current levels of transit,	Region profile: • population – 259,698 • jobs – 119,240

Scenario	Description	Data Inputs
	parking pricing, land use, and regional rail	Land use: • population density (pop/sq. mi) – 2,512 • land use mix – 0.42 Mode shares: • auto, drive alone – 85.3% • auto, rideshare – 9.4% • transit – 0.4% • bike – 0.3% • walk – 1.4% • Other – 3.2% Average vehicle occupancy, auto rideshare – 2.37 Average vehicle trip lengths, one-way (miles): • auto, drive alone – 10.2 • auto, rideshare – 11.8 Trip Time (min) • transit, total – 66
Scenario 1: TDM Program for Petrochemical Employees	Provide subsidies for carpooling, ridematch and guaranteed ride home programs to 7,500 employees	• $50 per employee subsidy for carpooling • Ridematch and guaranteed ride home programs
Scenario 2: Scenario 1 + Transit Improvement in North Lake Charles	Reduce the average transit trip time of residents of North Lake Charles	Trip Time (min): • transit, total – 55 (reduced from 66 in 2040 BAU)
Scenario 3: Scenario 2 + Parking Pricing in Downtown Lake Charles	Price public parking used for non-work trips to Downtown Lake Charles	• 50 cents per hour parking charge
Scenario 4: Scenario 3 + Smart Growth Land Use	Increase land use densities and land use mixing	Land use (From 2040 BAU): • Weighted average values for all TAZs in IMCAL MPO increase from 2040 BAU as follows: • population density: 14.1% • land use mix: 2.7%

3.4. Emissions Analysis

In TEAM, the MOVES analysis is focused on generating activity-weighted, regional average emission rates from the model that represent the general parameters of the study region. IMCAL results presented here rely on the local data provided by IMCAL and model default inputs, along with the processing methodology described in Section 1.5.2. The resulting emission rates are shown in Table 3-4.

Table 3-4. IMCAL Emission Rates

Emissions	g/mi		g/start	
	Base Year (2015)	Future Year (2040)	Base Year (2016)	Future Year (2040)
Auto (Motorcycles + Passenger Cars + Passenger Trucks)				
CO_2e	380.56	218.65	101.09	73.33
NOx	0.35	0.03	0.88	0.16
$PM_{2.5}$	0.01	0.01	0.01	0.00
VOC	0.07	0.01	1.08	0.20
Transit Vehicles (buses)				
CO_2e	1500.78	1391.65	123.18	127.66
NOx	10.15	1.22	0.03	0.01
$PM_{2.5}$	0.29	0.04	0.02	0.00
VOC	0.76	0.06	0.21	0.10
Vanpool (Passenger Trucks + Light-duty Trucks)				
CO_2e	463.22	270.72	121.39	86.36
NOx	0.56	0.04	1.22	0.18
$PM_{2.5}$	0.01	0.01	0.01	0.01
VOC	0.11	0.01	1.44	0.20

3.5. IMCAL Scenario Results

Table 3-5 provides the cumulative percent VMT and emission changes from the BAU for light-duty vehicles. Additional explanation is provided below.

Table 3-5. IMCAL Percent Change in VMT and Emissions for 2040 BAU Compared to 2040 Scenario

Scenario	Light Duty VMT	CO_2e	$PM_{2.5}$	NOx	VOC
Scenario 1: TDM Program for Petrochemical Employees	−0.07%	−0.07%	−0.07%	−0.07%	−0.07%
Scenario 2: Scenario 1 + Transit Improvement in North Lake Charles	−0.10%	−0.10%	−0.10%	−0.10%	−0.10%
Scenario 3: Scenario 2 + Parking Pricing in Downtown Lake Charles	−0.24%	−0.24%	−0.24%	−0.23%	−0.22%
Scenario 4: Scenario 3 + Smart Growth Land Use	−1.05%	−1.04%	−1.04%	−1.01%	−0.97%

Tables 3-6 and 3-7 provide the regionwide cumulative reduction in VMT and emission from the 2015 Baseline and 2040 BAU.

Table 3 6. IMCAL VMT and Emission Changes by Scenario Relative to 2040 BAU

Scenario	2040 BAU to 2040 Scenario				
	Light Duty VMT	CO_2e (kg)	$PM_{2.5}$ (kg)	NOx (kg)	VOC (kg)
Scenario 1: TDM Program for Petrochemical Employees	−4,913	−1,110	0.0	−0.2	−0.1
Scenario 2: Scenario 1 + Transit Improvement in North Lake Charles	−6,953	−1,569	0.0	−0.3	−0.2
Scenario 3: Scenario 2 + Parking Pricing in Downtown Lake Charles	−16,203	−3,643	−0.1	−0.8	−0.4
Scenario 4: Scenario 3 + Smart Growth Land Use	−70,996	−15,962	−0.5	−3.4	−1.9

Table 3 7. IMCAL VMT and Emission Changes by Scenario Relative to 2015 Baseline

Scenario	2015 Baseline to 2040 Scenario				
	Light Duty VMT	CO_2e (kg)	$PM_{2.5}$ (kg)	NOx (kg)	VOC (kg)
Scenario 1: TDM Program for Petrochemical Employees	1,954,245	−354,216	−8	−1,793	−686
Scenario 2: Scenario 1 + Transit Improvement in North Lake Charles	1,952,206	−354,675	−8	−1,793	−686
Scenario 3: Scenario 2 + Parking Pricing in Downtown Lake Charles	1,942,955	−356,750	−8	−1,794	−686
Scenario 4: Scenario 3 + Smart Growth Land Use	1,888,162	−369,068	−8	−1,796	−688

As shown in Table 3-5, the most comprehensive scenario, Scenario 4, would reduce VMT and emissions of each major pollutant by roughly 1%. Most of those reductions are attributed to the smart growth land use strategy, which makes up the difference in performance between Scenarios 3 and 4.

To contextualize the results in Table 3-5, the percent VMT reduction results from previous TEAM case studies of six other regions were examined for strategies like those selected by CUUATS. Table 3-8 shows the effects of the individual strategies on VMT and compares them to VMT reductions from IMCAL's individual strategies to the range of VMT reductions projected for similar strategies from previous TEAM analyses in other areas

Table 3-8. IMCAL Comparison of VMT Reductions Strategies and Previous Case Studies

Strategy	% Light Duty VMT Reduction IMCAL	Comparison Strategy Category	Previous Case Study Results for Category		
			Min.	Avg.	Max.
TDM Program for Petrochemical Employees	0.07%	Expanded TDM	0.43%	1.10%	2.80%
Transit Improvement in North Lake Charles	0.03%	Transit improvement	0.02%	0.41%	1.42%
Parking Pricing in Downtown Lake Charles	0.14%	Parking pricing	0.26%	1.13%	1.99%
Smart Growth Land Use	0.81%	Land use	0.16%	2.70%	6.43%

Many of IMCAL's strategies would produce VMT reductions at the low end of, or even below, the range of other case study results. This can be explained by the relatively small scope for applying the selected strategies. Except for smart growth land use, each strategy targets a small subset (about 5%) of the population or geographic region.

The TDM strategy produced results below the range of similar strategies assessed in previous case studies. This outcome is most likely due to the scenario's incentive focused on carpooling only, while typical TDM incentive programs analyzed in the TEAM framework generally encourage use of other modes as well. In addition, the strategy focused on workers in only one industry, albeit a dominant industry in the region.

The transit improvement strategy for North Lake Charles produced results within the range of previous results. Results for IMCAL were on the low end, because the strategy was only applied to bus routes that serve a single neighborhood, and the level of improvement in the bus route was modest.

The parking pricing strategy produced results below the range of previous case studies due to its applicability to only a small share of regional trips—i.e., non-work trips to downtown.

The IMCAL land use change strategy was in the low-to-medium end of the VMT reduction spectrum of other agencies' results. Although a 14% increase in the gross population density was projected, average land use mix increased only moderately (3%). For this scenario, data was not available for changes in job accessibility by auto and transit, or walking distance to the nearest transit stop; therefore, the land use strategy results show a smaller overall VMT impact. In other case studies, the impact of job accessibility is frequently the most powerful among the land use variables.

3.6. Transit VMT and Emissions

As discussed in Section 1.5.3, shifting travel from light-duty vehicles to transit can increase transit VMT and associated emissions. The results presented above in Table 3-5, Table 3-6, and Table 3-7 only include reductions in trips, VMT, and emissions for light-duty vehicles to retain consistency with and to allow comparison to previous TEAM analyses.

The transit improvement strategy in Scenario 2 was based on reduced wait and trip times. Headway and trip time reductions were assumed to be achieved by increasing the number of buses and thus route miles traveled along a given route. For example, halving the headway would require doubling the buses running that route. IMCAL estimated that average trip times in the improvement area would be 66 minutes in both the base year and future BAU, but would be reduced to 55 minutes in the future scenario; this reduction in travel time via transit would require a 20% increase in bus service. Using this approach, future-year BAU and scenario VMT was estimated from base-year VMT. Transit VMT estimates and emission rates were used to calculate the total annual emissions related to CUUATS' transit strategy. The resultant increases in transit-related VMT and emission are provided in Table 3-8.

Table 3 8. IMCAL Transit Vehicle Percent VMT and Emissions Increases from BAU

Strategies	Transit VMT	CO_2e (kg/day)	$PM_{2.5}$ (kg/day)	NOx (kg/day)	VOC (kg/day)
Transit Improvement	20.0%	77	0.001	0.034	0.002

4. State of Connecticut – Northeast States for Coordinated Air Use Management

4.1. Background

This analysis for the State of Connecticut was conducted in partnership with The Northeast States for Coordinated Air Use Management (NESCAUM). NESCAUM is a 501(c)(3) non-profit association of the state air quality agencies in Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. The directors of these agencies serve as NESCAUM's Board of Directors. NESCAUM provides scientific, technical, analytical, and policy support to the air quality and climate programs of member states.

To evaluate TEAM for broader application to other NESCAUM states and the multistate region, NESCAUM partnered with the State of Connecticut, specifically with the Connecticut Department of Energy and Environmental Protection (CT DEEP) and the Connecticut Department of Transportation (CT DOT), to evaluate the effect of travel efficiency strategies to reduce transportation-related greenhouse gases (GHGs). Under Connecticut's Global Warming Solutions Act, CT DEEP is charged with analyzing progress to date and additional actions needed to comply with the Act, including achieving an 80% reduction in greenhouse gas (GHG) emissions by 2050.[29] Additionally, CT DOT has an interest in TEAM to support its long-term GHG mitigation planning efforts.

NESCAUM is helping CT DEEP develop GHG mitigation scenarios that would achieve the reduction targets of the Global Warming Solutions Act, using the Long-Range Energy Alternative Planning framework. The framework, however, is not designed to assess the GHG reduction potential of specific VMT reduction measures.[30] While transportation demand models are available, they can be resource intensive and expensive to run; CT DOT was interested in a way to rapidly estimate the impact of specific travel efficiency strategies. NESCAUM, CT DEEP, and CT DOT view TEAM as a flexible, cost-effective planning tool to analyze potential VMT reduction measures that extend beyond current programs and would help achieve Connecticut's aggressive 2050 GHG target.

In 2015, Connecticut launched *"Let's Go CT!"*, the state's 30-year transportation vision to transform Connecticut infrastructure into a premiere, integrated, multimodal system.[31] *Let's Go CT!* calls for a complete reevaluation of bus services in Connecticut, with the goal to increase bus service availability in urbanized areas by 25%. Connecticut has been reevaluating the performance of the current bus network and its ability to connect people with jobs, education, health care, and essential services, and this case study represented an opportunity to support this work. Increased congestion levels, the need for reverse commuting to suburban locations, federal mandates to reduce air pollution, and the state's GHG mitigation requirements present a growing opportunity for bus transit, which in many cases is the most cost-effective and flexible transit mode. The state's existing network has operated with only minor

[29] Public Act No. 08-98 An Act Concerning Connecticut Global Warming Solutions; Sess. 2008. (C.T. 2008) www.cga.ct.gov/2008/ACT/PA/2008PA-00098-R00HB-05600-PA.htm.

[30] Heaps, C.G., 2016. Long-range Energy Alternatives Planning (LEAP) system. Stockholm Environment Institute. Somerville, MA, USA. www.energycommunity.org.

[31] "Let's Go CT: 30-Year Vision Document," Connecticut Department of Transportation, 17 Feb. 2015, www.transformct.info/img/documents/CTDOT%2030%20YR%20Corrected_02.17.2015.pdf.

adjustments for many years, often not responding to changing population and employment shifts throughout the state such as increased development outside the central business districts.

Let's Go CT! also includes a "complete streets policy" for designing improved bike and pedestrian conditions in community centers. Multimodal enhancements to the New Haven rail line to New York, the nation's busiest commuter rail corridor, are another focus. The state intends to transform the New Haven line from a "commuter railroad" to a "rapid transit" system with enhanced connectivity to bus lines and upgraded branch lines to interior Connecticut communities.

The Let's Go CT! measures could reduce VMT in the state and contribute to meeting the state's GHG reduction target in 2050. CT DOT is testing TEAM to help evaluate the GHG mitigation potential of these measures and identify enhancements to improve the program's climate mitigation potential along with improved transportation efficiency.

4.2. Scenario Development

This TEAM analysis examines travel activity within the state of Connecticut with emphasis on the corridor connecting New York City to New Haven. Let's Go CT, the 30-year vision, was not considered the BAU case for this analysis. Instead, the scenarios modeled for Connecticut reflect specific aspects of the vision. Previous modeling conducted with CT DOT's statewide travel demand model provided parameters for BAU mode shares and trip lengths at the state level. The model predicts a slight increase in driving alone and in transit ridership and a slight decline in carpooling in 2040.

Mode shares and trip lengths for the New York-New Haven corridor could not be extracted readily from the model. To estimate mode shares for the corridor, data from the 2015 American Community Survey was used to modify the statewide averages. American Community Survey data showed that transit mode share for work trips in Fairfield and New Haven counties (the two counties that comprise most of the corridor) is roughly 50% higher than the statewide average. Accordingly, the statewide BAU transit mode share was scaled up by 50% to estimate BAU transit mode share in the corridor. Mode shares for drive alone and carpool were scaled back accordingly. Average trip lengths for all modes in the New York-New Haven corridor were assumed the same as statewide average trip lengths.

Four strategies reflecting the *Let's Go CT* vision were selected for evaluation:

- Commuter rail improvements in the New York – New Haven Corridor
- Local bus improvements in the New York – New Haven Corridor
- Smart growth land use in the New York – New Haven Corridor
- Statewide VMT pricing

As typical in the TEAM approach, selected strategies of interest are combined to develop the following scenarios. This approach allows the agency to observe the cumulative effect of strategies over time. The details of each strategy within the scenarios are provided below.

4.2.1. Scenario 1 – Commuter Rail Improvements

This scenario evaluates potential improvements to the Metro North commuter trains that would reduce average travel times on the corridor by 15% through faster trains and shorter wait times on trains that serve the New York-New Haven corridor. The corridor geographic boundary is from *Let's Go CT!*.

The forecasted 2040 corridor population is 1,347,169. This value was used to estimate the population affected by this strategy. The corridor population was spread across both urban and rural areas in New Haven and Fairfield Counties. Some of the population can access the rail line with a short walk, drive, or bus trip to the rail station. Others live too far from stations for it to be a practical means of daily travel.

To avoid double-counting the impact of rail improvements (in this scenario) and bus improvements (in other scenarios), the corridor population must be divided by the most common mode of transit. Mode split data from the statewide travel demand model shows a transit ridership split of approximately 50/50 between bus and rail. Accordingly, it is estimated that 50% of the corridor population (673,585) are primarily rail riders and the other 50% are primarily bus riders.

Table 4-1 shows the parameters as input to the TRIMMS model. CT DOT estimated 47 minutes for the BAU trip time from Stamford, CT to Grand Central Station in New York City, NY for the 2040 BAU scenario and 40 minutes with the improvements proposed by the strategy. CT DOT provided an estimated BAU access time (average train transfer time at Stamford) of 5 minutes, decreasing to 3 minutes with the improvement strategy.

Table 4-1. NESCAUM TRIMMS Scenario 1 Input: Access and Travel Time Improvements (minutes)

Mode	BAU Access Time	Strategy Access Time	BAU Travel Time	Strategy Travel Time
Public Transport	5.00	3.00	47.00	40.00

4.2.2. Scenario 2 – Scenario 1 + Local Bus Improvements

This scenario would upgrade local bus service in all urban areas in the New York-New Haven corridor. The policy, modeled in TRIMMS, would reduce average travel times by a third. This policy was assumed to be consistent with Connecticut's goal to increase bus service availability in urbanized areas by 25% (per *Let's Go CT!*). As explained in Scenario 1 above, the mode split between bus and rail was applied to estimate the affected population of 673,585 for the bus improvements.

Table 4-2 shows the parameters as input to the TRIMMS model. CT DOT provided an estimated average BAU trip time on local buses of 15 minutes in the 2040 BAU scenario, decreasing to 10 minutes with the improvement strategy. CT DOT provided an estimated BAU access time (bus headway) of 5 minutes, decreasing to 3 minutes with the improvement strategy.

Table 4-2. NESCAUM TRIMMS Scenario 2 Input: Access and Travel Time Improvements (minutes)

Mode	BAU Access Time	Strategy Access Time	BAU Travel Time	Strategy Travel Time
Public Transport	5.00	3.00	15.00	10.00

4.2.3. Scenario 3 – Scenario 2 + Smart Growth Land Use

Scenario 3 added a policy that would increase densities and land use mix in the New York-New Haven corridor. CT DOT provided the following data for the roughly 530 traffic analysis zones (TAZ) in the corridor:

- Land area
- Population under 2040 BAU and scenario
- Average distance to nearest transit for residents (current transit network)
- Employment by retail and non-retail under 2040 BAU and scenario

A multivariate land use analysis was conducted outside of TRIMMS using these inputs.
The increase in the regionwide average that would result under the smart growth land use policy was calculated for the following three 'D' variables:

- Density (of population)
- Diversity (of land uses)
- Distance to transit

To calculate the regionwide average, 'D' values for each TAZ were weighted by the share of the population in each TAZ. Using a weighted average allowed calculation of a single value that summarizes change in each variable across the entire area that would result from this policy.

The other two 'D' variables typically included in an analysis of smart growth land use—job accessibility by auto and job accessibility by transit—were not calculated for this analysis because the required data were not available from the statewide travel model. Therefore, the VMT reduction for smart growth land use in this case study likely underestimates the potential reductions.

4.2.4. Scenario 4 – Scenario 3 + VMT Pricing

CT DOT's final scenario would add a statewide VMT fee of $0.05 per mile on all light-duty vehicle travel throughout the state. The impact of that strategy was modeled in TRIMMS.

Table 4-3 shows the input parameters. CT DOT provided an average cost of gas per vehicle trip of $1.85, assuming a cost of $0.23 per mile and an average trip length of 8.06 miles. Adding $0.05 per mile to that figure would yield a new trip cost of $2.26. Those figures were used for trips of single individuals (auto drive-alone). The cost per person was halved for auto-rideshare trips with an assumption of 2 people per vehicle.

Table 4-3. NESCAUM TRIMMS Input: Financial and Pricing Strategies (costs per person)

Mode	BAU Trip Cost	Strategy Trip Cost
Auto-Drive Alone	$1.85	$2.26
Auto-Rideshare	$0.92	$1.13

4.3. Scenario Summary

Input parameters are provided in Table 4-4 for current conditions in the 2020 baseline year, a 2040 BAU future year, and the four scenarios selected by CT DOT. Specific input values are provided for the scenarios.

Table 4-4. NESCAUM Scenario Details

Scenario	Description	Data Inputs
Current Conditions	Existing conditions across all strategies in 2020	Region profile (statewide): • Population – 3,728,635 • jobs – 1,625,665 Region profile (New York-New Haven Corridor): • Population – 1,279,610 • jobs – 563,438 Mode shares (statewide): • auto, drive alone – 73.8% • auto, rideshare – 24.6% • transit – 1.6% Mode shares (New York-New Haven Corridor): • auto, drive alone – 73.0% • auto, rideshare – 24.6% • transit – 2.4% Average vehicle occupancy, auto rideshare – 2.35 Average vehicle trip lengths, one-way (miles): • auto, drive alone – 8.12 • auto, rideshare – 8.12
Business as Usual (BAU)	2040 conditions with current levels of transit, parking pricing, land use, and regional rail	Region profile (statewide): • Population – 4,013,596 • jobs – 1,751,623 Region profile (New York-New Haven Corridor): • Population – 1,347,169 • jobs – 595,680 Mode shares (statewide): • auto, drive alone – 75.7% • auto, rideshare – 22.5% • transit – 1.8% Mode shares (New York-New Haven Corridor): • auto, drive alone – 74.8% • auto, rideshare – 22.5% • transit – 2.7% Average vehicle occupancy, auto rideshare – 2.35 Average vehicle trip lengths, one-way (miles): • auto, drive alone – 8.06 • auto, rideshare – 8.06 Land use: • population density (pop/sq. mi) – 4,831 • job access by auto – 140,608 • distance to transit (miles) – 1.48 • land use mix – 0.64 Trip Cost ($/mile): • auto – $0.25
Scenario 1: Commuter Rail Improvements	Improve travel speeds and reduce headways on the Metro-North commuter	Trip Time (min) • rail, in-vehicle – -15% • rail, wait time – -40%

Scenario	Description	Data Inputs
	rail service in the New York-New Haven corridor	Affected population: 673,585
Scenario 2: Scenario 1 + Local Bus Improvements	Improve travel speeds and reduce headways for local buses serving communities in the New York-New Haven corridor	Trip Time (min): • bus, in-vehicle – -33% • bus, wait time – -40% Affected population – 673,585
Scenario 3: Scenario 2 + Smart Growth Land Use	Increase densities and land use mixing in communities in the New York-New Haven corridor	Land use (Corridor TAZs change from 2040 BAU): • population density (pop/sq. mi) – +3.8% • distance to transit – -6% • land use mix – +0.1%
Scenario 4: Scenario 3 + VMT Pricing	Charge a fee for every mile traveled by a light-duty vehicle in Connecticut	Trip Cost ($/mile): • auto – +0.05

4.4. Emissions Analysis

NESCAUM results presented here rely on the individual county inputs provided by CT DOT and the processing methodology described previously.

CT DOT initially provided MOVES2014a run specification files and input databases for each of the eight counties in the region. Input data was provided for 2018, and for use in the TEAM analysis, these were used for 2020. For this update, local inputs describing the Low Emitting Vehicle program were removed to avoid uncertainty in the implementation of the program, applicable to certain northeastern states in future years. CT DOT also provided local meteorology, but the data were limited to July only. As TEAM relies on annual average emission rates, default annual meteorology was used in all runs. Inspection and maintenance program benefits were omitted, consistent with previous EPA case studies analyzed using TEAM.

Emission rates were produced for two different geographies: one for the two-county "corridor" and one for the entire state. In both cases, the resulting emission rates were determined by aggregating the resulting emissions and activity values from the individual county MOVES simulations. The ratio of the combined values was then determined to calculate activity-weighted emission rates, as described in Section 1.5.2. Only the two counties along the commuter rail corridor, Fairfield and New Haven Counties, were included in the average emission rate calculations for the corridor case. All eight counties in Connecticut were included in the statewide average emission rate calculations.

The resulting emission rates for the corridor and statewide cases are shown in Table 4-5 and Table 4-6.

Table 4-5. NESCAUM New York-New Haven Corridor Emission Rates

Emissions	g/mi		g/start	
	Base Year (2020)	Future Year (2040)	Base Year (2020)	Future Year (2040)
Auto (Motorcycles + Passenger Cars + Passenger Trucks)				
CO_2e	345.00	221.20	127.89	100.41
NOx	0.17	0.03	0.67	0.24
$PM_{2.5}$	0.01	0.01	0.02	0.01
VOCs	0.03	0.01	0.99	0.37
Transit Vehicles (buses)				
CO_2e	1355.20	1314.89	151.09	148.52
NOx	2.43	1.20	0.01	0.01
$PM_{2.5}$	0.06	0.03	0.01	0.00
VOCs	0.14	0.05	0.27	0.23
Vanpool (Passenger Trucks + Light-duty Trucks)				
CO_2e	400.17	262.85	145.07	114.66
NOx	0.22	0.03	0.75	0.24
$PM_{2.5}$	0.01	0.01	0.02	0.01
VOCs	0.04	0.01	1.02	0.35

Table 4-6. NESCAUM Connecticut Statewide Emission Rates

Emissions	g/mi		g/start	
	Base Year (2020)	Future Year (2040)	Base Year (2020)	Future Year (2040)
Auto (Motorcycles + Passenger Cars + Passenger Trucks)				
CO_2e	338.86	216.53	129.32	101.59
NOx	0.17	0.03	0.67	0.24
$PM_{2.5}$	0.01	0.01	0.02	0.01
VOC	0.03	0.01	1.01	0.38
Transit Vehicles (buses)				
CO_2e	1334.11	1289.65	152.11	149.53
NOx	2.39	1.17	0.01	0.01
$PM_{2.5}$	0.05	0.03	0.01	0.00
VOC	0.13	0.05	0.27	0.23
Vanpool (Passenger Trucks + Light-Duty Trucks)				
CO_2e	392.63	256.91	146.62	115.92
NOx	0.22	0.03	0.75	0.25
$PM_{2.5}$	0.01	0.01	0.02	0.01
VOC	0.04	0.01	1.03	0.36

4.5. Scenario Results

Table 4-7 provides the cumulative percent VMT and emission changes from the BAU for light-duty vehicles.

Table 4-7. NESCAUM Percent Change in VMT and Emissions for 2040 BAU Compared to 2040 Scenario

Scenario	Light Duty VMT	CO_2e	$PM_{2.5}$	NOx	VOC
Scenario 1: Commuter Rail Improvements	−0.40%	−0.40%	−0.40%	−0.41%	−0.42%
Scenario 2: Scenario 1 + Local Bus Improvements	−0.95%	−0.95%	−0.95%	−0.98%	−1.00%
Scenario 3: Scenario 2 + Smart Growth Land Use	−1.18%	−1.18%	−1.17%	−1.16%	−1.14%
Scenario 4: Scenario 3 + VMT Pricing	−5.42%	−5.44%	−5.45%	−5.54%	−5.64%

Table 4-8 and Table 4-9 provide the regionwide cumulative reduction in VMT and emissions from the 2015 Baseline and 2040 BAU.

Table 4-8. NESCAUM VMT and Emission Changes by Scenario Relative to 2040 BAU

Scenario	2040 BAU to 2040 Scenario				
	Light Duty VMT	CO_2e (kg)	$PM_{2.5}$ (kg)	NOx (kg)	VOC (kg)
Scenario 1: Commuter Rail Improvements	−361,742	−82,888	−3	−22	−20
Scenario 2: Scenario 1 + Local Bus Improvements	−857,065	−196,385	−7	−51	−48
Scenario 3: Scenario 2 + Smart Growth Land Use	−1,068,241	−243,451	−8	−60	−55
Scenario 4: Scenario 3 + VMT Pricing	−4,919,398	−1,125,891	−38	−290	−269

Table 4 9. NESCAUM Travel and Emission Changes by Scenario Relative to 2015 Baseline

Scenario	2015 Baseline to 2040 Scenario				
	Light Duty VMT	CO_2e (kg)	$PM_{2.5}$ (kg)	NOx (kg)	VOC (kg)
Scenario 1: Commuter Rail Improvements	9,835,067	−7,841,461	−234	−14,424	−7,151
Scenario 2: Scenario 1 + Local Bus Improvements	9,339,743	−7,954,957	−238	−14,453	−7,179
Scenario 3: Scenario 2 + Smart Growth Land Use	9,128,568	−8,002,023	−240	−14,463	−7,186
Scenario 4: Scenario 3 + VMT Pricing	5,277,411	−8,884,463	−270	−14,692	−7,400

The most comprehensive scenario, Scenario 4, would reduce VMT and emissions of each major pollutant in Connecticut by 5–6%. Most of those reductions were attributed to the VMT pricing strategy, which made up the difference in performance between Scenarios 3 and 4.

These results were compared to results from previous TEAM case studies. Table 4-10 compares the VMT reductions from NESCAUM's individual strategies to the range of VMT reductions projected for other regions with similar strategies.

Table 4-10. NESCAUM Comparison of Strategy VMT Reductions with Previous Case Studies

Strategy	% Light Duty VMT NESCAUM	Comparison Strategy Category	Previous Results for Comparison Category		
			Min.	Avg.	Max.
Commuter Rail Improvements	0.40%	Transit improvements	0.02%	0.41%	1.42%
Local Bus Improvements	0.55%	Transit improvements	0.02%	0.41%	1.42%
Smart Growth Land Use	0.23%	Land use	0.16%	2.70%	6.43%
VMT Pricing	4.25%	Road pricing	3.83%	6.70%	9.56%

NESCAUM's four strategies all produce results within the range previously observed.

Both the transit strategies, Commuter Rail Improvements and Locus Bus Improvements, had results near the average previously observed for transit improvements. This is an indication of strategies that provide meaningful improvements to transit for a significant part of the state's population, even though most residents of the state live outside the affected areas.

The land use strategy NESCAUM selected resulted in reductions near the low end of the range. Reductions were low due to a relatively small (4%) increase in gross population density and no increase in land use mixing. Importantly, analyzing an increase in job accessibility was not possible because of data limitations. If job accessibility had been included in the analysis, the resulting VMT reduction would have been higher. The land use strategy also was not applied to the entire case study area, as land use strategies have generally been in the past.

NESCAUM's VMT pricing strategy would increase driving costs by $0.05 per mile, a typical value found in previous case studies. Accordingly, the results here are well within the previously observed range.

4.6. Transit VMT and Emissions

As discussed in Section 1.5.3, shifting travel from light-duty vehicles to transit can increase transit VMT and associated emissions. The results presented above in Table 4-7, Table 4-8, and Table 4-9 only include reductions in trips, VMT, and emissions for light-duty vehicles to retain consistency with and to allow comparison to previous TEAM analyses.

The commuter train and bus improvements components of Scenario 1 and 2, respectively, were based on reduced wait and travel times. Headway and trip time reductions were assumed to be achieved by increasing the number of transit vehicles, and thus route miles traveled along a given route. For example, a reduction in headways from 20 minutes to 10 minutes implies that twice as many transit vehicles are running the route each hour. Therefore, we would assume that route miles are doubled. The reduced headways in the scenarios would require an increase of 67% in transit route miles over the

BAU for both buses and rail. Using this approach, future-year BAU and scenario VMT was estimated from base-year VMT. Bus and rail VMT estimates and emission rates were used to calculate the total annual emissions related to these transit strategies. The resultant increases in transit-related VMT and emissions are provided in Table 4-10.

Table 4-10. NESCAUM Transit Vehicle Percent VMT and Emissions Increases from BAU

Strategies	Transit VMT	CO_2e (kg/day)	$PM_{2.5}$ (kg/day)	NOx (kg/day)	VOC (kg/day)
Commuter Train + Local Bus Improvements	66.7%	163,149	1	50	2

Additional details on the methodology for calculations in Table 4-10 are provided in Section 4.7.

4.7. Additional Transit Analysis Details

Estimating the VMT and emission impacts of the transit strategies presented a challenge due to the number of transit agencies and differing transit vehicles and fuels operating in the New York - New Haven transit corridor. The following agencies and associated transit modes operate in the corridor:

- Metro-North Commuter Railroad Company: commuter rail
- Connecticut Department of Transportation – CT Transit New Haven Division: bus
- Connecticut Department of Transportation – CT Transit Stamford Division: bus
- The Greater New Haven Transit District: bus
- Norwalk Transit District: bus
- The Greater New Haven Transit District: bus
- Connecticut Department of Transportation – CT Transit Waterbury: bus
- Greater Bridgeport Transit Authority: bus
- Housatonic Area Regional Transit: bus
- Milford Transit District: bus

For transit VMT, vehicle mileage data was collected from the Service Database in 2016 National Transit Database for the transit agencies and modes listed above, except for the Metro-North commuter rail miles. To estimate annual rail vehicle miles traveled, weekday and weekend Metro-North timetables for the New Haven Line were reviewed. The total number of trips and distance between stops were used to calculate weekly train miles within Connecticut (up to the Greenwich rail stop). Weekly miles were multiplied by 52 to estimate total annual Metro-North-New Haven Line train miles.

For criteria pollutants ($PM_{2.5}$, NOx, and VOC), region-specific base-year emission rates for each agency were developed using MOVES2014a. For GHGs, CO_2 emission rates were estimated using the fuel consumption data collected from the transit agency. Total fuel consumed by fuel type was multiplied by the emission factor for that fuel type to estimate the total CO_2 emitted when that fuel is consumed. Fuel emission factors (kg CO_2 per unit of fuel consumed) were compiled from EPA's Mandatory Reporting of Greenhouse Gases Final Rule documentation.[32] Total CO_2 emissions were divided by the

[32] Mandatory Reporting of Greenhouse Gases; Final Rule, 74 FR 56259, October 30, 2009, Tables C-1 and C-2. Table of Final 2013 Revisions to the Greenhouse Gas LNG sourced from: EPA (2008) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance – Direct Emissions from Mobile Combustion Sources, Table B-5.

transit VMT to estimate an average base-year CO_2 emission rate (kg CO_2/mile). This approach was used for all liquid or gaseous fuels consumed in transit vehicles.

However, Metro-North commuter trains use some electricity for vehicle propulsion. To estimate the average CO_2 emission rate for these trains, the regional electricity emission rate (in lbs. CO_2-equivalent per megawatt hour) was obtained from the 2014 EPA eGRID (Emissions & Generation Resource Integrated Database); the electricity emission rate for the Northeast Power Coordinating Council New England region (1,072.6 lbs. CO_2-e/MWh) was used for NESCAUM estimates.[33] This emission rate was then multiplied by the total electricity consumed for Metro-North commuter rail propulsion reported in the National Transit Database to estimate electricity-related CO_2 emissions. This emissions value was combined with the CO_2 emissions from commuter rail diesel and divided by the total train VMT reported in the National Transit Database to estimate the average emission rate.

[33] E. H. Pechan & Associates., Inc. The Emissions & Generation Resource Integrated Database (eGRID) for 2016 Technical Support Document. U.S. Environmental Protection Agency, Washington, D.C., 2010. Available at: https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

5. Puget Sound, Washington – Puget Sound Clean Air Agency

5.1. Background

The Puget Sound Clean Air Agency (PSCAA) is a local air agency based in Seattle, Washington with a jurisdiction that includes King, Kitsap, Pierce, and Snohomish Counties and all the cities and unincorporated areas therein. The agency represents roughly four million residents, approximately half the state's population. In 2014, the PSCAA Board of Directors adopted a strategic plan with the challenge to become the most climate-friendly region in the United States.[34] The strategies and targets within this plan were the basis of the Agency's letter of interest to be a TEAM case study area.

The initiatives in the 2014 to 2020 Strategic Plan necessitate significant actions by the Agency to meet climate targets. Roughly half the region's GHG emissions are from transportation sources, so PSCAA has chosen to focus on this sector. The health impacts of near-road pollution and exposures and existing congestion issues, coupled with likely dramatic growth in upcoming decades, further support this focus.

The PSCAA Board of Directors and other partners are committed to discussing and prioritizing potential transportation strategies, to achieve 2030 interim targets and strengthen 2050 targets. Agency staff wanted to develop an in-house, simple modeling approach for use in rapid evaluation of proposed scenarios and the associated uncertainties. A common area of concern regarding GHG emission inventories is consistent methodology and assumptions. TEAM is potentially a useful resource in supporting these interests.

PSCAA routinely works closely with regional partners, many of whom serve on the Agency's Advisory Council and Board of Directors. Some of these partners helped develop GHG reduction strategies and provided data for the TEAM analysis. The region's travel demand model, developed and maintained by the Puget Sound Regional Council (PSRC), covers the entirety of the four counties. Both PSRC and the Washington State Department of Ecology provided strategy analysis support with travel activity, population, and MOVES data.

5.2. Scenario Development

Four strategies supportive of the PSCAA Strategic Plan were selected for evaluation in the four-county Puget Sound Region:

- Expand the regional Commuter Trip Reduction Program
- Expand eligibility for transit subsidies and free transit for target populations
- Use Regionwide VMT pricing
- Use Smart growth land use

As in other case study areas, the TEAM approach combined the selected strategies of interest to develop several scenarios. This approach allowed the agency to observe the cumulative effect of strategies over time. The details of each strategy within the scenarios are provided below.

[34] "Strategic Plan 2014 – 2020.", Puget Sound Clean Air Agency, 17 Feb. 2015, www.pscleanair.org/DocumentCenter/View/445/2014-to-2020-Strategic-Plan-PDF.

5.2.1. Scenario 1 – Expand Commute Trip Reduction Program

This scenario would expand the region's successful Commute Trip Reduction (CTR) program to cover additional employees. In the Puget Sound region, approximately 25% of employees work for employers having 100 or more employees and therefore are covered under the CTR program. The CTR program provides financial incentives and support for the employees in using modes of transportation to work other than driving alone.

This policy would expand the applicability of the CTR program to employers that have 50 or more employees. As a result, it brings an additional 5% of regional employees (projected at 156,385 in 2040) under the CTR program.

This policy was analyzed in TRIMMS by inputting the number of new employees that would qualify for the CTR program (156,385) and selecting the following Transportation Demand Management (TDM) program options in the model, all of which are part of the CTR program:

- Program subsidies for carpool, transit, vanpool, bike, and walk
- Carpool matching service
- Emergency ride home
- Flexible work arrangements
- Telecommute work (telework) arrangements

5.2.2. Scenario 2 – Scenario 1 + Expand Access to Free Transit within Environmental Justice/Low-Income Populations

This scenario would add a strategy that expands on the existing One Regional Card for All (ORCA) Lift transit pass, which provides reduced fare transit in the Puget Sound region to approximately 5% of the region's population. This strategy would bolster that program in two ways:

- Make an additional 3.5% of the region's population eligible (169,000 people in 2040) for a total of 390,000 people
- Make transit free (instead of reduced fare) for the eligible populations

This strategy was analyzed in TRIMMS using two separate model runs for:

1. The 5% of the population who are already eligible for ORCA Lift and will see the fares reduced to zero
2. The 3.5% of the population who will be newly eligible for ORCA Lift

PSCAA provided all population and cost information for developing this scenario. For the first model run, a population of 220,868 (approximately 5% of the regional population) was input. Table 5-1 shows the pricing parameters as input to TRIMMS—a current trip cost on transit of $1.50 and a new trip cost of zero.

Table 5-1. PSCAA TRIMMS Input: Financial and Pricing Strategies for 1st Run (costs per person)

Mode	BAU Trip Cost	Strategy Parking Cost	BAU Trip Cost	Strategy Trip Cost
Public Transport	–	–	$1.50	$0.00

For the second model run, a population of 168,726 was input. Table 5-2 below shows the pricing parameters as input to TRIMMS—a current trip cost on public transit of $2.97 per trip and a new trip cost of zero.

Table 5-2. PSCAA TRIMMS Input: Financial and Pricing Strategies for 2nd Run (costs per person)

Mode	BAU Trip Cost	Strategy Parking Cost	BAU Trip Cost	Strategy Trip Cost
Public Transport	–	–	$2.97	$0.00

5.2.3. Scenario 3 – Scenario 2 + VMT Pricing

The Puget Sound region is unusual in that the MPO is already exploring VMT pricing in the update of its LRTP. An approximate charge of $0.10 per mile is included in the peak hour assumptions for the 2040 BAU in the MPO's Draft Regional Transportation Plan 2018.[35]

This scenario would increase VMT pricing $0.05 per mile for all light-duty vehicle travel in the region, from $0.10 per mile envisioned in the LRTP to $0.15 per mile. This policy was modeled in TRIMMS by entering the average driving trip cost with a $0.10 charge to represent the BAU, and the average driving trip cost with a $0.15 charge to represent the strategy. To estimate the average driving trip cost, the following input data were used:

1. Average trip length – PSCAA supplied average trip lengths for drive-alone, rideshare, and vanpool trips, which were provided by PSRC using the regional travel demand model.
2. Operating driving cost – The per-mile driving cost data were collected from the American Automobile Association's 2017 Your Driving Costs publication.[36] The American Automobile Association annually publishes estimates for passenger vehicle ownership and operating costs. For this analysis, the operating cost for medium sedans was used as a representative commute vehicle.
3. VMT price – The VMT prices were added to the variable cost to estimate the total variable cost of driving in the BAU and strategy analyses ($0.10 for BAU and $0.15 for the strategy).
4. Average vehicle occupancy – Average occupancy for driving trips was provided by PSRC using their regional travel demand model.

The average roundtrip length was multiplied by the total variable driving cost (including the BAU VMT price and strategy VMT price) and divided by the average occupancy to estimate the daily trip cost under the BAU and strategy scenarios. These costs were input into TRIMMS to model the impact of the higher pricing strategy. Table 5-3 shows the per-trip costs as input into TRIMMS.

Table 5-3. PSCAA TRIMMS Input: Financial and Pricing Strategies (costs per person)

Mode	BAU Parking Cost	Strategy Parking Cost	BAU Trip Cost	Strategy Trip Cost
Auto-Drive Alone	–	–	$3.88	$4.60
Auto-Rideshare	–	–	$1.29	$1.53

[35] On May 31, 2018, this draft plan was adopted by the MPO. Puget Sound Regional Council, Regional Transportation Plan, 2018. The final plan also includes the $0.10 per mile peak user fee.
[36] Your Driving Costs, American Auto Association, https://exchange.aaa.com/automotive/driving-costs/

5.2.4. Scenario 4 – Scenario 3 + Smart growth land use

Scenario 4 adds a policy that would increase densities and land use mixing in the Puget Sound region. PSCAA did not have access to detailed land use data by traffic analysis zone (TAZ) in the region's travel demand model. So, unlike other case study regions, this analysis did not vary BAU and strategy inputs by TAZ. Typically, the TEAM land use analysis involves calculating weighted regional averages of land use variables based on TAZ-level data. In this case, PSCAA simply provided input in the form of a percentage increase in each variable at the regional level.

PSCAA provided the specific input for percent change for all the following "D" variables:

- Population density: +50%
- Job accessibility by auto (within 30 minutes): 3%
- Job accessibility by transit (within 30 minutes): 60%
- Distance to nearest transit stop: −15%
- Land use mixing: +5%

Note that PSCAA's inputs are interpreted by the agency as an intensification of the BAU land use scenario in the PSRC LRTP and were provided without quantifying the BAU scenario in terms of the D variables. An important note is that the feasibility of these assumptions is unknown because PSCAA's regional land use scenario is not constructed from land use changes in individual TAZs. In addition, the percentage changes specified are regional averages, and some individual TAZs would experience greater or lesser changes than those averages.

5.3. Scenario Summary

Input parameters are provided in Table 5-4 for current conditions in the 2014 baseline year, a 2040 BAU future, and the four scenarios selected by PSCAA. Specific input values are provided for the scenarios.

Table 5-4. PSCAA Scenario Details

Scenario	Description	Data Inputs
Current Conditions	Existing conditions across all strategies in 2014	Region profile: • population – 3,745,413 • jobs – 1,945,129 Mode shares: • auto, drive alone – 39.4% • auto, rideshare – 38.2% • transit – 3.1% • bike – 1.7% • walk – 15.4% • Other – 2.2% Average vehicle occupancy, auto rideshare – 2.5 Average vehicle trip lengths, one-way (miles): • auto, drive alone – 7.70 • auto, rideshare – 6.20 Trip Cost ($/mi) • auto, drive alone – 1.61 • auto, rideshare – 0.57
Business as Usual (BAU)	2040 conditions with	Region profile:

Scenario	Description	Data Inputs
	current levels of Transportation Demand Management, reduced transit fare programs, and no VMT pricing	• population – 4,853,061 • jobs – 2,981,034 Mode shares: • auto, drive alone – 37.3% • auto, rideshare – 35.5% • transit – 4.4% • bike – 2.0% • walk – 18.8% • Other – 2.0% Average vehicle occupancy, auto rideshare – 2.5 Average vehicle trip lengths, one-way (miles): • auto, drive alone – 7.20 • auto, rideshare – 6.20 Trip Cost ($/mi) • auto, drive alone – 2.64 • auto, rideshare – 0.95
Scenario 1: Expand Commute Trip Reduction (CTR) Program	Expand the existing CTR program to cover employers with 50 or more employees	Mode shares for current CTR-covered employers
Scenario 2: Scenario 1 + Expand access to free transit within EJ/low-income populations	Make reduced fare transit free transit and expand eligibility among environmental justice/low-income populations	Affected population – 390,000 people eligible in 2040
Scenario 3: Scenario 2 + VMT Pricing	Add 5 cents per mile to the potential 10 cents per mile charge being explored currently by regional stakeholders	Trip Cost ($/mi): • auto – +0.15
Scenario 4: Scenario 3 + Smart growth land use	Increase population densities, land use mixing, job accessibility, and reduce distances to transit	Land use (Corridor TAZs change from 2040 BAU): • population density – +50% • jobs access by auto – +3% • Jobs access by transit - +60% • Distance to transit – -15% • Land use mix – +5%

5.4. Emissions Analysis

In TEAM, the MOVES analysis focuses on generating activity-weighted, regional average emission rates from the model that represent the general parameters of the study region. PSRC provided individual county- and year-specific run specification files and input databases that were used for the TEAM MOVES analysis. This data, created for the LRTP update, represents the most recent modeling data for the PSCAA region. PSRC's travel demand model provided parameters for BAU mode shares, trip lengths, and trip costs by mode. The model predicts a decrease in driving mode share from 2014 to 2040. The model also predicts a slight decrease in average driving distances. Data were available for the emissions analysis, consistent with the region's conformity analysis for the LRTP update.

PSRC also uses default values for population and VMT as inputs to the model and uses the same values for both existing and future years. This approach is adequate for the emissions rate approach in MOVES simulations, which does not depend on the population and VMT input values. Therefore, PSRC did not provide the county- and vehicle type-resolved VMT and population values typically used for the TEAM approach. Accordingly, all TEAM simulations for PSCAA were made using the VMT and population data provided by PSRC without change. The inspection and maintenance program was not included in the modeling, consistent with previous TEAM case studies, to enable comparisons of the results. The resulting emission rates are shown in Table 5-5.

Table 5-5. PSCAA Emission Rates

Emissions	g/mi		g/start	
	Base Year (2014)	Future Year (2040)	Base Year (2014)	Future Year (2040)
Auto (Motorcycles + Passenger Cars + Passenger Trucks)				
GHGs (CO_2-equivalent)	409.52	227.16	149.60	101.84
NOx	0.72	0.06	1.54	0.27
$PM_{2.5}$	0.02	0.01	0.03	0.01
VOCs	0.16	0.01	2.13	0.38
Transit Vehicles (buses)				
GHGs (CO_2-equivalent)	1434.16	1312.69	164.08	163.90
NOx	6.54	1.29	0.02	0.01
$PM_{2.5}$	0.14	0.03	0.01	0.00
VOCs	0.54	0.07	0.35	0.21
Vanpool (Passenger Trucks + Light-duty Trucks)				
GHGs (CO_2-equivalent)	484.31	270.14	176.78	115.80
NOx	1.07	0.07	2.04	0.29
$PM_{2.5}$	0.02	0.01	0.04	0.01
VOCs	0.24	0.01	2.85	0.39

5.5. PSCAA Scenario Results

Table 5-6 provides the cumulative percent change for VMT and emission from the BAU for light-duty vehicles.

Table 5-6. PSCAA Percent Change in VMT and Emissions for 2040 BAU Compared to 2040 Scenario

Scenario	Light Duty VMT	CO_2e	$PM_{2.5}$	NOx	VOC
Scenario 1: Expand CTR Program	−0.09%	−0.10%	−0.10%	−0.10%	−0.10%
Scenario 2: Scenario 1 + Expand access to free transit within EJ/low-income populations	−1.87%	−1.89%	−1.91%	−2.00%	−2.17%
Scenario 3: Scenario 2 + VMT Pricing	−5.11%	−5.16%	−5.21%	−5.44%	−5.86%
Scenario 4: Scenario 3 + Smart growth land use	−11.91%	−11.82%	−11.71%	−11.28%	−10.49%

Table 5-7 and Table 5-8 provide the regionwide cumulative reduction in VMT and emissions from the 2040 BAU and 2014 Baseline, respectively.

Table 5 7. PSCAA Travel and Emission Changes by Scenario Relative to 2040 BAU

Scenario	2040 BAU to 2040 Scenario				
	Light Duty VMT	CO_2e	$PM_{2.5}$	NOx	VOC
Scenario 1: Expand CTR Program	−92,586	−22,284	−0.7	−8.8	−5.7
Scenario 2: Scenario 1 + Expand access to free transit within EJ/low-income populations	−1,830,816	−442,901	−14.8	−179.4	−121.4
Scenario 3: Scenario 2 + VMT Pricing	−4,991,474	−1,206,800	−40.3	−487.3	−328.2
Scenario 4: Scenario 3 + Smart growth land use	−11,635,384	−2,765,817	−90.6	−1,010.2	−588.1

Table 5 8. PSCAA Travel and Emission Changes by Scenario Relative to 2014 Baseline

Scenario	2014 Baseline to 2040 Scenario				
	Light Duty VMT	CO_2e	$PM_{2.5}$	NOx	VOC
Scenario 1: Expand CTR Program	16,935,817	−11,036,988	−718	−63,684	−26,699
Scenario 2: Scenario 1 + Expand access to free transit within EJ/low-income populations	15,197,588	−11,457,605	−732	−63,854	−26,815
Scenario 3: Scenario 2 + VMT Pricing	12,036,930	−12,221,504	−758	−64,162	−27,022
Scenario 4: Scenario 3 + Smart growth land use	5,393,019	−13,780,521	−808	−64,685	−27,282

The most comprehensive scenario, Scenario 4, was estimated to reduce VMT and emissions of each major pollutant by 10–12%. Most of these reductions are attributed to the smart growth land use strategy, which makes up the difference in performance between Scenarios 3 and 4.

The results of this case study were compared to previous TEAM case studies. Previous case studies analyzed strategies similar to those selected by PSCAA. Table 5-9 compares the VMT reductions from PSCAA's individual strategies to the range of reductions projected for other similar strategies.

Table 5-8. PSCAA Comparison of VMT Reductions Strategies and Previous Case Studies

Strategy	% Light Duty VMT Reduction PSCAA	Comparison Strategy Category	Previous Case Study Results for Category		
			Min.	Avg.	Max
Expand CTR Program	−0.09%	Expanded Transportation Demand Management	−0.43%	−1.10%	−2.80%
Expand access to free transit within EJ/low-income populations	−1.78%	Transit pass	−0.99%	−1.16%	−1.33%
VMT Pricing	−3.24%	Road pricing	−3.83%	−6.70%	−9.56%
Smart growth land use	−6.80%	Land use	−0.16%	−2.70%	−6.43%

PSCAA's TDM strategy produced smaller reductions compared to previous analyses, largely due to the small population targeted in this TEAM analysis as compared to previous case studies. As stated previously, the Puget Sound region already has a successful CTR program covering employers with 100 or more employees, with almost 25% of the region's employees falling under the current program. The modeled strategy here would expand the program to cover 30% of regional employees. However, the 5% increase is smaller than the increase in TDM strategies analyzed in previous case studies.

The free transit pass strategy produced results above the previously observed range. The free transit pass strategy would affect nearly 10%, a relatively large proportion, of the regional population. Previous transit pass strategies analyzed in other case studies have applied to only about 5–6% of the regional population.

The VMT pricing strategy produced results slightly lower than the previously observed range. This is because this strategy represented an incremental increase on an assumed charge of $0.10 per mile that is already included in the Draft Regional Transportation Plan 2018, and which is considered part of the BAU scenario. As a result, increasing the charge from $0.10 to $0.15 had less influence on travel behavior than increasing the charge from zero to $0.05, as most other case studies have done.

PSCAA's land use strategy produces results slightly above the range of previous results. This outcome is not unexpected because PSCAA specified changes in the D variables that were more aggressive than other regions have done in the past.

The unique approach to producing land use inputs in this case study, described in Section 1.5, resulted in ambitious assumptions about land use across the entire region. In previous case studies, agencies have generally considered the potential for land use changes on a TAZ-by-TAZ basis. The PSCAA analysis was based on an aspirational regional average change, without consideration of the feasibility in individual TAZs.

5.6. Transit VMT and Emissions

As discussed in section 1.5.3, shifting travel from light-duty vehicles to transit can increase transit VMT and associated emissions. However, the impacts on transit VMT resulting from Scenarios 1 and Scenario 2 for this case study were assumed to be negligible, given the robust scale and scope of the BAU transit system. In other words, the future transit system in the BAU case would be able to accommodate all the additional transit riders. Therefore, no additional analysis of future scenario transit emissions was necessary.

6. Results and Observations

6.1. Regional VMT and Emission Results

The analysis and results for each individual region were discussed in Sections 2 through 5 of this report. This section shows the relative cumulative regional VMT and emissions changes for all the regions in Table 6-1, and then provides an overview of the technical lessons learned in preparing for and conducting the analyses.

Table 6-1. Percent Regional VMT and Emission Changes from the Case Study Areas

Percent Regional Emissions Changes for Future Year Business as Usual compared to Future Year Scenario					
Scenario	**Light-Duty VMT**	**GHG (CO_2 equivalent)**	**$PM_{2.5}$**	**NOx**	**VOC**
CUUATS					
Scenario 1: Local Transit Hubs and Bus Improvements + Bicycle and Pedestrian Improvements	−2.96%	−3.39%	−4.35%	−5.59%	−7.48%
Scenario 2: Scenario 1 + Parking Pricing at the University	−3.23%	−3.66%	−4.63%	−5.87%	−7.77%
Scenario 3: Scenario 2 + Smart Growth Land Use	−7.87%	−8.18%	−8.86%	−9.74%	−11.09%
Scenario 4: Scenario 3 + High Speed Rail	−8.09%	−8.38%	−9.04%	−9.88%	−11.16%
IMCAL					
Scenario 1: TDM Program for Petrochemical Employees	−0.07%	−0.07%	−0.07%	−0.07%	−0.07%
Scenario 2: Scenario 1 + Transit Improvement in North Lake Charles	−0.10%	−0.10%	−0.10%	−0.10%	−0.10%
Scenario 3: Scenario 2 + Parking Pricing in Downtown Lake Charles	−0.24%	−0.24%	−0.24%	−0.23%	−0.22%
Scenario 4: Scenario 3 + Smart Growth Land Use	−1.05%	−1.04%	−1.04%	−1.01%	−0.97%
NESCAUM					
Scenario 1: Commuter Rail Improvements	−0.40%	−0.40%	−0.40%	−0.41%	−0.42%
Scenario 2: Scenario 1 + Local Bus Improvements	−0.95%	−0.95%	−0.95%	−0.98%	−1.00%
Scenario 3: Scenario 2 + Smart Growth Land Use	−1.18%	−1.18%	−1.17%	−1.16%	−1.14%
Scenario 4: Scenario 3 + VMT Pricing	−5.42%	−5.44%	−5.45%	−5.54%	−5.64%
PSCAA					
Scenario 1: Expand Commute Trip Reduction Program	−0.09%	−0.10%	−0.10%	−0.10%	−0.10%
Scenario 2: Scenario 1 + Expand access to free transit within EJ/low-income populations	−1.87%	−1.89%	−1.91%	−2.00%	−2.17%
Scenario 3: Scenario 2 + VMT Pricing	−5.11%	−5.16%	−5.21%	−5.44%	−5.86%
Scenario 4: Scenario 3 + Smart growth land use	−11.91%	−11.82%	−11.71%	−11.28%	−10.49%

The range of results reflect the strategies and level of implementation envisioned by the partner agencies. As expected, the greatest reductions result from scenarios that represent a combination of strategies that are mutually supportive and apply to a significant portion of the regional population. Where strategies affect only a small subset of the regional population or only apply in a designated subarea of the region, the impacts were smaller in comparison.

It is important to note that the percent change in VMT and emissions shown in Table 6-1 are relative to the future year BAU case. If a strong program of travel efficiency strategies is already included in the LRTP for the region, the incremental addition or strengthening of strategies would result in modest changes compared to the BAU. Where a scenario represents an aggressive departure from the BAU and was applied broadly across the region, the reductions were more significant.

6.2. Observations and Lessons Learned

In each round of case studies, the application of TEAM for new strategies is based on the interests and capabilities of the partner agencies, and when necessary, new methods for assessing strategies can be developed. In this round of case studies, the interests of the partner agencies presented an opportunity to develop and test methods not previously considered with the TEAM approach. The new strategies and methods provide an opportunity to better understand the application and capabilities of TEAM and provide some lessons learned as detailed below.

6.2.1. Accessibility to Different Organizations

TEAM is accessible to a wide variety of organizations with varying degrees of topical and technical expertise. In past TEAM case studies, EPA partnered with larger organizations traditionally involved in transportation planning, such as MPOs or state DOTs. For this round of case studies, EPA partnered with an air quality agency (PSCAA), an air quality association (NESCAUM), and a smaller MPO (IMCAL). Both NESCAUM and PSCAA represent new types of partner agencies with a different set of core competencies and technical expertise. These organizations generally had less transportation data at their disposal. However, these organizations could still engage in the TEAM analysis with meaningful results. In some cases, the new partners coordinated with appropriate stakeholders. For example, NESCAUM worked closely with CTDOT and CTDEEP to gather the needed data. For IMCAL, surrogate data, such as data from various national datasets, were used to complete the work. EPA will continue to consider the applicability of national data sources when local data is not available. In short, TEAM has shown itself as a tool accessible to a variety of different organizations.

6.2.2.Flexibility of Strategy and Scenario Evaluation

TEAM is unique in its flexibility to explore an array of different travel efficiency strategies. Throughout the various case studies, partner agencies could select four future year scenarios for evaluation with each scenario comprised of one or more selected travel efficiency strategies of their choosing. In many instances, partners have suggested new strategies to evaluate in TEAM and we have developed methods to evaluate them. For example, this round of case studies included two agencies interested in rail strategies. CUAATS selected a high-speed rail strategy running from St. Louis to Chicago with a stop in Champaign-Urbana. NESCAUM explored a rail strategy that included potential improvements to reduce average travel times and shorter wait times on trains that serve the New York-New Haven corridor. Both strategies involved developing rail emission rates and ridership estimates that captured the travel activity and emissions that occur within the analysis area.

In previous rounds of case studies, we developed new methods to estimate VMT impacts of bicycle and pedestrian improvements, as well as evaluate land use changes. These methods were employed in this latest set of case studies as well.

Throughout the rounds of case studies, TEAM has been used to explore hypothetical "what-if" exercises, evaluate program level decisions, and been tested on numerous new strategy applications, yet, TEAM was flexible enough in each case to produce useful results.

6.2.3. Scalability of Affected Population and Geographic Area of Analysis

TEAM has been successfully used to evaluate the VMT and emission reduction benefits of strategies applied to a specific corridor, city or county, or entire state, and thus has been used to evaluate strategies targeted to a specific sub-population such as employees of specific industrial sector or people living along a specific corridor, as well as to a region's entire population. The analysis for the State of Connecticut, facilitated by NESCAUM, provided an opportunity to apply TEAM to a new geographic scale - an entire state. Previous TEAM case studies have focused on the MPO boundaries as the geographic scale of analysis, with some strategies applied to a sub-geography or to a sub-population within the region. The Connecticut-NESCAUM case study considered a state-wide analysis area, with a VMT pricing strategy applied state-wide and the remaining strategies applied in a defined transportation corridor extending from New York to New Haven. This involved developing separate travel data and weighted emission rates for each sub-geography. Though TEAM had not been previously applied at this geographic scale, the methodology was easily adapted. NESCAUM's case study paves the way for NESCAUM to apply the TEAM methodology to other states in its consortium, as well as for other states to consider applying travel efficiency strategies statewide.

6.3. Conclusion

These four case studies once again demonstrate the value of adopting travel efficiency strategies to reduce emissions of air pollutants. Federal regulations on vehicles and fuels have achieved great benefits, but when state and local agencies are looking to improve air quality further, the contribution of travel efficiency strategies cannot be overlooked. Of course, travel efficiency strategies have other benefits as well, such as reducing congestion and accidents.[37] EPA believes these case studies provide examples for other state and local agencies to consider to significantly reduce emissions.

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[37] See EPA, Potential Changes in Emissions Due to Improvements in Travel Efficiency – Supplemental Report: Analysis of Potential Co-Benefits, EPA-420-R-11-04, September 2011.