



## APT STANDARDS DEVELOPMENT PROGRAM **RECOMMENDED PRACTICE**

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Sustainability Metrics Working Group

# Quantifying and Reporting Transit Sustainability Metrics

**Abstract:** This *Recommended Practice* provides guidance for reporting and tracking key indicators of sustainability for transit agency signatories to the APTA Sustainability Commitment.

**Keywords:** APTA Sustainability Commitment, sustainability metrics, sustainability reporting, energy use, water usage, air pollutant emissions, greenhouse gas emissions, greenhouse gas savings, vehicle miles traveled, recycling, operating expense, unlinked passenger trips

**Summary:** Sustainability is core to the mission of the transit industry. Transit agency signatories to the APTA Sustainability Commitment are required to quantify and annually report on a series of key performance indicators and to track performance against each metric over time. The APTA Standards Development Program created the Sustainability Metrics Working Group to provide technical assistance and guidance for transit agencies to report against these metrics. The Working Group created this *Recommended Practice* to develop a unified resource and tool for this reporting process. Its guidance reflects a basic framework and approach for quantifying each metric with examples, and provides a menu of alternative normalization factors from which to choose. The Working Group recommends that transit agencies select normalization factors that are context sensitive and best “tell the story” by representing each agency’s unique operating conditions. This *Recommended Practice* will remain a living document to serve as a repository for data and information as new and innovative quantification and reporting practices emerge.

This *Recommended Practice* represents a common viewpoint of those parties concerned with its provisions, namely, transit operating/planning agencies, manufacturers, consultants, engineers and general interest groups. The application of any standards, practices or guidelines contained herein is voluntary. In some cases, federal and/or state regulations govern portions of a transit system’s operations. In those cases, the government regulations take precedence over this standard. APTA recognizes that for certain applications, the standards or practices, as implemented by individual transit agencies, may be either more or less restrictive than those given in this document.

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# Quantifying and Reporting Transit Sustainability Metrics

## 1. Introduction

### 1.1 APTA Sustainability Commitment

The APTA Sustainability Commitment ([www.apta.com/resources/hottopics/sustainability/Documents/APTA-Sustainability-Commitment.pdf](http://www.apta.com/resources/hottopics/sustainability/Documents/APTA-Sustainability-Commitment.pdf)) is designed to give transit agency signatories credit for their efforts to identify sustainability as a strategic objective, to increase the sustainability of their own organizations, and to serve as a leader in sustainability agendas in their constituent communities. Signatories are asked to measure and communicate on the results of these actions on an annual basis. The commitment establishes nine performance metrics for transit agencies to report:

- Water usage and pollutant discharge
- Criteria air pollutant emissions
- GHG emissions
- GHG savings
- Energy use
- Recycling levels/waste
- Operating expense
- Unlinked passenger trips
- Vehicle miles traveled

For recognition, the commitment requires signatories to establish a baseline and to track progress against each of these indicators on an annual basis.

The Working Group recommends supplementing the environmentally focused metrics included in the initial version of the Sustainability Commitment with social and economic sustainability metrics in subsequent versions. For a more complete discussion on this topic, please see Section 4.

### 1.2 APTA Standards Sustainability Metrics Working Group

The APTA Standards Development Program, which exists to develop, implement and maintain standards, recommended practices and design guidelines to achieve safety, reliability and efficiency in transit system design and operation, created the Sustainability Metrics Working Group (“Working Group”) to provide technical assistance and guidance for reporting against these metrics. The Working Group has two complementary goals:

- **Goal 1:** To develop standards for all signatories, large and small, to use in quantifying and reporting against APTA Sustainability Commitment performance metrics, establishing initial guidance and eventually recommended practices for identifying and measuring sustainability metrics.
- **Goal 2:** To build a robust system of support for all signatories to use the standards, through publications, online tools and interactive communications.

### 1.3 Purpose of this *Recommended Practice*

This document represents the Working Group’s attempt to develop a unified resource for transit agency signatories to reference in measuring and communicating on the results of their sustainability initiatives. This *Recommended Practice* reflects prevalent practices among current transit agency signatories, which were surveyed during the document’s development. It is the Working Group’s intention that this *Recommended Practice* remain a living document to serve as a repository for data and information as new and innovative reporting practices emerge.

The Working Group concedes that the wide variety of transit agency signatories, both in terms of diversity and scale of operations, belies true standardization of metrics. To the extent possible, the practices recommended in this document reflect a “lowest common denominator” approach to quantification methodologies to ensure its guidance is accessible and applicable to all sizes and types of agencies. As such, the Working Group has sought to respect the inherent differences that exist between signatories by providing a requisite level of flexibility, while at the same time constructing basic and consistent methodological approaches that comport with other performance measures being reported across the industry.

The Working Group encourages transit agencies with the additional resources and capacity or whose operating characteristics and service conditions may be inherently different from the fundamental assumptions presented in each of the metrics to elaborate upon these “basic” approaches with more nuanced methodologies that more closely reflect the uniqueness of their organization. The spirit of the APTA Sustainability Commitment is one of self-assessment and continual improvement. Signatories should not use this *Recommended Practice* for inter-agency comparisons. Rather, all signatories should use its guidance to develop metrics that measure progress in a meaningful way for each individual agency.

### 1.4 Value of reporting

Sustainability is core to the mission of the transit industry. The APTA Sustainability Commitment calls for signatories to establish systems and actions that demonstrate the value of transit in achieving broader sustainability objectives and a basis for ensuring continual improvement. Sustainability performance measurements are an essential tool to fulfill both of these important objectives.

Performance measurement is not new to the transit industry. Historically, agencies have used metrics as a part of service planning and project development. But the emphasis in recent years to incorporate environmental, social and economic sustainability into decision-making processes has driven an increased demand for performance measurement into the realm of sustainability planning.

According to the U.S. EPA’s “Guide to Sustainable Transportation Performance Measures”:

More and more agencies have begun to measure the ability of their systems to help protect natural resources, improve public health, strengthen energy security, expand the economy, and provide mobility to disadvantaged people. ... Many agencies have found that, once they begin to report sustainable transportation performance measures, stakeholders quickly see their value and come to expect regular reporting of measures and more explicit linkages between the measures and public agency decisions.

**NOTE:** See the EPA’s “Guide to Sustainable Transportation Performance Measures.”  
[www.epa.gov/smartgrowth/pdf/Sustainable\\_Transpo\\_Performance.pdf](http://www.epa.gov/smartgrowth/pdf/Sustainable_Transpo_Performance.pdf).

## 1.5 APTA sustainability resources

This document complements a continuum of documents created under the APTA sustainability umbrella to support the development of sustainability plans and programs at member agencies. Other APTA-sponsored sustainability guidance documents include the following:

- **“Quantifying Greenhouse Gas Emissions from Transit”**: This *Recommended Practice* provides guidance to transit agencies for quantifying their greenhouse gas emissions, including both emissions generated by transit and the potential reduction of emissions through efficiency and displacement by laying out a standard methodology for transit agencies to report their greenhouse gas emissions in a transparent, consistent and cost-effective manner.
- **“Compendium of Transit Sustainability Practices”**: The guidelines introduced in this document are designed to address transit practices that will lead to realization of the following sustainability objectives:
  - improving mobility via improved and enjoyable transit services;
  - reducing per capita automobile vehicle miles traveled;
  - reducing passenger transportation-generated carbon dioxide (CO<sub>2</sub>) and other greenhouse gases, creating livable communities through facilitating more environmental friendly forms of mobility such as walking, biking and public transit;
  - increasing the number of routine destinations that are accessible safely and comfortably by walking, biking and public transit;
  - reducing passenger transportation-caused ambient hazards, such as noise, particulates in the air, vibration, physical threats and mental stress to the public in general and particularly to pedestrians; and
  - reducing stress, loss of productivity, traffic deaths and injuries and related health-care costs caused by automobile travel.
- **“Transit Sustainability Guidelines”**: This *Recommended Practice* introduces guidelines for designing and operating sustainable transit that both reduces a community’s environmental footprint from transportation and enhances its quality of life by making travel more enjoyable, affordable and timely.
- **“Guidelines for Climate Action Planning”**: This *Recommended Practice* presents reasons why agencies should undertake climate action planning, lays out a framework for approaching such planning and discusses considerations to keep in mind as an agency goes through the planning process.

Additional sustainability resources for the transit industry are available at [www.apta.com/sustainability](http://www.apta.com/sustainability).

## 1.6 Summary tables

The APTA Sustainability Commitment requires signatories to develop a sustainability inventory of their organization based on nine performance metrics to be reported on an annual basis. An overview of each metric is provided in **Table 1**; an overview of potential normalization factors and recommended applications is provided in **Table 2**.

**TABLE 1**  
Performance Metrics

Water Usage & Pollutant Discharge	Criteria Air Pollutant Emissions
<p><b>Overview:</b> Measures metered use of potable water.  <b>Data needs:</b> Utility invoices, normalization factor.  <b>Summary calculation:</b>                      X = Water utility invoices                      A = Normalization factor (for normalization options by metric, see <b>Table 2</b>.)</p> <p style="text-align: center;"><b>Water Usage Per Unit = X/A</b></p> <p>The Working Group recommends against using pollutant discharge as a metric at this time.</p>	<p><b>Overview:</b> Measures criteria air pollutant emissions from mobile fleets; can also be used to estimate emissions avoided by transit.  <b>Data needs:</b> Inputs to and defaults from EPA Diesel Emissions Quantifier. Criteria air pollutants: nitrous oxides (NOx), particulate matter (PM), hydrocarbons (HC), carbon monoxide (CO).  <b>Summary calculation:</b>                      EPA Diesel Emissions Quantifier (available at: <a href="http://www.epa.gov/cleandiesel/quantifier/references.htm">www.epa.gov/cleandiesel/quantifier/references.htm</a>)</p>
Greenhouse Gas (GHG) Emissions	GHG Savings (Displacement)
<p><b>Overview:</b> Measures CO<sub>2</sub>-equivalent emissions from mobile and stationary sources.  <b>Data needs:</b> Utility invoices, National Transit Database (NTD) reports or comparable Canadian government data source, normalization factor.  <b>Summary calculation:</b>                      X = Stationary sources (building heat and electricity)                      Y = Mobile sources (diesel, gasoline, propulsion power)                      A = Normalization factor</p> <p style="text-align: center;"><b>GHG (CO<sub>2</sub>-Equivalent) Emissions = (X+Y)/A</b></p>	<p><b>Overview:</b> Measures the impact of transit on reducing greenhouse gases based on mode shift (omits other greenhouse gas (GHG) displacement impacts, such as congestion relief and transit-oriented land uses, which are available in the APTA <i>Recommended Practice</i> “Quantifying Greenhouse Gas Emissions from Transit”).  <b>Data needs:</b> NTD reports.  <b>Summary calculation:</b>                      X = Passenger miles traveled                      Y = Mode-shift factor                      Z = Average regional fuel economy</p> <p style="text-align: center;"><b>GHG (CO<sub>2</sub>-Equivalent) Displacement = (X × Y × 0.00881) / Z</b></p>
Energy Use	Recycling and Waste
<p><b>Overview:</b> Measures annual agency energy usage.  <b>Data needs:</b> Utility invoices, British Thermal Unit (BTU) conversion table, normalization factor.  <b>Summary calculation:</b>                      X = Energy type (electricity, diesel, gasoline, natural gas, heating oil, district steam)                      Y = Matching BTU conversion factor                      A = Normalization factor</p> <p style="text-align: center;"><b>Energy Usage (BTU) = [(X<sub>1</sub> × Y<sub>1</sub>) + (X<sub>2</sub> × Y<sub>2</sub>) + (X<sub>N</sub> × Y<sub>N</sub>)...] / A</b></p>	<p><b>Overview:</b> Measures municipal waste quantities and recycling diversion rates.  <b>Data needs:</b> Waste hauling invoices, normalization factor.  <b>Summary calculation:</b>                      X = Total waste tonnage                      Y = Recycled tonnage                      A = Normalization factor</p> <p style="text-align: center;"><b>Waste Generation = X / A</b>  <b>Recycling Generation = Y / A</b>  <b>Diversion Rate = Y / (X + Y)</b></p>

**TABLE 1**  
Performance Metrics

Operating Expense	Unlinked Passenger Trips
<p><b>Overview:</b> Compares relative efficiency of changes in agency operating expenditures (OpEx) by service mode to industry-wide OpEx by service mode.</p> <p><b>Data needs:</b> NTD reports (agency profile and national aggregate totals), normalization factor.</p> <p><b>Summary calculation:</b>                      X = Agency OpEx (by mode)                      Y = Industry OpEx (by mode)                      A = Normalization factor</p> <p style="text-align: center;"><b>Relative OpEx Efficiency =</b>  <math display="block">\frac{[\text{Year 2 } (X / A) - \text{Year 1 } (X / A)] / \text{Year 1 } (X / A)}{[\text{Year 2 } (Y / A) - \text{Year 1 } (Y / A)] / \text{Year 1 } (Y / A)}</math></p>	<p><b>Overview:</b> Number of times passengers board an agency-operated vehicle.</p> <p><b>Data needs:</b> NTD agency profile.</p> <p><b>Summary calculation:</b>                      X = Unlinked passenger trips                      Y = Population in service area</p> <p style="text-align: center;"><b>UPT Per Capita = X / Y</b></p>
Vehicle Miles Traveled	
<p><b>Overview:</b> Travel trends in the region served by the agency, as measured by daily vehicle miles traveled.</p> <p><b>Data needs:</b> Federal Highway Administration (FHWA) “Highway Statistics” publication, Section 4.4.5. Urbanized Area Summaries, Section 4.4.5.2. Selected Characteristics and Table HM-72</p> <p><b>Summary calculation:</b> Report the daily vehicle miles traveled per person for the federal-aid urbanized area served by the agency (available at <a href="http://www.fhwa.dot.gov/policyinformation/statistics">www.fhwa.dot.gov/policyinformation/statistics</a>) or comparable Canadian government data source.</p>	

**TABLE 2**  
Normalization Factors

Passenger Miles Traveled (PMT)	Vehicle Revenue Hours (VRH)
<p><b>What it is:</b> The cumulative sum of the distances ridden by each passenger.</p> <p><b>Why to use it:</b> To measure service consumed in a way that takes into account productivity and operational efficiency and captures efforts to increase ridership or vehicle occupancy rates.</p> <p><b>For which metrics:</b> Water usage, criteria air pollutants, GHG emissions, energy use, operating expense</p>	<p><b>What it is:</b> Hours traveled when the vehicle is in revenue service.</p> <p><b>Why to use it:</b> To measure service provided in a way that accounts for operational efficiency and captures efforts to reduce deadheading and roadway congestion.</p> <p><b>For which metrics:</b> Water usage, criteria air pollutants, GHG emissions, energy use, operating expense</p>

**TABLE 2**  
Normalization Factors

Vehicle Miles (VM)	Vehicle Revenue Miles (VRM)
<p><b>What it is:</b> Miles traveled from the time a vehicle pulls out from its garage to go into revenue service to the time it pulls in from revenue service, including "deadhead" miles without passengers to the starting points of routes or returning to the garage.</p> <p><b>Why to use it:</b> To measure service provided in a way that accounts for facility, vehicle and fuel efficiency and captures efforts to purchase and retrofit vehicles and facilities with cleaner and more efficient technologies.</p> <p><b>For which metrics:</b> Water usage, criteria air pollutants, GHG emissions, energy use, operating expense</p>	<p><b>What it is:</b> Miles traveled when the vehicle is in revenue service.</p> <p><b>Why to use it:</b> To measure service provided in a way that accounts for both operational efficiency as well as facility, vehicle and fuel efficiency, capturing efforts to reduce deadheading and roadway congestion, as well as efforts to purchase and retrofit vehicles and facilities with cleaner and more efficient technologies.</p> <p><b>For which metrics:</b> Water usage, criteria air pollutants, GHG emissions, energy use, operating expense</p>
Unlinked Passenger Trips (UPT)	Produced Seat Miles (PSM)
<p><b>What it is:</b> The number of times passengers board vehicles, no matter how many vehicles they use to travel from their origin to their destination and regardless of whether they pay a fare, use a pass or transfer, ride for free, or pay in some other way. Also called boardings.</p> <p><b>Why to use it:</b> To measure service consumed in a way that takes into account productivity and operational efficiency and captures efforts to increase ridership or vehicle occupancy rates. Unlike passenger miles traveled (PMT), will not account for the relative amount (distance) of service provided to each passenger on each mode.</p> <p><b>For which metrics:</b> Water usage, criteria air pollutants, GHG emissions, energy use, operating expense</p>	<p><b>What it is:</b> The total seating capacity of vehicles in revenue service multiplied by total vehicle miles.</p> <p><b>Why to use it:</b> To measure service provided in a way that takes into account seating capacity of vehicles, which can be useful for comparing systems utilizing different capacity vehicles; overlooks standee capacity as a component of overall vehicle capacity.</p> <p><b>For which metrics:</b> Water usage, criteria air pollutants, GHG emissions, energy use, operating expense</p>
Revenue Vehicle Length (RVL)	Per Capita in Service Area of Operation
<p><b>What it is:</b> The size of a vehicle based on the distance from the front of a vehicle to the back of a vehicle</p> <p><b>Why to use it:</b> To measure the relative efficiency of vehicle washing systems in a way that accounts for the relative size of vehicles and captures efforts to reduce the amount of water required to effectively clean each vehicle. When compared within an agency and across the industry, both maintenance practices and design criteria can be reviewed/shared to minimize potable water usage.</p> <p><b>For which metrics:</b> Water usage</p>	<p><b>What it is:</b> The number of people with access to transit service in terms of population served and area coverage (square miles), based on definitions contained in the Americans with Disabilities Act (ADA) and reported to the National Transit Database.</p> <p><b>Why to use it:</b> To measure service provided in a way that accounts for total extent of operations and captures measures to increase transit mode share and to reduce the number and distance of trips taken by private automobiles within the service area of operation.</p> <p><b>For which metrics:</b> unlinked passenger trips; vehicle miles traveled</p>



## 2. Sustainability metrics

### 2.1 Normalization factors

APTA’s Sustainability Commitment features performance metrics that are normalized by measures of service levels, efficiency, capacity, size and utilization. Normalization factors are a useful way for a transit agency to “tell its story,” and the Working Group recommends that industry members select normalization factors that are context sensitive and best represent their unique operating conditions.

#### 2.1.1 Passenger miles traveled (PMT)

- **Definition:** PMT is the cumulative sum of the distances ridden by each passenger.
- **Value:** This metric represents the distance traveled by all passengers and is calculated using on-board checks, automated electronic passenger-counters or sampling techniques. It will measure service productivity or effectiveness in addition to operational efficiency and will account for the combined effects of relative efficiency of vehicles by mode and changes in ridership or vehicle occupancy rates. Passengers traveling on a more crowded vehicle will make trip more more efficient, so this metric will capture efforts to improve efficiency by attracting passengers and increasing service productivity.
- **Potential applicability:**
  - Water usage
  - criteria air pollutants
  - GHG emissions
  - Energy use
  - Operating expense

#### 2.1.2 Vehicle miles (VM)

- **Definition:** VMs are all the miles a vehicle travels from the time it pulls out from its garage to go into revenue service to the time it pulls in from revenue service, including “deadhead” miles without passengers to the starting points of routes or returning to the garage. For conventional scheduled services, it includes both revenue miles and deadhead miles.
- **Value:** This metric measures operational efficiency and will be sensitive to efforts to purchase cleaner and more efficient vehicles and fuels and to improve the efficiency of facilities (e.g., office buildings or train stations).
- **Potential applicability:**
  - Water usage
  - Criteria air pollutants
  - GHG emissions
  - Energy use
  - Operating expense

#### 2.1.3 Vehicle revenue hours (VRH)

- **Definition:** VRHs are the hours traveled when the vehicle is in revenue service (i.e., the time when a vehicle is available to the general public and there is an expectation of carrying passengers). Vehicles operated in fare-free service are considered in revenue service. Revenue service excludes school bus service and charter service.
- **Value:** This metric captures efforts to improve operational efficiency by reducing deadheading and roadway congestion. By excluding deadhead hours (the time that vehicles spend traveling while out of service, such as returning to a garage or storage facility), this metric will capture efforts to reduce inefficiencies through improvements to scheduling, routing or other service planning changes. By accounting for the time spent in service rather than the distance traveled, this metric reflects any local

congestion effects, which will depress performance per unit of time in revenue service. This will improve comparison of the relative efficiency of agencies facing different levels of congestion.

- **Potential applicability:**
  - Water usage
  - Criteria air pollutants
  - GHG emissions
  - Energy use
  - Operating expense

#### 2.1.4 Vehicle revenue miles (VRM)

- **Definition:** VRMs are the miles traveled when a vehicle is in revenue service (i.e., the time when a vehicle is available to the general public and there is an expectation of carrying passengers). Vehicles operated in fare-free service are considered in revenue service. Revenue service excludes school bus service and charter service.
- **Value:** Like vehicle revenue hours (VRH), this metric captures efforts to improve operational efficiency by reducing deadheading and roadway congestion. Like vehicle miles (VM), the metric also captures operational efficiencies sensitive to efforts to purchase cleaner and more efficient vehicles and fuels and to improve the efficiency of facilities.
- **Potential applicability:**
  - Water usage
  - Criteria air pollutants
  - GHG emissions
  - Energy use
  - Operating expense

#### 2.1.5 Unlinked passenger trip (UPT)

- **Definition:** UPT is the total number of times passengers board public transportation vehicles. Passengers are counted each time they board vehicles, no matter how many vehicles they use to travel from their origin to their destination and regardless of whether they pay a fare, use a pass or transfer, ride for free or pay in some other way. Also called boardings.
- **Value:** This metric captures efforts to improve service productivity or effectiveness, in addition to operational efficiency, and will account for the changes in ridership or vehicle occupancy rates. The transport of passengers aboard more crowded vehicles is more efficient, so this metric will capture efforts to improve efficiency by attracting passengers and increasing service productivity. Unlike PMT, UPT will not account for the relative amount (distance) of service provided to each passenger on each mode.
- **Potential applicability:**
  - Water usage
  - Criteria air pollutants
  - GHG emissions
  - Energy use
  - Operating expense

#### 2.1.6 Produced seat mile (PSM)

- **Definition:** PSM is calculated by multiplying vehicle revenue miles by average seating capacity for each vehicle by mode. Seating capacity is defined by the number of seats that are actually installed in the vehicle.

- **Value:** This metric merges VM and seat capacity to measure the relative efficiency of types of modes and vehicle types. PSM can be used to compare systems utilizing different capacity vehicles, but it overlooks standees as a component of overall vehicle capacity.
- **Potential applicability:**
  - Water usage
  - Criteria air pollutants
  - GHG emissions
  - Energy use
  - Operating expense

### 2.1.7 Revenue vehicle length (RVL)

- **Definition:** RVL is measured by calculating the distance from the front of a vehicle to the back of a vehicle. This metric uses intercompany fleet data that measures consumption to wash/maintain revenue vehicles. The infrastructure of washing revenue vehicles are typically constructed to function based on when the vehicle enters/exits the wash room. This is a function based on vehicle length, speed and water flow rates delivered.
- **Value:** This metric measures the relative efficiency of vehicle washing systems in a way that accounts for the relative size of vehicles and captures efforts to reduce the amount of water required to effectively clean each vehicle. When compared within an agency and across the industry, both maintenance practices and design criteria can be reviewed/shared to minimize potable water usage.
- **Potential applicability:**
  - Water usage

### 2.1.8 Per capita in service area of operation

- **Definition:** The number of people with access to transit service in terms of population served and area coverage (square miles). The reporting transit agency determines the service area boundaries and population for most transit services using the definitions contained in the Americans with Disabilities Act of 1990 and reports that service area population to the National Transit Database. If applicable, use the Canadian equivalent of this data source.
- **Value:** This metric measures service provided in a way that accounts for total extent of operations and captures measures to increase transit mode share and reduce the number and distance of trips taken by private automobiles within the service area of operation.
- **Potential applicability:**
  - Unlinked passenger trips
  - Vehicle miles traveled

## 2.2 Definitional issues

The Working Group applied the following definitions for the purposes of devising calculation methodologies:

- **Scope of analysis:** Metrics are based on the “operational control” method of quantifying agency impacts. The operational control method is defined as all operations over which the agency has full authority to introduce or implement operating policies. This may be established by wholly owning an operation or facility or by having full authority to introduce and implement operational and health, safety and environmental policies. In general, if an agency reports data on a service to the National Transit Database (NTD) or comparable Canadian database, it should be considered to have operational control over that service.
- **Reporting period:** Agencies are permitted to select the reporting cycle that best suits their purposes. Recommended metrics in this document are based on annual National Transit Database (or

comparable Canadian database) reporting cycles, with the exception of GHG emissions, which should be reported on an calendar year basis, where possible.

- **Data availability:** Where limited availability of data is expected, estimation techniques are suggested.

## 2.3 Water usage

### 2.3.1 Overview of metric

Water quality and supply are of increasing concern in many jurisdictions. Measuring water's use encourages better management and more efficient use of the resource. For many transit agencies, the primary use of potable water occurs at maintenance facilities where vehicles are washed. Additional uses include irrigation at company facilities, park-and-rides, and stations.

Quantifying and developing performance metrics for water use enables agencies to identify inefficient or wasteful practices. Reducing potable water use demonstrates good environmental stewardship, which is particularly important for transit agencies located in areas with arid climates and where potable water supplies are threatened.

Lack of data availability for some types of facilities, such as administrative and/or rented buildings, can make comprehensive agency-wide calculations difficult. In these cases, agencies can calculate water usage at a facility level, as described below. Gallons are recommended as a unit of measure, although many facilities are invoiced based on hundreds of cubic feet (CCF) or cubic meters (m<sup>3</sup>). Conversion factors are provided below.

**NOTE on Pollutant Discharge:** The Working Group recommends against using pollutant discharge as a metric at this time. Requirements to test and track water pollutant discharges vary widely across various Publicly Owned Treatment Works (POTW) in different regions of the United States. Industrial waste water discharges to sanitary sewer districts may or may not require self-monitoring testing in addition to that performed by representatives of the POTW. Additionally, storm water discharges are visual inspections of storm water quality associated with storm water runoff or snow melt. The analytical testing of industrial waste water discharges and the visual inspections of storm water runoff are based on pass/fail to measure compliance. The pass/fail monitoring of water pollutant discharge does not demonstrate progress towards a measureable goal, which is not suitable as a sustainable metric. Best management practices (BMP) for cleaning, fueling, maintenance and storage areas for equipment, materials, and vehicles should be implemented to prevent pollutants from entering industrial waste water discharges and storm water discharges.

### 2.3.2 Basic approach

#### Data needs

- **Source 1:** Utility invoices from water utilities
- **Source 2:** Conversion factor to gallons
  - 1 hundred cubic feet (CCF) = 748 gal
  - 1 cubic meter (m<sup>3</sup>) = 264 gal
- **Source 3:** Normalization factor

#### For revenue vehicle length (RVL) calculation:

- **Source 4:** Fleet type and linear length of vehicle
- **Source 5:** Number of vehicles by type and linear length

#### Calculation steps

- **Step 1:** Total the 12-month period of water usage invoices that corresponds to the agency's NTD (or Canadian database) reporting time frame.

- **Step 2:** Convert invoice totals to gallons by multiplying by the following conversion factors:
  - 1 hundred cubic feet (CCF) = 748 gal
  - 1 cubic meter (m<sup>3</sup>) = 264 gal
- **Step 3:** Divide the annual potable water usage by the corresponding normalization factor.

**For revenue vehicle length (RVL) calculation:**

This metric measures water specifically consumed for the purposes of washing and maintaining revenue vehicles. The vehicle washing machine is typically designed to function based on when vehicles enter the wash room. The amount of water consumed is a function of vehicle length, the speed at which it is run through the washing machine, and water flow rates. Normalizing water consumption by vehicle length is one way to measure the relative efficiency of an agency’s vehicle washing machines and for the industry to review maintenance practices and design criteria to minimize potable water usage.

- **Step 4:** Group revenue vehicles by the manufacturer’s model year and linear length (see **Table 3**). If data can be separated by facility, do so to monitor intracompany performance. If not, report as a total combined fleet.

**TABLE 3**  
Example of RVL Calculation Inputs

Vehicle Type	Model Year	Quantity	Linear Length/Bus	Total Linear Feet
Bus – Optima	2006	10	29 ft	290 ft
Bus – Gillig	2006	31	41 ft	1271 ft

- **Step 5:** Aggregate invoices from facilities where potable water is used to wash/maintain revenue fleet vehicles. If possible, separate the aggregates by vehicle type if the washing and maintenance facilities are separate for the vehicle types
- **Step 6:** Divide the potable water consumed at facilities and/or combined facilities where washing/maintenance occurs by the linear feet for the vehicles maintained at the facility and/or combined facilities.

**2.4 Criteria air pollutant emissions**

**2.4.1 Overview of metric**

The U.S. EPA sets National Ambient Air Quality Standards (NAAQS) for six criteria air pollutants: particulate matter (PM), ground-level ozone (O<sub>3</sub>), carbon monoxide (CO), sulfur oxides (SO<sub>x</sub>), nitrogen oxides (NO<sub>x</sub>), and lead. Quantifying and developing performance metrics for these emissions will track agency efforts to reduce air-quality impacts from transit systems and services, while at the same time demonstrating the effectiveness of transit as a solution for improving air quality in its service region. These performance metrics will enable transit agencies to be involved in community planning and policymaking processes. The basic approach below assumes diesel as fuel.

Emission standards for heavy-duty diesel engines are expressed in terms of the amount of pollutant per work performed – grams per brake horsepower-hour (g/bhp-hr). Units of g/bhp-hr are converted to g/mi, using the conversion factor cited below. While not included in this calculation, indirect emissions from use of propulsion power can be found from the U.S. EPA’s eGRID guidance, which provides emission rates for NO<sub>x</sub> and SO<sub>x</sub> by region, or the comparable Canadian government data source.

## 2.4.2 Basic approach

EPA has developed an online tool called the Diesel Emissions Quantifier (see this metric’s “Resources and References” section). The Quantifier was developed to assist those without modeling experience to estimate emissions of NO<sub>x</sub>, PM, HC, CO and CO<sub>2</sub> for “highway” and “non-road” vehicles. In addition, it allows users to incorporate various reduction strategies, such as cleaner fuels, idling policies and equipment classes to increase the accuracy of its calculations and to track the impact of vehicle retrofits.

**NOTE:** There is ongoing work to update the Quantifier as appropriate with EPA Motor Vehicle Emission Simulator (MOVES); it cannot be used for State Implementation Program (SIP) or conformity purposes.

### Data needs

Using the EPA Diesel Emissions Quantifier will require the following data sources:

- **Source 1:** Fleet type
- **Source 2:** Model year
- **Source 3:** Number of vehicles for each fleet type and model year
- **Source 4:** Retrofit year (explained in the calculation steps)
- **Source 5:** Fuel type
- **Source 6:** Fuel usage (gal/year)
- **Source 7:** Vehicle miles traveled for fleet count (miles/vehicle/year) — use “on highway”
- **Source 8:** Hours spent idling (hours/vehicle/year) — FTA/APTA default value is 600 hours

### Calculation steps

- **Emissions per VMT for bus:**
  - **Step 1:** Group bus vehicle miles by the manufacturer’s model year and technology type (see [Table 4](#)).

**TABLE 4**  
Example of Diesel Emissions Quantifier Inputs

Technology Type	Group Count	Model Year	Fuel Type	Gallons/year	Mi/vehicle/year	Idle Hrs/vehicle/year
Particulate filter equip.	50	2007	ULSD	312,500	25,000	600

- **Step 2:** Enter inputs, following the Quantifier guide under the “Getting Started” section.
- **Step 3:** The Quantifier will calculate the tons/year for NO<sub>x</sub>, PM, HC, CO and CO<sub>2</sub> for the entire fleet and is recorded on the “Baseline of Entire Fleet” for each emission.
- **Step 4:** Multiply each emission by a conversion factor of 908,800 g/ton and divide by the VMT from the agency’s NTD submittal. This will yield the emission rate in g/mi for the NTD reporting year.

### Emissions Savings per PMT for bus

- **Step 1:** Multiply the PMT from NTD for buses times the emission rate for a passenger car of a given criteria air pollutant (see [Table 5](#)). Multiply the resulting product with appropriate mode shift factor that can be found in Section 2.6.2.
- **Step 2:** Divide the quantity of emissions from Step 1 by 908,800 g/ton. This is the emissions that were avoided by transit.
- **Step 3:** If the emissions determined in Step 2 are greater than the VMT emissions, then subtract the VMT emissions from the PMT emissions. This is the emissions that were saved by transit.

**TABLE 5\***  
Average Emissions and Fuel Consumption for Passenger Cars

Pollutant/Fuel	Emission and Fuel Consumption Rates	Calculation	Annual Emissions and Fuel Consumption
Hydrocarbons (HC)	1.36 g/mi	$1.36 \text{ g/mi} \times 12,000 \text{ mi/year} \times 1 \text{ lb}/454 \text{ g}$	36.0 lb
Carbon monoxide (CO)	12.4 g/mi	$12.4 \text{ g/mi} \times 12,000 \text{ mi/year} \times 1 \text{ lb}/454 \text{ g}$	32.8 lb
Nitrogen oxides (NOx)	0.95 g/mi	$0.95 \text{ g/mi} \times 12,000 \text{ mi/year} \times 1 \text{ lb}/454 \text{ g}$	25.1 lb
Particulate matter (PM <sub>10</sub> )	0.0052 g/mi	$0.0052 \text{ g/mi} \times 12,000 \text{ mi/year} \times 1 \text{ lb}/454 \text{ g}$	0.14 lb
Particulate matter (PM <sub>2.5</sub> )	0.0049 g/mi	$0.0049 \text{ g/mi} \times 12,000 \text{ mi/year} \times 1 \text{ lb}/454 \text{ g}$	0.13 lb
Carbon dioxide (CO <sub>2</sub> )	369 g/mi	$369 \text{ g/mi} \times 12,000 \text{ mi/year} \times 1 \text{ lb}/454 \text{ g}$	9760 lb
Gasoline consumption	0.0417 gal/mi	$(12,000 \text{ mi/year}) / (24.0 \text{ mi/gal})$	500 gal

\* The table only shows emission and fuel consumption rate conversion factors for gasoline fueled vehicles.

#### Emissions Savings per PSM for bus

- **Step 1:** Record the bus type for a given manufactured year and record in Column 1.
- **Step 2:** Record the annual vehicle miles for each bus type in Column 2.
- **Step 3:** Record the seat capacity of the bus type in Column 3.
- **Step 4:** Multiply the vehicle miles times the passenger seats per vehicle. This is the PSM for a given bus type per manufacture year.

**TABLE 6**  
Example of PSM Calculation

Bus Type	Vehicle Miles	Passenger Seats Per Vehicle	Produced Seat Mile
2006 Gillig 40 ft Transit	1,766,679	38	67,133,802
2009 Gillig 40 ft Transit	2,410,249	37	89,179,213

- **Step 5:** Add up the produced seat miles for each bus type.
- **Step 6:** Multiply the total PSM from Step 5 times the emission rate for a passenger car of a given criteria air pollutant.
- **Step 7:** Divide the grams for each criteria air pollutant in Step 6 by 908,800 g/ton. Subtract the VMT emissions from the PSM emissions. This is the emissions savings produced by transit.

#### 2.4.3 Resources and references

- Department of Transportation, Federal Transit Administration, “Transit Bus Life Cycle Cost and Year 2007 Emissions Estimation,” FTA-WV-26-7004.2007.1, July 2007. [www.proterra.com/images/WVU\\_FinalReport.pdf](http://www.proterra.com/images/WVU_FinalReport.pdf)
- Environmental Protection Agency, Office of Transportation and Air Quality, “Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks,” August 2005.
- Environmental Protection Agency, Air and Radiation, “Update Heavy-Duty Engine Emission Conversion Factors for MOBILE6,” January 2002. <http://ebookbrowse.com/r02006-pdf-d77350101>

- EPA Diesel Emissions Quantifier: [www.epa.gov/cleandiesel/quantifier/references.htm](http://www.epa.gov/cleandiesel/quantifier/references.htm)

## 2.5 Greenhouse gas (GHG) emissions

### 2.5.1 Overview of metric

The impact of transit on greenhouse gas emissions can be divided into two categories:

- **Emissions produced by transit.** This category accounts for the “debit” side of net transit emissions. The major element is mobile combustion — i.e., tailpipe emissions from transit vehicles or electricity use for rail agencies. It also includes stationary combustion, such as on-site furnaces and indirect emissions from electricity generation. These debits are calculated at the agency level.
- **Emissions displaced by transit.** This category accounts for the “credit” side of net transit emissions, through reduced emissions from private automobiles. These credits are calculated at the regional or national level.

This document provides guidance to transit agencies for quantifying the greenhouse gas emissions they produce. Guidance for quantifying emissions displaced by transit is provided in the subsequent section, “GHG displacement (savings).” This metric is intended to be used as a tool for measuring progress through internal benchmarking and, when used in conjunction with an agency’s GHG displacement, as a message to promote the significant environmental benefit of using the public transportation system.

This metric presents a simplified version of APTA’s *Recommended Practice* “Quantifying Greenhouse Gas Emissions from Transit,” which draws heavily from The Climate Registry’s “General Reporting Protocol” (GRP), providing specific interpretation of the GRP for transit agencies. The links to these documents are in this section’s “Resources and references.”

### 2.5.2 Basic approach

This basic approach is a simplified version of APTA’s *Recommended Practice*. Agencies that are members of The Climate Registry or of any other recognized GHG reporting entity should continue to follow reporting protocols required by that membership and are encouraged to report their emissions to APTA in the same manner. When reporting tiers are suggested, agencies should try to use the highest-quality reporting tier available to them. The basic approach is intended to be a starting point for agencies that may not have the resources to compile a complete inventory. The basic approach describes lower-quality tiers, which are generally easier to obtain when first calculating GHG emissions.

Provide as complete and accurate an inventory as possible given the availability of data and other resources. The ultimate goal of this metric is to report emissions for the entire transit agency, including all mobile (revenue and nonrevenue fleets) and stationary sources. However, the basic approach prioritizes reporting in the event that full reporting is not feasible. At a minimum, transit agencies should report emissions resulting from the revenue fleet, purchased electricity, natural gas and steam for stationary sources, and purchased electricity for trains.

APTA acknowledges that compiling a complete and accurate organization-wide inventory can be time-consuming and challenging in the first few years. Therefore, rather than including all six greenhouse gases that are required for full reporting, the basic approach is to report carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O).

APTA’s “Quantifying Greenhouse Gas Emissions from Transit” recommends the following levels of aggregation (grouping) for transit agencies:



- **Mobile fleet:** Report emissions from the aggregated (all-inclusive) revenue fleet. If possible, report mobile source emissions for each NTD or comparable Canadian transit mode separately, as well as emissions from the nonrevenue fleet; as shown in the examples. However, the basic approach recognizes that it may be difficult for some agencies to disaggregate (separate) fleet emissions by mode or to report nonrevenue emissions accurately. In that case, the fleet emissions may be either reported as a whole or aggregated under the basic approach.
- **Buildings and structures:** Offices, sales outlets, customer service facilities, maintenance yards and administrative facilities may be aggregated and reported as a single facility. This will capture most of an agency’s emissions from stationary sources, with the exception of some stations (addressed below). Ideally, maintenance yards should be disaggregated and reported separately, but this is not required.
- **Traction electricity:** Stations and other emissions on a contiguous right-of-way (e.g., signals that draw power from the electrified rail) may be reported as a single facility, analogous to a pipeline or electricity transmission and distribution system. If data are available on individual stations, agencies are encouraged to disaggregate these emissions further or include station data with buildings and structures, above.

As the agency gains experience in reporting, then breaking down emissions (disaggregating) by NTD transit mode and type of facility will help facilitate energy management by identifying the largest sources and allowing for year-to-year comparisons.

**Data needs**

- **Source 1:** Data obtained for reporting APTA’s energy metric will inform the GHG calculation (energy purchases / utility invoices – fuel, electricity, etc.).
- **Source 2:** Data obtained for reporting APTA’s criteria air pollutant metric will aid in quantifying CH<sub>4</sub> and N<sub>2</sub>O emissions. In general, data will be available for transit agencies through NTD/Canadian Urban Transit Association (CUTA) reporting, fuel purchases and similar purchase records (revenue fleet mileage, revenue fleet fuel consumption).
- **Source 3:** GHG emissions factors for fossil fuel consumption (see this section’s “Resources and references” for link to U.S. EIA tables, or use TCR’s “General Reporting Protocol”).
- **Source 4:** GHG emissions factors for electricity consumption (see this section’s “Resources and references” for link to U.S. EPA eGRID, or use TCR’s “General Reporting Protocol”).

**Calculation steps**

- **Step 1:** Organize agency into mobile and stationary emissions sources (see **Table 7**). For mobile sources, distinguish among transit modes to the extent possible.
- **Step 2:** Compile energy use for organization (see **Table 8**).

**TABLE 7**  
Example of Emissions Source Inputs

Category	Description	Scope
Mobile	Fuel for revenue fleet	Scope 1
Mobile	Purchased electricity for trains	Scope 2
Stationary	Purchased electricity/steam for offices, admin buildings, depots, shops and yards	Scope 2
Stationary	Natural gas for heating offices, admin buildings, depots, shops and yards	Scope 1

**TABLE 8**  
Sample Transit Agency Energy Matrix

Mobile Sources				
Energy Type	Category	Unit of Measure	Source	NYCT
Electricity	Con Ed	kWh	Facilities (Non-Prop)	18,000
	LIPA		Traction (Propulsion)	16,856,000
	LIPA		Facilities (Non-Prop)	2,929,000
	NYPA NY		Traction (Propulsion)	1,759,838,965
	NYPA		Facilities (Non-Prop)	439,309,005
<b>Grand Totals (Electricity)</b>		<b>kWh</b>		<b>2,218,950,970</b>
Fuel: vehicles and equipment – fueling facilities	Gasoline	Gallons	Nonrevenue	200,561
	Diesel		Nonrevenue	818,312
	Diesel		Revenue, Dept of Buses	31,675,596
	BIO Fuel – B5		Revenue, Dept of Buses	8,232,492
	CNG	Therms	Revenue, Dept of Buses	10,223,937
Fuel card: nonrevenue vehicles and equipment	Gasoline	Gallons		570,158
	Diesel			216,233
	Gasoline		Paratransit	1,677,477
	Diesel		Paratransit	6,620,736
<b>Grand Totals (Fuel)</b>		<b>Gallons</b>		<b>50,011,566</b>
		<b>Therms</b>		<b>10,223,937</b>
Stationary Sources				
Energy Type	Category	Unit of Measure	Source	NYCT
Heating	Oil #2	Gallons		3,876,362
	BIO Fuel – B5			1,537,087
	Natural gas	Therms	National Grid	6,257,488
	Natural gas		ConEd	1,968,544
<b>Grand Totals (Heating)</b>		<b>Gallons</b>		<b>5,413,449</b>
		<b>Therms</b>		<b>8,226,032</b>

- **Step 3:** Calculate direct emissions (Scope 1) from mobile sources for revenue vehicles.
  - **3A:** Calculate total annual fuel consumption by fuel type:

**Calculate Total Annual Fuel Consumption:**

$$Total\ annual\ fuel\ consumption^* = [Annual\ fuel\ purchases] + [fuel\ stock\ at\ beginning\ of\ year] - [Fuel\ stock\ at\ end\ of\ year]$$

**NOTE:** If beginning- and end-of-year inventories are not available, it is acceptable to use fuel purchase data for the calendar year for the basic approach. This is reasonable for high-quantity fuel use (i.e., at least one delivery per week).

- **3B:** Calculate total CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions using most recently available U.S. EPA emission factors for transport fuels. These factors are found in The Climate Registry’s “General Reporting Protocol” (see “Resources and references”).

**Calculate Total CO<sub>2</sub> emissions for all mobile fuel types:**

$$\begin{matrix} \text{Fuel A CO}_2 \text{ Emissions} = & \text{Fuel Consumed} \times & \text{Emission Factor} / 1000 \\ (\text{metric tons}) & (\text{gal}) & (\text{kg CO}_2/\text{gal}) & (\text{kg/metric ton}) \end{matrix}$$

$$\begin{matrix} \text{Fuel B CO}_2 \text{ Emissions} = & \text{Fuel Consumed} \times & \text{Emission Factor} / 1000 \\ (\text{metric tons}) & (\text{gal}) & (\text{kg CO}_2/\text{gal}) & (\text{kg/metric ton}) \end{matrix}$$

$$\begin{matrix} \text{Total CO}_2 \text{ emissions} = & \text{Fuel A CO}_2 + \text{Fuel B CO}_2 + \dots \\ (\text{metric tons}) \end{matrix}$$

**Calculate Total CH<sub>4</sub> emissions for all mobile fuel types:**

$$\begin{matrix} \text{Fuel A CH}_4 \text{ Emissions} = & \text{Annual Distance} \times & \text{Emission Factor} / 1,000,000 \\ (\text{metric tons}) & (\text{mi}) & (\text{g CH}_4/\text{mi}) & (\text{g/metric ton}) \end{matrix}$$

$$\begin{matrix} \text{Fuel B CH}_4 \text{ Emissions} = & \text{Annual Distance} \times & \text{Emission Factor} / 1,000,000 \\ (\text{metric tons}) & (\text{mi}) & (\text{g CH}_4/\text{mi}) & (\text{g/metric ton}) \end{matrix}$$

$$\begin{matrix} \text{Total CH}_4 \text{ Emissions} = & \text{Fuel A CH}_4 + \text{Fuel B CH}_4 + \dots \\ (\text{metric tons}) \end{matrix}$$

**Calculate Total N<sub>2</sub>O emissions for all mobile fuel types:**

$$\begin{matrix} \text{Fuel A N}_2\text{O Emissions} = & \text{Annual Distance} \times & \text{Emission Factor} / 1,000,000 \\ (\text{metric tons}) & (\text{mi}) & (\text{g N}_2\text{O}/\text{mi}) & (\text{g/metric ton}) \end{matrix}$$

$$\begin{matrix} \text{Fuel B N}_2\text{O Emissions} = & \text{Annual Distance} \times & \text{Emission Factor} / 1,000,000 \\ (\text{metric tons}) & (\text{mi}) & (\text{g N}_2\text{O}/\text{mi}) & (\text{g/metric ton}) \end{matrix}$$

$$\begin{matrix} \text{Total N}_2\text{O Emissions} = & \text{Fuel A CH}_4 + \text{Fuel B CH}_4 + \dots \\ (\text{metric tons}) \end{matrix}$$

- **3C:** Use the global warming potential (GWP) factors to convert to CO<sub>2</sub> equivalent. Then sum the emissions of all three gases to determine the total Scope 1 mobile emissions.

**NOTE:** See APTA’s “Quantifying Greenhouse Gas Emissions from Transit” (“Direct emissions from mobile combustion”) and Chapter 13 of The Climate Registry’s “General Reporting Protocol” for more detailed information.

**Converting to CO<sub>2</sub>e and determining total emissions:**

$$\text{CO}_2 \text{ Emissions (metric tons CO}_2\text{e)} = \text{CO}_2 \text{ Emissions (metric tons)} \times 1 \text{ (GWP)}$$

$$\text{CH}_4 \text{ Emissions (metric tons CO}_2\text{e)} = \text{CH}_4 \text{ Emissions (metric tons)} \times 21 \text{ (GWP)}$$

$$\text{N}_2\text{O Emissions (metric tons CO}_2\text{e)} = \text{N}_2\text{O Emissions (metric tons)} \times 310 \text{ (GWP)}$$

$$\text{Total Emissions (metric tons CO}_2\text{e)} = \text{CO}_2 + \text{CH}_4 + \text{N}_2\text{O (metric tons CO}_2\text{e)}$$

- **Step 4:** Calculate indirect emissions (Scope 2) from electricity use for trains (traction electricity).
  - **4A:** For transit agencies using electricity that purchase power directly from a specific source, generator-specific emission factors may be used. Other transit agencies should use eGRID region-specific emission factors, provided in The Climate Registry protocol Chapter 14.

**Calculate emissions from traction/propulsion electricity use:**

$$\begin{matrix} CO_2 \text{ Emissions} & = & Electricity \text{ Use} & \times & Emission \text{ Factor} & / & 2,204.62 \\ (metric \text{ tons}) & & (MWh) & & (lbs \text{ CO}_2/MWh) & & (lbs/metric \text{ ton}) \end{matrix}$$

$$\begin{matrix} CH_4 \text{ Emissions} & = & Electricity \text{ Use} & \times & Emission \text{ Factor} & / & 2,204.62 \\ (metric \text{ tons}) & & (MWh) & & (lbs \text{ CO}_2/MWh) & & (lbs/metric \text{ ton}) \end{matrix}$$

$$\begin{matrix} N_2O \text{ Emissions} & = & Electricity \text{ Use} & \times & Emission \text{ Factor} & / & 2,204.62 \\ (metric \text{ tons}) & & (MWh) & & (lbs \text{ CO}_2/MWh) & & (lbs/metric \text{ ton}) \end{matrix}$$

- **4B:** Use the global warming potential (GWP) factors to convert to CO<sub>2</sub> equivalent. Then sum the emissions of all three gases to determine the total Scope 2 emissions from traction/propulsion electricity.

**NOTE:** See APTA’s “Quantifying Greenhouse Gas Emissions from Transit” (“Indirect emissions from electricity use”) and Chapter 14 of The Climate Registry’s “General Reporting Protocol” for more detailed information.

**Converting to CO<sub>2</sub>e and determining total emissions:**

$$CO_2 \text{ Emissions (metric tons CO}_2\text{e)} = CO_2 \text{ Emissions (metric tons)} \times 1 \text{ (GWP)}$$

$$CH_4 \text{ Emissions (metric tons CO}_2\text{e)} = CH_4 \text{ Emissions (metric tons)} \times 21 \text{ (GWP)}$$

$$N_2O \text{ Emissions (metric tons CO}_2\text{e)} = N_2O \text{ Emissions (metric tons)} \times 310 \text{ (GWP)}$$

$$Total \text{ Emissions (metric tons CO}_2\text{e)} = CO_2 + CH_4 + N_2O \text{ (metric tons CO}_2\text{e)}$$

- **Step 5:** Calculate emissions from electricity and steam (Scope 2) and heating fuels (Scope 1) for the agency’s facilities.
  - **5A:** For transit agencies that purchase electric power directly from a specific source, generator-specific emission factors may be used. Other transit agencies should use eGRID region-specific emission factors, provided in The Climate Registry protocol, Chapter 14.

**Calculate emissions from facility (non-traction/non-propulsion) electricity use:**

$$\begin{matrix} CO_2 \text{ Emissions} & = & Electricity \text{ Use} & \times & Emission \text{ Factor} & / & 2,204.62 \\ (metric \text{ tons}) & & (MWh) & & (lbs \text{ CO}_2/MWh) & & (lbs/metric \text{ ton}) \end{matrix}$$

$$\begin{matrix} CH_4 \text{ Emissions} & = & Electricity \text{ Use} & \times & Emission \text{ Factor} & / & 2,204.62 \\ (metric \text{ tons}) & & (MWh) & & (lbs \text{ CO}_2/MWh) & & (lbs/metric \text{ ton}) \end{matrix}$$

$$\begin{matrix} N_2O \text{ Emissions} & = & Electricity \text{ Use} & \times & Emission \text{ Factor} & / & 2,204.62 \\ (metric \text{ tons}) & & (MWh) & & (lbs \text{ CO}_2/MWh) & & (lbs/metric \text{ ton}) \end{matrix}$$

- **5B:** Use the global warming potential (GWP) factors to convert to CO<sub>2</sub> equivalent. Then sum emissions of all three gases to determine the total Scope 2 emissions for the agency’s facilities.

**Converting to CO<sub>2</sub>e and Determining Total Emissions:**

$$CO_2 \text{ Emissions (metric tons CO}_2\text{e)} = CO_2 \text{ Emissions (metric tons)} \times 1 \text{ (GWP)}$$

$$CH_4 \text{ Emissions (metric tons CO}_2\text{e)} = CH_4 \text{ Emissions (metric tons)} \times 21 \text{ (GWP)}$$

$$N_2O \text{ Emissions (metric tons CO}_2\text{e)} = N_2O \text{ Emissions (metric tons)} \times 310 \text{ (GWP)}$$

$$Total \text{ Emissions (metric tons CO}_2\text{e)} = CO_2 + CH_4 + N_2O \text{ (metric tons CO}_2\text{e)}$$

- **5C:** In general, data on direct emissions from stationary combustion (natural gas/oil boilers) will not be available through NTD reporting. Agencies should determine annual fuel use by using fuel receipts or purchase records, together with data on changes in stocks.

- **5D:** Calculate total annual fuel consumption by fuel type.

**NOTE:** If beginning- and end-of-year inventories are not available, it is acceptable to use fuel purchase data for the calendar year for the basic approach. This is reasonable for high-quantity fuel use (i.e., at least one delivery per week).

**Calculate Total Annual Fuel Consumption:**

$$\text{Total annual fuel consumption}^* = [\text{Annual fuel purchases}] + [\text{fuel stock at beginning of year}] - [\text{Fuel stock at end of year}]$$

- **5E:** Calculate total CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions using most recently available EPA emission factors for stationary combustion.

**NOTE:** See APTA’s “Quantifying Greenhouse Gas Emissions from Transit” (“Direct emissions from stationary combustion”) and Chapter 12 of The Climate Registry’s “General Reporting Protocol” for more detailed information on emission factors for stationary sources. See “Indirect emissions from electricity use” in the *Recommended Practice* and Chapter 14 of The Climate Registry protocol for more detailed information on emissions factors from electricity.

**Calculate total CO<sub>2</sub> emissions for all stationary fuel types:**

$$\text{Fuel A CO}_2 \text{ Emissions} = \text{Fuel Consumed} \times \text{Emission Factor} / 1000$$

(metric tons)                      (gal)                      (kg CO<sub>2</sub>/gal)                      (kg/metric ton)

$$\text{Fuel B CO}_2 \text{ Emissions} = \text{Fuel Consumed} \times \text{Emission Factor} / 1000$$

(metric tons)                      (gal)                      (kg CO<sub>2</sub>/gal)                      (kg/metric ton)

$$\text{Total CO}_2 \text{ emissions} = \text{Fuel A CO}_2 + \text{Fuel B CO}_2 + \dots$$

(metric tons)

**Calculate total CH<sub>4</sub> emissions for all stationary fuel types:**

$$\text{Fuel A CH}_4 \text{ Emissions} = \text{Annual Distance} \times \text{Emission Factor} / 1,000,000$$

(metric tons)                      (mi)                      (g CH<sub>4</sub>/mi)                      (g/metric ton)

$$\text{Fuel B CH}_4 \text{ Emissions} = \text{Annual Distance} \times \text{Emission Factor} / 1,000,000$$

(metric tons)                      (mi)                      (g CH<sub>4</sub>/mi)                      (g/metric ton)

$$\text{Total CH}_4 \text{ Emissions} = \text{Fuel A CH}_4 + \text{Fuel B CH}_4 + \dots$$

(metric tons)

**Calculate total N<sub>2</sub>O emissions for all stationary fuel types:**

$$\text{Fuel A N}_2\text{O Emissions} = \text{Annual Distance} \times \text{Emission Factor} / 1,000,000$$

(metric tons)                      (mi)                      (g N<sub>2</sub>O/mi)                      (g/metric ton)

$$\text{Fuel B N}_2\text{O Emissions} = \text{Annual Distance} \times \text{Emission Factor} / 1,000,000$$

(metric tons)                      (mi)                      (g N<sub>2</sub>O/mi)                      (g/metric ton)

$$\text{Total N}_2\text{O Emissions} = \text{Fuel A CH}_4 + \text{Fuel B CH}_4 + \dots$$

(metric tons)

- **5F:** Use the global warming potential (GWP) factors to convert to CO<sub>2</sub> equivalent. Then sum the emissions of all three gases to determine the total Scope 1 emissions for the agency’s facilities.

**Converting to CO<sub>2</sub>e and determining total emissions:**

$$CO_2 \text{ Emissions (metric tons } CO_2e) = CO_2 \text{ Emissions (metric tons)} \times 1 \text{ (GWP)}$$

$$CH_4 \text{ Emissions (metric tons } CO_2e) = CH_4 \text{ Emissions (metric tons)} \times 21 \text{ (GWP)}$$

$$N_2O \text{ Emissions (metric tons } CO_2e) = N_2O \text{ Emissions (metric tons)} \times 310 \text{ (GWP)}$$

$$\text{Total Emissions (metric tons } CO_2e) = CO_2 + CH_4 + N_2O \text{ (metric tons } CO_2e)$$

- **Step 6:** Sum CO<sub>2</sub>-equivalent emissions by scope to determine overall agency GHG footprint.

**TABLE 9**  
Sample Transit Agency Energy Matrix

Category	Description	Scope	Total MtCO <sub>2</sub> e = CO <sub>2</sub> + CH <sub>4</sub> + N <sub>2</sub> O
Mobile	Fuel for revenue fleet	Scope 1	Total MtCO <sub>2</sub> e from Step 3C.
Mobile	Purchased electricity for trains	Scope 2	Total MtCO <sub>2</sub> e from Step 4B.
Stationary	Purchased electricity/steam for offices, admin buildings, depots, shops and yards.	Scope 2	Total MtCO <sub>2</sub> e from Step 5B.
Stationary	Natural gas for heating for offices, admin buildings, depots, shops and yards.	Scope 1	Total MtCO <sub>2</sub> e from Step 5F.

**2.5.3 Resources and references**

- APTA, Climate Change Standards Working Group, *Recommended Practice* “Quantifying Greenhouse Gas Emissions from Transit.” APTA SUDS CC-RP-001-09, 2009. [www.aptastandards.com/Portals/0/SUDS/SUDSPublished/APTA\\_Climate\\_Change\\_Final\\_new.pdf](http://www.aptastandards.com/Portals/0/SUDS/SUDSPublished/APTA_Climate_Change_Final_new.pdf) APTA CC-RP-001-09
- The Climate Registry, “General Reporting Protocol” v 1.1 and “GRP Updates and Clarifications,” 2008. [www.theclimateregistry.org/downloads/GRP.pdf](http://www.theclimateregistry.org/downloads/GRP.pdf)
- The Climate Registry, “Performance Metrics for Transit Agencies,” 2010. [www.theclimateregistry.org/downloads/2010/07/Performance-Metrics-for-Transit-Agencies-v.-1.0.pdf](http://www.theclimateregistry.org/downloads/2010/07/Performance-Metrics-for-Transit-Agencies-v.-1.0.pdf)
- Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009, USEPA #430-R-11-005), 2011: [www.epa.gov/climatechange/emissions/usinventoryreport.html](http://www.epa.gov/climatechange/emissions/usinventoryreport.html)
- U.S. Energy Information Administration, “Voluntary Reporting of Greenhouse Gases Program Fuel Emission Coefficients,” 2011. <http://205.254.135.24/oiaf/1605/coefficients.html>
- Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID). [www.epa.gov/cleanenergy/energy-resources/egrid/index.html](http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html)

**2.6 GHG displacement (savings)**

**2.6.1 Overview of metric**

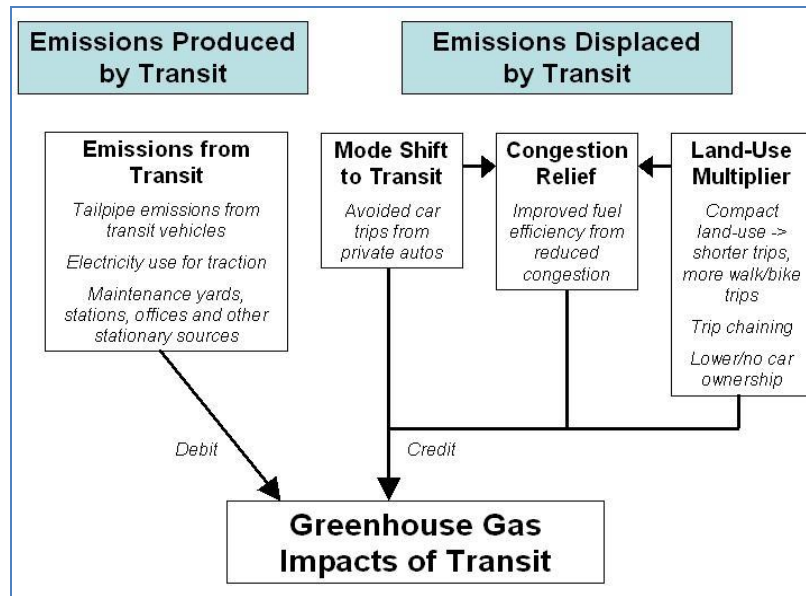
The impact of transit on greenhouse gas emissions can be divided into two categories:

- **Emissions produced by transit.** This category accounts for the “debit” side of net transit emissions. The major element is mobile combustion — i.e., tailpipe emissions from transit vehicles or electricity use for rail agencies. It also includes stationary combustion, such as on-site furnaces and indirect emissions from electricity generation. These debits are calculated at the agency level.

- **Emissions displaced by transit.** This category accounts for the “credit” side of net transit emissions, through reduced emissions from private automobiles. These credits are calculated at the regional or national level.

**FIGURE 1**

Greenhouse Gas Emissions Conceptual Model



Source: APTA

This document provides guidance to transit agencies for quantifying the greenhouse gas emissions they displace. Guidance for quantifying emissions produced by transit is provided in the preceding section, “Greenhouse gas (GHG) emissions.” This metric is intended to be used as a tool for promoting the significant environmental benefit a public transportation system provides and, when used in conjunction with an agency’s GHG emissions, a tool for measuring progress through internal benchmarking.

### 2.6.2 Basic approach

GHG displacement is calculated at the regional or national level and can be divided into three subcategories:

- Avoided car trips through **mode shift** from private automobiles to transit.
- **Congestion relief** benefits through improved operating efficiency of private automobiles, including reduced idling and stop-and-go traffic.
- The **land-use multiplier**, through transit enabling denser land-use patterns that promote shorter trips, walking and cycling, and reduced car use.

The basic approach for calculating GHG displacement draws on APTA’s *Recommended Practice* “Quantifying Greenhouse Gas Emissions from Transit.” In the interest of accessibility and simplicity, this approach recommends only the mode shift factor as the method for estimating GHG displacement.

#### Data needs

- **Source 1:** Passenger miles traveled (obtain from the NTD Form S-10 or comparable Canadian data source).

- **Source 2:** Mode shift factor. Not all transit trips displace passenger car trips, as many transit riders do not have access to a car or would otherwise bike, walk or not take the trip if transit were not available. Therefore, it is critical to account for this by using a mode shift factor, which is a ratio of passenger car miles displaced to transit passenger miles. Using **Table 10**, find the mode shift factor that best represents the service area in which the agency operates.

**TABLE 10**

Mode Shift Factor by Service Area Type and Population

Service Area Type and Population	Mode Shift Factor
Small < 500,000	0.34
Medium 500,000 to 1,250,000	0.42
Large > 1,250,000	0.47
Large Suburban > 1,250,000	0.44

Source: Transit Performance Monitoring System (TPMS) Results, Phases I and II (2002) and Phase III (2004), APTA.

- **Source 3:** Average fuel economy for year of analysis (see the EPA’s “Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends” cited below, or comparable Canadian data source.)
- **Source 4:** Gasoline carbon conversion factor (each gallon of gasoline burned emits an estimated 0.00881 metric tons of carbon dioxide equivalent).

#### Calculation steps

- **Step 1:** Quantify annual passenger miles traveled.
- **Step 2:** Obtain a mode shift factor
- **Step 3:** Multiply the agency’s annual passenger miles traveled by the agency’s mode shift factor for displaced vehicle miles traveled.
- **Step 4:** Divide the displaced vehicle miles traveled by the average regional fuel economy for the year of analysis.
- **Step 5:** Multiply the gallons of gasoline saved by 0.00881 to calculate the carbon emissions the agency displaces annually.

#### 2.6.3 Resources and references

- APTA, Climate Change Standards Working Group, *Recommended Practice* “Quantifying Greenhouse Gas Emissions from Transit.” APTA SUDS CC-RP-001-09, 2009. [www.aptastandards.com/Portals/0/SUDS/SUDSPublished/APTA Climate Change Final new.pdf](http://www.aptastandards.com/Portals/0/SUDS/SUDSPublished/APTA%20Climate%20Change%20Final%20new.pdf)
- National Transit Database. [www.ntdprogram.gov/ntdprogram/data.htm](http://www.ntdprogram.gov/ntdprogram/data.htm)
- APTA, in cooperation with the Federal Transit Administration, “Transit Performance Monitoring System (TPMS) Results,” Phases I and II (2002) and Phase III (2004). [www.fta.dot.gov/documents/tpms\\_summary\\_I\\_and\\_II.pdf](http://www.fta.dot.gov/documents/tpms_summary_I_and_II.pdf)
- Environmental Protection Agency, “Report on Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010.” [www.epa.gov/otaq/fetrends.htm](http://www.epa.gov/otaq/fetrends.htm)
- The Climate Registry “General Reporting Protocol” v1.1, Table 13.1 U.S. Default CO<sub>2</sub> Emission Factors for Transport Fuels.” [www.theclimateregistry.org/downloads/GRP.pdf](http://www.theclimateregistry.org/downloads/GRP.pdf)



## 2.7 Energy use

### 2.7.1 Overview of metric

Energy usage is a key indicator of operational efficiency and environmental responsibility. Improving energy efficiency is financially beneficial because it manages utility and maintenance costs and risks. It is environmentally beneficial because it reduces emissions from energy generation. By quantifying energy usage in common terms, this metric is intended as a tool to benchmark energy performance, to assess energy management goals over time and to identify strategic opportunities for savings and recognition programs.

The total energy usage attributed to a transportation agency's operation and maintenance of the transportation system will be measured and tracked annually on a calendar-year basis. This includes the following:

- **Mobile combustion of fuels in the revenue fleet.** Includes all modes, such as heavy rail, light rail, buses, etc., powered by all fuel types, including diesel fuel, gasoline, liquefied petroleum gas, liquefied natural gas, compressed natural gas, bio-diesel fuel and other alternative fuels.
- **Purchased electricity, steam and natural gas, as well as heating oil or other fuels (if data are available) used to provide power, heating and cooling at stationary facilities.** Facilities include depots, shops, yards, stations, offices and administrative buildings that are under the operational control of the transportation agency. Usage data for heating oil or other fuels may be difficult to calculate for some agencies, especially those with multiple facilities receiving individual invoices for heating fuel deliveries. If this is the case, heating oil may be omitted from the scope of this metric.
- **Purchased electricity used for traction power for trains.** For some agencies, electricity used for traction comprises a large share of the total electricity consumption.

### 2.7.2 Basic approach

#### Data needs

- **Source 1:** Listing of energy (utility) accounts and locations of stationary facilities. The listing should include the type of facility or location or use to the level of detail that is possible.
- **Source 2:** Listing of all revenue services and fuel types (e.g., compressed natural gas (CNG) buses, electric traction-powered light rail).
- **Source 3:** Utility bills/ invoices from energy suppliers for the full calendar year being reported. This typically includes but may not be limited to the following:
  - **For mobile sources:** Monthly fuel purchase invoices for all fuel types, electricity purchase records, purchase agreements (e.g., for traction power).
  - **For stationary sources:** Monthly invoices from electric power suppliers, natural gas suppliers, purchased steam suppliers, fuel suppliers (such as heating fuel).
- **Source 4:** List of conversion factors for electricity and fuels, provided in **Table 11** and the NAFA Fleet Management Association's Gasoline Gallon Equivalent Table ([www.nafa.org/Template.cfm?Section=Energy\\_Equivalents](http://www.nafa.org/Template.cfm?Section=Energy_Equivalents)), to convert the various energy sources into Btu.
- **Source 5:** Normalization factor.

#### Calculation steps

- **Step 1:** Obtain and record monthly raw energy data from utility and fuel supplier invoices for revenue fleet and for stationary facilities, using the data sources records described above, for the calendar year. A spreadsheet program such as Excel is an appropriate tool for this.
- **Step 2:** For each source of energy, total 12 months of data to obtain energy usage for the calendar year.

- **Step 3:** Convert the raw energy usage data to Btu for each energy type, using the conversion factors in **Table 11** for energy used in stationary sources. For transportation fuels, the Btu value per gallon is provided in the Gasoline Gallon Equivalent Table.

**TABLE 11**  
Energy Conversion Factors for Energy Used in Stationary Facilities

Type of Energy Used	Starting Units	Multiply by This Factor to get Btu
Electricity	kilowatt hours	3412
Diesel fuel	U.S. gallons	138,700
Heating oil (No. 2)	U.S. gallons	138,700
Natural gas	therms (preferred)	100,000
	CCF (if therms not available)	102,900
District steam	pounds	1,194

Source: [www.energystar.gov/ia/business/tools\\_resources/target\\_finder/help/Energy\\_Units\\_Conversion\\_Table.htm](http://www.energystar.gov/ia/business/tools_resources/target_finder/help/Energy_Units_Conversion_Table.htm)

- **Step 4:** Total the energy usage in Btu for all sources to obtain total energy usage (Btu).
- **Step 5:** For easier reporting of large Btu values, divide by 1000 to report in kBtu (thousand Btu).
  - **Result:** Total energy usage for calendar year (in kBtu).
- **Step 6:** Apply normalization factor.

### 2.7.3 Resources and references

- APTA, Climate Change Standards Working Group, *Recommended Practice* “Quantifying Greenhouse Gas Emissions from Transit.” APTA SUDS CC-RP-001-09, 2009. [www.aptastandards.com/Portals/0/SUDS/SUDSPublished/APTA\\_Climate\\_Change\\_Final\\_new.pdf](http://www.aptastandards.com/Portals/0/SUDS/SUDSPublished/APTA_Climate_Change_Final_new.pdf) APTA CC-RP-001-09
- For official energy statistics from the U.S. government, go to the Energy Information Administration website: [www.eia.gov](http://www.eia.gov). If applicable, use comparable Canadian data source. This agency is part of the Department of Energy.
- For more information on energy management at stationary facilities, refer to the Energy Star program, a joint effort of the Environmental Protection Agency and the Department of Energy. This program has developed an energy management tool called the Energy Star Program’s Portfolio Manager ([www.energystar.gov/index.cfm?c=evaluate\\_performance.bus\\_portfoliomanager](http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager)).

## 2.8 Recycling and waste

### 2.8.1 Overview of metric

The inclusion of this metric as one of the nine key performance measures reflects the importance of waste management and minimization in the context of an agency’s broader commitment to a process of continual improvement in environmental stewardship.

**NOTE:** See “Basic approach” for a discussion of normalization metrics. For this metric, normalization factors should be based on units of service provided.

Recycling and waste indicators can vary based on units of measure and quantification methodology, although a survey of existing APTA Sustainability Commitment signatories found a high level of consistency among respondents. Typically, data are gathered through utility invoices and internal audits. Agencies compile utility

invoices from disposal agencies and facility records. Several agencies break down recycling levels/waste tracking and measuring by types of material disposed (e.g., paper, organics, hazardous). Several agencies also calculate a “diversion rate” — a measurement indicating the ratio of recycled waste to total waste. This diversion rate is uniformly calculated by dividing recycled material by total waste; the resulting number is the waste “diverted” from landfills.

Though the calculation methodologies themselves are straightforward, discrepancies exist in the scope (variety) of analyses. How agencies define “waste” and “recycling” is an important methodological decision point, and a challenge given the wide variety of waste (and recycling) streams that are generated by transit agency operations. For example, analysis can focus on employee or passenger waste, municipal or industrial waste, or hazardous vs. non-hazardous waste. The fence-line of analysis also can vary: Waste and recycling can be measured at a facility, agency or city/regional level. In any case, being clear about the scope of analysis is important.

For transit agencies, waste management and minimization strategies are a central objective to improve performance on the environmental pillar of sustainability. The APTA Sustainability Commitment requires performance to be tracked over time to measure progress toward this objective. For the purposes of establishing a baseline indicator, the APTA Sustainability Metrics Working Group recommends initially narrowing the definition of recycling and waste indicators and gradually expanding to include a more in-depth analysis over time based on data availability. Methodological guidance is provided in the following section.

## 2.8.2 Basic approach

### Data needs

- **Source 1:** Invoices for waste hauled from administration buildings, maintenance shops and depots, passenger stations and vehicles (i.e., for all facilities and vehicles for which invoices can be obtained).
- **Source 2:** Uncompacted cubic yard capacity of waste hauling compactors and containers (if tonnage is not available from invoices).
- **Source 3:** Waste composition analysis and/or volume-to-weight conversion table (available from the Environmental Protection Agency; see the “Resources and references” section).
- **Source 4:** Normalization factor.

### Calculation steps

- **Step 1:** Tabulate hauling invoices.
  - **1A:** If hauling invoices list tonnage data: sum annual invoices and total for waste and recycling, and for each tier where data are available, and skip to Step 4.
  - **1B:** If hauling invoices do not list tonnage data, then see Steps 2 and 3 below. The amount of waste hauled will be calculated based on the capacity of the compactors and containers picked up (in cubic yards) and the frequency of pickup. Then the total amount of waste hauled (in cubic yards) can be converted to tons using a volume-to-weight conversion factor.
- **Step 2:** Calculate cubic yard capacity and utilization.
  - **2A:** Inventory number and cubic yard capacity of all compactors and containers
  - **2B:** Tabulate total number of annual services (number of times “pulled” i.e. “emptied”) for each compactor and container
  - **2C:** Apply compaction ratio (Suggested – 3:1) to normalize each unit by uncompacted cubic yard capacity
  - **2D:** Apply utilization ratio (Suggested – 8:10) to all units to estimate cubic yard utilization (i.e., it is assumed that each compactor or container is on average 80% full when pulled).
  - **2E:** Sum all units to calculate total uncompacted cubic yard utilization

**TABLE 12**  
Example

Waste or Recycling	Service Location	Number of Annual Services/Pulls			Uncompacted Cubic Yards		
		40 Cubic Yard Compactor	4 Cubic Yard Container	20 Cubic Yard Container	Compaction Ratio	Annual Capacity	Estimated Utilization
Waste	Midvale Yard	46			3	5,520	4,416
	Media Yard		72		1	288	230
	Broad & Lehigh Yard			40	1	800	640
	<b>TOTALS</b>	<b>46</b>	<b>72</b>	<b>40</b>		<b>6,608</b>	<b>5,286</b>
Recycling	Woodland Yard	16			3	1,920	1,536
	<b>TOTALS</b>	<b>16</b>	<b>0</b>	<b>0</b>		<b>1,920</b>	<b>1,536</b>

- **Step 3: Convert Volume-to-Weight**
  - **3A:** In order to apply the most accurate volume-to-weight conversion factors, the best option is to conduct a waste composition analysis (in partnership with hauler or local collection facility). If composition information is not available, apply Step 3B using the “mixed municipal waste” conversion factor.
  - **3B:** Calculate total weight based on uncompacted volume (or quantity) for each known material type and its proportion of total waste stream

**TABLE 13**  
Volume to Weight Conversion Table

Type of Material (Waste and Recycling)	Volume (Cubic Yards)	Conversion Factors	Weight (Tons)
Mixed Municipal Waste		See “Resources and references” Section	
Glass Bottles			
Aluminum Cans			
Newspaper			
Office Paper			
Mixed Paper (Excluding Cardboard)			
Cardboard			
Plastic Bottles			
Plastic (Other)			

**TABLE 14**  
Example

Waste or Recycling	Service Location	Type of Waste and/or Recyclable Material						TOTAL TONNAGE
		Mixed Municipal Waste	PET	Newspaper	Cardboard	Aluminum Cans	Glass Bottles	
	Tons per Cubic Yard	0.1125	0.0175	0.3	0.55	0.031	0.5	
Waste	<i>Proportions by Weight</i>	100%	n/a	n/a	n/a	n/a	n/a	
	Midvale Yard	497	n/a	n/a	n/a	n/a	n/a	497
	Media Yard	26	n/a	n/a	n/a	n/a	n/a	26
	Broad & Lehigh Yard	72	n/a	n/a	n/a	n/a	n/a	72
	<b>TOTALS</b>	<b>595</b>	<b>n/a</b>	<b>n/a</b>	<b>n/a</b>	<b>n/a</b>	<b>n/a</b>	<b>595</b>

		Mixed Municipal Waste	PET	Newspaper	Cardboard	Aluminum Cans	Glass Bottles	TOTAL TONNAGE
	Tons per Cubic Yard	0.1125	0.0175	0.3	0.55	0.031	0.5	
Recycling	<i>Proportions by Weight</i>	n/a	30%	20%	20%	15%	15%	
	Woodland Yard	n/a	8	92	169	7	115	391
	<b>TOTALS</b>	<b>n/a</b>	<b>8</b>	<b>92</b>	<b>169</b>	<b>7</b>	<b>115</b>	<b>391</b>

- **Step 4:** Calculate metrics
  - **4A:** Based on normalization factors
  - **4B:** Based on diversion rate total recycling divided by total waste

**TABLE 15**  
Example

	Tons
Waste	595
Recycling	391
Diversion rate	39.4%

### 2.8.3 Resources and references

- EPA Volume-to-Weight Conversion Table:  
[www.epa.gov/osw/partnerships/wastewise/pubs/conversions.pdf](http://www.epa.gov/osw/partnerships/wastewise/pubs/conversions.pdf)

## 2.9 Operating Expense

### 2.9.1 Overview of Metric

Operating expense is a key measure of efficiency and an indicator of financial performance. APTA defines operating expenses as “the expenses associated with the operation of the transit agency and goods and services purchased for system operation.” (For more information regarding operating expense functions and object classes, please see the APTA Fact Book Glossary.) The management of these ongoing costs is critical to a transit agency’s financial stability.

**NOTE:** APTA Fact Book Glossary: <http://www.apta.com/resources/statistics/Pages/glossary.aspx#4>

The value of this metric as it relates to sustainability is that it rounds out environmental and social focused metrics with an economic indicator. APTA recognizes the triple bottom line impacts of sustainability – accounting for the environmental, social, and economic challenges facing an organization, and the value that transit provides along those lines to the broader region in which its services are provided. Economic indicators are important for measuring that broader impact.

As transit systems and services evolve, operating expense performance is a key tool for measuring the relative efficiency of the new system that emerges. To the extent that transit agencies strategically seek to expand the depth and breadth of their reach within a service territory, total operating expenses may be expected to rise over time. Normalized measures of operating expenses based on units of service provided allow a transit agency to evaluate the relative efficiency of its cost structures as changes to the system occur.

Inflation also tends to cause organizational cost structures to increase. Operating expense performance metrics allow transit agencies to compare relative efficiency with some industry benchmark. In so doing, the metric serves as an indicator that enables a broader comparison with expense trends impacting the industry as a whole.

### 2.9.2 Basic Approach

#### Data Needs

- **Source 1:** National Transit Database (NTD) Agency Profile or comparable Canadian database
- **Source 2:** NTD Appendix A: “National Transit Profile Summary - All Agencies”
- **Source 3:** Normalization factor

#### Calculation Steps

- **Step 1:** Use NTD Agency Profile or comparable Canadian source to Establish Baseline
  - **1A:** Extract operating expense by mode for baseline year
  - **1B:** Select normalization factor
  - **1C:** Extract data for normalization factor by mode
  - **1D:** Divide operating expense by normalization factor to establish agency baseline operating expense performance metric by mode
- **Step 2:** Repeat Step 1 by Using NTD Appendix A: “National Transit Profile Summary - All Agencies” or comparable Canadian database to Establish Industry Baseline
  - **2A:** Extract operating expense by mode for baseline year
  - **2B:** Select the same normalization factor from Step 1
  - **2C:** Extract data for normalization factor by mode
  - **2D:** Divide operating expense by normalization factor to establish industry baseline operating expense performance metric by mode
- **Step 3:** For Subsequent Years:
  - **2A:** Repeat steps 1 and 2 for the most recent year available

- **2B:** Calculate year-on-year percent change for agency and industry by using the following formula:

$$\text{Percent Change} = [\text{Year 2}-\text{Year 1}]/\text{Year 1} * 100$$

- **2C:** Subtract industry-wide percent change from agency percent change for each mode to determine relative operating expense performance

**TABLE 16**

Example

2009 (BASE YEAR)						
Mode	Agency (in Millions)			Industry-Wide (in Millions)		
	Operating Expense	Passenger Miles	Performance Metric	Operating Expense	Passenger Miles	Performance Metric
Motor Bus	\$533.8	524.8	\$1.01	\$18,704.0	21,477	\$0.87
Heavy Rail	\$158.0	423.0	\$0.37	\$6,310.5	16,805	\$0.38
Commuter Rail	\$219.8	501.8	\$0.44	\$4,625.7	11,232	\$0.41

2010						
Mode	Agency (in Millions)			Industry-Wide (in Millions)		
	Operating Expense	Passenger Miles	Performance Metric	Operating Expense	Passenger Miles	Performance Metric
Motor Bus	\$550.0	524.8	\$1.05	\$18,399.2	20,569.7	\$0.89
Heavy Rail	\$166.1	422.1	\$0.39	\$6,369.7	16,406.9	\$0.39
Commuter Rail	\$236.4	518.1	\$0.46	\$4,595.2	10,773.7	\$0.43

COMPARISON							
Mode	Agency			Industry-Wide			Difference
	2009	2010	Percent Change	2009	2010	Percent Change	Agency vs. Industry
Motor Bus	\$1.02	\$1.05	2.94%	\$0.87	\$0.89	2.30%	+0.64%
Heavy Rail	\$0.37	\$0.39	5.41%	\$0.38	\$0.39	2.63%	+2.77%
Commuter Rail	\$0.42	\$0.46	9.52%	\$0.41	\$0.43	4.88%	+4.65%

### 2.9.3 Resources and references

- National Transit Database: [www.ntdprogram.gov/ntdprogram/data.htm](http://www.ntdprogram.gov/ntdprogram/data.htm)
- Appendix A: “National Transit Profile Summary - All Agencies” (2010): [www.ntdprogram.gov/ntdprogram/pubs/national\\_profile/2010NationalProfile.pdf](http://www.ntdprogram.gov/ntdprogram/pubs/national_profile/2010NationalProfile.pdf)

## 2.10 Unlinked passenger trips (UPT) per capita

### 2.10.1 Overview of metric

UPT per capita in service area of operation is a metric intended to provide a simple measure of service effectiveness (i.e., how many rides is the agency getting from the communities it serves?), which might be considered a social sustainability metric as well as a key performance indicator. It could also provide insight from an economic sustainability perspective, as higher ridership is likely to mean higher cost-effectiveness and leverage of public investments.

From an environmental perspective, the metric is also a key indicator of how effective an agency’s service is in getting people out of their cars and the environmental benefits that follow from that, including greenhouse gas and criteria air pollutant reductions.

### 2.10.2 Basic approach

Using an agency’s data in the National Transit Database (NTD) , calculate the “total annual UPT” for each mode, then divide by the “total population in service area” to arrive at UPT per capita.

#### Data Needs

- **Source 1:** NTD Agency Profile or comparable Canadian database

#### Calculation Steps

- **Step 1:** Establish baseline
  - Extract unlinked passenger trips by mode from the NTD agency profile or comparable Canadian source for base year, combine to get total and divide by service area population for the base year

**TABLE 17**  
Base Year

Mode	Unlinked Passenger Trips	Service Area Population
Bus	[Per NTD Agency Profile]	[Per NTD Agency Profile]
Heavy Rail	[Per NTD Agency Profile]	[Per NTD Agency Profile]
Commuter Rail	[Per NTD Agency Profile]	[Per NTD Agency Profile]
Light Rail	[Per NTD Agency Profile]	[Per NTD Agency Profile]
Demand Response	[Per NTD Agency Profile]	[Per NTD Agency Profile]
Trolley Bus	[Per NTD Agency Profile]	[Per NTD Agency Profile]

- **Step 2:** For Subsequent Years
  - Extract unlinked passenger trips by mode from the NTD agency profile or comparable Canadian database for the most recent year available, combine to get total and divide by Service Area Population for the most recent year available

### 2.10.3 Resources and references

- National Transit Database: [www.ntdprogram.gov/ntdprogram/data.htm](http://www.ntdprogram.gov/ntdprogram/data.htm)



## 2.11 Vehicle miles traveled (VMT) per capita

### 2.11.1 Overview of metric

Vehicle miles traveled in region is intended to measure the impact that transit service is having on travel trends in the region an agency serves, which might be considered an environmental and/or social sustainability metric, as well as a key performance indicator.

From an environmental perspective, the metric is also a key indicator of how effective an agency's service is in getting people out of their cars and the environmental benefits that follow from that, including greenhouse gas and criteria air pollutant reductions.

### 2.11.2 II) Basic approach

#### Data Needs

FHWA's "Highway Statistics" publication; 4.4.5. Urbanized Area Summaries, Section 4.4.5.2, Selected Characteristics, Table HM-72: [www.fhwa.dot.gov/policyinformation/statistics](http://www.fhwa.dot.gov/policyinformation/statistics)

#### Calculation Steps

- **Step 1:** Report the "daily vehicle miles traveled per person" datum on an annual basis for the "Federal-Aid Urbanized Area" served by the agency, as defined in FHWA's "Highway Statistics" publication or comparable Canadian entity; 4.4.5. Urbanized Area Summaries, Section 4.4.5.2, Selected Characteristics, Table HM-72.

**NOTE:** A "Federal-Aid Urbanized Area" is "an area with 50,000 or more persons that, at a minimum, encompasses the land area delineated as the urbanized area by the Bureau of the Census."

### 2.11.3 Resources and references

- Example from Portland Metro region: [http://library.oregonmetro.gov/files//1990-2009\\_dvmt-portland-us.pdf](http://library.oregonmetro.gov/files//1990-2009_dvmt-portland-us.pdf)

## 3. Summary of recommendations

### 3.1 Looking ahead to Version 2.0 of APTA Sustainability Commitment

The Working Group's primary objective for this *Recommended Practice* is to develop standards for signatories to use in quantifying and reporting against APTA Sustainability Commitment performance metrics, establishing initial guidance and eventually recommended practices for identifying and measuring environmental sustainability metrics. In this, the process of developing standards will be iterative – over time, metrics will become more standardized as they become more commonly known and reported across the industry. The Working Group anticipates serving as a resource for transit agencies as sustainability metrics quantification and reporting practices evolve.

As the APTA Sustainability Commitment embarks upon its own version of continual improvement, the Working Group notes a need to continually reevaluate the extent to which the metrics required by the Sustainability Commitment reflect the depth and breadth of public transportation's contribution and value to our communities, environment, and quality of life.

#### 3.1.1 Refining social and economic metrics

According to the Sustainability Commitment: "Sustainability is about practices that make good business sense and good environmental sense. It is balancing the economic, social and environmental needs of a community." Currently, the Working Group finds that the Commitment's environmental indicators are more

refined than its economic and socially oriented metrics: operating expenses; unlinked passenger trips per capita in service area of operation; and vehicle miles traveled per capita in service area of operation.

The Working Group recommends that transit agencies continue to use these metrics to round out its indicators of sustainability performance. Over time, the industry will learn from these metrics as it seeks new ways to refine its methods for quantifying and reporting with measures of economic and social significance. Agencies are encouraged to explore novel methods within their own regions for measuring impacts on sustainability; these independent pilot efforts will inform the development of new metrics in version 2 of the *Recommended Practice*.

In future iterations of the Commitment, it will become increasingly important to include more nuanced measures of economic and social elements of sustainability. These might include:

- **A measure of the connectivity of the public transportation network.** As noted in APTA’s Transit Sustainability Guidelines, “A transit system can consist of the greenest of earth-friendly, energy-efficient facilities and fleet, but it does little good if it is not used”. A metric or number to represent the “coverage” of the transit system or bus system and quantifying “accessibility” may help to prioritize and justify whether to invest in expansion or enhancement.
- **A measure of the financial impact of transit nodes.** Quantification of land real-estate values, income levels, or sales tax revenues surrounding transit/bus stations would be measured against areas without transit access to illustrate the financial effects of transit nodes/TODs.
- **“Transit-Friendliness” public policy indicator.** Policies shape public transportation delivery from funding, administrative structure, and operations, to alignments, timelines and delivery dates. An assessment of the “transit-friendliness” of a city might include an inventory of policies which impact public transit directly or indirectly. The steps could first include inventorying these policies, and then further steps would involve investigating these policies to inform future policy decisions and provide foundation and leverage for advocacy and planning.
- **A measure of inter-agency cooperation.** A measure which denotes the level of cooperation or shared programs between related metropolitan agencies might take the form of an inventory of inter-agency programs such as using GPS technology already existing on buses to gather and contribute information about traffic patterns. Private service-providers could be included.
- **Costs of time.** The value of an individual’s time is often a significant determinate of whether to use public transportation. The cost of time might be included in measuring a transit system’s economic sustainability. Just as highways take measurement of average speed (which translates to time lost or gained), devising a metric which illustrates a rail/bus line or system’s time efficiency would be a useful indicator. Possibly something like a series of maximum and minimum travel times averaged within a matrix of distances and times-transferred. Leading research for this might also include development of an index of how much people’s time is worth for a given community. Taking this information and mapping it against availability to transit could inform how important the cost of time measurement actually is for a given node or line.

### 3.1.2 Developing new “human scale” metrics

The Working Group notes a need for future iterations of the transit sustainability metrics to feature a “customer lens,” focusing on the extent to which the transit agencies are actually affecting individual end-user decisions. Such human-scale metrics will help to refine the industry’s ability to emphasize and market its value.

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## Definitions

**baseline:** An agency’s chosen “starting point” year in which initial measurements are made. Future performance metrics will be measured against the baseline year.

**best management practices (BMPs):** Methods or techniques found to be the most effective and practical means in achieving an objective (such as preventing or minimizing pollution) while making the optimum use of the agency's resources.

**continual improvement:** To demonstrate an ongoing effort to improve products, services, and processes, and to measure progress in a meaningful way for each individual agency; a key principle of the APTA Sustainability Commitment.

**criteria air pollutants:** The U.S. EPA sets National Ambient Air Quality Standards (NAAQS) for six criteria air pollutants: particulate matter (PM), ground-level ozone (O<sub>3</sub>), carbon monoxide (CO), sulfur oxides (SO<sub>x</sub>), nitrogen oxides (NO<sub>x</sub>), and lead.

**data availability:** Where limited availability of data is expected, estimation techniques are suggested.

**Federal-Aid Urbanized Area:** An area with 50,000 or more persons that, at a minimum, encompasses the land area delineated as the urbanized area by the Bureau of the Census.

**global warming potential:** Global warming potential (GWP) is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming.

**greenhouse gases (GHG):** Greenhouse gases are those that can absorb and emit infrared radiation and thus trap heat in earth’s atmosphere; for example H<sub>2</sub>O, CO<sub>2</sub>, CH<sub>4</sub>, or N<sub>2</sub>O.

**non-revenue vehicles:** Agency-owned vehicles which are not intended to carry passengers.

**normalization factors:** A denominator metric intended to improve the accuracy of performance metrics by controlling for variability (PMT, VM, VRH, VRM, UPT, PSM, RVL, per capita).

**passenger miles traveled (PMT):** The cumulative sum of the distances ridden by each passenger.

**performance metric:** A calculation intended to measure and communicate progress toward an objective or a goal.

**produced seat miles (PSM):** PSM is calculated by multiplying vehicle revenue miles by average seating capacity for each vehicle by mode. Seating capacity is defined by the number of seats that are actually installed in the vehicle.

**reporting period:** Agencies are permitted to select the reporting cycle that best suits their purposes. Recommended metrics in this document are based on annual National Transit Database (or comparable Canadian database) reporting cycles, with the exception of GHG emissions, which should be reported on an calendar year basis, where possible.

**revenue vehicle length (RVL):** RVL is measured by calculating the distance from the front of a vehicle to the back of a vehicle.

**scope of analysis:** Metrics are based on the “operational control” method of quantifying agency impacts. The operational control method is defined as all operations over which the agency has full authority to introduce or implement operating policies. This may be established by wholly owning an operation or facility or by having full authority to introduce and implement operational and health, safety and environmental policies. In general, if an agency reports data on a service to the National Transit Database (NTD) or comparable Canadian database, it should be considered to have operational control over that service.

**APTA Sustainability Commitment:** The commitment sets out common sustainability principles, an action plan and a course for progress. The commitment also supports the exchange of good practice and aims to mark the achievements in sustainability the public transportation industry is making overall. See <http://www.apta.com/sustainability> for more information.

**State Implementation Program (SIP):** A plan administered by the U.S. Environmental Protection Agency (EPA) in compliance with the Federal Clean Air Act. The SIP consists of narrative, rules, technical documentation, and agreements that an individual state will use to clean up polluted areas.

**sustainability:** Practices that make good business sense and good environmental sense; balancing the economic, social and environmental needs of a community.

**tailpipe emissions:** Direct emissions produced from combustion vehicle operation. As opposed to indirect emissions from electricity consumption, water use, or waste disposal, for example.

**traction power:** Electricity consumed for rail propulsion.

**transit-oriented development (TOD):** A TOD is a mixed-use residential or commercial area designed to maximize access to public transportation, and often incorporates features to encourage transit ridership.

**unlinked passenger trips (UPT):** UPT is the total number of times passengers board public transportation vehicles. Passengers are counted each time they board vehicles, no matter how many vehicles they use to travel from their origin to their destination and regardless of whether they pay a fare, use a pass or transfer, ride for free or pay in some other way. Also called boardings.

**vehicle miles (VM):** VMs are all the miles a vehicle travels from the time it pulls out from its garage to go into revenue service to the time it pulls in from revenue service, including “deadhead” miles without passengers to the starting points of routes or returning to the garage. For conventional scheduled services, it includes both revenue miles and deadhead miles.

**vehicle revenue hours (VRH):** VRHs are the hours traveled when the vehicle is in revenue service (i.e., the time when a vehicle is available to the general public and there is an expectation of carrying passengers).

**vehicle revenue miles (VRM):** VRMs are the miles traveled when a vehicle is in revenue service (i.e., the time when a vehicle is available to the general public and there is an expectation of carrying passengers).

## Abbreviations and acronyms

<b>ADA</b>	Americans with Disabilities Act
<b>BMP</b>	best management practices
<b>BTU</b>	British Thermal Units
<b>CCF</b>	hundred cubic feet
<b>CH<sub>4</sub></b>	methane
<b>CNG</b>	compressed natural gas
<b>CO</b>	carbon monoxide
<b>CO<sub>2</sub></b>	carbon dioxide
<b>CUTA</b>	Canadian Urban Transit Association
<b>EPA</b>	U.S. Environmental Protection Agency
<b>FHWA</b>	Federal Highway Administration
<b>GHG</b>	greenhouse gas
<b>GWP</b>	global warming potential
<b>HC</b>	hydrocarbon
<b>MOVES</b>	Motor Vehicle Emission Simulator
<b>NAAQS</b>	National Ambient Air Quality Standards
<b>NO<sub>x</sub></b>	nitrogen oxides
<b>N<sub>2</sub>O</b>	nitrous oxide
<b>NTD</b>	National Transit Database
<b>O<sub>3</sub></b>	ozone
<b>PET</b>	polyethylene terephthalate
<b>PM</b>	particulate matter
<b>PMT</b>	passenger miles traveled
<b>POTW</b>	publicly owned treatment works
<b>PSM</b>	produced seat miles
<b>RVL</b>	revenue vehicle length
<b>SIP</b>	State Implementation Program
<b>SO<sub>x</sub></b>	sulfur oxides
<b>TOD</b>	transit-oriented development
<b>UPT</b>	unlinked passenger trips
<b>VM</b>	vehicle miles
<b>VRH</b>	vehicle revenue hours
<b>VRM</b>	vehicle revenue miles