Transportation Sector

Part 4 of 6 Supporting Documents

Sector-Specific Issues and Reporting Methodologies Supporting the General Guidelines for the Voluntary Reporting of Greenhouse Gases under Section 1605(b) of the Energy Policy Act of 1992

Examples

Figures

Tables

4.0 Transportation Sector

This document supports and supplements the General Guidelines for reporting greenhouse gas information under Section 1605(b) of the Energy Policy Act (EPAct) of 1992. The General Guidelines provide the rationale for the voluntary reporting program and overall concepts and methods to be used in reporting. Before proceeding to the more specific discussion contained in this supporting document, you should read the General Guidelines. Then read this document, which relates the general guidance to the issues, methods, and data specific to the transportation sector. Other supporting documents address the electricity supply sector, the residential and commercial buildings sector, the industrial sector, the forestry sector, and the agricultural sector.

The General Guidelines and supporting documents describe the rationale and processes for estimating emissions and analyzing emissions-reducing and carbon sequestration projects. When you understand the approaches taken by the voluntary reporting program, you will have the background needed to complete the reporting forms.

The General Guidelines and supporting documents address four major greenhouse gases: carbon dioxide, methane, nitrous oxide, and halogenated substances. Although other radiatively enhancing gases are not generally discussed, you will be able to report nitrogen oxides (NO_x), nonmethane volatile organic compounds (NMVOCs), and carbon monoxide (CO) after the second reporting cycle (that is, after 1996). The transportation sector is a significant source of these emissions.

The Department of Energy (DOE) has designed this voluntary reporting program to be flexible and easy to use. For example, you are encouraged to use the same fuel consumption or energy savings data that you may already have compiled for existing programs or for your own internal tracking. In addition, you may use the default emissions factors and stipulated factors that this document provides for some types of projects to convert your existing data directly into estimated emissions reductions. The intent of the default emissions and stipulated factors is to simplify the reporting process, not to discourage you from developing your own emissions estimates.

Whether you report for your whole organization, only for one project, or at some level in between, you will find guidance and overall approaches that will help you in analyzing your projects and developing your reports. If you need reporting forms, contact the Energy Information Administration (EIA) of DOE, 1000 Independence Avenue, SW, Washington, DC 20585.

4.1 Transportation: Overview

This supporting document provides technical guidance on reporting greenhouse gas emissions and emissions reductions in the transportation sector. Transportation activities give rise to the emission of three of the greenhouse gases treated in detail in these guidelines: carbon dioxide (CO_2), methane (CH_4), and nitrous

oxide (N_2O). This document provides guidance for reporting activities that reduce the emissions of these gases by reducing emissions from individual vehicles, improving the overall efficiency (and associated emissions levels) of vehicle fleets, and influencing the level and type of demand for transportation.

Activities that may be undertaken to reduce transportation-related emissions include the following:

- Marketing more fuel-efficient vehicles, vehicles that use cleaner fuels, and equipment (such as tires) that makes vehicles more fuel efficient

- Operating or maintaining a vehicle fleet more efficiently (including the purchase and use of vehicles that use cleaner fuels)

- Reducing or modifying demand for transportation (for example, through telecommuting, reduced travel, or increased bus ridership) and modifying infrastructure to reduce fuel consumption (for example, through modifying signalization to improve traffic flow)[(a)]

- Accelerating scrappage of older, less efficient vehicles.

All of these types of activities have the potential to reduce emissions and can be reported under the EPAct Section 1605(b) program. Note, however, that you may report any type of project that reduces greenhouse gas emissions so long as you are able to perform a credible project analysis. You are not restricted to reporting only those projects mentioned explicitly in this document. For example, some transportation-related emissions originate from vehicles, such as hydraulic-assisted boom trucks for use in working on utility lines, that operate primarily in idling mode. While specific emissions factors for this type of operation are not provided in this document, if you have the necessary data you can compute and report emissions and emissions reductions associated with using these vehicles.

This document provides technical assistance and illustrative examples to support each of the steps involved in estimating emissions and emissions reductions for the transportation sector. Note that each example is provided for illustrative purposes only; other appropriate ways to evaluate the hypothetical projects may exist.

4.1.1 Reporting Entities in Transportation

A typical reporting entity in transportation could be a vehicle manufacturer, tire manufacturer, airline, railroad, delivery firm, rental fleet operator, public transit agency, or local government planning agency.

(a) In reporting infrastructure modification projects, you should take care to ensure that reductions actually occur, as some infrastructure modifications can have the effect of *increasing* emissions.

Transportation activities are conducted or influenced by the following five groups:

- Infrastructure suppliers: organizations or government agencies that supply or manage transportation infrastructure (such as highways and railways)
- Vehicle suppliers: the manufacturers and sellers of vehicles
- Fuel suppliers: organizations that manufacture and sell transportation fuel
- Service suppliers: those who use vehicles and fuel to move passengers or goods (such as households, delivery firms, rental car agencies, airlines, and railways)
- Users: those who demand the movement of people or goods.

These groups may each take actions to reduce transportation-related emissions or may be affected by the actions of the other groups. Except for fuel suppliers, these groups are referred to throughout this supporting document. Reductions in emissions from the fuel manufacturing process are discussed in the supporting document for the industrial sector.

4.1.2 Sector-Specific Issues

A key issue in the transportation sector is the complex network of interactions among potential reporters in transportation activities. Opportunities for third-party reporting and multiple reporting are particularly numerous in this sector. Similarly, you may find your analysis of possible unintended and off-site effects of projects to be difficult.

You may choose to report through a third party, which could aggregate the emissions reductions for a group of entities with similar characteristics. The third party could ease the reporting burden on individual companies and use aggregate data to inform the public of their group's accomplishments toward reducing greenhouse gas emissions. A third party may provide an additional layer of confidentiality, since the contributions of any individual entity would not need to be identified in the report. (You should familiarize yourself with the confidentiality discussion in the General Guidelines.) A third party may also provide technical assistance in conducting the emissions-reducing projects and reporting. In this case, the emissions reductions might be reported jointly. Possible third parties include industry trade associations, electric utilities, gas utilities, and government agencies responsible for air quality.

A third party reporter would be responsible for developing aggregated reports and tracking the individual contributions of reporting entities. The third party would not be responsible for verification or certification; that responsibility remains with you as the reporting entity. If you report your emissions through a third party, you should retain in your files the information you used to compute your emissions and emissions reductions.

You may report activities undertaken jointly with others. If you do so, you need to identify other potential reporters of the same activity so that the voluntary reporting program can account for multiple reports of the same activities. (You may further wish to make prior arrangements with these other potential reporters, in the form of contracts or sales agreements.) Similarly, if you are providing data on emissions reductions to several third parties—for example, two trade associations of which you are a member—you should identify those parties in your report to track possible multiple reporting.

Joint activities in transportation primarily involve transactions that take place repeatedly between manufacturers and consumers where negotiated contracts generally are not involved. For example, the use of high-efficiency automobiles may be considered a joint activity. On the one hand, the purchaser of a high-efficiency car makes the ultimate decision to reduce emissions related to personal transportation. On the other hand, the automobile manufacturers who shifted their sales fleet composition are enabling the automobile owners to obtain more efficient automobiles. In another example, a utility company could be involved in an electric vehicle program that reduces overall emissions when power plant emissions are compared with tailpipe emissions.

It may be particularly difficult to identify all the effects of a transportation project, since vehicle use, market shares, infrastructure conditions, and other factors play sometimes pivotal roles in determining the effects of any given project on emissions. Many of these factors may be beyond your control, though they may affect your project. Thus, even when you can identify all possible effects, you may not be able to quantify them.

4.2 Organization of This Supporting Document

As described in the General Guidelines, EPAct Section 1605(b) addresses the reporting of annual emissions as well as emissions reductions and carbon sequestration. Section 4.3 provides guidance on reporting emissions, especially at the whole-entity level. Section 4.4 builds on the discussion of project analysis in the General Guidelines and provides a framework for understanding how your emissions reduction project relates to the reference cases, project effects, and estimation approaches described in the General Guidelines. Section 4.5 provides general guidance on methods for estimating reductions in transportation fuel use and on translating fuel use into emissions. Tables with emissions factors for transportation fuels are located in Section 4.5.

The remainder of this chapter is organized by type of emissions-reducing activity. Sections 4.6 through 4.9 provide guidance on analyzing projects and estimating emissions for the four types of activities mentioned in Section 4.1. The specific locations of guidance for these activities are listed in Table 4.1.

Table 4.1. Where to Find Guidance for Reporting Transportation-Related Emissions Reductions

Emissions-Reducing Activity	Location
Marketing Vehicles and Equipment	
- more fuel efficient vehicles	Section 4.6.1
- vehicles that use cleaner fuels	Sections 4.6.2, 4.6.3
- equipment (primarily tires) that makes vehicles more fuel efficient	Section 4.6.4
Operating or Maintaining a Vehicle Fleet More Efficiently	Section 4.7
Modifying Transportation Demand or Infrastructure	Section 4.8
Accelerating Vehicle Scrappage	Section 4.9

Except as noted, all data sources cited by name in Sections 4.5 to 4.9 can be found summarized in the *Transportation Energy Data Book* sponsored by the U.S. Department of Energy, Office of Transportaion Technologies and updated annually by Oak Ridge National Laboratory.

4.3 Estimating and Reporting Greenhouse Gas Emissions

The General Guidelines (Section GG-4, "What is Involved in Reporting Emissions?") explain that reporting information on greenhouse gas emissions for the baseline period of 1987 through 1990 and for subsequent calendar years on an annual basis is considered an important element of this program. If you are able to report emissions information for your entire organization, you should consider providing a comprehensive accounting of such emissions so that your audience can gain a clear understanding of your overall activities. As noted in the General Guidelines, some users of the database may find your reported estimates of emissions reductions more credible when accompanied by data on your organization's total emissions for the year of the reduction and for the baseline period of 1987 through 1990 and for subsequent years. You may wish to report this information for all or as much of your organization as possible, particularly if it would be important to users of your report.

Your emissions report should include all emissions you control, whether or not they are related to transportation, plus those indirect, off-site emissions attributable to your use of electricity. Typically, not all the emissions you control directly will be related to transportation. You will usually have other, non-transportation emissions; if you are able to estimate these emissions, you should include them in your emissions report. For example, vehicle manufacturers would have industrial emissions arising from the vehicle production process. Many other transportation entities consume energy in office buildings that have associated greenhouse gas emissions, both direct (from the use of fuel) and indirect (from the use of electricity). Guidance for estimating such non-transportation emissions is found in other supporting documents. Those for the electricity supply, residential and commercial buildings, and industrial sectors may be particularly relevant to reporters of transportation-related emissions. In general terms, to report direct non-transportation emissions, you should compute direct emissions from fuel use data and the emissions

factors in Appendix B (or your own, more site-specific emissions factors). To report indirect emissions from electricity use (other than that used for electric vehicles), you may use the default state level emissions factors in Appendix C or calculate utility-specific factors using the guidance provided in the supporting document for Electricity Supply.

To compute transportation-related emissions, you should determine the amount and type of fuel and electricity you consume for transportation purposes and translate that fuel and electricity use into emissions. Section 4.5 provides specific guidance on estimating vehicle fuel use and translating it into emissions. You should use the emissions factors provided in Section 4.5 to compute emissions unless you have specific information on the emissions rate for your vehicle(s) or electricity supplier. If you use different emissions factors from those in Section 4.5, you should document the values and the basis for them in your report.

Many entities maintain and report data that can be used to estimate their total emissions. For example:

- Airlines and major railroads are likely to maintain accurate records of fuel consumption for internal purposes and for required reporting to the Federal Aviation Administration or the Interstate Commerce Commission. In addition, you may have utility bills or summaries for office and vehicle support functions (e.g, refueling stations, refueling trucks, and baggage handling equipment operated by airlines).

- If you lease vehicles, you record odometer readings at the beginning and end of lease periods but are likely to have only limited information about fuel consumption. If you have EPA fuel economy ratings (discussed in Section 4.5) for your vehicles, you may estimate fuel consumption by dividing the miles each vehicle is driven by its fuel economy rating. A conservative approach to the estimate would use the urban fuel economy rating, unless you can provide supporting information that the combined or highway ratings are more representative of your vehicle use patterns. As noted in Section 4.5, the combined fuel economy rating should be divided by 1.15 (or a specific factor for your vehicle) before use in these calculations.

- If you are an infrastructure supplier, you may record information about your own energy consumption, which includes that from operating construction equipment, maintenance equipment (for example, street sweeping, snow plowing), and service equipment (for example, fueling equipment and baggage handling equipment when operated by airport authorities rather than the airlines). Infrastructure facilities themselves can consume energy; for example, electricity is used in inland waterways to operate locks, in road systems for illumination and control signals, in rail systems for control signals, in airports for control towers and terminal space conditioning, and in bus and truck depots for maintenance and refueling. Many infrastructure agencies also operate and maintain offices that use energy.

To compute your total emissions, you should add your transportation emissions to other emissions (for example, from industrial or building energy use) computed as described elsewhere in these supporting documents. You should report a total emissions level (in physical units such as pounds or metric tons) for each gas you emit. You do not need to separate transportation emissions from other emissions in your emissions

report, although you may wish to do so if your total transportation emissions will also constitute a reference case for a particular emissions-reducing activity being reported.

4.4 Performing Project Analysis

Your project may consist of a single, discrete action (for example, improved maintenance or routing that reduces the fuel consumption of a delivery fleet without reducing service); several activities, perhaps as part of an energy efficiency program (for example, a program at an auto manufacturing plant to reduce energy and fuel use for vehicle manufacture, in-plant transportation, and vehicle shipping); or your entire organization, where you report the change in total emissions for your organization.

The analysis of emissions reduction projects in the transportation sector follows the process described in the general guidance provided in the General Guidelines:

1. Establish the reference case as a basis for comparison with the project.

2. Identify the effects of the project.

3. Estimate emissions for the reference case and the project.

The General Guidelines describe two categories of reports: standard project reports and reporter-designed project reports. Standard project reports are those that use only default values—specifically, emissions factors (emissions per unit energy or fuel) and stipulated factors (standard energy or fuel savings or emissions reduction values for specific types of projects). No standard projects exist for the transportation sector at this time. Most reports will use emissions factors together with fuel and energy savings estimates, but you will need to develop these estimates on a case-by-case basis. Thus, the rest of this supporting document discusses only reporter-designed project reports.

4.4.1 Establish the Reference Case

As described in the General Guidelines, under this program you may choose a basic or a modified reference case (see Section GG-5.1, "What Should I Compare the Project To?"). You should be thoroughly familiar with that discussion before proceeding with project analysis.

If you are a vehicle manufacturer, your reference case and project case should be based on the vehicles sold in a calendar year. Although your "model year" may not correspond to the calendar year, if possible you should define the reference case and project case based on the calendar year. If the data needed to compute project effects on a calendar year basis are not available, you can use a model year basis for your report. However, you should be aware that users of the EPAct 1605(b) database will find your report more useful if it is based on the actual vehicles sold in a calendar year. Your report must specify which type of reporting year you used.

A basic reference case uses only historical emissions data as a basis for comparison with project emissions. Depending on the nature of and circumstances associated with your reporting, a basic reference case may provide a suitable and appropriate benchmark against which to compare project emissions. Some users of the EPAct 1605(b) database may have more confidence in reports that use a basic reference case than in reports that use a modified reference case.

In some cases, you may determine that a modified reference case is most appropriate. If so, you may choose to also report the emissions change using a basic reference case, to enable users of the database to evaluate U.S. efforts to reduce emissions with respect to an historic baseline.

The remainder of this section discusses one type of modified reference case that is based on emissions per unit of activity. If you do not need this information, you can skip to Section 4.4.2.

A form of modified reference case that may be of particular interest to reporters of transportation projects is a reference case that accounts for changes in the level of activity over time. An organization can take steps to improve the efficiency of its transportation activities but experience increases in the demand for its goods or services that cause total emissions to increase, even though emissions per unit activity (for example, emissions per ton-mile) are decreasing. In such a situation, you may wish to use a modified reference case based on the level of activity.

In simple terms, you could compute emissions per unit of activity production before the emissions-reducing project is conducted, and then determine what emissions would have been if the higher level of activity had been conducted at the "old" emissions rate. This value is the modified reference case. Current emissions are compared to the reference emissions to determine the reportable reduction.

If you develop a modified reference case, you may use only physical measures of activity (for example, miles driven, passenger-miles flown, ton-miles carried) to compute emissions per unit of activity. Dollar values (for example, sales figures) cannot be used as the unit of activity. You may calculate emissions per unit of activity for your entire entity or for discrete projects, taking care to account for all project effects within and outside of your organization.

Example 4.1 - Modified Reference Case

Note: This example illustrates only one approach to analyzing a project; your analysis, methods, and calculations will vary depending on your particular circumstances, the geographic location of the project, and other factors.

A small trucking firm that carries 250 million ton miles per year computed that it produced emissions of 0.02 lb CO_2 per ton mile. The firm instituted an efficiency program that involved rerouting and driver training, and achieved reductions of 10% in unit emissions, such that emissions were 0.018 lb CO_2 per ton mile. At the same time the firm experienced an increase in business of 50 million ton miles per year.

Before the project and the increase in business, total annual emissions were as follows (the basic reference case, bref):

$$\text{Emissions}_{bref} = 250 \text{ million ton miles} \bullet 0.02 \text{ lb } CO_2/\text{ton mile}$$

$$= 5 \times 10^6 \text{ lb } CO_2.$$

To compute the modified reference case (mref) for CO_2 emissions, the firm determined what the annual emissions would have been in the absence of the project using the "old" emissions rate and the new activity level.

$$\text{Emissions}_{mref} = 300 \text{ million ton miles} \bullet 0.02 \text{ lb } CO_2/\text{ton mile}$$

$$= 6 \times 10^6 \text{ lb } CO_2.$$

$$\text{Emissions}_{proj} = 300 \text{ million ton miles} \bullet 0.018 \text{ lb } CO_2/\text{ton mile}$$

$$= 5.4 \times 10^6 \text{ lb } CO_2.$$

$$\text{Emissions Reduction} = \text{Emissions}_{mref} - \text{Emissions}_{proj}$$

$$= 6 \times 10^6 \text{ lb } CO_2 - 5.4 \times 10^6 \text{ lb } CO_2$$

$$= 6 \times 10^5 \text{ lb } CO_2 = 300 \text{ short tons.}$$

Thus, in the absence of other effects, the firm could report an annual emissions reduction relative to the modified reference case of 300 short tons CO_2, even though total emissions increased by 200 short tons relative to the basic reference case.

4.4.2 Identify the Effects of the Project

Your report should address all the identifiable effects of your project, as described in the General Guidelines (see Section GG-5.2, "What Effects Did the Project Have?"). You should quantify these effects whenever possible. You should identify all potential effects, even if you are not able to quantify all of them.

Projects in the transportation sector run the gamut from discrete, well-defined projects to projects that can have both reinforcing and antagonistic effects within and outside of a reporting entity. When projects begin to interact such that the effects of each project cannot clearly be separated, you should consider reporting your total emissions reduction rather than the emissions reduction associated with individual projects. For example, you may wish to compute the emissions associated with your total energy use (for transportation alone or for all activities) before and after the project. After accounting for project effects outside the entity (for example, increased off-site emissions associated with outsourcing), you can report the reduction in total emissions. If you choose to report in this way, you must identify the specific projects or, at a minimum, categories of projects you undertook to reduce emissions, even if you are not able to determine the fraction of your total emissions reduction associated with each project.

You may account for some unintended effects by defining your project to include them. For example, if you are a vehicle manufacturer, you can capture the effects of shifts in your sales mix by defining your project to include sales of all of your vehicles. In fact, some users of the 1605(b) database may find your report more credible if you report for your entire sales rather than for specific models. By also including emissions from manufacturing, you can capture changes in emissions resulting from changes in production processes as well as those resulting from changes in what is sold. Other types of effects, such as the way that vehicle purchasers use the vehicles, or changes in your market share, are essentially beyond your control, although in some cases you may be able to estimate their magnitude.

Projects to influence the demand for transportation or to modify infrastructure to reduce fuel consumption have perhaps more potential for unintended effects. For example, an increase in carpooling or telecommuting means that more vehicles are left at home during the day, where other household members have the opportunity to use them. Where an urban area has severe traffic congestion, adding highway capacity has the potential to improve traffic flow and reduce fuel consumption, but also to attract additional traffic. Additional congestion during capacity reconstruction or expansion can offset subsequent reductions in congestion and emissions. If you are an infrastructure planner, you probably estimate the size of some of these effects already and should report them if you do.

Example 4.2 - Identifying the Effects of the Project

Note: This example illustrates only one approach to analyzing a project; your analysis, methods, and calculations will vary depending on your particular circumstances, the geographic location of the project, and other factors.

A vehicle manufacturer modified the engine in one of its models (Model A) in a way that improved vehicle efficiency, and wished to determine whether a reportable emissions reduction existed. The company needed to identify the potential effects of the project and determine their magnitude. To do this, the manufacturer looked at each stage of the automobile's life that influences emissions: vehicle manufacture, sale, use, and scrappage. Because the model is a redesign and replacement of a previous model with no change in interior space, statistics on the previous model could be used to determine the reference case. In this situation, the manufacturer chose a modified reference case, computed by determining what the emissions would have been if the cars sold that calendar year had been the original Model A rather than the improved version.

The most important effect of the project was reduced emissions from use of the more efficient vehicle rather than the previous model. Other potential effects are evaluated below.

1. *Manufacture*. The vehicle manufacture did not result in any change in manufacturing-related energy use or emissions, nor had any changes been made in the supply of parts (that is, no increase or decrease in outsourcing), relative to the reference case.

2. *Sales*. Sales of improved Model A decreased slightly relative to the reference case; however, the sales appeared to have shifted to a similar model in this manufacturer's sales fleet (Model B). No overall change in sales relative to competitors' models appeared to have occurred.

3. *Use*. A survey of vehicle purchasers revealed that users of the improved Model A were driving an average of 5% farther per year than had been the case for the reference case model. However, other use characteristics (for example, maintenance) appeared unchanged.

4. *Scrappage*. The improved engine had no effect on the extent to which the vehicle can be recycled or on vehicle lifetime.

Therefore, the manufacturer determined that project effects had occurred in the sales and use stages, and was able to quantify the effects.[a] Using EPA combined fuel economy values (adjusted by a factor of 1.15 in accordance with the guidance in Section 4.5) and its own data on miles driven, it computed the reference case emissions, the emissions from the use of the improved Model A (adjusted for the 5% increase in driving), and the emissions from the incremental increase in sales of Model B and reported the net emissions reduction for each greenhouse gas. The calculations are shown in Example 4.3. (If the manufacturer had not had access to a survey on driving characteristics, it would have used national aggregate statistics on vehicle use but adjusted the miles driven as described in Section 4.6.1.)

(a) Note that if the manufacturer had not been able to quantify these effects, the emissions reduction report may have lost credibility with some users of the 1605(b) database. To address this, the manufacturer could define the project to include all of its sales rather than just one model.

4.4.3 Estimate Emissions for the Reference Case and the Project

Your analysis of emissions for the reference case and project and your report must meet the minimum reporting requirements described in the General Guidelines (see Section GG-6, "What Are the Minimum Reporting Requirements?"). Your report will lose credibility if you do not use analytic and estimating practices commonly acceptable in the professional community. You may want to review the guidance provided in Sections 4.5 through 4.9 that describes procedures for estimating fuel savings and emissions reductions for several types of emissions-reducing measures. Section 4.3 describes examples of data you may already maintain that could be used to estimate some reference case and project emissions.

The guidelines recognize three categories of data:

Physical Data. This is information that describes the activities involved in your project and must be included in every report. For example, what types of operational and maintenance improvements did you undertake to improve the efficiency of your vehicle fleet? In what portion of your total vehicle production did you install more efficient engines? What fraction of your fleet did you convert to alternative fuels or replace with high-efficiency vehicles? The specific actions that you undertook should be identified clearly in your report.

Default Data. As noted previously, the primary category of default data applicable to the transportation sector is emissions factor data. These data are provided in Section 4.5.3. Stipulated factors (average fuel savings or emissions reductions for specific types of projects) can be used only when there are standard emissions-reducing activities and widespread agreement on how much they reduce emissions. These conditions are not applicable to the transportation sector at this time.

Reporter-Generated Data. These are data you develop for estimating the effects of your project. There are two categories of reporter-generated data:

- *Measured Data*. These are data collected directly from the project that you use in estimating your project's accomplishments. For example, you may monitor fuel gauges, odometers, or electricity used to charge electric vehicle batteries, or you may keep detailed fuel purchase records. Direct measurement of greenhouse gas emissions is not feasible for projects in the transportation sector.

- *Engineering Data.* These are data that you derive from various sources such as manufacturer's equipment specifications, surveys, reports, academic literature, and professional judgment.

Your choice of estimation methods will be constrained by the availability of data. For example, you may combine metered or measured values with emissions factors, physical data, and other parameters to determine the emissions reductions associated with your project. Using several methods and comparing the results may increase the confidence that database users have in your estimations.

Specific estimation methods for fuel consumption, vehicle use, and emissions are described in Section 4.5.

4.5 Estimation Methods for Fuel Consumption, Vehicle Use, and Emissions

Analysis of transportation-related emissions and emissions reductions requires information on how the type and amount of fuel used and the distance traveled (vehicle use) have changed between the reference case and the project case. This section provides guidance on estimating fuel consumption and vehicle mileage and translating them into emissions values. The process for performing these calculations for light-duty vehicles is illustrated in Figure 4.1.

4.5.1 Measured Fuel Consumption

In general, if you supply transportation services to yourself or others, you can use information from vehicle fuel gauges or fuel purchase records to determine actual fuel consumption. Measured data, of course, would be the most accurate data, and you should use them if you collect them. However, you may not find direct collection of this information cost effective but have other procedures to collect information that will support estimates of fuel consumption.

If you manufacture vehicles and components, you may measure fuel consumption directly via sensors or microprocessors, perhaps on a sample basis. You may aggregate partial or sample information collected during vehicle servicing and project it to all vehicles of that model sold during the year to allow a fairly direct estimation of fuel consumption for vehicles sold in a given year. You may be able to account for systematic differences between the characteristics of vehicles serviced at dealerships and those serviced elsewhere. A more indirect method would be asking vehicle purchasers to report their fuel consumption to you.

4.5.2 Estimated Fuel Consumption and Vehicle Use

You may estimate emissions and reductions using information on vehicle fuel economy and the characteristics of vehicle use (annual distance traveled). You may estimate fuel consumption by dividing vehicle use (for example, miles) by vehicle fuel economy (for example, miles per gallon). Data sources for these two pieces of information are discussed below.

Fuel Economy. You may use several sources of fuel economy data. Manufacturers of light-duty highway vehicles (cars, pickup trucks, and light vans) are now required to have production vehicles tested for fuel economy and emissions using the EPA Federal Test Procedure (FTP) and are required to report their fuel economy test results, vehicle sales, and the sales-weighted average fuel economy to determine compliance with the Corporate Average Fuel Economy (CAFE) program. Emissions testing does not address specific greenhouse gases, such as methane and nitrous oxide, but categories of gases

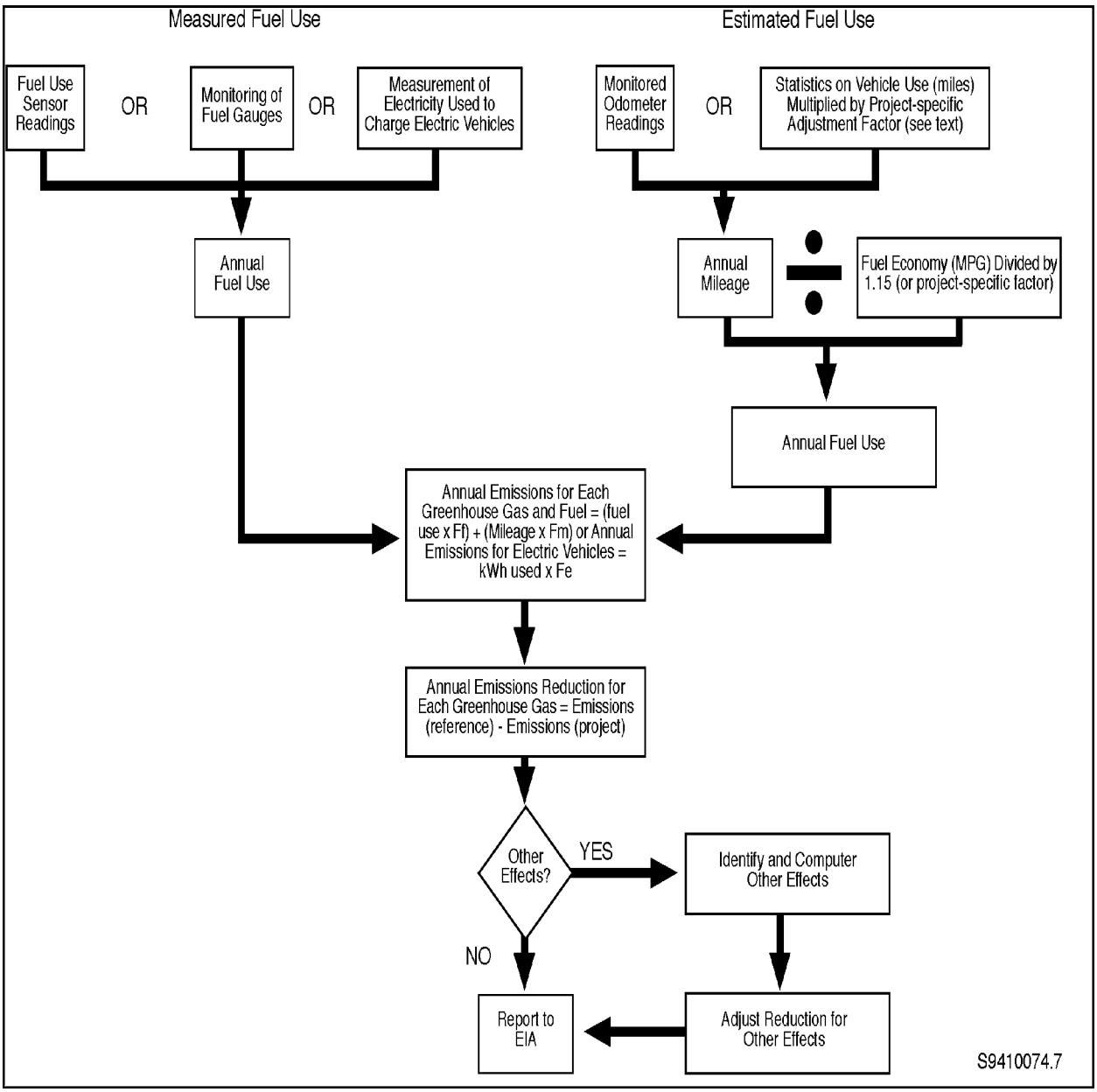

Figure 4.1. Computing Emissions Reductions for Light-Duty Vehicles

that include them. Because the information needed to separate the emissions of greenhouse gases from those of other gases in these categories does not exist at this time, the FTP emissions values cannot be reported directly to the EPAct Section 1605(b) reporting program; rather, the fuel economy data should be used along with vehicle use data to estimate emissions and emissions reductions.

The test procedure provides two measures of fuel economy: urban and highway. A combined urban/highway value also is reported for use in the CAFE program. You should use the combined value divided by a factor of 1.15 to account for the difference between the CAFE value and what the average driver actually achieves. Alternatively, if you have specific information for your vehicle(s) indicating that a different adjustment factor should be used, you can use this value instead. You should document the value used and the basis for it in your report. Except when specifically noted in the discussion of alternative fueled vehicles, any mention of a fuel economy rating in this guidance should be interpreted to mean the combined MPG rating adjusted as above.

Note that, as described in Section 4.6.2, if you are computing emissions reductions associated with electric vehicles or other alternative fueled vehicles, you should use the urban fuel economy rating instead of the combined value. You can use the urban values directly; no adjustments to the FTP values are needed.

Vehicle Use. If you are not the user of the vehicle(s) included in your project, you will need to obtain information on vehicle use (annual distance traveled) to determine vehicle fuel consumption. You will also need this information to compute emissions for light-duty vehicles other than electric vehicles. You can obtain vehicle use information in several ways. For example:

1. *Surveys*. You can conduct surveys of vehicle owners to collect odometer readings. (Note that odometer readings recorded at specified intervals are considered more accurate than self-reporting of mileage driven over a similar interval.)

2. *Data Collection During Vehicle Service*. You can record odometer readings during scheduled vehicle service, adjusted if necessary to reflect any systematic differences in vehicle use between users whose data you collect and users who have their vehicles serviced elsewhere.

3. *Statistics*. You can use statistics on light-duty vehicle use, which are available in the form of national, fleet-wide averages. The Energy Information Administration (EIA) uses the Residential Transportation Energy Consumption Survey (RTECS) to collect data on odometer readings and to determine the average number of miles driven by vehicle age for automobiles. The *Transportation Energy Data Book* (Davis and Strang 1993) provides information on light-duty truck use. Analysis of the effects of improved fuel economy on driving shows a small aggregate tendency to drive farther as vehicle fuel economy increases, reducing overall fuel savings by 5 to 15 percent from what they would be if the additional driving did not occur. Given current fuel price and fuel economy trends, a decrease in fuel savings of 10 percent is a reasonable assumption.

   However, as detailed in Section 4.6.1, to compute transportation emissions based on vehicle use statistics, you will need to know the specific miles driven in the project case. Therefore, you will need to

convert the assumed reduction in fuel savings into the corresponding change in miles traveled. To do this, you will need to compute a project-specific adjustment factor that you can apply to the reference case miles traveled to obtain the miles traveled in the project case. The procedure for doing this is described in Section 4.6.1.

Note that these national statistics will generally better reflect sales of a diversified manufacturer's complete product line than of a portion of it. Also, in some cases, such as alternative-fueled vehicles, the characteristics of the vehicle affect its use, such that aggregate national statistics should not be used (see Section 4.6.2). In such situations, estimates of emissions and reductions should use estimates of vehicle use, fuel use, and transportation demand based on modeling, surveys, or other sources.

If you have other data for specific vehicles, you may use that information in estimating emissions and emissions reductions. For example, you may perform your own fuel economy testing on heavy trucks, locomotives, and aircraft, which are not subject to industry-wide fuel economy testing and reporting. Aggregate fleet estimates of vehicle use may be unavailable for these types of vehicles. If you cooperate closely with others in maintenance, troubleshooting, and other activities, you may be able to acquire information on vehicle use and/or fuel consumption. (For example, a vehicle manufacturer may cooperate with a fleet operator in maintaining the fleet.) You should use any such data you have in estimating your emissions and emissions reductions.

4.5.3 Translating Fuel Consumption and Vehicle Use into Emissions

Fuel consumption and vehicle use should be translated into emissions using the emissions factors in Tables 4.2 through 4.6. The emission factors for use in computing emissions for light-duty vehicles (Tables 4.2 and 4.3) and heavy trucks (Tables 4.3 and 4.4) are given in two parts: a factor per mile driven and a factor per unit of fuel placed into the car. The effects of these two factors are additive, so that total emissions for each greenhouse gas are computed as follows:

$$\text{Annual Emissions}_{i,j} = \text{Annual Mileage} \bullet Fm_{i,j} + \text{Annual Fuel Use} \bullet Ff_{i,j}$$

where $Fm_{i,j}$ = emissions factor per mile driven for greenhouse gas i and fuel j
$Ff_{i,j}$ = emissions factor per unit of fuel used for greenhouse gas i and fuel j.

The reason that both factors must be used is that, for each greenhouse gas, the two emissions factors address different types of emissions, as explained below.

Fm, the emissions factor per mile driven, is given in Tables 4.2 and 4.4. It addresses the following emissions:

CH_4: tailpipe emissions—based on tailpipe emissions standards for criteria pollutants
N_2O: tailpipe emissions—based on tailpipe emissions standards for criteria pollutants
CO_2: emissions from unintentional burning of oil in vehicle engines.

Because these factors are based on emissions standards and unintentional burning of oil, they are valid over a broad range of vehicle fuel economy values. Also, because the emissions standards are given in metric units, the factors in Tables 4.2 through 4.6 are also given in these units.

Ff, the emissions factor per unit of fuel placed into the vehicle, is given in Tables 4.3 and 4.5. It addresses the following emissions:

CH_4: upstream emissions (from fuel extraction, processing, delivery, and storage)
N_2O: upstream emissions (from fuel extraction, processing, delivery, and storage)
CO_2: tailpipe emissions and upstream emissions (from fuel extraction, processing, delivery, and storage).

Note that, for heavy trucks, Fm is given in terms of brake-horsepower hours rather than miles.

The factors in Tables 4.2 through 4.6 are derived from an analysis of full fuel-cycle emissions (ANL 1991, ANL 1993). The analysis estimates energy consumption and other sources of greenhouse gas emissions associated with extracting fossil fuels, moving them to refineries, power plants, or other conversion facilities, converting them to final form, moving the products to fueling points, and placing fuel into vehicles. Thus, for petroleum-based fuels, these emissions include leakages of methane associated with crude petroleum; energy spent in extracting crude petroleum and products; energy consumed in refining; energy required for pumping into and out of storage at petroleum terminals; energy used to move product by rail, barge, and truck; and energy used in pumping product into retailers' tanks and pumping out of retailers' tanks into vehicles. The analysis identifies similar kinds of operations and estimates emissions for other types of fuels, including electricity. These "upstream" emissions are important when comparing the effects of switching fuels, because a fuel that has few or no emissions of CO_2, CH_4, or N_2O in the vehicle can have much larger "upstream" emissions than a fuel that has higher emissions in the vehicle. Although the published analysis reported emissions in terms of global warming potentials rather than emissions of individual gases, the default factors provided in Tables 4.2 through 4.6 use unaggregated emissions factors obtained from the author of the published reports.

More details on the emissions factors included in Tables 4.2 through 4.5 may be found in Section 4.6.2, "Alternative Fueled Vehicles." If you have specific emissions factors for your project, you should use those values in computing your emissions reductions. This is especially important for alternative fuels, because the emissions from these fuels can vary significantly depending on the feedstocks and processes used to produce them (see Section 4.6.2). If you use factors other than those in Tables 4.2 through 4.5, you must document the values you use and their basis in your report.

Only one emissions factor is used for electric vehicles. You should compute emissions for electric vehicles by multiplying the kWh used to charge the vehicles by the appropriate emissions factor (Fe) from Table 4.6 or by the specific emissions factor for your project.

$$\text{Annual Emissions}_{\text{electric vehicles}} = \text{Annual Electricity Use} \bullet Fe_i$$

where Fe_i = emissions factor per kWh for greenhouse gas i.

Thus, if you are a vehicle manufacturer, you could determine the distribution of your fleet or sales among the states and use state-specific emissions factors for the appropriate fractions of your fleet. If you have more specific emissions factors for the utilities that supply your electricity, you are encouraged to use those factors. You must document the values you use and their basis in your report.

Table 4.2. Emissions Factors for Miles Driven by Automobiles and Light Trucks Using Gasoline and Alternative Fuels (grams/mile driven)

Fuel Type	N_20/Mile	CH_4/Mile	CO_2/Mile
Gasoline	0.05	0.05	2.0
Reformulated gasoline	0.05	0.05	2.0
Ethanol from corn	0.05	0.03	1.5
LPG	0.05	0.05	2.0
Methanol from natural gas	0.05	0.03	2.0
Compressed natural gas	0.05	1.00	1.0

Source: Computed from coefficients based on ANL (1991) and ANL (1993). See text for discussion of methodology used.

Table 4.3. Emissions Factors for Use of Gasoline and Alternative Fuels by Automobiles and Light Trucks (grams/unit of fuel placed into the vehicle)

Fuel Type	Fuel Unit	Btu per Fuel Unit	N_20 per Fuel Unit	CH_4 per Fuel Unit	CO_2 per Fuel Unit
Gasoline	gallon	$1.25x10^5$	0.175	8.67	$1.10x10^4$
Reformulated gasoline	gallon	$1.22x10^5$	0.171	8.47	$1.05x10^4$
Ethanol from corn	gallon	$8.46x10^4$	7.88	32.8	$7.48x10^3$
LPG	gallon	$8.93x10^4$	$3.57x10^{-2}$	1.65	$6.23x10^3$
Methanol from natural gas	gallon	$6.45x10^4$	$8.39x10^{-2}$	8.30	$5.92x10^3$
Compressed natural gas	standard cubic foot	$1.03x10^3$	$5.00x10^{-4}$	0.15	64.6

Source: Computed from coefficients based on ANL (1991) and ANL (1993). See text for discussion of methodology used.

Table 4.4. Emissions Factors for Distance Driven by Heavy Trucks Using Diesel Fuel and Alternative Fuels (grams/brake-horsepower hour)

Fuel Type	N_20/bhp-hr	CH_4/bhp-hr	CO_2/bhp-hr
Diesel	0.06	0.10	4.0
Ethanol from corn	0.06	0.05	4.0
LPG	0.06	0.10	3.0
Methanol from natural gas	0.06	0.05	4.0
Compressed natural gas	0.06	3.0	2.0

Source: Computed from coefficients based on ANL (1991) and ANL (1993). See text for discussion of methodology used.

Table 4.5. Emissions Factors for Use of Diesel Fuel and Alternative Fuels by Heavy Trucks (grams/unit of fuel placed into the vehicle)

Fuel Type	Fuel Unit	Btu per Fuel Unit	N_20 per Fuel Unit	CH_4 per Fuel Unit	CO_2 per Fuel Unit
Diesel	gallon	1.39×10^5	0.139	8.61	1.17×10^4
Ethanol from corn	gallon	8.46×10^4	7.88	32.8	7.48×10^3
Liquefied petroleum gas	gallon	8.93×10^4	3.57×10^{-2}	1.65	6.37×10^3
Methanol from natural gas	gallon	6.45×10^4	8.39×10^{-2}	8.30	6.05×10^3
Compressed natural gas	standard cubic foot	1.03×10^3	5.00×10^{-4}	0.15	66.1

Source: Computed from coefficients based on ANL (1991) and ANL (1993). See text for discussion of methodology used.

Table 4.6.Emissions Factors For Electric Vehicles by State and Region[(a)]
(grams/kWh)

State	N_20	CH_4	CO_2	State	N_20	CH_4	CO_2
New England				**South Atlantic**			
Connecticut	0.027	0.496	$3.82x10^2$	Delaware	0.053	1.63	$1.06x10^3$
Maine	0.028	0.258	$1.85x10^2$	District of Columbia	0.041	1.21	$7.29x10^2$
Massachusetts	0.042	1.05	$7.67x10^2$	Florida	0.043	1.20	$7.84x10^2$
New Hampshire	0.029	0.582	$3.72x10^2$	Georgia	0.039	1.18	$6.69x10^2$
Rhode Island	0.035	1.15	$6.43x10^2$	Maryland	0.041	1.21	$7.28x10^2$
Vermont	0.014	0.087	$5.25x10^1$	North Carolina	0.041	1.23	$6.92x10^2$
				South Carolina	0.027	0.672	$3.82x10^2$
				Virginia	0.036	0.985	$5.65x10^2$
				West Virginia	0.054	1.83	$1.03x10^3$
Mid Atlantic				**East-South Central**			
New Jersey	0.029	0.749	$4.32x10^2$	Alabama	0.041	1.28	$7.21x10^2$
New York	0.033	0.821	$5.42x10^2$	Kentucky	0.054	1.83	$1.03x10^3$
Pennsylvania	0.04	1.20	$6.83x10^2$	Mississippi	0.037	1.11	$6.32x10^2$
	0			Tennessee	0.041	1.25	$7.08x10^2$
East-North Central				**West-South Central**			
Illinois	0.032	0.880	$5.06x10^2$	Arkansas	0.038	1.17	$6.61x10^2$
Indiana	0.056	1.93	$1.09x10^3$	Louisiana	0.040	1.27	$7.13x10^2$
Michigan	0.046	1.49	$8.41x10^2$	Oklahoma	0.047	1.59	$8.92x10^2$
Ohio	0.051	1.69	$9.49x10^2$	Texas	0.044	1.45	$8.16x10^2$
Wisconsin	0.045	1.450	$8.16x10^2$				
West-North Central				**Mountain**			
Iowa	0.052	1.76	$9.91x10^2$	Arizona	0.036	1.05	$5.93x10^2$
Kansas	0.048	1.56	$8.78x10^2$	Colorado	0.055	1.88	$1.05x10^3$
Minnesota	0.045	1.43	$8.08x10^2$	Idaho	0.015	0.046	7.98
Missouri	0.050	1.64	$9.26x10^2$	Montana	0.044	1.38	$7.77x10^2$
Nebraska	0.039	1.18	$6.67x10^2$	Nevada	0.051	1.73	$9.81x10^2$
North Dakota	0.058	2.0	$1.12x10^3$	New Mexico	0.057	1.95	$1.10x10^3$
South Dakota	0.032	0.912	$5.13x10^2$	Utah	0.055	1.86	$1.04x10^3$
				Wyoming	0.058	1.99	$1.12x10^3$
Pacific Contiguous				**Pacific Non-Contiguous**			
California	0.026	0.645	$3.59x10^2$				
Oregon	0.016	0.187	$1.03x10^2$	Alaska	0.019	0.287	$2.16x10^2$
Washington	0.017	0.249	$1.38x10^2$	Hawaii	0.045	0.732	$9.16x10^2$

(a) Values are grams/kWh delivered to the vehicle, based on the average kilowatt-hour generated in the state in 1992. Values are computed from coefficients based on ANL (1991) and ANL (1993) and are consistent with the electricity generation fuel mixes and technologies underlying the emissions factors in Table C.1. The values include emissions from the power plant and emissions upstream from the power plant to extract, process, and deliver the fuel. They account for electricity losses in transmission and distribution, and the production of N_2O from transmission lines. They do not account for the transfer of electricity across state lines.

4.6 Estimating the Effects of Marketing Vehicles with Lower Emissions

This class of project encompasses three general types of actions:

- Marketing vehicles that are more fuel efficient
- Marketing vehicles that use cleaner fuels
- Marketing components (primarily tires) that make vehicles more fuel efficient.

Specifics on estimating fuel use and emissions reductions resulting from these actions are discussed below.

4.6.1 Improved Fuel Economy

You may define a project based on the average fuel economy for all of the vehicles you sell or for a selected portion of your sales (for example, introducing a new model with high fuel economy). You should identify the specific actions you took to improve the fuel economy of your model(s) or sales fleet.

Your project should be based on the number of vehicles sold in a calendar year. Although most manufacturers use a "model year" that doesn't coincide with the calendar year, if possible you should define the reference case and the project based on the calendar year. If the data needed to compute the project effects on a calendar year basis are not available, you can use a model year basis for your report. However, you should be aware that users of the EPAct 1605(b) database will find your report more useful if it is based on the actual vehicles sold in a calendar year. Your report should specify which type of reporting year you used.

Defining a project to cover only a portion of your fleet could result in internal project effects if the models selected take or lose market share from the remainder of your sales fleet. You may use internal marketing research to assess effects between model lines. If the model included in your project is a redesign and replacement of a previously existing model, sales data for the previous model can be used to assess these effects. You could also choose to expand the definition of your project to include all effects that occur within your organization—for example, expand a project from a single vehicle model to all vehicles in your fleet. You must still be sure to identify and, where possible, quantify effects that occur outside your organization.

If your project covers only a portion of the vehicles you sell, the vehicle use characteristics for this portion may differ from the national averages in the RTECS and the *Transportation Energy Data Book*. If you have specific data for the vehicles covered by your project, you should use these data in your report, documenting the values used and the method you used to estimate them.

Your reference case emissions would be computed by determining the fuel economy and average use for all of the vehicles covered by your project that were sold in the reference case year(s). If your project covers only selected models (as opposed to your entire sales fleet), the models used to estimate the reference case should be comparable in performance and interior volume to the new or improved models that constitute your project.

As noted earlier, analyses show that (1) automobile and truck users tend to drive farther as fuel economy increases, reducing expected fuel savings by 5 to 15 percent, with 10 percent a reasonable assumption given current fuel price and fuel economy trends, and (2) the EPA combined fuel economy ratings tend to be about 15 percent higher than the fuel economy that is actually achieved. Thus, if you based your calculation of fuel use reductions on combined fuel economy statistics or vehicle use statistics rather than specific data for your vehicle, you should (1) divide the combined fuel economy values by a factor of 1.15 before computing fuel consumption and savings and (2) determine the increase in miles traveled that corresponds to the 10 percent decrease in fuel savings using the following equation:

$$\frac{miles_{proj}}{miles_{ref}} = t\left(\frac{mpg_{proj} - mpg_{ref}}{mpg_{ref}}\right) + 1$$

where $miles_{proj}$ = miles traveled in the project case
$miles_{ref}$ = miles traveled in the reference case
t = assumed reduction in fuel savings (default value = 0.1)
mpg_{proj} = fuel economy (miles per gallon) in the project case
mpg_{ref} = fuel economy (miles per gallon) in the reference case.

For example, if the statistic for miles driven in the reference case is 10,000 miles, and the fuel economy in the project and reference cases is 40 mpg and 30 mpg, respectively, the project-specific adjustment factor is as follows:

$$\frac{miles_{proj}}{miles_{ref}} = 0.1\left(\frac{40 - 30}{30}\right) + 1 = 1.033$$

$$miles_{proj} = 1.033 \bullet miles_{ref} = 1.033 \bullet 10{,}000 = 10{,}330 \text{ miles}.$$

If you have data indicating that some other factor should be used to adjust the vehicle use or fuel economy data for your specific project, or if you have data on the actual miles driven or the fuel economy of your vehicles under their actual conditions of use, you should use this information instead. You should document the data you use and the basis for them in your report.

Because a vehicle with improved fuel economy continues to save fuel beyond the year in which it is sold and first used, you may wish to report emissions reductions in future years from the continued use of the vehicles in your project. You may report these reductions on an annual basis, after the emissions reductions for the year have taken place. For consistency, these reductions should be reported using the same reference case as the original project report. Reports of such continuing reductions should be reported separately from new projects. For continuing reductions, the number of vehicles in the project should be reduced over time. Scrappage and survival rates for automobiles and light trucks are reported in the *Transportation Energy Data Book* and should be used in computing your future reductions unless you have specific data on the

scrappage and survival rates for your project. You should document the basis for any values you use that differ from those in the *Transportation Energy Data Book*.

Fuel economy also tends to decline slightly with vehicle age because of deterioration and limited maintenance. For continuing projects, you should also reduce the fuel economy of the vehicles in your project and the associated emissions reductions over time. However, no published information exists that could be used to adjust fuel economy ratings for vehicle age. Vehicle service departments and state-mandated vehicle inspection programs might collect data related to fuel economy in older vehicles, but they do not measure fuel economy directly. If you have information about the effect of age on fuel economy for your own vehicles, you should use it to calculate emissions reductions in continuing projects. If you do not have such data, you should assume no decline in fuel economy over time.

Example 4.3 - Estimating Emissions Reductions Resulting from Improved Fuel Economy

Note: This example illustrates only one approach to analyzing a project; your analysis, methods, and calculations will vary depending on your particular circumstances, the geographic location of the project, and other factors.

The vehicle manufacturer in Example 4.2 redesigned and replaced its Model A with a version with improved fuel economy. In calendar year 1991, the year before the project, the manufacturer sold 5,000 of the original Model A vehicles. In calendar year 1992, the year of the project, the manufacturer sold 4,500 of the improved Model A vehicles and 500 additional Model B vehicles (which are similar to the original Model A but with lower fuel economy). No changes appear to have occurred in overall market share relative to competitors. All vehicles are fueled with gasoline.

The combined fuel economy values from the EPA Federal Test Procedure are 25 mpg for the original Model A, 30 mpg for the improved Model A, and 23 mpg for Model B. These values must be adjusted by a factor of 1.15 in computing fuel use.

The manufacturer chose a basic reference case based on what the emissions would have been in the absence of the project, assuming that sales of the original Model A would have been the same in calendar year 1992 as in 1991—that is, 5,000 vehicles would have been sold at a fuel economy of 25 mpg.

The manufacturer had data on odometer readings for the reference and project cases recorded during scheduled vehicle service. This information indicated that the original Model A was driven 10,000 miles per year and that the improved Model A was driven slightly farther—10,500 miles per year. Model B was driven 9,500 miles per year.[(a)]

Total Mileage

Reference case: Total Mileage = 5,000 vehicles • 10,000 miles/vehicle = 5.0×10^7 miles

Project case: Total Mileage = (4,500 vehicles • 10,500 miles/vehicle) + (500 vehicles • 9,500 miles/vehicle)
= 4.7×10^7 miles + 4.8×10^6 miles = 5.2×10^7 miles

Total Fuel Use

Total fuel use was computed as follows:

$$\text{Fuel Use} = \frac{\text{Mileage}}{\text{Fuel Economy / 1.15}}$$

Reference case: Total Fuel Use = (5.0×10^7 miles) / (25 mpg/1.15) = 2.3×10^6 gallons

Project case: Total Fuel Use = (4.7×10^7 miles) / (30 mpg/1.15) + (4.8×10^6 miles) / (23 mpg/1.15)
= 2.04×10^6 gallons

Emissions

$$\text{Annual Emissions} = \text{Annual Mileage} \bullet Fm_{gasoline} + \text{Annual Fuel Use} \bullet Ff_{gasoline}$$

Emissions were computed using the emissions factors from Tables 4.2 and 4.3.

Reference Case Emissions

N_20 Emissions	=	5.0×10^7 miles • 0.05 g/mile	+	2.3×10^6 gal • 0.175 g/gal	= 2.9×10^6 kg
CH_4 Emissions	=	5.0×10^7 miles • 0.05 g/mile	+	2.3×10^6 gal • 8.67 g/gal	= 2.24×10^7 kg
CO_2 Emissions	=	5.0×10^7 miles • 2 g/mile	+	2.3×10^6 gal • 1.1×10^4 g/gal	= 2.54×10^{10} kg

Project Case Emissions

N_20 Emissions	=	5.2×10^7 miles • 0.05 g/mile	+	2.04×10^6 gal • 0.175 g/gal	= 2.96×10^6 kg
CH_4 Emissions	=	5.2×10^7 miles • 0.05 g/mile	+	2.04×10^6 gal • 8.67 g/gal	= 2.03×10^7 kg
CO_2 Emissions	=	5.2×10^7 miles • 2 g/mile	+	2.04×10^6 gal • 1.1×10^4 g/gal	= 2.25×10^{10} kg

Example 4.3 - (con't)

The manufacturer can report the effects of the project as follows:

N_2O: $Emissions_{ref} - Emissions_{proj} = 2.9x10^6$ kg $- 2.96x10^6$ kg $= -6x10^4$ kg (increase)
CH_4: $Emissions_{ref} - Emissions_{proj} = 2.24x10^7$ kg $- 2.03x10^7$ kg $= 2.1x10^6$ kg (decrease)
CO_2: $Emissions_{ref} - Emissions_{proj} = 2.54x10^{10}$ kg $- 2.25x10^{10}$ kg $= 2.9x10^9$ kg (decrease)

(a) If the manufacturer had not had data on miles driven, statistics on vehicle use could have been used for the reference case but the adjustment described in Section 4.6.1 would have been required to compute project case emissions.

4.6.2 Alternative Fueled Vehicles

Alternative fueled vehicles (AFVs), which include electric vehicles, present a number of challenges to estimating emissions and emissions reductions. In general, the calculation of emissions reductions requires estimating the amount of alternative fuel used, the amount of gasoline that would have been used but for the project, the emissions from each, and the difference.

If you do not measure fuel consumption directly, you will need to compute it from information on vehicle fuel economy and vehicle use. AFVs are expected to have different performance and shorter driving ranges between refuelings, so vehicle purchasers probably will use AFVs somewhat differently from conventional vehicles. However, at present there are too few AFVs in use and too little experience with these vehicles to project how they will be used, although the number of AFVs is expected to increase during the next 6-10 years as various state, local, and federal mandates take effect. If you are a vehicle manufacturer and have or can obtain use characteristics for a representative sample of the AFVs you sell, you should use this information in computing your emissions reduction. If you do not have such information, you should assume that the average AFV is driven as far as the average petroleum-fueled vehicle.

In reporting emissions reductions associated with the sale of AFVs, you should consider whether the vehicles sold actually replace other vehicles. For example, if an electric vehicle is purchased and used as a supplemental vehicle for short trips where the owner previously walked or took public transportation, overall emissions could increase.

To construct a credible reference case and comparable data for both the reference and project cases, you need to account for two factors:

- *Differences in use*. Given that AFVs are expected to have more limited driving ranges and to be used primarily in urban markets, you should use the gasoline-equivalent fuel economy for the urban (not combined) driving cycle in these calculations.

- *Equivalence between gasoline and any alternative fuel used.* Details of fuel economy testing for production AFVs will remain uncertain until such vehicles are routinely submitted for testing. Until a fuel economy rating is assigned, you need to estimate fuel economy using your own data and express that estimate in terms of gasoline equivalence (that is, as the miles per gallon that would be

achieved if the fuel were gasoline). Thus, multiplying the fuel economy by the estimated distance driven for a new vehicle and by the number of vehicles sold would yield the reference case gasoline consumption. Then you should estimate the factor needed to convert the fuel economy to equivalent mileage per unit of the alternative fuel in order to estimate fuel consumption for the project case.

If you have fuel economy data expressed in terms of units of the alternative fuel per distance driven, then the reference case should be calculated using the fuel economy for the urban driving cycle for a conventionally fueled model with comparable interior volume. Multiplying the fuel economy for the alternative vehicle by the distance driven and the number of vehicles would yield the project case.

Another consideration in reporting is the type of alternative fuel used and its source. Some alternative fuels have low or even zero emissions of greenhouse gases if measured at the vehicle tailpipe, but higher emissions than conventional fuels when the production of the fuel is taken into consideration. Reporting emissions reductions for alternative fuels should reflect the production as well as the use of the fuel. Unfortunately, analysts do not agree about which alternative fuels, feedstocks, and production processes yield reductions of greenhouse gas emissions relative to gasoline in a comparable vehicle; for those alternative fuels where there is agreement that reductions occur, differences exist on the magnitude of the reductions.

If you wish to report reductions from the sale of AFVs, you should report the alternative fuel type and quantity as well as emissions and emissions reductions. Tables 4.2 through 4.6 in Section 4.5 contain estimated emissions per unit of alternative fuel based on a large, comprehensive study using consistent assumptions and using wide bounds on the fuel cycle to account for all effects of fuel switching on emissions. You may wish to base your calculations on this study. You should be aware that the reporting program may recalculate emissions reductions based on subsequent studies if results warrant, especially after more experience is gained with producing, marketing, and using alternative fuels. If you have specific information on the emissions for your vehicles and fuels, you should use these data instead. You should document the values used and the basis for them in your report.

The choice of a feedstock also can affect the life-cycle emissions—that is, the total of emissions for every step in making a fuel. For example, methanol made from coal is estimated to yield more emissions than gasoline, while methanol from natural gas is expected to yield slightly less than gasoline. Electricity from coal-fired steam-turbine power plants (used to charge electric vehicle batteries) is estimated to yield more emissions than gasoline, although electricity from other plants is expected to yield fewer emissions (ANL 1991). Ethanol from corn, contrary to many expectations, is estimated to yield higher emissions because the fermentation process requires energy that, at present, is typically supplied by burning coal. Thus, a vehicle manufacturer wishing to report emissions reductions from marketing AFVs must ascertain what share of the fuel market is being supplied from which feedstock in order to determine whether the use of this fuel actually reduces emissions.

In the future, as alternative fuels gain market share, it is likely that information about sources and production processes will be collected and reported by DOE, the Alternative Fuels Data Center at the National Renewable Energy Laboratory, or other organizations. Again, reporting should include estimated fuel quantities as well as emissions, to permit recalculating of reductions if subsequent information suggests

revising those that have been reported. In the meantime, you should assume that methanol comes from natural gas and electricity from the state-specific fuel mixes that underlie the emissions factors in Table 4.6. A vehicle manufacturer should determine what fraction of its electric vehicle market is located in each state and use these data together with the emissions factors in Table 4.6 or your own utility-specific data to compute emissions reductions associated with electric vehicles.

4.6.3 Flexible Fueled Vehicles

Flexible-fueled vehicles (FFVs), which can use varying mixtures of gasoline and methanol or gasoline and other fuels, could perform very similarly to vehicles that use only gasoline, although FFVs aren't optimized for either fuel so some deterioration of performance could occur. Average use statistics could be used for these vehicles, although project-specific information would be more accurate. Estimating the emissions reductions requires information on how much of the alternative fuel was substituted for gasoline in these vehicles. In these cases, you may wish either to survey a sample of customers to determine actual fueling choices or, if FFV sales are concentrated among public or commercial fleets, to request information from fleet operators. This information also could be collected by sensors in the FFV fuel system and retrieved during regularly scheduled vehicle maintenance by the manufacturer's service outlets. If you have such data, you should use them in computing your emissions and emissions reductions.

4.6.4 Equipment that Improves Fuel Economy

This section provides guidance on reporting emissions reductions resulting from the use of tires that reduce vehicle fuel consumption. If you wish to report emissions reductions associated with other types of equipment, you should follow the same general guidance as that discussed for tires.

Reduced rolling resistance by tires would reduce vehicles' fuel consumption. However, very little data exist on the extent of improved fuel economy. Under the Climate Change Action Plan, a testing and rating program for rolling resistance by tires will be developed. Until tires are rated, emissions reduction projects that involve improved rolling resistance can only be analyzed using your own data.

In general, reporting will require the same kind of information on vehicle fuel use that vehicle manufacturers would have to estimate to report the projects described in Section 4.6.1, adjusted for the effects of tires. However, the estimation problem is compounded by the number of potential reporters, each with partial information: the tire manufacturer, the vehicle manufacturer, the consumers who use vehicles equipped with the tires, and (possibly) tire dealers who replace tires.

The tire testing and rating is anticipated to allow calculation of the effects of improved rolling resistance as a percentage of fuel economy (for example, a tire model used on all four wheels of a car results in a 3 percent increase in MPG). A tire manufacturer who has a contract to supply tires for a manufacturer's new vehicles should be able to obtain from the vehicle manufacturer the number, fuel type, and fuel economy ratings of vehicles using the tires as standard equipment. The tire manufacturer then can estimate vehicle use and calculate fuel consumption with the project and reference case tires. Tire and vehicle manufacturers who report should each indicate the other as other possible reporting entities.

As with vehicle sales, the project case for tires may best be based on the number and type of tires sold. For consistency and credibility, the reference case should be based on the same testing program as the project case. Thus, the reference case should be based on tires sold during the first year of the testing and labeling program, and projects reported for the second and subsequent years of the testing program. Again as for vehicles, if you are a tire manufacturer, defining a project based on part of your sales increases the potential for unintended project effects and inaccuracies from using national vehicle use statistics. Given the other complexities in reporting emissions reductions from tire sales, your report's credibility will be enhanced by reporting for your entire sales to new vehicles, rather than portions of your product line.

Second-and-subsequent-year reports could be submitted on emissions reductions from the cohort of vehicles supplied with the tires, but you must account for scrappage rates of the vehicles and scrappage rates of the tires. Because average vehicle mileage reflects a range of use, and because scrappage can be influenced by equipment damage as well as normal wear, tire scrappage rates cannot be calculated directly from average vehicle use and expected tire mileage. You may wish to (1) reanalyze the Residential Transportation Energy Consumption Survey (RTECS) to estimate variation in mileage and expected tire scrappage rates or (2) survey vehicle purchasers, or (3) collaborate with vehicle manufacturers if they survey vehicle purchasers.

Emissions reductions from tires purchased as replacement equipment are much more difficult to estimate accurately. You may not be recording or have access to information on the age and make of car on which replacement tires are installed. You may wish to develop reporting systems to begin gathering this information from retailers, or you may wish to develop customer surveys or other methods of sampling to estimate tire-vehicle combinations or even vehicle or fuel use. Lacking this information, you may wish instead to calculate fuel consumption using the Energy Information Administration's (EIA's) reported average fuel economy for the nation's automobile fleet (published with a year's delay) and the RTECS to estimate average mileage for the fleet; these values can be used to calculate average fuel consumption in the reference and project cases for replacement tires. Unfortunately the EIA fleet average is for passenger cars only; it does not include light trucks. A comparable series probably can be constructed, at some cost, for light trucks using published information on yearly sales and average fuel economy for light trucks.

If you submit continuing reports on reductions from both tire sales for new vehicles and sales of replacement tires, you need to adjust average fleet fuel economy used in replacement sales to avoid reporting the same reduction twice. (Some of the fleet average fuel economy would be based on tires purchased as original equipment on new vehicles.) You may use the average fleet fuel economy of several years prior to the year of actual replacement tire sale, based on estimates of tire scrappage rates or expected lifetimes for the tires on new vehicles. Second-and-subsequent-year projects for replacement tires will become increasingly less reliable.

4.7 Estimating the Effects of Operating or Maintaining a Vehicle Fleet to Reduce Emissions

A transportation service supplier or fleet operator may reduce greenhouse gas emissions in a number of ways, including the following:

- purchasing and using high-MPG vehicles
- purchasing and using alternative fueled vehicles
- improving the maintenance of existing vehicles to reduce fuel consumption
- improving operating practices (for example, acceleration, braking, idling) to reduce fuel consumption
- improving routing to reduce distances traveled
- matching equipment to tasks to reduce fuel consumption
- changing vehicle dispatching or other practices to improve fleet fuel economy.

Some growing service suppliers may be able to report reductions in aggregate emissions resulting from large increases in efficiency that more than offset the effect of growth in the demand for service. (See the discussion of modified reference cases based on unit of service in Section 4.4.) These suppliers are encouraged to report, taking account of activity shifting, outsourcing, and other possible project effects.

Audits of operations, maintenance, vehicle stock, and routing for service delivery fleets using highway vehicles have identified potential reductions in fuel consumption of up to 34 percent, with reductions of 20 percent considered actually achievable (Erkut and MacLean 1992). Improved routing alone has allowed rural school districts to reduce school bus mileage by up to 20 percent (Graham 1993). Vehicle operating practices also can affect fuel consumption. For example, increasing the operating speed of an automobile above 55 miles per hour can increase fuel consumption 5-30 percent, depending on the vehicle (Holcomb et al. 1987). Idling the engine of a heavy truck during cold weather keeps fuel warm but uses 10-20 times as much diesel fuel as a fuel heater that accomplishes the same thing (Transport Topics 1988). Short-term training of vehicle operators has been shown to change behavior and reduce fuel consumption by 10 percent in the short term (Greene 1986), although some of this reduction may not persist in the long term.

You can undertake any of the activities listed above by itself or in concert with other activities, for your entire fleet or for part of it. If you undertake activities for part of the fleet, you must consider the possibility of additional project effects within the fleet. For example, partial replacement of a fleet with AFVs could result in changes in how they or other vehicles in the fleet are used, assigned, or routed to compensate for different characteristics (for example, limited range between refuelings) of the new vehicles.

Another possible project effect results from outsourcing, defined here as contracting with another firm to provide some of the transportation service. If your sole action to reduce emissions is to contract out for service, you have not reduced emissions (unless the supplier operates at a lower level of emissions), and you

should not report a reduction under this program. If the supplier operates at a lower level of emissions and you can compute these emissions, you could report a new reduction if no other effects offset the reduction.

Unlike vehicle manufacturers, service suppliers are in a position to monitor actual fuel consumption for individual vehicles in their fleets and for the fleets themselves. Vehicles such as aircraft monitor fuel consumption directly, while consumption in other vehicles can be monitored by recording quantities used during refueling. Some trucking firms are beginning to install extensive vehicle monitoring equipment that includes distance and fuel consumption monitoring.

If you report for part of a fleet, estimating emissions reductions can become complicated, because additional project effects become more likely. Similarly, reporting can become complicated if you try to estimate the magnitudes of reductions resulting from each of several simultaneous projects (for example, a public transportation agency or a delivery company might purchase alternative fueled vehicles for use on selected routes, improve routing, improve vehicle maintenance, and improve operator behavior). In the latter situation, you may wish to report the total reduction in emissions for your organization, your fleet, or part of your fleet. You need not undertake detailed analysis to determine how much of the reduction in emissions resulted from each of these measures. However, to facilitate the process of learning how to reduce emissions, the project description should include information about the various measures undertaken and some rough assessment of the relative importance of each in achieving the reductions reported.

If you organize your fleet into distinct territorial or other divisions with relatively little interaction between division boundaries, a project might be implemented and reported for only one or a few divisions. Where divisional boundaries are loose, so that a change in activities in one division affects those in another, the project can have effects on emissions in other divisions, and expanding the project definition to encompass all of the interacting divisions would capture more of the project effects.

4.7.1 Data Sources for Service Suppliers

Many transportation service suppliers already measure their fuel consumption directly for required reporting to federal agencies or for their own business purposes.

Airlines presently are required to report fleet fuel consumption, revenue ton-miles, and revenue passenger miles to the Federal Aviation Administration's Office of Airline Statistics (Form 41, required under 14 CFR Part 241). An airline may report a reference case as fleet fuel consumption and fuel consumption per revenue ton-mile in a specific year (by converting revenue passenger miles to revenue ton-miles as now done to complete the form), define a project to reduce fuel consumption per revenue ton-mile, and report emissions reductions calculated as the difference in fuel consumption per ton-mile in the specific and project years, multiplied by the ton-miles in the project year. The calculations should include both scheduled and non-scheduled service to account for all project effects.

Class I railroads presently are required to report fleet fuel consumption and freight ton miles to the Interstate Commerce Commission (Schedule 750, lines 4 and 6; Schedule 755, line 14). A Class I railroad may report a

reference case as fleet fuel consumption and fuel consumption per ton-mile in a specific year, define a project to reduce fuel consumption per ton-mile, and report emissions reductions calculated as the difference in fuel consumption per ton-mile in the reference and project years, multiplied by the ton-miles in the project year. The present form collects information only on diesel fuel. A railroad that uses fuels other than diesel fuel should include consumption of the other fuels as well.

Other transportation service suppliers are not now required to report levels of fuel consumption and services supplied. However, they are likely to collect and analyze this information for their own business purposes and may report in a manner similar to those noted above.

4.7.2 Alternative Fueled Vehicles

If you report emissions reductions involving shifting the mix of vehicles in your fleet by operating alternative fueled vehicles (AFVs), several issues arise. Significant uncertainties exist in developing AFV programs and in life-cycle emissions data. Some of these are addressed in Section 4.6.2. This section focuses on potential reporters who purchase and operate, rather than market, AFVs.

First, several Federal and state mandates for large fleets to purchase AFVs have been enacted but have not yet taken effect. The Federal programs and probably the state programs will require record keeping and reporting about these purchases, but the reporting requirements for these programs have not yet been finalized. These reporting requirements are likely to include some information that can be used in EPAct Section 1605(b) reports.

Second, as in the case of AFV manufacturers, service suppliers wishing to report reductions from AFV use face uncertainty about which alternative fuels actually reduce greenhouse gas emissions and by how much. For this reason, an organization that reports reductions from the use of AFVs should report fuel consumption for each fuel in the reference and project cases as well as emissions reductions.

AFVs using two types of alternative fuels—electricity and natural gas—can be refueled from facilities that use these fuels for other purposes (for example, lighting, office equipment, space conditioning). You do not have to establish separately metered fueling stations in order to report reductions from using alternative fuels, but where multiple uses are metered jointly you must estimate the proportion of transportation uses (or you may define the project to include all other functions using the same fuel or energy sources as well as vehicle operations). This can be done by recording fuel supplied using an in-line meter as the vehicle is filled or by measuring fuel in the vehicle before and after each refueling in order to establish the magnitude of the fill. A less reliable and more cumbersome approach would be to estimate historic consumption of the alternative fuels prior to the purchase of the AFVs, adjust it as needed for fluctuations in weather-related space conditioning or other variables, and subtract it from total fuel consumption after the AFVs entered service.

You can use the factors in Table 4.6 to estimate emissions and emissions reductions associated with electric vehicles. However, if you have more specific information for your project, such as the emissions rate from your electricity supplier and the time of day that vehicle charging takes place, you are encouraged to use this

information in computing your emissions and emissions reductions. You must document any such data you use and their basis in your report.

4.8 Estimating the Effects of Modifying Demand and Infrastructure

This section provides guidance on reporting emissions reductions resulting from demand modification and infrastructure improvements. A number of programs and activities are designed to manage demand for transportation or reduce travel-related emissions. The most prominent of these are mandated employer programs to reduce commuting and encourage telecommuting. Both types of programs are intended to reduce the number of cars and light trucks driven to work each day by employees. At the same time, some improvements in infrastructure are designed to improve the operating efficiency of the vehicles that use it.

4.8.1 Demand Modification

The Clean Air Act Amendments of 1990 (CAAA) require states and metropolitan areas that violate ambient air quality standards to enact legislation mandating that large employers increase vehicle occupancy rates among their commuting employees. Emissions reductions achieved through these or other demand-reduction programs can be reported to the 1605(b) program.

The general approach[(a)] to implementing the CAAA involves three steps. First, employees are surveyed to establish a reference case of commuting behavior. The employer then develops and implements a plan for achieving targeted increases in vehicle occupancy rates or other measures of performance specified in the legislation. Third, the employer resurveys the employees after a year to determine if the targets have been met.

This type of program puts into place several features that can be used to report emissions reductions from these mandates, but the information may be insufficient to report the project. The first survey in the program establishes a reference case, and subsequent surveys allow calculation of project cases. Annual reporting of survey results to an administering agency can provide aggregated results while protecting confidentiality and reducing the reporting burden for individual employers.

Unfortunately the survey instruments that have been used to date often do not need to request information that could be used to calculate fuel consumption or mileage driven of individual employees or employers. Information about distance driven by employees or the make and type of vehicle driven often is unnecessary to achieving the specific program objectives. Adding questions about this information increases the reporting burden, and, if such questions are added after the initial survey, comparison with the reference case becomes difficult. In addition, the largest reductions in commuting driving are expected in the early years of these programs, so using a subsequent year as the reference case may yield few reductions in fuel consumption and

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(a) The approach described here is what has been used prior to the 1990 Clean Air Act Amendments; a similar process will likely be implemented under the Amendments.

emissions. If you anticipate becoming subject to travel reductions under the 1990 Clean Air Act Amendments, you may wish to add questions on vehicle type and distance driven to your initial and follow-up surveys.

Given an estimate of the number of single-occupant vehicle commuting trips eliminated and information about how the affected commuters are now getting to work (for example, carpooling, or public transportation), several data sources can be used to estimate fuel consumption, as follows:

- Many metropolitan planning organizations (MPOs) have survey information that can be used to estimate average commuting distance, sometimes for employers located in different parts of the metropolitan area.

- The National Personal Transportation Survey, administered periodically by the Federal Highway Administration, has been analyzed to estimate national averages for commuting distances.

- In the absence of information about the vehicles used for commuting, the average fuel economy for the nation's automobile fleet can be used to estimate fuel economy; the Truck Inventory and Use Survey, which is conducted by the Bureau of the Census, has been analyzed to estimate fuel economy for the nation's light truck fleet. Information on the fuel economy of the combined fleet is not available in public form.

Although these estimates will be rough, they will allow reporting. More accurate information can be acquired only by increasing the survey burden.

Carpooling and vanpooling eliminate some vehicle trips but do so at the expense of some extra travel to collect and disperse the participants at their various residences. Again, information on the magnitude of this offsetting distance may be available from MPOs. Otherwise, unless you have survey data, adjustments to the distance can only be approximate, which will decrease the accuracy of a report.

Public transit trips are more problematic, as the routes and distances traveled are unlikely to be the same for any individual commuter. You may assume a bus trip of the same distance as the car trip eliminated. If the local public transit agency collects and makes them available, local estimates of fuel consumption per passenger mile are probably more accurate than national aggregates of this information, which must be computed from data collected by the Federal Highway Administration and the American Transit Association. These national computations, in Btus per passenger mile, are published in the *Transportation Energy Data Book* and can be converted to diesel fuel using conversion factors published there. The national estimates again will be rough but, absent local surveys conducted by MPOs or local transit agencies, cannot be improved without substantial cost and burden.

Little information exists on unintended effects of telecommuting. Studies of telecommuting have found that at least in the early years among early adopters of telecommuting, household travel behavior does not adjust to offset reductions in commuting behavior. The phenomenon is too recent for any long-term effects to have been measured, and it remains unknown whether early adopters and later adopters will behave similarly.

Telecommuting does lead to a slight increase in building energy use which appears to be quite small in comparison with the energy saved by not commuting. Until more households are equipped with meters that allow households to develop real-time or activity-based indications of their rates of energy consumption, information on this will not be readily collected by the telecommuter. In addition, consumption rates will vary with local climate and cannot be estimated well from national statistics should they become available in the future. Generally, these effects cannot be readily estimated given presently available data, and telecommuting should be regarded as eliminating a commuting trip entirely. However, if you have more specific data on the effects of your project, you should use this information in your report.

Many of these estimates may be made more easily by the agency that administers the program, both because it can perform the estimates once using aggregate data from many employers, and because it may have better access to data from the local MPO. If you wish to report reductions on your own to the voluntary reporting program, you should agree with the administering agency on how to identify or avoid multiple reporting if the agency reports aggregate reductions.

Once estimated, the information above is sufficient to define a project case based on the present number of employees and a reference case based on the same number of employees commuting as they did before the project.

Employers not subject to trip reduction mandates may also wish to report reductions, especially if they take actions to promote telecommuting or "cash out" employee parking as proposed under the Climate Change Action Plan. You may not need to conduct surveys to collect information if only a few targeted measures are undertaken and if management approval is required for employees to take these measures voluntarily. In these circumstances, you may request information only from those employees who participate, and you might reasonably request information on commuting distance and vehicle type that could be used to estimate fuel consumption more accurately. Some resurveying of the participating employees would be required to determine current levels of participation, as it would be relatively easy for employees to move in and out of telecommuting programs.

4.8.2 Improvements in Infrastructure and Transportation System Efficiency

State and local governments engage in a continual process of planning for transportation improvements, land development associated with growth, and impacts on the local economy and environment. This process involves forecasting travel activity and the effect of different changes in infrastructure, operating practices, or policies on either the level of this activity, the performance of the transportation system, or air quality. The general approach and many of the models used are well documented. You may use these tools to assess the impact of travel demand measures, usually on system performance or air quality.

These methods may be the only tools available at present for establishing reference cases and evaluating impacts for some kinds of activities, including land-use planning. However, the focus of these models on transportation congestion and local air quality limits their usefulness for the reporting program; they either

must be supplemented with information on travel demand and use, or their information may be used indirectly to calculate emissions reductions.

Infrastructure improvements that might reduce traffic congestion and reduce emissions include improving the synchronization of traffic signals, installing left-turn lanes, widening roads, developing high-occupancy-vehicle lanes, and building dedicated roadways for truck access to ports or terminals. Decisions to make such improvements typically are based on measurements of traffic volumes and speeds that are used in traffic engineering models to assess the effects of improvements on traffic conditions.

The information used to identify and plan needed improvements can be used to define a reference case and project case for reporting to the EPAct Section 1605(b) program, although additional work will be required to estimate emissions and emissions reductions from model results (traffic speed, delay, and volumes) that were used in planning. Users of the database will have greater confidence in emissions reductions estimates based on measurements of traffic volumes and congestion after the improvements have been completed than they will in estimates based entirely on model projections. Your report should account for, and compute, if possible, other project effects resulting from the construction process (emissions resulting from traffic diversion or increased congestion as well as emissions from construction vehicles), increased demand for travel generated by the improved infrastructure, and any other factors. As a result, reporting of infrastructure improvement projects should be done only by metropolitan planning organizations and similar agencies that have the ability to estimate impacts on a metropolitan or regional scale and account for all project effects.

4.9 Estimating the Effects of Accelerating Vehicle Scrappage

Transportation service suppliers may accelerate the scrappage and replacement of inefficient vehicles in their fleets with more efficient vehicles. Guidance for this type of project is provided in Section 4.7. The guidance in this section applies to a different activity that has received recent attention, in which an entity undertakes to accelerate the scrappage of vehicles in fleets that it does not operate, as a way of improving local air quality or for some other goal. There has been relatively little experience with this type of project; the earliest and most significant project was conducted by Unocal which in 1990 paid owners of pre-1971 vehicles in Southern California to allow it to scrap the vehicles (U.S. Congress 1992).

Similar projects have been suggested as a way to improve the fuel economy of the nation’s automobile fleet, possibly with some credit given under the CAFE program to automobile manufacturers who accelerate scrappage of old vehicles. If such a CAFE credit program is established for automobile manufacturers, it is likely to specify methods for calculating fuel savings, and these methods may be used to report fuel and emissions reductions under the 1605(b) reporting program.

Under the Clean Air Act Amendments of 1990, the EPA has published guidance for computing emissions reductions from accelerated scrappage programs. The publication, "Guidance for the Implementation of Accelerated Retirement of Vehicles Programs," is a technical addendum to the EPA's "Interim Guidance on the Generation of Mobile Source Emissions Reduction Credits" (58 FR 11134, February 23, 1993). You may wish to use this guidance in computing vehicle scrappage emissions reductions to be reported under the

EPAct 1605(b) program. For information and copies of the technical addendum, contact the EPA Emissions Planning and Strategies Division at 2565 Plymouth Road, Ann Arbor, Michigan 48105.

The remaining discussion of this type of project is intended to be used for an accelerated scrappage project implemented without any credit under the CAFE program. Reporting requires information about the fuel consumption of the vehicle being scrapped and about what replaces it. The Unocal program subjected a sample of vehicles to the Federal Test Procedure to determine emissions of criteria pollutants, and this procedure could be used to estimate fuel economy for a sample of vehicles. Similarly, the Unocal program also surveyed drivers of the scrapped vehicles to determine their estimates of how far the vehicles had been driven.

More accurate mileage information might be collected if the state department of motor vehicles recorded odometer readings at the time of annual relicensing or taxation. Given average values derived from these data, you could calculate the fuel consumption of the vehicles scrapped. Testing a sample of vehicles and surveying the drivers would become less necessary over time if information collected about these variables were to be made available to others, for example, as part of the educational use of the 1605(b) reporting program.

In the absence of testing a sample of vehicles and surveying the owners, or drawing on data collected by similar vehicle scrappage programs, fuel consumption estimates must be based on assumptions and available published information, in ways similar to projects involving the sale of new fuel efficient vehicles. The fuel economy testing program did not begin until the 1973 model year, and the CAFE program did not begin until 1978. Cars older than 1973 should probably be assumed to have the fuel economy found by Unocal, 12.1 MPG; fuel economy for those of 1973-1977 vintage can be obtained from early EPA fuel economy reports. Alternatively, fuel economy for these vehicles can be assumed to be the earliest reported combined domestic CAFE estimates (19.9 MPG for automobiles in 1978, 18.2 MPG for light trucks in 1978). Fuel economy for more recent vehicles can be taken from EPA fuel economy reports or actual CAFE values for the appropriate model year. Vehicle mileage can be estimated from the EIA's Residential Transportation Energy Consumption Survey for automobiles or the Truck Inventory and Use Survey.

Vehicles that are scrapped provided transportation service prior to scrappage, and this service usually must be continued. If the replacement has occurred prior to scrappage, surveying the vehicle owners can determine the age and type of the replacement vehicle; this can be cross-referenced with model/year-specific or year-specific fuel economy ratings. Such a survey would be less reliable if the replacement vehicle has yet to be purchased. In this case, or in the absence of any survey at all, you should assume an average vehicle from the nation’s vehicle fleet replaces the one scrapped, and use the fleet average fuel economy rating for the year in which the scrappage occurs.

The project case for vehicle scrappage is estimated as the amount of fuel estimated to be consumed by the replacement vehicles, driven the distance the scrapped vehicles would have been driven. The reference case is estimated using the fuel consumption estimated for the vehicles that have been scrapped, driven the same distance.

If the scrappage program truly accelerates the scrappage of old vehicles, then the vehicle would have been used for another few years, and second-and-subsequent-year projects might be defined, based on what the lifetime of the vehicle would have been had it not been scrapped. Very little information is publicly available on the survival rates and expected use of very old vehicles. You may use vehicle survival rates for the fleet in the *Transportation Energy Data Book*; these can be used to estimate the proportion of scrapped vehicles that would have been used in the project. Mileage estimates for very old vehicles probably are best based on the mileage obtained by surveying the owners of scrapped vehicles. Some states may record vehicle odometer mileage as part of vehicle registration or taxation, and average values based on this information might be used to estimate mileage for very old vehicles.

In addition to the EPA guidance noted earlier, you may wish to consult the Office of Technology Assessment report, *Retiring Old Cars: Programs to Save Gasoline and Reduce Emissions*, Report OTA-E-536, on which the discussion above draws heavily. The report contains sample calculations of fuel savings from accelerated scrappage projects.

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