12.0 Project Development and Preliminary Design

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12.1 What Is Included?

This stage of greenhouse gas (GHG) assessment includes consideration of GHG emissions in the development and preliminary design of a transportation project. GHG considerations at this stage may include

- The selection and design of the alternatives (e.g., project footprint, modal accommodations, traffic flow options).
- Construction and maintenance requirements, including factors such as construction staging and detour routes.

Materials, equipment, and fuels for construction may be considered at this stage but should also be treated more generally as a State Department of Transportation's (DOT's) policy in standard specifications (see Section 14.0 on construction and Section 15.0 on maintenance).

Project-related GHG emissions are often considered and described as part of the environmental documentation that is completed for the project. However, emissions may still be considered in project development and design even if environmental documentation is not required. This section discusses GHG considerations in project development and design in general. Section 13.0 provides specific suggestions on how these considerations might be reflected in environmental documents.

12.2 Why Address GHGs in Project Development and Design?

Consideration of GHG emissions at the project level allows decision-makers and the public to understand what effect the selection and completion of a project will have on GHG emissions associated with that facility. Since GHG emissions are long lasting in the atmosphere and a transportation project will be in place and operational for a long period of time, selection of an alternative could influence the implementation and success of a State's climate change goals and objectives. If GHG emissions were considered in the selection and construction of a preferred alternative for all major projects in a State DOT's program, the cumulative effect could help in attaining a State's climate change policy. However, the largest impacts on emissions would likely be a result of strategic decisions made at the programmatic level, rather than decisions involving the specific design of individual projects.

For many processes and activities, such as materials selection and equipment operating procedures, it will generally be more efficient to make programmatic assessments and decisions than to reconsider GHG impacts on a project-by-project basis. It may be, however, that a particular project allows for materials and pavement engineers to consider other mixes for the design conditions, choose or develop an uncommon specification with above-the-local-market norms for material substitutes with industrial by-products, and then ask the producers for that new mix. Some project design decisions that may affect GHGs (e.g., choice of intersection versus roundabout or method of accommodation of alternative modes) may need to be made on a project-by-project basis if they involve significant tradeoffs with other considerations such as cost, traffic flow, safety, or right-of-way requirements.

12.3 Level of Effort

For a project-level analysis of GHG emissions, the level of effort can vary greatly, depending on a number of factors. One of the main determinants of the level of effort involved in a project-level GHG assessment is whether the assessment will be qualitative or quantitative. For a qualitative project-level GHG assessment, the level of effort should be low to moderate, perhaps a few hours to describe the various GHG sources and how they may be impacted.

The effort for a quantitative assessment may range from moderate (a few days) to extensive (100s of hours), depending upon the sources assessed, the depth and level of detail of the analysis, and whether related data already are available (e.g., from an air quality analysis). If a quantitative air quality analysis already is being performed, then including GHG analysis may be just a modest additional effort for traffic-related emissions. More effort will be needed if an emission factor model such as Motor Vehicle Emission Simulator (MOVES) [or Emission Factor (EMFAC) in California] is run from scratch. Additional effort will also be needed to estimate construction and maintenance emissions and to evaluate any mitigation measures that might be considered.

12.4 Complementarity/Consistency with Other Transportation Goals

Many design elements of transportation projects support reductions in GHG emissions compared to the No-Build alternative. DOTs, through their project development and preliminary design, include elements designed to reduce congestion, smooth traffic flow, and reduce bottlenecks. Elements such as intelligent transportation system (ITS), transit accommodation, active transportation facilities, and traffic signal actuation and coordination are common examples of such design elements. Depending on the scope and scale of a project and its purpose and need, it may include one or more of such elements. In addition to consistency with goals related to congestion and traffic flow, these design elements help achieve other, complementary transportation goals, including safety and mobility. These elements typically also reduce emissions of criteria pollutants and improve air quality. In nonattainment areas subject to transportation conformity requirements, inclusion of these elements likely contributes to successful conformity determinations, whether at the transportation plan, program, or project level. These elements also help meet energy conservation goals by reducing fuel use (most commonly petroleum-based fuels) by diverting trips to transit or allowing for smoother operation of vehicles on the transportation

system. Finally, these design elements in a project contribute to sustainability goals by saving resources that would otherwise be consumed in the near term for future generations.

12.5 Who—Roles and Responsibilities

Executive	Admin	Planning	Programming	**Environmental**
Design	Construction	Maintenance	Operations	**Regions/Districts**

Potential roles in GHG consideration in this functional area include

- **Executives—**Send a clear signal to the development team that GHGs are to be considered and should shape projects as one of many considerations. The degree of weight ascribed to GHG reduction compared to other considerations will likely be a function of the State's and the DOT's priorities.
- **Project Manager—**Ensure that the analysis is done with access to project data.
- **Environmental Staff—**Determine that all the required data are available. Use available tools to perform analysis in a technically sound manner.
- **Traffic Engineer—**Develop and provide necessary travel activity data to support a project-level GHG analysis, coordinating with environmental staff on data needs.
- **Region/District Staff—**Using local knowledge, assist in developing design elements for the project that will be most effective in the project area.
- **Engineering Project Manager and Specification Writer—**Should be involved to the extent that materials and fuel specifications are considered at this stage.

12.6 Goal and Target Setting

It is conceivable to set targets to reduce project-related GHGs by some percentage compared to standard procedures or designs for the project. At a minimum, environmental documentation guidance may suggest that the Build alternative not increase emissions compared to the No-Build alternative. However, target setting will most often be done at a programmatic level, with projects designed and implemented to help achieve targets.

12.7 Strategy Identification

While the major decisions affecting overall transportation system emissions will be made at the planning level, project-level decisions can also affect GHG emissions. For example, additional design elements that reduce congestion and smooth traffic flow may be considered for incorporation into the project, as may elements that support alternatives to travel in less carbon-intensive modes or vehicles. The project could also be designed to minimize carbon emissions from materials, construction, and maintenance, or it could incorporate measures such as solar panels or revegetation to assist in offsetting emissions from the facility. The effects of the selected design elements may be evaluated qualitatively or quantitatively for their emission benefits. A one-time programmatic assessment of benefits may be made for strategies that are implemented programmatically (e.g., standard materials specifications) rather than on a project-specific basis. Examples of project-level mitigation strategies are shown in Table 12.1. These could be implemented on either a project-specific basis or programmatically.

Table 12.1 Project-Level GHG Mitigation Strategies (Including Programmatic Strategies)

Mitigation of Emissions from Traffic	Mitigation of Emissions from Construction and Maintenance
• Introduce design elements to encourage use of active modes and public transportation. • Implement design and operations strategies to improve traffic flow and reduce congestion and idling. • Implement operations strategies in the construction phase, including detour route alternatives and construction. Stage construction activities to minimize traffic delays and vehicle miles traveled (VMT). • Include project elements to support electric and alternative fuel vehicles (e.g., recharging stations).	• Specify use of low-carbon construction materials made with a high level of recycled content that displaces cement or virgin steel or virgin asphalt. Review environmental product declarations. • Reuse or recycle materials where feasible. • Specify use of low-carbon fuels in construction and maintenance equipment. • Build in renewable energy generation mechanisms (e.g., solar, wind). • Implement revegetation/reforestation to support carbon sequestration. • Purchase offsets for construction and maintenance activity emissions.

12.8 Strategy Evaluation

A project-level GHG analysis typically consists of two primary components:

- An analysis of the emissions of vehicles using the facility once the project is completed and open for use by the public.
- An analysis of the emissions during construction of the project, including embodied emissions from major materials and emissions during maintenance and operation of the project, and once construction is completed, over a fixed period of time (30 years is considered a typical lifetime of a highway project).

12.8.1 Emissions from Traffic Using the Facility

Vehicle operating emissions are often estimated to be lower for a Build scenario than a No-Build scenario due to reductions in congestion, although the magnitude of difference is usually small. A 2015 review of 112 projects on the active Environmental Impact Statement (EIS) list found seven projects for which a quantitative analysis was performed, with GHG differences among alternatives ranging from 700 to 230,000 tons per year and a median difference of 47,000 tons per year (Zamurs, 2016). In comparison, the traffic on a typical 10-mile highway segment with 150,000 annual average daily traffic (AADT) (FHWA's approximate threshold for quantitative analysis in its air toxics guidance—see FHWA, 2016b) and 10 percent trucks would generate about 220,000 tons per year of CO_2 emissions. Furthermore, the traffic simulation analysis that informs these estimates often does not systematically account for changes in travel demand that may result from improved travel conditions associated with the Build condition that could increase emissions.

If a quantitative air quality analysis will be performed, a quantitative GHG analysis can be performed that builds on this effort to estimate GHG emissions from traffic for each project alternative. Such an analysis consists of adding another pollutant (usually CO_2e) to the Pollutant and Processes Panel in the MOVES run spec [U.S. Environmental Protection Agency (EPA), 2016], or EMFAC in California. The results of the MOVES (or EMFAC) emission run(s) would then be compiled and compared for the various alternatives under consideration and reported in the environmental document.

If a quantitative air quality analysis is not being undertaken, additional analysis is required for quantitative reporting of GHG. Sufficient data would need to be gathered to set up the necessary MOVES run(s) to generate operational GHG emissions. This would involve compiling the necessary traffic information, such as volumes, speeds, congestion, vehicle fleet mix, etc., as well as inputs specific to MOVES, such as scale of analysis, grade, years of analysis, temperature, road type, etc. [See *NCHRP Web-Only Document 210* (2015) for information on developing MOVES inputs.] The results of the MOVES emission run(s) can then be compiled and compared for the various alternatives under consideration and reported in the environmental document.

If MOVES or EMFAC is not being used, the impacts of changes in traffic volume due to mode-shifting or induced demand can be estimated using fuel-based emission factors, for example:

? Emissions = ? AADT * Segment Length * g CO_2/gal / mi/gal

Where emissions are computed for each type of vehicle using the facility (passenger car, light truck, heavy truck, etc.) and then summed.

The effects of changes in average traffic speeds may also be evaluated using speed-based emission factors obtained from another analysis, using an equation such as:

? Emissions = AADT * Segment Length * (EF_{speed2}–EF_{speed1})

Where ? Emissions is summed across vehicle types and time periods (e.g., peak and off-peak, which may have different speeds), and EF is the emission factor (grams per vehicle-mile) at speed x for a given vehicle type. Environmental staff may be able to provide a table of EFs by speed and vehicle type to assist in this calculation.

Evaluating the effects of changes in traffic flow conditions (e.g., acceleration and idling) will typically require MOVES, EMFAC, and/or a traffic simulation model that produces emissions outputs.

Additional tools to directly quantify GHG effects of individual transportation projects include the FHWA Congestion Mitigation and Air Quality (CMAQ) Emissions Calculator Toolkit and the California Air Resources Board (CARB) SB1 Grant Program Emissions Calculator. In some cases, a “project” might involve the replacement of vehicles or vehicle fleets with clean vehicles (e.g., drayage trucks at ports or a fleet of municipal refuse trucks or school buses); additional tools are available from

EPA and Argonne National Laboratory for projects focused on vehicle and fuel technology. Finally, data and information may be used from the following sources:

- Tools for estimating traffic volume/demand changes and mode shifts (see Section 10.9).
- Tools for estimating emissions from traffic operations changes (see Section 15.9).

Table 12.2 provides a summary of available tools for project-level evaluation and the types of projects they can analyze.

Table 12.2 Project-Level GHG Evaluation Tools

Tool	Emission Rates/ Factors	Traffic Flow/ Operations	Transit Investment and Operations	Nonmotorized Improvements	Freight Rail and Marine	Clean Vehicles and Fuels
MOVES/EMFAC	●	●				●
CMAQ Emissions Calculator Toolkit		●	●	●		●
CARB SB1 Grant Programs Emissions Calculator		●	●	●		●
Argonne—Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET)	●					●
U.S. EPA—Heavy-Duty Vehicle Emissions Calculator	●				●	●
U.S. EPA—Diesel Emissions Quantifier	●					●

12.8.2 Emissions from Construction, Maintenance, and Operation of the Facility

For construction and maintenance GHG emissions, various tools and data sources are available to estimate those emissions. If the project alternatives are made from the same materials, the GHG differences are relative to the quantity of the materials. If the quantities are roughly the same, the GHG differences will be nominal. If, however, the material for the chosen design is evaluated for alternative mixes, the GHG differences may be large enough to justify analysis.

Tools for measuring construction and maintenance emissions are described in Section 14.9. Two frequently used tools include the Greenhouse Gas Calculator for State Departments of Transportation (GreenDOT) and the FHWA Infrastructure Carbon Estimator (ICE).

12.9 Implementation

Implementation means that the results of a GHG analysis (if one is performed) are considered seriously in the selection of an alternative for construction. With other factors being equal, the selection of an alternative (including the No-Build) may be based, in part or substantially, on the lowest emissions of GHGs.

As with "most things DOT," implementation of project-level GHG considerations will generally follow established patterns as illustrated in Table 12.3; that is, consider potential net value (plan), roll out on a pilot basis (do), assess in light of experience (check), and adjust in light of real-world experience (act). Given the relative costs and difficulties, most DOTs would be expected to begin with qualitative assessments for major projects and project types and move on to quantitative assessments from there as experience is acquired and the value of assessments is verified. As implementation proceeds, examples may be incorporated into training and guidance materials, and specifications may be factored into contract updates—with these improvements subject to further evaluation as more experience is gained. Design and Environmental units would typically have the lead on advancing such an initiative. As an alternative to project-level consideration, GHG assessment and consideration might be performed, mainly at the planning level, and programming and design decisions might be made consistent with plan-level priorities. For example, such planning-level considerations might include priorities for the direction of funding to different types of investments, as well as the development of low-carbon materials specifications applying to all projects.

Table 12.3 GHG Management Cycle/Project Development, Preliminary Design, and Environmental Review

Plan	Set policy	Establish targets	Make assignments
Do	Develop procedures	Train staff	Implement

Check	Report	Consolidate reports	Evaluate performance
Act (Improve)	Check in agencywide	Explore alternatives	Revise procedures

Source: Adapted from the American Association of State Highway and Transportation Officials (AASHTO) (2003) and FHWA (2010b).

12.10 Monitoring, Evaluation, and Reporting

As outlined above, it is a "best practice" to conduct before-and-after studies of projects and procedures to observe what benefits were achieved and what investments were required to affect these benefits. In this case, the DOT might cross-check projected GHG reductions with project type and may even want to verify projected traffic flow changes (volumes, speeds, etc.). Control points may be needed to verify that changes occurring after the project is complete are directly related to that project rather than to broader changes in the area. For example, before-and-after volumes can be compared on other roadways in the community to estimate how much traffic changes on the facility were related to the improvements versus other factors that led to increased or decreased traffic. Well-controlled before-and-after studies are difficult to perform, but they can be useful for other purposes, such as measuring actual versus projected mobility and safety benefits, not just for GHG or air quality.

12.11 Self-Assessment: Project Development and Preliminary Design

A self-assessment worksheet is provided to assist State DOT staff involved in project development and design to determine their level of engagement in GHG assessment and additional steps they could take to estimate and reduce GHG emissions. The worksheet is meant to be used as a guide and completed with any markings and notes that are helpful.

Click to download – Self-Assessment: 12.0 Project Development and Preliminary Design

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