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Data and Capacity Needs for Transportation NAMAs

Report 2: Data Selection

THE CENTER FOR CLEAN AIR POLICY
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Executive Summary

This is the second in a series of three CCAP research reports assessing data and capacity needs for developing, implementing and evaluating successful transportation NAMAs. Report 1 focuses on current data availability, Report 2 focuses on data needs, and Report 3 focuses on technical assistance resources and needs.

This report provides an overview of how to select transportation data for estimating GHG emissions reductions from transport NAMAs *ex ante* (during planning) and *ex post* (as MRV). It begins with some key principles for evaluating NAMAs (GHG emissions baselines, non-GHG benefits, cost-effectiveness, level of certainty of estimated quantities, and whether the NAMA is part of a broader low-carbon development strategy). It provides a flow chart that could serve as a guide for deciding how to evaluate NAMAs. Finally, the paper includes two appendices. The first appendix describes options for the evaluation of ten specific types of transportation NAMAs, while the second presents the specific types of data recommended for NAMA evaluation (as mentioned in the first appendix) and up to three sources or collection methods for each.

The following general types of possible transport NAMAs are considered in detail: low-carbon transportation plans; bus or rail rapid transit; non-motorized infrastructure; travel demand management; road and fuel pricing; congestion relief; fuel economy or GHG standards or incentives; low-carbon or renewable fuel standards; low-carbon or renewable fuel incentives; and land-use planning and implementation. For each of these, definitions and examples of the NAMA are given, some key questions related to GHG emissions reductions from the NAMA are presented, and the typical scope of the measure (national, regional, or local) is listed. A series of tables then describes the types of data that would be needed for baseline assessment, ex-ante project evaluation and ex-post project evaluation, as well as the quality of data needed (locally applicable vs. default) to evaluate the NAMA for two levels of stringency. Strategy-specific "context indicators" are also discussed – these are indicators that help an evaluator to determine whether the NAMA fits into a broader GHG mitigation strategy for the transportation sector and the likelihood of successful implementation of the NAMA.

This report also offers three suggestions for capacity-building efforts to improve the design, implementation and evaluation of transportation NAMAs:

- **Develop a library of data for the observed impacts of GHG mitigation projects in the transportation sector.** This includes success of implementation, GHG reductions, co-benefits (health, mobility, congestion relief, etc.), and cost effectiveness.

- **Invest in building local capacity for transportation planning.** Including data collection, modeling, analysis, training, institutional collaboration, etc.

- **Conduct research on the synergistic effects of transportation measures and develop models that include these effects.** It would be extremely useful to be able to quantify how well-coordinated packages of measures have much more significant impacts than the sum of the impacts if each measure is implemented individually.

Objectives of Report

This report presents recommendations and guidelines for choosing the type and quality of data to evaluate transport projects proposed as nationally appropriate mitigation actions (NAMA) to achieve greenhouse gas (GHG) reductions in developing countries. This paper follows *Report #1*: *Data Availability*, which evaluates the availability and quality of different types of transport-related data in developing countries.

The primary focus of this report is on data for evaluating the GHG mitigation benefits of a NAMA. The report addresses data for pre-project, or *ex-ante*, evaluation, which may be conducted by a national government or international funding agency for the purposes of determining which projects to identify as NAMAs and possibly to support using climate funds. It also addresses data for post-implementation, or *ex-post*, evaluation, which may be performed to estimate what GHG benefits the project has actually accomplished, and how its performance compares to predicted performance – i.e., monitoring, reporting, and verification (MRV).

The report focuses only on data and not on evaluation methods. This is because the NAMA concept was developed as an alternative to the Clean Development Mechanism (CDM) framework for providing assistance to developing countries' GHG reduction efforts. A CDM project is a clearly-defined action with GHG benefits quantified using a prescribed approach. In contrast, a NAMA may be construed as a broader set of actions for which the precise GHG benefits are not necessarily well known, although the general direction and order of magnitude can be estimated. Rather than prescribe a certain methodology for evaluation, we approach the issue from the perspective that NAMA proposers and evaluators will want to negotiate from a menu of options that allows them to choose the right alternative to match differing degrees of rigor and technical capacity. This guide is intended to identify the key data items that are needed to support those various evaluation options.

The heart of this report is a set of tables showing the data recommendations for initial evaluation and subsequent MRV of NAMAs (Appendix A). Each table cross-references specific data items to another table (Appendix B) showing potential ways of collecting that data item. While the primary focus is on data to estimate the GHG mitigation benefits of the particular project or strategy, the tables also identify other "context" factors that should be evaluated to assess the potential for the action to contribute to a broader program of GHG mitigation in the transport sector. Examples include consistency with a low-carbon transport plan, national policies supporting appropriate pricing of carbon, or efficiency standards, etc. These "context" factors also include indicators of the likelihood that a GHG reduction action will be successfully implemented, e.g., by examining political, institutional, and fiscal capacity for implementation.

NAMA proposers and funders may agree on different data schemes depending upon the type of NAMA, type of project, size/scale of project, fiscal and technical capacity of the implementing country, and other factors. For example, three types of NAMAs have been defined – unilateral, conditional, and credit generating.[1] In general, data requirements are likely to be least stringent for unilateral NAMAs and most stringent for credit-generating NAMAs, which must have verifiable emission reductions that can be traded on the open market. More reliable, and therefore data-intensive, evaluations may also be required for larger projects or for countries with greater fiscal and institutional capacity to gather the needed data. While not being prescriptive, this report establishes a general data framework for evaluating NAMAs and also identifies how the evaluation approach may vary depending upon the required level of stringency or local availability of data.

The report recognizes that in many cases, basic data to evaluate a proposed or implemented NAMA may not even exist. Therefore, the report makes recommendations for reliable and appropriate methods of data collection when existing data are not adequate to support even basic evaluation of NAMAs.

Appendix C includes a list of acronyms and abbreviations used in this paper.

Types of Projects Considered for NAMAs

A separate CCAP paper[2] discusses how transport actions might be included within a NAMA framework. A wide variety of transport projects, policies, and programs might be considered for designation as NAMAs. These generally include:

- Capacity building, including planning and research; this includes preparing comprehensive low-carbon transportation plans, improving tools such as travel and land use models and collecting the data necessary to support NAMA activities.
- Policy and regulation, such as fuel economy standards and fiscal measures; and
- Physical infrastructure, such as bus rapid transit (BRT) systems and alternative fuel filling stations.

The first post-Copenhagen submission of proposed NAMAs on January 31, 2010 provides some insight into what types of projects might be proposed. Nineteen parties submitted

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[1] CCAP's paper on a transport NAMA framework establishes the following definitions: 1) unilateral NAMAs – autonomous actions taken by developing countries to achieve emissions reductions without outside support or financing; 2) supported NAMAs – developing-country actions undertaken with financial or other support from developed-country parties, which also represent developing countries' contribution to climate mitigation; and 3) credit-generating NAMAs – actions that could be partially or fully credited for sale in the global carbon market after an agreed-upon crediting baseline has been reached. See: Center for Clean Air Policy (2010). *Transportation NAMAs: A Proposed Framework.* Prepared by Adam Millard-Ball et al., January 2010.

[2] CCAP (2010), *ibid*.

proposals that addressed the transport sector. Applications for the Global Environment Facility (GEF) also provide ideas for the types of projects that might be considered. Table 1 shows the number of January 2010 NAMA submissions and GEF projects as of Fall 2009 by type of project.

Table 1. NAMA Submissions and GEF Project Types

	January 2010 NAMA Submissions[a]	Approved GEF Projects[b]	
Type of Project	Number of Countries	Percent of Projects	Percent of Funds
Transit Infrastructure and Service	9	29%	32%
Nonmotorized Infrastructure		29%	19%
Travel Demand Management (TDM)		8%	2%
Pricing/Fiscal Incentives	4		
Congestion Relief (Capacity, Operations)	2		
Alternative Fuels	3	6%	25%
Freight	2		
Planning	2	8%	
Capacity-Building		7%	
Eco-Driving/Maintenance	1		
Education/Awareness		6%	
"Regulatory" (Unspecified)	8		
"Energy Efficiency" (Unspecified)	9		

[a] Dalkman, H., and A. Binsted (2010). "Copenhagen Accord NAMA Submissions: Implications for the Transport Sector." Bridging the Gap.

[b] Replogle, M. (2009). "GEF Transport Sector Project Analysis," October 14, 2009 Interim Working Draft.

Key Principles

A number of key principles must be considered in developing an evaluation framework for NAMAs.

Definition of a Baseline. GHG changes as a result of a NAMA are compared relative to some hypothetical baseline (i.e., what would have happened without the action). The baseline must be defined but cannot actually be measured if the action is implemented. To establish a baseline, an appropriate analysis scope considering geography (e.g., corridor, city, country) and subsector (e.g., light-duty, heavy-duty, nonroad vehicles) must first be specified. Because of the general growth of travel in most countries, the baseline in most cases will be increasing over time, i.e., higher in a future evaluation year once the project is implemented compared with a base year or pre-implementation year without the action. Therefore, any particular NAMA is only likely to result in a decrease in GHG *relative to the baseline*, rather than in absolute terms relative to current conditions. It must also be noted that the true baseline is highly uncertain as it depends on population, economic, and income growth as well as demographic and socioeconomic changes, cultural changes, and changes in the organization of activities – all factors which are impossible to forecast accurately.[3]

Consideration of Non-GHG Benefits. For most actions in the transport sector, especially those that improve transport infrastructure and services, the value of other benefits to society is likely to be considerably greater than the value of GHG benefits alone.[4] So-called "co-benefits" often include mobility, accessibility, safety, air quality, economic development, and cost savings to travelers. Transport projects should be evaluated within a holistic framework, considering such co-benefits, rather than solely based on their GHG impacts. It may be desirable to quantify, and to the extent possible, monetize these benefits so that they may be more easily included as part of project evaluation. Many of the data items needed to evaluate co-benefits will be the same as those required for GHG evaluation.

Cost-Effectiveness. While this report focuses on estimating the total GHG reductions from an action, cost-effectiveness (i.e., dollars per tonne of GHG reduced) is generally a more useful metric when comparing different candidate actions because it places projects of different scales on equal footing. Consistent with the need to consider co-benefits, cost-effectiveness metrics should include non-GHG benefits to the extent possible.[5] Benefits that cannot be quantified can be included within a multi-criteria evaluation framework, or by setting different cost-effectiveness thresholds for different types of projects with different co-benefits.

Level of Certainty and Confidence in Estimates. A major motivation for incorporating the transport sector in the NAMA framework is that climate funds could be used to support GHG mitigating actions for which it is not possible to achieve a sufficiently reliable estimate of GHG benefits to fund the project through a market-based program such as the Clean Development Mechanism. Both the projection and the MRV of GHG benefits at this level of confidence is generally challenging if not impossible for most transport projects

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[3] For a discussion of baseline forecasting issues, see Millard-Ball, A. (2010). "Transport in the Global Carbon Market: Baseline Challenges with Sectoral No-Lose Targets." Presented at the 89th Annual Meeting of the Transportation Research Board, Washington, D.C., January 2010.

[4] Schipper, L.; E. Deakin and C. McAndrews (2010). "Carbon Dioxide Emissions from Urban Road Transport in Latin America: CO_2 Reduction as a Co-Benefit of Transport Strategies." Presented at the 89th Annual Meeting of the Transportation Research Board, Washington, D.C., January 2010.

[5] Co-benefits can be included in the cost-effectiveness calculation by subtracting the monetary value of the co-benefits from the project implementation cost before dividing by GHG reductions, i.e., [(implementation cost) – (monetized benefits)]/GHG reductions.

(CCAP, 2010), requiring more evaluation resources than are warranted given the cost of the project (or requiring an extremely conservative estimate of benefits). This report, therefore, considers three different levels of certainty/confidence that may be sufficient depending upon the action and its context:

1. **Directionality –** At a most basic level, does it appear that the action will actually reduce GHG emissions relative to the baseline? Establishing directionality does not require a quantitative estimate of GHG reductions.

2. **Order of Magnitude –** A quantitative estimate may be developed, but may be uncertain enough that it is likely to bracket actual emission reductions within a factor of 5 or 10. Even this may be sufficient to establish a very basic estimate of cost-effectiveness for comparison with other projects.

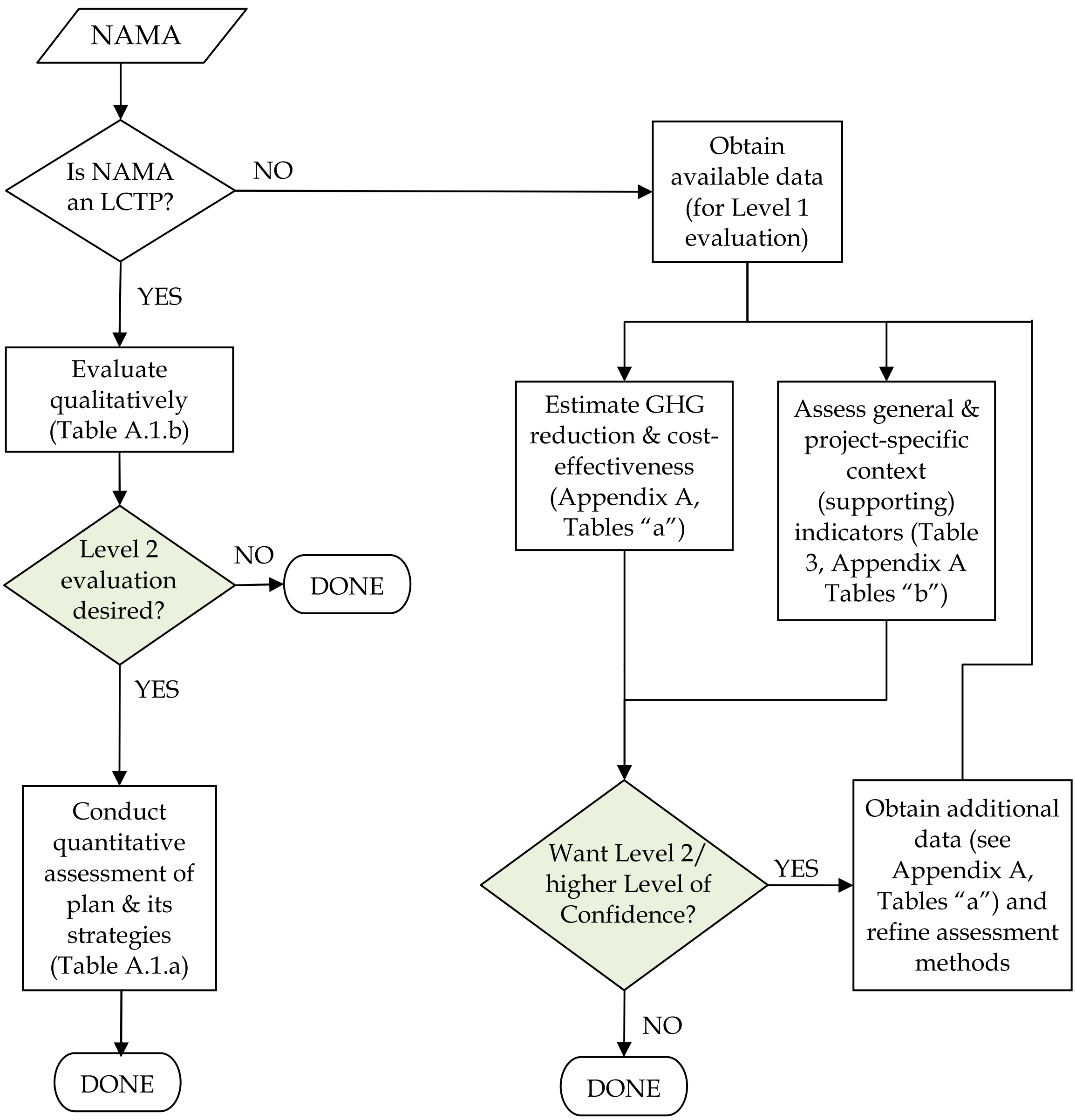
3. **More Robust Estimate –** Refinements to data, such as increased local data collection, more sophisticated analytical techniques, etc., may be developed such that the uncertainty of the GHG and cost-effectiveness estimate are reduced to 25-50 percent or even less.

Inclusion of NAMA as Part of a Broader Framework of GHG Mitigating Policies. A candidate NAMA action can be evaluated narrowly based on the GHG mitigating potential of the action relative to not taking the action. However, CCAP (2010) recommends that NAMAs also be evaluated based on the extent to which they support a larger set of GHG mitigating policies and actions. The purpose of doing so is twofold. First, the presence of other supportive policies and actions should increase the likelihood that the NAMA will actually result in emission reductions at least consistent with the estimated level. Second, doing so rewards governments that have developed GHG mitigation programs and, therefore, may leverage larger GHG reductions than are achieved through the project alone. This report, therefore, proposes criteria and associated data needs for evaluating non-GHG supportive factors as well as GHG mitigation potential.

Evaluation Process

Figure 1 illustrates a proposed evaluation process for NAMA projects. This process can support both *ex-ante* project evaluation (pre-implementation, to support project selection and funding) and *ex-post* evaluation (post-implementation or monitoring, reporting, and verification that emission reductions were actually achieved). The analyst first determines whether the NAMA represents a low-carbon transport plan (LCTP), that is, it addresses multiple strategies for reducing transportation GHG emissions, or if the NAMA is an individual project. If it is an LCTP, the analyst is begins by evaluating the LCTP as a whole from a qualitative perspective, as is appropriate for Level 1 evaluation (see following text for a discussion of different levels of evaluation). If it is deemed desirable to evaluate the plan from a quantitative GHG reduction perspective, then a Level 2 evaluation must be performed on the plan and its individual strategies. For individual projects, available data is then obtained and an initial evaluation suitable for Level 1 evaluation is made of both GHG reductions and supporting context factors. If the resulting information is sufficient to make a funding decision (for *ex-ante* evaluation) or draw conclusions about the effectiveness of the project (for *ex-post* evaluation), the evaluation is complete. If not, and a more rigorous evaluation is required (e.g., Level 2, or a higher Level of Confidence within Level 2), additional data is obtained and the analysis repeated in a more rigorous fashion.

Figure 1. NAMA Evaluation Options Framework



The *ex-post* evaluation may also be conducted with varying levels of rigor. Measuring the aggregate impacts of an LCTP can be reasonably straightforward, needing only good estimates of fuel sales if alternative energy sources are limited. For smaller projects or when resources are not available, it may be sufficient to examine proxy indicators that relate to likely GHG emissions. Major projects or those offering carbon credits may need a more detailed estimation of GHG emissions based on observed performance data. Other factors may also be evaluated such as co-benefits or whether a broader low-carbon transport plan has been implemented as proposed. One benefit of the proposed NAMA framework is a more flexible approach to evaluation of project results. Nevertheless, a rigorous post-project evaluation can serve a number of important functions, including providing information that will be useful in future transportation planning, policy design and refinement of development strategies.

Two basic evaluation levels are considered here and used in further developing the evaluation framework proposed in this document:

- **Level 1 –** GHG evaluation is based largely on default data and "rules of thumb;" other factors are evaluated primarily on a qualitative basis; and

- **Level 2 –** Default data for GHG evaluation are replaced with locally available data to varying degrees, depending upon the importance and availability of specific data items. Some quantitative evaluation is conducted of other factors.

Within the two basic levels different degrees of confidence can exist:

- **Low –** Directional only (positive or negative);

- **Moderate –** Order of magnitude estimate of GHG reduction;

- **High-1 –** GHG reduction estimate within +/- 25-50 percent; and

- **High-2 –** Strong confidence (90 percent?) that GHG reductions will *at least* meet the estimate (i.e., this is a conservative estimate of reductions).

When choosing the level of evaluation and confidence level to apply to a NAMA – and, therefore, the associated data and analysis requirements – the following factors should be considered:

- **Stage of Evaluation –** An initial, screening-level evaluation is often conducted using readily available data, to determine whether the project is worth evaluating further as a GHG reduction strategy and to assess what additional data (if any) might be required for a more rigorous evaluation. If a fuller evaluation is needed, the process is repeated after obtaining additional supporting data.

- **Type of NAMA (unilateral, conditional, or credit-generating) –** As noted previously, evaluation requirements may become increasingly rigorous for higher levels of NAMA.

- **Size of Project –** A small, inexpensive project may deserve a less rigorous evaluation than a larger, more costly project. It is usually not worth spending as much on evaluation as on the project itself (unless unique information can be gained that informs decisions about many other similar projects). On the other hand, for a major project requiring tens of millions of dollars in capital investment, spending a few hundred thousand dollars on evaluation may be worthwhile to ensure that these funds are used effectively. A project sponsor's evaluation requirements may be in proportion to the amount of funding they would be providing for the project.

- **Cost/Effort of Data Collection Versus Utility of Data –** Some types of data may be relatively easy to collect and highly useful for informing the GHG estimate. Other types of data may be expensive or may add only marginally to the accuracy of the estimate. Data collection should be prioritized to focus on the items that are most important/uncertain and can also be feasibly gathered.

- **Local Capacity –** Less extensive and rigorous data collection and analysis may be required for local agencies that are limited in financial resources and technical capacity. However, it is important to provide capacity-building assistance to ensure that capacity is developed over time to support good planning and project evaluation.

Table 2 provides a guide to apply to different types of NAMA projects.

Table 2. Application of Evaluation and Confidence Levels to NAMA Project Evaluation Purposes[a]

Evaluation Level	Level 1		Level 2		
Confidence Level	**Low**	**Moderate**	**Moderate**	**High-1**	**High-2**
Screening Evaluation					
Unilateral NAMA (Any)	R				
Conditional NAMA – Smaller Project or Lower Capacity	R				
Conditional NAMA – Larger Project and Higher Capacity		R			
Full Evaluation					
Unilateral NAMA (Any)	R[b]				
Conditional NAMA – Smaller Project or Lower Capacity		R	(P)		
Conditional NAMA – Larger Project and Higher Capacity			R	(P)	
Credit-Generating NAMA					R

[a] R = Recommended Minimum; (P) = Preferred.

[b] Higher levels of confidence are preferred for unilateral projects to assist local agencies in planning and decision-making, if resources permit.

The ASIF Framework

"ASIF" is a commonly used framework for bottom-up evaluation of GHG emissions from transport. Broadly speaking, this framework states that emissions g) in the transport sector are dependent on the level of travel activity a) in passenger kilometers (or ton-km for freight), across all modes; the mode structure (S); the fuel intensity of each mode (I), in liters per passenger-km; and the carbon content of the fuel or emission factor (F), in grams of carbon or pollutant per liter of fuel consumed.[1] The relationship between these parameters is represented mathematically by the "ASIF" equation:

$$G = A * S_i * I_i * F_{i,j}$$

Where i refers to various modes and j to fuel types.

A variation on this is proposed for use in evaluating Clean Technology Fund (CTF) projects, as follows:

$$G = \sum_{m=n}^{m=1} A_m * I_m$$

Where A_m is the total vehicle activity within the project boundary by mode m, and I_m is the modal GHG emissions intensity, including both vehicle and fuel characteristics.[2]

Similarly, the Clean Development Mechanism identifies three ways of reducing emissions from transport: 1) reduce emissions per (vehicle)-kilometer (comparable to I and F), 2) reduce emissions per unit transported (comparable to S), and 3) reduce distances or number of trips (comparable to A). Actual project evaluation methods for the CDM are specific to each type of project.[3]

ASIF is a basic framework for evaluation of any transport project. However, different projects will affect different parameters to varying degrees and the challenge is to determine the change in each parameter. For example, a BRT project may affect total travel activity a) if travel options are increased, the modal structure of activity (S) due to a shift from personal travel to transit or among transit modes, and the intensity of fuel usage by existing modes if congestion is reduced. This document therefore provides guidance on key data items that are relevant to estimating the various pieces of the ASIF equation for any given transport project or strategy.

[1] Schipper, L., C. Marie-Lilliu, and R. Gorham. 2000. *Flexing the Link between Transport and Greenhouse Gas Emissions: A Path for the World Bank.* International Energy Agency, Paris. www.iea.org/textbase/nppdf/free/2000/flex2000.pdf.

[2] CTF Trust Fund Committee. *Clean Technology Fund Result Measurement System.* CTF/TFC.3/8, Washington, D.C., April 24, 2009.

[3] GTZ (2007). "The CDM in the Transport Sector." Module 5d of *Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities.*

Evaluating General Context

Table 3 presents a number of evaluation indicators that should be assessed for any type of proposed GHG reduction project.[6] These indicators are based on those proposed by Millard-Ball (CCAP, 2010). They have two objectives. The first is to indicate the likelihood that the project will actually result in GHG emission reductions as estimated – e.g., implementation capacity exists, and other actions are being taken simultaneously that support GHG reductions from transport. The second is to assess other benefits or factors that may favorably affect an agency's decision to support a project, such as co-benefits, local commitment (as demonstrated by cost-sharing), etc.

Table 3. General Project Context and Benefit Indicators

Rating[a]	Evaluation Factor	Comments
Y/N	**Consistency with Low-Carbon Transport Plan**	See also Table A.1.a for evaluation of LCTP
	National plan: __adopted __in progress Regional plan: __adopted __in progress Local plan: __adopted __in progress	
S/M/L/N	**Catalytic Potential**	
	Qualitative assessment of catalytic effects	
S/M/L/N	**Sustainable Development Co-Benefits**	Quantitative assessment may be performed for Level 2
	Mobility – Reduced travel times and transport expenditures Safety Air quality Economic development Social equity Other	
S/M/L	**Local Implementation Capacity**	
	Institutional Financial Political	
% Local	**Cost-Sharing**	
	Appropriate portion of costs shared locally (varies by income level)	
Y/N	**Alternative Implementation Opportunities**	
	More sustainable and/or cost-effective alternatives available to accomplish same objective?	

[a] Y/N: Yes/No. S/M/L/N: Strong/Moderate/Limited/None.

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[6] The term "project" is used in the broad sense to refer to an infrastructure project, policy or regulation, program, or collection of individual projects or programs.

- **Consistency with Low-Carbon Transport Plan –** A comprehensive, integrated Low-Carbon Transport Plan can provide benefits beyond the sum of its individual parts. Evaluating the overall planning context of a NAMA is thus an important factor because it assesses the extent to which an individual project will be implemented in conjunction with other supportive projects and actions – thus increasing the overall effectiveness through a "bundle" of GHG reduction projects and policies. Is a national, regional, and/or local plan adopted? Under development? If the proposed NAMA is itself an LCTP, then Table A.1.b in Appendix A presents a qualitative framework for assessing the strength of the plan, based on its scope and elements (types of policies/ strategies considered), the process for plan development (e.g., are key stakeholders involved), demonstrated capacity to implement the plan, and modeled/forecasted GHG outcomes. This table presents criteria both for plans that are in progress and for those that are adopted. Table A.1.a includes guidance on data for quantitative assessment of a low-carbon transport plan.

- **Catalytic Potential –** What is the potential of the project to contribute to additional GHG reductions beyond the immediate impact of the project itself? For example, is it likely to serve as an important demonstration case or catalyze other projects?

- **Sustainable Development Co-Benefits –** For most transportation infrastructure projects, the project's co-benefits – such as mobility, safety, air quality, economic development, and equity – may be considerably more significant to the local population than its GHG benefits. At a minimum, a qualitative assessment of co-benefits (direction of impact, description of expected effects) should be made. For larger projects with substantial impacts, a quantitative assessment may be warranted.

- **Local Implementation Capacity –** These are qualitative assessments of the ability of the project sponsor to implement the project as intended, covering three dimensions: 1) institutional (e.g., staff resources/technical know-how); 2) financial; and 3) political (support from key stakeholders, partners, etc.).

- **Cost-Sharing –** This is a demonstration of the project sponsor's commitment to the project based on its willingness to share cost. A greater local cost share means that the international funding agency's resources can be leveraged across more projects. Greater levels of cost-sharing may be expected from project sponsors with larger resources (i.e., in higher-income countries).

- **Alternative Implementation Opportunities –** An assessment of whether the proposed project is really the most effective way of accomplishing its objectives. Are there other approaches that would have lower costs or impacts, greater co-benefits, etc.?

Using the Appendices

Appendix A, Strategy Specific Evaluation Elements, contains tables that are intended to guide data and evaluation choices for specific strategies. For each strategy, a brief definition and examples are first provided, and the key factors determining GHG emissions benefits are identified. The typical geographic scale(s) of analysis also are identified. This information is provided to show the range data variables that can be used to evaluate a given type of transportation NAMA. As nationally appropriate measures are proposed and considered, the parties involved in the process will be able to reference this information to facilitate negotiation and agreement on how to evaluate proposals and how to monitor future success. Because each NAMA proposer and funder will have different circumstances, and NAMA will vary by type, the diversity of data options offered in this Appendix should prove valuable in supporting the success of the NAMA framework internationally.

Tables are provided for the following types of GHG reduction strategies. These include many of the strategies that are most likely to be proposed as NAMAs, considering the information shown in Table 1. Other types of GHG reduction strategies may also be proposed that would require similar data.

- Regional low-carbon transport plan (Tables A.1.a and A.1.b);
- Bus or rail rapid transit (Tables A.2.a and A.2.b);
- Nonmotorized infrastructure (Tables A.3.a and A.3.b);
- Travel demand management (Tables A.4.a and A.4.b);
- Road and fuel pricing (Tables A.5.a and A.5.b);
- Congestion relief (Tables A.6.a and A.6.b);
- Fuel economy or vehicle GHG standards or incentives (Tables A.7.a and A.7.b);
- Alternative fuel requirements (Tables A.8.a and A.8.b);
- Alternative fuel incentives (Tables A.9a and A.9.b); and
- Land use planning and implementation (Tables A.10.a and A.10.b).

The first table in each pair (the "a" tables) provides a listing of required and optional data items to support GHG quantification. Data items are listed for obtaining a baseline assessment, ex-ante project impact evaluation, and ex-post project impact evaluation. Different requirements are shown for Level 1 versus Level 2 evaluation. Within Level 1 and Level 2, increasing the use and quality of local as opposed to default data, and improving the assessment methods, should result in increasingly greater Levels of Confidence. However, the actual Level of Confidence can only be determined with an assessment of the data and methods used to evaluate a specific strategy in question. For each data item, this table also provides a "data type reference" number, which refers the user to Appendix B for information on where to obtain the data, as discussed in the next section. In these tables:

- Only basic data elements are shown. The tables are not a recipe for how to combine these data elements to calculate GHG emissions or benefits. Data needs are "cumulative" from one section to the next, i.e., "Project Evaluation, Ex-Ante" usually also requires the data elements shown for the Baseline Assessment, but they are not repeated in this section.

- The symbols indicate whether local data (project or context-specific) is required, or default data is acceptable (e.g., emission rates or ridership estimates obtained from other projects or data sources). The symbols are: ◆ = Local Data Required; ❍ = Default Data Acceptable.

- Brackets around a symbol [◆] indicate that the data item is optional even for a Level 2 evaluation, or that it is an alternative means of obtaining data that can also be calculated using other data shown in the table.

- Unless noted, the "data elements" are intended to be collected for the geographic area of analysis defined for the strategy. The reviewer will need to define an appropriate analysis area that encompasses the strategy's most significant impacts.

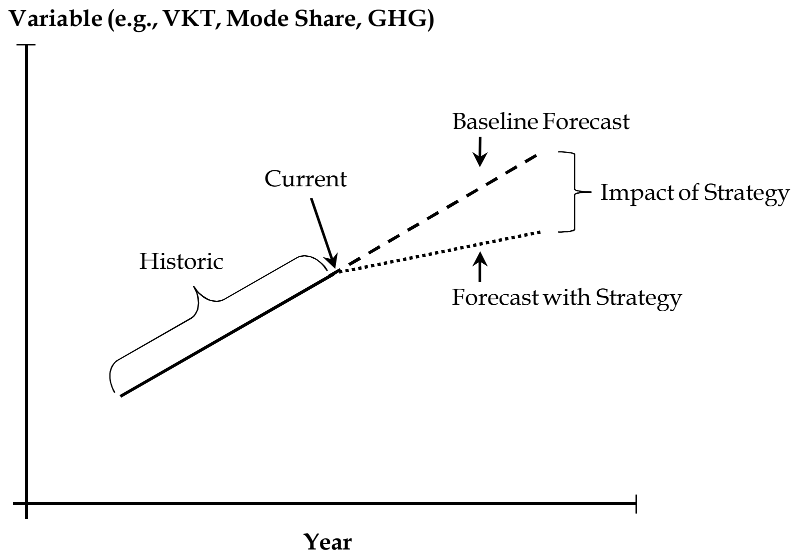
- In the "data elements" column, dimensions of data shown in parentheses (e.g., vehicle type, time of day) are optional and depend upon data availability and the evaluation level required. Common dimensions include:

  – Vehicle type. At a minimum, it is usually necessary to define traffic by light-duty vehicles (cars and light trucks) versus heavy-duty vehicles (heavy trucks). Many countries will need to define two-wheelers as a separate category. In some cases, it may be desirable to have additional categories depending upon the types of vehicles in use locally. Category definitions should consider: i) vehicles with substantially different emissions characteristics; (ii) vehicle types with very different responses to the strategy; and (iii) data availability.

  – Time of day. The usual breakdown of this dimension is peak (most congested) versus off-peak (less congested). The length of the peak period can be defined locally.

- The Baseline Assessment should ideally use *baseline forecast* data for the evaluation year(s) in which the strategy is being evaluated. If the evaluation year is in the very near future, or if the variable is not expected to change much by the evaluation year, existing (current or most recently available) data can be used. If a significant change is expected between the most recent observations and the evaluation year, either trend projection or a more sophisticated forecasting approach can be used to develop a baseline forecast. The difference between existing, baseline forecast, and policy/strategy forecast is illustrated in Figure 2.

Figure 2. Current, Baseline Forecast, and Strategy Impact



The second table in each pair (the "b" tables) provides various indicators of how well local conditions support achieving GHG reductions via the project. These are context indicators that can be used to supplement – or in the absence of – quantitative estimates of GHG reduction. For example, a bus rapid transit project can achieve emission reductions both by improving traffic operations in the corridor, and encouraging mode shift from private vehicles to transit. Land use conditions – density and mix of uses, pedestrian access, etc. – are important indicators of the ridership potential of the project. The relative improvement in travel speeds for bus versus private vehicle in the corridor is an important indicator of potential mode shift, while the absolute improvement for all vehicle types is an important indicator of potential fuel efficiency improvements from reduced congestion.

For each indicator, the data collection and evaluation method may be more or less rigorous, depending upon the level of evaluation required. Data requirements for both Level 1 and Level 2 evaluation are shown. Suggested criteria ranges also are shown to assist the reviewer in assigning a rating for each indicator, based on a three-point (High/Moderate/Low) scale.

In conjunction with the general context and benefit indicators in Table 3, the strategy-specific indicators in the "b" tables can be used to provide an overall assessment of the project's likely benefits in the absence of a quantitative GHG reduction estimate. Also, high ratings on these context indicators suggest an improved likelihood that the project will achieve GHG reductions as estimated – thereby helping to bolster confidence in these estimates.

Appendix B, Data Type Inventory and Sources, provides a comprehensive inventory of data items that may be useful for GHG evaluation of the strategies discussed in this report. The tables also indicate the various sources or methods that may be used to obtain a particular data item. This information is provided separately from the strategy-specific data tables shown in Appendix A to avoid redundancy, as many data types are common to multiple strategies. The tables in Appendix B list data items in six categories:

1. People and the built environment;
2. Vehicles;
3. Fuels;
4. Travel patterns;
5. Transportation network; and
6. Behavior.

Many data items may be obtained via multiple sources or methods. In some cases, a particular source or method is preferred; these are indicated in boldface. In other cases, the best method will depend upon the quality of the underlying data. For example, VKT per capita may be obtained using a "top-down" approach of measuring total VKT via traffic counters and dividing by total population from a census; or using a "bottom-up" approach of measuring VKT for a representative sample of travelers. The best method may depend upon the quality of the underlying data that can be obtained. The choice of data sources also is likely to be constrained by the resources available for data collection.

The reviewer/evaluator is responsible for assessing the quality of data underlying any given estimate. Factors that should be considered in assessing the quality of a particular data item include:

- How recently were the data collected? Have conditions changed significantly since then?
- Is the sample population sufficiently representative of the entire population of interest (e.g., origin-destination survey includes cross-section of income groups and household types, vehicle survey includes all ages and types of vehicles)?
- Are the data sufficiently representative in terms of temporal and spatial coverage (e.g., accounting for traffic conditions that may vary by time of day)?
- Were proper data collection procedures and appropriate quality controls applied when collecting the data?
- Were the data obtained from unbiased sources?
- If the data were transferred from another situation or context (i.e., "default" rather than local), how similar was that situation or context to the current situation or context? Can the transferred data reasonably be applied to the current situation?

Conclusions and Recommendations for Further Research and Capacity-Building

The evaluation options framework described in this report is intended to be a flexible framework that can be applied to different types of NAMAs in different contexts. It provides guidance on the data needed to develop quantitative GHG reduction estimates. It also provides a variety of "context" indicators that can be used to assess confidence in GHG reduction estimates, or in the absence of quantitative estimates to indicate the likelihood that a project will be successful at reducing GHG emissions. It allows for choosing different levels of effort and rigor in evaluation, consistent with local technical capacity and data availability as well as the scale of the project.

An important theme of this framework is the need to implement and evaluate a project not as an isolated GHG reduction action, but rather as part of a larger set of coordinated actions to reduce GHG emissions from transport. Therefore, the framework emphasizes consistency with a low-carbon transport plan as a critical factor. The framework also provides guidance on how the strength of such a plan might be evaluated.

The framework acknowledges that while high-quality local data is usually desirable as a basis for estimating GHG impacts, it often cannot be obtained for a reasonable level of effort, or with existing local technical capacity. Lack of adequate data or technical capacity for evaluation should not be a barrier to implementing GHG-reducing projects and programs. However, it is essential that data and analysis capabilities throughout the developing world be improved in order to ensure that the most effective decisions are being made to mitigate climate change. Improved data and technical capacity will also support transport improvements vital for achieving other goals – including mobility, safety, air quality, economic development, and social equity.

As NAMAs are proposed and implemented in the future we recommend that the following steps be taken to improve knowledge and capacity-building to support NAMA strategy evaluation and transport planning:

- **Develop a "library" of data on the observed impacts of GHG reduction projects**. The library should include descriptive information on the project and its implementation context, available proxy indicators that relate to GHG reduction (e.g., transit ridership, change in traffic speeds), and any quantitative estimates of GHG reduction and cost-effectiveness. Such a library would allow project sponsors and evaluators to transfer experience from other areas when local data are not available, and also to assess the reliability of local forecasts. The library should include appropriate cautions about when it may or may not be appropriate to transfer data from other contexts.
- **Invest in building local capacity for transport planning.** Methods such as university programs, training courses, peer exchanges, site visits, and on-line resources can all be used to improve the capability of local staff to conduct transport planning, collect data, and analyze projects. Funds may be provided for regularly conducted critical data

collection efforts such as origin-destination surveys and traffic counts, or to improve vehicle registration databases. Such investment will be critical to using the more rigorous aspects of this evaluation framework (e.g., many of the "Level 2" data items and approaches) and will benefit transport planning for all purposes, not just GHG reduction.

- **Conduct research on synergistic effects among strategies and develop analysis tools that account for these effects**. For example, it is widely believed that the GHG benefits of coordinated transit, land use, nonmotorized investment, and pricing strategies are likely to be greater than the sum of strategies implemented individually. However, there is little empirical or modeling evidence to quantify these synergistic effects. A modeling framework such as that proposed in a 2003 report for the U.S. Environmental Protection Agency gives one example of how synergistic effects could be accounted for at a regionwide level of analysis.[7]

[7] See Figure 5.5 of Cambridge Systematics, Inc. (2003). *Simplified Travel Demand Forecasting for Developing Countries: Phase I Final Report.* Prepared for U.S. Environmental Protection Agency.

Appendix A
Strategy-Specific Evaluation Elements

1. Strategy: Comprehensive Low-Carbon Transport Plans

Definition: A comprehensive, integrated plan listing all of the strategies that are being pursued to reduce transportation GHG emissions in a country, province, region or city.

Examples of strategies:

- National-level standards for fuel economy or GHG emissions of new and/imported vehicles, or incentives for purchasing efficient vehicles such as "feebates" in which vehicle sales are taxed based on their fuel economy or GHG emissions
  - National or provincial low-carbon fuel standards or renewable fuel standards designed to reduce the GHG intensity of transportation fuels used in the country.
- Regional, municipal, or national-level transport and/or land use plans with the objective of (among other benefits) reducing GHG emissions from transport (relative to some future baseline) by reducing the total Vehicle Kilometers Traveled (VKT). The plan may only address the transportation system, or it may also address land use and growth patterns and urban design practices that affect local and regional travel demand. The plan may include a variety of infrastructure strategies as well as other strategies such as pricing, travel reduction incentives, alternative fuel infrastructure, etc. In most cases these plans will most effectively be developed at a regional level, given the regional orientation of the transportation-land use system, although they may also be developed by individual cities, or for a country as a whole.

Key questions to answer with respect to GHG emissions:

What are the GHG impacts of individual strategies included in the plan?

What are the synergistic or antagonistic effects of the strategies included in the plan?

Are legal authority, institutional arrangements, funding, etc. in place to implement the plan?

Most common analysis geography:

- Region;
- City; and
- National.

Table A.1.a Low-Carbon Transport Plans
GHG Assessment Data

Data Element	Level 1 Evaluation	Level 2 Evaluation	Data Type Reference
Baseline Assessment			
Existing regional (local, national) VKT by vehicle type	◆	◆	4.11
Forecast year(s) VKT by vehicle type	◆	◆	4.12
Existing average fuel efficiency by vehicle type	❍	◆	2.21
Forecast year(s) average fuel efficiency by vehicle type	❍	◆	2.22
Project Evaluation, Ex-Ante			
Forecast change in VKT by vehicle type in forecast year(s) for low-carbon plan versus baseline	◆	◆	See evaluation for individual strategies contained in plan[a]
Forecast change in average fuel efficiency by vehicle type for low-carbon plan versus baseline	◆	◆	
Forecast change in average carbon content/life-cycle GHG emissions per unit fuel for low-carbon plan versus baseline	◆	◆	
Project Evaluation, Ex-Post			
Comparison of VKT/capita (by vehicle type), mode shares, fuel consumption/capita, and/or other indicators for postplan versus preplan trend	◆	◆	Various
Comparison of observed with forecast VKT/capita (by vehicle type), mode shares, fuel consumption/ capita, and/or other indicators (with and without plan)	◆	◆	

◆ = Local data required, ❍ = Default data acceptable, [ ] = Optional or alternative data item.

[a] Additional analysis may be needed to determine interactions among strategies (synergies, redundancies, or antagonistic effects).

Table A.1.b Low-Carbon Transport and Land Use Plans
Strategy-Specific Context Indicators

Rating	Evaluation Factor	Required/Optional
Plan in Progress		
Y/N	**Scope Considerations – Intention to Examine:**	**Required**
	Transit infrastructure and service improvements and regulatory issues	
	Nonmotorized improvements	
	Pricing policies and strategies	
	TDM policies and strategies	
	Land use coordination	
S/M/L/N	**Process for Plan Development**	**Required**
	Defined process and timeline for completion	
	Involvement of key stakeholders, including: __ Regional and national transport planning and regulatory agencies __ Local municipalities, including transport and land use staff and elected officials __ Business interests __ Freight interests __ Traveling public	
Plan Completed		
S/M/L/N	**Plan Elements and Emphasis**	**Required**
	Emphasizes transit over highway investment	
	Emphasizes nonmotorized infrastructure and supporting policies	
	Prioritizes operational improvements over capacity expansion	
	New/expanded highway capacity is priced	
	Includes TDM strategies	
	Includes low-carbon goods movement strategies	
	Includes strategies for coordinating land use and transportation planning	
S/M/L/N	**Implementation Capacity**	**Required**
	Plan contains specific action steps, responsibilities, and timeline	
	Extent to which institutional authority exists to implement plan elements	
	Extent to which funding sources have been identified for projects and policies proposed in plan	
	Demonstrated political support for plan (endorsement by government agencies and other key stakeholders)	

2. Strategy: Bus or Rail Rapid Transit

Definition and examples of strategy:

- This strategy includes fixed-guideway transit. Examples include bus rapid transit (BRT), streetcar, light rail, and heavy rail (subway or metro).

Key questions to answer with respect to GHG emissions:

1. How does personal VKT change, as a result of mode-shifting to transit?
2. How does transit VKT change, and what is the relative efficiency of the new versus previously used transit vehicles?
3. What improvements to traffic flow/operations are brought about by reducing the number of transit vehicles on the street and/or rationalizing their operations?

Most common analysis geography:

- Corridor (transit facility, parallel main roadway, and adjacent/nearby roadways).

Table A.2.a Bus or Rail Rapid Transit
GHG Assessment Data

Data Element	Level 1 Evaluation	Level 2 Evaluation	Data Type Reference
Baseline Assessment			
VKT in analysis area by vehicle type	◆	◆	4.11, 4.12
Traffic speeds in corridor by vehicle type (and time of day)	◆	◆	5.21, 5.22
Emission rates by vehicle type and speed[a]	❍	❍/◆	2.32, 2.34
Project Evaluation, Ex-Ante			
Proposed change in transit VKT from operations (by vehicle type)	◆	◆	4.17
Forecast change in transit ridership	◆	◆	4.42
Trip lengths of new transit trips	❍	◆	4.34
Prior mode shares of new transit riders	❍	◆	4.44
Forecast change in private vehicle VKT by vehicle type (modeled)	–	[◆]	4.13
Forecast travel speeds by vehicle type after strategy implementation	◆	◆	5.22
Emission rates for new transit vehicles (by speed)	❍	◆	2.34
All data items by time of day	–	[◆]	
Adjust for induced traffic due to lower congestion	–	[❍/◆]	4.71
Project Evaluation, Ex-Post			
Direct observation of as many ex-ante data items as possible, with following priorities:			
New transit project ridership	◆	◆	4.41
Prior mode and trip lengths of users of new transit service	❍	◆	4.34, 4.44
Actual BRT, other transit, and general traffic speeds in corridor	❍	◆	5.21
Actual fuel consumption rates for BRT, other transit	❍	◆	2.34

◆ = Local data required, ❍ = Default data acceptable, [ ] = Optional or alternative data item.

[a] Analysis of emissions by speed may be optional, if speed data or speed-based emission factors are unavailable. However, since operational benefits are an important part of the emissions benefits of most transit projects, this analysis is strongly recommended, even if based on rough speed estimates and international model default emission/speed correction factors.

Table A.2.b Bus or Rail Rapid Transit
Strategy-Specific Context Indicators

Indicator	Level 1 Evaluation	Level 2 Evaluation	Range/Criteria
Potential for improved travel conditions in corridor	Qualitative assessment – Peak-period travel speed in corridor	Simulation analysis – Relative improvement in peak-period travel speed in corridor (kph, %) (5.21, 5.22) ___ BRT versus existing transit ___ General traffic ___ BRT versus general traffic	High = Slow existing speeds (<15 kph), strong speed improvement (>10 kph) Mod = Moderate existing speeds (15-25 kph), mod speed improvement (5-10 kph) Low = High existing speeds (>25 kph), low speed improvement (<5 kph)
Land use density in corridor	Qualitative assessment of transit-supportive characteristics	Population and job density within 0.5 – 1 km of corridor or stations (1.21, 1.22)	High = >500 jobs + persons per hectare Mod = 200-500 jobs + persons per hectare Low = <200 jobs + persons per hectare
Parking availability in corridor	Qualitative assessment based on field observations or satellite imagery	Parking inventory – spaces/job, spaces/capita, typical/average cost Percent of corridor land devoted to parking (1.41, 1.42, 1.11, 1.12)	High = Low availability (<0.25 spaces/job or capita), all market price, <5% of land devoted to parking Mod = Moderate availability (0.25-0.5 spaces/job or capita), 5-10% of land devoted to parking Low = High availability (>0.5 spaces per job or capita), free, >10% of land devoted to parking
Pedestrian access	Qualitative assessment	Pedestrian facilities inventory and metrics, e.g., __ Sidewalk coverage (percent street frontages) __ Average spacing of pedestrian crossings on arterials __ Pedestrian network density (linear km/sq km) (1.32, 5.34)	See research for FTA's New Starts program for examples
Transit-supportive land use plans (TOD, parking, pedestrian access)	Qualitative assessment of transit-supportive characteristics	Assessment of metrics (such as allowable densities, mix of uses, pedestrian design requirements, parking requirements) (1.51)	See FTA New Starts guidance for examples[a]

a Federal Transit Administration (2004). *Guidelines and Standards for Assessing Transit-Supportive Land Use.* http://www.fta.dot.gov/planning/newstarts/planning_environment_2620.html.

3. Strategy: Nonmotorized Infrastructure

Definition and examples of strategy:

- This strategy includes improvements to infrastructure for pedestrians, bicycles, and other nonmotorized vehicles. Examples of this strategy include bicycle lanes and paths, bicycle parking, sidewalk improvements, pedestrian crossings and signal controls, signage, and traffic calming devices. Nonmotorized infrastructure may be accompanied by supporting policies and programs such as education, law enforcement, and requirements for bicycle parking in new development.

Key questions to answer with respect to GHG emissions:

1. How does personal VKT change, as a result of mode-shifting from motorized to nonmotorized modes?

2. Are there significant effects on automobile or transit traffic operations, e.g., due to reallocation of road space?

Most common analysis geography:

- Subarea (city, neighborhood, subregion); and
- Corridor (specific bicycle facility).

Table A.3.a Nonmotorized Infrastructure
GHG Assessment Data

Data Element	Level 1 Evaluation	Level 2 Evaluation	Data Type Reference
Baseline Assessment			
Analysis area population or households (existing or forecast)	◆	◆	1.11, 1.13
Total trips per capita or household	◆	◆	4.81
Nonmotorized mode shares (existing or baseline forecast)	◆	◆	4.31, 4.32
Trip lengths of nonmotorized trips	❍	◆	4.34
Total PKT for nonmotorized modes (existing or baseline forecast)[a]	[◆]	[◆]	4.51, 4.52
Project Evaluation, Ex-Ante			
Forecast change in nonmotorized mode share or trips per capita	◆	◆	4.32
Expected prior mode shares of new nonmotorized trips	❍	◆	4.44
Project Evaluation, Ex-Post			
Total nonmotorized traffic volumes	◆	◆	4.51
Prior mode shares of new nonmotorized trips	❍	◆	4.44
Trip lengths of new nonmotorized trips	❍	◆	4.34
Actual mode shares	[◆]	[◆]	4.31

◆ = Local data required, ❍ = Default data acceptable, [ ] = Optional or alternative data item.

[a] PKT may be estimated based on factored counts, as an alternative to basing on total trips, mode shares, and trip lengths.

[b] Level 1 evaluation may use existing levels as proxy for baseline forecast.

Table A.3.b Nonmotorized Infrastructure
Strategy-Specific Supportive Indicators

Indicator	Level 1 Evaluation	Level 2 Evaluation	Range/Criteria
Nonmotorized network continuity	Qualitative assessment	Pedestrian and bicycling facilities inventory and metrics, e.g., - Sidewalk coverage (percent street frontages) - Average spacing of pedestrian crossings on arterials - Length of bikeways (any class) - Pedestrian network density (linear km/sq km) - Bicycle path network density (linear km/sq km)	See research for FTA's New Starts program for examples of pedestrian measures, the World Bank's Global Walkability Index,[a] and Multimodal Level of Service Concepts,[b] the Pedestrian Environmental Quality Index[c] and the Bikeability Toolkit[d]
Nonmotorized network quality	Qualitative assessment	Pedestrian and bicycling facilities quality assessment, e.g., - Sidewalk and path functional width - Portion of sidewalks and paths meeting current design standards - Portion of sidewalk and paths in good repair	
Traffic calming facility presence	Qualitative assessment of separation of nonmotorized and motorized traffic at high traffic volumes and speeds	- Distance between traffic lanes and sidewalk paths - Presence of physical separators such as trees, medians and bollards - Speed control devices	
Amenity factor (walkability, bikeabiliy)	Qualitative assessment of topography, sense of security, wayfinding and weather protection elements, cleanliness	Assessment of the amenities, e.g., - Portion of sidewalks and paths with steep inclines - Reported security incidents - Portion of sidewalk and paths with lighting and visibility - Availability of signs, maps and information services - Presence of shade trees and awnings - Effectiveness of sidewalk and path cleaning programs	
Supportive transportation policies and practices (bicycles given rights for roadway use, enforcement practices)	Qualitative assessment of NMT-supportive characteristics	Assessment of metrics such as education and promotion programs, dedicated staff for nonmotorized modes, commute programs, timing of traffic lights for nonmotorized crossings	
Supportive land use plans and policies (TOD, parking, pedestrian access)	Qualitative assessment of NMT-supportive characteristics	Assessment of metrics (such as allowable densities, mix of uses, pedestrian design requirements, parking requirements)	

[a] World Bank Global Walkability Index. http://www.cleanairnet.org/caiasia/1412/article-60499.html.
[b] Multimodal Level of Service. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_616.pdf.
[c] San Francisco Department of Public Health, http://www.sfphes.org/HIA_Tools_PEQI.htm.
[d] TravelSmart Bikeability Toolkit. http://www.travelsmart.gov.au/bikeability/index.html.

4. Strategy: Travel Demand Management

Definition and examples of strategy:

- Travel demand management (TDM) includes a variety of incentives, requirements, or outreach programs to encourage people to travel by more efficient modes (ridesharing, transit, nonmotorized) or to avoid making trips. It is most commonly applied at the worksite level but can also be applied to retail centers, residential neighborhoods, or other target populations. Examples of TDM strategies include:
  - Subsidized transit passes;
  - Parking pricing, cash-out (i.e., employees are given the option of cash in lieu of a free parking benefit), or differential pricing by vehicle type based on size or efficiency;
  - Subsidized or employer run vanpools;
  - Ridematching programs;
  - Promotion of alternative travel modes through provision of information, one-time incentives, recognition programs, etc.;
  - Telework or compressed work-week programs;
  - Elimination of company car benefit, or provision of cash in lieu of the car benefit; and
  - Carsharing programs.

Key questions to answer with respect to GHG emissions:

1. What is the impact of the TDM strategy on vehicle trip rates and mode shares for commuters? Shoppers? Residents?

Most common analysis geography:

- Site (e.g., office park, activity center);
- City; and
- Region (regional ridematching, vanpooling, outreach programs).

Table A.4.a Travel Demand Management
GHG Assessment Data

Data Element	Level 1 Evaluation	Level 2 Evaluation	Data Type Reference
Baseline Assessment			
Existing or baseline forecast employment in analysis area (by type) [a]	◆	◆	1.12, 1.14
Existing or baseline forecast population in analysis area [b]	◆	◆	1.11, 1.13
Existing trip rates in analysis area	❍	◆	4.35
Existing mode shares in analysis area	◆	◆	4.31
Existing trip lengths in analysis area	❍	◆	4.34
Project Evaluation, Ex-Ante			
Expected number of employees or residents offered TDM incentive or travel option	◆	◆	Program analysis
Expected response (change in mode share) of target population to strategy implementation	◆	◆	4.33
Project Evaluation, Ex-Post			
Actual number of employees or residents offered TDM incentive or travel option	◆	◆	Program analysis
Observed change in mode share after strategy implementation	◆	◆	4.31

◆ = Local data required, ❍ = Default data acceptable, [ ] = Optional or alternative data item.

[a] For worksite-based TDM.

[b] For residential/neighborhood TDM.

Table A.4.b Travel Demand Management
Strategy-Specific Context Indicators

Indicator	Level 1 Evaluation	Level 2 Evaluation	Range/Criteria
Availability of travel alternatives	Qualitative assessment of transit, biking and pedestrian network as well as transit-supportive characteristics	Transit coverage and quality of service indicators in corridor or pricing area. Assessment of transit-supportive land use metrics (see Table A.1.a)	See Transit Capacity and Quality of Service Manual for examples of transit service metrics[a] See FTA New Starts guidance for examples of land use metrics[b]
Cost and availability of parking in area	Qualitative assessment	Parking survey (price, supply, occupancy)	
Existence of institutions to support outreach programs	Existence of employer/ business associations		

[a] *Transit Capacity and Quality of Service Manual*, 2nd Edition (2009). Transit Cooperative Research Program Report 100.

[b] Federal Transit Administration (2004). *Guidelines and Standards for Assessing Transit-Supportive Land Use.* http://www.fta.dot.gov/planning/newstarts/planning_environment_2620.html.

5. Strategy: Road and Fuel Pricing

Definition and examples of strategy:

- This strategy includes pricing measures that affect the cost of driving, either generally or in particular times and/or locations. Examples include tolled facilities, managed lanes (e.g., high-occupancy/toll lanes), congestion pricing, cordon pricing, general road pricing (e.g., VKT fee), and fuel or carbon taxes.

Key questions to answer with respect to GHG emissions:

1. How do personal and commercial VKT change, as a result of reduced vehicle travel because of higher prices?

2. For pricing that varies by time of day or location, how much traffic is shifted to other, lower-priced or unpriced times or locations?

3. What are the effects of the changes in traffic volumes on traffic operations and emissions?

Most common analysis geography:

- Corridor (major roadway) – Tolling, congestion pricing, managed lanes;
- Subarea (e.g., central business district, activity center) – Cordon pricing;
- Region – VKT fee, network-level tolling or pricing; and
- National – Fuel/carbon pricing, VKT fee.

Table A.5.a Road and Fuel Pricing
GHG Assessment Data

Data Element	Level 1 Evaluation	Level 2 Evaluation	Data Type Reference
Baseline Assessment			
Set 1:			
VKT by vehicle type in analysis area (existing or baseline forecast)	◆	◆	4.11, 4.12
Emission rates by vehicle type	❍	◆	2.21
Set 2:[a]			
VKT in analysis area by speed (existing or baseline forecast)	◆	◆	5.22
VKT in analysis area by time of day (existing or baseline forecast)	◆	◆	5.12
Emission rates by average speed	❍	◆	2.32
Project Evaluation, Ex-Ante			
Forecast change in VKT by vehicle type for analysis area and time period affected by pricing scheme	◆	◆	4.13
Forecast change in VKT by vehicle type for areas and/or time periods not covered by pricing scheme	–	◆	4.14
New forecast VKT in analysis area by speed (including areas and times affected and not affected by pricing)	–	◆	5.22
Project Evaluation, Ex-Post			
Observed VKT by vehicle type for analysis area and time period affected by pricing scheme	◆	◆	4.11
Observed VKT by vehicle type for areas and/or time periods not covered by pricing scheme	◆	◆	4.11
Observed VKT in analysis area by speed (including areas and times affected and not affected by pricing)	–	◆	5.21
Observed VKT on other facilities in region unaffected by pricing scheme or diversion (as control)	–	◆	4.11

◆ = Local data required, ❍ = Default data acceptable, [ ] = Optional or alternative data item.

[a] Set 2 – Time-of-day data required for pricing strategies that vary by time of day; speed data recommended for strategies that significantly affect traffic volumes and speeds.

Table A.5.b Road and Fuel Pricing
Strategy-Specific Context Indicators

Indicator	Level 1 Evaluation	Level 2 Evaluation	Range/Criteria
Availability of travel alternatives	Qualitative assessment of transit, biking and pedestrian network as well as transit-supportive characteristics	Transit coverage and quality of service indicators in corridor or pricing area. Assessment of transit-supportive land use metrics (see Table A.1.a)	See Transit Capacity and Quality of Service Manual for examples of transit service metrics[a] See FTA New Starts guidance for examples of land use metrics[b]
Revenue management institutions	Qualitative assessment of how revenue collection is linked to policy outcomes	Concessionaire or collecting agency compensation tied to system and environmental performance through predefined indicators	See FHWA Office of Innovative Program Delivery for examples.[c,d] Also see results related to London Congestion Pricing Scheme.
Policies implemented to minimize avoidance/diversion of vehicle travel to other times and locations	Assessment of geographic and temporal scope of pricing Assessment of availability and attractiveness of alternative routes or destinations	Modeling of spatial and/or temporal diversion effects	High – Diversion effects likely to offset only a small percentage of project benefits Moderate – Diversion effects likely to offset only a moderate percentage of project benefits Low – Diversion effects likely to offset most if not all of project benefits
Pricing scheme is equitable	Assessment on whether structure of charging scheme is the same for all individuals or progressive with respect to income	Cost per type of user by category of user, e.g., - Income; - Mode; and - Location.	Horizontal – Equal treatment, use, allocation resources Vertical with respect to income and social class – Affordability, impacts on low-income communities, employment opportunities Vertical with respect to need and ability – Universal design, disabled policies

[a] *Transit Capacity and Quality of Service Manual*, 2nd Edition (2009). Transit Cooperative Research Program Report 100.

[b] Federal Transit Administration (2004). *Guidelines and Standards for Assessing Transit-Supportive Land Use.* http://www.fta.dot.gov/planning/newstarts/planning_environment_2620.html.

[c] http://www.fhwa.dot.gov/ipd/revenue/index.htm.

[d] U.K. Commission for Integrated Transport (CfIT) Report World Review of Road Pricing Report 1 and 2. http://cfit.independent.gov.uk/pubs/2006/wrrp/wrrp2/case/pdf/wrrp2-casestudies.pdf.

6. Strategy: Congestion Relief

Definition and examples of strategy:

- This strategy includes traffic control/operations and capacity measures that seek to reduce congestion or vehicle delay. Examples include installation of traffic control devices, signal timing improvements, signal synchronization, lane controls, enforcement of parking/loading restrictions, incident management, intersection geometric improvements, grade separation, capacity expansion, or other measures to improve traffic flow on the roadway network.

Key questions to answer with respect to GHG emissions:

1. How do traffic flow and associated emissions change?

2. How much additional travel is "induced" because of increased travel speeds/reduced travel times?

Most common analysis geography:

- Corridor (main roadway and adjacent/nearby roadways); and
- Subarea (e.g., central business district).

Table A.6.a Congestion Relief
GHG Assessment Data

Data Element	Level 1 Evaluation	Level 2 Evaluation	Data Type Reference
Baseline Assessment			
Existing or baseline forecast traffic volumes (by vehicle type) affected by traffic control strategy (including any major cross-streets affected)	◆	◆	5.11, 5.12
Average travel speeds in corridor, and/or average stopped delay at intersections	◆	◆	5.21, 5.23
Emission factors by vehicle type and speed	❍	❍/◆	2.32
Traffic volumes and speeds on nearby roadways with expected significant traffic volume changes due to diversion	–	[◆]	5.11
Traffic volumes and speeds by time of day (peak, off-peak)	–	[◆]	5.21
Project Evaluation, Ex-Ante			
Projected change in average corridor travel speed, and/or change in average stopped delay, as result of strategy	◆	◆	5.22, 5.24
Induced demand offset	–	❍	4.71
Projected change in emissions from traffic simulation and emission factor models	–	[◆]	2.35
Project Evaluation, Ex-Post			
Observed traffic volumes	◆	◆	5.11
Observed traffic speeds and/or delay	◆	◆	5.21, 5.23
Modeled emissions based on observed volumes and speeds	–	[◆]	2.35

◆ = Local data required, ❍ = Default data acceptable, [ ] = Optional or alternative data item.

Table A.6.b Congestion Relief
Strategy-Specific Context Indicators

Indicator	Level 1 Evaluation	Level 2 Evaluation	Range/Criteria
Existing travel speeds in corridor (peak, off-peak)	Qualitative assessment from driving corridor	Field measurements of travel speeds (travel time runs using stopwatch or GPS) (5.21)	High = slow existing speeds (<15 kph), strong speed improvement (>10 kph) Mod = moderate existing speeds (15-25 kph), mod speed improvement (5-10 kph) Low = high existing speeds (>25 kph), low-speed improvement (<5 kph)
Existing levels of delay at intersections or bottlenecks	Qualitative assessment from driving corridor	Field measurements of intersection delay or Level of Service (5.23)	High = Level of Service F (>80 sec/ intersection) Mod = LOS D/E (35-80 sec/ intersection) Low = LOS A-C (<35 sec/ intersection)
Field observations of operational problems	Qualitative assessment	Qualitative assessment	
Expected delay reductions or speed improvements from traffic control	Observations from applications of similar treatments elsewhere	Simulation modeling or Highway Capacity Manual method calculation (5.22, 5.24)	High = Improvement >30 sec/intersection or 20% travel speed over corridor Mod = Improvement 15-30 sec/intersection or 10-20% travel speed over corridor Low = Improvement <30 sec/ intersection or <10% travel speed over corridor
Congestion pricing implemented to manage induced demand	Congestion pricing implemented or planned for corridor/area	Prices set at appropriate rates to achieve economic efficiency (incorporating externalities)	

7. Strategy: Fuel Economy/GHG Standards and Incentives

Definition and examples of strategy:

- This category includes national-level standards for fuel economy or GHG emissions of new and/or imported vehicles, or incentives for purchasing efficient vehicles such as "feebates" in which vehicle sales are taxed based on their fuel economy or GHG emissions.

Key questions to answer with respect to GHG emissions:

1. How much will new vehicle fuel economy improve compared to the existing vehicle fleet?

2. Allowing for fleet turnover, how will the benefits of these improvements be realized over time in the on-road fleet?

3. What unintended consequences might the policy have that could reduce its benefits, e.g., people keep older vehicles longer, import more used vehicles, or drive more because vehicle operating costs are less?

Most common analysis geography:

- National.

Table A.7.a Fuel Economy/GHG Standards and Incentives
GHG Assessment Data

Data Element	Level 1 Evaluation	Level 2 Evaluation	Data Type Reference
Baseline Assessment			
Basic Assessment			
Total vehicle stock (by type)	◆	◆	2.11
Average fuel economy of on-road vehicle fleet (by vehicle type)	◆	◆	2.21
Total VKT by vehicle type (base year)	◆	◆	4.11
Total VKT by vehicle type (future-year projections)	◆	◆	4.12
Refined Assessment[a]			
Current and recent historical efficiency (test cycle) of new vehicles, by vehicle type to be regulated	[❍]	[◆]	2.24
Adjustment for actual on-road efficiency/emissions versus test cycle/certification efficiency	[❍]	[◆]	2.27
Future-year projections of new vehicle efficiency (baseline)	[❍]	[◆]	2.25
Future-year projections of new vehicle sales (by vehicle type)	[❍]	[◆]	2.15
Vehicle scrappage/turnover rates or age distribution by vehicle type	[❍]	[◆]	2.12
Mileage accumulation rates by vehicle type	[❍]	[❍]	2.13
Project Evaluation, Ex-Ante			
Future-year projections of new vehicle efficiency by vehicle type (with policies)	◆	◆	2.26
"Rebound effect" – Percent increase in VMT due to decreased cost/mile	–	[❍]	6.12
Price of fuel (required for rebound effect)	–	[◆]	3.31
Expected incremental change in cost of new vehicle (by type)[b]	–/◆	❍/◆	2.51
"Purchase effect" – Expected shift in consumer purchases by vehicle efficiency or type in response to price differential[b]	❍	◆	6.21
"Turnover effect" – Expected slower rate of fleet turnover due to higher new vehicle cost	–	[❍]	6.22
"Import effect" – Expected increase in used imported vehicles due to higher new vehicle cost	–	[❍/◆]	6.23

Table A.7.a Fuel Economy/GHG Standards and Incentives (continued)
GHG Assessment Data

Data Element	Level 1 Evaluation	Level 2 Evaluation	Data Type Reference
Project Evaluation, Ex-Post			
Observed, sales-weighted new vehicle efficiency by vehicle type	◆	◆	2.24
Observed increase in cost of new vehicle (by type)	–	[◆]	2.52
Observed increase in volume of imported used vehicles	–	[◆]	2.16
Observed change in vehicle sales by vehicle type (class-switching)	–	[◆]	2.14

◆ = Local data required, ❍ = Default data acceptable, [ ] = Optional or alternative data item.

[a] Refined assessment is only needed if vehicle mix (percent by type) and/or efficiency are expected to change significantly over time. If these are not expected to change significantly, the Basic assessment can be used for either a Level 1 or Level 2 evaluation.

[b] Only required for feebate/incentive system, not for standards.

Table A.7.b Fuel Economy/GHG Standards and Incentives
Strategy-Specific Context Indicators

Indicator	Level 1 Evaluation	Level 2 Evaluation	Range/Criteria
All passenger vehicles regulated at roughly equitable levels (e.g., no major differences by vehicle type/class)	Note: Full evaluation of fuel economy regulations or incentives is complex. Reviewers are referred to studies from countries that have implemented such programs to review program design elements and expected impacts.		
Policies implemented to discourage avoidance through import of used vehicles (e.g., import tax or rebate based on fuel efficiency)			
Institutional mechanism in place to enforce fuel economy regulations or collect taxes/feebates			

8. Strategy: Low-Carbon or Renewable Fuel Standards

Definition and examples of strategy:

- This category includes low-carbon fuel standards or renewable fuel standards designed to reduce the GHG intensity of transportation fuels used in the country.

Key questions to answer with respect to GHG emissions:

1. How will the carbon/GHG intensity of fuels change over time, considering life-cycle GHG effects?

2. Are there any unintended consequences that may reduce the effectiveness of the strategy, e.g., low-carbon fuels are simply diverted from other uses rather than displacing conventional fuels?

Most common analysis geography:

- National.

Table A.8.a Low-Carbon or Renewable Fuel Standards
GHG Assessment Data

Data Element	Level 1 Evaluation	Level 2 Evaluation	Data Type Reference
Baseline Assessment			
Current volume of transportation fuels sold in country, by fuel type	◆	◆	3.11
Forecast-year volume of transportation fuels sold in country, by fuel type	◆	◆	3.12
Life-cycle emissions associated with unit of fuel, by type	❍	◆	3.21
Project Evaluation, Ex-Ante			
Percent reduction in average fuel carbon content/ GHG emission requirements, by evaluation year	◆	◆	3.22
Renewable fuel requirements and GHG performance standards by fuel type	◆	◆	3.23
Project Evaluation, Ex-Post			
Fraction of new vehicles sold capable of using alternative fuels	❍	◆	2.14
Actual volume of fuel sold by fuel type/life-cycle GHG emission levels	◆	◆	3.11, 3.21
Total volume of fuels sold within broader region, by fuel type (to examine diversion effects)	–	[◆]	3.11
Actual life-cycle emissions considering production pathways used	–	[◆]	3.21

◆ = Local data required; ❍ = Default data acceptable; [ ] = Optional or alternative data item.

Table A.8.b Low-Carbon or Renewable Fuel Standards
Strategy-Specific Context Indicators

Indicator	Level 1 Evaluation	Level 2 Evaluation	Range/Criteria
Standard/ incentive is designed to account for full fuel-cycle GHG emissions	Note: Full evaluation of fuel standards is complex. Reviewers are referred to the literature examining this topic and regulations adopted elsewhere.		
Similar low-carbon standards/ incentives adopted or proposed in neighboring countries			
Expected ability of fuel suppliers to meet carbon/GHG performance standards or incentives			

9. Strategy: Low-Carbon or Renewable Fuel Incentives

Definition and examples of strategy:

- This category includes incentives for consumers to purchase vehicles capable of using fuels with lower GHG intensity and/or to use such fuels. Examples may include refueling infrastructure, tax incentives for low-carbon fuels, and tax incentives or subsidies for purchase of alternative fuel vehicles.

Key questions to answer with respect to GHG emissions:

1. How effective will the incentive be at encouraging consumers to switch to different types of fuels?
2. What are the full life-cycle GHG impacts of the alternative fuels for which incentives are provided?

Most common analysis geography:

- National.

Table A.9.a Low-Carbon Fuel Incentives
GHG Assessment Data

Data Element	Level 1 Evaluation	Level 2 Evaluation	Data Type Reference
Baseline Assessment			
Current volume of transportation fuels sold in country, by fuel type	◆	◆	3.11
Forecast- year volume of transportation fuels sold in country, by fuel type	◆	◆	3.12
Life-cycle emissions associated with unit of fuel, by type	❍	◆	3.21
Project Evaluation, Ex-Ante			
Fraction of existing vehicle fleet capable of using alternative fuel(s) targeted by policy	◆	◆	2.14
Availability of refueling infrastructure after policy implemented (percent of consumers/area served)	◆	◆	3.41
Projected fuel cost differential versus conventional fuel after incentive, and net change in vehicle operating cost for consumer	◆	◆	3.32
Projected change in vehicle purchase price (for dedicated-fuel vehicles) and payback period given projected fuel prices	◆	◆	2.51
Differences in key performance attributes for alternative fuel versus conventional fuel vehicles (e.g., range, cargo capacity, safety)	◆	◆	Policy-specific analysis
Difference in life-cycle emissions for alternative versus conventional fuel types	❍	◆	3.21
Analysis of whether alternative fuel demand would be new, or diverted from other existing uses	–	[◆]	Policy-specific analysis
Project Evaluation, Ex-Post			
Extent to which renewable/low-GHG fuel infrastructure is deployed and fuel available	◆	◆	3.42
Fraction of new vehicles sold capable of using alternative fuels	❍	◆	2.14
Volume of fuels sold within country, by fuel type	◆	◆	3.11
Total volume of fuels sold within broader region, by fuel type (to examine diversion effects)	–	[◆]	3.11
Actual life-cycle emissions considering production pathways used	–	[◆]	3.21

◆ = Local data required, ❍ = Default data acceptable, [ ] = Optional or alternative data item.

Table A.9.b Low-Carbon Fuel Standards and Incentives
Strategy-Specific Context Indicators

Indicator	Level 1 Evaluation	Level 2 Evaluation	Range/Criteria
Incentive is designed to account for full fuel-cycle GHG emissions	Note: Full evaluation of fuel incentives is complex. Reviewers are referred to the literature examining this topic and regulations adopted elsewhere.		
Similar low-carbon standards/ incentives adopted or proposed in neighboring countries			
Expected ability of fuel suppliers to produce and distribute low-carbon/GHG fuels			
Expected ability of vehicle manufacturers to produce dedicated or bi-fuel vehicles			

10. Strategy: Land Use Planning and Implementation

Definition and examples of strategy:

- This strategy includes regional and land use planning and plan implementation to develop communities that reduce vehicular travel needs. Examples include integrated regional transport and land use plans; municipal sustainable development plans; subarea plans; transit station area plans; and actions to implement these plans such as revisions to zoning codes, impact fees, catalyst projects, public investment, etc. Such plans will typically emphasize dense, mixed-use, walkable development that maximizes opportunities for using transit and nonmotorized modes and minimizes the need for travel in personal vehicles.

Key questions to answer with respect to GHG emissions:

1. What are the expected impacts of the plan and its associated implementation actions on development patterns?

2. What are the expected impacts of changes in development patterns on travel by different modes?

Most common analysis geography:

- Region;
- City;
- Subarea; and
- Site.

Table A.10.a Land Use Planning and Implementation
GHG Assessment Data

Data Element	Level 1 Evaluation	Level 2 Evaluation	Data Type Reference
Baseline Assessment			
Total population by subarea	◆	◆	1.11
Total employment by subarea	◆	◆	1.12
Population density by subarea	◆	◆	1.21
Employment density by subarea	◆	◆	1.22
Mix of uses	◆[a]	◆	1.31
Walkability/pedestrian design (building setbacks, active facades, etc.)	◆[a]	◆	1.32
Project Evaluation, Ex-Ante			
Planned changes in density	◆	◆	1.51
Planned changes in mix of uses	◆[a]	◆	
Planned changes in walkability/pedestrian design	◆[a]	◆	
VKT per capita or employee as a function of density and other land use characteristics	❍	❍/◆	6.31
Trip rates and mode shares as a function of density and other land use characteristics	[❍]	[❍/◆][b]	6.32
Trip lengths by mode as a function of density and other land use characteristics	[❍]	[❍/◆][b]	6.33
Regional change in VKT for land use plan versus without plan case (modeled)	–	[◆]	4.13
Project Evaluation, Ex-Post			
Characteristics of new/recent developments (location, density, mix of uses, walkability/pedestrian design) compared to previous developments typical in the city/region	◆[a]	◆	1.61
Observed trip rates and mode shares in new developments (by land use characteristics)	–	◆	4.31
Observed trip lengths by mode in new developments (by land use characteristics)	–	◆	4.34

◆ = Local data required, ❍ = Default data acceptable, [ ] = Optional or alternative data item.

[a] Qualitative assessment.

[b] VKT can be calculated from trip rates, mode shares, and trip lengths.

Table A.10.b Land Use Planning and Implementation
Strategy-Specific Context Indicators

Indicator	Level 1 Evaluation	Level 2 Evaluation	Range/Criteria
Legal/regulatory authority exists to implement and enforce land use plan provisions	Does the government have the legal authority to approve or reject development based on consistency with the plan? Is there zoning? Is there a process for enforcing zoning regulations?		See FTA New Starts guidance for examples of high/moderate/low ratings
Implementation tools available to direct/ encourage development patterns consistent with plan	Is there a design review process? Are there fiscal incentives or disincentives in place to encourage consistency with plan? Are there outreach programs to work with landowners and developers on development practices? Are government construction and infrastructure investment practices consistent with and supportive of the plan?		
Stakeholder support for plan (local government staff and officials, developers, landowners)	Were key stakeholders involved in plan development? Did they endorse the plan?		
Government has demonstrated past willingness to guide land use decisions	Are recent development patterns consistent with existing plans? Has the plan, zoning approval, or design review process been used on a regular basis to achieve plan objectives?		

Appendix B
Data Type Inventory and Sources

Table B.1 People and Built Environment

Data Type	Data Item	Source/Method (1)	Source/Method (2)	Source/Method (3)
1.11	Total population – historical/ current (by subarea)	Census with growth estimates for interim years		
1.12	Total employment – historical/current (by sector, subarea)	Census with growth estimates for interim years	Employer survey	
1.13	Total population – forecast (by subarea)	Trend projection	Population forecasting model	Analysis of development plans
1.14	Total employment – forecast (by sector, subarea)	Trend projection	Land use forecasting model	Analysis of development plans
1.21	Population density (by subarea)	Population (1.11)/land area		
1.22	Employment density (by sector, subarea)	Employment (1.12)/land area		
1.31	Mix of uses	Qualitative assessment based on field survey	Index based on detailed land use data	
1.32	Walkability/pedestrian design (building setbacks, active facades, etc.)	Qualitative assessment based on field survey	Index based on quantitative metrics	
1.51	Planned land use characteristics (see above dimensions)	Qualitative evaluation of proposed land use plans and site plans	Performance metrics computed from GIS analysis of proposed land use plans and site plans	
1.61	Characteristics of new/ recent developments (see above dimensions)	Qualitative valuation of recent development proposals (site plans and subarea plans) and built projects	GIS evaluation of recent development proposals (site plans and subarea plans)	

Table B.2 Vehicles

Data Type	Data Item	Source/Method (1)	Source/Method (2)	Source/Method (3)
2.12	Vehicle scrappage/turnover rates or age distribution (by vehicle type)	Vehicle registration data	Household travel survey	Default data from similar country
2.13	Mileage accumulation rates (by vehicle type)	Odometer readings from vehicle registration or inspection program data	Household travel survey	Default data from similar country
2.14	New vehicle sales (annual number by type)	Sales tax data	Registration data	
2.15	New vehicle sales projections (by vehicle type)	Trend projection from historical sales (2.14)	Sales forecasting model tied to GDP, population, and/or other variables	
2.16	Annual volume of used vehicle imports (by age, type)	Vehicle registration data	Import data	
2.21	Average fuel economy of on-road vehicle fleet (by vehicle type)	Estimated from total VKT (by vehicle type), total fuel sales, and fraction of fuel use by vehicle type	Estimated from total VKT by vehicle type and efficiency by vehicle type (from certification data, international data source, or field measurements)	
2.22	Baseline forecast average fuel economy of on-road vehicle fleet (by vehicle type)	Trend extrapolation of existing fuel economy (2.21)	Modeled based on new vehicle standards and vehicle mix by year, mileage accumulation, and turnover rates	
2.23	Policy forecast average fuel economy of on-road vehicle fleet (by vehicle type)	Modeled based on new vehicle standards and vehicle mix by year, mileage accumulation, and turnover rates		
2.24	Average fuel economy of new vehicles (by vehicle type)	Fuel economy test data weighted by sales data by model	Data from country with similar mix of new vehicles sold	
2.25	Baseline forecast of new vehicle fuel economy (by vehicle type)	Trend projection of historical efficiency trends	Existing fuel efficiency regulations	
2.26	Policy forecast of new vehicle fuel economy (by vehicle type)	Policy analysis of proposed regulations		
2.27	Difference between in-use and standard fuel economy	Field instrumentation	Comparison of total fuel use (calculated from VKT and efficiency) versus total fuel sales (observed)	Data from similar country

Table B.2 Vehicles (continued)

Data Type	Data Item	Source/Method (1)	Source/Method (2)	Source/Method (3)
2.32	Fuel consumption and GHG emission rates by vehicle type – (by speed)	International Vehicle Emissions model or other international data source	Field instrumentation	
2.34	Fuel consumption and GHG emission rates by vehicle type – transit (by speed)	International Vehicle Emissions model or other international data source	Field instrumentation or lab tests	
2.35	Emission rates under simulated traffic operational conditions	Traffic simulation and emissions model(s)		
2.41	Efficiency of nonroad freight transport modes	Total VKT or ton-miles by mode/ Fuel consumption by mode		
2.51	Projected change in vehicle cost due to fuel efficiency standard, feebate system, or technology/fuel requirement	Country-specific evaluation	Regulatory impact or research studies from other countries	
2.52	Actual change in vehicle cost due to fuel efficiency standard, feebate system, or technology/fuel requirement	Time-series analysis of average vehicle cost by vehicle type/class		

Table B.3 Fuels

Data Type	Data Item	Source/Method (1)	Source/Method (2)	Source/Method (3)
3.11	Total fuel sales by motor vehicles (by fuel type)	Sales/taxation data		
3.12	Projected fuel sales (by fuel type)	Forecast of VKT by vehicle type, percent fuel use by vehicle type, and vehicle efficiency	Trend projection of historical fuel sales data	
3.21	Life-cycle GHG emissions from fuel production (by fuel type)	Apply life-cycle analysis model using country-specific data	Apply existing life-cycle analysis model using default parameters	Study conducted by other country/ agency
3.22	Percent reduction in average fuel carbon content/GHG emission requirements, by evaluation year	Policy analysis		
3.23	Renewable fuel requirements and GHG performance standards by fuel type	Policy analysis		
3.31	Average fuel price (by fuel type)	Retail price surveys		
3.32	Projected average fuel price (by fuel type)	Existing fuel price (3.31), analysis of future cost differentials from literature, and differential tax rates		
3.41	Projected availability of alternative fuel infrastructure	Policy analysis		
3.42	Actual availability of alternative fuel infrastructure	Field surveys or reporting		

Table B.4 Travel Patterns

Data Type	Data Item	Source/Method (1)	Source/Method (2)	Source/Method (3)
4.11	Existing VKT in analysis area (by vehicle type)	Traffic counts factored to estimate VKT	VKT/capita (1a) * total population from census (subregion or region only)	
4.12	Baseline forecast VKT in analysis area (by vehicle type)	Existing VKT (4.11) * growth factor or trend extrapolation of time-series counts	Travel demand forecasting model	
4.13	Forecast change in private VKT from strategy implementation (by vehicle type)	Travel demand forecasting model, including mode choice	Forecast change in mode share * trip length of mode-shifters	Elasticity of VKT with respect to strategy parameter
4.14	Forecast private VKT diverted from strategy area or time period to another time/location	Network model (spatial diversion)	Time-of-day diversion model	Observed data from similar project/ context
4.17	Change in transit VKT from project (by transit vehicle type)	Transit operations analysis		
4.21	Existing VKT per capita (by vehicle type)	Trip lengths, mode shares, and vehicle occupancy from O-D survey	Total VKT (by vehicle type) from traffic counts (4.11)/total population from census	Forecasting model incorporating sociodemographics and other variables
4.22	Baseline forecast VKT per capita (by vehicle type)	Extrapolation of trend of existing VKT/capita (4.21)	Forecasting model incorporating sociodemographics and other variables	
4.31	Existing mode shares (by purpose)	Household/O-D survey	Multimodal traffic counts	Worksite or intercept survey
4.32	Baseline forecast mode shares (by purpose)	Extrapolation of recent mode share trend	Forecasting model, including mode choice	
4.33	Change in mode shares from strategy implementation	Transfer from similar project/ context	Forecasting model, including mode choice	Stated-preference survey of target population
4.34	Trip lengths by mode (purpose)	Intercept or transit on-board survey	Household/O-D survey	Transfer from similar context
4.35	Trip rates (by purpose)	Multimodal traffic counts	Household/O-D survey	

Table B.4 Travel Patterns (continued)

Data Type	Data Item	Source/Method (1)	Source/Method (2)	Source/Method (3)
4.37	Average private vehicle occupancy (by mode, purpose)	Household/O-D survey	Field observations	
4.41	Observed transit ridership by route	Field observations		
4.42	Forecast change in transit ridership	Ridership/mode choice model developed from local survey or transferred parameters	Estimates based on similar project(s) experience	
4.44	Prior modes of travel of new transit or nonmotorized travelers	Intercept or transit on-board survey	Transfer from similar project/ context	
4.51	Existing nonmotorized PKT	Counts factored to estimate person-km	Calculated from trips/capita, mode shares, and trip lengths	
4.52	Baseline forecast nonmotorized PKT	Trend projection from existing/historical (4.51)		
4.53	Forecast change in bicycle/pedestrian traffic in response to improvements	Transfer from similar project/ context	Forecasting model, including nonmotorized mode choice	
4.54	Bicycling and walking trip lengths	Intercept survey	Household/O-D survey	Transfer from similar context
4.55	Prior/foregone travel choices of bicyclists and walkers	Intercept survey	Household/O-D survey	
4.71	Induced traffic (change in traffic volumes or VKT in response to change in travel conditions)	Network model	Demand elasticity applied to change in travel time and/or cost	
4.81	Existing trips per capita or per household	Household/O-D survey		

Table B.5 Transportation Network

Data Type	Data Item	Source/Method (1)	Source/Method (2)	Source/Method (3)
5.11	Existing traffic volumes (by vehicle type, time of day)	Traffic counts	Forecasting or simulation model	
5.12	Forecast traffic volumes (by vehicle type, time of day)	Existing volumes (5.11) * growth factor	Forecasting or simulation model	
5.21	Existing speeds in corridor (by vehicle type, time of day)	Field measurements	Forecasting or simulation model	
5.22	Forecast speeds in corridor (by vehicle type, time of day)	Existing speeds (5.21) * growth factor with speed-demand elasticity	Forecasting or simulation model	
5.23	Existing levels of delay	Highway Capacity Manual methods or simulation model	Field measurements	
5.24	Forecast levels of delay	Highway Capacity Manual methods or simulation model		
5.33	Bicycle infrastructure (locations of facilities)	GIS database	Field surveys	
5.34	Pedestrian infrastructure (locations of facilities)	GIS database	Field surveys	

Table B.6 Behavior

Data Type	Data Item	Source/Method (1)	Source/Method (2)	Source/Method (3)
6.11	Demand elasticity – change in VKT with respect to change in travel time	Country-specific studies	Literature findings for similar contexts	
6.12	Demand elasticity – change in VKT with respect to change in vehicle operating cost	Country-specific studies	Literature findings for similar contexts	
6.21	"Purchase effect" – expected shift in consumer purchases by vehicle efficiency or type in response to price differential	Country-specific studies	Literature findings for similar contexts	
6.22	"Turnover effect" – expected slower rate of fleet turnover due to higher new vehicle cost	Country-specific studies	Literature findings for similar contexts	
6.23	"Import effect" – expected increase in used imported vehicles due to higher new vehicle cost	Country-specific studies	Literature findings for similar contexts	
6.31	VKT per capita or employee as a function of density and other land use characteristics	HH travel survey and/or travel model	Evidence from literature	
6.32	Trip rates and mode shares as a function of density and other land use characteristics	HH travel survey and/or travel model	Evidence from literature	Household, worksite, or intercept survey
6.33	Trip lengths by mode as a function of density and other land use characteristics	HH travel survey and/or travel model	Evidence from literature	Household, worksite, or intercept survey

Appendix C
Abbreviations and Acronyms

BRT	Bus rapid transit
CDM	Clean Development Mechanism
CO_2	Carbon dioxide
FHWA	United States Federal Highway Administration
FTA	United States Federal Transit Administration
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
GIS	Geographic information system
GPS	Global positioning system
HH	Household
LCTP	Low-carbon transport plan
LOS	Level of service
MRV	Monitoring, reporting, and verification
NAMA	Nationally Appropriate Mitigation Action
NMT	Non-motorized transportation
O-D	Origin-destination
PKT	Person kilometers of travel
TDM	Travel demand management
TOD	Transit-oriented development
VKT	Vehicle kilometers of travel