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Transit Sustainability Guidelines

Framework for Approaching Sustainability and Overview of Best Practices

Abstract: This *Recommended Practice* introduces guidelines for designing and operating sustainable transit that both reduces a community's environmental footprint from transportation and enhances its quality of life by making travel more enjoyable, affordable and timely.

Keywords: Alignment, ambient environment, art, crime prevention through environmental design (CPTED), emissions, energy, Environmental Management System, facility, green building, infrastructure, land use, life-cycle cost, livable neighborhood, noise and vibration, optimization, public health, , resource efficient, sustainability, transit vehicle, wayfinding, waste management.

Summary: Designing and operating sustainable transit requires a new way of thinking. For the transit industry to achieve true sustainability, it must take a holistic approach toward what a transit agency can and should contribute. Improving transit systems' performance and integrating transit with community development is more vital to sustainability than simply reducing the environmental footprint of agency facilities. A transit system can consist of the greenest of earth-friendly, energy-efficient facilities and fleet, but it does little good if it is not used. An empty bus cannot be a sustainable bus. If transit doesn't succeed in integrating with and serving the community, it can be an environmental and economic burden and even a scar on the landscape. These guidelines cover a wide spectrum of sustainability in regard to transit.

Scope and purpose: This document is intended to assist signatories of the American Public Transportation Association's Sustainability Commitment by first sharing a framework to approach sustainability and then suggesting best practices. An underlying goal of this document is to communicate the belief that transit agencies need to do everything in the realm of sustainability which is within their control or influence. This requires vision and occasionally radical innovation.

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

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Introduction

Designing and operating sustainable transit requires a new way of thinking. For the transit industry to achieve true sustainability, it must take a holistic approach toward what a transit agency can and should contribute. Improving transit systems' performance and integrating transit with community development is more vital to sustainability than simply reducing the environmental footprint of agency facilities. A transit system can consist of the greenest of earth-friendly, energy-efficient facilities and fleet, but it does little good if it is not used. An empty bus cannot be a sustainable bus. If transit doesn't succeed in integrating with and serving the community, it can be an environmental and economic burden and even a scar on the landscape. A holistic practice of transit sustainability leads to a healthier and happier lifestyle and a more livable community.

These guidelines cover a wide spectrum of sustainability in regard to transit, but foremost are the objectives introduced below. While working on these objectives, attention should also be given to sustainability factors such as energy-efficiency and recycling. But in no case, should sustainability considerations addressed by conventional metrics be permitted obscure the bigger picture of making travel more enjoyable, affordable, and timely.

Sustainability practices by the transit industry should aim at having broad impact through the following:

- Improving mobility via enjoyable transit services.
- Creating livable communities through facilitating more environmentally friendly forms of mobility, such as walking, biking, and public transit, and increasing the number of routine destinations that are safely and comfortably accessible through these modes.
- Reducing per capita automobile vehicle miles traveled (VMT).
- Reducing stress, loss of productivity, traffic deaths and injuries, and related health-care costs caused by automobile travel.
- Reducing passenger transportation-generated CO₂ and other greenhouse gases.
- Reducing passenger transportation-caused ambient hazards such as noise, pollution, and vibration.

The framework and guidelines introduced in this document are designed to lead to the realization of the above sustainability objectives.

Note, that details and case studies related to these Guidelines are available in APTA's "Transit Sustainability Practice Compendium". See Section 7 for further information.

1. Executive Summary

1.1 Scope

Each section of this document reflects the sequence of creating, operating and maintaining a transit system. Transit systems, no matter what the mode, have basic components that vary slightly among transit service providers, and consist of the following four elements:

System route and transit mode/node

- Rail transit operates on track right-of-way (guideway) and fixed station site properties.
- Bus transit uses shared or dedicated roadways and stops.
- Ferry transit has routes across designated waterway and accesses terminal ports.

Infrastructure and facilities

- Rail transit's track and right-of-way requires civil/structural, power and communication systems, as well as revenue and nonrevenue facilities supporting transit operations.
- Bus transit uses shared or dedicated roadways or guideways and has its own communication system, as well as revenue and nonrevenue facilities supporting transit operations.
- Ferry transit has its own and shared communication systems, and revenue and nonrevenue facilities supporting transit operations.

Rolling stock and fleet

- Rail transit has trains (assemblies of rail cars) for revenue service and a significant amount of nonrevenue rail and rubber-tire vehicles supporting maintenance and operations. Heavy rail also has locomotives.
- Bus transit has buses as well as supporting vehicles.
- Ferry transit has boats or vessels.

Operations and Maintenance

- The unique operating attribute of a transit system is the combination of operating moving parts (fleet), stationary parts (infrastructure and facilities), and the interaction of the two. To effectively develop the practice of sustainability, transit agencies have unique challenges to integrate and optimize holistic operation and maintenance of fleet, infrastructure and other facilities.

1.2 Sustainability indicators for transit industry

Planning, designing, constructing, and operating a transit system have direct and lasting impact to livability, environmental quality, and economical prosperity of a community. A sustainable transit system should be an agent for stimulating the economy, preserving environmental quality, and enhancing social equality. With its power of moving people safely, connecting destinations, , and keeping neighborhoods pleasant, a sustainable transit system should bring about favorable outcomes to its community with respect to the following five sustainability indicators for the transit industry.

- **Smart land use and livable neighborhood.** The impacts of transit agencies' planning, development and operations policies and programs to local and regional land use, mobility and placemaking.
- **Materials and construction/operations optimization.** Material selection, construction and fabrication of transit system physical components. Also includes policies and programs that promote sustainable operations, as well as materials and products used in operations, such as cleaning products and chemicals.
- **Energy and resources efficiency.** Power, fuel and water consumption. Includes opportunities for energy efficiency and renewable energy.

- **Quality of ambient environment and health.** Positive riding experience, system cleanliness, sense of safety and security, ambience, placemaking, as well as easy access and navigation.
- **Emissions and pollution control.** Emissions and discharges related to fuel, chemical use, solid waste management, wastewater, stormwater and other sources of pollution.

1.3 Sustainability as a business strategy

These five indicators are applicable to the elements discussed above. The matrix in Table 1 conceptualizes scale of opportunities for implementing each of the five sustainability indicators in each of the four transit elements. The scale provides an indication that each of the transit elements has its unique potential to maximize opportunities for implementing sustainability that can be measured within the five sustainability indicators.

TABLE 1
Opportunity for Implementing Sustainability Measures

		Transit Element			
		System Route, Transit Mode and Node (Section 2)	Infrastructure and Facilities (Section 3)	Rolling Stock/Fleet (Section 4)	Operations and Maintenance (Section 5)
Sustainability Indicator	Smart land use and livable neighborhood	***	**	**	*
	Materials and construction/operations optimization	*	***	***	***
	Energy and resource efficiency	**	**	**	**
	Quality of ambient environment and health	***	***	***	***
	Emissions and pollution control	*	**	**	***

Implementation opportunity: * Less, ** More, ***Most.

Leadership for sustainable transit business practices

- Practicing sustainability within transit agencies is about departing from “business as usual”. It is about respect for the environment, sensitivity to community needs, and optimizing available resources within transit agency business.
- Describing the attributes and background that would make up an excellent sustainability lead within a transit agency is difficult. The background of this lead may be engineering, architecture, planning, operations, or maintenance. Regardless of how an individual’s career has evolved, the lead should be a professional capable of taking a holistic approach to a wide range of business issues.
- Section 5.2.1 addresses policies, programs and organizational management.

2. System route, transit mode and node

The physical siting and the alignment of public transportation routes have a profound impact on urban growth patterns and sustainability potential, more so than any other aspect of transit design. The following guidelines address transportation planning as community building through attention to context.

There are many complex interfaces involved in transit system planning: transit users, transit operators, planning agencies, property owners and numerous government agencies and community jurisdictions. A framework for the co-development of transit and land-use planning will promote compact development patterns, encourage transportation choices and optimize public interest and investment in the transit line. Furthermore, planning for access and connectivity among all transportation modes, including bicycling and walking, will promote transit as a viable alternative to automobile use.

There are also multiple public health considerations related to system route, transit mode and node. Safety and physical activity associated with accessing transit can enhance public health, both physical and mental.

These guidelines are aimed at optimizing urban vitality through integrating the transit design and land-use planning processes. Transit-oriented development concepts and partnering with local agencies and governments are critical. This integrated, process-oriented approach also introduces performance measures for evaluation criteria established under the FTA “New Starts” program.

2.1 Smart land use and livable neighborhood

2.1.1 Partner with planning agencies to create transit-supportive land-use policies

1. Integrate transport and land-use decision making in all project development.
2. Participate in region-wide sustainability planning.
3. Develop, in conjunction with the relevant metropolitan planning organization (MPO) or other regional planning organization, an integrated transit/land-use plan to reduce the acres of developed land per capita in each community and thereby reduce VMT.
4. During station location planning, assess the built-form conditions, including ownership and assembly patterns, future growth scenarios and physical impact of alignment on property development.
5. Coordinate with municipal planning staff to audit existing land-use codes and develop station area plans to ensure compliance with the “Five D’s”: density, design, diversity, distance to transit and destination connectivity.
6. Set measurable indicators within the catchment area to influence station performance, such as mode split, density and people per acre for commercial enterprise.
7. Adopt urban design standards for transit agency development that promote community identity. Standards should mitigate the effects of large-scale infrastructure through implementation or encouragement of some or all of the following:
 - development at a human scale
 - appropriate community amenities
 - distinctive identity features such as historic patterns and buildings
 - appropriate cultural context
 - seamless connections to the surrounding neighborhoods
8. Incorporate adaptive reuse of historic structures.
9. Carefully consider location of ancillary buildings, such as substations, maintenance facilities, etc., in terms of both operational efficiency and urban context.
10. Internal transit agency land-use policy should provide protocols for private-sector engagement with strategies for partnerships, demonstration and/or catalyst projects to spur desired uses.
11. Mitigate the effects of large-scale infrastructure by including incentives for development at a human scale:
 - support of green building practice
 - provision of high-quality and distinctive identity features
 - support for seamless and integrated connections to the surrounding neighborhoods
12. Identify short- and long-term impacts to adjacent land uses along alignment.
13. Use and adapt brownfield sites, underutilized sites and existing rail alignments.

14. Participate in station or transit node area land-use decisions by working with city/community planning, economic development, transportation officials and relevant stakeholders. Engage in early dialogue in land-use policy and planning to align interests, goals and opportunities.

2.1.2 Promote partnerships for transit-oriented development

1. Work with jurisdictional partners to identify a set of transit nodes appropriate for focused capital and infrastructure improvements.
2. Prioritize station-siting options that encourage development of residual lands, high trip generating land uses and provide future flexibility.
3. Develop a framework to engage members of the local and/or national development community to proactively steer future development toward station and transit node sites.
4. Demonstrate leadership by seeking regulatory assistance or providing financial assistance for initial transit-oriented development projects to catalyze market growth.
5. Where opportunity for new community development exists, integrate appropriate mode of mobility with land use and community development.

2.1.3 Make livable neighborhoods a centerpiece of system planning

1. Prioritize alignment and station-siting options that will encourage appropriate future high density and transit compatible development, create place and catalyze market growth in accordance with overall regional plan.
2. Promote infill development to encourage more compact and walkable urban environments.
3. Make transit stations and associated infrastructure public destination points in their own right, by understanding user needs to ensure that transit architecture can act as a catalyst for the surrounding environment.
4. Promote adjacent multifaceted land uses that encourage transit use across a variety of times (peak period, mid day, nighttime, weekend) so as to encourage “round the clock” activity in and near transit stations.
5. Provide easy access from transit to dining, shopping, landmarks, special attractions, unique neighborhoods and everyday services.
6. Connect transit stations and stops to adjacent communities with pathways which are accessible to individuals with disabilities. Improve existing pathways for better access.
7. Use universal design and good wayfinding to make public transport easy to use for all users.
8. Design public spaces along the systems to encourage social interaction.
9. Fund transit projects to include improvements beyond the footprint or ROW of the transit agency to ensure pedestrian connections within the local jurisdiction’s ROW.

2.1.4 Integrate transit alignments and nodes into neighborhoods through use of appropriate scale

1. Ensure that transit is just one part of the overall public experience by using the scale of transit to fit the grain that exists or is desired.
2. Lower-capacity systems (such as streetcar and bus systems) may be integrated directly into dense, pedestrian-oriented town centers making use of urban rights-of-way.
3. The faster and greater the capacity of the transit system, the more it should be considered adjacent to, rather than at the center of, pedestrian-oriented spaces.

2.1.5 Encourage intermodal connections and transfers, including non-motorized access

1. Plan for and optimize non-motorized access to transit nodes by integrating traffic, pedestrians, bicycling and various forms of transit into a single comprehensive plan.

2. Analyze transportation coordination on a range of scales from neighborhood, corridor and regional planning.
3. Develop performance-based transit node access strategies and design stations with special attention to a walkable urban design context.
4. Develop bike and pedestrian paths along transit alignments.
5. Establish a strong collaboration with the relevant MPO to exert influence on achieving more sustainable modal splits in each area of service.

2.1.6 Optimize parking and reduce long-term automobile dependence

1. Use market analysis and education to encourage creative parking strategies, such as separating the purchase of parking spaces from residential units near transit, shared parking between residential and commercial development, and reducing the need for overall vehicle ownership through agency support of car-sharing organizations.
2. Where necessary, plan station and transit node areas to give private vehicles lower on-street priority than pedestrians in order to optimize transit and pedestrian flow, scale and quality of experience.
3. Where parking is required to ensure ridership numbers are met, develop strategies to replace parking over a mandated time period with high-density development, while ensuring original ridership numbers are maintained.
4. When parking is provided, consider building parking structures and developing remaining surplus land in higher-intensity uses. Ensure that station and transit node parking includes alternatives such as vanpool, carpool and compact spaces.
5. Establish an eco-parking program to provide for priority parking for electric vehicles, high occupant vehicles, car share programs, and similar uses.
6. Understand and make use of best practices in transportation demand management and price parking fees to make bus, bicycle and pedestrian access to stations and transit nodes more attractive.
7. Include bike-parking as part of agency-wide parking programs to further the recognition that bicycling is a legitimate mode of access to transit systems. Make bike parking covered, safe, and secure.
8. Design parking areas and structures to minimize heat island effect.

2.1.7 Engage stakeholders early on in the design and integration process

1. Establish a comprehensive stakeholder engagement process for all new projects.
2. Provide a framework for public input to address the urban design quality of the station/alignment and contribute to area placemaking.
3. Engage local groups including community development and housing advocacy groups to co-lead planning of station and transit node areas.
4. Ensure that the stakeholder group is broad and inclusive: municipalities, the people with disabilities community, seniors, cyclists, pedestrians, cultural groups, business owners, public interest groups, etc.
5. Address infrastructure's impact on neighboring buildings early via community public outreach.

2.2 Energy and resource efficiency

These guidelines are aimed at leveraging alignment and route planning to minimize the overall energy consumption of the transit system.

2.2.1 Consider energy consumption in mode choice

1. Evaluate energy consumption and overall life-cycle costs when selecting a transit mode for a planned alignment. Weigh initial capital cost against cost/energy use of ongoing operations over the planned service life of the system. Consider future trends in energy prices and types of fuel.

2. As a part of early project feasibility assessments, calculate the efficiency of the proposed route in terms of speed and energy consumption.

2.2.2 Design alignment to optimize energy use

1. Identify opportunities to optimize energy use through fundamental decisions about routing, alignment and track engineering.
2. Seek out and leverage the specific opportunities for energy optimization based on the climate/geographic condition of the transit system.

2.2.3 Develop partnerships for renewable energy

1. Partner with utility companies, the state or provincial department of energy, “energy trusts” and private energy providers in the transmission and distributed generation of electricity.
2. Consider whether the transit system’s right-of-way has opportunities for alternative energy generation, such as solar or wind.
3. Investigate other renewable energy sources, including geothermal/ground source heating or cooling and cogeneration.

2.3 Quality of ambient environment and health

These guidelines are aimed at improving overall public health through appropriate transit planning and advocacy.

2.3.1 Promote healthy modes of transportation

1. Design and locate stations/terminals/stops to promote environmentally friendly and health-promoting modes of transport, such as walking and bicycling.
2. Work with municipalities to provide pedestrian- and bike-friendly routes, including good visibility, separation from high-speed vehicular traffic, separation from pollution sources (such as truck routes), and shade where appropriate. Connect pedestrian and bike paths and routes to transit stations or transit nodes.

2.4 Emissions and pollution control

These guidelines are aimed at controlling emissions and pollution generated by transit systems while improving their performance, and at reducing potential emissions and pollution by others through increasing ridership of efficient transit service.

2.4.1 Evaluate long-term impact of modal choices

2.4.2 Design to minimize noise and vibration

1. When possible, utilize grade-separated solutions, thereby maximizing speed, efficiency and capacity of the transit system.
2. When possible, utilize grade-separate transit alignments, in order to reduce impacts of transit at the pedestrian level. Grade separation will also permit the more efficient flow of transit, automobile, truck and other transit and rail traffic, potentially reducing emissions due to unnecessary idling and more optimal travel speeds.
3. Where grade separation is not possible, choose routes to optimize both ridership and travel time. Shifting a route by a block or two may have a large effect on both.
4. Optimize frequency and location of bus stops to minimize impact of noise and emissions at street level.
5. Consider underground alignment as one means of helping to control noise and vibration near sensitive land uses such as hospitals and residences.

3. Infrastructure and facilities

This section includes guidelines for planning, design and construction of all physical elements (excluding fleet). Stations, transit nodes, terminals, supporting facilities and systems, and corridors are addressed.

“Green buildings make efficient and effective use of resources — energy, water, raw materials, and land — and provide a healthy environment for working, learning, and living. By applying green building practices to new construction and refurbishment of existing facilities, transit agencies can conserve resources through lower construction, operations, and maintenance expenditures.” — Federal Transit Administration

FTA, in its Transit Green Building Action Plan, published in July 2009, identifies several green-building rating and analysis systems that provide trusted framework for planning and execution of sustainable rehabilitation and construction: USGBC LEED™, UK BREEAM, Green Building Initiative’s Green Globes, U.S. DOE and EPA’s Energy Star, and ASHRAE. Integrated design of facilities and infrastructure shall follow the core concepts and principles as well as strategies outlined in the existing green building rating systems as applicable.

3.1 Smart land use and livable neighborhoods

3.1.1 Integrate transit facilities with neighborhood design along system route

1. Design transit stations and facilities in aesthetic, historic and functional accord with the surrounding community. Where applicable, conduct a community outreach workshop to engage the neighborhood.
2. Provide safe patron seating areas, weather protection, information, route maps and directional signage to promote connectivity between transit modes and transit operators.
3. Provide covered, safe, and secure bicycle parking including bike racks and bike lockers.
4. Provide for bike repair and rental businesses.
5. Design trackways as greenways to improve the environment and to reduce noise and heat island effects.
6. Size stations appropriately. When smaller facilities are sufficient, resources including energy will be saved during both construction and operation. Where appropriate, design for future expansion.

3.2 Materials and construction/operations optimization

These guidelines are aimed at improving the sustainability of material elements unique to transit infrastructure and facilities. Materials traditionally considered environmentally preferable are not always best for transit systems. However, green building rating systems reference numerous sources for material selection that achieve both environmental and performance objectives.

3.2.1 Design for service life, durability and flexibility

1. Select materials with environmentally and economically superior service lives when designing core infrastructure.
2. Aim to avoid materials with suspected negative environmental health effects likely to be regulated within their service life. (An example of a preferred material characteristic is “low VOC” by USGBC definition).
3. Design for flexibility, including system expansion, increases in ridership and alternative uses of supporting facilities.
4. Ensure that materials used in the construction of transit structures are scaled and detailed appropriately for urban communities. For example, they should be detailed for weather resistance, provide visual interest at the pedestrian level and permit the passage of light.

3.2.2 Design for material applicability and low maintenance

1. Ensure quality of experience for the transit user by investing in the correct materials to suit the transit mode application.
2. Choose materials that are easily maintainable but high quality for customers for transit stations, transit nodes, terminals, stops and supporting facilities. Ensure that materials used in the construction of transit structures are long lasting and easily maintained to maintain functionality and the visual quality of the urban environment.
3. Avoid materials with complicated repair, removal and disposal requirements for health and safety, air quality, waste management, and cost reasons.

3.2.3 Select materials with low embodied energy (i.e., local, recycled, recyclable)

1. Incorporate recycled materials into transit projects as long as transit-specific requirements are also met: longevity, durability, low-maintenance, etc. Favor post-consumer recycled content.
2. Favor materials that can be further reused within transportation system or recycled at the end of their useful life within the transportation system.
3. Favor materials that require minimal energy to produce.
4. Favor materials that do not involve excessive transportation at any stage of their lifecycle (i.e., “local” materials by USGBC definition).
5. Favor component materials that are able to quickly regenerate (i.e., “rapidly renewable” materials by USGBC definition).
6. Engage in a local material exchange program (such as WasteMatch).

3.2.4 Incorporate innovative sustainable construction practices

1. Refer to applicable green-building rating system strategies and documentation for sustainable construction methodologies.
2. Develop a checklist of construction practices that are environmentally friendly and can be utilized during various project phases.
3. Maximize use of existing infrastructure, facilities and components.
4. Seek local feedback from construction organizations and local construction firms.
5. Incorporate prefabricated components, both unique to transit and generally available.
6. Obtain information on local regulations to clarify opportunities for innovative construction practices.
7. When excavating, explore opportunities to utilize excavated materials on-site instead of hauling them away.

3.3 Energy and resource efficiency

These guidelines are aimed at improving the energy efficiency of infrastructure and facilities that are unique to transit. Where appropriate, the guidelines address specific modes, including bus and rail.

To lower the energy consumption and carbon footprint of infrastructure and facilities, the following groups of methods should be explored for applicability and feasibility at the design phase of all new construction and rehabilitation projects: energy harvesting, energy conservation and recovery, energy efficiency, and on-site generation (to avoid transmission losses and/or provide renewable energy). Water efficiency measures found in Section 3.5 also contribute to energy and resource efficiency. Green-building rating systems can provide a good framework for achieving and measuring of energy efficiency endeavors.

3.3.1 Energy harvesting

1. Plan facilities to reduce energy consumption during the design phase, as the size and placement of station facilities also affects energy consumption.
2. Consider alignment design with humped track at stations to aid acceleration and deceleration.

3. Orient and design aboveground facilities to take advantage of prevailing winds and maximize the use of natural ventilation to replace or augment mechanical ventilation.
4. Orient and design aboveground facilities to maximize the use of natural lighting to replace or augment electrical lighting with the help of photo sensors. Consider tubular daylighting delivery into underground spaces.
5. Consider incorporating solar thermal systems to replace or augment fuel-based space and water heating.
6. Consider incorporating passive solar systems to replace or augment fuel-based space heating (e.g., SolarWall technology).
7. Consider incorporating ground-source heat pump systems to replace or augment fuel-based space heating and cooling.

3.3.2 Energy conservation and recovery

1. Use heat recovery units (also known as energy recovery ventilators) to provide heating and cooling.
2. Design fenestration and shading to avoid unwanted solar gain (by using low-emissivity glass or external light shelves).
3. Design facilities with increased wall and roof insulation, including vegetative roofs.
4. Use motion sensors to minimize idle lighting.
5. Use air-quality sensors and variable-frequency ventilators to adjust air exchange.
6. Use rapid roll-up doors to minimize losses of conditioned air in maintenance and repair facilities.
7. Consider process heat recovery for domestic hot water.
8. Incorporate light and temperature controls at facilities' offices.
9. Minimize right-of-way electrical transmission losses through optimized substation spacing.
10. Minimize right-of-way transmission losses through use of a better conductive material for contact rail or catenaries (e.g., aluminum/aluminum composite third rail).
11. Employ regenerative braking systems on trains and buses to capture energy from braking vehicles and feed it back into the power distribution system for use by adjacent trains or to charge batteries on buses. Alternatively, regenerated power can be stored in wayside storage systems.

3.3.3 Energy efficiency

1. Use premium-efficiency motors and other equipment.
2. Design for efficient lighting (lumens per watt), as well as task lighting.
3. Consider the use of small-scale photovoltaic systems (with or without inverter) for signage, emergency phones, canopy lighting, closed circuit systems, microwave transmitters and other applications to power small-load equipment.
4. Incorporate intelligent control systems for new electrical meters to permit measurement of electricity consumed and to promote conservation efforts.
5. Install permanent carbon dioxide monitoring systems that provide feedback on space ventilation performance in a form that affords operational adjustments and energy savings.

3.3.4 On-site generation

1. Consider integrating a photovoltaic system to provide electrical power for all or some loads.
2. Consider integrating wind turbines to provide electrical power for all or some loads.
3. Consider integrating co-generation equipment to provide electrical power and heat for all or some demand.
4. Consider integrating fuel cells to provide electrical power for all or some loads, as well as some heat for domestic uses.

3.3.5 Consider innovative approaches to energy usage

1. Utilize electric vehicle connections at stations. Charge cars during off-peak hours.
2. Develop contracts to promote improved energy consumption through cost sharing of demonstrated improvements through innovation.

3.3.6 Partner with local power utility

1. Ensure early dialogue with the local utility when exploring new approaches to energy efficiency, production and purchasing. Review scope of work with the utility and potential impacts, including challenges and benefits. Establish a general understanding of the extent of utility impact. Get support from the utility.
2. Leverage the utility's expertise in energy production to produce and/or purchase renewable energy.
3. Leverage the transit agency's long-term facility ownership.
4. Utilize energy efficiency and renewable energy pilot projects to study the effectiveness of possible improvements. Select projects that fit transit capital goals, funding and budgets.

3.4 Quality of ambient environment and health

These guidelines are aimed at creating a positive and healthy ambient environment within transit facilities and along transit corridors in order to attract and maintain riders. The ambient environment is considered in three tiers: comfort, health and safety.

3.4.1 Enhance security and safety (friendly, safe and secure for all demographics)

1. Implement crime prevention through environmental design (CPTED, pronounced "sep-ted"): a low-tech strategy that encourages people on the street and in neighborhoods to look out for one another. The following three principles are aimed at reducing fear and incidence of crime and maintaining quality of life:
 - **Natural surveillance:** Create an environment that encourages people to observe the spaces around them. Maximize visibility and views of streets and neighborhoods.
 - **Natural access control:** Use strategic placement of entrances, exits, fencing, lighting and landscaping to control or limit access. Limit access and increase natural surveillance to either keep criminal intruders out or make them more easily marked as intruders.
 - **Natural territorial reinforcement:** Design the environment to clearly delineate private space, in order to create a sense of ownership among neighborhood residents. Design and siting of buildings, fencing, pavement, signs, lighting and landscape elements can express ownership while defining public, semi-public and private spaces.
2. Use visible crime prevention elements, such as posting information on security cameras and providing ample and accessible phones.
3. Partner with the community to achieve safe walking and biking routes to transit. Achieve high-quality streetscapes with wide walkways that encourage community use (walking, biking, wheelchairs, etc.).
4. Incorporate safe bicycle storage.
5. Develop security plans for transit systems. Integrate design, technology and operations into security plans early in the planning and budgeting stages.
6. Particularly in regard to anti-terrorist measures, employ transparent security, invisible to the public eye, to further enhance the sense of openness within transit public spaces (see also number 9). However, there are locations and times when public officials require a show of security and force, based on potential threats, activities, tips and public events. Transit systems planning should allow for the flexibility to increase or reduce security levels and activities.
7. Provide good, even lighting throughout publicly accessible spaces to serve as a deterrent to crime. In addition, during an emergency, the public should be able to readily identify exits in order to leave stations and buildings quickly and directly.

8. Clearly mark emergency signage. The numbers, locations and widths of the exits should be planned to allow peak loads of people to exit in a short time.
9. Mitigate the impact of vehicular threats and help protect people and facilities from potential damage in a blast through providing such measures as setbacks from the street and bollards, planters, barriers, benches, and other street furniture engineered to resist vehicles.
10. Design acoustical environment to allow travelers to hear public address announcements on the platforms and help control excess noise and vibration.

3.4.2 Provide inviting spaces

1. Public spaces should be clean and free of litter, unpleasant odors and graffiti.
2. Lighting levels and fixtures should be functional and aesthetic, to provide good visibility and additional security. Consideration should be given to daylighting regularly occupied spaces. See also Section 3.3.1, guideline 4.
3. Public amenities can include shops, telephones, benches and safe, clean toilet facilities.
4. Use landscaping and hardscaping (such as paving and retaining walls) to make spaces pleasant.
5. Overhead aerial structures, vents, tunnels and other elements should be designed collaboratively between architects and engineers to blend aesthetics with essential technical criteria.
6. Design spaces and provide openings to visually connect the indoor environment with outdoor spaces.
7. Integrate art within and around public transportation facilities to complement the design of stations and transit infrastructure.
8. Further enhance the experience of the public ridership with the integration of entertainment at appropriate spaces. Acoustics and pedestrian flows must be considered. Create possibilities for local entertainers to enhance the experience of their neighbors while gaining exposure.
9. Leverage opportunities to aesthetically enhance necessary and functional architectural and structural spaces and elements; consider color, texture and rhythm of elements.
10. Reflect the history and cultural diversity of station and transit node locations, linking the transit system to communities.
11. Consider integrating literature into the transit experience. Integrate renowned or obscure poetry at waiting areas or on trains, enhancing the riders' experience.

3.4.3 Provide a comfortable experience

1. Maintain thermal comfort. Provide wind breaks, where needed.
2. Design stations/transit nodes/stops/terminals to protect riders from weather conditions (wind, rain, snow, sun and extreme heat and cold).
3. Design and provide high-quality amenities at all transit stations and stops (such as sidewalks, seating and lighting), including design for safety and security.
4. Ensure that all facilities are well designed and well maintained to promote cleanliness and comfort.
5. Provide high-quality customer information, both electronically (including next-bus or next-train information) and (at facilities) through staff and stationary signage, to ensure that riders know of transit services, general information, and rapid and accurate information on service disruptions.
6. Implement single card fares, where practical.

3.4.4 Implement high-quality wayfinding systems (where and when)

1. Identify stations and hubs with signage such that the public (pedestrians, bicyclists, private automobile users and transit riders) recognizes station and hub locations. Use operator logo and particular colors to identify various transit services or routes.
2. Within each station, transit node and hub, provide wayfinding signage consisting of directional signage and maps to train platforms, bus stops, shuttle stops, ferry docks, taxi stands, bicycle routes and pedestrian routes.

3. Identify specific platforms and stops with operator logos and route designations (colors, numbers and letters) and destination names.
4. Within each station/transit node/hub, include wayfinding signage and maps directing customers out to nearby streets, attractions and landmarks.
5. Provide real-time transit information letting customers know exactly when to expect their next bus or train. This should be provided with real-time electronic displays outside and throughout each station, transit node or hub, and on the Internet.
6. Provide regional transit information by phone, Internet and via takeaway brochures and maps.
7. Clearly communicate fares and schedules.
8. Make wayfinding simple and intuitive — easy to understand, regardless of the user's experience, knowledge, language skills, abilities or disabilities or current concentration level.
9. Provide information on local points of interest, restaurants and shops. Consider marketing cultural events, sporting activities and local attractions through visual elements within and around transit systems. Posters, signage and electronic billboards can provide opportunities for informing riders about local activities.
10. Efficiently design transit facilities so that communication, ticketing, signage, etc. are centrally located to reduce maintenance required to support these various elements.
11. Information should be presented in a consistent manner among transit systems to aid customers' understanding.

3.5 Emissions and pollution control

These guidelines are aimed at proactively reducing the potential contribution of transit systems infrastructure and facilities to air and water pollution beyond current regulatory requirements. Methods to reduce air emissions, wastewater discharges, hazardous waste and pollution in general are presented. The guidelines also discuss greenhouse gas emissions, water conservation and waste minimization.

3.5.1 Mitigate contaminated areas and brownfields

1. Favor construction of new facilities and infrastructure on previously developed land, including land contaminated with hazardous waste or pollution (brownfields), thus providing an opportunity to restore degraded urban land while promoting infill and reducing sprawl.

3.5.2 Control hazardous materials, water effluent and air pollution

1. Eliminate existing and reduce the use of new known and suspected hazardous materials in transit stations, transit nodes, terminals, stops and supporting facilities (see Section 3.2).
2. Design facilities to minimize mold and mildew growth through material selection, insulation design and indoor environmental quality control (ventilation, temperature, humidity).
3. Clean tunnels for improved air quality (AQ).
4. Take steps during construction to protect indoor air quality. For example, develop and implement an indoor air quality (IAQ) management plan for the construction and pre-occupancy phases of facilities.
5. Take steps during construction to protect the surrounding ecosystem and community. For example, develop and implement a construction activity pollution prevention plan to mitigate soil erosion, control sedimentation, protect streams and ecologically sensitive areas, reduce noise and dust exposure, and prevent off-gassing of volatile compounds.

3.5.3 Design for water efficiency and reuse

1. Utilize water-efficient plumbing fixtures.
2. Minimize vehicle washer water waste.
3. Reclaim and treat wastewater from the car-washing system for reuse within the washer.
4. Neutralize effluents from the car-washing system before they are directed to city sewers.

5. Design and operate water-efficient irrigation systems. Make plant selections in accordance with water conservation principles.
6. Promote natural infiltration of water back into ground in order to filter contaminants, help prevent water pollution, recharge the aquifer and slow down stormwater runoff.
7. Design the project site to maintain natural stormwater flows by promoting infiltration.
8. Use stormwater management techniques such as pervious pavements, bioretention basins (rain gardens), vegetated roof treatments, and landscaped areas.
9. Collect stormwater for nonpotable uses such as landscape irrigation, toilet and urinal flushing and platform and station washing and other custodial uses.
10. Provide an oil/water separator system, bioswale or similar mechanism to intercept runoff from parking facilities and to filter contaminants.

3.5.4 Establish greenhouse gas monitoring on facilities

1. Establish a baseline of greenhouse gas emissions of facility and infrastructure use.
2. Monitor energy use in all forms (electricity, fuel, natural gas) as well as industrial use of gases with high global warming potential (including refrigerants).

3.5.5 Implement waste management and recycling procedures (other guidelines and standards)

1. Set a target for construction and demolition debris diversion from landfill through on-site and off-site reuse and/or recycling.
2. Use recycling of certain materials as a source of revenue.
3. Include containers for recyclables at stations, station sites, transit nodes and other facilities, and establish a robust post-collection recycling program.
4. Consider requiring concessionaires to eliminate non-compostable and non-recyclable items (e.g., eliminate plastic bags).
5. Consider use of compostable food packaging and flatware in the facilities' food service.
6. Minimize packaging of all incoming commodities.

4. Rolling stock/fleet

This section provides guidelines for improving the sustainability of elements unique to the transit vehicle fleet. Recommendations are relevant to planning, procurement, design, construction and operation of fleet. For the purposes of these guidelines, the term “fleet” includes the following:

- **Rubber-tired buses**, including various types of propulsion systems, such as diesel, diesel hybrid, hydrogen fuel cell, compressed natural gas (CNG) and electricity.
- **Rail vehicles**, including heavy and light rail, as well as streetcars and self-propelled railcars.
- **Nonrevenue vehicles** used by transit staff and contractors to support the transit service.

These guidelines are intended to integrate vehicle design with environmental principles in order to reduce the impacts over the vehicle life cycle. This would result in effectively implementing pollution prevention and creating savings over the vehicle life cycle by optimizing energy use and concurrently reducing emissions. These steps promote a positive rider experience and therefore encourage higher ridership and utilization of transit alternatives. The recommendations seek to provide ecological protection while maintaining stable economic conditions for the transit agency. Benefits include savings and revenue from improved environmental performance, enhanced environmental compliance; pollution prevention and resource conservation, more customers and markets, increased efficiency, reduced costs, enhanced employee morale, improved image with the public, and greater employee awareness of environmental issues and responsibilities. Innovations in industrial ecology are encouraged. Engineering tools for estimating costs and

ramifications of sustainable development must be developed, tested and evaluated. Processes and formulas must be developed to measure and report energy used per passenger mile traveled and passenger capacity per system mile available.

4.1 Smart land use and livable neighborhood

These guidelines are aimed at optimizing transit system planning, land use and site configuration to reduce vehicle operational carbon footprint and enhance livable neighborhood measures.

4.1.1 Consider vehicle choice in system planning

1. Consider modal integration, context-sensitive designs, correctly sizing the vehicles and frequency of service.
2. Match the size and speed of the fleet to the neighborhood being served.
3. Match the type of fleet to the neighborhood being served where possible. Fleets may be comprised of a variety of vehicles to suit varying local operating conditions and size of ridership.

4.1.2 Design vehicle and fleet capacities to match transit network size

1. Consider use of smaller buses on low-volume routes
2. Consider use of a streetcar circulator to start or connect to a light rail system.
3. Consider intercity rail service using self-propelled diesel multiple unit (DMU) vehicles.
4. Consider use of articulated buses for heavily traveled standard bus routes.
5. Consider a modified seating layout to allow more standees and/or bicycles.
6. Consider optimizing seat spacing on railcar designs to maximize seating capacity.
7. Consider using exclusive/dedicated bus rapid transit (BRT) lanes and optimizing station spacing to emulate light rail vehicle (LRV) service.

4.1.3 Design vehicle with neighborhood and geography in mind

1. Develop a neighborhood circulator bus or streetcar to link with rail service.
2. Utilize historic streetcars to brand specialized service where appropriate.
3. Utilize historic streetcars or other vehicles to recall the nature of historic boulevards, such as Market Street in San Francisco.
4. Use electric trolley buses in areas with street grades of more than 15 percent.
5. Utilize geographic landmarks, such as the San Antonio River Walk Streetcar.
6. Consider wireless power distribution to eliminate power distribution infrastructure from cluttering the landscape.
7. Use retro designs on new stations and guideways to recall historic times, such as the Embarcadero “E” line in San Francisco or using historic neon signs at stations, such as on the BRT system in Las Vegas.

4.2 Materials and construction/operations optimization

These guidelines are aimed at improving the sustainability of materials unique to transit. The long-term viability of these materials is critical for the sustainability of transit fleet. Manufacturing and maintenance processes should take a holistic approach to green engineering for transit fleets. The guidelines include consideration for the advancements in computer applications and modeling methods such as life-cycle assessment, materials flow analysis, input/output economic models and other novel metrics for measuring sustainable systems. Understanding materials flow and taking advantage of such understanding to substitute less toxic, longer-lived materials are important to enhanced sustainability. The effects of appropriate substituted materials on waste streams should be considered.

4.2.1 Incorporate environmentally preferable materials

1. Specify which environmental attributes are important — recyclability, weight, chemical safety, carbon footprint, etc. — and prioritize among them.
2. Consider the use of ultra-capacitors in conjunction with batteries to reduce the load on the batteries, extend their life and reduce waste.
3. Encourage the development of improved electronics and battery materials.
4. Specify the use of lightweight materials including plastics, composites, aluminum and other materials. Consider offering weight-saving incentives in the procurement contract.
5. Specify improved glazing materials and proper choice of exterior colors to reduce heat losses and to reduce undesirable heat gain.
6. Specify materials that are durable, easy to maintain/clean and resistant to graffiti.
7. Use improved insulation and sound-deadening materials to reduce thermal losses and lower noise levels.
8. Utilize environmentally acceptable refrigerant (in accordance with the Montreal Protocol) in vehicle heating, ventilation and air conditioning (HVAC) units.
9. Apply low-VOC and water-based adhesives and coatings to reduce harmful emissions.
10. Consider flooring and other finishes selected with environmental friendliness as well as durability in mind (refer to LEED system for typical selection criteria).
11. Utilize multiplexing in electrical systems to reduce wiring, which will reduce copper usage and vehicle weight.
12. Consider requesting a life-cycle assessment as part of vehicle design and procurement to be supplied according to ISO 14000. This assessment compares the relative importance of environmental impacts during production, operation and disposal.
13. Consider establishing a complete list of chemicals to be prohibited or restricted in vehicle production. The list should include a CAS identification number for each chemical.
14. Use LED lighting to reduce energy consumption and give a long life.

4.2.2 Consider bus-specific preferred materials

1. Specify designs that minimize welding and allow for body panel replacement without using welding or fiberglass.

4.2.3 Consider rail-specific vehicle design and preferred materials

1. Consider using an electric locomotive if ridership on passenger rail can justify the expense, such as is done on the Amtrak Northeast Corridor.
2. Consider using locomotives powered by alternative fuels, such as LNG or fuel cells.
3. Utilize rail lubricators to reduce wheel/rail friction and improve fuel efficiency.
4. Consider recyclability of rail car materials during design.

4.3 Energy and resource efficiency

These guidelines are aimed at improving the sustainability of energy elements unique to transit fleet. The long-term viability of these elements is critical for the sustainability of transit fleet manufacturing and maintenance processes, which should take a holistic approach to green engineering for transit fleets.

4.3.1 Integrate vehicle design and related systems

1. Conserve energy through innovative, more efficient, lighter-weight vehicles and component design. Use aluminum and lightweight composite materials to reduce vehicle weight.
2. Consider the use of alternative propulsion systems include adding photovoltaic electric, battery electric, flywheel generator, hybrid battery generator, fuel cell and regenerative electric drives or a gas turbine.

4.3.2 Consider alternate fuels and energy consumption

1. Utilize biodiesel fuel. It should be noted that the quality control of biodiesel fuel and what is used for feedstock to manufacture biodiesel fuel are critical elements to the successful use of this fuel. ASTM specifications for this fuel must be followed. These are available at www.astm.org.
2. Utilize diesel-electric hybrid buses.
3. Utilize all-electric and fuel-cell buses.
4. Measure and target reduced consumption of energy.

4.3.3 Consider operation during design

1. Conserve energy by utilizing electronic engine and transmission controls.
2. Conserve energy by utilizing hybrid bus designs. These designs incorporate steady-state operations and regenerative braking, which reduces energy consumption especially on routes with frequent stops.
3. Investigate developments in battery and hydrogen fuel cell bus technology.
4. The use of synthetic lubricants which will decrease the frequency of oil changes required, extend drivetrain life, and reduce maintenance costs and waste materials.
5. Developments in electronic technology allow for the use of modular and roof-mounted air conditioning and engine cooling systems. This results in less auxiliary load on the vehicle power plant, thus reducing energy consumption.
6. Conducting proper preventive maintenance on rolling stock which will increase fuel efficiency and reduce emissions.
7. Provide bus rapid transit, where feasible, saving energy and reducing emissions while improving service.
8. Utilize intelligent transportation and transit priority systems.
9. Consider automated train control systems that optimize acceleration and braking and minimize power/brake transitions. This saves on power required, thus conserving energy.
10. Specify innovative and efficient railcar designs that incorporate ideas such as lighter-weight wheels, fewer motors and lighter-weight HVAC systems. Lighter-weight train cars decrease the amount of energy required to operate.
11. Use railcars and buses equipped with regenerative braking systems to reduce energy consumption. Consider retrofitting fleets during a midlife overhaul.
12. Consider using a system that stores regenerated electricity in either a wayside or on-vehicle storage unit.

4.4 Quality of ambient environment and health

These guidelines are aimed at creating a positive, healthy ambient environment for riders on vehicles and vessels. When riding transit is enjoyable, people will be more likely to choose transit over other modes of transportation.

4.4.1 Design for pleasant riding

1. Transit vehicles should be clean and free of litter, unpleasant odors and graffiti.
2. Low-floor vehicles allow ease of passenger loading/unloading and can reduce dwell time.
3. Minimize noise and vibration.
4. Maintain thermal comfort.
5. Lighting levels should be specified to provide good visibility and additional security. Lighting fixtures should be functional and aesthetic.
6. Design spaces and provide openings to visually connect the indoor environment and outdoor spaces. Use large windows, and for underground travel consider using cameras filming the outdoor route with images displayed in vehicles.

7. Use universal design to improve experience for people with impaired mobility, vision or hearing.
8. Ensure that transit vehicles are well-designed and well-maintained with adequate passenger circulation, high-quality and well-maintained seating, good lighting and climate control, security cameras, good ride quality, bicycle and luggage storage facilities, and if possible an off-board fare collection system.
9. Provide excellent rider information; including maps, customer service bulletins and public address systems.
10. Provide modern amenities such as wireless technology for Internet access to provide maximum productivity for riders.

4.4.2 Enhance bus-specific riding experience

1. Branding and livery encourages a new attitude toward bus riding.
2. Create “train-like” and “specialized” bus designs to attract new riders.
3. Install a bike rack inside the bus to increase security.
4. Provide a rear-facing wheelchair position which is more easily operated by bus passengers who use wheelchairs.
5. Kneeling buses allow easier access for people with impaired mobility.

4.4.3 Enhance the rail-specific riding experience

1. Consider adding amenities such as power outlets for laptops and Wi-Fi (wireless wide area) Internet access.
2. Provide clear and interactive system maps and announcements of next stop.

4.5 Emissions and pollution control

These guidelines are aimed at reducing greenhouse gas air emissions and the transit fleet’s potential contribution to air pollution. When appropriate, the guidelines address specific modes, including bus and rail.

4.5.1 Measure and reduce greenhouse gas emissions from vehicle operation

1. Baseline GHG emissions should be measured so that emission levels after changes to vehicle operations can be measured for comparison. Many of the measures recommended and case studies cited for energy savings also reduce emissions and pollution.
2. Establish an in-house emissions monitoring system to track real time emissions of the entire vehicle fleet.

4.5.2 Reduce diesel use from fleet operation

1. Consider using renewable or alternative fuels. The appropriateness of various fuels depends on agency-specific conditions, such as weather, fuel availability and route type. Alternative fuels that may be appropriate for an agency’s fleet include bio-diesel, CNG, LNG, LPG, dual fuel (diesel and natural gas), Fischer-Tropsch, coal to liquids (CTL), gas to liquids (GTL), biomass to liquids (BTL), methanol and ethanol, hydrogen, and ultra-low-sulfur diesel.

5. Operations and maintenance

Once designed, constructed and commissioned, the transit operation commences. The environmental sustainability opportunities in the operation of a transit system are addressed in this section. These opportunities include operational efficiency, use of renewable energy, energy efficiency, pollution prevention, hazardous materials management, waste reduction and recycling, and responsible purchasing.

5.1 Smart land use and livable neighborhood

These guidelines allow a transit system to consider aspects of its operations and maintenance activities when planning new or updated features of the system, including facility configuration, land use and site design.

5.1.1 Consider livable neighborhood measures for service planning and scheduling

1. Work with stakeholders to expand programs for populations with few transportation options.
2. Support and partner with initiatives that promote public transit use.
3. Develop a service model that cross-links factors such as minimum frequency of service to maximum walking distances to the service in order to maximize ridership and customer service.
4. Coordinate with related transportation agencies, regional planning organizations and/or municipal divisions and develop a strategic approach to ongoing transportation planning, such as an overall “vision plan” across the various agency and departmental offices for individual projects.
5. Utilize public participation to build support for use and maintenance of transit. Utilize input from representatives of a broad cross-section of the community.
6. Ensure early, open dialogue with city/community officials and developers to create collaborative goals. Align interests with each party’s development goals, and agree on the scope of the transit sustainability initiatives.

5.1.2 Optimize type and siting of fueling and maintenance facilities

1. Evaluate the location of fueling sites for buses in relationship to the existing routes and new or modified routes during service planning in order to minimize deadhead distances and save fuel.

5.2 Materials and construction/operations optimization

These guidelines are aimed at specifying and using materials for maintenance in a way that applies concepts of life-cycle assessment, increased length of use, potential for reuse/recycle and reduction of toxins.

5.2.1 Policies, programs and organizational management

1. Make contracting with disadvantaged business enterprises (DBEs) part of the design and construction policy.
2. Put sustainability on the agenda of regular staff meetings.
3. Establish an employee recognition program for contributions to the organization’s sustainability efforts.
4. Put in place a sustainability hotline for employees and the general public.
5. Integrate sustainability into employee and contractor performance management.
6. Put in place a sustainable procurement policy and/or supply-chain policy that is based on comprehensive sustainability principles.
7. Become viewed as a sustainability leader in the community by playing an active role of partnering in established community programs.
8. Establish a chief sustainability officer or equivalent post within the transit agency or organization.
9. Establish a climate action plan for the agency including adaptation strategies addressing changes such as sea level rise.
10. Obtain “green business” certification of all corporate offices (where available).
11. Establish a policy to hold a regular and rigorous program of internal study/presentations into sustainable building and transit technologies.
12. Specifically target the business community to explain how transit can meet its needs. Highlight the potential competitive advantages of accessibility of the workforce and businesses to transit, including the following:
 - Reduced absenteeism due to transportation problems. Access to transit gives employees options in case of car trouble or traffic jams.

- Increases the attractiveness of a business to potential new hires, (money savings, stress reduction).
 - Added value to company facilities.
 - Reduced need to build or otherwise subsidize parking.
 - Opportunity to capture trade of transit users by locating businesses in convenient proximity to transit (i.e., within transit-oriented development).
 - Opportunity to target economic development entities to explain how transit is an advantage to a community's economic health by helping businesses in the ways mentioned above.
13. Create an internal marketing group or work with a private firm to develop a marketing strategy. Ensure that the public is getting sufficient information to make informed choices. Considering targeting youth to develop a habit of traveling by transit at an early age, before auto dependency forms.
 14. Ensure that the public is educated about goals and process through a community relations campaign.
 15. Promote transit through advertising the benefits of a healthier, community-connected lifestyle. Use signs, commercials and other media.
 16. Put in place services to help customers become more sustainable themselves.
 17. Put in place partnerships that can allow for resource exchanges to achieve sustainability.
 18. Develop an agency sustainability awareness program. Ensure early and ongoing dialogue to coordinate sustainability programs, share results of efforts, and reinforce an agency wide culture of sustainability.
 19. Investigate how to quantify, measure and determine the carbon footprint for each product utilized or produced.
 20. Work systematically with customers to establish more sustainable processes and products.
 21. Put in place targets for costs savings from the use of recycled materials and energy efficiency measures in all new projects.
 22. Put in place a regular internal reporting system on the progress of sustainability initiatives.
 23. Establish an organization-wide policy and action plan that covers economic, social and environmental sustainability.
 24. Initiate an ISO 14001, energy management system (EMS) and/or sustainability management system (SMS) process.
 25. Carry out a systemwide energy and/or resource-use audit and a waste stream audit.
 26. Set a minimum recycling policy.
 27. Establish policies for reducing paper use.
 28. Adopt an energy-efficient appliance purchasing policy and other sustainable office equipment and supplies.
 29. Establish a "sustainable proposals" policy (e.g., proposals for bids sent in on 100 percent recyclable paper, double-sided, only one hard copy, maximum set for amount of pages, etc.)
 30. Establish a comprehensive measuring and reporting process on targets set, progress made and results achieved that is disseminated both internally within the organization as well as externally. Make it available to all interested stakeholders by publishing an annual sustainability report.
 31. Formulate an environmental policy stating environmental goals, intentions and an overall mission. Set specific goals to improve environmental performance, detailing how goals will be met and how employees will be responsible in meeting these goals.

5.2.2 Green procurement for maintenance and upgrades

1. Establish a green purchasing policy for purchase of products and leasing/purchase of equipment – to address energy use, recycled content, transport distance, and recyclable packaging.
2. Consider application of life-cycle assessment (LCA) processes to equipment, product and vehicular procurement, understanding that a realistic starting point and timeframe applicable to each specific LCA must be agreed upon and consistently applied.

3. Create an inventory listing of prohibited and limited-use chemicals, and include the inventory in the transit agency's environmental management system audit and continuous improvement programs. Include a procedure that allows for research and approval for use of alternative products to reduce the inventory of limited-use chemicals.
4. Establish minimum "green" qualifications for designers of renovations, specifiers and purchasers.
5. Utilize standard environmental labeling programs for specifying products.
6. Put in place procurement methods that require (or favor) sustainable practices for at least one product line or area.
7. Identify and purchase office supplies that make use of recycled products or have other environmentally friendly attributes.
8. Research, access and participate in state- or regional-level databases for reused and recycled materials, such as that held by the California Integrated Waste Management Board
9. Participate in multi-agency requests for proposals (RFP) programs, thereby increasing leverage and encouraging sustainable approaches and reducing cost.

5.2.3 Paints, solvents and cleaners

1. Utilize low-VOC and water-based paints and solvents.
2. Develop a solvent reclamation program
3. Specify nontoxic cleaners whenever possible.
4. Manage procurement of cleaning supplies on a regular or computerized schedule to reduce shipping and stock waste.

5.2.4 Refrigerants, oils, engine coolant and batteries

1. Specify nontoxic materials whenever possible.
2. Reduce refrigerant, oil, engine coolant and battery waste products by recycling or filtering for reuse onsite.

5.3 Energy and resource efficiency

These guidelines are aimed at reducing energy consumption in transit operations and maintenance, investigating ways to improve energy efficiency and identifying what renewable energy systems might work for various operations and maintenance activities within the system. When appropriate, the guidelines address specific modes, including bus and rail.

5.3.1 Implement energy and water conservation procedures for operations and maintenance

1. Reduce water usage at facilities:
 - Capture, treat and reuse vehicle wash wastewater and storm drain runoff instead of potable water in vehicle, equipment and facility wash operations and for irrigation at yards and station campuses.
 - Install water filters at taps in offices and shops instead of purchasing bottled water. Ensure regular replacement of filters.
 - Work with local agencies to promote potential for use of water from dewatering operations, or other treated water of suitable quality to supplement groundwater recharge where geotechnical conditions are suitable.
 - Become paperless. Take advantage of electronics and computerized systems to get away from paper-based communications in offices, yards and shops.
2. Alter bus operations and routes based on optimized energy usage. Establish metrics against which service plans are measured to determine if a route is being implemented as sustainably as possible (e.g., passengers per revenue mile, fuel consumption per passenger mile, and other metrics.) Computer models are available to do this.
3. Use computer modeling of transit operations and passenger loading patterns to optimize stop locations.
4. Conduct or participate in an energy audit. Energy suppliers such as Pacific Gas & Electric offer free energy audits.
5. Tailor preventive and other maintenance to minimize energy usage by automating equipment and vehicle maintenance schedules and developing an efficient maintenance training program. Shop tools and lifts can be also be used more efficiently, in a way that reduces energy consumption.
6. Communication-based train control (CBTC) improves the operational efficiency of a train system by allowing trains to be spaced closer together, resulting in more customers per hour. It also helps limit the amount of energy used because the train will automatically slow down, with a decreased need for energy needed for braking, thus minimizing electrical consumption.
7. Install automated on/off switching for auxiliary systems on light rail vehicles. This is especially useful during yard stays, thereby achieving significant savings in kilowatt-hours and energy costs.

5.3.2 Improve energy efficiency of operations and lower peak demand

1. Establish energy-saving goals or protocols for operations and maintenance activities, if possible matching state and regional goals. Include staff training on energy and efficiency requirements into operation of vehicles. Right-size vehicles. Establish policies regarding location of meetings, avoiding unnecessary trips. Provide operator training to ensure the smooth use of power and to reduce fuel/energy consumption. Reduce fuel usage by reducing bus idle times.
2. Utilize energy-saver and hibernate functions on motors and equipment.
3. Monitor vehicle fuel consumption. A transit agency's finance department typically keeps track of all fuel being used every day. This department can provide information regarding fuel consumption per bus. Using this information, incentives for the lowest fuel use, individual accountability and a need to use energy responsibly can be established.
4. Reduce ownership and operation of nonrevenue vehicles. Consider participating in car sharing organizations such as Zipcar or City Car Share instead of owning a fleet of nonrevenue vehicles. A transit agency, as a major customer, has influence and the ability to leverage car sharing and to encourage car-sharing organizations to use non-fossil or hybrid technologies.
5. Utilize telephone or web-based meetings and training sessions whenever possible.
6. Install a signal to let vehicle operators or structure occupants know that doors are open to conserve heat/cooling. Be accountable for energy used year by year, and include energy conservation as a performance measure for facility operators and owners/maintainers. Adjust set points for heating and

air conditioning to save energy wherever possible. Also, provide controls and procedures to operate facilities with less heating and cooling when not occupied.

7. When replacing lighting, use energy-efficient technology such as fluorescent lamps, including both thin tubes and CFLs for tunnel lighting, station lighting, etc., LED lights (in signals, emergency lights, signage, etc.), and induction lighting.
8. Use motion sensors and photoelectric dimmers in ancillary rooms and other remote work areas to reduce electricity consumption.
9. Use photocells and timers to control exterior lighting fixtures.
10. Incorporate advanced lighting control and power regulating system to optimize power consumption.
11. Install energy metering specific to facilities. Where individual cost centers have separate metering, they can be held accountable for energy consumption.
12. Establish a policy of recommissioning existing HVAC systems to ensure optimal performance and energy efficiency.

5.3.3 Use renewable energy resources

1. Purchase Renewable Energy Credits (RECs). By participating in a state-level or province-level REC program, a transit agency can legitimately claim to use green power, incentivizing carbon-neutral power suppliers and essentially subsidizing power-generating utilities that obtain some or all of their electricity from renewable energy such as solar or wind power.
2. Purchase electricity directly from renewable sources or establish percentage targets for renewable energy when issuing large scale electricity contracts.

5.4 Quality of ambient environment and health

These guidelines are aimed at transit system operation and maintenance practices to create a positive, safe and healthy ambient environment for patrons.

5.4.1 Provide clean and attractive vehicles, stations and transit nodes

1. Keep vehicle windows, wayfinding signage and interiors clean and free from graffiti.
2. Repair body damage. Repaint when needed, and regularly on predetermined schedules.
3. Provide periodic thorough cleaning to eliminate stains and odors, particularly in elevators.
4. Allow for rider input at stations regarding status of restrooms, escalators and elevators. Check regularly and provide prompt response.
5. Maintain properly stocked first-aid kits and emergency responder supplies at stations.
6. Consider providing hand-sanitizer dispensers at strategic locations to encourage hand cleansing for better public health.

5.4.2 Ensure friendly and courteous service

1. Provide training to operators to be helpful and courteous. Train them to be goodwill ambassadors and the face of transit to the riding public.
2. Provide for an operator's rapid contact with and connection to available internal and external emergency support services on buses and rail.
3. Prohibit texting and other operator distractions while driving.
4. Enforce agency uniform standards.
5. Provide information to the operator on delays on road calls so they can make informed decisions about their options.

5.4.3 Plan for crowd control and monitor riding comfort

1. Consider the needs of all riders. Some may wish to sit and read, daydream, chat, look out the window and experience the sensation of movement. Others may prefer to stand, especially if they have

strollers or luggage with them. Take steps to understand and address riders' wants through surveys or other methods.

2. Optimize headways and scheduling to prevent vehicles from becoming overcrowded. Incorporate customer experience into level of service. Set a target for every passenger to get a seat after a certain time limit standing, and monitor to ensure results.
3. Let riders waiting on platforms know the length of the approaching train and where various-length trains stop along the platform. With this information, passengers can distribute themselves along the platform and increase their chances of quickly entering and finding a seat.
4. When possible, mark the platform to indicate where car entrances are located to facilitate organized queuing and easier exiting for disembarking passengers.
5. Monitor and control noise levels to which riders are exposed.
6. Monitor and control air temperature and flow.
7. Maintain and publicize safety records to make riders feel safe on transit.
8. Maintain tracks and wheels to reduce in-vehicle noise.
9. Announce each stop visually and verbally.
10. Maintain electronic security cameras on buses and trains, providing regularly scheduled testing and repair/replacement.

5.4.4 Consider innovative health and safety devices and programs

1. Coordinate with local police security organizations to allow for passenger escorts at stations, stops, or parking lots/garages during late-night operations or for those who may require help.
2. Partner with local health agencies to support health-based initiatives.

5.5 Emissions and pollution control

Pollution reduction and prevention requires close monitoring of operations and implementation of environmental policy, as well as training. Training for emergency response for situations such as spills, for example, is normally part of an environmental management system. A transit organization's environmental management system uses management policy, commitments and implementing procedures to set goals; achieve them; and monitor and continuously improve environmental performance.

For a transit agency, reduction of pollution and emissions primarily relates to prevention of spills, leaks and air emissions, as well as reduction of waste and the reduction and proper storage, use and disposal of hazardous materials. Where possible, materials purchased should be evaluated to ensure that the least hazardous materials appropriate for the designated use are being purchased. Hazardous materials should be tracked and systematically eliminated from use where possible. As discussed in Section 5.2.2, a green procurement process can be used to track and prevent the purchase of identified hazardous materials.

The reduction of solid waste can be achieved in many ways. Preventing waste and recycling are the most prevalent. Most materials can be recycled or reused. In a transit organization, it is typical to recycle metals, wood, paper, batteries, waste oil, solvents, grease, used oil filters, antifreeze, tires, and electronic equipment, to name a few. Also, at the end of their useful life, vehicles can be sold for scrap or for other uses. From an environmental sustainability perspective, it is important to know the end destination of these recycled products. Green procurement, or environmentally responsible purchasing, is valuable for establishing this type of information in a large organization.

5.5.1 Implement pollution reduction strategies (eliminate, reduce, reuse and recycle)

1. Reduce hazardous-waste and chemical usage in all agency facilities through the use of an inventory and criteria for what is to be eliminated, what is to have limited use, and processes to ensure proper management of these wastes and chemicals.
2. Establish a system to divert organic waste to composting facilities, where available.

3. Establish a reduced idling policy for buses and other revenue and nonrevenue vehicles.
4. Introduce methods that extend the life of lubricants.
5. Reduce pesticide and herbicide use. Utilize integrated pest management. Refer to the EPA's Integrated Pest Management program at www.epa.gov/pesticides.
6. Reduce vehicle wash water use reduction through efficient system design (spray, pressure, reused water cycles). Take care to ensure that recycled water does not contain contaminants such as chlorides.
7. Implement waste reduction and recycling programs, such as recycling of railroad ties, electronic devices, lamps and ballasts.
8. Document the final destination of recycled products such as motor oil and computer components.
9. Divert waste from landfills. Recycle paper products, bottles, cans and compostable materials such as landscape and food waste.
10. Keep records of existing hazardous material quantities in stock, and store them in an established, secure on-site location by type as close as possible to where they will be used, along with standard MSDS precautions and spill response supplies.
11. Optimize employee travel by using teleconferencing equipment, transit ridership, cycling, walking, carpooling and other sustainable options:
 - Have a green mobility plan (bike, telecommute, webcasting, car-sharing, ride-sharing, no-parking policy, etc.) for the agency/organization, and offer transit passes as part of employee benefits.
 - Establish a business travel policy focused on sustainability, encouraging the reduction of carbon emissions and air pollutants.
12. Reduce the carbon footprint of meetings (e.g., establishing collaborative sites and using email distribution of documents as part of a paper-reduction policy).
13. Initiate training for employees on sustainability overall and systems or practices such as EMS, SMS and ISO 14001.

5.5.2 Enhance facility performance and longevity

1. Perform regular and appropriate maintenance to optimize quality and longevity of facilities, systems and vehicles.
2. Monitor energy use and emissions, and make adjustments to optimize efficiency of systems.
3. Research, plan and perform upgrades to optimize efficiencies and to reduce emissions of facilities, systems and vehicles.

5.5.3 Manage wastewater

1. Treat wastewater from car-washing system for recycling within the washer.
2. Neutralize effluents from car-washing system before they are directed to city sewers.
3. Utilize oil-water separators and maintain their operation.

6. Implementation tools

This section includes tools that have proven successful for transit agencies to implement the sustainability guidelines provided herein. This section is limited to overview information. Details and case studies are available in APTA's "Transit Sustainability Practice Compendium" and at links cited below. **Table 2** lists key implementation tools and benefits.

TABLE 2
Sustainability Implementation Tools

Tool	Key Benefit
Environmental management systems/ sustainability management systems (EMS / SMS)	Develop a systematic, comprehensive framework for approaching and improving sustainability.
Life cycle assessment and multiple account evaluation	Gain a fuller understanding of environmental impacts that result from agency decisions. Get a better understanding of where to focus sustainability efforts.
Advocacy: transit benefits and green practices	Increase ridership and public support for transit. Build and strengthen image as an environmental leader.
External and internal partnering	Get the support needed to implement practices recommended in this document and institutionalize sustainability within agency.
Measurement	Determine if efforts to improve sustainability are achieving intended results or if approaches should be changed

6.1 Advocacy

An empty bus cannot be a sustainable bus. Therefore one of the primary goals of the guidelines is to enhance transit so it becomes more viable than traveling by automobile. Transit agencies can learn from the effectiveness of automobile industry promotion that has convinced public to buy and drive cars. Transit advocacy means promoting sustainability internally and to the community. Actively market the benefits of transit to the community. Be sure the community is getting information on the “good neighbor” role transit plays in reducing pollution. Marketing should reframe transit by promoting its strengths and highlighting the competitive advantages of choosing transit over driving:

- **Money savings.** Reduce vehicle use and ownership, taking into account costs such as car purchase, insurance, repairs, maintenance, gas and parking.
- **Safety.** Highlight transit’s superior safety record, using statistics to provide detailed information on how much less likely accidents and injuries are on transit vehicles compared to automobiles. Consider displaying comparative safety statistics in stations, transit nodes and vehicles and through television commercials and website articles.
- **Comfort.** Promote the design features of transit that make riding comfortable, such as large windows, sufficient personal space, and Wi-Fi.
- **Improve health.** Clarify the health benefits associated with transit, such as comparing the average air quality on a subway car and a freeway and the increased physical activity from walking and biking to stops and stations. Obtain data from the public health department on the community to be served, when possible.
- **Environment.** Highlight transit’s contribution to the reduction of greenhouse gases and other emissions linked to cancer, asthma, etc.
- **Improved time management.** Make sure potential riders know exactly when transit will arrive and depart.
- **Reduced stress.** Point out that public transit is dependable and easy to use; allows riders to relax or work on the trip; and eliminates traffic and parking challenges.
- **Improved quality of life.** Promote transit’s ability to strengthen the community by getting people into public spaces.
- **Enjoyment.** Highlight that riding transit can be a fun experience, and that spending more time in the community helps people feel connected.

6.2 Partnering

Building mutually beneficial relationships with a diverse group of external stakeholders and internal staff, management, board members and others can help a transit agency reach its goals. Ensure early and ongoing dialogue with partners to coordinate sustainability efforts, share results and institutionalize an agencywide culture of sustainability. Provide appropriate funding and resources for sustainability education, training and outreach functions.

Some important points:

- Generate open, early dialogue with stakeholders.
- Seek and utilize input from a broad cross-section of stakeholders.
- Align interests and develop collaborative goals.
- Begin commissioning by creating measures to accompany goals.
- Document meetings and distribute information to partners to promote common understanding and accountability.
- Work with state or provincial and local officials to develop collaborative goals. Agree to the scope of the transit project as it aligns with relevant jurisdictional goals and programs. Seek input from stakeholders in relevant jurisdictions. **Table 3** lists authorities and agencies to consider.

TABLE 3

Potential Partners for Transit Agencies

Examples of state agencies:	Examples of local agencies (city, county, other)
Department of Transportation	Department of Transportation
Parks and Recreation	Parks and Recreation
Historic Preservation Office	Historic Landmarks
Environmental Quality	Water
Housing and Community Services	Housing Authority
Economic Development	Local and Regional Planning
Land Conservation	Economic Development
Economic Development	Environmental Services
Public Health	Arts and Culture

- Provide adequate feedback and a strong graphic component to outreach to ensure good public relationship and to mitigate risk.

6.3 Systematic evaluations and performance management

Multiple account evaluation is a systematic, comprehensive evaluation method, incorporating both qualitative and quantitative costs and benefits, used to compare and assess alternate projects or initiatives. Performance management is used to track how an agency is performing and to document its results.

Measurement will allow the agency to monitor projects and programs to make them more effective, and to more efficiently use resources. Agencies should develop an internal or third-party sustainability commissioning program. Those individuals charged with developing sustainability measures should meet

with agency administration, human resources, legal, planning, operations, maintenance, marketing and public affairs stakeholders to align interests, goals, opportunities, protocols and reporting processes.

Some goals that could be monitored include the following:

- Use sustainable practices in the operations and maintenance of organizations and transit systems.
- Establish new energy efficiency targets for key products.
- Improve sustainability performance of key products.
- Obtain third-party verification of measurements and reductions.

6.4 Life-cycle assessment

Life-cycle assessment is a tool to evaluate and weigh “cradle to grave” environmental impacts and costs of materials and processes.

6.5 Environmental and sustainability management systems

This is a systematic, comprehensive approach to managing environmental impacts (and social and economic impacts for an SMS) in ways that are best suited for each individual agency:

- Establish resources and tools for use by employees, clients and the community on what sustainability means and how it can be achieved.
- Establish an in-house knowledge management system on sustainability.
- Establish employee green team(s) or other formal programs for employee engagement in the organization’s sustainability program.
- Achieve carbon neutrality and/or have a carbon neutral policy.
- Delegate responsibilities, set up and conduct employee training, and communicate energy management system (EMS) goals and procedures to employees.
- Assess environmental impacts, goal attainment and methods used to monitor and measure environmental impacts. Record past environmental issues and the mechanisms utilized to prevent recurrence.
- Evaluate the system in terms of effectiveness and appropriateness for reaching agency goals. Identify new goals and make adjustments to the EMS.

7. Background and more information

Information within this document is based on content from APTA’s “Transit Sustainability Practice Compendium,” which is a living document created by an expert team of transit practitioners. The compendium is far more comprehensive in scope and detail than this *Recommended Practice*.

The compendium provides transit agencies with a broader range of best practices and case studies for improving their systems and achieving their sustainability objectives. It focuses on practices that are unique to transit. Best practices that are not unique to the transit industry but are applicable to many aspects of transit facilities and operations — such as the LEED Rating System and ISO 14000 — are listed as Reference Standards.

The compendium addresses all modes of transit, all service areas and all sizes of operations. Recommended practices attempt to consider the degree of control or influence transit agencies have in particular areas, as well as expected environmental and social improvements. The compendium serves as:

- An informational resource for policy makers seeking a holistic approach to environmentally sustainable transit and transit professionals, municipalities and communities looking to become more informed;
- A reference to promote a common language and maximize effective transit investments;
- A resource to highlight the need and advantages of partnerships;
- A reference book for transit professionals and decision makers looking for tangible means to improve the sustainability of transit systems; and
- A tool to aid in better understanding and accounting for the sustainability of current systems.

The compendium is available on APTA's website.

References

American Public Transportation Association, “Transit Sustainability Practice Compendium,” Editor-in-Chief Tian Feng, draft August 2009.

Definitions

community. The people living in a specific locality (urban, suburban, or rural area) where there are common destinations for households such as workplaces, schools, medical facilities, shops, commercial and cultural establishments. A community may bridge across governmental jurisdictions. Community is “society at large” in a particular area.

Fischer-Tropsch process: A set of chemical reactions that convert a mixture of carbon monoxide and hydrogen into liquid hydrocarbons. See http://en.wikipedia.org/wiki/Fischer%E2%80%93Tropsch_process.

mobility. Ability to transport people; ability for people to travel among their chosen destinations and homes with or without motorized transportation systems.

transit. A motorized passenger transportation system capable of carrying a mass of people operating in a fixed route, openly accessible by general public.

passenger transport. All modes of motorized transportation systems for moving people via air, land, and water. In the United States, the majority of passenger transport is based on the automobile.

transit node. A rail station, bus stop, transit center, or ferry terminal. There are also intermodal nodes where various public transit modes share a common node.

Abbreviations and acronyms

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	ASTM International, formerly the American Society for Testing and Materials
AQ	air quality
BREEAM	BRE Environmental Assessment Method
BRT	bus rapid transit
BTL	biomass to liquids
CAS	Chemical Abstracts Service
CBTC	communication-based train control
CFL	compact fluorescent lamp
CNG	compressed natural gas
CTL	coal to liquids
CPTED	crime prevention through environmental design
DBE	disadvantaged business enterprise
DMU	diesel multiple unit
DOE	Department of Energy
EMS	energy management system
EPA	Environmental Protection Agency
FTA	Federal Transit Administration
GHG	greenhouse gas
GTL	gas to liquids
HVAC	heating, ventilation and air conditioning
IAQ	indoor air quality
LCA	life cycle assessment

LED	light-emitting diode
LEED	Leadership in Energy and Environmental Design
LNG	liquefied natural gas
LRV	light rail vehicle
MPO	metropolitan planning organization
MSDS	material safety data sheet
REC	Renewable Energy Credit
RFP	request for proposal
ROW	right-of-way
SMS	sustainability management system
USGBC	United States Green Building Council
VMT	vehicle miles traveled
VOC	volatile organic compound